Electromobility.

**PEM Fuel Cells.**

Highly efficient, environmentally compatible, future-proof.
Experience mobility – Drive the future.
The ElringKlinger Group.

We are dedicated to developing cutting-edge solutions and new technologies for current and future generations of vehicles. As an expert development partner and approved OEM supplier, we take an all-embracing approach and focus on the vehicle system as a whole. Our particular strength is that we are one of the few automotive suppliers capable of developing and manufacturing technologically sophisticated components for all types of drive system – based on either combustion engines or electric solutions. Customized components from ElringKlinger for engine, transmission, exhaust gas system, underbody, chassis, and body are used by virtually all vehicle and engine manufacturers and countless automotive suppliers worldwide. Our product range includes gaskets, lightweight polymer components, shielding systems, battery and fuel cell technology, transmission control plates, exhaust gas purification systems, components made of high-performance plastics, tooling technology, and development services. Building on our innovative products, we set industry benchmarks and help to achieve environmentally compatible mobility. We also supply an extensive range of spare parts to the aftermarket sector in more than 140 countries. In addition, ElringKlinger boasts a successful track record in other branches of industry, e.g., with exhaust gas purification systems, PTFE products, and fuel cells. These efforts are supported by a dedicated workforce of more than 9,000 people at 49 ElringKlinger Group locations around the globe.

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ADDITIONAL MATERIAL

We have produced separate brochures with detailed information on our entire e-mobility range, our product solutions in battery technology, and the products and services offered by our strategic partner hofer powertrain. Areas of application outside the automobile industry are described, for example, in our corporate brochure “The ElringKlinger Group” and in brochures published by our subsidiary new enerday GmbH.
ElringKlinger worldwide.

North America

CANADA
Leamington

USA
Plymouth
Southfield
Buford
Austin
Fremont

South America

BRAZIL
Toluca
Piracicaba

Africa

SOUTH AFRICA
Johannesburg

Cylinder-head gaskets
Sealing systems
Transmission control plates
Lightweight plastic components
Plastic modules
Thermal and acoustic shielding systems
Exhaust after-treatment systems
Europe

GERMANY
Dettingen/Erms
Langenzenn
Runkel
Geretsried-Gelting
Thale
Lenningen
Bissingen/Teck
Bietigheim-Bissingen
Heidenheim
Mönchengladbach
Idstein
Rottenburg am Neckar
Magdeburg
Neubrandenburg
Nürtingen

GREAT BRITAIN
Redcar
Gateshead

FRANCE
Nantiat
Chamborêt
Poissy

SWITZERLAND
Sevlen
Elsau

NETHERLANDS
Enschede

SPAIN
Reus

ITALY
Settimo Torinese
Milan

HUNGARY
Kecskemét-Kádafalva

ROMANIA
Timisoara

TURKEY
Bursa

Asia

PR CHINA
Changchun
Suzhou
Qingdao
Chongqing

SOUTH KOREA
Gumi
Seoul

INDIA
Ranjangaon

INDONESIA
Karawang

THAILAND
Bangkok

JAPAN
Tokyo
Saitama

Battery technology
PEM fuel cell stacks
Electric Drive Unit
Development services with hofer powertrain
PTFE components
Engine development services
Tooling technology
Electromobility.  
From future vision to reality.

The automotive industry is undergoing a period of transformation, the focus being on sustainable mobility and alternative drive technologies. ElringKlinger has consistently been one step ahead of these developments and so is actively helping to shape the future of the automotive industry. Whether electric motor, hybrid system, or combustion engine: we offer innovative, tailor-made solutions for all types of drive technology.

Through our strategic partnership with hofer powertrain, an engineering company in Nürtingen that specializes in electric drive technology, we have significantly expanded our expertise and range of products and services in the area of e-mobility. Drawing on this know-how, we can therefore support our customers at an even earlier stage and even more comprehensively in the realization of future-oriented drive concepts.

**BATTERY AND FUEL CELL:**  
**ELECTRIFYING SOLUTIONS**

An efficient energy storage unit is regarded as key technology for future-proof electric vehicles. ElringKlinger already manufactures various components for lithium-ion batteries in highly economical series production, e.g., cell contact systems and module connectors. In addition, we also develop and manufacture entire battery modules, battery systems, and integrated energy storage units (see also our brochure "Battery technology").

One of the key benefits of buses and passenger cars equipped with fuel cell propulsion systems is their long range. Fuel cells can also be used as range extenders for battery-operated vehicles. Depending on system design, the electric drive can thus be supplied with energy directly or the battery can be recharged. In the field of fuel cell technology, the advantages offered by ElringKlinger are its proprietary stacks, patented designs for metal bipolar plates, and plastic media modules that allow substantial simplification of the fuel cell system.

