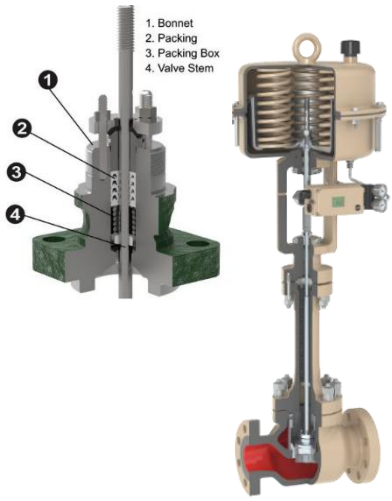
Factsheet "PFAS in PAMCo”

Process Automation, Measuring, Control

		
Fig. 1: True Air Radar Level measurement	Fig. 2: Guided Wave Radar Level Measurement	Fig. 3: Pressure sensors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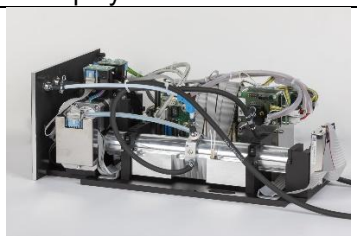
		
Fig. 34: Fidas24 in EL3000 housing - high temperature resistant sealing required, solenoid valves and PCBs included	Fig. 35: Limas21 module - different piping versions offered, pressure sensor included	Fig. 36: pressure sensor

Industry Overview and Products:

Market:
Process **A**utomation, **M**onitoring, **Co**ntrol (PAMCo) is a €194B global industry and a €56B European Industry. It consists of measurement, monitoring and control systems and associated instrumentation.[i]

Function:
Process Automation, Monitoring, Control and Drives equipment enables delivery of essential resources such as

- clean water, waste water
- other infrastructure (power and energy management, it and telecommunication, transport)
- safe food and beverage
- high quality pharmaceuticals, including vaccines and medical devices
- high quality biological pharmaceuticals
- reliable energy,
- metals and metal alloys,
- pulp and paper,
- building materials,
- mobile equipments (vehicles, mobile machines as for Construction, Agriculture, Forestry and Material Handling
- mobile devices (phone, tablet computers)
- transportation,
- recycling materials,

and essential goods such as

- electronic components,
- chemicals,
- oil & gas,
- fertilizer,
- technical gases (Oxygen, Green Hydrogen …),
- clean exhaust and combustion gases (marine sector)
- defense equipment.

Scope:

The scope of PAMCo products consists of a wide range of devices that measure parameters and that controls processes.

Scope of PAMCo Equipment in particular:

- **Sensors**
  Pressure, Flow, Level, Temperature, Force, Vibration, Inductive, Photoelectric, Capacitive, Magnetic, Valve, Cylinder sensors, Ultrasonic, Density, Viscosity, Gas and liquid process Analysis, Corrosion, Erosion & Heat Trace Monitoring, Flame & Gas Detection, Gas analyzers, Energy Monitoring, Dust, Light
- **Actors**
  Electrical Drives, pneumatic actuators, hydraulic actuators, pumps, self-operated regulators, valves
- **Encoder**
  Transformation of mechanical information into electrical information
- **Monitoring and Control**
  Basic Process control system (BPCS), Distributed Control Systems (DCS),
  Safety Control system (SCS), Plant Asset Management System (PAMS),
  Continuous emission monitoring systems (CEMS)
- **Process Infrastructure**
  Interfaces, piping, accessory as solenoid, pneumatic booster, filter-regulator and connecting systems, Electrical Power Distribution

The PAMCo devices operate as a unit and failure could be catastrophic. Any errors could create an unstable and unsafe situation that may result in severe harm to people and/or the environment. PAMCo equipment has boundless configuration flexibility to accommodate the broad processing needs of the many industries served.

The operating profile, to which PAMCo equipment is exposed, is defined by the industries that leverage the technology such as chemical processing plants, nuclear power plants, semiconductor manufacturing, mining, wastewater management, alternative fuels, oil and gas, rail and other mass transportation, and construction operations. These applications often involve exposure to multiple extreme environmental conditions simultaneously.

Market Information:

- PAMCo market:
  - Turnover: 194 Billion € worldwide / 56 Billion € Europe [1)]
  - Employees: approx. 500.000 employees
  - PFAS related: approx. 75%

The operating profile, to which PAMCo equipment is exposed, is defined by the industries that leverage the technology such as chemical processing plants, nuclear power plants, semiconductor manufacturing, mining, wastewater management, alternative fuels, oil and gas, rail and other mass transportation, and construction operations. These applications often involve exposure to multiple extreme environmental conditions simultaneously.

- PAMCo environmental conditions:
  - Hazardous environments are prevalent and include fire, explosion, and toxic chemical threats. These environments often require equipment certifications, namely ATEX Directive 2014/34 in Europe.
  - Broad chemical exposure is common due to the massive number of chemicals processed every day. These chemicals span the entire pH range and are processed at different temperatures and pressures. Example harsh chemicals include sulfuric acid, hydrofluoric acid and chlorine.
  - Low temperatures near -60°C. Beyond this for cryogenic processing, IAMC equipment can be exposed to temperatures down to -200°C.
  - High temperatures near +200°C.
  - High pressures near 150 bar to accelerate and influence reaction rates and to increase volume-time efficiencies. Pressures up to 1000 bar exist in some chemical processes.

