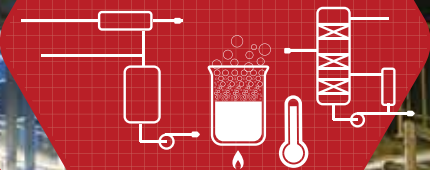


ACID RECOVERY

**DISTILLATION
& EVAPORATION**



$$Q = UA\Delta T$$
$$P_a = p^\circ x_a$$

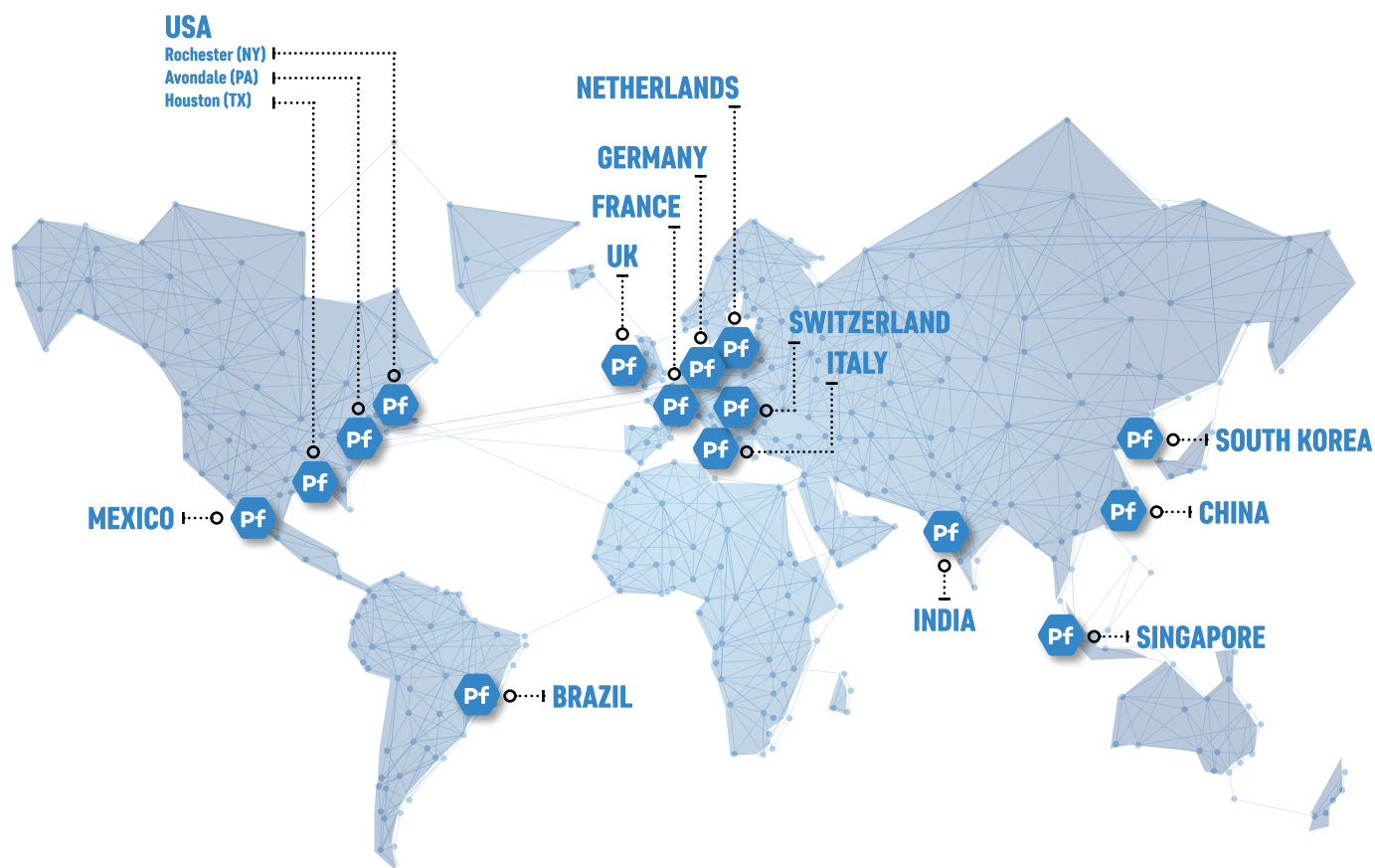
**PROCESS
ENGINEERING**

Pf
Pfaudler

Defining the standard

Worldwide Presence

One single source responsibility with access to all Pfaudler Technologies, Systems, Services worldwide



Pfaudler is a global Group offering a wide range of **corrosion-resistant technologies, systems and related services** for the **chemical, pharmaceutical and food industries**.