As regards the automotive future, both concepts, the battery and the fuel cell, are viable options on account of their specific characteristics and benefits. In addition, they can display their strengths in combination. Our mission is to drive innovations forward, set standards, and play an active role in technological change with highly competitive, top-quality product solutions. For sustainable mobility – worldwide.
PEM fuel cells.
Energy converters with a future.

The demands on modern vehicles are exacting. They are required to be efficient, environmentally compatible, and climate-friendly – safe yet powerful. The technological shift towards e-mobility is already in full swing. As a system partner to the automobile industry, ElringKlinger was quick to address the issue of alternative drive systems and actually launched its first project on fuel cell technology as far back as the turn of the millennium. In 2004, the company started producing solid oxide fuel cell stacks for APU applications. Serial production of components for fuel-cell-driven automobiles began in 2008, initially with bipolar plates and gasket solutions. Three years later, the product range was extended to include polymer electrolyte fuel cell stacks (PEMFC stacks) for use in cars and commercial vehicles. In the meantime, we have assumed a pioneering role in this segment thanks to a wide range of projects and collaborations.

MAKING THE MOST OF OUR CORE AREAS OF EXPERTISE

What gives us the edge are our core areas of expertise in metalworking, plastics processing, and tooling technology, combined with our unique capabilities in materials. Automated serial production processes in metalworking and plastic injection molding, automated stacking, ultra-modern joining and coating technology, and our in-house tool and mold making capabilities make ElringKlinger the ideal partner for the commercialization of fuel cell products.

The PEMFC is a low-temperature fuel cell that converts chemical energy to electrical energy using hydrogen and oxygen. PEMFC stacks from ElringKlinger have already demonstrated outstanding performance and durability in field trials and on the test rig. From the initial idea through design and prototype building, testing, and validation to cost-effective and certified serial production, we are already in a strong position and are confident that this technology will make the breakthrough into various applications.
PEM fuel cell technology can be deployed to advantage wherever pure hydrogen is available as a fuel and high electrical efficiency is required. If the hydrogen is produced via electrolysis from electricity generated through renewable sources, zero-emission mobility is possible.

The benefits of PEMFC stacks are more than convincing: they offer a high power density and highly dynamic power supply, are ideal for mobile applications, and are already viable with local hydrogen networks. In this area, too, ElringKlinger has long-standing expertise; thanks to our own development capacities and component and stack production, we can respond flexibly to customer requirements and offer the ideal fuel cell stack for numerous applications. Another advantage is that our PEMFC stacks are trialed and approved at our own test facilities in accordance with customer specifications and under simulated system conditions.

Stacks from ElringKlinger for integration into customer systems are available with an electrical output of 2 to 80 kW. In 2018, a larger stack format with capacities of up to 150 kW will be added to the range. Stacks with peripheral components and system functionalities integrated into the end plate module are also available as an option. These features enable considerable simplification and cost reduction of the fuel cell system.

Apart from buses and cars, PEM fuel cell stacks can also be used for industrial applications in the mobile segment, e.g., in small commercial vehicles and fork lift trucks.
The NM5 PEM fuel cell stack developed and produced by ElringKlinger was optimized to ensure a low pressure drop in the reaction gases and a long service life. It is therefore ideal for use in commercial vehicles and comparable applications. The stack is operated by hydrogen and air; it is cooled with a commercial coolant, a mixture of water and ethylene glycol. On the hydrogen side, dead-end operation with anode circulation is necessary, while the electrical connection to the system uses a standard connector solution from the automotive segment.

NM5 stacks are available in various power classes from 20 to 240 cells. In addition, customer-specific stacks can be provided with a higher or lower number of cells. The following table shows the performance characteristics for a 100-cell stack. Performance data and media influences can be scaled for other stack sizes.
### General Data Stack NM5, 100 Cells

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Power Atmospheric Operation $P_{\text{rated, atm}}$ (KW)</td>
<td>13.1</td>
</tr>
<tr>
<td>Rated Power at 2.5 Bar, $P_{\text{rated, 2.5 bar}}$ (KW)</td>
<td>19.2</td>
</tr>
<tr>
<td>Cell Count</td>
<td>100</td>
</tr>
<tr>
<td>Rated Voltage $U_{\text{rated}}$ (V)</td>
<td>60</td>
</tr>
<tr>
<td>Max. Voltage $U_{\text{max}}$ (V)</td>
<td>113</td>
</tr>
<tr>
<td>Rated Current Atmospheric $I_{\text{rated, atm}}$ (A)</td>
<td>210</td>
</tr>
<tr>
<td>Rated Current at 2.5 Bar, $I_{\text{rated, 2.5 bar}}$ (A)</td>
<td>340</td>
</tr>
<tr>
<td>Current Range Atmospheric (A)</td>
<td>20...210</td>
</tr>
<tr>
<td>Current Range at 2.5 Bar, (A)</td>
<td>50...340</td>
</tr>
<tr>
<td>Dimensions (MM)</td>
<td>246 * 164 * 269</td>
</tr>
<tr>
<td>Weight (KG)</td>
<td>13.7</td>
</tr>
</tbody>
</table>

