Sealing Solutions for Heating, Ventilation, Air Conditioning

Parker Prädifa

ENGINEERING YOUR SUCCESS.

Thermal Extremes and Chemical Attack – a Challenge to Seals and Sealing Materials

Cooling in summer – heating in winter: “HVAC” (Heating, Ventilation, Air Conditioning) is a collective term for both stationary systems and mobile devices performing their functions in diverse applications: in office and residential buildings, factory halls, shopping centers, schools, and in all kinds of other public facilities. In addition, air conditioning systems are used in automobiles and aircraft.

Higher comfort expectations, climatic changes, new technologies with a better environmental footprint, enhanced efficiency, and other factors have resulted in an increasingly wider variety of systems, devices and uses in the context of heating as well as of ventilation and air conditioning.

The diversity of HVAC devices and technical systems is matched by the variety of the requirements to be met by the seals and sealing materials they use. For all of these needs, Parker Prädifa offers suitable sealing solutions and sealing materials, i.e., high-quality compounds based on proprietary formulations. Our materials are tailored specifically to meeting the challenges in HVAC applications and ensure optimum performance combined with maximum service life.

The following are key criteria to be observed in the selection of the sealing materials optimally suiting the intended application:

Temperature Resistance

The application temperatures or temperature ranges that a sealing material is able to cover play an important role in HVAC applications. In many cases, the required range between the lowest and the highest permissible temperature is very wide and poses one of the greatest challenges to the sealing material.

In the event of excessive operating temperatures, for instance, the selection of the wrong sealing material may lead to accelerated aging and ultimately the destruction of the seal.

Chemical Resistance

The chemical resistance of the material against the media to be sealed in an HVAC application plays a crucial role. Whereas in air conditioning devices and systems a wide variety of refrigerants and refrigerant oils results in a large number of potential combinations of the media used, the challenge in heating systems often lies in a rather nonspecific condensate of combustion residues.

In either case, the utilization of a sealing material without the required media resistance may permit a chemical attack on the seal resulting in seal damage and leakage.

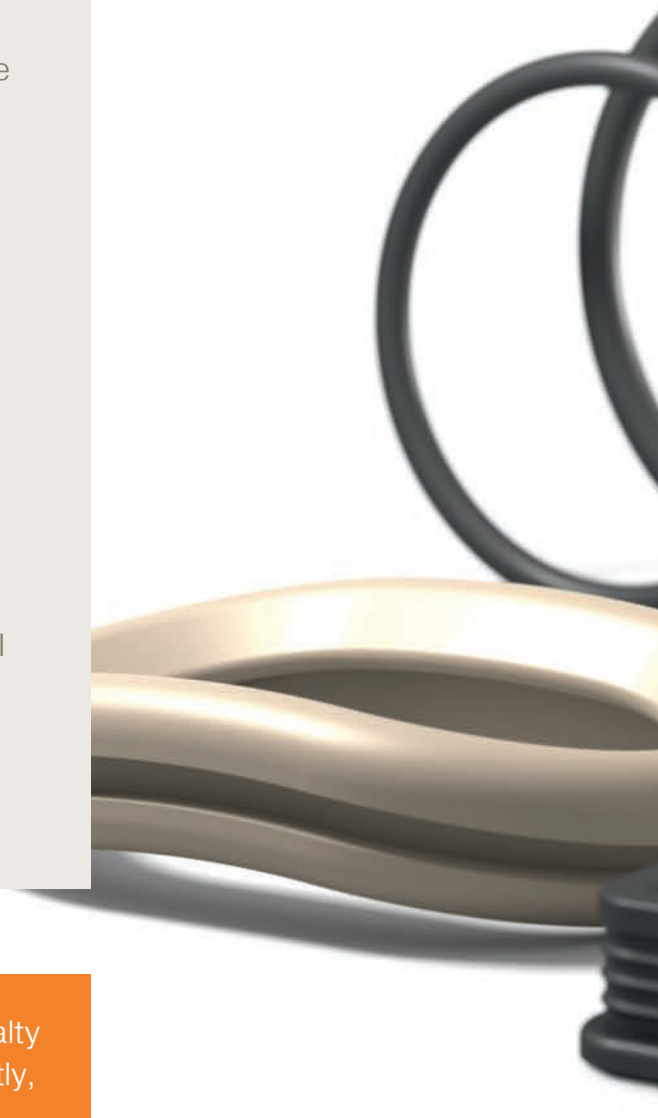
Setting Behavior and Service Life at High Temperatures

Heating systems and/or cold climate heat pumps often have a service life of several decades. In combination with the high temperatures prevailing in such systems, the long-term durability of seals poses a unique challenge. The setting behavior of seals at high temperatures throughout their service life is of particular importance in this context.

