



Valves

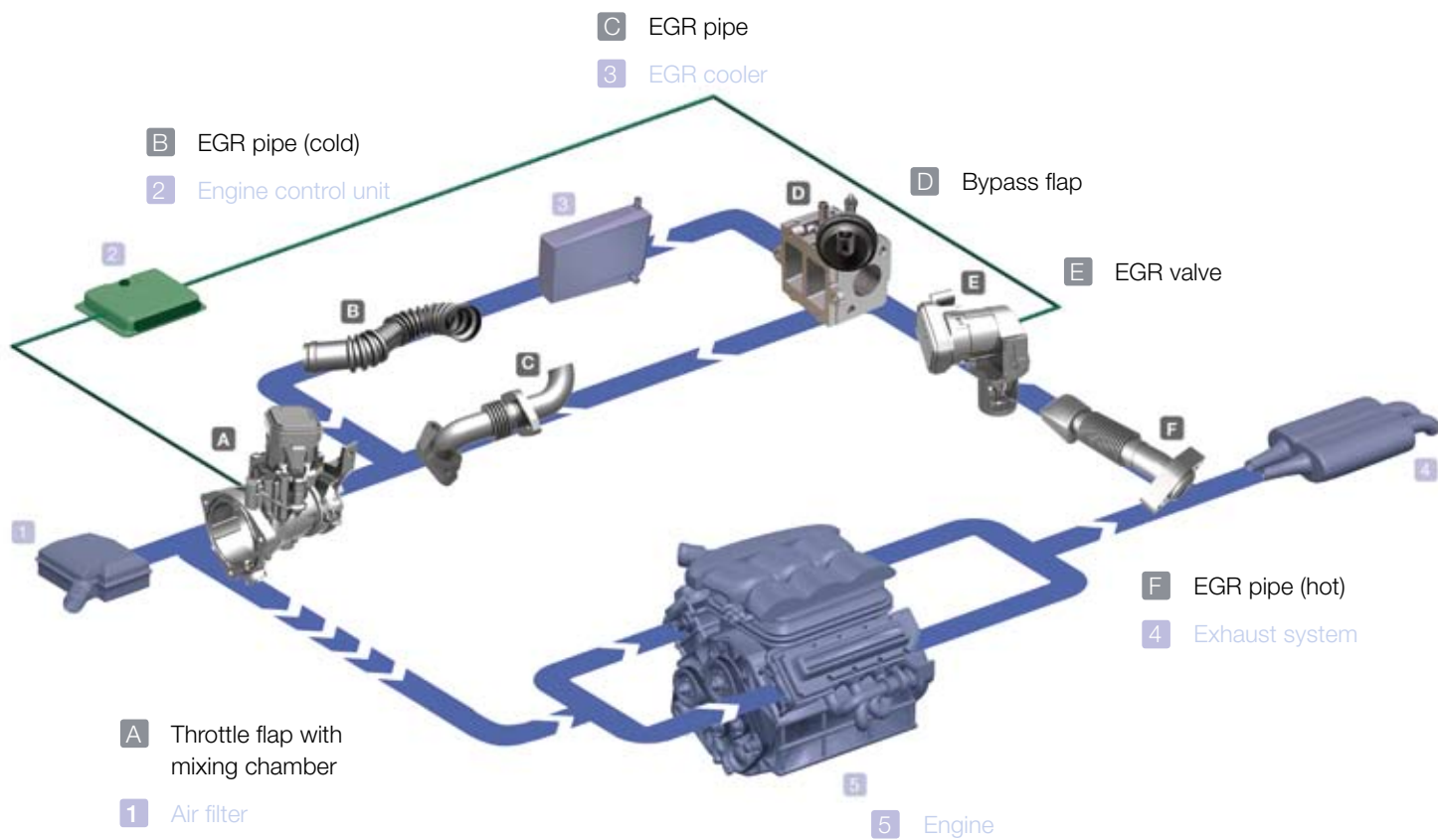


Wahler – Solutions in Partnership.
Products for Exhaust Gas and Temperature Management.