- Key success factors of PFAS in PAMCo products:
  - Broad chemical resistance to virtually all chemicals
  - Low temperature performance down to -200°C
  - High temperature performance up to +260°C
  - Corrosion resistance
  - Intrinsic flame resistance with a high heat of combustion and limiting O2 Index
  - Good electrical properties, excellent dielectric properties, high permeability for microwaves
  - Low friction / Non-adhesive resistance
  - Purity / inert

Other polymers can demonstrate superior performance in one single property. For example, Polyetheretherkeytone (PEEK) has slightly higher temperature performance than fluoropolymers. However, fluoropolymers are the best choice when both high temperature and chemical resistance are needed simultaneously.

Requirements Profile

- (Lifetime: 15+ years
- Internal development times: 2-5 years
- PAMCo certification times: 2-4 years
- Supplier certification times: 2-4 years
- Customer certification times: 2-4 years
- Required availability time

of spare parts: 10-25 years after product termination

- Temperature resistance: -196 °C up to +260 °C
- Dielectric strength: $\varepsilon_r < 3$
- Flame retardancy: UL 94 V0/V1

- Standards, certification/approvals, market/customer requirements:
  - EU / UKCA / Ordinary Location
  - Ex-approval (with multiple country transcriptions - Europe / America / Asia / Africa / Oceania)
  - Safety Approvals
  - Ship approvals
  - Food contact materials (Europe / USA / China)
  - Hygienic approvals (Europe / USA)
  - Radio approvals (Worldwide)

The fact that PFAS are used in 100 thousand of different certified products, the ban of PFAS would cause an extreme workload on research, engineering and certification resources. Europe does not have the resources to do all the needed development projects at the same time. Therefore, designing out PFAS would require about three times longer than the mentioned numbers.

Identified PFAS Uses

In Finished Products / In Processes / In Machinery and Equipment of the Production Processes

1. Non-Contact Radar Level Measurement sensors using microwaves

PFAS substance/substance group:	**PFAS-containing material/component:**
• PTFE • PFA • PVDF • FFKM/FKM	• Microwave antenna and waveguide • Parts in contact with substances to be measured • Electroniocs Enclosures • O-Ring sealings

Reason for PFAS Use/ Requirements Profile:

- Very low dielectric constant
- Temperature resistance at high and low temperature
- Huge range of chemical resistance
- Very good water resistance, very low water absorption
- Longterm radiation resistance
- Approved flame / burn characteristics
- High UV radiation resistance
- Material strength even at very high and low temperatures
- Explosion proof standards EN60079 for Zone 0/Zone1 separation
- Less friction, low abrasion and low adhesion

2. Contact Radar Level Measurement sensors using microwaves



PFAS substance/substance group:	**PFAS-containing material/component:**
• PTFE • PFA • FFKM • FEPM	• **Parts in contact with substances to be measured** • **O-Ring sealings**

Reason for PFAS Use/ Requirements Profile:

- Very low dielectric constant
- Temperature resistance at high and low temperature
- Huge range of chemical resistance
- Very good water resistance, very low water absorption
- Longterm radiation resistance
- Approved flame / burn characteristics
- High UV radiation resistance
- Material strength even at very high and low temperatures
- Less friction, low abrasion and low adhesion

3. Pressure measurement sensors





PFAS substance/substance group:	**PFAS-containing material/component:**
• PTFE • FKM	• Seals • Pressure compensation membranes • Cables

Reason for PFAS Use/ Requirements Profile:

- Huge range of chemical resistance
- Temperature resistance at high and low temperature
- Constant dielectric properties

4. Diaphragm Seal

By using diaphragm seals, pressure measuring instruments can be adapted to even the most difficult of conditions within process industries. A diaphragm made of the appropriate material separates the medium from the measuring instrument.

Diaphragm seal

PFAS substance/substance group:	**PFAS-containing material/component:**
• PFA, PTFE	• Lining of the diaphragm seal

Reason for PFAS Use/ Requirements Profile:

- Diaphragm seals ensure reliable measurement results, e.g. when critical media are involved (acids, media with high temperatures, etc.)
- The pressure is transmitted in the diaphragm seal system and thus the medium is separated from the measuring device

Industries:

- Hygienic applications (food, pharmaceuticals, ...)
- Application according to substances (suitable for viscous substances such as oil, diesel, ...)

Effect of PFAS restriction:

- Certain substances (acids, etc.) /conditions (heat, etc.) attack the material of the measuring device
- Diaphragm seal systems that are not protected by PTFE can be a source of danger due to destruction by aggressive media
- For hydrofluoric acid, for example, no other material currently known
- Adhesions of viscous media can disturb the measurement and thus the entire process

5. Various devices

Pressure sensor

PFAS substance/substance group:	**PFAS-containing material/component:**
• FKM, FVMQ	• Sealings

Reason for PFAS Use/ Requirements Profile:

- Seals are essential for the functioning of the products, as they provide the barrier to the environment
- FKM and FVMQ are universally applicable for many different substances (Oils, lubricants, fuels, ...)
- FVMQ has unique low temperature properties

Industries:

- Hydrogen applications
- Renewable energies (wind turbines)
- Hydraulics (construction machinery, etc.)

