LABPARK

Educational Chemical Engineering Pilot Plants Catalog

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LABPARK

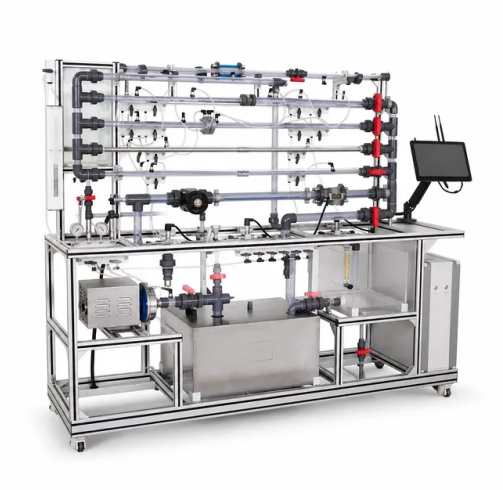
COMPANY PROFILE

>>> About Us

Labpark is a high-tech enterprise serving universities, research institutes, and enterprises in fields such as chemical engineering, biotechnology, and environmental science. Our main product lines are Educational Unit Operations Pilot Plants and Practical Training Unit Operations Pilot Plants, designed to support practical engineering education. Supported by our own R&D platforms and 209 technical patents, we operate a production facility with a planned area of 49,000 square meters, dedicated to helping institutions enhance laboratory infrastructure and practical training capabilities.

Comprehensive Fluid Mechanics Educational Unit Operations Pilot Plant

Item Number: LPK-BFMC-C



Introduction

Hands-on fluid mechanics pilot plant for engineering education covering over 13 principles including pipe flow, minor losses, flowmeter calibration, and pump performance with industrial-grade components, smooth and rough piping, venturi and orifice flowmeters, and centrifugal pump testing and analysis.

Learn More

Module / System Component	Description & Target Measurements
Physical Dimensions	Maximum footprint: 2200 mm × 580 mm × 1800 mm (L × W × H)
Frame & Structural Support	High-quality, industrial-grade aluminum alloy profile with heavy-duty swivel casters
Pipe Flow Evaluation	- Smooth and rough piping sections (thin and thick) - Laminar and turbulent flow regimes - Straight pipe resistance coefficient (λ) vs. Reynolds number (Re)
Local Resistance Analysis	- Minor losses in abrupt contraction pipelines - Local resistance coefficient (ζ) of standard process valves
Flow Metering Stations	- Orifice plate flowmeter & Venturi flowmeter calibration - Flow coefficients (C_o, C_v) vs. Reynolds number (Re) - Evaluation of permanent pressure drop across metering devices
Pumping Operations	- Centrifugal pump characteristic curves (Head, Power, and Efficiency vs. Flow Rate) - Pipeline system curve plotting and operating point determination
Calibration & Static Measurement	High-level water tank, inverted U-tube manometer, and volumetric calibration vessel

Experimental Module	Core Knowledge Points	Directly Correlated Textbook Terminology
Pipe Friction Losses	Fluid friction in conduits, laminar flow development, boundary layer effects, Colebrook equation, Moody chart.	*Unit Operations of Chemical Engineering* *Transport Processes and Unit Operations*
Minor Fittings Losses	Form friction, local resistance coefficients, expansion/contraction energy losses, equivalent length method.	*Unit Operations of Chemical Engineering* *Chemical Engineering Design*
Flow Meter Calibration	Conservation of mass and energy, Bernoulli’s equation, discharge coefficients, restriction flowmeters, pressure recovery.	*Transport Processes and Unit Operations* *Unit Operations of Chemical Engineering*
Pumping Performance	Fluid machinery, net positive suction head (NPSH), system curve matching, pump efficiency, brake horsepower.	*Chemical Engineering Design* *Transport Processes and Unit Operations*

Pressure Swing Adsorption Educational Unit Operations Pilot Plant

Item Number: LPK-BYXF

Introduction

Integrated bench-scale pressure swing adsorption pilot plant for hands-on teaching of gas-solid separation, mass transfer, and process optimization using nitrogen-oxygen model, featuring dual-column design, industrial touchscreen control, digital assessment suite, and customizable hardware and software configurations for educational laboratories.

Learn More

System Component / Parameter	Specification / Educational Function
Adsorption Column Assembly	Dual-column configuration (Column A & Column B) utilizing premium corrosion-resistant alloy, optimized for solid adsorbent packing and even gas distribution.
Gas Feed & Flow Control	Equipped with integrated flow meters and pressure regulators to manage and monitor feed air inlet conditions.
System Pressure Range	Designed for safe educational pressure swing ranges, utilizing robust pressure transmitters with digital readouts on the control panel.
Control Interface	Integrated industrial touch-screen panel with real-time process flow visualization, solenoid valve control, and cycle timer settings.
Gas Analysis Potential	Configurable for gas composition testing, allowing students to measure separation efficiency during nitrogen/oxygen production runs.
Auxiliary Equipment	Includes reliable pressure relief valves, buffer tanks for feed and product gases, and a quiet-running vacuum pump/compressor assembly.

