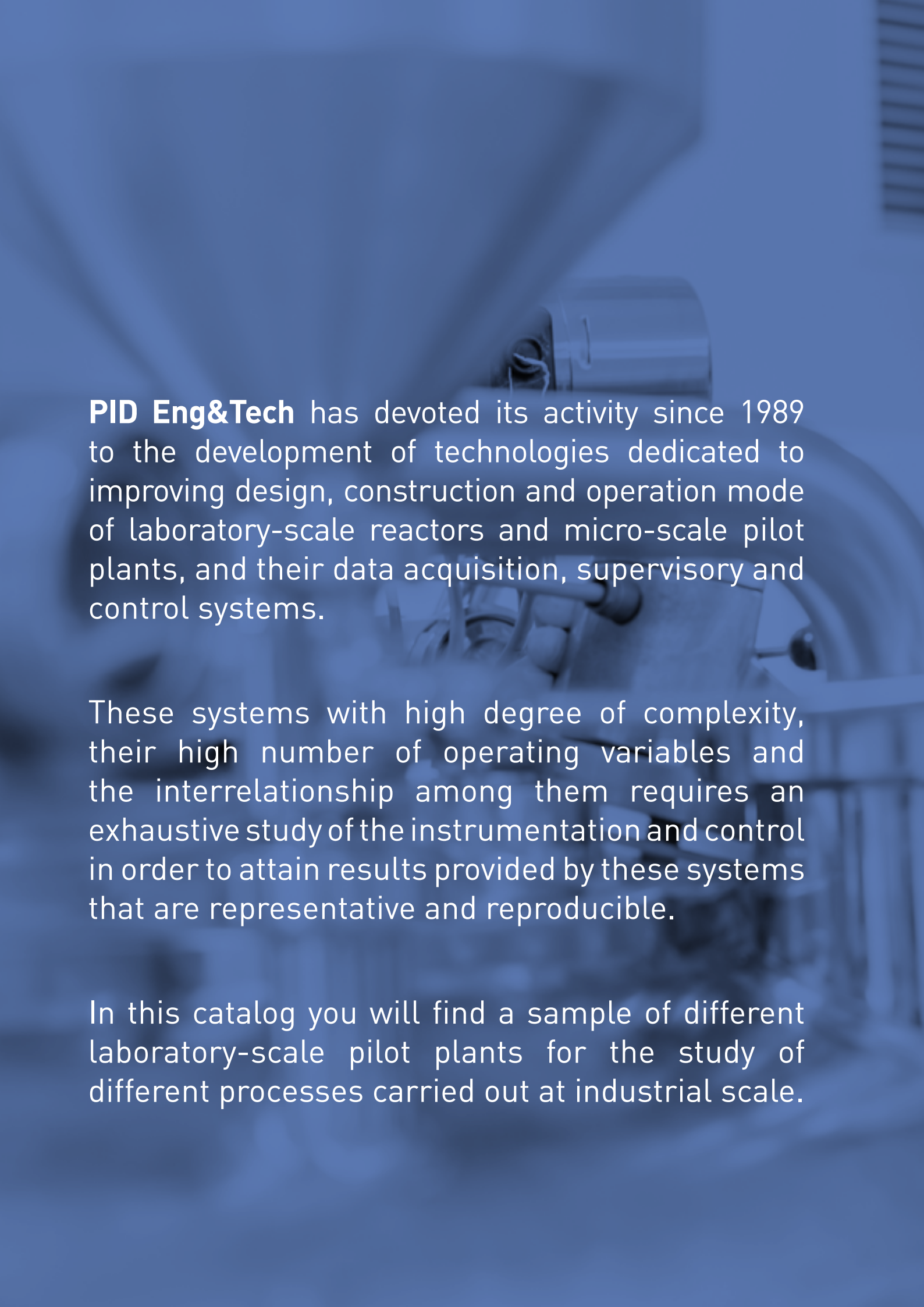


**SPECIALISTS IN
DESIGNING AND BUILDING
CUSTOM MADE
PILOT PLANTS
AND LABORATORY REACTORS**



a **mi** micromeritics® company



PID Eng&Tech has devoted its activity since 1989 to the development of technologies dedicated to improving design, construction and operation mode of laboratory-scale reactors and micro-scale pilot plants, and their data acquisition, supervisory and control systems.