Applications in Heating Technology

Heating systems deliver comfortable warmth in winter and hot water all year long. Therefore, it practically goes without saying that robustness and long life are required and expected of them. However, heating systems entail a combination of factors that make exacting demands on seals and sealing systems.

The following generally applies to conventional heating systems to include increasingly used heat pumps as well as future systems: The high temperatures prevailing there and the resulting setting behavior or compression set (CS) of the material on the one hand and its chemical resistance on the other directly impact the service life of the seal. In the case of alternative technologies such as fuel cell heaters, which are still relatively rare at the moment, the operating conditions and therefore some of the requirements for seals differ.



Parker Prädifa offers solutions in the form of specialty compounds that master these challenges perfectly, and processes them into products featuring even highly complex geometries using state-of-the-art development and manufacturing methods.

Typical Applications in Heating Systems

- Sealing of burner doors
- O-Rings and molded parts in feeder lines
- O-Rings and molded parts in the exhaust system

High Temperatures as a Potential Risk

Naturally, high temperatures occur on many components in heating systems. The selection of a wrong sealing material that is not suitable for such temperatures may lead to seal failure. The first stage of seal failure is manifested in loss of dimensional stability and/or higher wear. This often leads to changes in the compound's hardness and may result either in hardening or softening of the material.

In addition, elastomers have a much higher thermal expansion coefficient (10 times higher on average) than metals. This means that especially seals with larger cross sections can expand so heavily that the contact pressure and thus friction exceed permissible levels.

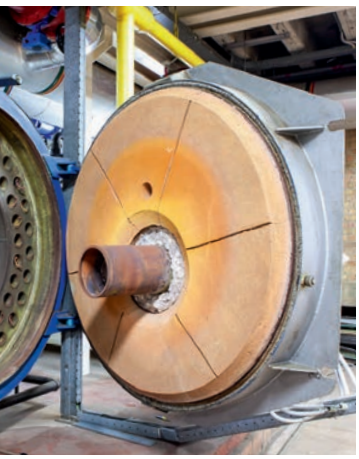
However, accelerated aging is regarded as one of the main causes of damage to seals and sealing materials. It may reduce seal life significantly and therefore cause seal failure even after a short period of time.

Chemical Resistance as a Basic Prerequisite

A conventional facility heating system uses a wide variety of media, spearheaded by the system's source of energy. In many cases, energy is supplied by hydrocarbon-based fossil fuels such as mineral oil or gas.

On the other hand, water is frequently used to transport heat to the desired places. Last but not least, modern heating systems, so-called condensing systems, due to low temperatures, generate condensates that may be highly acidic and sulfurous and chemically attack sealing compounds. An exact definition of such condensates is often difficult and, therefore, so is an exact definition of an optimally suited sealing material. These acids that may be highly aggressive can deposit in the system over time due to redrying and thus form highly concentrated acids (e.g. sulfuric acid).

In complex serial testing, Parker Prädifa has developed optimized elastomeric compounds superbly meeting this challenge.



Long-Term Setting Behavior for Long Service Life

Low compression set (CS) at potentially high temperatures across their entire service life is one of the prerequisites for seals and sealing systems in heating applications. A factor that plays only a minor or even no role at all at low temperatures becomes a challenge at high temperatures that should not be underrated.

Compression set refers to permanent deformation under certain conditions. CS tests are performed according to DIN ISO 815 or ASTM D395 Method B on test pieces and finished parts, which are compressed by 25% and stored in air at a defined temperature in a heating cabinet. Storage tests in other media are possible as well.
Generally speaking: the better the compression set, i.e., the lower the permanent deformation in percent related to the deformation of the test piece, the higher the quality.

Compression set depends on the type of elastomer, mixture composition, processing conditions, test temperature and duration, deformation in percent, thickness of the test piece, and the test medium.

Robust Sealing Materials for Heating System Applications

Good compression set, chemical resistance against condensates and water, and long service life: Parker Prädifa's special compounds combine all of these characteristics. With temperature resistance of up to 150 °C (up to 180 °C in water and steam), plus chemical resistance against organic and inorganic acids, the EPDM compounds provide a robust and long-life solution for seals in heating systems.
For higher temperature requirements (up to 200 °C), Parker Prädifa offers special FKM compounds for heating system applications featuring good compression set and outstanding acid resistance.