Effect with PFAS restriction:

- No safe processes (Risk of confusion / high effort if there is a seal for each medium)
- Possible consequences: Leakage (release of oils or fuels into the environment), damage or failure of entire systems
- Extremely long development/modification time (searching for new materials, testing, approval)

6. Photoelectric sensors

PFAS substance/substance group:	**PFAS-containing material/component:**
• PTFE	• Seals • Membranes

Reason for PFAS Use/ Requirements Profile:
- chemical resistance (e.g. alcoholic and alkaline cleaning agants, oils and lubricants)

7. Flow Measurement devices

PFAS substance/substance group:	**PFAS-containing material/component:**
• PTFE • PFA • FEP • ETFE • PVDF • FKM • FFKM	• Liners • Seals • Insulations • Pressure compensating membranes • Signal processing units • Cables

Reason for PFAS Use/ Requirements Profile:
- Temperature resistance at high and low temperature
- Huge range of chemical resistance
- Approved flame / burn characteristics
- Less friction, low abrasion and low adhesion
- Purity / inert
- Mechanical strength

8. Temperature measurement
(Sensors, transmitters and accessories)

PFAS substance/substance group:	**PFAS-containing material/component:**
• FEP, FP, FT, PFA, PTFE, PVDF, FPM, FKM, FPMX, ETFE	• Protection fittings, gaskets, o-rings, cables, pipes, heat shrink sleeving

Reason for PFAS Use/ Requirements Profile:

- Combination of properties with respect to high/low temperature, aggressive media/chemicals, abrasion, diffusion, friction, swelling, tensile strength, repelling surface, electrical isolation

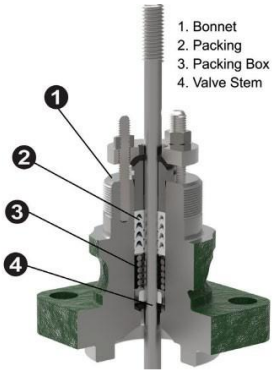
9. Process analytics
(Sensors, measuring systems, transmitters, accessories and assemblies)

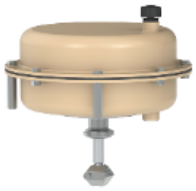
Process analytics (pH, chlorine, conductivity, disinfection, oxygen..) is absolute necessary for long-term monitoring and limit monitoring of processes with stable process conditions: • Chemical industry • Pulp & paper industry • Power plants (e.g. flue gas washers, boiler feed water) • Incineration plants Food & Beverage • - CIP/SIP applications	Water & wastewater treatment: • Drinking water • Cooling water • Well water • Wastewater treatment plant Biotech and pharma industries • Bioreactors/fermenters: process control in enzyme production • Bioreactors/fermenters: control of culture growth
PFAS substance/substance group: • PTFE, PVDF, FFKM, FKM, FPM, FEP	**PFAS-containing material/component:** • Plastic parts, gaskets, o-rings, cables for e.g. electrode isolation, process connections, diaphragms, flow-through assemblies

Reason for PFAS Use/ Requirements Profile:

- Combination of properties with respect to high/low temperature, aggressive media/chemicals, abrasion, diffusion, friction, swelling, tensile strength, repelling surface

10. Valves





PFAS substance/substance group:	**PFAS-containing material/component:**
• PTFE • PCTFE • ETFE • PVQM • FKM, FFKM	• Seal packing • Seats • Diaphragm,

Reason for PFAS Use/ Requirements Profile:
- Huge range of chemical resistance
- Temperature resistance at high and low temperature
- Long term stability
- Purity / inert
- Mechanical strength (Compressive modulus)

11. Lined Control valve

PFAS substance/substance group:	**PFAS-containing material/component:**
• PTFE, PFA	• Valve lining (and others as Fig 1)

Reason for PFAS Use/ Requirements Profile: Pharmaceutical control valve, Cleaning and inertness
- Agressive process media (e.g. Chlor)

12. Self operated pressure regulator and component

PFAS substance/substance group:	**PFAS-containing material/component:**
• PTFE, FKM, FFKM, PVQM	• Sealings (packing. O-Rings) lubricants, diaphragm, bushing

Reason for PFAS Use/ Requirements Profile:
- Chemical resistance, little friction temperature resistance, long life, good sealing, low emissions

13. Mixing or Flow dividing valve with Electric actuator for District energy

PFAS substance/substance group:	**PFAS-containing material/component:**
• PTFE/ PTFE compound	• Sealing, O-ring, bushing, gearbox

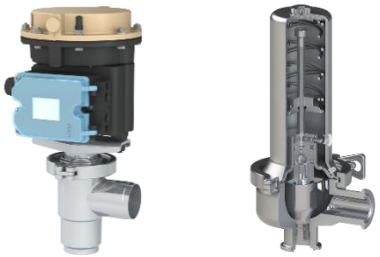
Reason for PFAS Use/ Requirements Profile:
- chemical resistance, little friction temperature resistance, long life, good sealing, low emissions

14. Self operated regulator with electric setpoint actuator for District energy

PFAS substance/substance group:	**PFAS-containing material/component:**
• PTFE/ PTFE compound	• Sealing, O-ring, bushing, gearbox

Reason for PFAS Use/ Requirements Profile:
- Chemical resistance, little friction temperature resistance, long life, good sealing, low emissions

15. Control valves for aseptic (pharma) and hygienic (food) applications



PFAS substance/substance group:	**PFAS-containing material/component:**
• PTFE	• Diaphragm, bushing,/packing

Reason for PFAS Use/ Requirements Profile:
- Inert to process media , hygienic requirements, cleaning

16. Membrane valve for aseptic and hygienic application

PFAS substance/substance group:	**PFAS-containing material/component:**
• PTFE	• Diaphragm, bushing,/packing

Reason for PFAS Use/ Requirements Profile: Agressive process media (e.g. Chlor)
- Hygienic requirements, cleaning, Inert to process media