### Media Systems Stack NM5, 100 Cells

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cathode – Air</td>
<td>Humidified, r.h. 70...95 %</td>
</tr>
<tr>
<td>Air Quality</td>
<td>Filtered air without solid, liquid or gaseous impurities</td>
</tr>
<tr>
<td>Air Pressure</td>
<td>Atm. to max. 2.5 bar</td>
</tr>
<tr>
<td>Air Flow Rate at $I_{\text{rated, atm}}$ (NM³/H)</td>
<td>35.4</td>
</tr>
<tr>
<td>Air Flow Rate at $I_{\text{rated, 2.5 bar}}$ (NM³/H)</td>
<td>57.4</td>
</tr>
<tr>
<td>Anode – Hydrogen</td>
<td>3.0, without CO</td>
</tr>
<tr>
<td>Hydrogen Quality</td>
<td>Ethylene glycol/demin. water-mixture 48/52 %</td>
</tr>
<tr>
<td>Operating Pressure $[\text{Bar}]$</td>
<td>1.2...2.5</td>
</tr>
<tr>
<td>H₂ Consumption at $I_{\text{rated, atm}}$ (NM³/H)</td>
<td>8.78</td>
</tr>
<tr>
<td>H₂ Consumption at $I_{\text{rated, 2.5 bar}}$ (NM³/H)</td>
<td>14.22</td>
</tr>
<tr>
<td>Coolant</td>
<td>≤ 2</td>
</tr>
<tr>
<td>Operating Pressure $[\text{Bar}]$</td>
<td>2.5</td>
</tr>
<tr>
<td>Coolant Flow (Rated Power ATM) (L/Min)</td>
<td>21</td>
</tr>
<tr>
<td>Coolant Flow (Rated Power 2.5 Bar) (L/Min)</td>
<td>35</td>
</tr>
<tr>
<td>Temperatures</td>
<td>3...85</td>
</tr>
<tr>
<td>Environmental Temperature ($^\circ$C)</td>
<td>-35...70</td>
</tr>
<tr>
<td>Altitude Range</td>
<td>&lt; 2000 m above sea level</td>
</tr>
</tbody>
</table>
Model of a 100-cell stack including media module with integrated system functionalities, e.g., complete anode circuit, condensate trap, and pressure and temperature sensors (dimensions in mm).

The NM5 stack module from ElringKlinger can be used from an atmospheric pressure at the stack outlet to an operating gas pressure of 2.5 bar absolute. Stack output increases along with operating pressure. Other operating conditions: air stoichiometry 1.7, anode not humidified, anode in dead-end arrangement with recirculation.

STACK MODULE NM5

Process diagram of NMS stack with media module
The stack dimension in the z-axis depending on number of cells is calculated using the following formula:

**STACK DIMENSION IN Z-AXIS (MM) = 38 + 80 + (1.51 * N CELLS)**

For a 100-cell stack the dimension in z-axis is 269 mm, for a 50-cell stack it is 193.5 mm. These stack dimensions do not include the media connectors. NM5 stacks are available with media connectors with various connection options and sizes. The stack output at a cell voltage of 0.6 V is around 130 W/cell for atmospheric operation and about 205 W per cell for operation at a pressure of reaction gases of 2.5 bar absolute. These values can be used to easily calculate the output for stacks of various sizes. NM5 stacks come in standard sizes of 20, 50, 100, 200 and 240 cells.

Apart from a complete anode circuit, stacks with media module have integrated solenoid valves for purge and condensate drain, sensors for pressure and/or temperature at the air outlet, and coolant and hydrogen inlets.
Metal bipolar plates. End and media modules.

PEM fuel cell stacks consist of alternating stacks of membrane electrode assemblies (MEAs) – the active elements as such – and bipolar plates. They are interspersed with porous layers that serve to distribute the gas and transfer the electrical current. The bipolar plate separates the media and distributes them to the stack. It also ensures uniform cooling of the stack and transfers the electrical current to the adjacent cells.

