Statement GEA Heating and Refrigeration Division
Use of PFAS in Heating and Refrigeration Technologies

1. Affected Component

PTFE	Shaft seals /Bushings / Seal Seats / Piston Rings / Flat Seals / Gaskets
FEPM	Seals / O-Rings
FFKM	Seals / O-Rings
AFM	Flat Seals / Gaskets

… in industrial heating and refrigeration systems and gas compression facilities.

2. Sector of the affected Component

Industrial and large-scale refrigeration:
Refrigeration for industrial processes e.g., food, beverage, pharmaceutical, chemical, ware housing, marine, as well as for climatization in larger building complexes and recreational facilities.

Industrial and large-scale heating:
Heat pumps for industrial processes e.g., food, beverage, pharmaceutical, chemical, as well as for heating of communal neighborhoods or in larger building complexes and recreational facilities.

Industrial gas compression e.g., chemical, petro-chemical industries.

3. Key Functionality of the affected Component

Static and dynamic sealings, seal seats and bushings:
Heating and refrigeration systems consist of screw or piston compressors, oil separators, various heat exchangers, vessels, valves and fittings in the complex distribution and control system, as well as electric propulsion, actuation, sensors, and electric and electronic controls. Static and dynamic sealings, seal seats and bushings play an integral role for the safety and efficiency of the equipment, as they guarantee system tightness and separation of refrigerants, lubricants, and other media at low friction. Depending on the application of the respective system, hot components on the high-pressure side of the systems can reach 120 - 160°C already today, and in our research, we are even experimenting with temperatures >200°C to make heat pumps available for certain industrial applications. On the cold side of the system, temperatures can go down below -60°C. System pressures vary between 26 bar up to 60 bar and more, which causes respective mechanical loads on sealings. Chemical resistance against refrigerants e.g., ammonia, hydrocarbons, and lubricants need to be ensured over the entire range of conditions.
Reliability and longevity of refrigeration systems and heat pumps are very important to ensure continuous supply of cold and heat in these large-scale processes at a maximum of energy efficiency. The service life of our products is typically more than 30 years and customers expect wide maintenance intervals with predictable measures, hence the availability of spare parts must be guaranteed over the entire life cycle of the products.

4. Amount of Fluoropolymers used for the affected Component

The amount of fluoropolymers and their compounds is very small compared with the total mass of heating and refrigeration systems, but still they play an integral role in the functionality. The total mass of PTFE components in our products is in the order of 1000 kg per year, the

remaining sealings containing fluoropolymers and their compounds have a total mass in the order of 100 kg year.

5. Replacing PFAS in the affected Component

Alternative materials do not exist.
5.1. Materials which may be used as alternatives:
none
5.2. Amount of material replaceable with 5.1.
none
5.3. Amount of material not being replaceable
All
5.4. Problems and Risks if Material(s) 5.1. is used:

PTFE: No alternative over the same range of applications/conditions is available. PEEK might be a candidate for some applications, but has not been validated, yet. The mechanical properties of PEEK are different from PTFE.

FEPM and FFKM: We are using these compounds only when our standard materials HNBR and CR are no longer compatible with the physical and chemical conditions in the respective applications. These applications include more extreme temperatures and increased pressures to widen the range of heat pumps and refrigeration systems to further reduce the use of fossil energy in the industries. These applications have partly been made available because of the beneficial material properties of fluoropolymers.

6. Consequences of Banning Fluoropolymers in the affected Component

A ban of PTFE would be a large throwback in the heating and refrigeration technology and would require significant re-design, validation, and certification of alternative materials, once these are available. It would also add significant costs to a variety of our products. Spare-part availability over the next decades is also important for the systems in operation already, to ensure a reliable supply of cold and heat.
A loss of high-performance sealing materials e.g., FEPM and FFKM would limit the range of applications in the heat pump business significantly. This would have an impact on the entire industry transformation away from fossil energy towards a more sustainable future using excessive heat for processes and heating. These technologies offer a great opportunity to reduce CO_2 emissions and are already factored into the assumptions and models to reduce global warming.
The before mentioned materials play an important role in GEAs Heating and Refrigeration Technologies Division with an annual revenue of 524 M€ in 2022, and approximately 1750 FTEs. Not only the future of our industry, but also our customers', is depending on a reliable and economically feasible supply of cold and heat over a broad range.

