Development of filter systems with durable materials for alternative fuels in the on- and off-highway area

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Content

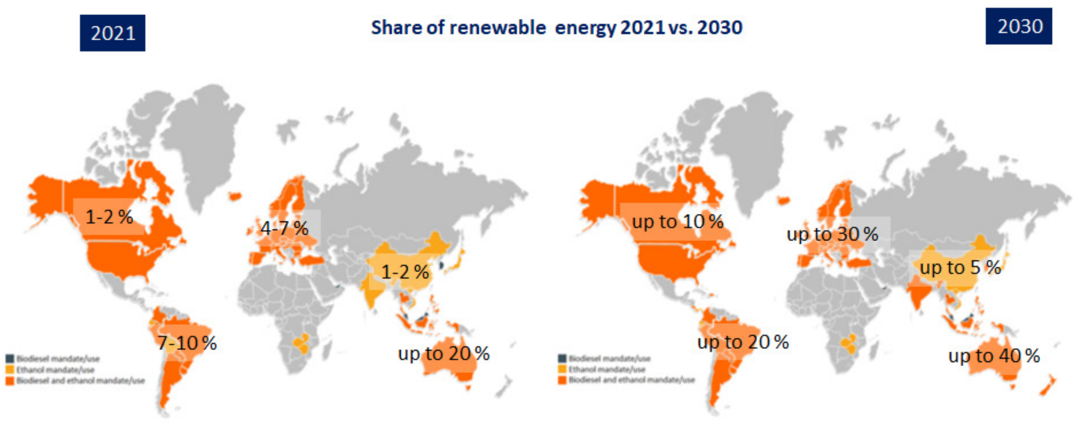
Introduction

In commercial vehicles and in the off-highway sector in particular, the combustion engine will remain the most widespread drive system for many years to come. In order to advance climate protection, Hengst is further developing the fuel filter systems for these applications so that they can also be used when using alternative fuels. Among other things, the resistance of the filter materials to aged and therefore acidic biofuels has been verified using the latest testing methods. One example is the innovative Blue.maxx modular fuel filter system, which, thanks to a modular concept, can be quickly and easily adapted to the specific requirements of the respective application.

Alternative fuels on the rise worldwide

In the area of heavy commercial vehicles and off-highway applications, combustion engines, and diesel engines in particular, will remain one of the most important sources of motive power in the future, alongside alternative concepts such as battery-powered e-drives or fuel cells. The diversification of propulsion options supports the countless special requirements in many different segments, such as agriculture, construction, material handling, mining and power generation, but also in long-distance overland goods transport and the specific conditions in different regions worldwide.

Alternative fuels make it possible to reduce greenhouse gas emissions from diesel engines in order to implement socially and politically specified climate targets. They can either be used in their pure form or mixed with fossil fuels. However, fuels made from biogenic raw materials in particular have physical and chemical properties that differ greatly from those of commercially available diesel, which can affect the service life of the materials used in the fuel filtration path. This creates some uncertainty among vehicle and engine manufacturers, because their customers naturally expect the usual properties of the diesel engine, such as low operating costs, high reliability and availability as well as durability, regardless of the fuel used. Known problems include



Source: SGS, Global Biofuels Outlook

Fig. 1: Expected global increase in alternative fuels

increased water absorption, formation of acids through aging, increased risk of fungi and bacteria (the so-called diesel plague) and the formation of polymers through reaction with oxygen. In the field, this can lead to filter clogging, corrosion and, if the materials are unsuitable, swelling of the seals and damage to the filter elements. Efficient water separation by the filter helps both to avoid diesel plague and to reduce corrosion in the fuel system.