Classic Textbook Reference	Associated Unit Operations & Theoretical Concepts	Corresponding Experimental Module
Unit Operations of Chemical Engineering	Gas-solid separation processes, adsorption equilibrium isotherms, mass transfer zones, and bed regeneration dynamics.	Dynamic adsorption breakthrough curve determination and regeneration efficiency studies.
Transport Processes and Unit Operations	Mass transfer in packed beds, gas diffusion coefficients, and transient-state concentration profiles.	Evaluation of mass transfer resistance and concentration profiles across the dual adsorbent beds.
Chemical Engineering Design	Process instrumentation and control loops, cycle timing optimization, and vessel safety relief systems.	Programming PLC cycle times, optimizing purge-to-feed ratios, and testing pressure-swing sequencing.

Methane Cracking Educational Unit Operations Pilot Plant

Item Number: LPK-CJWL

Introduction

This bench-scale methane cracking educational pilot plant provides hands-on catalytic conversion training with a 1000°C furnace, seven mass flow controllers, and real-time automation for safe, curriculum-aligned experiments. Designed for university teaching of unit operations and reaction engineering.

Learn More

Module / System Component	Technical Specifications	Curriculum & Textbook Alignment
Fixed-Bed Reactor System	Material: 316L Stainless Steel; Max Pressure: 2 MPa; Quick-disassembly coupling design.	**Chemical Reaction Engineering** • Heterogeneous Catalysis and Kinetics • Fixed-Bed Reactor Design and Pressure Drop
Thermal Management System	Three-stage programmable heating; Range: 0–1000°C; Accuracy: ±1°C.	**Transport Processes and Unit Operations** / **Unit Operations of Chemical Engineering** • Conductive and Convective Heat Transfer • Non-isothermal Reactor Operation
Gas Delivery & Flow Control	7 Mass Flow Controllers (MFC); Flow range: 0–500 mL/min; Integrated gas mixing manifold.	**Transport Processes and Unit Operations** • Fluid Flow and Gas Dynamics • Mass Transfer in Gas Mixtures
Process Control & Data Acquisition	15-inch industrial touchscreen; real-time data logging, cloud-based monitoring, and export.	**Chemical Engineering Design** / **Process Dynamics and Control** • Instrumentation and Control Loop Design • Automated Data Acquisition
System Safety & Auxiliaries	Integrated over-temp/over-pressure alarms; dual gas-leak detection options; heavy-duty caster frame.	**Chemical Engineering Design** • Process Safety Management (HAZOP concepts) • Pilot Plant Layout and Piping

Multi-Functional Special Distillation Educational Pilot Plant

Item Number: LPK-SDMC

Introduction

Versatile multi-functional special distillation pilot plant for chemical engineering education. Supports continuous, vacuum, azeotropic, reactive, extractive distillation. Transparent glass columns enable real-time visual observation of hydrodynamics and separation processes.

Learn More

Experimental Module / System Component	Technical & Operational Specifications	Associated Textbook Concepts & Unit Operations
Column Assembly & Packing	Double transparent glass columns; insulated outer walls; configurable with structured or random packing; 3–5 side ports per column for multi-point sampling and feed tray selection.	**Chemical Engineering Design**: Packed column hydraulics, HETP (Height Equivalent to a Theoretical Plate) calculations, feed tray optimization, and column internal selection.
Continuous & Vacuum Distillation System	Integrated vacuum pump, pressure gauges, and digital reflux ratio controller adjustable from 1 to 99.	**Unit Operations of Chemical Engineering**: McCabe-Thiele method, reflux ratio optimization, boiling point elevation, and vacuum distillation calculations.
Azeotropic & Extractive Distillation Modules	Dual feeding pumps with auxiliary solvent/entrainer introduction systems; precise temperature-controlled reboilers.	**Transport Processes and Unit Operations**: Vapor-Liquid Equilibrium (VLE) modifications, separation of close-boiling systems, and the selection criteria for solvents/entrainers.
Reactive Distillation Module	Dedicated catalytic packing zone with integrated temperature sensors to monitor exothermic/endothermic profiles.	**Unit Operations of Chemical Engineering**: Simultaneous mass transfer and chemical reaction, shifting chemical equilibrium, and reaction conversion enhancement.

Steam Methane Reforming Hydrogen Production And Purification Educational Pilot Plant

Item Number: LPK-CCHTH

Introduction

This bench-scale educational pilot plant combines steam methane reforming with hydrogen purification, offering safe, hands-on unit operations training for university engineering laboratories. Its customizable design and high-precision monitoring enable real-time study of catalysis, phase separation, and process dynamics.

Learn More

Experimental Module / System Component	Technical Specifications	Curricular Focus & Target Measurements
Steam Reforming Reactor System	High-temperature catalytic reactor chamber; 316L/304 stainless steel construction; integrated ceramic fiber insulation jacket.	Heterogeneous catalysis, calculation of reaction conversion rates, and thermal energy efficiency in endothermic reactions.
Separation & Purification Column	Multi-stage condensation and separation column; precise liquid level monitoring; integrated gas-liquid separator.	Gas-liquid equilibrium (VLE), phase separation fundamentals, and mass transfer efficiency under steady-state conditions.
Thermal Monitoring & Control Network	High-precision Type K thermocouples; digital temperature transmitters; system accuracy of 0.1°C.	Process dynamics, PID temperature controller tuning, and transient thermal behavior analysis.
Fluid Delivery & Vaporization Unit	Micro-metering liquid pumps; mass flow controllers for gases; high-efficiency steam generator.	Stoichiometric feed ratio control, vapor-liquid feed mixing, and fluid flow dynamics in packed beds.