Edlon, Interseal, Mavag, Normag and Pfaudler are our Branded Product Lines. These product lines are specialized and perfectly integrated to **meet the most complex Client needs**. We are in the position to offer a **complete turn-key package** for each of the critical aspects of chemical and pharmaceutical processing.

Technologies and process systems of our Group are installed in more than 100 countries and across six continents.

Unique expertise and skills, **manufacturing capability**, targeted investments in strategic markets, innovation and competitiveness allow the Pfaudler group to be a landmark in the industry.

Around the world our Customers rely on the quality and performance of our supply to obtain efficient, reliable, profitable and safe chemical process systems.

Our network organization is designed to:

- strengthen our local presence alongside Customers and markets;
- accelerate decision-making processes through a less-centralized management;
- improve Pfaudler's ability to attract new talent at the local level.

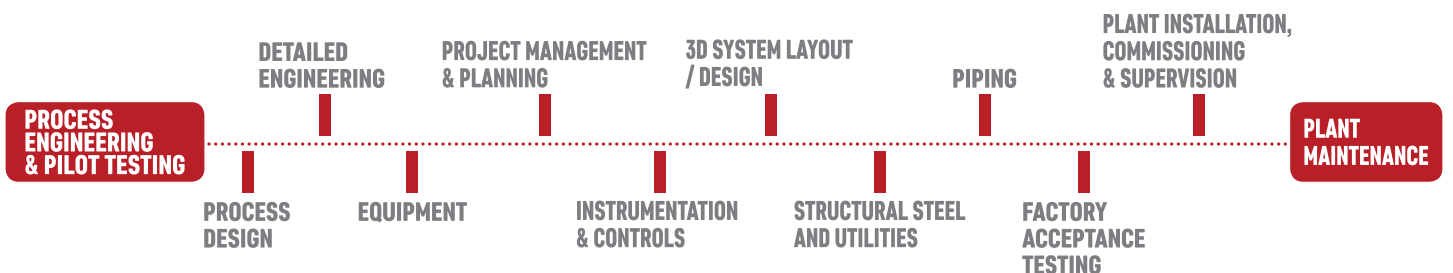
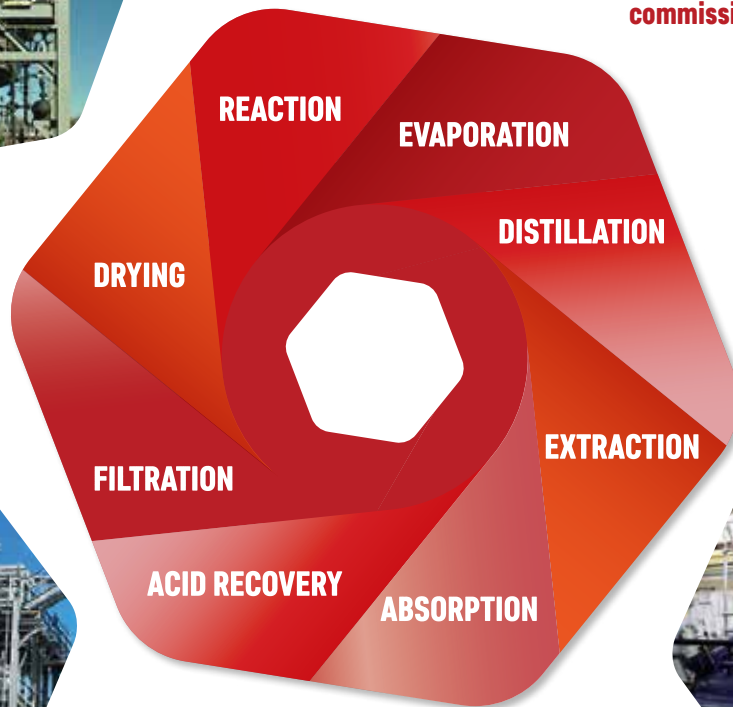
Design Process Technology

Pfaudler capabilities are not limited to the individual technologies themselves. We can combine technologies and services into complete and efficiently **operating process systems.**

Our expertise allows us to design process technology to solve complex requirements. Our focus is to provide our Customers innovative solutions and comprehensive service offerings around the world.



