Metaloflex® metal layer cylinder head gaskets.
The future is in the head.
ElringKlinger—present in automotive markets

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Cylinder head gaskets | Specialty gaskets | Housing modules | Topographic housing components | Shielding systems | Transmission applications

4 | Metaloflex® cylinder head gaskets
5 | Composition
6 | Coined stoppers
12 | Partial coating
13 | Designs
15 | Special design solutions
17 | Engineering
Experience mobility—Drive the future:
The ElringKlinger group of companies.

ElringKlinger—innovative development partner and series supplier to the international automotive industry and other industries. We think ahead and take on responsibility. For more sustainability and environmental compatibility. Today and tomorrow.

Our trendsetting technologies and sophisticated product solutions contribute to further reduce fuel consumption and emissions, and enable the use of alternative fuels and the development of new drive technologies. With comprehensive engineering and production expertise, we allow more freedom of design for engines, transmissions, exhaust systems, and auxiliary aggregates. Together with our customers, we successfully promote new technologies. To this end, we have around 3,400 employees working at 21 locations throughout the world.
**Metaloflex® cylinder head gaskets.**
Solutions are born in the head.

In modern engines, Metaloflex® cylinder head gaskets (CHG) are well-established as part of the global scene. As key components, they contribute to efficient, reliable, and economical engine operation.

The cylinder head gasket ensures a reliable seal between the cylinder head and block for fuel gases, coolants, and engine oil. It also acts as a load transmission element between the crankcase and the cylinder head, and as such, has considerable influence on the distribution of forces within the entire distortion system and the resulting elastic component deformations.

**Maximum freedom of design**

Metaloflex® from ElringKlinger: globally recognized brand mark for innovative metal layer CHG made of beaded, elastomer-coated spring steel layers—single-layer or multi-layer depending on the application. Thanks to the modular structure with the functional components including coating, bead, and stopper, this sealing system can be adapted individually and precisely to suit the specific requirements of the engine. And this saves time-consuming and costly iterative steps in development and testing. For maximum creative freedom required for engine design.

The technical strength of the metal layer CHG is especially apparent in diesel engines and high-performance gasoline engines with direct injection. Introduced to the European market by ElringKlinger at the beginning of the 90’s, today this sealing system reigns supreme in the international automotive industry. With Metaloflex®, ElringKlinger is the world’s largest manufacturer of metal layer CHGs.

**Innovations for even more performance and operating efficiency**

Innovative coined stoppers including segment stoppers, honeycomb stoppers, and serpentine stoppers as well as dimple stoppers for backland support, all of which can also be designed (topographically) with height profiling, help achieve more economical solutions while simultaneously increasing functional potential.

In the area of partial coating, ElringKlinger has developed a new elastomer formula, which is optimally adapted to suit the extreme requirements of modern, high-performance engines especially with regard to stability.
Composition.
Expertise in sealing systems, layer by layer.

The optimum interaction of the individual design elements of Metaloflex® metal layer CHGs guarantees the functionality and reliability of the sealing system.

**Half beads**
Half beads generate two-line compression. They seal along the coolant and engine oil passages, around the bolt holes, and the circumference of the outer sealing contour.

**Full beads**
Full beads generate three-line compression around the circumference of the combustion chamber. This elastic sealing element enables the sealing of very high ignition pressures, even in the presence of large dynamic sealing gap oscillations.

**Functional layers**
These elastomer-coated spring steel layers are equipped with elastic beads.

**Center layer**
The main function of the center layer is to adapt the gasket thickness to the installation conditions required by the design.

**Stopper**
The engine components are elastically prestressed by the stopper around the circumference of the combustion chamber. This helps achieve a reduction in the sealing gap oscillations caused by the gas force, while simultaneously preventing an impermissible deformation of the full beads. After folded stopper layers and laser-welded stoppers, coined stoppers (illustration in the figure: honeycomb design) represent the newest generation of modern stoppers.
The third generation—coined stoppers.
Flexible solutions with additional functions.