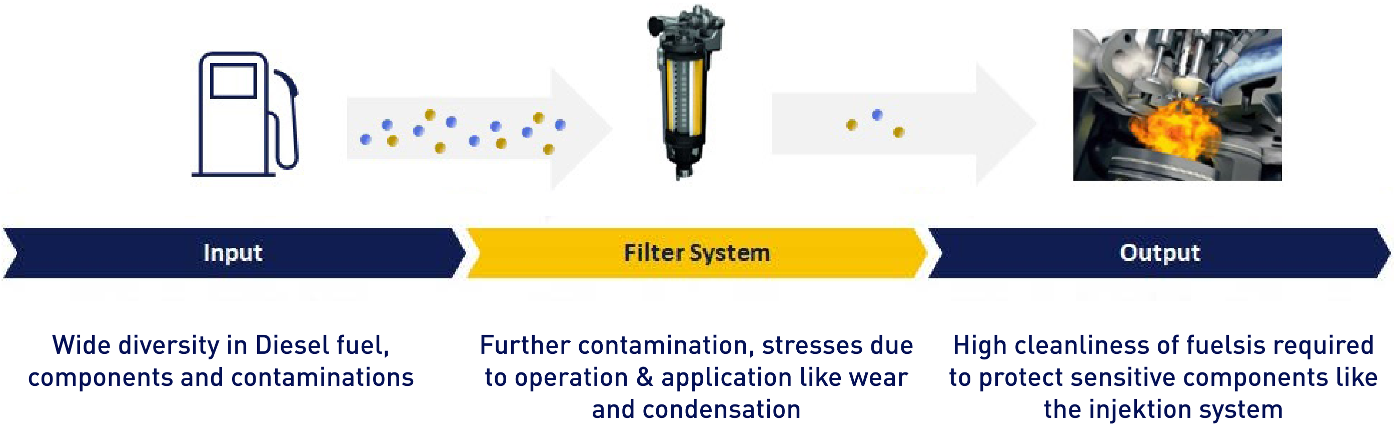


Fig. 2: Chain of action from the fuel to the engine

Problem of fuel aging

Hengst is one of the leading manufacturers of fuel filter systems and has been pursuing the goal of further improving the environmental friendliness of diesel engines through product developments and innovations for many decades. In order to promote climate protection, Hengst is further developing the fuel filter systems for commercial vehicles and off-highway areas so that they can also be used when using alternative fuels.

An important building block of this is a special test methodology with which materials for filter systems are specifically selected and developed for use with biofuels. The basis is the selection and chemical analysis of the alternative fuels that will be relevant in the future in the different regions of the world for the various areas of application. During use in the field, the high aging potential of biofuels, which depends on temperature and storage conditions, leads to higher risks of failure. This can result in aggressive acids that can significantly reduce the service life of the fuel filter system. In the benchmarking comparison of the various biofuels, fatty acid methyl ester compounds, also known as FAME (Fatty Acid Methyl Ester), turned out to be particularly critical in this context. They are obtained by transesterification of vegetable oil. Depending on regional availability, rapeseed (RME, in Europe), oil palm (in Malaysia, Indonesia) or soya (SME, in Argentina, Brazil, USA) are the primary raw materials used. In contrast, alternative fuels such as hydrogenated vegetable oils (HVO) and synthetic fuels did not show any properties that differed from diesel (EN 590) and do not have to be given special consideration in the development of future fuel filter systems in terms of aging resistance.

Alternate refueling:
High additions of HVO in fossil or in bio can lead to strong flocculation of otherwise dissolved oligomers/ polymers, to the reduced solubility of HVO.

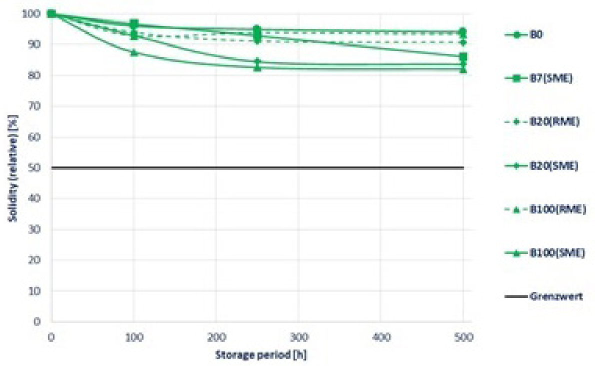
Fig. 3: Potential risks with FAME

The knowledge gained from the laboratory tests led to key points for the company's own material tests at Hengst, with which the everyday conditions on the test bench can be realistically reproduced:

- The resistance of filter media is largely determined by the acid number of the fuel used. The level of the acid number depends on the conditions in the region in which the filter is to be used. While in Europe, Japan and possibly also in North America, standard-compliant diesel fuels can be expected (acid number <0.5 milligrams of potassium hydroxide/gram), an acid number of> 1.0 milligrams of potassium hydroxide/gram must also be expected if the components are used internationally.
- In order to create realistic conditions, the fuels are artificially aged before the tests. The aging temperature is based on the maximum usage temperature and therefore varies depending on the region and application.