Complete process systems including all engineering, design, equipment, piping, instrumentation, controls, commissioning.





Meet your
Sustainability goals
with our Acid Recovery
processes

Recycle

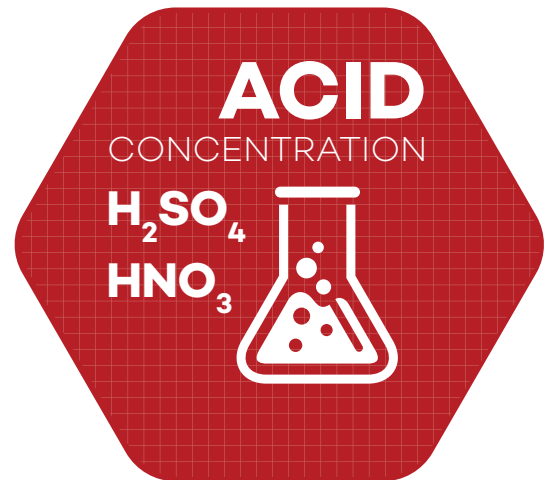
Concentrate

Reuse

Reduce
Waste

Acid Recovery

The Chemical industry produces thousands of tons of diluted inorganic waste acids containing inorganic and organic impurities. These acid waste streams are often neutralized prior to transfer to wastewater treatment facilities. However, rising operating costs in difficult economic times create the need to recover the acid for further use. Stricter environmental regulations globally also mandate recovery of acid rather than waste treatment.

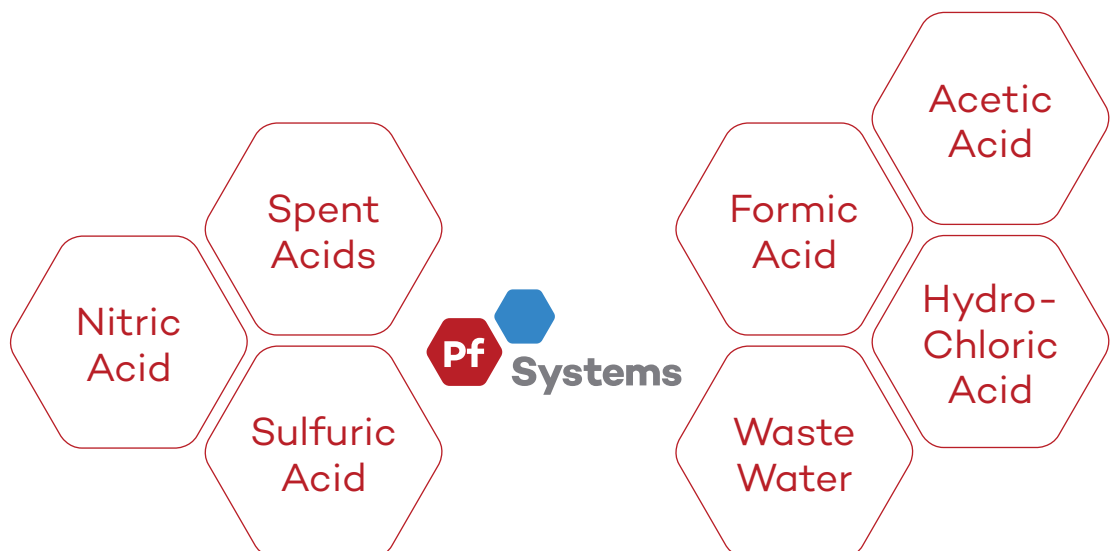


Pfudler's Acid recovery capabilities

We offers Acid Concentration plants with process technology and a complete range of Engineering services provided by **Pfudler Systems Group**, active in the field of acid treatment and all related services for decades. Our highly experienced team of Process Developers, Project Managers and Experts from all related disciplines evaluate the most appropriate process technology for the given application. The offered plant is based on the latest state of technical knowledge and all plant units are optimized with respect to investment costs and operability of the plant. The scope of supply is proven to be suitable in regards to safety and operability.

