

EMGreport

Magazine for Customers of the Engineered Materials Group Europe



**4 SMOOTH ASSEMBLY
OF SEALS**


Application of ParCoat®
Coatings Achieves Desired
Surface Properties

**16 RELIABLY SHIELDED
AND SEALED**

Parker Offers Extensive Portfolio
for E-Mobility

**30 SUITABLE FOR
WORLDWIDE USE**

New EPDM Material from Parker
Prädifa with all Relevant Drinking
Water Approvals and Wide
Application Range



“TOP QUALITY
– but please keep
a handle on costs”

*Jochen Nigge
General Sales Manager EMEA
Engineered Materials Group Europe*

Dear Customers and Business Partners,

Top quality – at reasonable costs: This is a challenge you have to tackle just like we do on a daily basis. As your trusted supplier and development partner of engineered material and sealing solutions, we support you in mastering this balancing act with pioneering innovations. In this issue of your EMG Report, we are pleased to show you a number of new attractive options that will directly affect the efficiency of your production processes and therefore result in cost benefits for you as well.

With our new Roll2Seal[®], we are presenting to you a clever solution for reliable and simple closing of bores using an equally new assembly process. Read the article and learn how the patent-pending “rolling instead of slipping” principle works in detail while saving space and costs.

With our ParCoat[®] coatings for seals and other elastomeric components, you benefit from avoiding mistakes as well as achieving higher speed and efficiency in your production processes.

From simplified assembly and maintenance, and the resulting cost reductions, to new development potential: with our composite technology for sealing elements and engineered components, we provide you with a range of attractive benefits.

By means of 3D printing technology, Parker Chomerics delivers rapid prototyping of EMI housings and gaskets, and thereby supports you in accelerating your time to market. And in case you should have missed its premiere at the Hanover Fair, you can learn all about our new sealing material for drinking water applications here. Having been awarded all the required approvals, it is truly a “global player.”

With our strong distribution network, we ensure that you are also provided with optimum local technical support and supply of our products. This is where our distribution partners are the key players and we are pleased to present to you some of our long-standing and proven partners on **pages 32 to 37**.

These are just a few examples of our commitment and capabilities that go to show that you can always expect us to deliver top quality at reasonable costs – in keeping with our promise: **ENGINEERING YOUR SUCCESS**.

I hope you will enjoy some interesting moments while reading this issue and in closing wish you and your families a peaceful holiday season. We appreciate your continuing loyalty.

*Jochen Nigge,
General Sales Manager EMEA, Engineered Materials Group*

EMG Report

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Heavy-Duty On- and Off-Highway Engines (Conference)	Friedrichshafen, Germany	26.11. – 27.11.2019
Disposable Solutions for Biomanufacturing	Berlin, Germany	18.02. – 20.02.2020
IFPE (International Fluid Power Exposition)	Las Vegas, U.S.A.	10.03. – 14.03.2020
Electric & Hybrid Vehicle Technology Expo	Stuttgart, Germany	28.04. – 30.04.2020
Farnborough International Airshow	Farnborough, United Kingdom	20.07. – 24.07.2020

We look forward to your visit.

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SMOOTH ASSEMBLY OF SEALS

APPLICATION OF PARCOAT® COATINGS ACHIEVES DESIRED SURFACE PROPERTIES

Elastomer seals are found in a wide range of challenging Automotive and Industrial applications. While durability and reliable performance are initially ensured by perfect quality of the sealing product, the assembly process entails major risks that may lead to premature seal failure. These risks can largely be avoided by applying suitable coatings to the finished sealing elements.



Dr. Stefan Reichle
Market Unit Manager Alternative
Mobility and Industry,
Prädifa Technology Division

With their specific material properties, especially their good elasticity, as well as temperature, pressure, chemical and mechanical resistances according to the relevant requirement profiles, materials from the large family of elastomers including thermoplastic elastomers are predestined for a wide range of sealing tasks in challenging applications with fluids. Consequently, elastomers are some of the most commonly used and viable sealing materials of all.

Seal Failure Leads to Total System Failures

Basic quality, reliability and required durability of a sealing system are initially ensured by selecting the best-suited elastomer compound in combination with the appropriate geometric design of the sealing solution. All seals used in automotive and industrial applications of any kind have to meet exacting demands because seal failure may lead to failure of a total technical system resulting in respective damage and costs, which may extend from costly and image-tainting product recalls to product liability actions on account of personal or environmental damage. Reputable seal manufacturers such as Parker Prädifa are conscious of the critical importance of their products and assure their quality by certified manufacturing and quality assurance processes, among other things. So far so good? Basically, yes, but in many cases this is not enough.

Assembly as a Risk Factor

After the seal has left the manufacturer's plant in perfect quality, it has to be installed at the customer's site into the system to be sealed and in which it subsequently has to deliver reliable performance. Experience has shown that this stage entails potential risks, i.e. "assembly mistakes"



in diverse forms. Any of these may sooner or later lead to seal failure, and thus failure of the total system, with the aforementioned adverse effects.

Mistakes in the assembly process are particularly critical because they go undetected in many cases – until the system to be sealed fails because, for instance, the wrong seal was installed due to mix-ups or the right seal was damaged during assembly and the damage went unnoticed. Now how can this happen? The following brief look at the two major risk factors explains how:

1. Risk of Mix-ups

Many seals look very similar in terms of shape and color. This makes them hard to distinguish from each other externally. Whenever several superficially similar sealing elements with different technical properties or functions

are used there is a risk of mix-up, which subsequently may lead to failure of the seal and the system.

2. Damage during Installation

Both in manual and fully automated assembly, seals slide across surfaces and may, for instance, be expanded or squeezed in the process. Due to high friction or severe sticking of the surfaces to the assembly equipment, the sealing elements may be exposed to high mechanical stress, which in turn may lead to heavy – and partially lasting – deformation such as twisting or cracking. Because it is hard to detect during the assembly process, such damage often goes unnoticed and is therefore particularly serious with respect to a higher risk of seal failure.

Assembly Forces and “Stacking” Make Seal Assembly More Difficult

In addition to the risk of damage to the seal itself, the presence of particularly high assembly forces may clearly make seal assembly more difficult or even prevent it completely. If assembly forces in automated processes rise to such levels that the machines, due to inadequate or severely varying assembly forces, are no longer able to effectively position the sealing elements, this results in machine downtimes which, consequently, prevents cost-efficient and trouble-free assembly.

Similar consequences can result from the so-called “stacking” of seals. Stacking refers to elastomeric seals sticking together on account of their surface properties. This problem primarily occurs in large-volume production. Here smaller components such as seals are frequently delivered as bulk goods, separated in conveyor systems and fed to the assembly systems. Stacking of seals significantly interferes with such assembly processes and may even cause the line to stop.

Systematic Surface Optimization Using Suitable Coatings

The afore-mentioned risk factors can largely be avoided by systematically optimizing the sealing surfaces. Therefore, Parker Prädifa has developed an extensive portfolio

of coatings under the brand name of ParCoat® especially for elastomer compounds. They have no negative effect on the elasticity and chemical resistance of the elastomeric components and only result in relatively minor additional costs that are in no relation to the consequential costs incurred due to assembly mistakes or disruptions of the assembly process.

The coatings are suitable for all commonly used elastomer types and clearly reduce assembly forces, among other things. Clean separation, loading and feeding in large-volume production is ensured by selecting an appropriate ParCoat® coating as well.

Color Coding Prevents Mix-ups

Various coatings are available in colored and transparent versions, depending on the application requirements. Colored versions serve to mark products and to avoid mix-ups. In addition, elastomer seals can be provided with coatings in the customer’s company colors for corporate identity purposes. Especially for small or special series, for which in most cases the development of a respectively colored compound is not economically feasible, ParCoat® coatings offer a simple means of providing elastomeric components with the desired color. Transparent versions on the other hand are used for coating colored base compounds whose color must not be changed by the coating.