Non-aged fuel

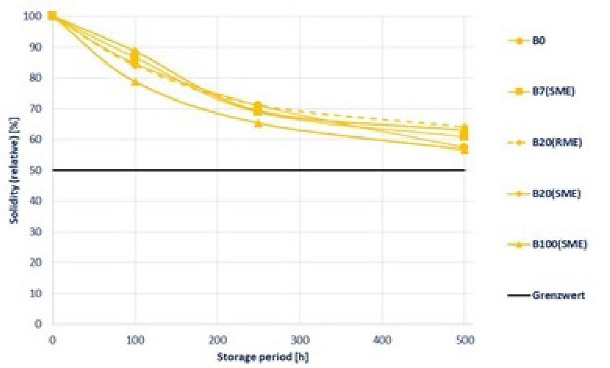
During aging of a standard filter medium in a basic fuel with different biofuel content there are only minor differences in the aging effects. The aging effects tend to be minor.



Borderline aged fuel

(e.g. Europe, Japan, USA)

Even if the acidvalue increases to the standard permissible value of 0.5 mg KOH/g, stability losses of up to 45% can be expected under these test conditions. Due to the high initial stability of such filter media, this value would be just sufficient.



Critual fuel

(e.g. Brazil, Indonesia, Malaysia)

A further increase of the acid value to 1 mg KOH/g causes aging effects of more than 50%. Since the increase in the acid value depends primarily on the biofuel content, a B0 fuel was not used in the stability test with an acid value of 1.0 mg KOH/g.

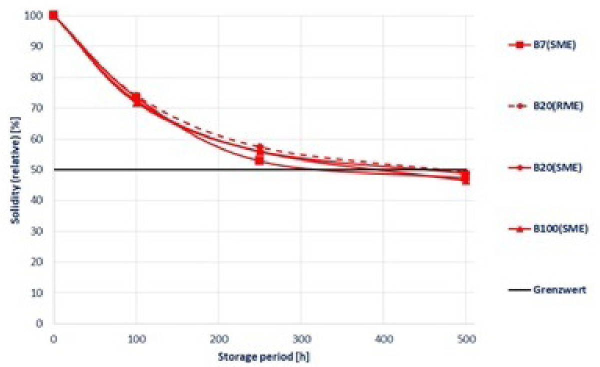


Fig. 4: Rising acid number with fuel aging

Overall development process covers laboratory and field tests

In order to develop tailor-made filtration solutions for specific customer requirements, Hengst has established an overall development process that extends from the first draft of a new filter module through simulation and testing of materials, components and the entire system to long-term tests in the real vehicle and the application of the finished component. The scope of testing goes far beyond the standards customary in the industry and required by vehicle and engine manufacturers.

The figure shows the essential components of the development process of a fuel filter system from the filter medium to the filter element, material aging is only a small part of it. The tests with hydraulic oils are excellently suited for comparative investigations of the various filter media. Tests with standardized dusts according to ISO12103 provide initial indications of the loading behavior, but are not conclusive on their own, which is why Hengst also carries out time-lapse tests of real dusting on the refueling test stand. Reference fuels (CEC fuels) enable the tests to be compared, but fluctuating qualities are not covered, so that they provide too little insight into what is happening under real conditions. Therefore, Hengst supplements the investigations on the pulsation/vibration test stand and the service life analyses with extensive real tests on the road, both with entire vehicle fleets and individual vehicles for endurance tests.

The test filters are assessed after use in the vehicle, for example with regard to their real dust absorption and thus remaining service life as well as the actual water separation at the end of their service interval. The vehicle tests provide the most meaningful results, but slow down the development process. This means that Hengst uses the tests as an upstream development step. The performance of the filter is guaranteed by the overall development process, which is based on the comparison of the entire chain from the filter material (particles) and coalescer (water) to the feedback of the filter diagnosis after field use.

The development process thus also covers challenges that only become apparent in the field. In addition to the problems with biodiesel mentioned, there are, for example, fluctuating fuel qualities due to the differing fuel standards worldwide and very often impurities that are introduced in refineries, pipelines or at the filling station. Under these challenging conditions, the fuel filter system must guarantee a lifetime of filter performance on the downstream or clean side of the filter that prevents damage from particles or corrosion and minimizes wear-and-tear on engine parts and components such as the injection pump or injector. The developers pay particular attention to alternating loads, which unavoidably occur due to pulsation or vibrations in real operation and can lead to the detachment of particles and their entry into the fuel on the clean side.