As Acid is highly corrosive ranging from low to high concentrations, Pfudler offers corrosion-resistant materials such as glass-lined steel (**Glasteel®**), fluoropolymer-lined steel and reactive metals (Zirconium and Tantalum) technologies that help in the safe containment and processing for acid recovery.

Our capabilities expand across the globe, designing and engineering plants for the following Acid recovery processes:



Our Acid Concentration System Features

Extensive experience in corrosion resistant equipment and system design.

- invented glass-lined steel in 1884
- first to fabricate with Zirconium in 1938 and Tantalum in 1946
- pioneered use of fluoropolymers for process systems in 1964

Heat recovery systems integrated into design for substantial operational cost savings.

- Gravity flow integrated into design to minimize rotating equipment, operating costs, and maintenance costs and to increase system on-line time.
- Efficient designs allow for compact system designs which provide capital cost savings, reduce required plant space and minimize operational acid volumes to maximize protection of personnel, property and the environment.

Multiple system designs including forced circulation, thermosiphon and multi-effect for energy conservation.

Laboratory test facility allows for proof of concept/performance, optimization of design and data collection for commercial scale system design.

Emission control systems provided as an option to control organics, NO_x and emissions when plant pollution control systems do not exist or are not designed for the additional load.

Utility systems designed and provided for plants where existing utilities are insufficient to service the Acid Concentration System

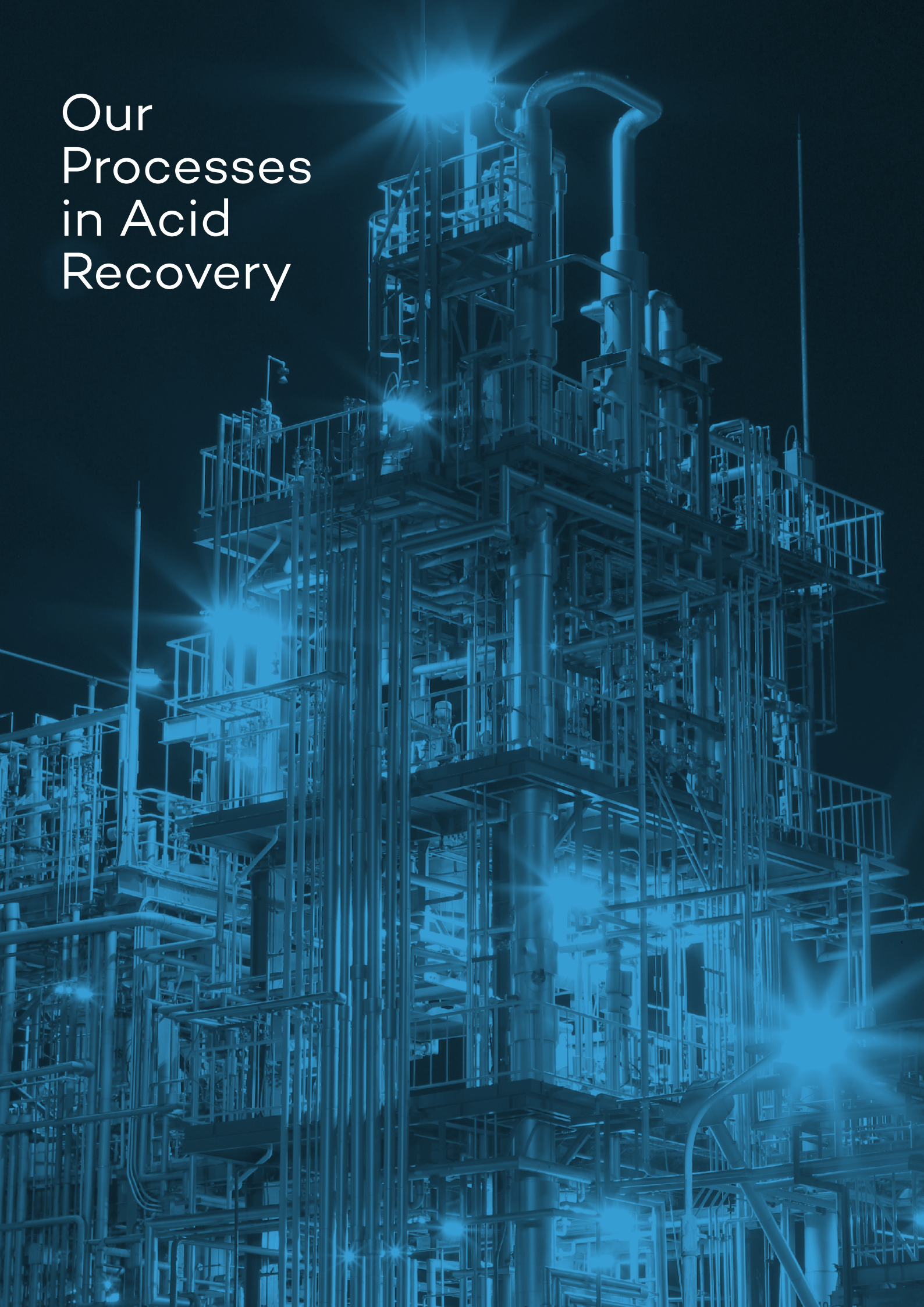
Control systems are included to provide for safe, reliable operation.