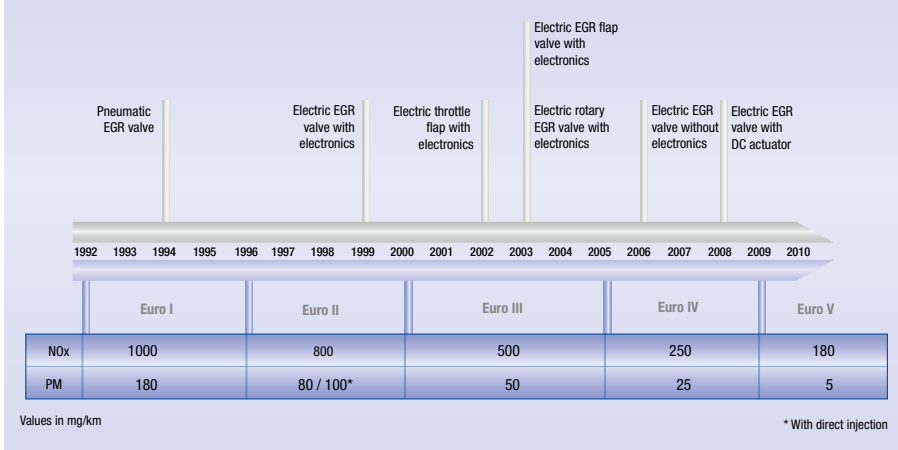


EGR Components

Key components for clean engine power



Development of Euro standards and Wahler EGR components



The demands made on driving comfort and engine power are constantly increasing. At the same time a growing awareness of the environment and more stringent exhaust gas limit values world-wide demand reduced emissions of hazardous substances, particularly of nitric oxide and particle distributions.

EGR for reducing NO_x

The most effective method for reducing the share of nitric oxides (NO_x) is achieved by exhaust gas return (EGR). Here, the exhaust gas is mixed with the

sucked-in ambient air. This leads to a lower oxygen concentration in the air/fuel mixture for the same load quantity in the combustion chamber, and thus to slower combustion. The subsequently achieved reduction in the peak combustion temperatures results in the reduced formation of nitric oxide.

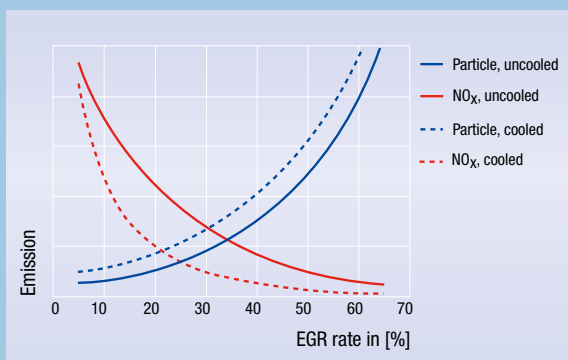
The reduced combustion temperature leads to an increase in the particle distribution in diesel engines. Post-oxidation of the particles and their complete burn-out would only take place at high temperatures. A conflict of objectives with the technical term 'Trade-Off'.

EGR Systems

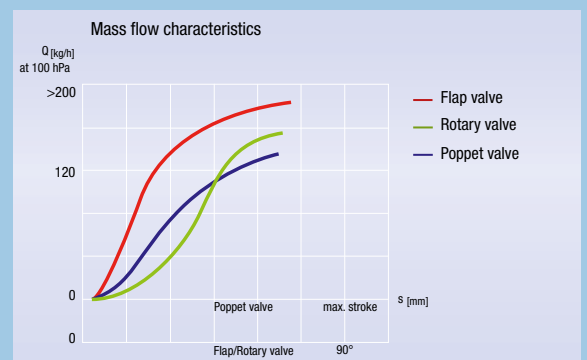
The combustion under differing operating conditions of the engine is always kept within the optimum working range via respective functions of the engine control unit and the implementation of EGR systems.

The EGR valve enables the quantity of the recirculated exhaust gas to be regulated. Depending on the engine temperature, the exhaust gas can be conducted through the bypass flap via the EGR cooler, or to the mixing chamber, uncooled. The throttle flap in the intake channel allows the differential pressure to rise and thereby the EGR quantity to increase.