Trials by Hengst show, for example, that a filter medium with a beta value in the laboratory of 1000 at 4 µm (particle count ratio 1000 before and 1 after passage through the filter) may only achieve a beta value of 5 in actual operation (out of 1000 particles, 200 Particles on the clean side). A filter element, which achieves a stable, high degree of separation even with vibration and pulsation, protects the sensitive injection system, with its tight tolerances, against wear and thus also ensures high engine efficiency over the service life.

The challenges for the filter system have risen sharply in recent years, because the increasingly complex injection systems react more and more sensitively to contamination in the fuel. A few years ago, a filtration efficiency of 99 percent was sufficient (corresponds to a beta value of 100), but modern Hengst systems now achieve a filter efficiency of 99.99 percent (beta value

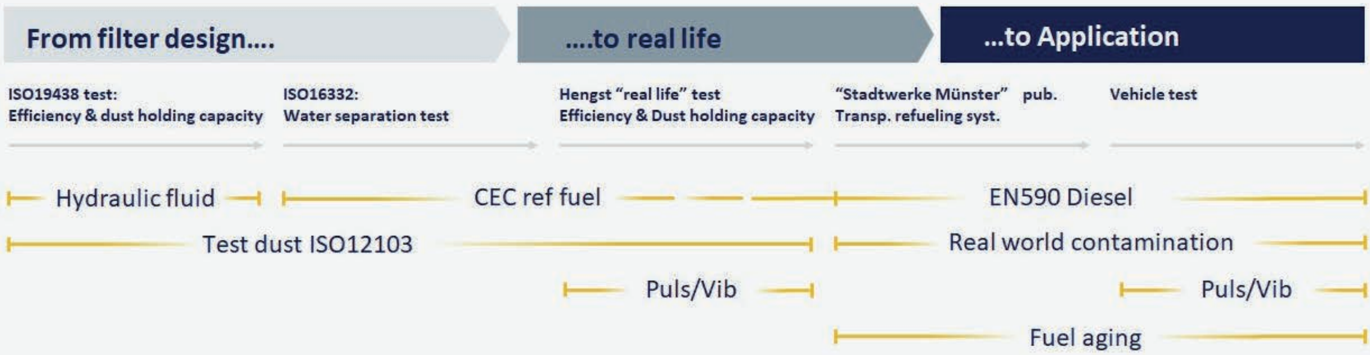


Fig. 5: Overall development process of new filter systems at Hengst

10,000). At the same time, new filter media (materials) have even tripled the dust storage capacity of the competition, to around 180 grams/cubic decimeter today. With higher filter performance, the systems offer identical or even longer service lives than just a few years ago, even under adverse operating conditions.