Single-source responsibility:

- process design
- engineering design
- construction
- performance guarantee
- installation supervision
- maintenance services
- spare/replacement parts

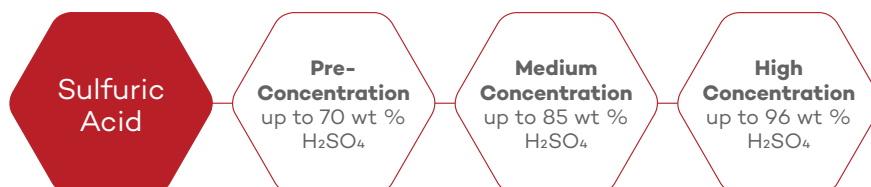


Our Processes in Acid Recovery



Sulfuric Acid Recovery

Concentration of Sulfuric Acid can be divided into 3 different fields of process technology. The differences are the potential operating conditions, the necessity of a water vapor purification and the applicable materials of construction (MoC).



Pre-Concentration of Sulfuric Acid up to 70 wt% H₂SO₄ – PoSA

The PoSA process can be operated under vacuum or atmospheric conditions. Even at atmosphere the boiling temperature of Sulfuric Acid of 70 wt% H₂SO₄ is about 166°C.

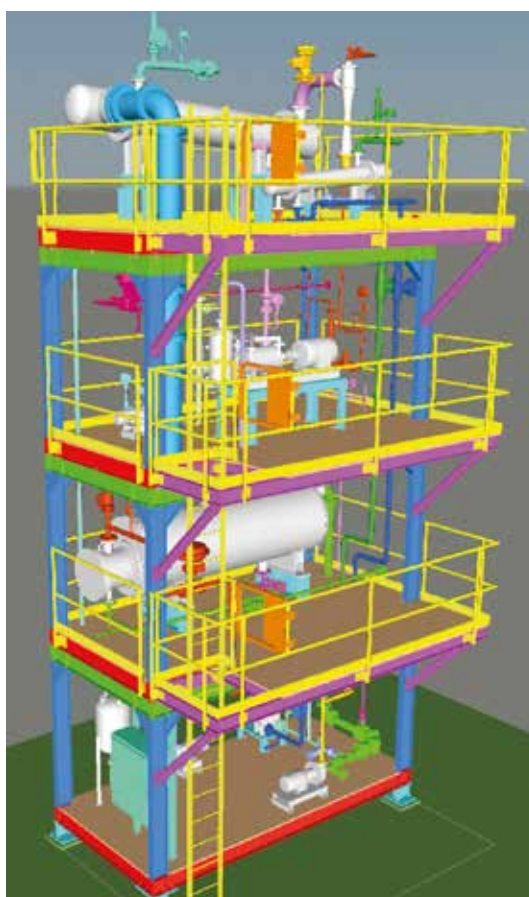
This allows the use of “normal” steam for evaporation. Also heaters, evaporators and piping can be made out of high-alloys or lined FRP. Due to the vapor pressure of H₂SO₄ an additional vapor treatment is normally not necessary.