The figure on the left shows all the EGR components that complement each other due to Wahler's close collaboration with the engine manufacturers to form a perfectly adapted EGR system. The implementation of EGR systems in the engines of the future will continue to increase, in order to adhere to the emission standards that are continually becoming more and more stringent.



'Trade-Off' – NO_x versus particle emission



Mass flow characteristics of the different valves

EGR Poppet Valves

Proven in the past and still up-to-date



Features of the EGR poppet valves

- Application for small to medium EGR rates (passenger cars, approx. 130 kg/h at 100 hPa and 20°C gas temperatur)
- Continuously variable control of the EGR mass flow rate
- Tight closure of the EGR channel during full-load operation
- Fail-safe function in the case of an actuator failure
- Pneumatic or electric actuator
- On-board diagnosis possible with position sensor
- Option – with or without controller
- With/without cooling for use on hot/cold side

Wahler was one of the first to realise the significance of exhaust gas return and played a decisive role in its development. Since 1994 we have been producing pneumatic EGR valves in series and the figures speak for themselves. Over 10 million poppet valves have since been regulating the flow of exhaust gas in the engines of the most varying manufacturers.

Proven a millionfold

In the case of the poppet valve, the valve seat is integrated in the housing. It is closed by a poppet disc with a closely fitting geometry and thereby has very low leakage values. The poppet disc itself is connected to the actuator by a shaft. Pneumatic poppet valves have a vacuum actuator with a membrane that controls the poppet disc. If the vacuum pressure system should fail, a return spring ensures that the 'fail-safe' position 'valve closed' comes into effect. It similarly produces a counteracting force and thereby ensures a linear course of the characteristic.

Modern actuator

The introduction of the electronic control units (ECU) for engines gave rise to the requirement for enabling the EGR valves to be controlled by the engine software. An electro-pneumatic transducer therefore converts the control signals of the ECU to pneumatic pressure signals. As a result, the link was established between mechanics and electronics.

Following the requirements of modern combustion engines, Wahler fitted his successful poppet valves with an electric actuator in 1999. The electric poppet

valve ensures short positioning times and high positioning accuracy of less than 0.1 mm. The actuation via a rotary solenoid or a DC actuator enables direct access of the engine control unit.

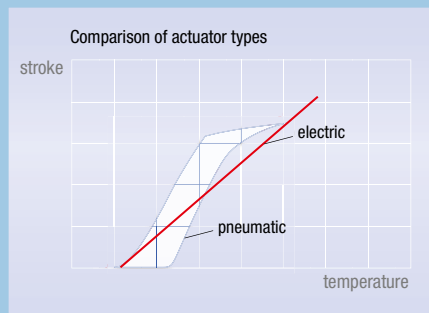
Intelligence of its own

A sensor for detecting the valve position enables real control. This takes place in the case of the rotary solenoid either via the engine control unit – like also in the case of the DC actuator – or via the own intelligence of the valve. In this case the engine control unit sends a set value via a powerless connection, that the valve holds independently, even in the case of variable differential pressure on the poppet.

In addition, the sensor enables the increasingly important OBD function. Diagnostic data can be recorded by the control unit and stored for later error diagnosis.



Pneumatic EGR valve with throttle flap



Hysteresis-free control for the electric poppet valve



Poppet valve with DC actuator

EGR Rotary and Flap Valves

Continuously variable from low to high mass flow rates



EGR flap valves at a glance

- Application for high EGR rates (medium and large-sized engines for commercial vehicles)
- Continuously variable control of the EGR mass flow rate
- Closure of the EGR channel during full-load operation
- Fail-safe function in the case of an actuator failure
- On-board diagnosis with position sensor

With the increasing complexity of modern combustion engines, the demands made on EGR components change. Due to the differing laws on emissions, different requirements result world-wide. New valves have been developed as a result of increasing exhaust counter pressure and variable differential pressure on the valve, the demand for continuously variable control of large flow rates and an exact control of small quantities of exhaust gas.