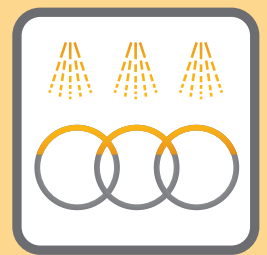
Surface finishing typically includes several process steps, although not every one of them is required in all coating methods:



- 1 **Cleaning** of the elastomer surface, e.g. by ultrasound, ionized air, washing equipment or high-pressure cleaning



- 2 **Surface activation** to enhance the bond between the coating and seal, e.g. by plasma treatment



- 3 **Coating** using the drum method (for small symmetric articles in large volumes) or spray coating (for large, symmetric geometries or partial coating) depending on volume, dimension and type of coating

Optimal Bonding between Coating and Elastomeric Base Material

The primary goal of the finishing process of seal surfaces is to achieve optimal bonding between the coating and elastomeric base material. A clean seal surface without wetting impairment substances such as greases, oils and release agents is essential to optimum bonding. The coating must effectively adhere to the surface and be equally elastic as the elastomeric component itself. The risk of separation or cracking of the ParCoat® coating, which has a thickness of just a few micrometers and excellent anti-frictional properties, in case of deformation during the installation process etc. must be excluded.

Learn more about
ParCoat®



Summary

ParCoat® coatings with their thickness of just a few micrometers and excellent anti-frictional performance make it possible to modify the tribological properties of seals so that they can be installed with clearly reduced exertion of force, and thus less stress acting on the components. This largely avoids the risk of damage and additionally facilitates the assembly process. At the same time, due to the availability of the coatings in various colors, the risk of mix-ups is largely excluded. The relatively minor additional costs of the coating are in no relation to the typical costs that may result from installation damage which is detected either too late or not at all or by disruptions of the assembly process.



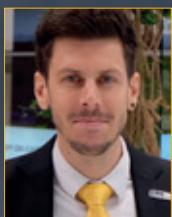
④ **Inspection** of the friction-reducing properties by measurement of the assembly forces, bending tests to check elasticity and checking of the homogeneity of the coating by optical inspection methods



⑤ Subsequently, the product finished with a ParCoat® coating is **packaged, labeled** and shipped to the customer. Thus, at reasonable costs, customers receive significant added value that facilitates their assembly processes, enhances efficiency and, above all, excludes the risk of premature seal failure due to installation mistakes with all the related consequences in the application.

ParCoat® Coatings at a Glance

- Suitable for all commonly used elastomer types
- Clearly reduced assembly forces
- Prevention of assembly damage
- Fast, cost-efficient assembly
- Reliable and clean separation, loading and feeding
- Avoidance of stacking
- Color coding for the purposes of differentiation or corporate identity
- Transparent coatings for colored base materials available
- Properties of base material are retained



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SKILLFULLY COMPOSED

COMPOSITE SOLUTIONS FROM PARKER PRÄDIFA
ENHANCE EFFICIENCY, REDUCE COSTS AND
OPEN UP NEW DEVELOPMENT POTENTIAL

From simplified assembly and maintenance to new development potential: The utilization of composite technology for sealing elements and engineered components offers a range of attractive benefits that Parker Prädifa converts into innovative solutions for diverse applications based on relevant materials and manufacturing know-how.

In composite solutions, components made of diverse materials are combined into an integrated functionally reliable molding using the best suited joining technology for the respective application. This alone results in significant benefits: the number of individual parts in component assemblies is reduced, which allows for designs that clearly enhance the efficiency of the assembly process and subsequent maintenance.

The following aspects are particularly attractive for customers: By means of composite technology the specific advantages of diverse materials can be combined in a single component. Thanks to extensive freedom of design even complex product geometries can be achieved. This results in compact and weight-saving solutions allowing for the realization of completely new development potential.

Functional Reliability Combined with Space and Cost Savings

A closer look at composite solutions reveals details of the afore-mentioned advantages: The stabilization of small and delicate parts results in easier handling, which reduces the risk of mistakes in the assembly process. Loss of parts and sub-assemblies during installation and subsequent use is avoided. The bonding of seal geometries avoids the potential risk of leakage. All these factors combined lead to greater functional reliability.

Composite solutions score in terms of space and cost benefits, too: The smaller number of components enables more compact designs and thus reduces the required design space. The dimensional stabilization of the elastomeric seal geometry cuts assembly costs while the reduction of parts diversity saves administrative,

warehousing and logistics costs, and higher process quality has a positive effect on quality costs.

Extensive Materials Portfolio Offers Diverse Combination Options

Parker Prädifa offers an extensive range of advanced composite solutions featuring diverse material combinations such as rubber/plastics, rubber/metal and plastics/plastics. Particularly 2-component rubber/plastics direct composite solutions stand out from others in this context. Due to the substitution of metal, this type of composite requires no primer and is therefore beneficial for human health and the environment.

The chart below shows an overview of typical combinations with and without primers that Parker Prädifa offers as direct composite solutions.

Together with the customer, Parker Prädifa's in-house application engineering team evaluates the requirements to be met by the component and selects the best suited materials and manufacturing methods under the aspects of functional reliability, durability, cost efficiency and environmental friendliness.

Substitution of Metal by Plastics

Rubber/metal combinations have proven their viability in many applications, especially since metal can be combined with a large number of elastomers. However, metal is relatively heavy, cost-intensive and prone to corrosion. That is why these solutions require a primer system and

Summary

Compared to “single components,” composite solutions for sealing elements and engineered moldings offer a whole host of efficiency and cost benefits for established products as well as for innovative new developments. Like in all other areas of seal and component engineering, the extensive materials and process know-how and expert advice provided by a specialized manufacturer such as Parker Prädifa are essential to creating and producing durable and reliable solutions.

thus additional process steps and technical equipment. In addition, the manufacturing process leads to solvent emissions requiring special precautions such as extraction systems for environmental and health protection reasons.

In contrast, rubber/plastics combinations have benefits such as lower weight, lower costs and no risk of corrosion. Above all, however, they enable manufacturing solutions without the use of primers. As a result, production complexity, parts price and weight can be significantly reduced and durability enhanced while the environment benefits as well.

Therefore, it pays to consider a substitution of metal by plastics particularly for new developments. Whether or not an optimization of the sealing element or engineered component is possible by substituting metal depends on the desired technical characteristics.

“Classic” Methods and Forward-Thinking Techniques

Parker Prädifa uses “classic” methods to achieve indirect positive-fit and direct adhesive connections using primer systems, as well as forward-thinking, eco-friendly and cost-efficient techniques of direct adhesive connections that require no primers and additionally make it possible to substitute materials as described above.

Like all technologies, each of these methods has advantages and disadvantages that must be weighed against each other. Extensive expertise in materials, engineering design and process technology is essential to achieving reliable and durable composite solutions. Know-how in joining technology and suitable combinations is important in terms of materials whereas engineering design expertise is essential in the area of joining thin-walled components and taking undercuts into account. Moreover, the range of manufacturing requirements to be fulfilled in achieving composite solutions combining durability with reliable performance includes current and future challenges to be met by the joining methods and the characteristics of the joined components.

Versatile Applications in a Wide Range of Industries

Thanks to an extensive selection of materials with diverse combination potential and suitable manufacturing methods Parker Prädifa offers the development and production of 2-component products like housing components with static sealing functions (also conforming to relevant IP Codes), functional elements for translatory motion, sealing elements with positive-/non-positive-locking retention, dimensionally stable carrier plates with sealing functions and more. They are used in areas such as mobile machines, the automotive and general industrials sectors, aerospace, life sciences and the oil and gas industry.