These systems with high degree of complexity, their high number of operating variables and the interrelationship among them requires an exhaustive study of the instrumentation and control in order to attain results provided by these systems that are representative and reproducible.

In this catalog you will find a sample of different laboratory-scale pilot plants for the study of different processes carried out at industrial scale.

FOUR RUNS MICROACTIVITY TEST UNIT MAT ASTM D3907

MAIN FEATURES

The Four Runs Microactivity Test Unit MAT ASTM D3907 is a fully automatic, controlled and computerized laboratory reactor for the analysis of Fluid Catalytic Cracking (FCC), using as feedstock petroleum oils or renewable sources such as bio-oil

- ▶ Allows studying the catalyst activity and selectivity based on the ASTM D3907 method
- ▶ Performs continuous and automatic control of up to four independent, programmed and consecutives FCC tests
- ▶ Versatile operation modes
 - Fixed and normalized conditions based on the ASTM D3907
 - Conditions determined by the operator for each independent run and independent step during the experiment
 - ✓ Catalyst/oil ratio
 - ✓ Gas flow rate
 - ✓ Injection flow rate
 - ✓ Injection time
 - ✓ Temperatures
- ▶ Quasi-zero dead volume using a perfectly engineered reactor size, precise pipe lengths and distances
- ▶ The standard unit can be adapted to meet specific requirements with extra-equipment (mass flow controllers, simultaneous dosing pumps, special materials of construction...)

With an excellent reaction temperature control and making use of a precise syringe pump for gasoil feeding, even for a very short reaction time, this unit carries out reaction and regeneration in-situ and consecutives stages, including coke quantification. The four liquid products obtained are collected in a cooled receiver until the end of the experiments while gases can be analyzed online in a gas chromatograph



PYROLYSIS / GASIFICATION

Due to the renewed interest in innovative ways to convert the existing fuel reserves with improved technologies such as gasification and pyrolysis, PID Eng&Tech has worked in collaboration with important researchers in the field of biofuels in order to develop the most versatile pilot plant existing in the market nowadays. Its versatility and complete automatization, allows determining optimal experimental conditions and detecting possible operational problems in industrial gasification or pyrolysis reactors



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MAIN FEATURES

Feeding system

Continuous and non-fluctuation system for feeding solids (0.5 – 2.0 kg/h) in constant and reproducible manner

Gasifying agent inlets

Gases streams (air, O₂, steam, N₂...) are preheated up to 400 °C. Complete facility for steam generation is included

Fluidized bed reactor

The reactor is divided into the reactor zone and freeboard zone

Homogeneous operating temperature up to 650 – 850 °C for pyrolysis and gasification, respectively. Radiant furnace (up to 1000 °C) with three heating zones to improve temperature profile

Provision for fluidization velocity determination

Cyclones and filter

Two heated cyclones connected in series and a high temperature filter to remove solid particles from gas stream, reducing ash content in the final product

Condensation train

A system of SS316 shell-tube exchanger, several vessels and coalescence filters allow cooling the hot gases and obtaining tar and bio-oil in efficient manner

Under request, temperature controlled implementation to obtain fractionated bio-oil

OPTIONAL EQUIPMENT

Additional hopper

Solid refill without affecting the operating pressure of the plant to increase the experiment time



Additional liquid feeding system

High precision pump (up to 25 mL/min) for liquid feeding. Heat traced lines or cooling provision depending on the properties of the liquid

Tar collection with baths as normative

Modular sampling train based on cool traps where the tar (high molecular weight organic compounds) is collected with the help of solvents

Electrostatic precipitator

Recommended for pyrolysis, the electrostatic precipitator has been designed for fogging oil separation: it enables to collect liquid particles that cannot be obtained by condensation

Automatic gas sampling system

μ GC is integrated into the plant allowing online gas sample analysis and mass balance calculations

Scrubber

For retention of contaminants before venting the product gas stream

Gas meter totalizer

For measurement of the gas quantity that has been produced. It includes temperature and pressure correction

Burner

For combustion of remaining contaminants of the product gas stream

Gas recycle / compression system

Outlet gas stream can be fed again into the pilot plant at atmospheric pressure through thermal mass flow controller or it can be compressed to be fed into other equipment