Electric rotary valve

For engines with a displacement of 2.5 - 9 litres (large passenger cars to medium-sized commercial vehicles) the rotary valve takes over both the exact and continuously variable control of small exhaust gas flows during full-load operation as well as the throughput of large flow rates during partial load operation.

In this case, the valve disc does not operate against the exhaust pressure like the poppet valve but, in a rotary movement, clears the window openings for the exhaust gas to flow through. The special contour of these openings enables the said requirements for controlling the exhaust gas flow to be fulfilled.

Electric flap valve

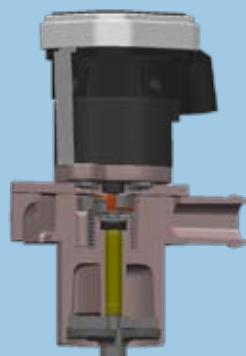
The flap valve fulfils the requirement for high exhaust gas return rates. These are required for large volume engines in heavy commercial vehicles. This valve is outstanding due to its short positioning times and its exact and continuously variable regulation of large flow rates. Appropriately adapted housing and flap geometries also ensure low leakage values.



Electric EGR rotary valve



Cross-section: electric EGR flap valve



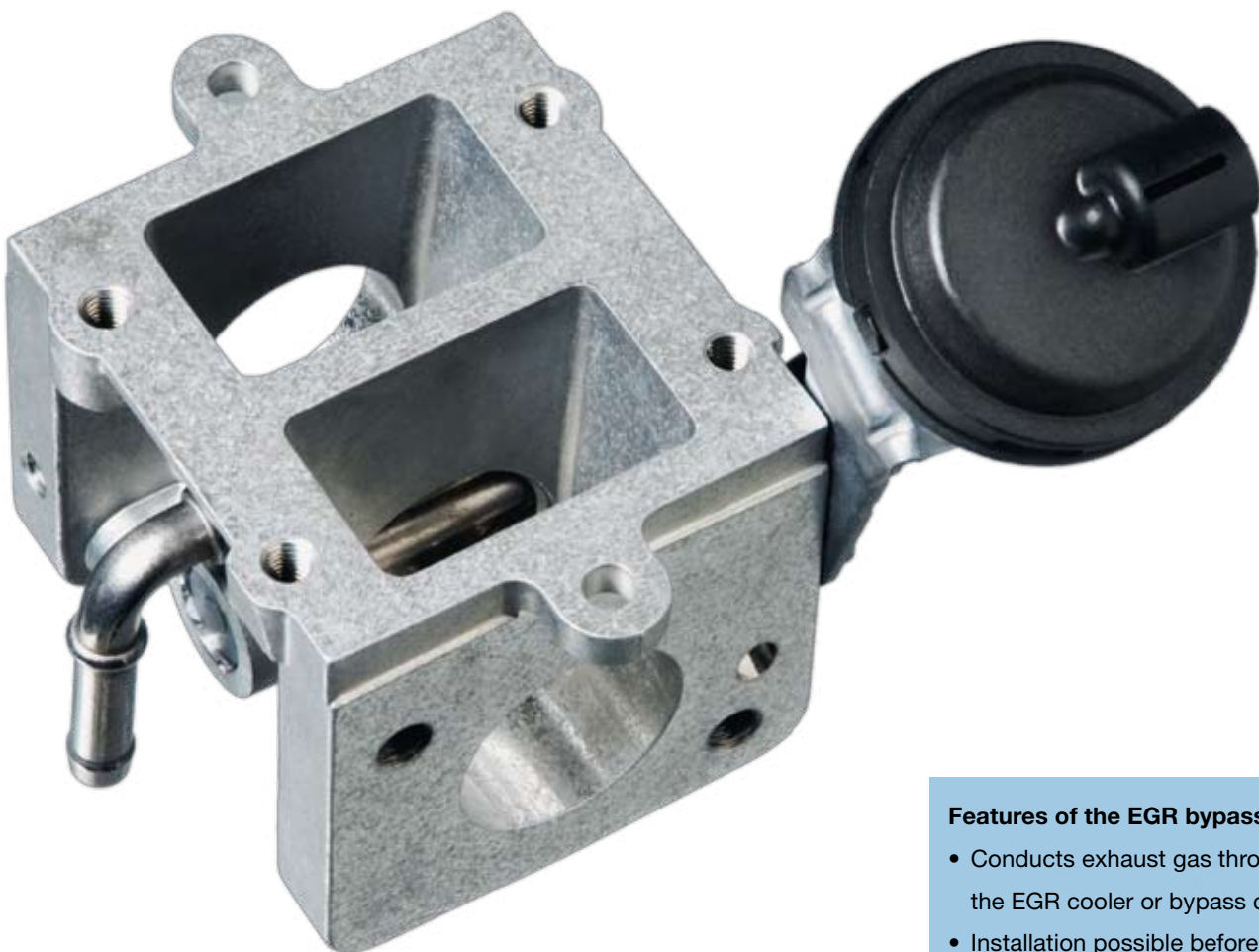
Cross-section: electric EGR rotary valve