Medium-Concentration of Sulfuric Acid up to 85 wt% H₂SO₄ – MoSA

The concentration of Sulfuric Acid up to 85 wt% can be operated under vacuum or atmospheric conditions, depending on available heating media and necessary treatment steps. No additional water vapour might be needed, as the vapour pressure of H₂SO₄ is in the range of 1 wt%. Due to the strong corrosive behaviour of Sulfuric Acid at the elevated temperature and concentration level, corrosion resistant materials like glass, glass-lined steel and Tantalum have to be used. The final selection of process conditions is made in accordance with the client's site conditions and requirements for product quality and effluents.

High-Concentration of Sulfuric Acid up to 96 wt% H₂SO₄ – HoSA[®]

For concentrating Sulfuric Acid up to 96 wt% either high temperature or high vacuum condition is required. High vacuum process allows the use of high-pressure steam and a Tantalum heater, however, a vacuum of about 10 to 20 mbar has to be maintained and the use of chilled water is mandatory for reaching a final concentration above 93 wt% H₂SO₄. Also the lifetime of the materials is limited at these concentrations and operating conditions. The high-temperature process based on the Pfadler HTX (High Temperature Heat-Exchanger) allows the use of a moderate vacuum of about 80 to 100 mbar, most often the same vacuum if the overall process consists of several concentration steps. This allows the use of standard cooling water but makes



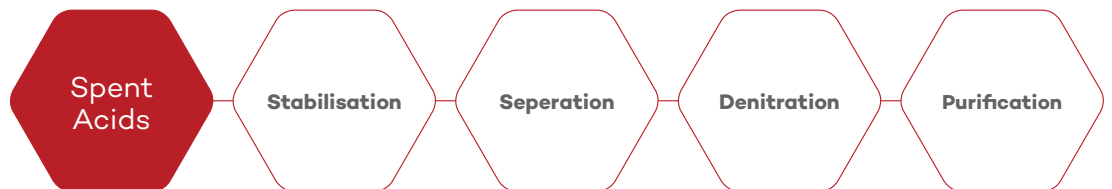
Thermal oil as heating media necessary. In combination with an oxidative agent, very pure product qualities can be achieved. Pfaudler can offer the most suitable process, depending on the available

utilities or the requested purity of the end product.

Spent Acids Recovery

Spent Acid, which is normally a mixture of Sulfuric Acid, Nitric Acid, water and the related organic compound is generated mainly by nitration processes. This Spent Acid, depending on the production process needs several treatment steps:

- Stabilisation, to secure safe storage and destroy unstable organic components.
- Separation of Nitric Acid and Sulfuric Acid.
- Denitration of the Sulfuric Acid.
- Purification, which is a thermo-chemical pre-treatment under atmospheric conditions.



Nitric Acid High Concentration - HoN

To break the azeotropic point for achieving concentrations up to 99 wt% Nitric Acid (HNO₃), an extractive rectification is necessary. Pfaudler offers two different processes for carrying out the rectification.

- Sulfuric Acid (H₂SO₄) route. (HoN-SA[®] – process).
- Magnesium Nitrate (Mg(NO₃)₂) route. (HoN-MA[®] – process).

Within both the processes, the extractive agent is re-concentrated and fed back to the HNO₃ concentration column. This allows a closed loop without consumption of the agent. In both process technologies, an additional off-gas treatment is a part of the overall process design which helps in achieving a yield of more than 99.5% Nitric Acid.