For design engineers, the new stamping technologies from ElringKlinger open up a plurality of possibilities for influencing the distribution of forces in the sealing gap. Metaloflex® cylinder head gaskets with coined segment stoppers, honeycomb stoppers, and serpentine stoppers as well as dimple stoppers for backland support offer additional decisive advantages in addition to high operating efficiency.

Expertise. From the very beginning.

In the last 10 years, the development of the cylinder head gasket has essentially been characterized by the adaptation of the metal layer technology to the constantly increasing, diverse requirements of modern, high-performance engines. As the leader in this technology, ElringKlinger has repeatedly set new standards and further extended the limits of feasibility. With innovative sealing and production technology, we achieve even more economical solutions, while simultaneously increasing the functional potential. The development of the entirely new coined stopper is just one such milestone.

After Metaloflex® CHGs were first equipped with doubled stopper layers, ElringKlinger very successfully introduced laser-welded stoppers in series production in the middle of the 90’s. In the meantime, the next change of generation to the coined stopper was heralded. The objective of the development process was to use suitable stamping technologies for presenting the ideal stopper design for each Metaloflex® design. Basically, a distinction is made between stopper patterns in spring steel layers, i.e., functional layers (segment, serpentine, dimple), and in the carrier plate (honeycomb).

Still more design flexibility through supporting elements
The manufacturing process used for coined stoppers allows almost any geometrical profiling with respect to both stopper width and stopper thickness. Without restricting to the area of the classic stopper surface, the design engineer now can avail of the possibility of integrating additional supports almost anywhere on the gasket.
The first Metaloflex® generation: folded stopper layers.

With center layer.  
Without center layer.

The second Metaloflex® generation: laser-welded stoppers.

With center layer.  
Without center layer.

The third Metaloflex® generation: coined stoppers.

Honeycomb stopper in center layer. 
Serpentine stopper in functional layer.

Segment stopper in functional layer.
**Segment stopper in spring steel layers.**

The segment stopper is mainly used in metal layer gaskets with an increased carrier plate thickness and topographical stopper design. The segmentation of the stopper makes it possible to flange even the highly resistant spring steels used for functional layers around the circumference of the combustion chamber. The required effective stopper dimension is achieved by means of a stamping process of the carrier. In addition to the required stopper thickness, this type of topographical stoppers can also be achieved with almost any variance of the thickness profile.

The special advantages of this concept involve the extremely high stiffness of design, particularly in very narrow stoppers. Thus stable, minimum stopper widths of 1 mm in part can also be easily implemented in diesel engines.

**Honeycomb stoppers in center layers.**

To compensate for engine production tolerances, different installation thicknesses achieved via variable carrier plate thicknesses are generally used in diesel engines. The advantage of this is that the behavior of the gasket is not affected by the different layer thicknesses.

The stopper pattern in the carrier plate is in honeycomb geometry. The stiffness of these stoppers is comparable with that of welded stoppers. The stamping process developed by ElringKlinger enables both planar and topographical stoppers to be manufactured with a high degree of precision.
Serpentine stopper in spring steel layers.

The serpentine stopper enables the ideal utilization of the surface determined geometrically by the engine for the stopper. A “microbead” stamped in the serpentine form creates a thickening, which can substitute the laser-welded stopper used until now, with almost identical stiffness. The reason: The numerous windings caused by the serpentine geometry increase the stiffness of the stopper so that the latter is prevented from settling and exhibiting an undesired property of elasticity during engine operation; Such an elastic stopper would lead to an increase in the sealing gap oscillations under ignition pressure in the engine and thus adversely affect the durability of the system.

The stiffness achieved with a serpentine stopper is almost identical to that achieved with a laser-welded stopper.