Short introduction of the EGR rotary valves

- Application for medium EGR rates (passenger cars and medium-sized commercial vehicles)
- Continuously variable control of the EGR mass flow rate
- Exact control of low return rates
- Closure of the EGR channel during full-load operation
- Fail-safe function in the case of an actuator failure
- On-board diagnosis possible with position sensor
- Option – with or without electronics
- Option – with or without cooling

EGR Bypass Flap and Actuator

Pneumatics with a groundbreaking task



Features of the EGR bypass flap

- Conducts exhaust gas through the EGR cooler or bypass channel
- Installation possible before or after the EGR cooler
- Drive via pneumatic actuator
- Fail-safe function in the case of an actuator failure
- On-board diagnosis with position sensor
- Option – with or without cooling

After the quantity of exhaust gas actually needed has branched off via the EGR valve and has been conducted into the recirculation system, the further path of the EGR flow has to be determined, this depending on the engine and exhaust gas temperature. A bypass flap determines whether it should flow through the EGR cooler or through the bypass channel.

Each flap is different

The design of the flap has to be adapted to the respective cooler used and thus there are different designs and housing materials. For reasons of weight, the housing of a conventional bypass flap, is mostly made of aluminium die-cast. Depending on the application and

installation circumstances, the mechanics of these bypass flaps has to be protected by a suitable liquid cooling. For a high temperature-resistant variant without a liquid cooling, investment casting or steel casting is used. More recent developments use deep-draw housings made of stainless steel.

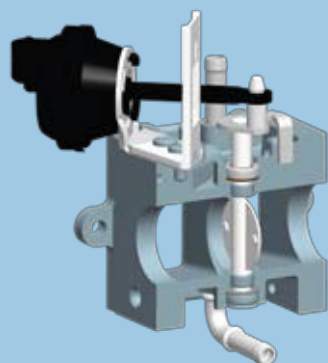
Universal actuator

The bypass flap is commonly activated via a pneumatic actuator. These versatile actuators fulfil various other functions on different engine components. Here, the membrane of a vacuum actuator is directly linked to a driving rod that can operate flaps for sound modulation in turbocharger applications, or for diesel particle filter regeneration (DPF) etc. Fitted with a position sensor, the actuator can also be used for applications where it is necessary to detect the stroke of the actuator (e.g. sound flap, turbocharger).

These mechanical components with their versatile applications are integrated with electronic control circuits by the use of an electro-pneumatic transducer.



Pneumatic actuator



Cross-section of bypass flap



Driving rod of the actuator

Profile of the pneumatic actuator

- Takes over different adjustment functions on the engine
- Membrane produces a lifting movement
- High actuating force in proportion to weight and installation space
- Fail-safe function in the case of a pressure system failure

Throttle Flap

The gateway from the intake channel to the engine



Functions of the throttle flap

- Mostly integrated in the mixing chamber
- In connection with the EGR valve, it controls the EGR rate by setting a defined differential pressure
- Controls the mass flow in the regeneration mode of the diesel particle filter
- Tight closure prevents the shut-down stroke when the engine is switched off
- On-board diagnosis with position sensor
- Fail-safe function in the case of an actuator failure

As a rule, the throttle flap is mostly integrated in the mixing chamber. Originally its scope of application was restricted to throttling the intake air in diesel engines and – by increasing the differential pressure – thereby increasing the amount of the returned exhaust gas. The demands for control precision and manipulating speed were comparably low.