17. Electric Accessories Positioner, solenoid valve, limit switch


PFAS substance/substance group:	PFAS-containing material/component:
• PTFE, FKM, FFKM, PVQM	• Sealings (O-Rings) lubricants, diaphragm, bushing

Reason for PFAS Use/ Requirements Profile: Agressive process media (Chlor)
- Chemical resistance, little friction, temperature resistance, long life, good sealing, low emissions

18. Pneumatic accessories: Air volume booster, Reversing amplifier, Filter regulator



PFAS substance/substance group:	PFAS-containing material/component:
• PTFE, FKM, FFKM, PVQM	• Sealings (O-Rings) lubricants, diaphragm, bushing

Reason for PFAS Use/ Requirements Profile: Agressive process media (Chlor)
- Chemical resistance, little friction, temperature resistance, long life, good sealing, low emissions

19. Continuous emission monitoring systems (CEMS)

PFAS substance/substance group:	PFAS-containing material/component:
• PTFE • FKM • FFKM • PVDF • PFA	• Gas-conducting hoses • Seals, tubes, fittings, hoses • Insulations • Membranes

Reason for PFAS Use/ Requirements Profile:
- High temperature resistance
- Huge range of chemical resistance
- Dielectric prperty at elevated temperature

20. Gas analysis systems

PFAS substance/substance group:	PFAS-containing material/component:
• FKM • FFKM • FPM • PFA • PTFE • PVDF • Fluorocarbon gas: R134a	• Seals, gaskets, fittings • Filter elements, tubings, hoses • Membranes • Insulating shells • Valves

Reason for PFAS Use/ Requirements Profile:

- Temperature resistance at high and low temperature
- Huge range of chemical resistance
- Approved flame / burn characteristics
- Purity / inert
- Mechanical strength
- Dialectric property at elevated temperature
- Non-reactive inertness
- Diffusion resistance

21. Gas sample probe / Heated & unheated probes

Gas sample probe

- The gas composition must remain unchanged.
- Product is attached to the extraction flange on the process stack.
- Materials must resist a wide range of environmental conditions from polar frost to maritime salt air or extremely high process temperatures.

PFAS substance/substance group:	PFAS-containing material/component:
• Fluoropolymers: PTFE, PVDF, FKM (Viton®), FFKM	• Tubing, seals, O-rings, valves, filter housings, mounting flanges, cables & wires, electronic components, and metal coating of housings

Reason for PFAS Use/ Requirements Profile:

- Thermal performance at high temperatures
- Pressure resistance
- Corrosion resistance
- Non-reactive inertness
- Mechanical strength & flexibility
- Diffusion resistance
- Dielectric properties

22. Gas coolers / Peltier & compressor coolers

Gas cooler

- Condensate, usually water or acids, is removed by cooling the sample gas.
- There are compressors and Peltier coolers, or a combination of both.
- The sample gas coolers can adapt to the specific process conditions.

PFAS substance/substance group:	**PFAS-containing material/component:**
• Fluoropolymers: PTFE, PVDF, FKM (Viton®), FFKM • Fluorocarbon gas: R134a	• Seals, O-rings, insulation lubricants, heat exchangers, refrigerant, connectors, tubing, valves, cables & wires, electronic components, and metal coating of housings

Reason for PFAS Use/ Requirements Profile:

- Non-flammable refrigerant
- Thermal performance at high temperatures & low tempratures
- Pressure resistance
- Corrosion resistance
- Non-reactive inertness
- Mechanical strength & flexibility
- Diffusion resistance
- Dielectric properties

23. Sample gas pumps / Membranes, bellows & peristaltic pumps

Sample gas pump

- Sample gas pumps increase or decrease the pressure of the gas sample flow to ensure the gas flow through the gas analyzer.
- Depending on the gas composition and conditions there are various designs: Full PTFE bellows pump, full PTFE diaphragm pump, electrically heated diaphragm pump, corrosion-resistant diaphragm pump.

PFAS substance/substance group:	**PFAS-containing material/component:**
• Fluoropolymers: PTFE, PVDF, FKM (Viton®), FFKM	• Seals, O-rings, insulation lubricants, heat exchangers, refrigerant, connectors, tubing, valves, cables & wires, electronic components, and metal coating of housings

Reason for PFAS Use/ Requirements Profile:

- Thermal performance at high temperatures
- Pressure resistance
- Corrosion resistance
- Non-reactive inertness
- Mechanical strength & flexibility
- Diffusion resistance
- Dielectric properties

24. Filters / Heated & unheated

Filters retain particles, dust and aerosols throughout the gas sampling and gas flow before the gas analysis.

PFAS substance/substance group:	PFAS-containing material/component:
• Fluoropolymers: PTFE, PVDF, FEP, FKM (Viton®), FFKM	• Seals, O-rings, filter elements, connectors, filter element holders, filter heads, cables & wires, motor & electronic components, metal coating of housings and lubricants.

Reason for PFAS Use/ Requirements Profile:

- Thermal performance at high temperatures
- Pressure resistance
- Corrosion resistance
- Non-reactive inertness
- Mechanical strength & flexibility
- Diffusion resistance
- Dielectric properties

25. Analyzer / Oxygen & multigas analyzers

- The analyzer is the main component of the test gas measurement technology. A' test gas' is a clean and dry gas mixture.
- The conditioned gas must meet the requirements of the complex' analyzer for a reliable measurement.
- It is possible to measure: O_2 (oxygen), CO (carbon monoxide), CO_2 (carbon dioxide), CH_4 (methane), NO (nitrogen monoxide), NO_2 (nitrogen dioxide), H_2 (hydrogen).