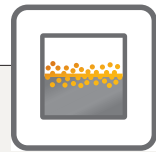
Learn more about
Composite Technology



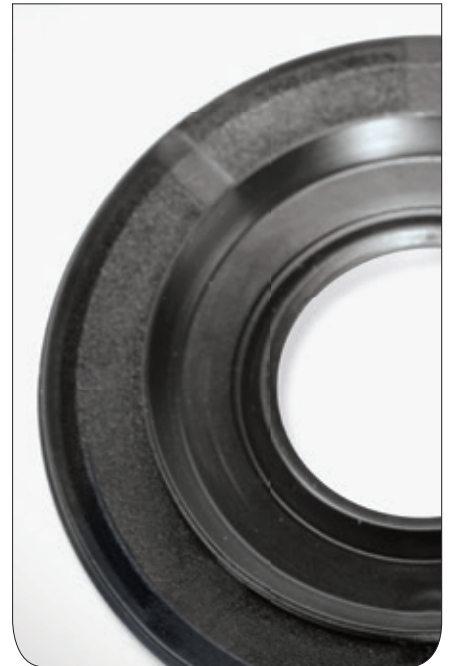
Form-fit
Connections



Adhesive
Connections
– with Primers



Adhesive
Connections
– without Primers



Substrate	Elastomer											
	AEM	EPDM	FKM	HNBR	NBR	NR/SBR	SBR	VMQ	TPU	TPE-E	TPE-S	TPE-O
Steel	•	•	•	•	•	•	•	■	•	•	•	•
Aluminum	•	•	•	•	•	•	•	■	•	•	•	•
Brass	•	•	•	•	•	•	•	•	•	•	•	•
ABS									•			
PA	■	■	■	■	■			■	•		•	•
PBT		■			■				•	•	•	
PC									•		■	
PEEK												
PP											■	■
PPE		■				■	■					
Rubber/fabric			■		■							

● Conventional composite technology

■ Possibility of direct composite without primer



Reinhold Waldeier
Market Development Manager
Engineered Materials Group Europe



ROLLING INSTEAD OF SLIPPING

NEW ROLL2SEAL® FROM PARKER PRÄDIFA SEALS BORES EASILY AND EFFECTIVELY

Roll2Seal® is an all-new sealing solution developed by Parker Prädifa for easy and effective sealing of bores in non-pressurized applications. The clever, patent-pending design combined with an equally new assembly process enables simple and accurate installation of the seal, which rolls into its seat undamaged and without a lead-in chamfer.

It is not uncommon for sealing tasks to entail challenges that call for special solutions. A case in point: What can be done if a bore requires radial sealing but lack of a lead-in chamfer prevents the installation of a seal? A situation like this occurs for instance when an existing bore should be closed with a cover and the space around the bore is too small for a classic flange seal. As the following article describes in detail the new Roll2Seal® from Parker Prädifa provides a viable solution precisely for this problem. In addition, it requires neither lubrication nor screws and therefore saves space and costs.

Roll2Seal® – Without a Lead-in Chamfer

A seal would not survive an attempt to install it in a bore without a lead-in chamfer. Part of the seal would be sheared off at the edge of the bore even if the edge were chamfered or rounded.

The Roll2Seal® concept solves this problem. Instead of destructively squeezing the seal at the critical edge it is simply made to roll across it. This is achieved by providing the cover with a geometry which, together with the edge of the bore, forces the seal to rotate. Subsequently, the triangular cross section of the seal makes it possible for the seal to roll off at the dangerous edge of the bore with a minimum seal height and thus without risk of seal damage. Of course, in the seal's actual seat, i.e. the final position after installation, sufficient seal height and thus compression must be ensured by all means. **Figure 1 on page 14** shows the individual steps involved in this process.

Roll2Seal® – Without Lubrication

The recommended lead-in chamfers of 15 to 20 degrees do not yet guarantee trouble-free installation by caus-

ing the seal to slip into the bore. Elastomers may exhibit considerable friction on dry, non-lubricated surfaces. While this is a desirable characteristic for instance on vehicle tires, it proves to be a major obstacle when installing seals. Consequently, a sufficient reduction of the friction coefficient between the seal and the chamfer by means of lubrication or an anti-friction coating is a prerequisite for seal installation.

Figure 2 on page 14 shows the problem of installing an O-ring where a 20-degree lead-in chamfer exists. Due to the self-locking effect that sets in at a friction coefficient of about 0.4, the installation of the seal is no longer possible in this example. The O-ring will be partially sheared off. Furthermore, in the case of unevenly distributed friction forces, for instance due to an off-center position of the components to be joined, twisting of the seal may occur. This is caused by unilateral rolling while the seal slides on the opposite side. Such assembly defects often go unnoticed.

The Roll2Seal® principle may be helpful here as well whenever the required friction factor cannot be achieved due to lack of lubrication, for instance on account of chemical incompatibility with lubricants, dispensing with paint-wetting impairment substances or simply for cost reasons, because high friction forces have no adverse effect on the assembly process of Roll2Seals®.

Roll2Seal® – Without Screws

As the installation progresses, the second special feature of this sealing concept becomes effective: the retention force of the cover in the bore.

This effect results from the fact that during the compression of the elastomer part the resulting contact stress forces of the top and bottom side are not exactly opposite each other – i.e. do not offset each other – but are offset laterally due to a slight chamfer of the bottom contact



Figure 1: Installation of the Roll2Seal® without a lead-in chamfer

area and, additionally, the net force on the bottom side is slightly slanted. This causes a force to act on the cover that pulls the cover into the bore.

Figure 3 illustrates this effect. After the assembly forces (negative here due to being opposed to the X direction) have been overcome the seal rolls into the area of the chamfer where the assembly force is reversed to positive values. The progression of the assembly forces over the assembly process gives the worker installing the seal a sure feeling for accurate installation. After the maximum force has been overcome, the end of the installation process is also acoustically perceptible at the dead stop.

Consequently, in the end position, an axial force is no longer needed to compress the seal. The retention force, which is positive now, prevents the cover from falling out. Its level can be adjusted in various ways: by the angle of the chamfer, the strength (hardness) of the material, the compression and the end position of the sealing element. Therefore, with non-pressurized systems, a cost-intensive screw connection of the cover can either be completely omitted or simpler fastening methods such as retention clips be used.

Figures 4 and 5 depict the correlation between material hardness, friction factors and retention force with a constant chamfer.

Roll2Seal® – For One-Time and Repeated Installation

Both one-time and repeated installation and removal of the Roll2Seal® is very easy and, thanks to the seal's immunity to unbroken edges, can be accomplished without damaging the seal.

Roll2Seal® – For Your Application

By means of Finite Elements simulation the required geometry can be adapted to the desired bore diameters and the assembly processed checked. The effects of varying friction conditions and material properties can be predicted as well.

Obviously, the selection of the material depends on the

Installation of an O-ring 25 x 3.5 mm, radial compression (piston seal)

Lead-in chamfer: 20° / Hardness: 75 IRHD / Compression: 23 %

a) Initial situation

b) With friction coefficient 0.3

c) With friction coefficient 0.4
– jamming of the O-ring, O-ring shears off

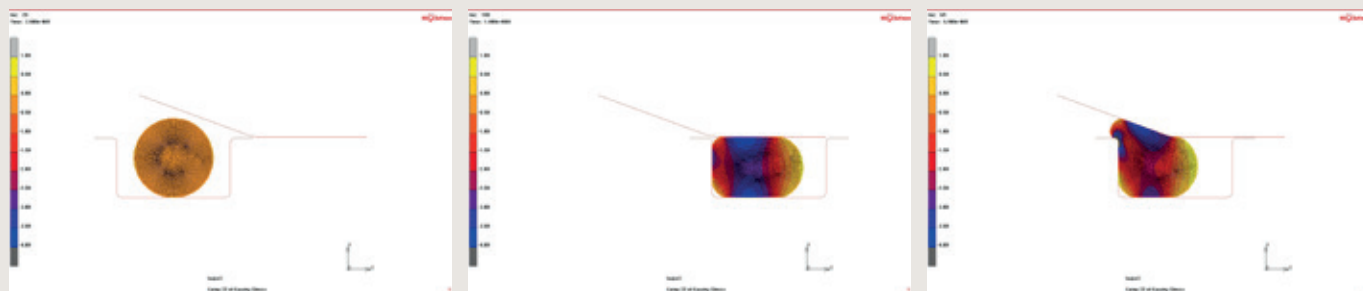


Figure 2: O-ring damage caused by excessive friction forces during assembly



thermal and mechanical requirements, beginning with PA6.6 for the seal carrier and NBR for the triangular seal as the most cost-efficient choices. The two-part sealing system is delivered in pre-assembled form. The Roll2Seal® concept provides design engineers with an alternative solution for radially sealing bores even without lead-in chamfers. By omitting this process step, this concept can either save costs or enable subsequent sealing of bores. Practical applications are found:

- where bores already exist for subsequent installation of additional component assemblies but require effective temporary or permanent sealing (e.g. for test runs or shipping),
- where lubrication during the assembly process is not possible,
- where non-pressurized systems require reliable sealing without screw connections.

The space- and cost-saving Roll2Seal® seal is produced from suitable materials according to the thermal and mechanical requirements. The sealing system, consisting of a plastic or metal cover and the seal, is available in pre-assembled form if desired.