Fitting accuracy

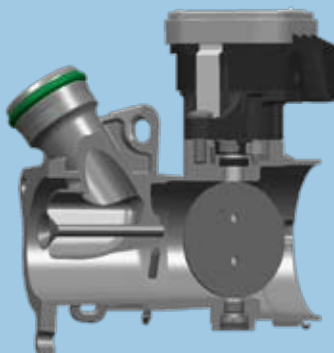
Today's diesel engines however, have to be operated with a defined air/fuel mixture, similar to gasoline engines. The modern throttle flaps take over important functions, e.g. the control of the incoming amount of air in the mode of the diesel particle filter regeneration. Complete closure of the throttle flap enables the temperature in the particle filter to increase until burn-off. The tight closure of the throttle flap is also beneficial when turning off the diesel engine. By interrupting the air-mass flow the engine only sucks in air at a very low density and stops without juddering. This contributes towards improving comfort, especially where large-volume engines in commercial vehicles are concerned.

Performance

High performance requires a progressive flow characteristic shortly before the throttle flap is in the closing position. If the angle for the closed flap is chosen at almost 90°, the flow characteristic is flat, as required. At smaller angles the characteristic is steeper and the control precision is reduced, as shown in the figure below.

Stable positioning

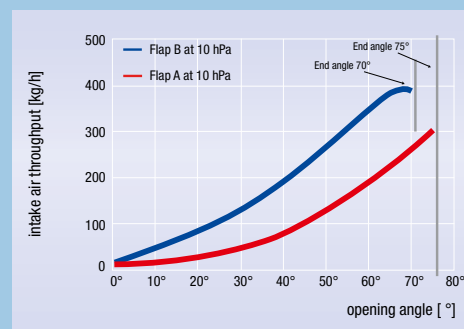
Besides integrating the algorithms for controlling the flap position completely with the engine electronics, the throttle flap can also be fitted with its own intelligence. This means the set value given by the engine control unit can be maintained even at variable differential pressures on the flap.