PFAS substance/substance group:	PFAS-containing material/component:
• Fluoropolymers: PTFE, PVDF, FKM (Viton®), FFKM	• Tubing, electronic valves, flow meters, connectors, cables & wires, electronic components, metal coating of housings

Reason for PFAS Use/ Requirements Profile:

- Thermal performance
- Corrosion resistance
- Non-reactive inertness
- Mechanical strength & flexibility
- Diffusion resistance
- Dielectric properties

26. Liquid Analyzers

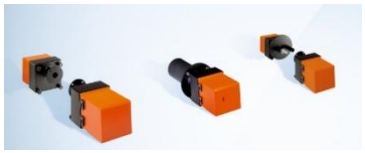
- Liquid analyzer are regulation-compliant online measurement of different parameter residues in drinking water and wastewater.
- The liquid analyzer monitors and controls:
  - Inlets of wastewater treatment plants
  - Outlets of wastewater treatment plants for documentation purposes
  - Aeration basins
  - Water treatment
  - Cleaning capacity of municipal and industrial wastewater plants
- It is possible to measure hardness, iron, TOC, COD, ammonium, aluminum, chromate, sodium, silica, orthophosphate,
  nitrite, total phosphate

PFAS substance/substance group:	**PFAS-containing material/component:**
• Fluoropolymers: PTFE, PVDF, FKM (Viton®), FFKM	• Tubing, electronic valves, flow meters, connectors, cables & wires, electronic components, metal coating of housings

Reason for PFAS Use/ Requirements Profile:

- Thermal performance
- Corrosion resistance
- Non-reactive inertness
- Mechanical strength & flexibility
- Diffusion resistance
- Dielectric properties
- Hygienic design

27. Dust measuring devices



PFAS substance/substance group:	**PFAS-containing material/component:**
• PTFE • FKM • FFKM • PVDF • PFA	• Seals • O-rings • Parts carrying sample gases (e.g. probes, hoses)

Reason for PFAS Use/ Requirements Profile:

- Chemical and temperature resistance
- Resistance to aggressive components in the sample gas

28. Encoders

PFAS substance/substance group:	**PFAS-containing material/component:**
• PTFE	• Seals • Lubricants • Gears • Circuit boards

Reason for PFAS Use/ Requirements Profile:

- Chemical resistance
- High temperature resistance

29. Sensors in harsh environments, like process with high temperatures

- Paint Draying
- Welding Process
- Lacquers process
- Wastewater Management
- Mobile Equipment (vehicles)
- Battery Draying

PFAS substance/substance group:	**PFAS-containing material/component:**
• PTFE • PFA • FKM • PFBS and its salts	• Housing • Seals (o-ring and other forms) • Cable

Reason for PFAS Use/ Requirements Profile:

- Temperature resistance at high and low temperature
- Good compression set in seals at high and low temperature
- Huge range of chemical resistance
- Mechanical, chemical resistance for cleaning process
- Less friction, low abrasion and low adhesion
- Very low μr (dielectric constant)
- Flame retardant and anti-dripping

30. Mobile Worker Equipment in Process Automation

Specifically: Mobile Communication Equipment for data, voice and video, intended for use in environments as defined in 2014/34/EU (ATEX)

- Affected Industries: Hydrogen, Food and Beverage Pharmaceutical, Chemical, Oil and Gas, Mining. Fire Fighting Operations.
- Affected Safety: Field Workers, Public Safety
- Use Case examples: Safety relevant communication, maintenance digital support, field service, manufacturing operations, incident management, public safety relevant communication

PFAS substance/substance group:	**PFAS-containing material/component:**
• PTFE • PFA • FKM • PVDF • PFBS and its salts	• Batteries • Sealings • Cables • Housing materials • Membranes covering speakers and microphones • Membrane for pressure compensation • Displays

Reason for PFAS Use/ Requirements Profile:

- Huge range of chemical resistance (at high and low temperature) since devices might be exposed to aggressive substances during usage
- Safety relevant properties as required by EU 2014/34/EU and harmonized standards
- Flame retardant and anti dripping properties of (certified) plastics
- Rechargeable Batteries: Batteries must be intrinsically safe to meet the requirements defined in the harmonized standards. Non-PFAS rechargeable batteries are not known yet.
- Displays (TFT/LCD): Non-PFAS based displays are not known yet.

31. Human Machine Interfaces in Process Automation
(intended for use in environments as defined in 2014/34/EU (ATEX))

- Affected Industries: Hydrogen, Food and Beverage, Life Science, Bio-Pharmaceutical, Pharmaceutical, Chemical, Oil and Gas, Mining.
- Affected Safety: Field Workers, Public Safety
- Use Case examples: Interaction with local control plant system, safety relevant communication, maintenance, field service, manufacturing operations, incident management, public safety relevant communication

PFAS substance/substance group:	**PFAS-containing material/component:**
• PTFE • PFA • FKM • PVDF • PFBS and ist salts	• Display - LCD • Keyboard, Mouse • Sealings • Cables • Housing materials • Membrane for pressure compensation and humidity control

Reason for PFAS Use/ Requirements Profile:

- Huge range of chemical resistance (at high and low temperature) since devices might be exposed to aggressive substances during usage
- Biological inactivity and inertia
- Safety relevant properties as required by EU 2014/34/EU and harmonized standards
- Flame retardant and anti dripping properties of (certified) plastics
- Displays (TFT/LCD): Non-PFAS based displays are not known yet.
- BIOS CMOS Batteries: Batteries must be intrinsically safe to meet the requirements defined in the harmonized standards. Non-PFAS BIOS CMOS batteries are not known yet
- Mechanical, chemical biological resistance for cleaning process