Combi Design

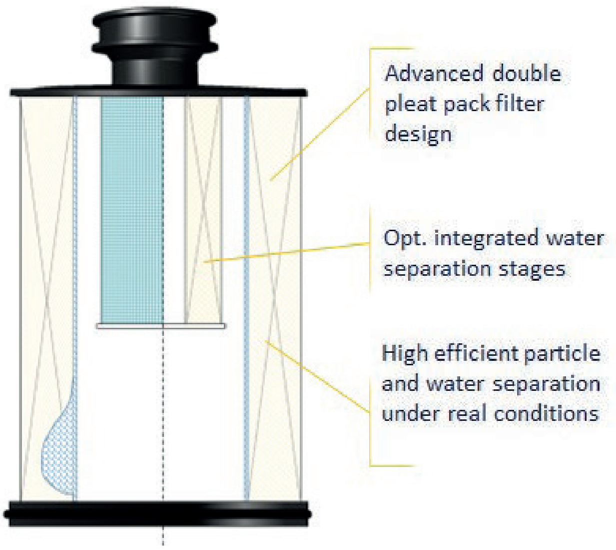


Fig. 6: Filter insert in combination design

Particle filtration

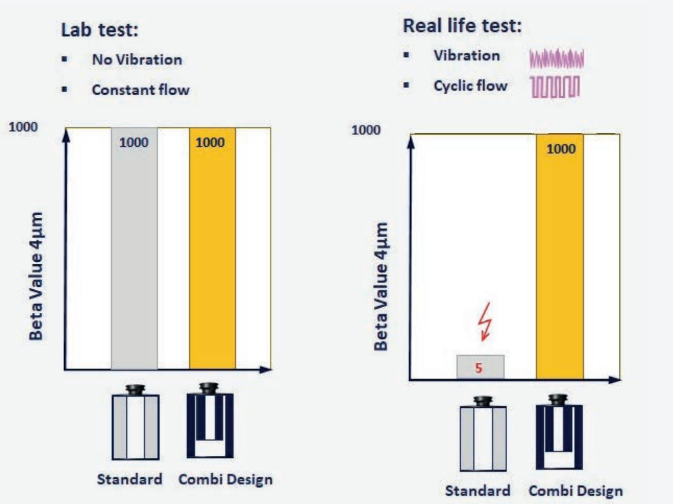


Fig. 7: Example vibration/pulsation: Only realistic tests provide information about the filter performance in the field

Filter efficiency and dust hold capacity

Specific flow rates, end Δp = 80kPa

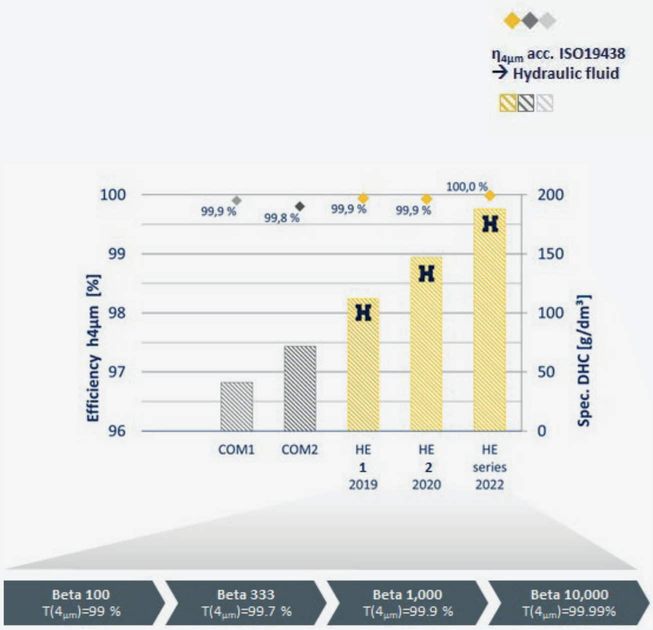


Fig. 8: Increasing filter efficiencies ensure that modern engine concepts can function properly

Blue.maxx – a modular system for all applications

The Blue.maxx fuel filter concept was created on the basis of Hengst's comprehensive system and development know-how. The system is suitable for all fuels that are currently used and those that are likely to be used in the future worldwide – both fossil, biogenic and synthetic.

In order to meet the diverse requirements of modern engine technology in the commercial vehicle and off-highway sectors, Hengst designed the fuel filter system in a modular manner. It can be quickly and easily adapted to different applications as an OE or aftermarket solution. The configurator available at **www.hengst.com/blue.maxx** provides assistance with selection and determines the ideal Blue.maxx solution for the individual application with just a few input clicks.

The design of the filter concept.