The Parker Prädifa EPDM and FKM compounds for heating applications feature excellent compression set and acid resistance.

Sealing Materials for Heating System Applications

Material	Polymer	Hardness [Shore A]	Temperature range [°C]	Setting behavior	Chemical resistance	Use in water
E3609	EPDM	70	-50 / +150	+	+	++
E8556	EPDM	70	-50 / +150	+	+	++
EJ820	EPDM	70	-50 / +150	+	+	++ *
E9330	EPDM	70	-50 / +150	++	+	++
V8995	FKM	70	-30 / +200	++	++	-
V8964	FKM	70	-40 / +200	++	++	+

* Suitable for drinking water applications

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Applications in Ventilation and Air Conditioning Technology

Whereas in heating technology the functions are clearly defined, i.e., heating of the surroundings and supply of hot water, the boundaries in ventilation and air conditioning technology are more varied and the functions cannot always be clearly assigned. Essentially, they encompass control of air temperature, humidity and air quality (e.g. CO_2 content) in a room in terms of required or desired parameters, plus potentially transporting fresh or treated air.

The functional range of air conditioning systems is much greater compared to heating systems. The diversity of the designs and functional principles of air conditioning systems and devices, and their applications (i.e., stationary, mobile/portable and on board of vehicles) is matched by the variety of requirements to be met by seals and sealing systems. The challenges here include both high and low temperatures, high operating pressures of up to 150 bar, and chemical resistance.

Parker Prädifa has developed specialty elastomer mixtures – CR, EPDM, NBR, HNBR and FKM compounds – optimally meeting requirements in a wide range of applications. Parker Prädifa additionally offers specialty seals for specific applications such as the "L-Seal" (a rubber-metal seal) for CO_2 applications.

Typical Applications in Air Conditioning Systems

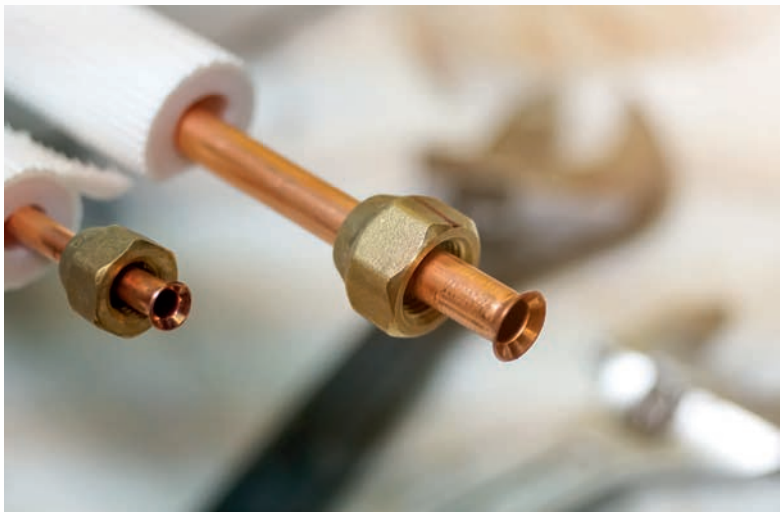
O-Rings and Molded Parts for

- Connections
- Lines
- Control and expansion valves
- Thermostats
- Chillers
- Heat exchangers

Air Conditioning Systems – One Sealing Material for Two Extremes

A defined temperature range in which the sealing material and seal have to function perfectly is the first application-specific demand to be met. A frequent requirement is very good high- and low-temperature performance, i.e., flexibility and good mechanical properties at very low and very high temperatures.

This is necessary because both extremes occur in the cooling circuit. Temperature differences of up to 140 °C (-40 °C to 100 °C) are not uncommon and dependent on the system's design, range of application, and refrigerant.



Chemical Resistance Against Refrigerants/Refrigerant Oils

Two different media can frequently be found in cooling units: the refrigerant itself and a refrigerant oil.

Refrigerants

Depending on their design and energy consumption, air conditioning systems use a wide variety of refrigerants that chemically interact with the sealing materials used in equally diverse ways. This poses special challenges such as solid-liquid extractions, where the refrigerant as a liquid extraction agent extracts substance components from the sealing compound.