32. Field Junction Boxes and Control Cabinets in Process Automation
(intended for use in environments as defined in 2014/34/EU (ATEX))

- Affected Industries: Hydrogen, Food and Beverage, Life Science, Bio-Pharmaceutical, Pharmaceutical, Chemical, Oil and Gas, Mining.
- Affected Safety: Field Workers, Public Safety and Explosion Protection
  Use Case examples: Mounting of electrical equipment in explosion hazardous areas, Power supply control, Plant safety

PFAS substance/substance group:	**PFAS-containing material/component:**
• PTFE • PFA • FKM • PVDF • PFBS and ist salts	• Sealings • Cables • Housing materials • Membrane for pressure compensation and humidity control

Reason for PFAS Use/ Requirements Profile:

- Huge range of chemical resistance (at high (+70°C) and low temperature (-40°C)) since devices might be exposed to aggressive substances during usage
- Safety relevant properties as required by EU 2014/34/EU and harmonized standards
- Flame retardant and anti dripping properties of (certified) plastics
- Displays (TFT/LCD): Non-PFAS based displays are not known yet.
- Mechanical, chemical resistance for cleaning process

33. Purge Enclosure in Process Automation (intended for use in environments as defined in 2014/34/EU (ATEX)

- Affected Industries: Hydrogen, Pharmaceutical, Chemical, Oil and Gas, Mining.
- Affected Safety: Field Workers, Public Safety and Explosion Protection
- Use Case examples: Power Applications, Variable Frequency Drives, Gas analyzers, HMIs, plant control, Electrical safety appliances, Motors, Environmental protection

PFAS substance/substance group:	**PFAS-containing material/component:**
• PTFE • PFA • FKM • PVDF • PFBS and ist salts	• Sealings • Cables • Housing Materials • Membrane for pressure compensation and humidity control

Reason for PFAS Use/ Requirements Profile: Agressive process media (Chlor)

- Huge range of chemical resistance (at high (+70°C) and low temperature (-40°C)) since devices might be exposed to aggressive substances during usage
- Safety relevant properties as required by EU 2014/34/EU and harmonized standards
- Flame retardant and anti dripping properties of (certified) plastics
- Displays (TFT/LCD): Non-PFAS based displays are not known yet.
- Mechanical, chemical resistance for cleaning processMechanical, chemical resistance for cleaning process

34. Inductive sensors for welding applications

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PFAS substance/substance group:	**PFAS-containing material/component:**
• PTFE	• Coating of housing

Reason for PFAS Use/ Requirements Profile:

- chemical resistance
- high temperature resistance
- non-stick properties

35. Capacitive sensors for applications within explosive atmospheres

PFAS substance/substance group:	**PFAS-containing material/component:**
• Fluorpolymers	• seals

Reason for PFAS Use/ Requirements Profile:

- chemical resistance
- high temperature resistance
- reliability

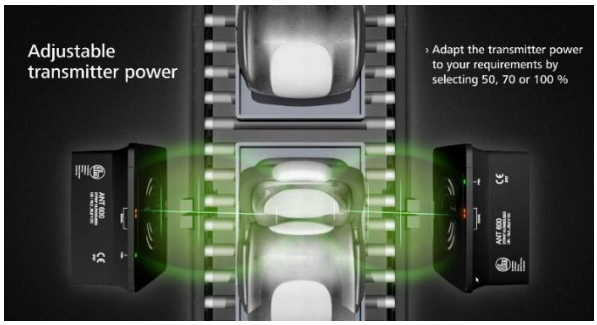
36. 2D- / 3D-Vision sensors / Cameras

example of Application (milking robot)

PFAS substance/substance group:	**PFAS-containing material/component:**
• PTFE • FKM	• Housing • Seals (O-Ring and other forms) • Pressure equalization element

Reason for PFAS Use/ Requirements Profile:
- Chemical resistance
- High temperature resistance
- Hygienic aspects

37. RFID devices



example of Application (factory)

PFAS substance/substance group:	**PFAS-containing material/component:**
• PTFE	• Pressure equalization element

Reason for PFAS Use/ Requirements Profile:
- Dirt and water repellent housing ventilation

Substitution

Non-fluoropolymer alternative materials do not exist today for specific PAMCo applications due to the harsh operating conditions in which the materials are required to operate. While finding suitable alternatives is extremely challenging, evaluating them is straightforward because the material limits of basic properties are often exceeded. In many cases, one just needs to look up materials property data in standard references to determine suitability. In our search for alternatives, other fluoropolymers often show up as the best secondary and tertiary choices. For example, PCTFE is a good back-up material for PTFE and vice versa.

Multiple classes of materials were considered as potential alternatives for fluoropolymers with none emerging as a direct replacement. These materials were identified and evaluated using a combination of available data, publications and thorough discussions with material experts and experts consulted from the broader materials industry.