Cross-section – throttle flap



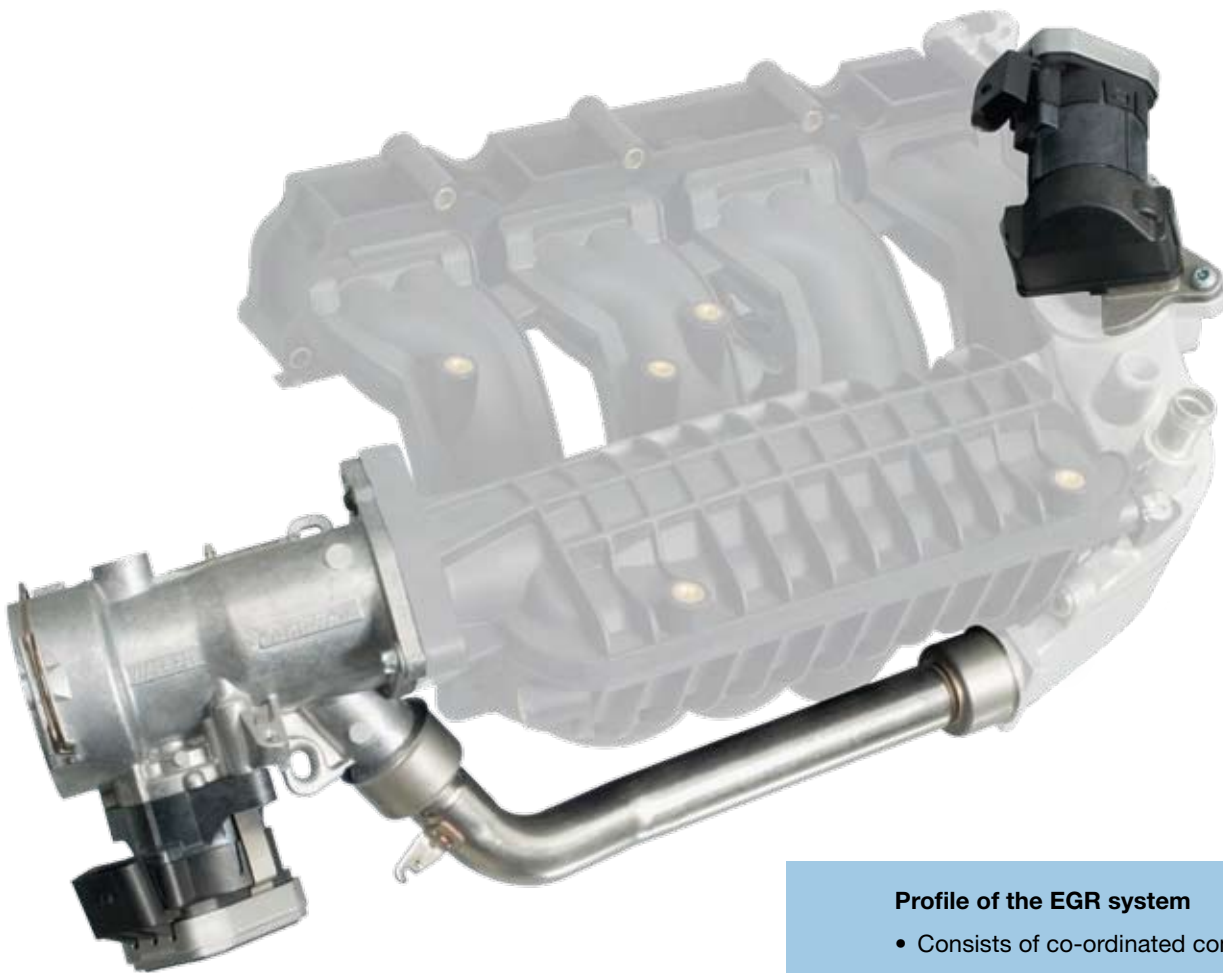
Adapted throttle flap with mixing chamber



Mass flow characteristics of different flaps

EGR Systems

Function and form – perfectly combined



Profile of the EGR system

- Consists of co-ordinated components
- Reduces the peak combustion temperature for reducing exhaust emissions
- The most effective method for reducing the NO_x emission
- More complex engines and more stringent environmental laws increase the demands
- One engineering partner – less co-ordination effort as well as lower prices

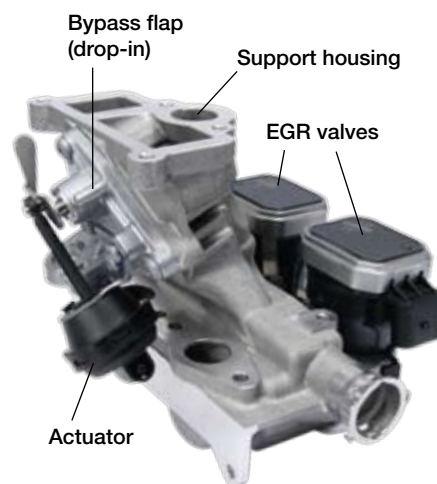
The engine concepts and thus also the concepts for exhaust gas return are undergoing continual further development. The individual components have to be adapted mutually in an optimum way, in order to fulfil the high demands for control precision and speed.

Competent development partner

The mere supply of isolated products is increasingly giving way to the joint development of sophisticated EGR components. Wahler is a long-standing, competent development partner for many automobile manufacturers and is in daily contact with the engine developers. Due to this close co-operation, well-adapted and efficient solutions result and signify a continuous improvement in engine technology.

The actuators of the future for example, will have a considerably smaller overall dimension for the same, or higher power density. EGR components are being fitted with sensors to an increasing extent and thus have an analogue or digital interface that enables them to be integrated in the engine control.