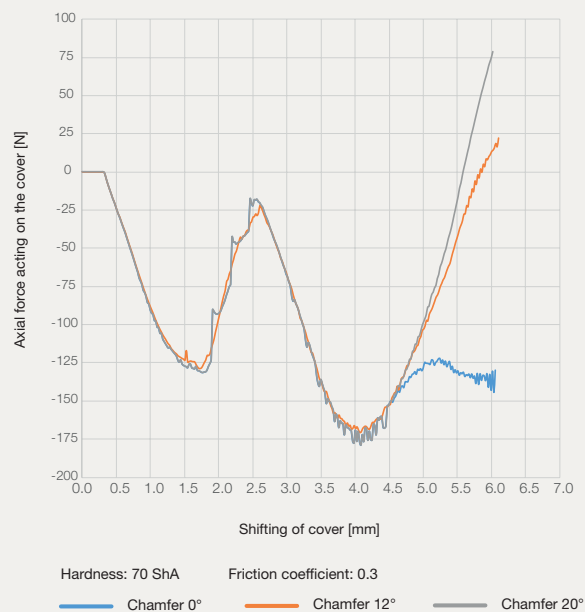


Figure 3: Impact of the chamfer angle on assembly/retention force

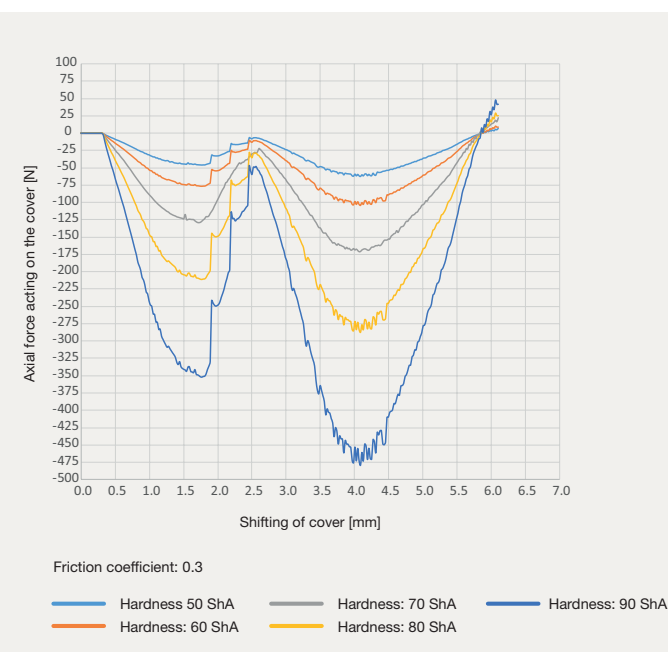


Figure 4: Impact of elastomer hardness on assembly/retention force

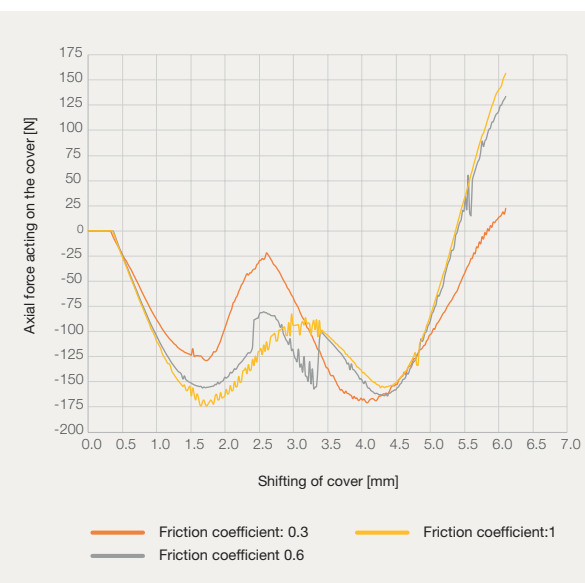


Figure 5: Impact of the friction coefficient on assembly/retention force



Video:
<https://youtu.be/7oRhndn-rlrc>



Dr. Stefan Reichle
Market Unit Manager
Alternative Mobility and Industry
Prädifa Technology Division



RELIABLY SHIELDED AND SEALED

PARKER OFFERS EXTENSIVE PORTFOLIO
FOR E-MOBILITY

Electric vehicles with their high-voltage systems and power electronics confront automotive OEMs and their suppliers with special challenges in the areas of sealing and shielding of electrical interference signals and thermal management. Drawing on decades of experience in these areas, in all kinds of automotive as well as electronic system applications, Parker offers an extensive range of solutions for Electric Mobility.

Components of alternative drive systems such as electric axles, batteries, power electronics and their control units entail a multitude of sealing and shielding requirements. All of them are aimed at ensuring efficient and reliable performance of on-board electrical systems, from charging current couplings to the traction battery to the electric drive motor.

Established Solutions Hallmarked by Efficiency and Reliability

Sealing solutions such as O-rings, press-in-place seals, rotary seals, integral seals (composite sealing plates) are available for these purposes, as well as other products for electrical shielding and heat dissipation such as EMI components, thermal gels and pads. Special benefits can be achieved by combining these functions in one component.

Environmental Sealing of Electrical On-Board Systems

Drive systems for hybrid electric and battery electric vehicles consist of a multitude of complex components with specific tasks and requirements. Electronic control units, power electronics or the electrified drive axle and their individual assemblies have to be reliably protected against environmental influences and electromagnetic interference. For these requirements, Parker offers an extensive product range for shielding and sealing of chassis/housing elements. Customers are able to select from a multitude of press-in-place frame seals, O-ring seals, chassis/housing components with integrated sealing systems to thermally conductive sealing gels.

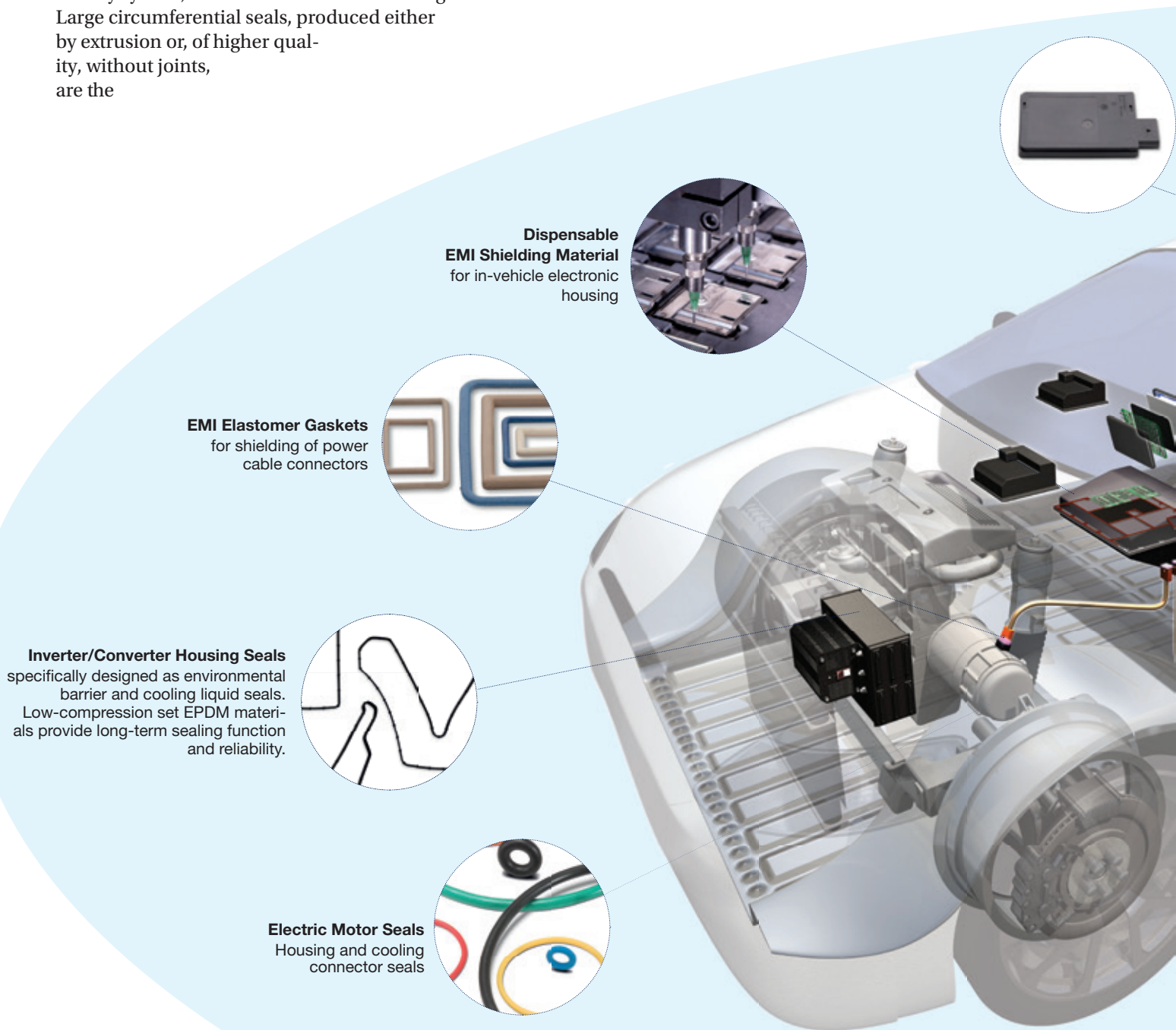
For sealing larger chassis/housings, such as those of the battery system, Parker offers XXL-size sealing solutions. Large circumferential seals, produced either by extrusion or, of higher quality, without joints, are the