Fluidized Bed Gas Solid Catalytic Reaction Educational Pilot Plant

Item Number: LPK-LHCQG

Introduction

Our educational fluidized bed gas-solid catalytic reaction pilot plant is ideal for chemical engineering labs. Students study fluidization dynamics, catalyst evaluation, and process control hands-on. Features include a customizable reactor, touchscreen HMI, and safety interlocks for safe, curriculum-aligned experiments.

Learn More

System Component / Module	Specification & Educational Function
Reactor Assembly	Customizable quartz or stainless steel reactor tube; operating within standard gas-solid reaction temperature ranges.
Heating Unit	Program-controlled split-type electric furnace for rapid heating and easy reactor access.
Instrumentation & Control	Touchscreen industrial panel PC; digital displays for temperature, pressure drop, and gas flow rates.
Safety Mechanisms	High-limit temperature cut-off and pressure relief systems with audible/visual alarms.
Experimental Module 1	**Fluidized Bed Hydrodynamics:** Determination of minimum fluidization velocity (U_{mf}) and bed pressure drop curves.
Experimental Module 2	**Gas-Solid Catalytic Kinetics:** Evaluation of catalyst activity, selectivity, and conversion rates under varying temperatures and flow rates.
Experimental Module 3	**Catalyst Deactivation & Regeneration:** Study of in-situ thermal regeneration under controlled air/gas flows.

Solid Spherical Heat Transfer Coefficient Determination Educational Chemical Engineering Pilot Plant

Item Number: LPK-CGXC

Introduction

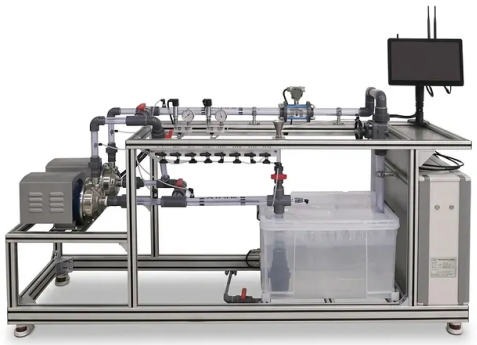
This educational chemical engineering pilot plant enables students to determine convective heat transfer coefficients and observe transient thermal behavior of solid spheres under natural convection, forced convection, fixed beds, and fluidized bed regimes.

Learn More

Module / Component	Technical Specification / Description	Associated Curriculum Concepts
Physical Dimensions	Max 1480 mm × 580 mm × 1500 mm (L × W × H); mounted on a mobile, high-quality aluminum alloy frame with lockable casters.	General Laboratory Layout & Space Management
Fluidization Column	Industrial-grade transparent column for clear observation of fixed bed and fluidized bed behavior of solid particles.	Fluidization, Minimum Fluidization Velocity, Two-Phase Flow
Air Supply System	High-efficiency blower with adjustable flow rate; integrated rotameter/flow meter for precise air velocity measurement.	Fluid Dynamics, Forced Convection, Flow Measurement
Heating & Pre-heating System	High-temperature pre-heating chamber with safety insulation for heating the test spheres before cooling.	Process Safety, Steady-State Pre-heating
Instrumentation	High-precision temperature sensors embedded in test spheres (core temperature) and fluid stream (ambient/air temperature).	Temperature Measurement, Transient Response
Experimental Module 1	Determination of cooling curves for small spheres under natural and forced convection.	External Convective Heat Transfer, Boundary Layer Theory
Experimental Module 2	Heat transfer coefficient determination within fixed and fluidized beds.	Packed Bed Transport, Gas-Solid Fluidized Systems
Experimental Module 3	Calculation of Biot number (Bi) to evaluate internal vs. external thermal resistance.	Unsteady-State Conduction, Lumped Parameter Analysis

Centrifugal Pump Performance Determination Educational Unit Operations Pilot Plant

Item Number: LPK-LXBZH



Introduction

This lab system determines centrifugal pump performance curves for unit operations. Students configure dual pumps in series or parallel for hands-on learning. Includes industrial controls, clear piping, and data logging. Customizable for chemical, mechanical, and environmental engineering programs.

Learn More

System Component / Parameter	Specification / Description
Pumping System	Two corrosion-resistant stainless steel centrifugal pumps, configurable for individual, series, or parallel operation.
Fluid Reservoir	High-capacity transparent water tank with integrated drain and suction fittings.
Instrumentation	Industrial pressure transmitters at pump suctions and discharges; electromagnetic or turbine flowmeter; power transducers for pump motor power measurement.
Control Interface	Industrial touch-screen computer terminal mounted on the frame, supporting real-time data visualization and remote operation.
Piping & Valves	Clear process piping with manual flow control valves and configuration-switching valves.
Framework	Heavy-duty, mobile aluminum alloy frame with locking casters.