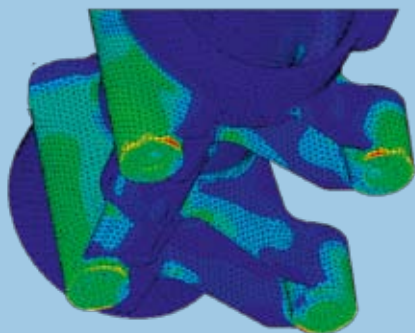
Only in this way shall we, together with our customers, be able to face the demands of the current engine development and the future legal requirements.



System solution including various components for exhaust gas return

Tradition and innovation

The development of new solutions is based on experience gained from previous projects. The development in the engine sector is progressing ever faster and Wahler is paving the way by modularising its products. New, decisive components for exhaust gas return thus develop from a successful mix of tradition and innovation. This reduces the time spent on development and provides new solutions based on proven concepts.



Pressure stress on the housing screw connections



Specialists with one aim – customer satisfaction



Compact EGR system

Continuous Improvements

Experience gained today are basis for the requirements of tomorrow



Research and development at Wahler

- A competent development partner for our customers
- Modern development methods
- Serial testing of all the components inhouse
- Continued development of automobile technology through innovation

At Wahler the product engineering process is determined by the quality assurance specifications of the automotive industry (VDA standards, QS 9000, DIN ISO 16949) and based on the progressive methods of APQP (Advanced Process Quality Planning).

Different aspects

A process-oriented structural organisation accompanies the development process from the initial idea through to the readiness for series production. Specialists from the Development, Production, Quality Assurance, Purchasing, Sales and Logistics already contribute their experience at an early phase in the new product's development.

Modern methods

The product development implements established methods and tools such as Finite Element Method (FEM), Computational Fluid Dynamics (CFD), Failure Modes and Effects Analysis (FMEA) and prototype construction. Particularly in the last point, Wahler is a convincing partner with its short response times and its fast availability of prototypes. The high flexibility of our medium-sized company helps to reduce the overall development time considerably.

At our company's own test benches the prototypes are put to the acid test and at our engine test bench, for example, they can prove their suitability for daily use.

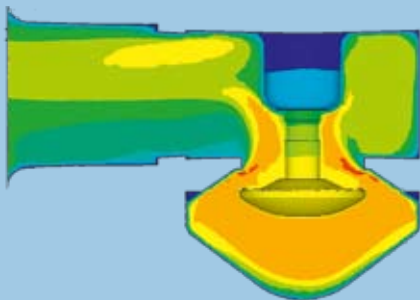
Once a product has reached the readiness stage for serial production, it is produced at modern, interlinked production lines. During production each valve is assigned a profile in which the origin and the testing parameters of each finally assembled product are recorded. This enables complete retracing of possible faults and ensures a consistent feedback of information from the quality assurance to the further product development.

Outlook

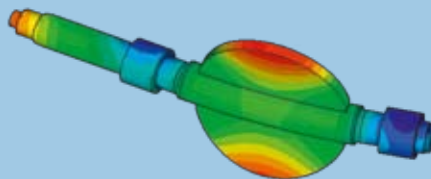
In the future, exhaust gas return in diesel engines will also be taking place during full-load operation and will thus involve the entire operating range of the engine. In the same way, the reduction of the NO_x emissions on a stratified-charge direct fuel injected gasoline engine calls for external EGR rates. As a result, the requirements for temperature resistance and solidity of the EGR components will rise. At the same time, the exhaust gas flow rate to be controlled will increase. This trend will demand new solutions for the housings, components and gaskets of the EGR components.

Fast, accurate and yet low-cost actuators will make their entrance, just as the assembly of individual components in a single unit makes up for the increasingly restricted installation conditions.

The growth in the application of EGR systems will be promoted by new engine concepts and more stringent emission standards. With its wide experience gained over many years, its motivated and highly qualified employees and its modern equipment, Wahler is optimally geared to this trend.



Visualisation of flow and temperature distribution



Examination of vibration stress



Test under real conditions at the engine test bench



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