Refrigerant Oils

The primary purposes served by refrigerant oils are lubrication of machine components, sealing within the compressor, and dissipation of the heat generated in the lubrication gap.

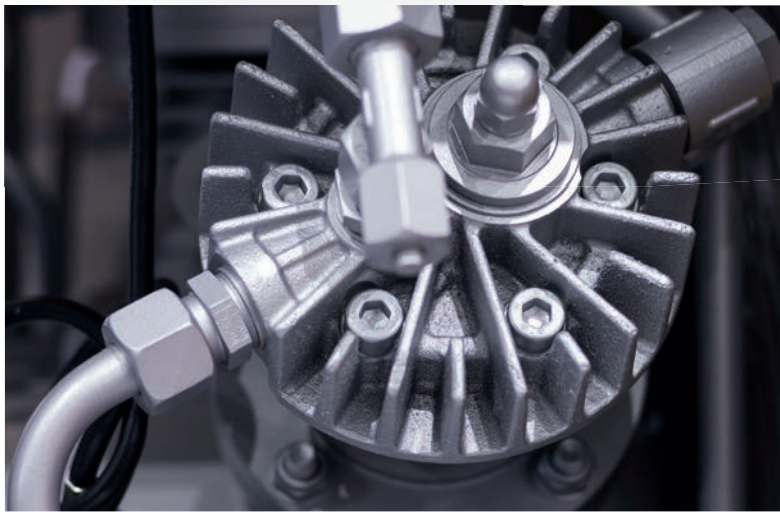
The bases on which refrigerant oils are produced vary. The most common ones are: mineral oil based, polyalphaolefins and polyglykols.

Due to this variance, it is not possible to define and use a single sealing compound for the diverse types of refrigerant oils. The various additives in the oils pose a challenge as well. Since most of them do not have to be declared it is difficult to make a preliminary assessment of the chemical resistance of a sealing material against additives in refrigerant oils.

Compression Set and Other Requirements

Due to the longevity of service life as well as simple and extended maintenance intervals that air conditioning systems require, outstanding compression set of the seals and sealing materials is imperative.

Other requirements to be met by the sealing components are high extrusion resistance, minimal gas permeability, and resistance against explosive decompression, plus the previously mentioned extraction resistance of the material against the refrigerant.



Sealing Materials for Air Conditioning Systems

Material	Polymer	Hardness [Shore A]	Temperature range [°C]	Setting behavior	Refrigerant oil resistance	Refrigerant types
C0557	CR	70	-40 / +100	-	PAG, PAO, POE	HC, HFC, HFO
E8556	EPDM	70	-50 / +150	+	PAG	HC, HFC, HFO
E8901	EPDM	75	-50 / +150	+	PAG	HC, HFC, HFO
N3831	HNBR	70	-30 / +150	+	AB, MO, PAG, PAO, POE	HC, HFC, HFO
V8703	FKM	75	-30 / +200	++	AB, MO, PAG, PAO, POE	HC
V8964	FKM	70	-40 / +200	+	AB, MO, PAG, PAO, POE	HC

Refrigerant oils
AB = Alkylbenzenes
MO = Mineral oils
PAG = Polyglykols
PAO = Polyalphaolefins
POE = Polyolester oils

Refrigerants
HC = Hydrocarbon
HFC = Fluorinated hydrocarbons
HFO = Hydrofluoroolefins

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CO_2 – The Refrigerant of the Future!?

The importance of carbon dioxide (CO_2) as a refrigerant (R744) for cooling applications keeps growing. Carbon dioxide is a natural substance that, unlike fluorinated refrigerants, is low-cost and environmentally compatible. It is colorless and, compared to conventional refrigerants, has the advantage of being neither flammable nor toxic.

The high operating pressure of the refrigerant, its low critical point[1)], formation of dry ice when temperatures drop below the triple point, and very high standstill pressure pose challenges and must be considered in the selection of the components for the cooling system.

R744 is an interesting alternative also for automotive applications because on-board air conditioning systems can be operated with this eco-friendly refrigerant. However, compared to the currently used R1234yf low-pressure refrigerant, all on-board components have to withstand high pressures of up to 135 bar.

At up to 180 °C, temperatures are in a critical range as well. In the case of soft seals, for instance, specialty elastomer compounds have to be used, with permeation behavior and resistance against explosive decompression playing an important role for impeccable sealing performance.