Metals

Corrosion resistant metals such as stainless steel (SS), titanium, Hastelloy, nickel, copper, and brass were explored as alternatives to fluoropolymer liners and considered unacceptable because of significant incompatibility with some chemicals and lack of purity in certain applications. PTFE is commonly used to coat metals such as 316L SS to protect the surface from corrosion in harsh chemicals. A study by Waseem Akram4 compared corrosion rates for 316L and PTFE-coated 316L SS in two acidic mediums, hydrochloric acid (HCl) and nitric acid (HNO_3). Results are provided in Table below and show a significant corrosion performance increase (less Mils Per Year) by adding the protective layer of PTFE.[ii]

Acids	Corrosion Rate: Mils Per Year (MPY)	
	Bare 316L SS	**316L w/PTFE Coating**
HCl	29.6	0.7
HNO_3	684.8	4.9

Table: Increase of Corrosion Performance by adding PTFE as a protective layer, study by Waseem Akram[iii]

All potential alternatives, metals, non-PFAS polymers, and non-PFAS elastomers, are high performance materials that will likely be persistent similar to fluoropolymers, resulting in substitution of one persistent material with an inferior performing one, leading to increased maintenance cycles and generation of higher amounts of environmental waste.

The following paragraphs provide a non-exhaustive collection of studies on the potential substitution of PFAS in the PAMCo sector:

The THINKTANK study[iv]

The study, published in early 2024, involved five companies from the fields of optical equipment technology, the automotive industry, medical technology and pharmaceuticals. The requirements and PFAS technology functionalities used in these sectors are similar to those in the field of process automation and measurement technology.

For the study, a proprietary AI system was trained using approximately 2,000 samples from the specialist literature. Subsequently, over 35,000 published articles from around the world were analysed and evaluated using the AI system, focusing on the six key PFAS technology functionalities.

This identified 420 substances with the potential to replace poly- and perfluorinated alkyl substances (PFAS) in various industrial applications. These substances were carefully analysed and categorised into 32 material groups to better understand their diversity and scope of application. Material-specific functional profiles were created, and the application-specific substitution potential of the identified substances was comprehensively assessed by the participating company experts.

The materials identified in the study can be divided into five classes:

- Polymer-based materials
- Ceramic materials
- Metallic materials
- Biomaterials
- Nanomaterials

The experts and companies involved in the study came to the following conclusion:

- the properties of the PFAS used to date are unique. They are used where their properties (usually a combination of them) are required.
- only 2 to 3 of the identified materials have the potential to replace PFAS in the future. However, no substitute that could be used immediately or in the near future could be found
- However, the 2 to 3 identified materials are all currently at the R&D stage. They still require extensive research and development work, which is likely to take significantly longer than 13.5 years
- The results of the study may, however, provide new starting points for the outstanding research and development work on PFAS substitutes
- A direct PFAS substitution does not appear possible at present

LUT University, Master's Thesis – "Material selection for non-contacting RADAR process seal antenna"[v]

The aim of this Master's thesis was to conduct a systematic material selection process with the objective of identifying PFAS-free materials for free-radiating radar level sensors.

The Master's thesis concluded that the PTFE currently in use possesses an exceptionally good and unique set of material properties that are extremely difficult to replace. The thesis proposes PEEK and PPS as possible PFAS-free alternatives. However, PTFE still outperforms the proposed alternative substitutes for this specific application.

Fraunhofer IFAM Bremen – Research into PTFE replacement materials[vi]

The research investigated specific PP, PE, PEI, PEEK and PMP grades with additives to improve thermal and chemical resistance as well as dielectric properties.

The research concluded that new (composite) materials must be developed in order to meet the properties required for certain groups of applications.

IKV Aachen – Research into PTFE replacement materials[vi]
In this research, the properties of PTFE were prioritised and compared with potential substitutes. The highest priority was given to the dielectric properties (i), followed by temperature resistance (ii) and chemical resistance (iii).

The research came to the following conclusion:

- no substitute combines all the properties of PTFE
- PE, PB and PP combine the dielectric properties and chemical resistance of PTFE
- PPS, PEI and PAI combine the temperature resistance and chemical resistance of PTFE

To completely replace PTFE, new (composite) materials must be developed.

KIMW Lüdenscheid – Research into PTFE substitute materials[vi]

This research was limited to semi-crystalline and unfilled polymers. In addition to dielectric properties, temperature resistance and chemical resistance, injection mouldability was also considered.

The research came to the following conclusion:

- PP, PE-H, PE-LD, LCP and PEEK are only suitable as substitutes for PTFE up to a temperature of <200°C
- PPS, PBT, PA66, PESU and EP (Type 871) are not suitable for HF applications due to their dielectric loss factor

Fraunhofer IWM – Replacement of polymeric PFAS in industrial applications with extreme environmental conditions[vii]

This study investigated PFAS-free substitutes in various applications for seals and lubricants.

The study came to the following conclusion:

- PFAS-free alternatives have a significantly shorter service life, limit the range of applications and increase maintenance requirements, depending on the specific use.
- Finding PFAS-free 1:1 substitutes is considered highly unlikely.
- Extensive R&D efforts are necessary to develop PFAS-free 1:1 substitutes

BMBF collaborative project: Research into PFAS-free radar sensors (EPFASRad)[vi]

The project, supported by the Federal Ministry of Education and Research, investigates potential PFAS-free alternative materials for radar applications. It was launched on 1 May 2025 and will run until 31 December 2027.

The participating organisations are:

- Wefapress Beck + Co.
- SKZ – KFE gGmbH
- Brandenburg University of Technology Cottbus-Senftenberg
- Fraunhofer Institute for Reliability and Microintegration
- VEGA Grieshaber KG (associate member)

Results are not yet available.