01 Manual feed pump / E pump

02 Bleed screw

03 Fuel heater (optional)

04 Patented Energetic® filter insert

05 Cover with integrated water collection area

06 Water drain plug
(Water level sensor – optional)

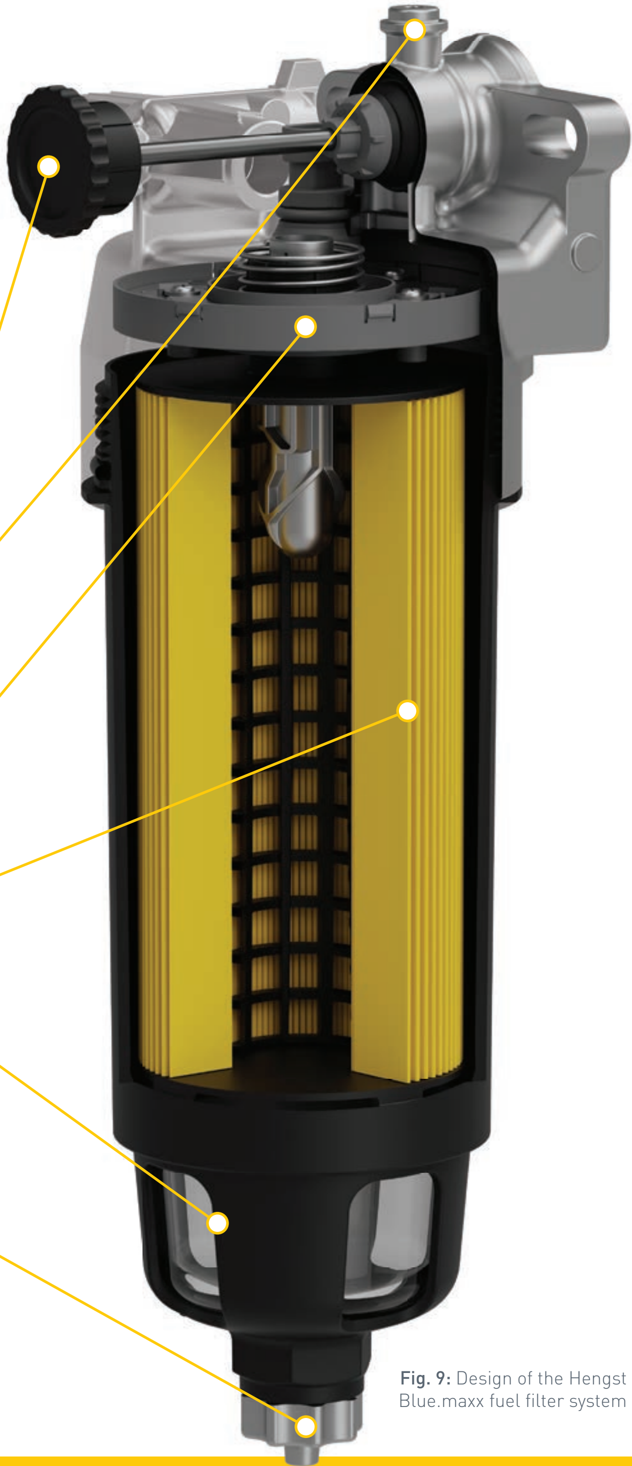


Fig. 9: Design of the Hengst Blue.maxx fuel filter system

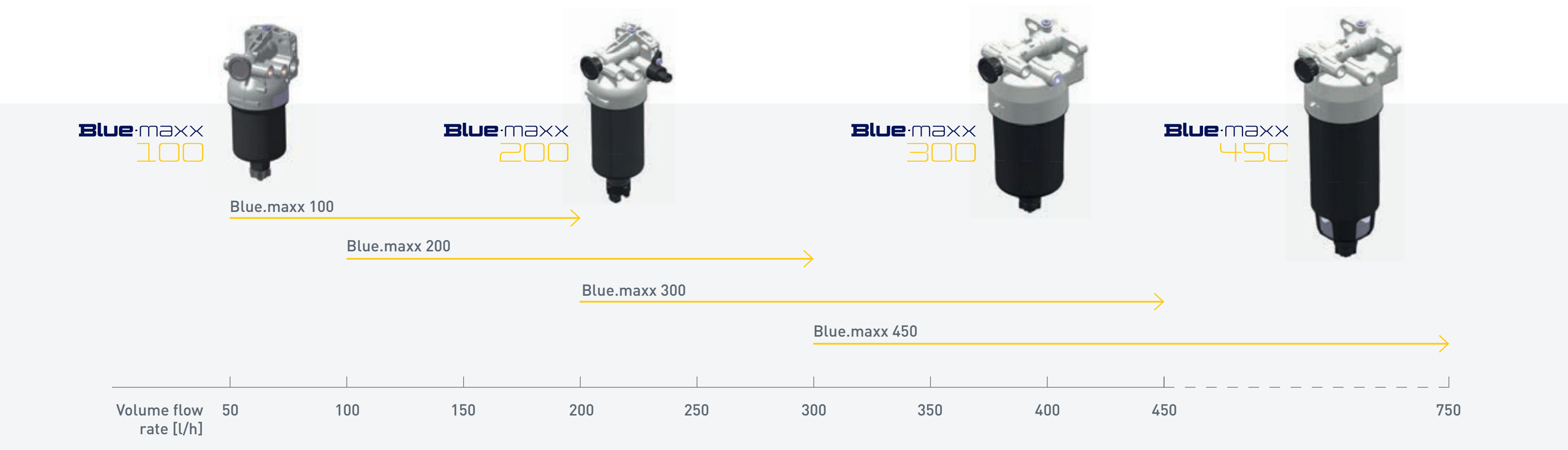


Fig. 10: The four basic sizes with all the flexibly combinable components cover a large part of the standard applications