[1)] The critical point, Pc, for carbon dioxide occurs at a temperature of more than 30.98 °C and a pressure above 73.75 bar. If both values are exceeded, supercritical CO_2 is formed. It has strong solvent properties and can extract soluble components from the sealing compound and therefore damage the material.

Requirements for Seals

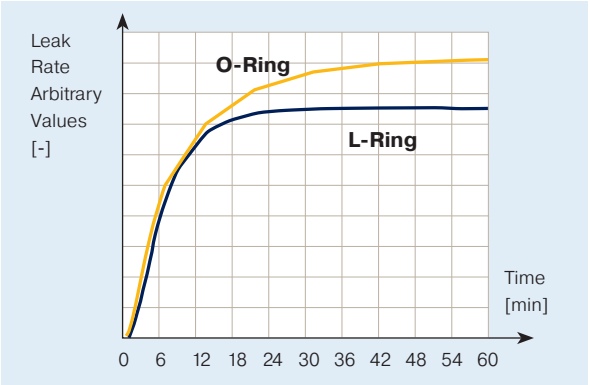
The seals used in the various air conditioning components play a significant part in complying with the specified maximum permissible leakage values. The major relevant requirements are good high- and low-temperature resistance, good media resistance, high extrusion resistance, minimal gas permeability, resistance again explosive decompression, and excellent long-term performance.

Minimizing Permeation
Permeation, i.e., the medium penetrating or migrating through the seal, has a major effect on the selection of the right material.

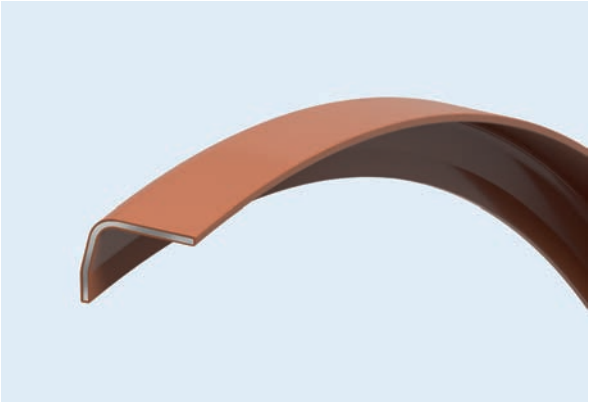
Low permeation is imperative in use with CO_2 because this medium dissolves easily in materials and therefore, by nature, can easily permeate the seal.

If no or only minimal permeation is permitted, Parker Prädifa offers rubber-metal seals such as the L-Ring and composite sealing washers using elastomers as the sealing material and metal carriers as permeation barriers for outstanding results.

The L-Ring is a rubber-coated metal seal combining the benefits of a rubber seal with those of a metal seal. The rubber coating of the L-Ring reduces the requirements for the surface quality of the groove as well as the assembly forces compared to conventional metal seals, while the actual metallic sealing element ensures low permeation. This combination of benefits resulting from the utilization of L-Ring seals enables permeation/leakage to be reduced by around 90% compared to conventional elastomeric sealing solutions.



In addition to metal and rubber-metal seals, the Prädifa Technology Division of Parker´s Engineered Materials Group has developed elastomer compounds for use in relevant applications and operating conditions. The materials already being used in CO_2 components are FKM, EPDM, HNBR and BIIR compounds for O-Rings and molded parts primarily serving as static seals.



Sealing Materials for CO_2 Applications

Material	Polymer	Hardness [Shore A]	Temperature range [°C]	Permeation	Explosive decompression	Refrigerant oil resistance
E3804	EPDM	90	-50 / +150	-	-	PAG
N8805	HNBR	90	-20 / +150	+	++	AB, MO, PAG, PAO, POE
V8771	FKM	90	-40 / +200	++	+	AB, MO, PAG, PAO, POE
V0709	FKM	90	-25 / +200	++	+	AB, MO, PAG, PAO, POE
B8885	BIIR	70	-60 / +120	++	-	PAG

Refrigerant oils
AB = Alkylbenzenes
MO = Mineral oils
PAG = Polyglykols
PAO = Polyalphaolefins
POE = Polyolester oils

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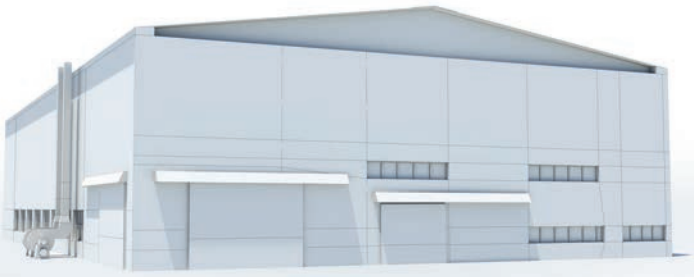
Fields of Application