Machine/ Application	Component	Material (CAS No.)	Quantity/a	Importance of Material Choice	Emissions in different life phases	Known Alternative	Impact w/o Alternative	Impact (Cost and Time) to implement Alternative	Additional Remarks
High pressure compressor and "hot" high pressure components in the respective system	Sealings (O-rings) and shaft seals, double faced axial shaft seals	Compounds of both, FEPM (27029-05-6) and FFKM (26425-79-6)	100 kg	FEPM and FFKM offer resistance against thermal conditions in high pressure compressors, in combination with natural refrigerants e.g. NH3 or other gases. A wide temperature range is important for variable operating conditions and efficiency. FFKM also offers the required mechaical robustness in respective components (double faced axial shaft seals). All Heat Pump Applications (>52 bar with Ammonia) are equipped with FEPM seals, FFKM is used for higher temp conditions, when FEPM is no longer suited.	No emissions in our productions and in service life. At the end of life all sealings could be collected and either be recycled or disposed as required.	None; CR and HNBR or silicon based materials are not suited in the respective temperature range	Higher maintenance frequency, for some components life would decrease significantly, by factor 10 or more. Service-life significantly reduced. Potentially more severe failures. Higher operating costs, more downtime and thus interference with supply of heat, cold, or other means of the respective system. Lower efficiency and higher energy (electricity) consumption. Increased waste. Increased risks due to possible leakages.	O-ring material and sealings could be replaced after minor re-engineering, validation and process alignment within approx. 3-4 years, once alternative materials have been developed, tested and been certified. That is estimated to happen within another 5 years, with uncertainty in the results.	High temperature and high pressure applications become more common with the use of excessive industrial heat for heat pumps, also for communal heating. These new technologies are key to reduce CO2 emissions and to achieve climate targets. Investigations are taking more natural refrigerants into account.
Piston compressors and control valves in screw compressors	Bearings	Compounds of PTFE (9002-84-0)	100 kg	PTFE and PTFE compounds offer resistance against thermal conditions in high pressure systems, in combination with natural refrigerants e.g. NH3 or other gases. A wide temperature range is important for variable operating conditions and efficiency. Bearing seats and other integral mechanical 3D PTFE components in valves offer low mechanical friction and resistance but durability along with good sealing properties. System pressure and leak tightness is critical for the safety. Both properties are essential for low operating costs and high efficiency.	No emissions in our productions and in service life. At the end of life all articles could be collected and either be recycled or disposed as required.	No alternative over the same range of applications/conditions. PEEK might be a candidate for some applications, but has not been validated, yet. The mechanical properties of PEEK are different from PTFE.	Higher maintenance frequency, for some components life would decrease significantly, by factor 10 or more. Service-life significantly reduced. Potentially more severe failures. Higher operating costs, more downtime and thus interference with supply of heat, cold, or other means of the respective system. Lower efficiency and higher energy (electricity) consumption. Increased waste. Increased risks due to possible leakages.	Bearing materials could be replaced after re-engineering, validation and process alignment within approx. 3-4 years, once alternative materials have been developed, tested and been certified. That is estimated to happen within another 5 years, with uncertainty in the results and extensive field testing to ensure similar service life.	High temperature and high pressure applications become more common with the use of excessive industrial heat for heat pumps, also for communal heating. These new technologies are key to reduce CO2 emissions and to achieve climate targets. Investigations are taking more natural refrigerants into account.
"hot" high pressure components in the respective system	(reinforced) gaskets	Compounds of both, PTFE, AFM and possibly other PFAS	100 kg	PTFE compounds offer resistance against thermal conditions in high pressure systems, in combination with natural refrigerants e.g. NH3 or other gases. A wide temperature range is important for variable operating conditions and efficiency. System pressure and leak tightness is critical for the safety.	No emissions in our productions and in service life. At the end of life all articles could be collected and either be recycled or disposed as required.	None; CR and HNBR or silicon based materials are not suited in the respective temperature range	Higher maintenance frequency, for some components life would decrease significantly, by factor 10 or more. Service-life significantly reduced. Potentially more severe failures. Higher operating costs, more downtime and thus interference with supply of heat, cold, or other means of the respective system. Lower efficiency and higher energy (electricity) consumption. Increased waste. Increased risks due to possible leakages.	Gasket materials could be replaced after minor re-engineering, validation and process alignment within approx. 3 years, once alternative materials have been developed, tested and been certified. That is estimated to happen within another 5 years, with uncertainty in the results.	High temperature and high pressure applications become more common with the use of excessive industrial heat for heat pumps, also for communal heating. These new technologies are key to reduce CO2 emissions and to achieve climate targets. Investigations are taking more natural refrigerants into account.