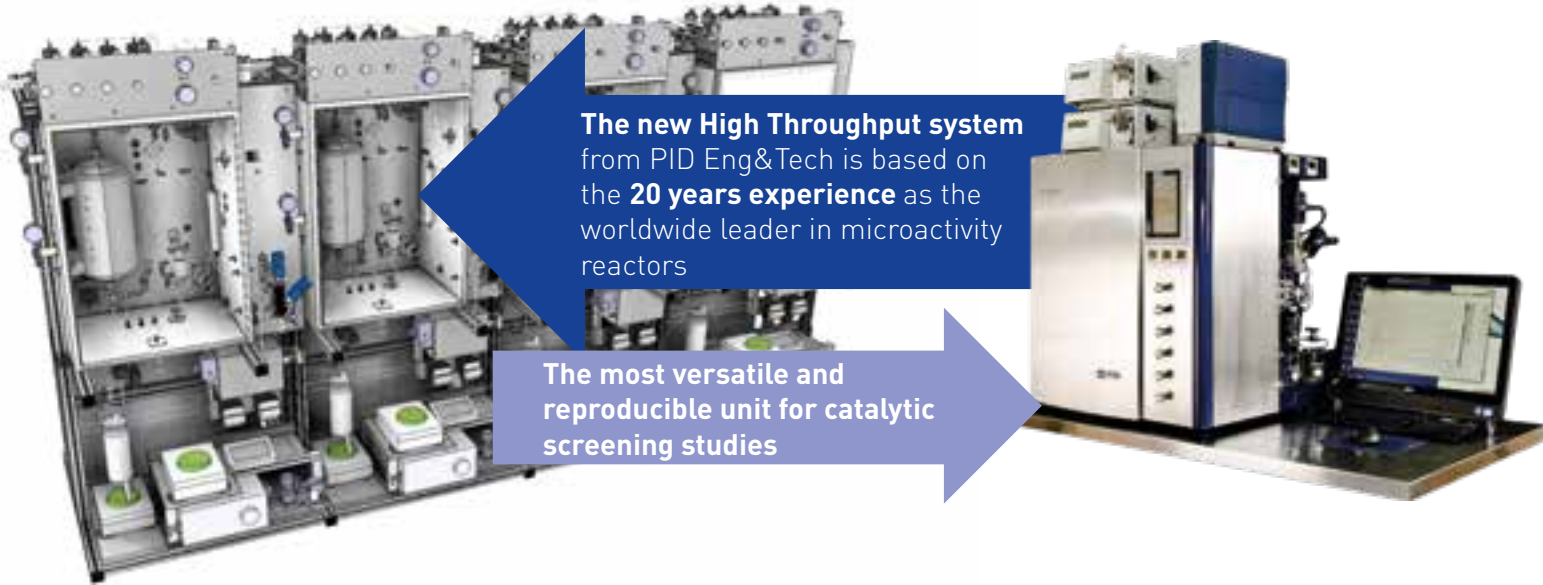
MICRO GASIFICATION & MICRO PYROLYSIS PILOT PLANT

Smaller scale pilot plant to carry out both gasification and pyrolysis processes, employing the same technology as applied for Pyrolysis and Gasification Pilot Plant, for solid flow rates from 20 to 200 g/h, depending on the characteristics of the raw material





HIGH THROUGHPUT MULTIREACTOR SYSTEM (4x / 8x / 16x)



The new High Throughput system from PID Eng&Tech is based on the **20 years experience** as the worldwide leader in microactivity reactors

The most versatile and reproducible unit for catalytic screening studies

4x / 8x / 16x modular reactor

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Completely independent parallel reactor system

- Independent gas and liquid feed
- Independent reactor temperature
- Independent pressure control
- Independent L/L/G separation system
- Independent liquid weighing balance

- Independent liquid multisampler
- Programmable multi-sampler (8 ports)
- 2 GC connected for online analysis (in 16x version)
- Several multi-way valves for automatic sampling
- 1 GC-MS for 150 liquid samples



MULTIPURPOSE SYSTEM WITH MULTIREACTOR UNITS

The Multipurpose System with Multireactor Units is a high throughput catalyst screening pilot plant based on four equal and independent modules which consist of three fixed bed reactors. The system is designed to carry out different catalytic studies such as hydroprocessing or hydrocracking at high pressure and high temperature during long reaction periods. Other configurations and specific process can be studied

MAIN FEATURES

Versatility

Each multireactor module is designed to be operated with high versatility and flexibility, under different operating modes:

- SERIAL. The reactors of the module can be operated in serial mode
- INDIVIDUAL. Each reactor can be operated individually. Simultaneous operation of all reactors of the module under request

Feeding system

- LIQUIDS. Each module includes precise dosing system to feed different liquids (including liquids from naphtha to vacuum gas oil) at suitable temperature and high pressure
- GASES. Several gas inlets per module for feeding high pressure hydrogen and nitrogen at high and low pressure or other gases as per process requirements

Reactors

Several fixed bed reactors (Hastelloy, 180 bar @ 450 °C, 400 ml catalyst volume) heated by suitable furnace (700 mm isothermal zone) with three heating zones. Other features under request

Product separation

One product section per reactor module including:

- High pressure separator with level control
- Low pressure separator with level control
- Automatic gas sampling
- Product vessel
- Scrubber for product gases cleaning
- Burner for remaining gas contaminants

Analysis system

- Possibility of gas chromatography analysis with data integration in the control software of the unit and online calculation of conversion and selectivity
- Online mass balance (weigh scales and gas flow meters are included)



STIRRED TANK REACTORS

This computerized and automatic pilot plant is based on a stirred tank reactor for operation in continuous, batch or semi-batch mode. The plant is high pressure certified according to current regulations and customer can design his own pilot plant by using as many options as required.

MAIN FEATURES

Gases

Up to six continuous gas feed lines to reactor as standard

Flow control system by thermal mass flow controllers (Bronkhorst High-Tech)

Gas line preheating system including temperature control loop can be installed

Liquids

Up to two liquid feed lines can be installed as standard

Pumps can be selected for micro-flow or standard process pumps for different pressures and flows

Liquid lines preheating/evaporating systems can be selected

Inertized vessels, heat tracing systems and other usual features can be installed

Phase separator at high pressure

A L1/L2/G patented separator system with very low dead volume, allows L/G separation even when water and hydrocarbons are obtained simultaneously at reactor outlet. Level control system includes liquid control valve for each liquid outlet

Two models (L/G or L1/L2/G) can be selected by the user

Stirred tank reactor

A stirred tank reactor (made of SS316, Hastelloy C, glass...) with magnetic coupling agitator

Standard volume from 25 to 4000 mL

Maximum pressure: up to 400 bar. Maximum temperature: up to 510 °C, depending on the reactor model

Different types of catalytic baskets as an option

All safety or operational devices such as pressure gauge, rupture disk, safety valve, vent valves or sample valves can be chosen

Temperature control system for reactor, by electrical furnace or fluid through heat jacketed reactor. Cooling coil is also available. Reaction temperature is measured inside the reactor

Wax collector at high pressure

Temperature controlled wax separator system for Fischer-Tropsch reactions (GTL)

Optional switching valve to avoid plugging at the liquid outlet filter and heating traced lines to prevent condensation

Pressure control system

Pressure control system for the reactor is based on the patented PID Eng&Tech microregulation servocontrolled valve. If fractionation is needed, two different pressure controllers can be selected for the reactor and separators



POLYMERIZATION

The Polymerization Pilot Plant, developed by PID Eng&Tech, is designed for continuous production at microscale. PID Eng&Tech in co-operation with important research and technology centers in different collaboration projects has developed a pilot plant to produce polyolefins. The plant consists of two continuous stirred-tank reactors that operate in series and it also includes a pre-treating raw material area. PID Eng&Tech computerized process control system allows direct control of temperature, level, pressure and gas composition in the reactors. Micro-Pilot Plant is fully automatized and all of the process parameters, such as gas and liquid flows, operating pressure and temperature, residence time per reactor, etc., can be selected by the user, or modified within a wide range



MAIN FEATURES

Feed and conditioning of gas and liquid feed stocks

- Up to five independent gas lines for both monomer and co-monomer feeding into each reactor and a nitrogen line for inertization purposes
- Two solvent lines. A common stream is divided in two, feeding the solvent into each reactor at real time
- A catalyst line for catalyst addition in slurry phase into the first reactor
- A co-catalyst line for its addition in a homogeneous solution into the first reactor