Experimental Module	Key Concepts Addressed	Textbook Reference & Core Topics
Single Pump Performance Curve Determination	Pump head (H), shaft power (N), overall efficiency (η), volumetric flow rate (Q), and characteristic curves.	*Unit Operations of Chemical Engineering* • Fluid statics and its applications • Transportation of fluids • Centrifugal pump characteristics and NPSH
Pumps in Series Configuration	Head addition at constant flow rate, system operating points, and energy efficiency.	*Transport Processes and Unit Operations* • Momentum transfer and fluid flow • Flow of incompressible fluids in conduits • Pumps and gas-moving equipment
Pumps in Parallel Configuration	Flow rate addition at constant head, combined performance curve construction, and system resistance matching.	*Chemical Engineering Design* • Piping design and pump selection • Hydraulic analysis of process piping • Utilities and energy conservation

Tubular Reactor Flow Characteristics Determination Educational Unit Operations Pilot Plant

Item Number: LPK-GSFYQ

Introduction

Educational pilot plant for investigating tubular reactor flow characteristics and residence time distribution Features adjustable recycle for plug flow and backmixing studies industrial touchscreen interface and real-time data acquisition Ideal for chemical engineering unit operations laboratory training and education

Learn More

System Component / Module	Technical Description	Educational & Curriculum Focus
Reactor & Flow Loop	Clear vertical tubular column with integrated bypass and recycle lines; variable speed pump for flow rate control.	Flow rate control, recycle ratio adjustments, and fluid velocity calculations.
Detection System	High-precision inline conductivity sensors located at key process points; pulse injection port for salt tracer.	Pulse tracer method, conductivity calibration, and signal processing.
Control Interface	Industrial all-in-one touchscreen workstation running dedicated data acquisition and analysis software.	Digital process monitoring, real-time plotting, and industrial control systems.
Plug Flow Experiment	Operation with the recycle loop closed ($R = 0$) to study ideal plug flow behavior.	Deviation from ideal plug flow, dispersion model, and Peclet number determination.
Recycle & Backmixing Experiment	Operation with varying recycle flows to simulate intermediate mixing levels.	Tanks-in-series model, backmixing degree, and reactor performance under recycle conditions.

Fixed Bed Gas Solid Catalytic Reaction Educational Pilot Plant

Item Number: LPK-GDCQG

Introduction

Fixed-bed gas-solid catalytic reaction unit operations pilot plant for chemical engineering education. Features split-furnace, mass flow controllers, PID control, safety interlocks. Ideal for heterogeneous catalysis, reactor dynamics, catalyst evaluation studies. Fully customizable configurations for university laboratories and academic research.

Learn More

System Component / Module	Technical Description & Parameters	Related Curriculum Concepts
Reactor Configuration	Fixed-bed tubular reactor (stainless steel or quartz options, customizable dimensions) rated for high-temperature operations.	Packed-bed dynamics, void fraction, catalyst bed loading.
Heating & Temperature Control	Programmable electric split-furnace with multi-zone PID temperature controllers and thermocouple sensors.	Reaction kinetics, activation energy, thermal effects in reactors.
Feed & Flow Control	Precision mass flow controllers (MFCs) for gas feeds; optional dosing pump for liquid vaporization feeds.	Space velocity (GHSV/LHSV), residence time distribution, stoichiometry.
Control & Instrumentation	Industrial Panel PC with integrated data acquisition software, real-time parameter display, and historical data export.	Process control, sensor calibration, computerized data acquisition.
Safety Interlocks	Dual-level over-pressure and over-temperature safety shutdown valves and audible/visual alarms.	Process safety management, pressure relief, industrial safety standards.
Experimental Capability	Catalyst activity testing, conversion rate calculation, regeneration cycles, and kinetic parameter determination.	Reaction rates, catalyst deactivation, Arrhenius plots, regeneration kinetics.

Liquid-Liquid Mass Transfer Coefficient Determination Educational Pilot Plant

Item Number: LPK-YYCZ

Introduction

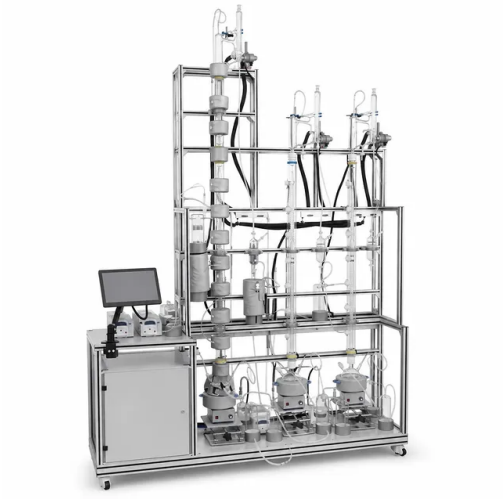
This bench-scale educational pilot plant for liquid-liquid mass transfer coefficient determination offers precise control of phase boundary, temperature, and agitation, enabling hands-on study of transport phenomena and unit operations in chemical engineering labs for teaching.