Safe Use: Prevention and Reduction of Emissions and Exposure

Precise PAMCo fluoropolymer emissions are more difficult to assess because they take place at the end of a 15+ year life. Both the benefits and impacts must be considered. On the positive side, fluoropolymer valve packing prevents emissions to the environment due to increased seal efficiency over competing materials. On the negative side, negligible and non-toxic emissions may be released over the entire life cycle of the fluoropolymer product. Despite the relatively small emissions in the PAMCo sector, there are further mitigating factors that tend to reduce the concern about emissions even more. The useful lives of PAMCo equipment and components are very long, often greater than 15 years. This is in contrast to single use and/or limited lifetime consumer products that reach their end-of-life stage more quickly. Moreover, due to the closed-loop and sealed structure of PAMCo equipment, the risk of environmental or human exposure is very limited during the use phase. Even equipment operators are unlikely to come in contact with the fluoropolymers in the system, as the fluoropolymers are utilized in discrete, solid plastic parts that are embedded or lined inside the components of the final end-products.

Concerns related to PFAS emissions during the manufacturing of fluoropolymers are expected to be addressed and should be manageable in a reasonable and defined timeframe, per feedback received in a recent inquiry. Implementation of various abatement technologies/emission control methods to reduce the environmental footprint are necessary and we intend to continue maintaining a responsible supply chain.

Another option for estimating PAMCo emissions is to leverage the similarities to the Petroleum and Mining use sector and assign values that are on the same order of magnitude.

Socio-economic Impact

Consequences of the Proposed Restriction

Exclusion of PAMCo as a use sector and implementation of an all-PFAS ban will have significant socioeconomic implications on the European economy. Industrial automation alone represents about 3-5% of major infrastructure capital; additional to this impact it needs to be noted that the number of essential products and services coming out of those facilities is orders of magnitude larger. If the REACH PFAS restriction proposal is enacted as written today, PAMCo equipment will be eliminated for all use sectors except for the 14 defined in the restriction proposal, which will result in devastating cuts and a direct reduction to the European economy based on elimination of most of the chemical processing industry alone.

Furthermore, through the possible elimination of PAMCo and fluoropolymers, the EU could fall behind other countries on technology competitiveness, especially in the area of chemical processing. Potential outcomes include reduction in manufacturing operations resulting in higher imports for everything from food to

pharmaceuticals. The materials used in PAMCo equipment are also used in the production of water and carbon sequestration equipment all of which are vital for long term sustainability success. Moreover, material limitations will continue to narrow the scope of technology-related activities that can be accomplished including those critical to Europe's future, namely alternative energy, transportation, and battery manufacturing. Materials are critical enablers of these technologies, and a derogation of fluoropolymers will enable Europe to maintain a level playing field, increasing the probability of achieving a successful outcome.

Number of Companies Affected by a PFAS Ban
All companies who manufacture PAMCo equipment will be affected by the restriction. We estimate this number to be around 2000 for Europe. Additionally, 100,000+ global customers will be affected given the large installed base and not viable replacement options.

Required Transition Period and/or Derogations

Fluoropolymers are clearly differentiated from other substances in this very broad group of PFAS chemicals. There is strong evidence that suggests that these materials will not give rise to situations of concern for human health or the environment, acknowledging as well that industry continues to make significant progress to limit the use of PFAS polymerization aids and to introduce adequate abatement techniques to keep emissions of potentially harmful fluorinated by-products under adequate control.

Fluoropolymers are known for providing many beneficial properties simultaneously (combined in single products) that allow the continued development of applications critical to society, not only related to technological progress, but specifically in terms of safety to the population and development of green energy alternatives.

In conclusion, we recommend incorporation of PAMCo as a new use sector and exclusion or at least a 12-year derogation for fluoropolymers for use in PAMCo equipment as part of the upcoming REACH PFAS restriction. This position is consistent with our continued commitment to preserving environmental sustainability and human health and as an advocate of restricting the use of harmful substances. We are also committed to compliance with all relevant environmental laws and regulations in the countries in which PAMCo equipment will operate.

We therefore request a two-fold derogation, as follows:

1. Incorporation of PAMCo equipment as a missing use,
2. Spare parts and refurbished products must in principle be exempted from the restriction. The repair-as-produced principle must be applied to the placing on the market of spare parts, wear parts and used parts. Especially in process industry 30 years use time is typical and therefore spareparts in approved/certified equipment must be available.
3. Fluoropolymers should
   - ➔ be excluded from the restriction scope
     or
   - ➔ should have a 12-year derogation for use in PAMCo equipment with review option for extension if no suitable substitutes are found

Our sector offers:

PAMCo equipment can be disassembled and separated at the end-of-life for processing or re-use in a circularity methodology. The fate of fluoropolymers at the end-of-life in this business sector is controllable and can be any one or more of the following:

Recovery and Recycling
Fluoropolymers can be chemically returned back to their building blocks for reconstruction without damage to their properties. Melt-processable fluoropolymers, which excludes PTFE, can be recycled through traditional mechanical methodologies. The challenge for non-melt processable fluoropolymers like PTFE is identifying ways to return materials to a facility that can perform chemical recycling. This is a difficult problem, but not insurmountable.

Incineration
There are available studies that strongly suggest that PTFE, the most stable fluoropolymer, undergoes complete thermal decomposition at a temperature of about 800°C and is safe for incineration at municipal incineration

facilities5. Therefore, it is assumed that most other fluoropolymers also thermally decompose within similar parameters and are also safe for incineration at most typical municipality incineration facilities.

Landfills
Fluoropolymers are inherently safe, non-mobile, non-bio accumulative and non-toxic.
Waste is chemically inert and therefore, fluoropolymers disposed in landfills do not pose any substantive threat to human health and the environment.

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