Reactors and flashes

- The plant consists of three SS316 stirred tanks with high pressure closure system
- Each one is provided with a magnetically coupled stirred head, a heating jacket, a cooling coil, valves and accessories
- In addition to temperature and pressure control, monomers composition ratios are measured continuously, near-real time.
- In this way, the integrated control pressure/ relation loop allows the user to work maintaining simultaneously a stable desired pressure and a stable desired monomers ratios during the reaction time

SUPERCRITICAL FLUID EXTRACTION (SFE)

A supercritical fluid (CO₂ as standard) is fed as a solvent to separate a component (extract) from a solid or liquid sample, with the advantage of the behaviour of supercritical fluids: it is simultaneously as a gas (high diffusion through sample) and a liquid (high solvating power). PID Eng&Tech supercritical extraction pilot plant is a modular and computerized unit built with SS 316L materials and high pressure specifications from Autoclave Engineers, Gyrolok, Swagelok, Classic Filters and others.

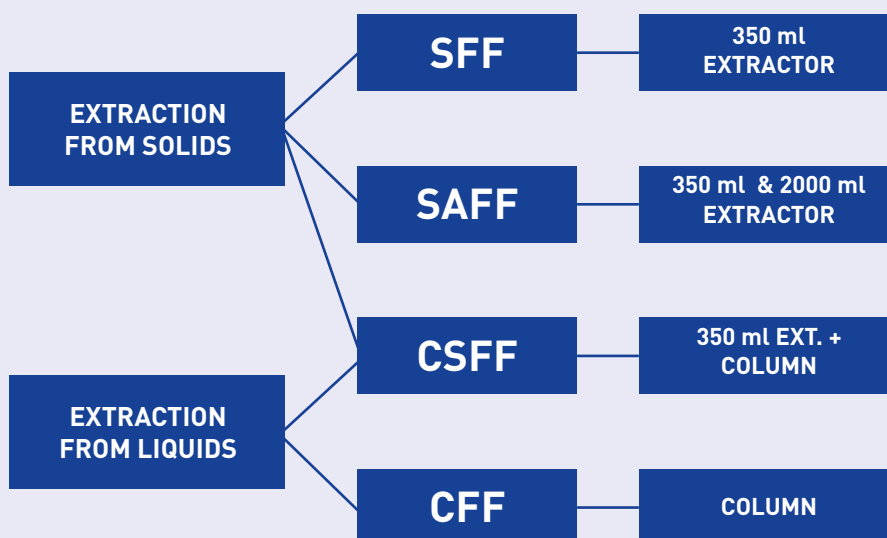
Advantages

- Safe
- "Green"
- Mild conditions
- Recyclable
- No residue
- Inexpensive
- No surface tension



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FOUR TYPES OF SFE PLANTS



SEPARATION COLUMNS

Distillation column

Distillation is one of the most studied basic operations in Chemical Engineering, both at educational level and research centers to optimize new or conventional process with promising chemicals. PID Eng&Tech can design and commissioning distillation columns according to customer requirements

- Tailored to specific requirements of each process
- Packed column
- Operation in continuous or batch mode
- Stainless steel as standard material of construction
- Controlled by PLC and touch screen



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Liquid- liquid extraction column

Liquid-liquid extraction is a well-known basic operation used to separate a component from a liquid mixture employing a solvent with high chemical affinity for this component. Apart from supercritical extraction pilot plants, PID Eng&Tech designs and supplies extraction columns to efficiently integrate the unit into a main process

- Magnetic agitation system to avoid leaks when high pressure is involved
- High surface contact
- Sight ports at different column heights to visualize the separation process
- Level control system (total and interface level)
- Jacketed column with temperature control for high temperature applications

WATER TREATMENT PILOT PLANT



▶ Membrane Bioreactor

The Membrane Bioreactor (MBR) has been specifically designed to carry out waste water treatment studies under controlled conditions. Its compact and modular design makes the MBR an easy operable lab scale unit for biological water treatment

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- Continuous operation for several months (until membrane saturation)
- Continuous waste water with suspended solids influent, treated water (permeate) withdrawal
- Gas recycle with compressor and sparge tube
- Possibility of chemical cleaning step implementation without dismantling
- Built in poly methyl methacrylate (PMMA) as standard
- Easily detachable
- Inerting system
- Lighting system over sliding rails for optimal distance selection for photocatalytic process
- Temperature, pressure, level, pH and conductivity measurement
- Several sampling points
- A membrane as standard, with the possibility of multiple membranes in parallel configuration
- Atmospheric pressure
- Ambient temperature as standard, possibility of temperature control under request