Climatic Comfort Has Many Facets

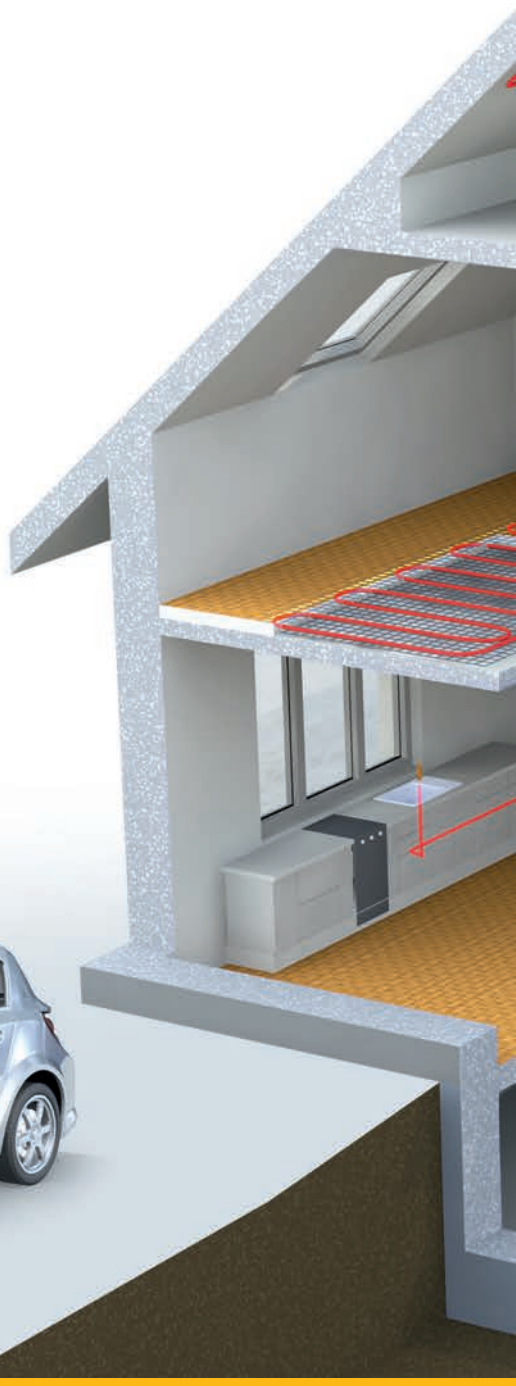


Industrial and Commercial Buildings

Working effectively is hard to imagine without heating and air conditioning systems – whether in small, medium-sized or large industrial and commercial facilities. Temperature control and fresh air supply, even in hard-to-access places, are prerequisites for climatic conditions at the workplace that employees perceive as pleasant and that exclude health risks. In these applications, which frequently operate 24/7, efficiency and reliability are imperative.

Residential Buildings

Proper temperature and ambient air control is an important factor of indoor comfort at home. Parker offers suitable sealing solutions for all challenges in the areas of heating, hot water, and air conditioning applications.



Automotive

An effective air conditioning system is expected as a standard feature of any modern automobile. Automotive air conditioning systems consist of a large number of refrigerant-carrying components such as compressors, condensers, dryers, expansion valves, evaporators and lines.

Avoidance of leakage is extremely important on all of these components for two reasons: first, an excessive escape of refrigerant from the circuit would be harmful to the environment and second, the system would no longer be functional and need to be refilled.

With both electrical powertrain components and internal combustion engines, the ideal operating temperature is playing an increasingly important role in efficient and eco-friendly operation. At the same time, customer expectations of cabin comfort have to be met. For air conditioning systems and all components of increasingly complex thermal management technologies in automobiles, Parker offers O-Rings, composite sealing washers, and other seals for reliable sealing across the vehicle's entire life.

Aviation

Air conditioning systems in aircraft are referred to as “Environmental Control Systems“ (ECS). Compared to air conditioning systems like those in buildings, an ECS controls air pressure in addition to temperature and air exchange. The seals used in aviation applications meet the most exacting demands in terms of power density in small grooves as well as maximum safety requirements.

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