ideal solution for large chassis/housings. Unlike adhesion-bonded chassis/housings, they enable easy revision when repairs are necessary.

For electromagnetic shielding that is intended to prevent undesirable interference with the components either from external sources or adjacent electrical systems, special-purpose sealing solutions using EMI materials are available.

Thermal Management

The compact design spaces of on-board electric systems such as the traction battery, power electronics and electric motor combined with their high power density require efficient



and intelligent thermal management solutions. Air-cooled or liquid-cooled systems call for sealing solutions with high temperature stability and long life. Inefficient cooling would result in major trouble for the total system and may lead to massive performance loss up to and including total destruction of the electronic components of the hybrid electric or battery electric vehicles.

In this area, Parker is able to draw on longstanding experience in the development of sealing compounds for cooling systems with particularly challenging demands in terms of service life and chemical resistance. In addition to static and dynamic sealing solutions such as flange, shaft or molded seals, Parker offers special thermal gels or pads for heat dissipation of electronic components or chassis/housings.

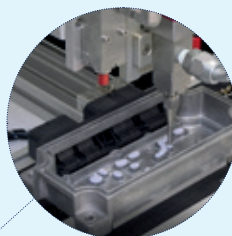
Comprehensive Know-how and Specialized Materials Portfolio

In the development and production of electric mobility product solutions, Parker offers comprehensive, long-standing know-how and an extensive, specialized materials portfolio in the field of sealing and shielding technology and thermal management.

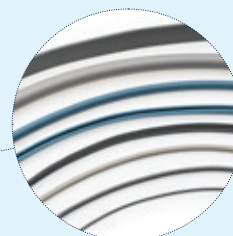
More information:
www.parker.com/emgev

Electrically Conductive Plastic

replaces metal or aluminum housing to give a weight saving of 35%



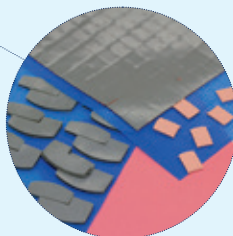
Thermally Conductive Dispensable Gels
for effective heat transfer of battery pack



EMI Co-extruded Gaskets
protect battery from environment, dirt, debris and fluids



Battery Housing Seals
Taylor-made seal profiles which are welded to fit even complicated housings. Laminated adhesive tapes or other assembly aids make installations easy and safe.



Thermal Gap Pads
for additional support, vibration dampening or dielectric strength of battery pack



Battery Pack Cooling Seals
made from low-compression set EPDM materials provide long-term sealing function and reliability for all cooling circuit interface seals

Automation

Med

Fig. 1: A typical example of a frame and gasket prototype which could be formed by additive manufacturing

3D PRINTING

Prototyping

Indu

Spare
parts

Additive
manufacturing

Gerard Young
Applications Engineering Team Leader
Chomerics Division Europe

3D PRINTING FOR PROTOTYPING EMI HOUSINGS AND GASKETS

A VALID ALTERNATIVE TO CONVENTIONAL MACHINE TOOLING?

The introduction of affordable 3D printing services, properly known as additive manufacturing (AM) services, has allowed electronics product manufacturers to consider a new approach to the production of prototypes. A 3D printing service can in many cases form a complex, rigid structure from a CAD tool rendering much more quickly and cheaply than a traditional machine tool workshop can.

The potential for cost and time savings has sparked the interest of Parker Chomerics, which manufactures EMI gaskets and shields to customer specifications for use in end products in the aerospace, automotive, industrial and communications equipment sectors (*see Figure 1, page 20*). When developing the prototype of an EMI shielding solution, a casing or frame can quickly be formed by an AM machine, and then sprayed with conductive paint. When combined with a gasket dispensed onto it, an AM-based prototype can be used to prove a concept or idea. This is, potentially, much less costly and time-consuming than producing conventionally machined parts. And the more iterations of the prototype are required, the greater the accumulated time and cost savings.

For this reason, Parker Chomerics engineers are today making considerable use of 3D printing for prototyping. They have learned a number of important lessons from their experiences of using both the Parker Hannifin Corporate Technology Ventures (CTV), a new state-of-the-art advanced manufacturing learning and development center in Ohio, USA, and commercial AM services in the product development process.

To benefit from the use of AM for prototyping, there are some considerations that must be taken into account:

Guideline 1: Draw on the AM Service Provider's Expertise

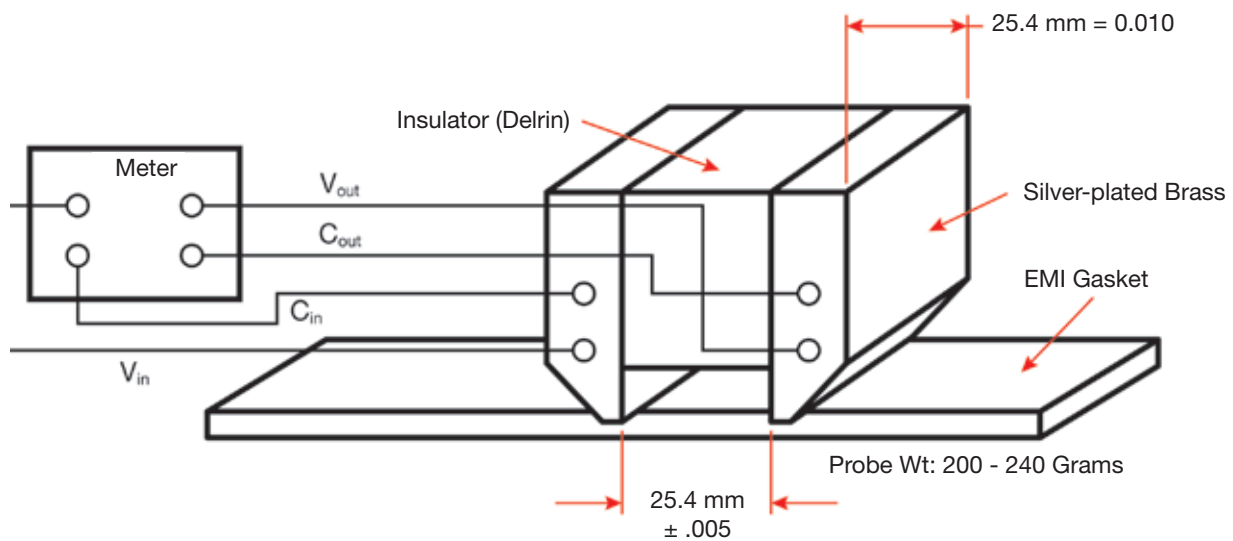
An understanding of the AM service's capabilities and materials is essential if the user is to produce a successful

prototype. An early discussion about the design features of the CAD model and the materials available for additive manufacture is likely to be productive, helping to save time and money by reducing the number of iterations required before a successful model is made. It is particularly helpful to draw on the expertise of an AM service provider when choosing the base material and the process technology.

