



# Akulon® Fuel Lock. Lightweight, low permeation polyamide for CNG tanks.

Natural gas has claimed its place in the automotive industry as a cost effective fuel with a low carbon footprint. Countries with major natural gas reserves are increasingly capitalizing on the advantages of using these resources, which is estimated to drive the growth of natural gas use by close to 25% in the coming years.

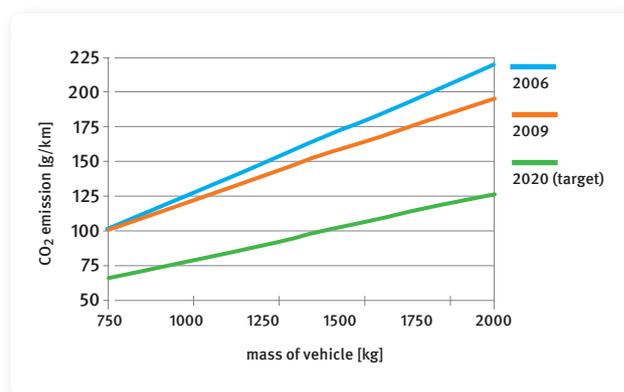
Compressed Natural Gas (CNG) reduces CO<sub>2</sub> emissions by 15% compared to current solutions in petrol or diesel. Further reduction of CO<sub>2</sub> emissions can be achieved using lightweight solutions, such as full composite Type IV tanks. Liners made from polyamide Akulon® Fuel Lock further reduce the impact on climate change compared to other plastic liners by reducing the permeation of methane which is a potent greenhouse gas. Permeation of methane is undesirable for tank installations in passenger vehicles, making an effective barrier of utmost importance not only for the wellbeing and the comfort of the people but also for the safeguard of the environment.

Akulon Fuel Lock enables the safe use of lightweight composite tanks with an extremely low permeation level.



## A focus on reducing weight

Steel tanks have the advantage of preventing methane permeation, however they add significant weight to the vehicle with detrimental consequences on fuel economy. The European Union recently adopted a set of mandatory emission reduction targets for new cars. Passenger cars need to comply with a maximum CO<sub>2</sub> emission of 95g/km, which is a reduction of 40% over the 2008 rate (sources: European Commission Regulation Proposal July 2012 and International Council on Clean Transportation July 2011).

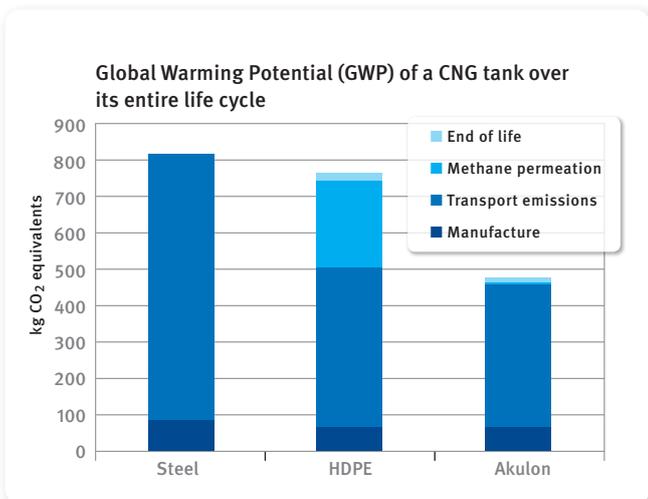


The challenge is clear: How can we effectively use CNG as a low carbon emission fuel while avoiding the CO<sub>2</sub> penalty that would result from the additional weight of traditional steel tanks? The solution is offered by Type IV tanks that enable the use of CNG as a fuel while reducing weight.

A traditional 40L steel tank weighs around 60kg, while a composite Type IV tank can weigh as little as 20kg. Every 100kg of vehicle weight reduction reduces CO<sub>2</sub> emissions by 10 g/ km, helping manufacturers to avoid the €95 per vehicle penalty.

### Low permeation to reduce methane emissions

But weight reduction is only part of the solution. Indeed, while lightweight composite Type IV tanks contribute to a better fuel economy compared to steel, they carry the risk of methane permeation. Since methane is a greenhouse gas (GHG) with 25 times higher Global Warming Potential (GWP) than CO<sub>2</sub>, its emission to air constitute an extra burden on climate change. Permeation of this gas represents a concern not only for the wellbeing and the comfort of the passengers but also for the environment. Type IV tanks need a liner made from an effective barrier material to prevent the permeation of this greenhouse gas. Akulon Fuel Lock provides a liner material that reduces methane emissions by a factor of at least 150 compared to conventionally used HDPE, enabling the use of Type IV tanks inside passenger cars. The assessment of the environmental impact of a CNG tank over its entire life cycle – from manufacturing to end of life, including its use in the vehicle for 10 years or 230,000 km – shows that moving from a steel Type I tank to a Type IV tank with an HDPE-based liner of 3mm wall thickness would decrease the total global warming potential of only less than 10%, due to HDPE's poor performance as a methane barrier.