Learn More

Feature / Module	Specification / Description	Corresponding Academic Concepts
Contactor Vessel	Borosilicate glass cylinder with a fixed, measurable interfacial boundary	Phase boundary determination; interfacial area calculations
Agitation System	Dual independent variable-speed DC motors with digital rpm displays	Convective mass transfer; turbulence and Reynolds number influence
Temperature Control	Constant-temperature water bath with external circulation pump	Thermal effects on diffusivity and solute solubility
Experimental Module 1	Determination of individual and overall liquid-liquid mass transfer coefficients	Two-film theory; interphase mass transfer resistance
Experimental Module 2	Kinetic study of concentration changes over time under constant agitation and temperature	Transient mass transfer; concentration-time curves
Experimental Module 3	Demonstration of liquid-liquid extraction principles	Phase equilibrium; partition coefficients; solvent extraction design

Continuous Batch Extractive Distillation Educational Pilot Plant

Item Number: LPK-SFZL



Introduction

Versatile pilot plant for continuous, batch, and extractive distillation training. High-borosilicate glass column for visualizing hydraulics, 15.6-inch touchscreen with data logging, precise reflux ratio control 1-99, and durable corrosion-resistant frame. Ideal for chemical engineering education and process research.

Learn More

Parameter	Specification
Operation Modes	Continuous distillation, batch distillation, extractive distillation
Column Construction	High-precision, transparent high-borosilicate glass columns
Control System	15.6-inch integrated touchscreen terminal with real-time data storage and processing
Reflux Ratio Control	Automatic split-type control, adjustable ratio range: 1–99
Thermal & Mixing Control	Reboiler vessels equipped with adjustable magnetic stirring and heating mantles
Feed & Product Management	Precision peristaltic pumps for steady liquid feed; graduated glass feed and product receivers
Pressure Monitoring	Visual U-tube differential pressure gauge for column pressure drop evaluation
Structure & Mobility	Corrosion-resistant aluminum alloy frame with adjustable, heavy-duty casters
Overall Dimensions	≤ 2200 mm × 580 mm × 3200 mm (Length × Width × Height)

Target Curricula & Classic Textbooks	Associated Unit Operations & Theoretical Concepts	Educational Laboratory Modules
Unit Operations of Chemical Engineering	Distillation, McCabe-Thiele method, reflux ratio, column efficiency, plate and packed column hydraulics, batch distillation calculations.	Determination of overall column efficiency, McCabe-Thiele construction validation, and study of reflux ratio influence on distillate purity.
Transport Processes and Unit Operations	Vapor-liquid equilibrium (VLE), mass transfer in separation processes, continuous distillation of binary mixtures, extractive distillation fundamentals.	Binary mixture separation, continuous steady-state distillation run, and evaluation of mass transfer coefficients.
Chemical Engineering Design	Column sizing, reboiler and condenser heat duties, process instrumentation, control loops, and pilot-scale system safety.	Mass and energy balance calculations, process control optimization via touchscreen interface, and hydraulic limit identification (flooding/weeping).

Two-Dimensional Fluidization Hydrodynamics Educational Pilot Plant For Unit Operations Training

Item Number: LPK-2DLHC

Introduction

Explore gas-solid and liquid-solid fluidization hydrodynamics with our transparent 2D educational pilot plant. Ideal for chemical engineering unit operations labs, it demonstrates fixed to fluidized bed regimes, measures pressure drop, and integrates QR-code digital learning for enhanced student training.

Learn More

Equipment Component / Module	Technical Description & Utility	Corresponding Academic Concepts & Textbook Reference
Gas-Solid Fluidization Column	Transparent 2D vertical chamber equipped with a gas distributor, variable-speed air blower, and calibrated gas flow meter.	Flow of Fluids through Granular Beds; Fluidization (*Unit Operations of Chemical Engineering*)
Liquid-Solid Fluidization Column	Transparent 2D vertical chamber with a liquid distributor, quiet circulation pump, storage reservoir, and liquid flow meter.	Motion of Particles in a Fluid; Fluidization (*Transport Processes and Unit Operations*)
Differential Pressure Manometers	Multi-point pressure tap connections along the bed height linked to U-tube manometers or digital differential pressure sensors.	Pressure Drop in Packed Beds; Minimum Fluidization Velocity (*Unit Operations of Chemical Engineering*)
Digital Auxiliary Suite	QR-code physical plates and cloud-based student learning management interface with experimental video guides.	Modern Engineering Lab Practicum; Process Visualization and Simulation (*Chemical Engineering Design*)

Quantitative Dosing And Liquid Flow Control Educational Unit Operations Pilot Plant

Item Number: LPK-DLJL

Introduction

Explore industrial fluid transport and automated process control with this quantitative dosing and liquid flow control educational pilot plant, featuring local and remote control cabinets, variable speed metering pump, high-precision flow sensors, and PLC-based SCADA integration for engineering students.