Two types of processes are used in industrial-grade AM: selective laser sintering (SLS) and fused deposition modeling (FDM). A third type, fused filament fabrication (FFF), is the most commonly found technology in hobbyist-grade machines, but SLS and FDM are generally the processes that produce industrial-grade components. To rank the three processes in order of their cost and the complexity of the components that they can produce, at the low end is FFF, followed by FDM. At the top end is SLS.

A user's choice of process depends primarily on the nature of the component being produced, the speed with which it needs to be produced, and the required quality of the finished item. The AM service provider can advise on this, and also on the choice of material from which the item is to be formed. Metals such as stainless steel, steel and titanium are commonly used in AM processes, as are aluminum-, copper- and nickel-based alloys.

A range of thermoplastic compounds are also in common use today, and more are constantly being made available. Common plastics such as acrylonitrile butadiene styrene (ABS) and polycarbonate are available



Note:

1. Dimensions are in mm
2. Tolerance shall be $\pm .01$

Fig. 2: Test set-up for continuity testing across a thickness.

today, as are nylons which may be filled with glass, carbon fibers or aluminum to modify the properties of the base plastic.

The AM service's experts will have first-hand knowledge of the performance of each of these materials after processing through an AM machine.

Guideline 2: Modify the Design to Suit Additive Manufacture

Designs which are optimized for machining or molding should sometimes be re-designed to take account of the unique nature of additive manufacture. In Parker Chomerics' experience, it is also sometimes necessary to pay for a few iterations of the production process to achieve better accuracy than the supplier's normal level. This is primarily because the material is added in layers, and each layer has a minimum thickness. It is often advisable to design the part's nominal dimension to match the thickness of an integer number of layers.

The user's choice of AM material might also have to find a balance between the need to produce adequate mechanical properties for the needs of the application while also matching the properties of the material from which the production component will eventually be made. For instance, in order to achieve a certain stiffness and elastic modulus in the AM part, the user might have to accept

that its thermal performance deviates somewhat from that of the production component.

A careful choice of prototyping substrate will ensure that its mechanical and thermal properties are sufficiently close to that of the machined metal or conductive polymer from which a production component will generally be made.

Guideline 3: Match the Paint to the AM Material

The AM process produces a formed part with the specified mechanical properties – but if it is to have useful EMI shielding properties, it needs to be sprayed with a conductive coating. Suitable acrylic or epoxy paints include the Cho-Shield 2056 or Cho-Shield 610 products from Parker Chomerics, which include conductive fillers. These coatings have a known thickness which needs to be taken into account when designing the part. Conductive coatings such as the products from Parker Chomerics are optimized for application to standard materials such as metal or thermoplastics. The interaction between AM materials and conductive coatings can be different.

To achieve a good result it is preferable to first spray a test piece to ensure that the paint system does not adversely affect the part. These coatings often contain solvents,

which can damage the part or which need to react with the surface in order to adhere to it. Normally, one-part acrylic paints are sprayed onto surfaces such as polycarbonate or ABS, and the solvents in them result in good paint adhesion. Two-part epoxies are used on metals and other substrates that do not react with the chemicals in the coating. The choice of one- or two-part coatings will depend on the type of AM material used.

It is also very important at this stage to ensure that the painting is done by an experienced operator. It is easy for an operator with no experience in conductive coatings to produce a poor finish because they behave so differently to normal decorative or protective coatings.

Guideline 4: Some AM Materials Do not Support Accelerated Curing

After spraying the part, the coating must be cured. Here again, careful consideration must be taken of the difference between the chosen AM material and the material from which the production part will be made. Some AM materials will not tolerate oven curing at all: curing at room temperature might take up to a week, and this detracts somewhat from the speed advantage that prototyping with AM processes normally affords.

Even if the AM material can tolerate oven curing, users should establish the highest temperature that can be used without damaging its structure and accept a longer curing time when baking at lower temperatures.

Guideline 5: Test the Part's Electrical Performance Carefully

Once the paint is cured, the user needs to check the conductivity and continuity of the conductive surface. This generally requires the use of a four-point low ohmmeter in conjunction with an appropriately designed probe such as the Parker Chomerics Cho-Probe. Continuity may also be measured across a thickness with two parallel plates (*see Figure 2*).

Once the resistivity has been checked and approved, the next stage is to apply the gasket. Depending on the geometry of the prototype, this could be as simple as an O-ring made from conductive elastomer such as Cho-Seal (*see Figure 3*). More complex assemblies might require the attachment of an A-section to a tang formed on the part, or dispensing form-in-place gasketing such as Cho-Form.

If using form-in-place gasketing, the same considerations apply with regard to curing as were listed for conductive coatings above.

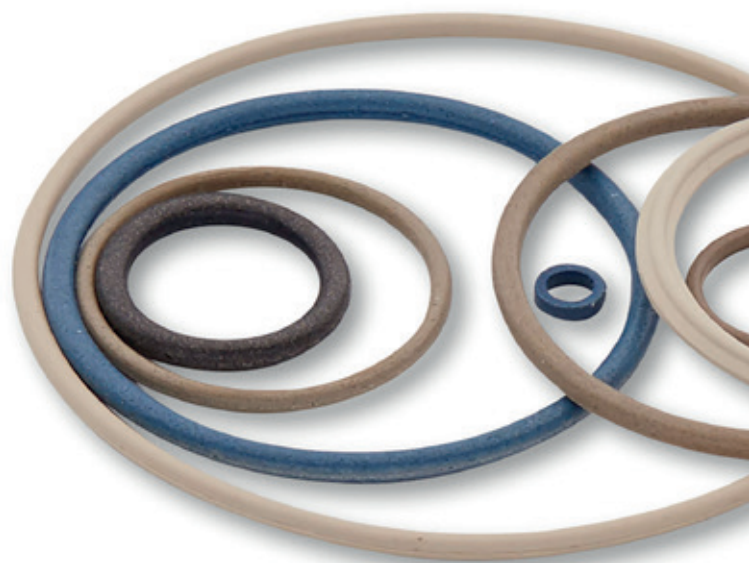


Fig. 3: D-ring and O-ring gaskets from Parker Chomerics offer EMI shielding and provide a moisture/pressure seal

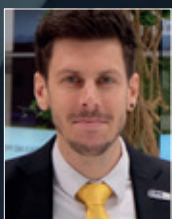
Guideline 6: Test the Final Assembly

Once the gasket is applied and, if necessary, cured, the final stage prior to inserting the item in the host device is to apply a final resistivity check. The resistivity check can be performed by applying probes to the gasket in certain positions and loadings around the component. It could alternatively be tested in a fixture that simulates the final assembly and use. In either case, care should be taken not to over-compress the gasket or to damage the coating or component.

Speed and Cost Advantages

What the Parker Chomerics engineers who design custom EMI shielding solutions have found is that AM provides them with a new way to prototype a design more quickly and more cheaply than by conventional methods. Care must be taken, however, to ensure the right process is chosen and the correct material selected. It always pays to take advice from the AM service provider on this and to use its recommendations to modify the design to make it suitable for additive manufacturing.

www.parker.com/chomerics



Daniel Glinka
Product Specialist
Prädifa Technology Division



TAILOR-MADE PROTECTION

CONTINUOUS PROFILES FOR RELIABLE SEALING,
DAMPING AND MOUNTING

Continuous profiles are used for sealing, damping and protection, and facilitate assembly work in countless technical applications. In all of them, both visual and functional requirements must be satisfied. Parker Prädifa offers a product portfolio that covers the gamut of possible uses and includes the optimum material combination for any requirement.

Long-standing experience in application engineering, material development and manufacturing technology provides the basis for reliable and durable solutions. Continuous profiles from Parker Prädifa are produced from elastic materials which are precisely adapted to the respective purpose. They withstand both dynamic and static loads in the application and are characterized by high elasticity combined with good resilience, among other things.

Optimum Selection and Adaptation of the Material

The desired product features of profiles can be achieved through proper selection and modification of the material to suit the intended purpose. This ensures that they will withstand the dynamic or static loads occurring in the application and exhibit the required elasticity. Compact elastomers, mixed-cell sponge rubbers and combinations of both materials are used as well as diverse thermoplastics.

Step by Step to the Tailored Product

Profiles from Parker Prädifa are produced as continuous seals using extrusion technology. The material is pushed through the machine and given its elastic shape according to the final product's purpose. Subsequently, the final product is cut to length or delivered on rolls, depending on the customer's preference. As a result, it simplifies the customer's assembly process by allowing for convenient manual removal and automated processing, among other things.