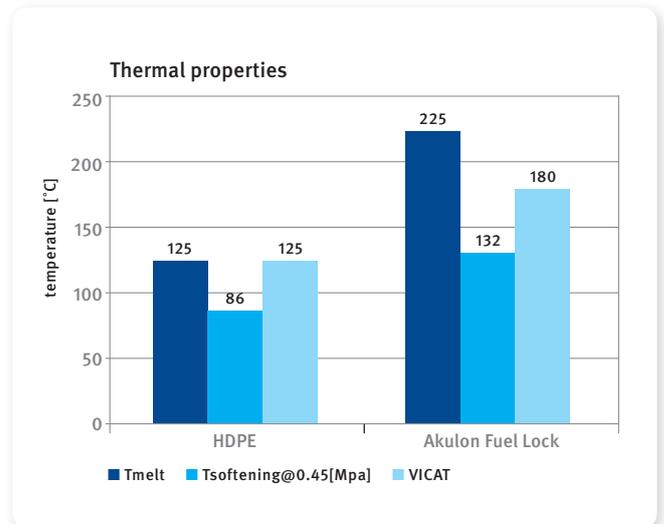


On the contrary, lining the tank with Akulon Fuel Lock (1.5mm wall thickness) would reduce GHG emissions up to more than 40% compared to steel. In addition, the potential reduction in wall thickness can increase tank volume by as much as 1.5L for a 40L tank, significantly extending the range.

Akulon Fuel Lock proves to be the most effective barrier, empowering the automotive industry to make full use of CNG as a future fuel for vehicles with lightweight construction and decreased impact on the environment.

### Safety is always a primary concern

Akulon Fuel Lock is a successful liner material because of the balance it strikes between low-temperature performance (down to -60°C) and low permeation, all while maintaining good processability. Tank temperatures drop to -60°C during the fast-filling process, causing shrinkage in the liner. At the same time, the pressure increases rapidly, resulting in fast expansion of the liner.



Akulon Fuel Lock is designed to handle the required elongation at low temperature, while also meeting the required impact performance during drop tests to comply with ECE R110. The material successfully passes the pressure cycle test at -40°C with >10,000 cycles and withstands extreme fast-filling at -40°C. Akulon Fuel Lock's high-temperature performance exceeds HDPE in dimensional stability (softening/creep), ensuring leak tight tanks at high temperatures in cars of up to 90°C.

### Akulon Fuel Lock: A drop-in replacement

Akulon Fuel Lock exhibits extremely high parison stability in the blow molding process. The parison stability allows to move towards a very narrow wall thickness distribution of 2.0 ± 0.1 mm for a 1 m long parison of 5 kilograms. The material can be processed on blow molding equipment suitable for HDPE with a L/D ratio of 25. In addition, cycle times can be reduced by 10 to 20% over HDPE. Direct inline re-use of up to 50% scrap has no effect on the parison stability or material performance. Akulon Fuel Lock is also available for injection molding and extrusion, giving you the freedom to design in virtually any configuration, and the ability to produce tanks for heavy-duty vehicles. In addition, DSM offers both design and on-site technical support so you get the maximum return on your investment.



### A proven track record

Akulon Fuel Lock enables safe use of lightweight composite tanks with an extremely low permeation level. The Akulon Fuel Lock portfolio consists of a number of impact modified, high barrier, polyamide 6 material grades for injection molding, blow molding and extrusion. These commercially available materials have been tested and used in this field of applications for several years without any accidents or issues. Akulon Fuel Lock is used in tanks that comply with ECE R110.

## Environmental information and methodological background

### Life Cycle Thinking

At DSM, sustainability lies at the heart of our business. That's why we focus on how our products and processes effect people, profit and the planet in their entire life cycle. We contribute to a brighter living with innovative solutions that create more value with less environmental impact.

The ecological benefits can be created at any stage of the product life cycle, from raw material through manufacturing and use to potential re-use and end-of-life disposal. To measure these benefits we use the Life Cycle Assessment methodology.

### Cradle to Gate Eco Footprint of Akulon Fuel Lock

The cradle to gate eco footprint values for 1kg of Akulon Fuel Lock in five impact categories are provided in the table below. They can be used to assess the environmental impact of Akulon Fuel Lock in footprinting studies further down the value-chain.

Eco footprint, cradle to gate of Akulon Fuel Lock		
Impact category	Unit	Value
Global warming (GWP100)	kg CO <sub>2</sub> eq	5.0
Ozone layer depletion (ODP)	µg CFC-11 eq	342
Photochemical oxidation	g C <sub>2</sub> H <sub>4</sub> eq	4.4
Acidification	g SO <sub>2</sub> eq	13
Eutrophication	g PO <sub>4</sub> <sup>3-</sup> eq	3.3

### Life Cycle Assessment (LCA) and Footprinting

DSM has a well-established LCA competence center. We routinely apply ISO 14000 series standards for LCA and The Greenhouse Gas Protocol for Carbon Footprinting. The Global Warming Potential (GWP) - or Carbon Footprint, expressed as CO<sub>2</sub> equivalents – was calculated using the Intergovernmental Panel on Climate Change method (IPCC 2007 GWP 100a).

The Eco Footprint was calculated using the methods prescribed by the International EPD® system. Details can be found at <http://www.gednet.org>.

For data on the raw materials processes background information from EcolInvent Database v2.01 from the Swiss Centre for Life Cycle Inventories was used.



## DSM Engineering Plastics

For further information, please see:  
[www.dsm.com](http://www.dsm.com) or contact:

### Europe

Tel +31 46 47 73796  
 Info-Europe.DEP@dsm.com

### Americas

Tel +1 800 333 4237  
 Info-Americas.DEP@dsm.com

### Asia Pacific

Tel +86 21 6141 8188  
 Info-Asia.DEP@dsm.com

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