The heart of the Blue.maxx is the Energetic fuel filter insert. Depending on the separation and fineness requirements, various single or multi-layer filter elements are available. When changing the completely thermally usable, metal-free insert, the shoring protection prevents incorrect handling and the installation of plagiarism. The Blue.maxx system can be designed in two parts as a pre- and main filter or as a combined main filter with integrated water separation. In addition to corrosion protection, water separation makes an important contribution to avoiding diesel plague. With the water separator integrated in the filter element, which consists of a coalescer and a sieve, the combined system achieves particularly effective water separation and ensures a high degree of fuel purity. The separated water is collected in the water collection chamber.

The Blue.maxx construction kit contains four basic variants for volume flows from 50 to 750 liters/hour, which can be individually adjusted using various additional elements.

For example, customers can choose between a manual and an electric fuel transfer pump. Both solutions offer a high delivery volume, high suction height, maximum functional reliability and low power losses thanks to a flow-optimized design. A rod heater and a more powerful ring heater are available for temperature control of the fuel, which are controlled by an integrated thermal switch. The water level in the collection chamber can be detected using active or passive sensors. Additional functions such as a water drain indicator make the Blue.maxx a smart component in the electronic system of the application

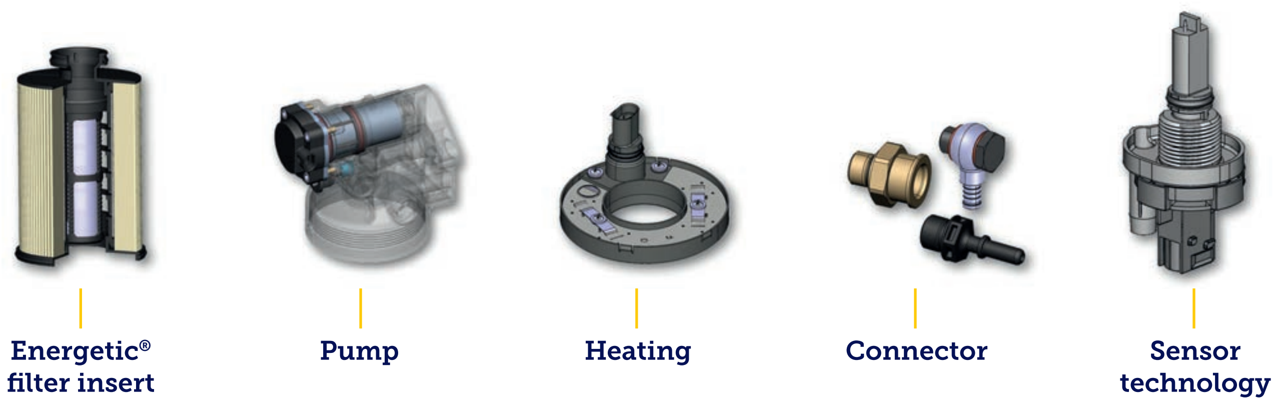


Fig. 11: Modular extension of the Blue.maxx filter system from the construction kit

Summary and Outlook

Due to the complex technology of today's internal combustion engines, the integration of a modern filter system that can separate a multitude of the finest particles, as well as water droplets, is essential. In the future, alternative fuels and their blends will increasingly be used in commercial vehicles and in the off-highway sector for environmental reasons. Due to signs of aging in the biofuels and the higher water absorption capacity, problems can arise during operation. Hengst has developed special test methods in order to optimally adapt the fuel filter system to alternative fuels.

They are embedded in the overall development process of advanced fuel filter systems and create the basic requirement for the reliability and longevity of modern engines. An example of the products developed in this way is the innovative Blue.maxx fuel filter system, which consists of basic variants that are available as standard and can be supplemented with special additional modules. An online configurator makes it easier to put together the right filter solution for the respective application. With innovations such as the Blue.maxx, Hengst creates the conditions for the worldwide use of efficient and climate-friendly diesel drives with high availability, reliability and service life.

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