As an additional option, Parker Prädifa offers lamination and kiss-cut finishing of profiles. In the lamination process, the product is combined with a self-adhesive coating. The double-sided adhesive tape is applied to the profile using a heat laminator. The parameters time, temperature and applied pressure result in the desired composite strength.

In the kiss-cutting process, the profile is cut except for the liner, which remains intact. This provides the advantage of facilitating the separation of the profile in the assembly and thus simplifies its application.



Sealing

For sensitive technical components such as those in electrical engineering or HVAC (heating, ventilation, air conditioning) systems, profiles are used for sealing against various media like water, dust or air. Protection and assurance of reliable performance are central aspects of these applications. In automobiles, for example, sealing profiles prevent ingress of rain water or other environmental influences and thus ensure protection and comfort of the occupants.



Damping

NVH (noise, vibration, harshness) damping provides protection and comfort. In automobiles, for instance, profiles prevent undesirable external road or door-closing noise or other acoustical influences inside the cabin, as well as the occurrence of frequencies in vehicle interiors. In addition, profiles prevent product damage, thus helping to preserve value.



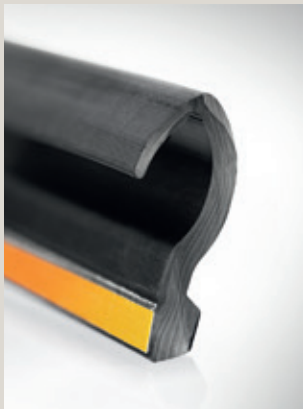
Protecting

Profiles used as edge protection help avoid injuries by sharp-edged components and corners. A protective profile can make an important functional contribution in shipping or assembly processes and possibly in subsequent operation as well.



Mounting

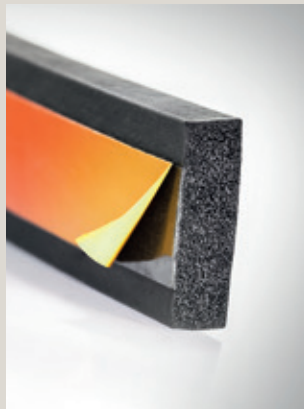
When used as spacers or bump stops, profiles facilitate the assembly process of component systems, for instance when mounting windshields to bodies-in-white in automotive engineering. Besides facilitating assembly, profiles used as spacers enhance precision because their geometries and contours ensure compliance with the required spacing in the assembly process.



Compact Elastomers

Due to their elastic properties, profiles made from these materials are suitable for sealing applications involving high closure and load forces

- High elasticity of compression, combined with good resilience
- Perfect sealing and damping material thanks to elastic properties
- Use with high closure and load forces
- Hardness: 35 – 90 Shore A



Sponge Rubber

Sponge rubber is used where high deformability and flexibility are required, for instance in tight assembly spaces. Due to the material's high elasticity of compression, adequate sealing action is ensured even under light pressure. Due to its open pore structure, the quantity of sponge rubber stock is measured as bulk density in kg/m³.

- No expansion of mass in the case of deformation thanks to largely open pore structure
- High elasticity of compression
- Sealing effect even when light pressure is applied
- High deformability and flexibility
- Bulk density: 65 - 350 kg/m³



Combination of Compact Elastomer and Sponge Rubber

Composite solutions of an elastomer and sponge rubber consist of a compact elastomer carrier material and a soft sponge-rubber contour. The advantages result from the synergy of the individual materials and their properties.

- The carrier material serves to position and fix the part in place
- Even light pressure ensures reliable sealing



Thermoplastics

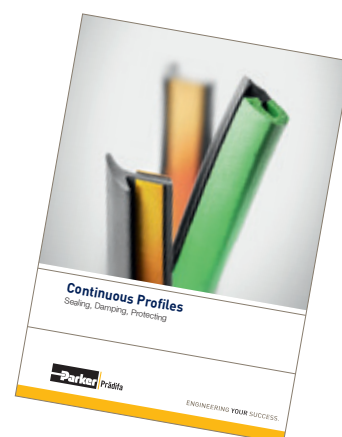
Thermoplastic materials, among other things, offer the advantage of containing no silicones (i.e. "paint-wetting impairment substances") and, due to their recyclability, are environmentally friendly. Profiles made from thermoplastics exhibit a rubber-like outer skin.

- Recyclable
- Temperature range: -40 °C to +110 °C
- Producing in all colors
- Hardness: 40 – 80 Shore A

The Right Profile for any Application

Continuous profiles are found in a wide range of applications and sectors such as in the automotive industry, in electrical engineering, in the construction industry in HVAC (heating, ventilation and air conditioning) and sanitary applications, in mechanical engineering and more. Parker Prädifa offers profile solutions that are tailored to the respective application and additionally supports customers regarding application methods, finishing and suitable logistic concepts.

Learn more about
Continuous Profiles







GIANTS OF THEIR KIND

XXL-SIZE SEALS AND MOLDINGS

Besides developing and manufacturing sealing systems of average sizes and in particularly small dimensions, seal manufacturers have to cover a growing demand for large seals today. For these requirements, Parker Prädifa offers an extensive portfolio of seal geometries and materials using specialized manufacturing methods. At the upper end, for instance in the case of metal C-rings, the range of sizes extends all the way to an enormous 7.6 meters. These seals are part of Parker Prädifa's XXL-portfolio as well as machined seals from polymeric high-performance compounds of up to (currently) 4.5 meters and precision O-rings in practically any desired diameter.

Large-scale manufacturing equipment, the entire energy sector from oil and gas to conventional power stations to renewable energies from wind turbines, mining and tunnel construction, buildings and pipelines, as well as modern high-tech medicine, the aerospace sector and many others require sealing solutions that exceed "normal dimensions."

With an extensive portfolio of polymeric compounds such as NBR, EPDM, FKM, PTFE and PEEK as well as metal, Parker Prädifa covers the entire range of materials for large-size seals and engineered components.

The appropriate manufacturing technology plays a key role in this context, too, because "small" cannot simply be converted into "large." Especially the development and production of large seals and other large-size engineered components requires a particularly high level of combined materials and process technology know-how. Through continuous new and further development of the products themselves and the materials used, as well as the manufacturing methods and technical equipment they require, Parker Prädifa ensures that even the largest seals in rather small volumes can be economically produced at the required level of quality.

[Learn more about available solutions and sizes and discover our case studies on our Website](#)

[Whitepaper:
Large-Diameter Seals and Moldings:
Materials and Special Manufacturing Aspects](#)

SUITABLE FOR WORLDWIDE USE

NEW EPDM MATERIAL FROM PARKER PRÄDIFA WITH ALL RELEVANT DRINKING WATER APPROVALS AND WIDE APPLICATION RANGE

Parker Prädifa has developed EPDM compound EJ820 as a robust sealing material with particular suitability for drinking water applications. Thanks to all relevant national and international drinking water approvals it is usable worldwide. Due to its low compression set combined with enhanced resistance against autooxidation, the material guarantees long life and reliable sealing performance, for instance in valves and fittings, and in pipe systems.



Elke Vöhringer-Klein
Territory Sales Manager
Engineered Materials Group

Sealing materials for applications in drinking water and service water systems are subject to diverse approval requirements worldwide. They serve to ensure that the seals and materials from which they are produced are toxicologically harmless and practically contain no extractables across the entire process chain: from the extraction of water via its treatment and transportation through to extraction by the final consumer. The EPDM compound developed by Parker Prädifa meets the requirements of a wide range of national and international market-specific approvals and conformities and therefore allows for global use of the sealing systems.

From the conventional O-ring (in imperial and metric dimensions with diameters of up to several meters) through to membranes and engineered moldings according to customer drawings the EJ820 compound can also be processed in rubber-metal combinations.

Reliable Long-Term Reliability

Thanks to outstanding mechanical properties and excellent permanent elasticity, i.e. low compression set, in combination with enhanced resilience against auto-oxidation seals produced from this material – whether as pipe seals, radial shaft seals in pumps or for sealing sensors in operations that process drinking water – deliver the required reliability and long service life. Domestic water pipes, for instance, are expected to last for a minimum of 30 years after installation.