▶ Supercritical Water Oxidation Pilot Plant

The Supercritical Water Oxidation (SCWO) is one of the most promising technologies to convert waste water to innocuous product. PID Eng&Tech SCWO Pilot Plant is a modular flexible unit which allows the researches to explore different possibilities with the aim of applying their findings in a larger scale equipment or industry

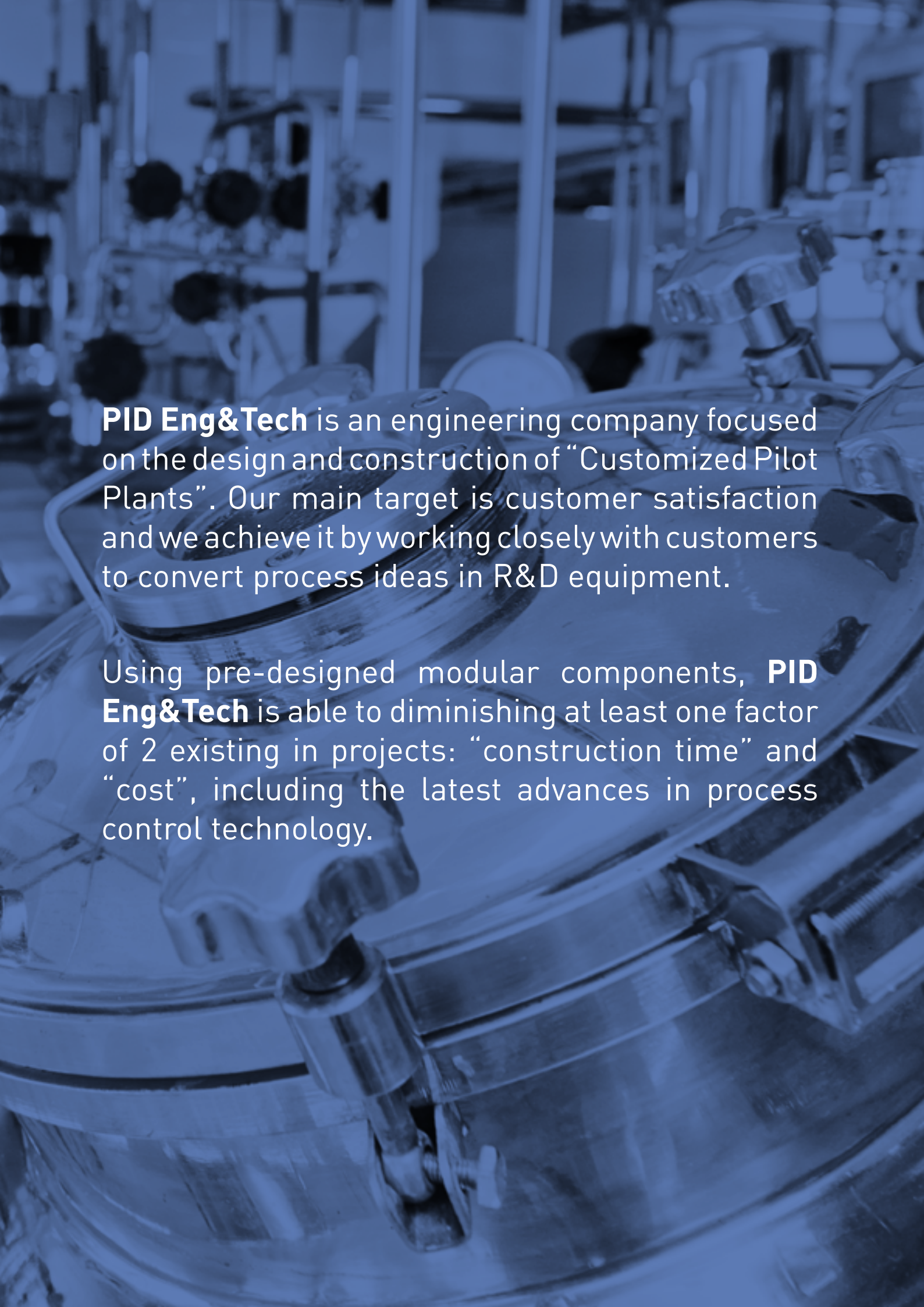
- High pressure (up to 250 barg as standard)
- High temperature (up to 400 °C as standard)
- Waste water flow rate of 15 L/h as standard
- Resistant materials for the operating conditions
- Designed for continuous operation
- Compressor system for oxygen

▶ Desalination Pilot Plant

Each PID Eng&Tech Desalination Pilot Plant is designed according to specific requirements of each research group, employing the accumulated knowledge during years of experience

- High capacity tanks (100 – 200 L) for brine water and treated water storage with heated elements and temperature control if required
- Corrosive and temperature resistant materials (PVC, PP, PVDF, PPH...)