Armatures, valves and fittings	Sealings (O-rings) and shaft seals	Compounds of FEPM and FFKM OVE and T10 coating	100 kg	FEPM and FFKM offer resistance against thermal conditions in high pressure compressors, in combination with natural refrigerants e.g. NH3 or other gases. A wide temperature range is important for variable operating conditions and reliability of armatures. These materials also offer the required mechaical robustness in respective components.	No emissions in our productions and in service life. At the end of life all sealings could be collected and either be recycled or disposed as required.	None; CR and HNBR or silicon based materials are not suited in the respective temperature range	Higher maintenance frequency, for some components life would decrease significantly, by factor 10 or more. Service-life significantly reduced. Potentially more severe failures. Higher operating costs, more downtime and thus interference with supply of heat, cold, or other means of the respective system. Lower efficiency and higher energy (electricity) consumption. Increased waste. Increased risks due to possible leakages.	O-ring material and sealings could be replaced after minor re-engineering, validation and process alignment within approx. 3-4 years, once alternative materials have been developed, tested and been certified. That is estimated to happen within another 5 years, with uncertainty in the results.	High temperature and high pressure applications become more common with the use of excessive industrial heat for heat pumps, also for communal heating. These new technologies are key to reduce CO2 emissions and to achieve climate targets. Investigations are taking more natural refrigerants into account.
Armatures, valves and fittings	Bearing seats, bushings and (reinforced) gaskets	Compounds of both, PTFE and AFM	1000 kg	PTFE and AFM compounds offer resistance against thermal conditions in high pressure systems, in combination with natural refrigerants e.g. NH3 or other gases. A wide temperature range is important for variable operating conditions and efficiency. Bearing seats and other integral mechanical 3D PTFE components in valves offer low mechanical friction and resistance but durability along with good sealing properties. System pressure and leak tightness is critical for the safety.	3D mechanical PTFE components are delivered in the respective design. In some cases minimal mechanical processing to correct dimensions. No emissions in our productions and in service life. At the end of life all components could be collected and either be recycled or disposed as required.	No alternative over the same range of applications/conditions. PEEK might be a candidate for some applications, but has not been validated, yet. The mechanical properties of PEEK are different from PTFE.	Higher maintenance frequency, for some components life would decrease significantly, by factor 10 or more. Service-life significantly reduced. Potentially more severe failures. Higher operating costs, more downtime and thus interference with supply of heat, cold, or other means of the respective system. Lower efficiency and higher energy (electricity) consumption. Increased waste. Increased risks due to possible leakages.	Bearing seats and structurual/functional components in armatures could be replaced after significant re-engineering, validation and process alignment within approx. 3-4 years, once alternative materials have been developed, tested and been certified. That is estimated to happen within another 5 years, with uncertainty in the results.	High temperature and high pressure applications become more common with the use of excessive industrial heat for heat pumps, also for communal heating. These new technologies are key to reduce CO2 emissions and to achieve climate targets. Investigations are taking more natural refrigerants into account.
Drive motors and actuators for components, e. g. valves, for all of our products	Electrical insulation and coatings of electric coils, connectors, bearings	PTFE, and others not named specifically	100 kg	Wide temperature range of operation, fire protection, electrical safety, importance for high electrical insulation, resistance against harsh environments, refrigerants, technical lubricants, and other media	No emissions in our productions and in service life. At the end of life all articles could be collected and either be recycled or disposed as required.			No information from manufacturers available, yet	Rising degree of automation and control.
Control Panels in Machinery Industries, affecting all our products.	Cables, Isolation, Connectors, Electronic components, Prited Circuit Boards, Batteries	PTFE , PVDF (24937-79-9), many others not named specifically, sources IPC, Semi, https://onlinelibrary.wiley.com/doi/10.1002/ajim.23362?af=R, etc.		Resistance against harsh environments, refrigerants, technical lubricants, and media, wide temperature range of operation, fire protection, electrical safety, mechanical intergrity and robustnes, importance for high electrical insulation to allow for high data rates, semi conductor industry. Used in fibre reinforced printed cicuit boards (PCB), liquid crystal displays, films in flat panel displays, lithium ion (and other) batteries for increased safety and capacity, as well as in fuel cells, advantages are low dielectric constant, high heat and flame resistance, as well as low variations of conductivity due to low moisture absorbance in circuit boards. Enable smaller components and final products, and enhance the installation and reliability of wires and optical and data cables.	No emissions in our productions and in service life. At the end of life all articles could be collected and either be recycled or disposed as required.			NO SUITABLE ALTERNATIVES No PFAS-free alternatives are currently available that provide adequate functional properties and performance. Requalification is an extremely complex process differing across technologies. Implies disproportionate costs and long development timeframe (approx. 15+ years). Risk of inability to produce and supply the EU with semiconductor technology.	Electronic components and conncted systems are becoming more and more important in the entire industry. Better service, reduced downtimes, safer systems and higher efficiency are just some of the advantages, so the dependence on innovative electronic products is increasing. E.g. activities by: "Industrieverband der Elektro- und Elektronikindustrie ZVEI".