Learn More

System Component / Parameter	Specification / Capability	Core Experimental Modules	Corresponding Academic Concepts
Pumping System	Industrial positive displacement / metering pump with variable speed drive control	• Pump calibration and characteristic curves • Flow rate vs. motor frequency analysis	Fluid transport machinery, pump performance, system head
Local Control Cabinet	Digital readouts, manual speed regulators, local start/stop, and status indicators	• Manual system startup and calibration • Local flow adjustment procedures	Process instrumentation, local operator interface (LOI)
Remote Control Cabinet	Integrated PLC system, communication modules, and remote status indicators	• Remote monitoring and SCADA integration • Automated batch dosing programming	Process automation, PLC programming, remote telemetry
Flow Metering & Dosing	High-precision inline flow sensor with pulse/analog output	• Quantitative batch delivery testing • Flow control loop tuning (PID)	Closed-loop control, sensor calibration, transient response

Throttling Effect Determination Educational Unit Operations Pilot Plant

Item Number: LPK-CGT

Introduction

Investigate the Joule-Thomson throttling effect with this educational unit operations pilot plant. Designed for engineering students, it enables hands-on comparative analysis of adiabatic gas expansion using precise process control, interactive digital interface, and eco-friendly operation, ensuring safe repeatable thermodynamic experiments.

Learn More

Parameter	Specification
Supported Test Gases	Air (cooling effect), Helium (heating effect)
Piping & Structural Material	Grade 304 Stainless Steel
Temperature Control System	Integrated constant-temperature water bath (precision: $\pm0.1^\circ\text{C}$)
Refrigeration Type	Fluorine-free, eco-friendly cooling
Flow Measurement	High-precision electronic mass flow meters
Sensors	Integrated RTD temperature sensors and industrial pressure transmitters
User Interface	Industrial touch-screen HMI with modular signal transmission
Power Supply	Standard single-phase AC (tailored to regional voltage requirements)

Laboratory Experiment Module	Key Thermodynamic Concept	Direct Textbook Alignment & Terminology
Joule-Thomson Coefficient Determination	Isenthalpic expansion, real gas behavior, inversion temperature curves	*Introduction to Chemical Engineering Thermodynamics* (Thermodynamic properties of fluids, volumetric properties of pure fluids)
Adiabatic Expansion of Compressible Gases	Open system energy balances, enthalpy changes, irreversible thermodynamic processes	*Unit Operations of Chemical Engineering* (Flow of compressible fluids, thermodynamic equations of state)
Fluid Flow and Pressure Drop Dynamics	Friction in pipes, throttling devices, expansion valves	*Transport Processes and Separation Process Principles* (Fluid mechanics, momentum transfer, mechanical energy balances)
Thermal System Energy Balances	Heat exchanger design, system boundary energy conservation, utility integration	*Chemical Engineering Design* (Energy balance calculations, piping and instrumentation design)

Potassium Salt Thermal Dissolution And Crystallization Separation Educational Unit Operations Pilot Plant

Item Number: LPK-CIRE

Introduction

This educational pilot plant allows chemical engineering students to perform potassium salt thermal dissolution and cooling crystallization experiments, integrating solubility studies, supersaturation control, and solid-liquid separation in a safe, compact, and customizable laboratory system for hands-on unit operations learning.

Learn More

Component	Specifications and Features
Dissolution Reactor	5L Jacketed Borosilicate Glass Kettle with thermal insulation wrap
Crystallization Reactor	5L Jacketed Borosilicate Glass Kettle, transparent for clear observation
Heating System	Circulating thermal oil bath (Ambient to 200°C) with digital controller
Agitation System	Dual overhead mechanical stirrers with variable speed control and digital RPM display
Separation Unit	Heavy-duty plexiglass bag filter with integrated material guide pump
Frame & Mobility	Corrosion-resistant aluminum alloy frame with lockable casters
Dimensions	≤ 1500 mm (Length) × 580 mm (Width) × 1700 mm (Height)

Experimental Module	Student Learning Outcomes	Core Academic Textbook Alignment
Solubility and Saturated Solution Preparation	Determining solubility curves, calculating mass balances, and preparing hot saturated salt solutions.	*Unit Operations of Chemical Engineering* (Solubility principles and material balances)
Controlled Cooling Crystallization	Observing nucleation, managing supersaturation, and analyzing the impact of cooling rates on crystal size.	*Transport Processes and Unit Operations* (Crystallization kinetics and mass transfer)
Fluid Agitation and Mixing	Evaluating the impact of impeller speed on dissolution rates and crystal suspension.	*Unit Operations of Chemical Engineering* (Agitation and mixing of liquids)
Solid-Liquid Vacuum Filtration	Calculating filtration resistance, cake washing efficiency, and mother liquor recovery rates.	*Transport Processes and Unit Operations* (Liquid-solid separation and filtration theory)
Jacketed Heat Transfer	Analyzing heat transfer coefficients across glass jackets during heating and cooling cycles.	*Chemical Engineering Design* (Heat transfer equipment and energy balance design)

Fluid Friction Resistance Determination Educational Unit Operations Pilot Plant

Item Number: LPK-LTZL

Introduction

Engineered bench-scale system for university engineering labs. Provides hands-on fluid mechanics experience: quantitative energy loss analysis, flow regime observation, friction coefficient determination. Features four-point pressure measurement, transparent sections, industrial touchscreen PLC, 3D virtual simulation. Ideal for chemical, mechanical, civil engineering.