Comparison of a rigid stopper with an elastic stopper for relief through ignition pressure. Under the same conditions, the elastic stopper causes vibrations with more than double the amplitude in the sealing gap.
**Coined stoppers**

<table>
<thead>
<tr>
<th></th>
<th>Segment stopper in the functional layer</th>
<th>Honeycomb stopper in the center layer</th>
<th>Serpentine stopper in the functional layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stopper width profiling</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Stopper thickness profiling</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Line compression on the component surface</td>
<td>lower</td>
<td>lower</td>
<td>higher</td>
</tr>
<tr>
<td>Double stopper possible</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Stiffness of the stopper</td>
<td>higher</td>
<td>higher</td>
<td>lower</td>
</tr>
<tr>
<td>Local supporting elements possible</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Preferred design for</td>
<td>3-layer and multi-layer CHG*</td>
<td>3-layer and multi-layer CHG*</td>
<td>Single-layer and two-layer CHG</td>
</tr>
<tr>
<td></td>
<td>Carrier plate thickness: 0.15–0.7 mm</td>
<td>Carrier plate thickness: 0.15–0.7 mm</td>
<td></td>
</tr>
</tbody>
</table>

* with carrier plate

**Backland support.**

The new high-performance engines stress the cylinder head gasket not only on the combustion chamber but also increasingly in the area of media sealing (oil and coolants). Due to these increased requirements, it is often necessary to provide a supporting element in the backland areas and on the combustion chamber alike. The components are prestressed so that the dynamics are reduced and the reliable functionality of the gasket over the entire running time of the engine is ensured.

Coined stoppers (dimple and honeycomb stoppers) are especially suitable to be used as supporting elements since they enable maximum freedom of design.

The dimple stopper, which is coined in the functional layers, is used in CHG designs without carrier plate.

The honeycomb stopper is preferred in CHG designs with a carrier plate.
Topographically coined stoppers.

With the design of the stopper, it is possible to selectively influence the distribution of sealing pressure and thus the sealing gap oscillations since they cause an increase in pressure and elastic preload of the sealing system. A thickness profiling of the stopper may be necessary if the adjacent engine components have inhomogeneous stiffness ratios. Coined stoppers offer significant functional advantages in this context: It is possible to achieve almost any topographical design required for the engine components. The height profiling can be defined variably both for each cylinder as well as for other areas on the gasket.

The topographical stopper allows compensation for inhomogeneous component stiffnesses. Areas with low stiffnesses can be prestressed, and thus the application of a uniform compressive load is ensured. In this way, the available bolt force can be exactly distributed and optimally utilized over the required areas.

Comparison of distribution of sealing pressure:
Left: a stopper with constant thickness.
Right: the optimized stopper with variable thickness.
Partial coating. Less is more.

Due to the partial elastomer coating, adapted to the required function, only those surface areas of the CHG that are relevant for sealing are coated. As a result, the sealing surfaces standing free in coolant or oil can remain uncoated, so that coatings no longer peel under critical boundary conditions. Other advantages of this process: The special coating application process can be used to select both the coating thickness and the coating medium in an application-oriented fashion. The somewhat differing coating requirements in the combustion chamber and in the fluid area can then be fulfilled selectively. Thus, for example, greater coating thickness and a softer elastomer are advantageous for significant component roughness or pores in coolant sealing and oil sealing. At the same time, lower coating thicknesses are required for sealing the ignition pressure in the combustion chamber area. These conflicts of objectives are resolved with the use of selective coating.

Newly developed coatings with optimized frictional behavior prevent wear on the components during engine operation. The outstanding adaptability, which already exists at room temperature, provides the basis for mastering the requirements in the cold leak test immediately following installation.

Different variants of partial coating are used depending on the application.