PEMFC metal bipolar plates offer advantages in respect of cost efficiency, the power density that is especially important for mobile applications, and the cold start capability of the fuel cells. Using high-precision, progressive tooling suited to volume production, ElringKlinger is already producing bipolar plates in a fully automated, interlinked manufacturing process.

Fuel cell stacks have to be permanently braced with a uniform contact pressure over the entire surface of the cell. This is achieved using end modules consisting of clamping system and, where necessary, media modules.

Production-ready end modules for PEMFC are hybrid assemblies consisting of metal components and high-performance plastics that meet all requirements while offering excellent dimensional stability. Like the media modules, they have to be mechanically stable, chemically resistant, and as light as possible. Using injection molding processes, ElringKlinger produces highly complex end modules that meet the strictest tolerance specifications. A special feature of the modules developed by us is the integration of parts of the system technology directly into the stack as a media module, which simplifies the system considerably.
Casings.

Housings protect the fuel cell stacks and their components from external influences. Depending on the area of application, the casing concept realized by ElringKlinger offers particular benefits such as multi-functionality, high thermal stability, low weight, design flexibility, and easy assembly.

PEMFC casings are made of thermoplastics, which not only save weight but also help reduce costs.
ElringKlinger has been an established engineering partner and component supplier to the automobile industry for many decades. Our strength lies in driving innovations in development and production quickly and economically. When developing fuel cell components we not only consider function and durability but also focus from the very start on the industrial feasibility of the production processes and the potential for cost-effective mass manufacturing.

Because we have our own tooling capabilities, we are able to push the boundaries of metal shaping, e.g., when manufacturing bipolar plates. This provides the basis for maximum power density and durability in the stack. New structures are developed on the basis of CFD simulation. We carry out testing in single and short stacks to ensure that the results can then be transferred to full-size stacks. When engineering the mechanical stack components the focus is also consistently on function, manufacturability, effectiveness, and customer benefits. As a result, for example, we have been able to considerably simplify the system for our customers by integrating system functions into the stack end plate. Sourced parts contained in the stacks undergo constant testing and are validated and further developed in collaboration with our suppliers. This allows ongoing improvement of stack capacity and durability.

LABORATORY AND TESTING ENVIRONMENT

We investigate the electrochemical behavior of the cells on state-of-the-art test rigs in our own test laboratory, where cell components are characterized, operating parameters optimized, and performance and endurance tests conducted. Our test environment allows us to carry out all relevant tests to ensure the safe operation of fuel cell stacks, from simple characteristic curves through cycle tests, frost start and start-stop tests to investigations on the air quality necessary for reliable operation. Our test rigs cover the capacity range from a single cell to automobile class stacks (maximum 150 kW).
Fuel cell stacks from ElringKlinger are tested and certified in our own laboratory and by independent establishments. As well as performance and endurance testing of stacks, we determine the characteristic diagrams for reliable operation, develop operating strategies, and conduct cold start tests and environmental simulations such as vibration or shock tests for use in highly stressed environments.

In its development processes and testing environment, ElringKlinger combines the sophisticated process and quality management capabilities of an established automotive supplier with the requirements for products for future drivetrains. Our stacks, for instance, have undergone safety evaluations in accordance with the relevant standards like DIN EN 62282-2 or VDE 0130-2:2013-01. They have also been tested for compliance with fundamental requirements and have been awarded TÜV-SÜD certification.
New types of products call for new, innovative manufacturing concepts. ElringKlinger attaches great importance to its own process development and the associated expansion of expertise to meet all quality requirements. All processes and procedures necessary for the products are validated and constantly refined. Thanks to the close interaction between development, prototype construction, and product commercialization, an optimum quality standard can be achieved from the very start of production.

Within a short space of time and to a very high standard, ElringKlinger produces samples and small batches at its in-house prototyping facility, the equipment of which is very close to that of full-scale production. We have resources available for all the manufacturing processes that are also used in series production, e.g., ultrasonic welding and laser welding systems.

In this way, we achieve continuity in all processes from prototyping to series production – only the degree of automation has to be adjusted. At an early stage, during prototype construction, it is possible to ensure seamless 100% traceability, as in subsequent series production.

ElringKlinger also operates high-performance production lines for manufacturing the various components in series. Adapted to specific customer requests and product requirements, we implement highly flexible, scalable or fully automated production solutions – integrated in a continuous quality concept. Our mission is to achieve competitive series production geared to specific product requirements. Efficiently, safely, and reliably. Worldwide.
The information provided in this brochure is the result of technological analyses and may be subject to changes depending on the design of the system. We reserve the right to make technical changes and improvements. The information is not binding and does not represent warranted characteristics. We do not recognize any claims for compensation based on this information. We accept no liability for printing errors.