Learn More

Experimental Module	Technical Parameters & Instrumentation	Core Academic Concepts & Textbook Associations
Straight Pipe Resistance Determination	Stainless steel & transparent pipelines; high-accuracy differential pressure transmitters; variable-speed centrifugal circulation pump.	Darcy-Weisbach Equation; friction factor (λ or f) vs. Reynolds number (Re) relationship; turbulent flow regime verification.
Local Resistance (Minor Loss) Analysis	Selected industrial valves (e.g., globe valve, gate valve); four-point pressure tap configurations; digital flow meters.	Local resistance coefficient (K); equivalent length method (L_e/D); flow contraction and expansion losses.
Process Control & Automation	Touchscreen PLC interface; digital sensor feedback loops; USB/Wi-Fi data export utilities.	Industrial instrumentation; automated data acquisition; real-time sensor calibration and logging.
3D Virtual Simulation Practice	Interactive 3D modeling platform; offline capability; online learning management integration.	Pre-lab preparation; digital twin applications; interactive process simulation.

Dual-Drive Stirred Gas-Liquid Mass Transfer Coefficient Determination Pilot Plant

Item Number: LPK-DSA

Introduction

Pilot plant for determination of gas-liquid mass transfer coefficients with independent dual-drive agitation. Isolate gas and liquid film resistances via two-film theory control of speeds, flow rates, temperature. Borosilicate vessel provides visual access. Customizable for chemical, environmental, food, pharmaceutical engineering.

Learn More

Component / Subsystem	Technical Description
Absorber Vessel	Borosilicate glass cell with dual-drive mechanical agitation
Agitation System	Dual independent variable-speed motors with digital tachometer readouts
Thermal Control	Integrated heating/cooling constant-temperature bath circulator
Flow Measurement	Calibrated gas rotameters and precision fluid delivery system
Pressure & Level Gauges	Dual vertical differential liquid manometers and pressure buffer vessels
Framework & Mounting	Industrial anodized aluminum profile frame with heavy-duty lockable casters

Academic Field	Associated Reference Textbooks	Corresponding Unit Operations & Core Concepts
Chemical Engineering	*Unit Operations of Chemical Engineering*	Gas Absorption, Interphase Mass Transfer, Two-Film Theory, Determination of Volumetric Mass Transfer Coefficients
Biochemical & Food Engineering	*Transport Processes and Unit Operations*	Gas-Liquid Dissolution, Aeration Hydrodynamics, Liquid-Film Controlled Resistance
Process & Environmental Engineering	*Chemical Engineering Design*	Absorber Sizing Principles, Stirred Tank Mass Transfer Correlations, Process Scale-Up Fundamentals

Bernoulli Equation Demonstration Unit Operations Pilot Plant

Item Number: LPK-BBNL

Introduction

Laboratory pilot plant for Bernoulli's equation demonstration with transparent PVC pipes, 23 piezometer tubes for pressure measurement, and hands-on experiments. Designed for engineering education to study energy conservation, hydraulic grade line, and localized losses in fluid steady-flow systems.

Learn More

System Component / Parameter	Specification / Feature	Pedagogical Value & Associated Lab Experiments
Pipeline Material	Transparent rigid PVC	Direct observation of flow development and boundary transitions.
Pressure Measurement	23 glass piezometer tubes mounted on an experimental panel	Measurement of static pressure distribution and construction of the Hydraulic Grade Line (HGL).
Special Flow Sections	Sudden expansion and sudden contraction segments with integrated venting	Investigation of localized energy losses and pressure recovery.
Flow Control & Measurement	Rotameter and manual control valves	Verification of the continuity equation by adjusting flow rates.
Dimensions	≤ 2200mm × 580mm × 1780mm (L × W × H)	Compact footprint suitable for standard laboratory configurations.
Support Frame	High-quality aluminum alloy with lockable casters	Durable, corrosion-resistant structure ensuring long-term laboratory safety.

Carbon Dioxide Hydrogenation Methanol Synthesis Educational Unit Operations Pilot Plant

Item Number: LPK-TBJ

Introduction

Pilot-scale educational system for carbon dioxide hydrogenation to methanol. Designed for unit operations teaching, it features a fixed-bed reactor, three-stage heating, dual mass flow controllers, and a 15.6-inch touchscreen with data acquisition. Perfect for chemical engineering and sustainable energy courses.