Usable in Many Challenging Media

Thanks to the material's outstanding durability EJ820 sealing elements can be used in a wide range of applications involving challenging media. In addition to drinking water, hot water and hot steam of up to 180 °C, the material is first choice in many organic and inorganic acids, detergents, sodium and caustic potash solutions, in polar solvents, in silicone oils and greases, and in hydraulic fluids based on phosphoric acid ester (HFD-R).

Efficient Processes Due to Simple, Low-Friction Installation

Seals with ParCoat® coatings (*see also article on page 4*) can be installed with low friction and minimal exertion of force using automatic equipment. Unlike surfaces treated with oils or greases, seals with ParCoat® coatings do not contaminate the handling and feeding units of automated assembly systems. The rings do not stick together, are not damaged and can be elongated by up to 150 % without the anti-friction coating cracking or breaking. The installation process can be repeated several times with identical assembly forces.

Wide Application Range beyond Drinking Water

In addition to drinking water applications, EJ820 is suitable, for instance, in service water systems, in heating technology, in pressure and temperature measuring technology and in solar thermal systems. In beverage industry applications, the resistance of the material in CIP/SIP cleaning processes is of major importance, while in the pharmaceutical sector its water resistance in aqueous processes such as steam pressure sterilization is essential. The application profile of EJ820 is complemented by possible uses in the chemical industry and in glycol-based brake fluids up to 150 °C, silicone oils and greases.

Compound Properties

- Good chemical resistance in hot water and steam up to 180 °C
- Cold resistance down to -50 °C
- Outstanding resistance in drinking water
- Certified toxicological harmlessness
- Perfectly suited for many polar solvents (alcohols, esters, organic and inorganic acids)
- Ozone-, age- and weather-resistant
- Long service life and high abrasion resistance
- Extensive international approvals and conformities

Recommended Applications

- Heating valves and pumps
- Drinking water and service water systems
- Pressure and temperature measuring technology
- Solar thermal systems
- Beverage industry, e.g. in CIP/SIP cleaning processes
- Aqueous pharmaceutical processes, e.g. in steam pressure sterilization
- Chemical industry
- Glycol-based brake fluids up to 150 °C
- Silicone oils and greases

LONG-TERM PARTNERSHIP

25 YEARS

DISTRIBUTION PARTNER **HilDi GmbH**

Bernd Wemmer (left), Sales Manager Central Europe, and Andreas Fink (right), Team Leader Sales Southern Germany, extended the best wishes and appreciation of the Parker Engineered Materials Group for the excellent long-standing partnership.

In 2006, Dirk Hilgendorf (center) succeeded the company's founder, his father, Dieter Hilgendorf, as CEO.

Today, the company has a modern facility with 1,700 square meters of usable area including extensive warehouse capacities in the industrial park of Gomaringen (Germany). 20,000 articles are constantly in stock and available to customers in the fields of mechanical engineering and fluid power. Two employees in application engineering ensure optimum technical consulting support.



45 YEARS

**DISTRIBUTION PARTNER
DICHTUNGSTECHNIK GMBH**



45 years ago, Dichtungstechnik GmbH in Bensheim (Germany) entered into a distribution agreement with Parker, which laid the foundation for a successful partnership and cooperation. Led by Sybille Rauber, the daughter of the company's founder, the sales company is now in its second generation of ownership. Today, 15 employees are engaged in selling seals and supplying products to customers in machinery and plant engineering, in medical device technology, the chemical industry and in the energy sector. The portfolio extends from standard O-rings to customized products and covers an enormous breadth.

Silvia Wendnagel (Inside Sales, Parker), Jürgen Kulzer (Head of Service Center, Parker), Klaus Burkart (Sales Engineer, Parker) and Andreas Fink (Team Leader Sales Southern Germany, Parker) extended Parker Prädifa's best wishes on the occasion and thanked the entire DTB team for the excellent cooperation by presenting a Parker award for the 45-year partnership that both parties can be equally proud of.



HD SLIPPERS ON COURSE FOR GROWTH

ITALIAN DISTRIBUTION PARTNER OF PARKER PRÄDIFA DOUBLES FACILITY SPACE



HD Slippers Srl based in Sasso Marconi near Bologna (Italy) has been designing and producing sealing systems for a wide range of industrial sectors since 1982. Since 1983 the company consisting of four partners and 11 employees and run by engineers has exclusively been selling products of the Parker brand as a certified distribution partner.

The successful development of the company, whose management team combines the experience of three generations, is not least reflected in the considerable expansion of its facility space: in the past two years, it has

nearly doubled in size from 550 to 950 square meters.

250 square meters are used by offices and the laboratory, and 350 square meters, respectively, by production and logistics operations. Two large automated high-bay warehouses are exclusively dedicated to Parker products.

With an extensive array of technical equipment, the in-house laboratory of HD Slippers covers a wide range of chemical and physical tests and analyses that are relevant to sealing technology.

The customers supported by HD Slippers with both standard sealing

products and tailored solutions are mainly found in the fields of fluid power, machine tools, power technology, the food and beverage industry, medical and sanitary technology, and in the oil and gas sector. Engineering expertise and consulting support, fast solutions even for complex customer problems in a dynamic industrial environment, in addition to quality, reliability and traceability of the manufactured products including their fast delivery, are the top priorities of the company that is justifiably proud of its success and has chosen a Japanese proverb as its motto: a vision without an action is a dream, an action without a vision is a nightmare.



STRONGER GOING FORWARD

DISTRIBUTION PARTNER
AEROSPACE SUPPLY LTD ACHIEVES
AS9120B ACCREDITATION, MOVES INTO NEW
COMPANY PREMISES AND APPOINTS UK
SALES MANAGER

Dedicated to serving the aerospace and defense markets, Aerospace Supply Ltd based in Dublin has been a valued distribution partner of Parker Prädifa and the Parker Engineered Materials Group for the United Kingdom and Ireland for almost 20 years. Previously certified according to AS9120A, the company, in 2018, was also awarded accreditation of AS9120B:2016, the quality standard aerospace customers require for the stocking and supply of parts and components.



Steve Taylor, Key Account Manager Aerospace UK, Parker
Robert Browne, General Manager, Aerospace Supply
Anne Hennigan, Customer Manager, Aerospace Supply
Deklan Bonfield, UK Sales Manager, Aerospace Supply
Andrew Hine, Regional Sales Manager, Parker

“AS9120B is a strong step forward in the continuing expansion of Aerospace Supply’s presence in this market,” says General Manager Robert Browne. “This certificate underlines our commitment to our customers and the wider industry. I am very proud of our team and this award is due to their hard work and dedication.” Parker EMG’s Regional Sales Manager Andy Hine says: “I want to congratulate Robert and his team in achieving this award and to continue building on the opportunities Aerospace Supply is developing.”

Founded in 2000, Aerospace Supply grew from small beginnings to become Parker Prädifa’s certified distribution partner following negotiation and signature of a distribution agreement. Since then Aerospace Supply has been successfully supporting Parker’s UK aerospace and defense customers with dedicated stocks of key components and helping to specify a range of products and services aimed directly at this demanding market sector. Recently, Aerospace Supply moved to new premises in a new technology business park, which is better suited to its operations.



“We are evolving our organization to reflect the changing needs and requirements of the modern aerospace industry. Our new premises are located close to key transport links with large international airports close by and to high-speed road links between cities. We work very closely with our loyal customer base, offering logistical support and technical assistance to manufacturers in the aerospace and defense sectors,” Browne adds.

Another important development is the appointment of a UK Sales Manager, Deklan Bonfield. Having previously worked in the aerospace and defense sector, Bonfield brings huge experience to Aerospace Supply and the new role brings an extra technical dimension to Aerospace Supply’s portfolio as industry looks increasingly for partners who can offer value added services.

It supports the company’s plans to make an engineering resource available to customers supported by Parker Prädifa’s world-class portfolio of materials and engineering expertise. Aerospace Supply has strong links to Parker’s teams in Europe and the United States and

intends to use those links to offer customers project management and program support from conception to full-scale production and beyond.

This is further enhanced by Aerospace Supply’s major focus and record of achievement in the area of Total Customer Satisfaction. Inventory management, incorporating customer forecasts, provides significantly lower inventory levels for the customer. The company is also a member of the ADS Group trade federation and has also recently become a member of WEAF (West of England Aerospace Forum).



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