PID Eng&Tech is an engineering company focused on the design and construction of “Customized Pilot Plants”. Our main target is customer satisfaction and we achieve it by working closely with customers to convert process ideas in R&D equipment.

Using pre-designed modular components, **PID Eng&Tech** is able to diminishing at least one factor of 2 existing in projects: “construction time” and “cost”, including the latest advances in process control technology.

CUSTOM MADE



Simulated Moving Bed Reactor



Biodiesel Pilot Plant

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Entrained Flow Pyrolysis of Biomass at High Pressure



High Pressure Co-Gasification with recirculation



Catalytic cracking of Plastics

Custom Made



Reforming and Prox in
Microchannel reactor



Multipurpose fixed bed reactors
pilot plant with transparent
enclosure

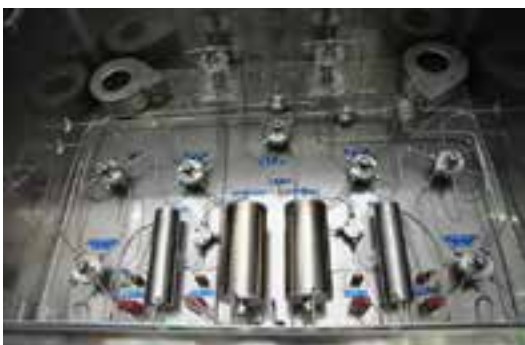


Multipurpose Hydroprocessing Pilot Plant
with Solid Feeding at High Pressure



Horizontal Reactor for Slow
Pyrolysis

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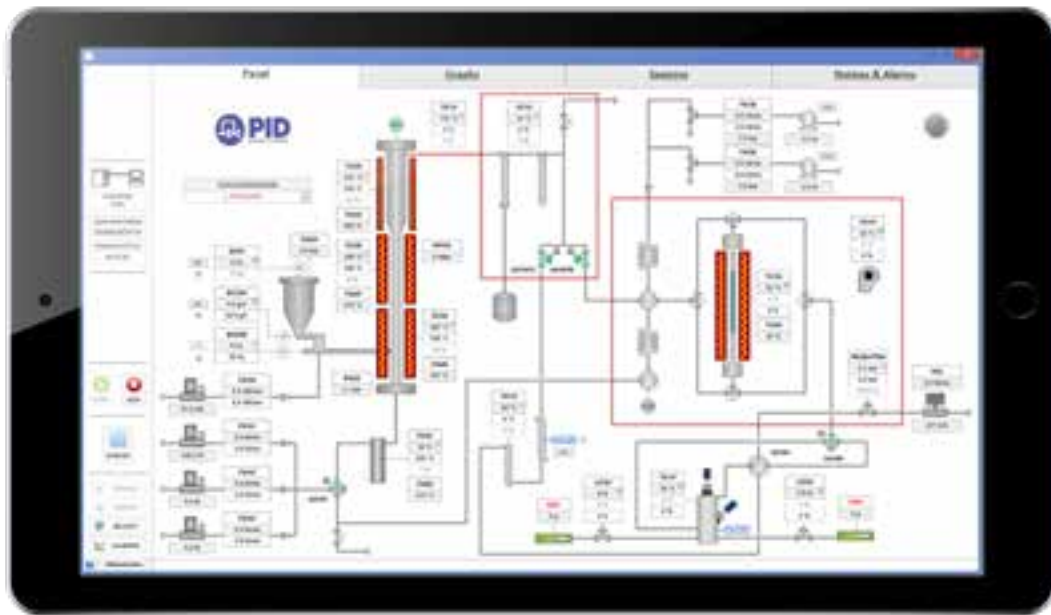