ElringKlinger has developed a new coating material, which is optimally adapted to the extreme requirements of modern, high-performance engines, especially with regard to stability.
**Designs. Tailored for highest performances.**

**Coined stoppers: the stopper generation of the future—**
with still greater functional potential

**Laser-welded stoppers: the proven solution—**
successfully in series production for many years

*Single-layer, 0.30–0.37 mm: design for gasoline engines.*

*Two-layer, 0.50–0.65 mm: two functional layers. Design for gasoline engines and diesel engines subjected to high stresses, without installation thickness matching. High sealing potential for the smallest installation thicknesses.*

*Three-layer, 0.70 mm and up: two functional layers, one center layer. Design for diesel engines and gasoline engines with installation thicknesses exceeding 0.70 mm.*

*Three-layer, 1.00 mm and up: two functional layers, one center layer. Design for diesel engines and also for gasoline engines.*

*Four-layer, 0.90 mm and up: with additional cover layer to compensate for surface irregularities on components (porosity, cavities).*

★These designs can also be equipped with topographical stoppers.
Depending on the respective influencing factors, a distinction can be made between the ranges of applications of the different CHG designs. The optimum technology for every engine, even with respect to operating efficiency. With Metaloflex®, ElringKlinger provides a modern, versatile sealing system allowing the development of the most effective and most economical solution for each application.
Design solutions for special applications. Flexibility is everything.

High-performance engines require high-performance gaskets. The outstanding design flexibility of Metaloflex® allows product solutions optimally adapted to suit the respective engine conditions, even with extreme requirements.

Metaloflex® CHG as multifunctional layer gasket for high sealing gap amplitudes.

If the sealing gap oscillations have a large amplitude, Metaloflex® CHG is used with three or four functional layers. This allows sealing over a larger spring travel. ElringKlinger tunes the systems so that the entire spring travel is always uniformly distributed over the beads. In connection with coined stoppers, multifunctional layer gaskets with topographical stoppers can also be manufactured. With this gasket design, durability is guaranteed even under very critical, dynamic conditions.
Metaloflex® CHGs with double stopper for reciprocating engines offer a high degree of lifetime reliability.

For engines with pressed-in or cast-in cylinder liners, ElringKlinger has developed a Metaloflex® CHG with double stopper system. The required preload force is thus distributed over two stoppers, thereby preventing the danger of the liner sinking. This ensures lifetime reliability even under critical conditions. Coined stoppers—segment, honeycomb, and serpentine—provide outstanding flexibility for the engine conditions, for example, by means of variable heights of the two stoppers in combination with a topography on the combustion chamber circumference.

Stopper-free Metaloflex® CHG for substantially reduced cylinder distortions.

This Metaloflex® design eliminates the stopper and thus combustion chamber camber at high compression. It consists of two functional layers with opposingly arranged beads in the main seal. A complex layout is required for ensuring the durability of the beads: the deformation of the beads is no longer defined by the stopper. Instead, the bead deformation depends only on the operating range in the engine and the dynamic sealing gap movements. ElringKlinger is the first series supplier in Europe to offer a series version of the stopper-free CHG.
Mastering extreme loads, constantly extending the boundaries of what is feasible. We develop innovative product solutions for the engine generations of today and tomorrow. Always keeping the overall engine system and the interaction of all components in mind. Every cylinder head gasket is tailor-made technologically: conceived in accordance with specific requirements, in close cooperation with our customers. Implemented using state-of-the-art development tools and testing tools with the objective of further optimizing development times and costs. Engineering service around the globe—from ElringKlinger.

Finite element method. Optimization up to the ideal solution.

The finite element method (FEM) is the decisive tool for the analytical testing of the sealing system. The FE method is used on the one hand to optimize functional components of bead and stopper in the gasket, including their manufacture, and on the other hand to analyze the structure of the entire sealing system in the engine. The following examples illustrate how the optimal sealing concept is designed to meet specific requirements.