Acid Recovery and Concentration for other Acids

Pfaunder also offers acid recovery and concentration plants for the following acids:

Hydro-Chloric Acid

Purification

Pre-Concentration
upto 21 wt% HCl

Medium Concentration
upto 35 wt% HCl

High Concentration
upto 100 wt% pure HCl gas

Formic Acid

Pre-Concentration
upto 60 wt% FA

Medium Concentration
upto 85 wt% FA

High Concentration
upto 98-100 wt% FA

Acetic Acid

Medium Concentration
upto 60 wt% AA

High Concentration
upto 98-100 wt% AA

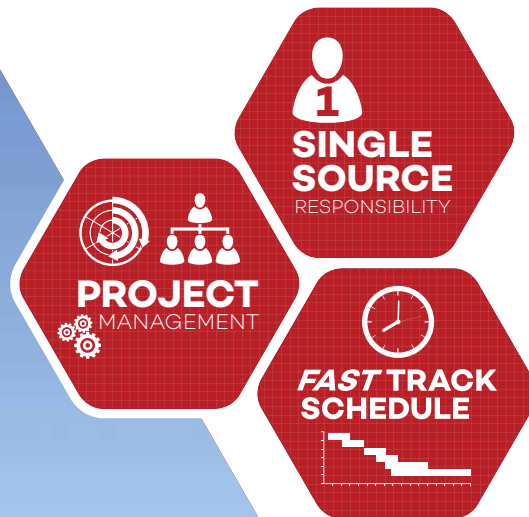
Waste Water

Recovery
of acidic waste water

Extraction
of organic compounds

Complete Process System Design

- Design Basis
- Process IP
- P&IDs / PFDs
- Equipment Specifications/Design
- Equipment Fabrication
- Instrument Specifications/Design
- PLC or DCS Systems
- Piping Specifications
- Corrosion Resistant
- Materials Selection
- System Layout
- Structural Steel Design
- Piping Drawings
- Bills of Materials
- Procurement
- Construction
- Commissioning
- Documentation
- Installation Instructions
- Operating Instructions
- Maintenance Instructions
- Performance Guarantee
- Installation
- Maintenance/Service
- Spare/Replacement parts



Complete Process System Design

Pfaunder's **Engineered Systems Group** designs, fabricates and commissions complete process systems with Pfaunder's Acid Concentration Technology at the core.

These complete systems include the acid concentrator/evaporator plus all ancillary equipment, instrumentation and piping completely assembled on structural steel modules or field fabricated.

Each system is designed specifically for our clients' process. The layout is custom designed to ensure proper system functionality and to ensure all equipment, instruments and valves are arranged for ease of operation and maintenance.

This **single source responsibility** ensures the design of every component is integrated into a complete system design to ensure proper system performance.

Our **modular design** provides:

- Reduced costs
- Shorter schedule
- High quality construction





PILOT

TESTING

CAPACITY



YIELD



PURITY



SCALABILITY



**ANALYTICAL
DATA**

Pilot Testing

Before chemical production begins, or construction starts, and before engineers design the facility, an optimal chemical process must be developed, and proven. At Pfaudler's world-class Process Test Facility, our experienced chemical process engineers develop & optimize your process, and collect the data required to design your commercial-scale facility.

Typical purposes for testing at Pfaudler's Process Test Facility include new process development, yield and purity improvement, process optimization for cost-reduction and increased profit, and VOC reduction to meet environmental regulations.

Pfaudler's Process Test Facility, can be configured for a variety of evaporation operations. Multiple utility systems provide a wide range of operating conditions, including: a high-capacity multi-stage vacuum system, for vacuum down to less than 0.01 millibar, hot thermal oil up to 345°C, steam to 180°C and water systems from -12° to 140°C.

Our Process Test Facility is designed to process flammable and corrosive chemicals, in volumes ranging from lab samples, to IBC (Intermediate Bulk Containers) tank quantities.

Pilot testing concludes with a comprehensive report that includes the scope, objectives, and sample analytical results, accompanied by conclusions, and recommendations.

Our Global Contacts

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A worker in a cleanroom, wearing a blue protective suit, hairnet, and mask, is operating a control panel on a large industrial machine. The machine is made of stainless steel and has various pipes and components. The background shows a clean, industrial environment with other machinery and pipes.

A reliable partner to improve plant performance

With extensive experience in the **chemical, pharmaceutical & food** industries and a wide range of **corrosion resistant technologies, systems and services**, Pfaudler supports customers around the globe for their needs.

pfaudler.com

Pfaudler 
Defining the standard