Multi Purpose Pilot Plant



Hydrates Pilot Plant

CONTROL AND DATA ACQUISITION SYSTEMS



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► Control System

PID Eng&Tech pilot plants are fully automated and instrumented, being all the process variables controlled by independent PID controllers. A programmable logic controller (PLC) controls the pilot plant having advanced communications through Ethernet with a PC and a touch screen

All parameters can be easily changed and controlled by the PLC touch screen of the pilot plant's control cabinet and SCADA software

► Alarm system

PID Eng&Tech pilot plants are designed for safe and continuous operation. The alarm system includes several independent safety levels:

- Automatic switch off in case of any emergency condition
- Pressure, level, temperature and gases (hydrocarbons, hydrogen sulfide, carbon monoxide...) concentration security systems

The alarm system is based on the PLC and all the alarms system actions are registered by software on the PC, including an automatic report of the alarms. Besides, it is designed under complete consultation with the customer, fixing the appropriate safety levels and safety actions for each variable

► Process@ Software

Process@ is an user-friendly SCADA software developed by PID Eng&Tech with LabVIEW for data acquisition and remote process control through a PC, that can be placed up to 50 m away from the pilot plant

- Intuitive and easy graphic system with dynamic data
- Exportable data to spreadsheets
- Historical and real time trending
- Daily / hourly report generation
- User configurable run sequences, including both conditional and temporal jumps, to easily automatize the experiments
- Integration and management of both online and offline data analysis (when analytical equipment is included)
- Automatic mass balance calculations with integration of gas chromatography software and results (when analytical equipment is included)



OTHER LAB EQUIPMENT

► Gas mixing box

Gas mixing box is designed for each customer according to specific requirements of the involved process

- Up to 6 gases as standard
- Operating pressure up to 100 bar as standard
- Flow rate is measured and controlled through high quality mass flow controllers with 1% of precision and 0.1% of repeatability
- Easy calibration for other gases
- Controlled by PLC and touch screen



► Scrubber

A scrubber can be used to remove pollutants from a gas stream to meet the emission regulations. PID Eng&Tech unit is designed specifically for each process requirements and it can be installed both in our pilot plants and at the final step of the customer process

- Tower dimensions: 1000 mm, D 200 mm
- Treated water tank: 200 L
- Tank dimensions: 600 mm, D 550 mm
- Recirculation magnetic pump: power 1/2 CV
- Gas flow: 200 NL/min
- Gas pressure: 0.5 barg



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► Liquefied gas feeding system

This system allows feeding different gases in liquid phase into a main process

- Flow rate from 0.1 to 5.0 mL/min as standard , up to 130 mL/min as special configuration
- Operating temperature from -10 to 5 °C as standard in the pump head
- Operating pressure up to 150 bar as standard
- Gases such as ethane, propane, butane, carbon dioxide, ammonia...
- Skid mounted



OTHER LAB EQUIPMENT

► Catalyst Calcination System



The Catalyst Calcination System (CCS) is a benchtop high temperature equipment which includes:

- 2 x thermal mass flow controllers. Up to 200 NmL/min N₂ (He) and 200 NmL/min H₂. Precision 1.0% FS, repeatability 0.1%. Digital Modbus communications
- Shut-off valves and check-valves (Kalrez elastomer) for each gas line, and turbulent flow gas mixer. Provision for additional gas feed line
- Reactor furnace in SS304 for tubular reactors up to 25,4 mm OD, with radiant ceramic fiber heaters. Maximum temperature 1000 ± 2 °C (depending on reactor MOC). Very low thermal inertia (no overshoot) and good temperature distribution
- Insulation box with furnace and layout tubing inside. High temperature shut-off valves inside the insulation box, installed before and after reactor
- Reactor temperature control. Pressure and temperature indication inside the box

► Stream conditioning system for GC

The stream conditioning system is a compact equipment to adequate different process gas lines for online GC analysis

- Up to four different gas lines as standard
- Reduction of pressure for high pressure product lines
- Increase of pressure for low pressure product lines
- Temperature conditioning system
- Dehumidification system for water elimination



► Gas compression system

Modular gas compression system to allow boosting a gas stream into other high pressure equipment:

- Non-fluctuating gas flow
- Gas cleaning system to condition the gas inlet if required
- Models for different gas flows and outlet pressure. Consult details for your application
- Controlled variable pressure outlet
- Safety devices
- Easy connection between low pressure and high pressure processes

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