Determination of the ideal stopper topography for increasing the sealing potential

Inhomogeneous component stiffnesses can be compensated for by using topographical stoppers, i.e., stoppers of variable thickness. The areas of lesser stiffnesses are thus prestressed in order to ensure a uniform application of the compressive load. All influencing variables must be taken into account when designing the topography: in addition to the stiffness of the adjacent engine components, such as cylinder head and engine block, the various operating conditions of the engine are also decisive. This means taking into account the prestressing of the bolts, temperature distribution, and above all, the gas pressure to be reliably sealed.
Every engine operating condition requires a specific topography, enabling uniform distribution of pressure on the stopper and thus a reliable sealing function. With the FEM, the ideal stopper topography geared toward all operating conditions is determined, thereby ensuring reliable sealing function even under critical conditions.

CHG with additional functions: supporting elements for reducing component deformations

The new stamping technology by ElringKlinger makes it possible to integrate additional supporting elements almost anywhere on the CHG even beyond the area of the classic stopper surface. For example, on the front of the engine, in order to prevent a deflection of the cylinder head. Normally, the deformation of the cylinder head is most pronounced in the end cylinders, since the greatest bolt force relative to the cylinder segment is introduced here. The cylinder head rests against the supporting elements of the CHG in order to be protected from a excessive deflection. A selective height matching of the supporting elements by means of FEM makes it possible to minimize the cylinder head deformation. This substantially reduces the distortions of the camshaft bearing gutter, and thus also reduces noise emission still further.

The FE calculation of the ideal stopper topography considers influencing variables such as the stiffness of the adjacent components, gas force, and preload force of the bolts.
Deformation of the cylinder head without supporting elements.

Deflection of the cylinder head as a function of supporting element thickness.

Supporting elements for the reduction of component stresses
Another important task of the supporting elements integrated in the CHG is to reduce stresses in the components. Supporting characteristics calculated exactly by means of the FEM can reduce critical stresses to a manageable level.
Topographical double stopper for reducing cylinder distortions

The cylinder distortion in the stressed sealing system determines the oil consumption of the engine.

Among the difficulties associated with oil sealing are the higher order cylinder form deviations because the piston rings are not able to follow the cylinder liner as well. The degree of this distortion depends primarily on the geometrical structure and stiffness of the components and can be considerably influenced by the cylinder head gasket. The use of a double stopper instead of the standard stopper helps reduce cylinder distortion by approximately 25% depending on the engine design. Further optimization using an additional topographical stopper can reduce distortions by more than 50%.

Influence of cylinder head gasket on cylinder distortion.
Simulation Testing under realistic conditions.

Complementing the FEM structural analysis, the durability of the sealing systems is ensured by simulation.

Servohydraulic testing
This station is used to preselect and test the gasket design. The sealing surfaces of cylinders are simulated with flanges in order to test the combustion chamber design of the CHG. The objective is to determine the maximum permissible amplitude of vibration for ensuring durability. Also, the minimum pressure necessary for sealing is calculated with pressure tests. These tests yield important information about the bead design.

Dynamic internal pressure simulation
The results of the tests on the servohydraulic system serve as the basis for testing the entire sealing system under realistic conditions by simulating the internal pressure dynamically. This functional test is performed on original engine parts (head, block, CHG) taking into account the ignition sequence and various temperature cycles. The correlation between the component stiffness, the dynamic oscillations occurring in the sealing gap, and the distortion system provide crucial data about the sealing system as a whole.

The dynamic internal pressure simulation considerably reduces the number of engine tests, saving both time and money, so that development times will be even shorter in the future.

Simulation of wear mechanisms on the engine
Due to increasing peak pressures, the relative movements occurring in the sealing gap and the resulting signs of wear must be taken into account as early as when designing the CHG.

With the wear test bench, ElringKlinger has developed a versatile tool for simulating wear behavior in engines. The objective is to determine the permissible range of the friction coefficient in the sealing gap. This requires parameter studies under realistic engine operating conditions. Taking into account the compressive and force relationships from the FE calculation, it is then possible to determine suitable designs and coatings for the prevention of wear as early as during the development phase.
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