Learn More

Feature / Component	Specification
Reactor Type	Fixed-bed tubular reactor, 316L stainless steel
Catalyst Compatibility	Copper-based catalyst (pre-loaded, customizable upon request)
Maximum Operating Pressure	3.0 MPa
Maximum Operating Temperature	500°C
Heating System	Three-stage electric furnace with a hinged, split-outer shell
Flow Control	Dual high-precision mass flow meters for reactant gases
Human-Machine Interface	15.6-inch touchscreen terminal with real-time data acquisition
Frame & Mobility	Corrosion-resistant aluminum alloy frame with locking casters
Dimensions	1480 mm × 580 mm × 1800 mm

Experimental Module	Key Pedagogical Focus	Textbook Association & Core Concepts
Catalyst Evaluation & Kinetics	Study of conversion rate, selectivity, and space velocity during carbon dioxide hydrogenation.	*Unit Operations of Chemical Engineering* • Heterogeneous reaction kinetics • Catalytic fixed-bed reactors
Reactant Flow Dynamics	Investigating the pressure drop across packed catalyst beds under different gas velocities.	*Transport Processes and Unit Operations* • Flow of fluids through packed beds • Pressure drop calculations
Thermal Profile Tuning	Analyzing heat transfer coefficients and heat management using three-stage control.	*Transport Processes and Unit Operations* • Heat transfer in reactively heated tubes • Thermal conductivity of packed solids
Process Control & Automation	Setting up closed-loop feedback systems for temperature, pressure, and flow rates.	*Chemical Engineering Design* • Piping and Instrumentation Diagrams (P&ID) • Process safety and pressure relief loops

Cavitation Phenomenon Demonstration And Analysis Educational Unit Operations Pilot Plant

Item Number: LPK-CATT

Introduction

Advanced educational pilot plant for demonstrating and analyzing cavitation phenomena in fluid systems. Features a transparent acrylic Venturi test section, high-precision pressure and flow sensors, digital data acquisition, and integrated safety relief valves for engineering curricula.

Learn More

Experimental Module / Component	Technical Details & Functions	Academic Focus & Textbook Correlation
Upstream Pressurized Vessel	Stainless steel construction, equipped with pressure gauges and relief valves; pressurized via external air source.	Fluid storage under pressure, energy balance in closed systems.
Cavitation Test Section	Precision-machined acrylic convergent-divergent nozzle (Venturi geometry) for localized velocity increase and pressure drop.	Bernoulli's equation application, localized vapor pressure threshold determination.
Instrumentation & Control Panel	Real-time digital displays for inlet/outlet pressure, differential pressure, and fluid flow rate.	Calibration of sensors, process variable monitoring, data acquisition practices.
Cavitation Inception Study	Determination of the critical velocity and pressure at which vapor bubbles first appear.	Vapor pressure concepts, phase equilibrium, cavitation index calculations.
Cavitation Collapse & Noise Observation	Visual and acoustic observation of bubble collapse in the divergent section of the nozzle.	Shockwave generation, erosion mechanics, mechanical wear in hydraulic systems.

Carbon Dioxide Hydrogen Methanol Synthesis Educational Unit Operations Pilot Plant

Item Number: LPK-CEJH

Introduction

Hands-on educational pilot plant for methanol synthesis from carbon dioxide and hydrogen. Enables practical study of high-pressure catalysis, unit operations, and process control. Features real-time data acquisition, safety systems, and customizable experiment modules for undergraduate and graduate chemical engineering laboratories.

Learn More

Component / Parameter	Specification	Educational & Operational Value
Reactor Assembly	316L stainless steel tubular reactor; rated up to 6 MPa operating pressure	Demonstrates industrial tube-reactor design, material durability, and high-pressure sealing techniques.
Heating System	Three-stage temperature-controlled furnace with high-density insulation	Allows students to study non-isothermal temperature profiles along the catalyst bed.
Feed Control	High-precision thermal mass flow controllers (MFCs) for gas feeds	Teaches precise molar ratio control and stoichiometric calculations for reactant mixtures.
Process Monitoring	32-channel digital signal monitoring and control module	Demonstrates automated data acquisition, sensor calibration, and process safety interlocks.
Safety Features	Quick catalyst unloading mechanism, shock-resistant pressure gauges (0-10 MPa), and overpressure relief systems	Instills industrial safety protocols, hazard mitigation, and pressure relief sizing principles.

Experimental Module	Core Target Concepts	Connection to Classic Engineering Curricula
Catalytic Reactor Characterization	Space velocity, catalyst packing density, bed voidage, and pressure drop	*Unit Operations of Chemical Engineering* (Fluid flow through packed beds, Ergun equation application)
Reaction Kinetics & Thermodynamics	Reaction rate constants, activation energy, temperature dependence of equilibrium conversion	*Transport Processes and Unit Operations* (Chemical kinetics, heat effects in reactors)
Process Optimization & Yield Analysis	Selectivity, single-pass yield, carbon dioxide conversion efficiency under varying pressure and feed ratios	*Chemical Engineering Design* (Process optimization, material balance verification, green chemistry metrics)
Automation and Control Loop Tuning	Closed-loop flow control, multi-zone cascade temperature control, safety interlock programming	*Chemical Engineering Design* / Process Control (PID tuning, system dynamics, and safety management)

Educational Pressure Swing Adsorption Ethylene Capture Unit Operations Pilot Plant

Item Number: LPK-CYBJ

Introduction

Advanced educational pilot plant for pressure swing adsorption ethylene capture provides comprehensive hands-on training in industrial gas separation processes, featuring an eight-column PSA system, real-time data acquisition, and fully customizable design for chemical engineering unit operations laboratories and research.

Learn More

System Component / Parameter	Specification Details	Educational & Experimental Utility
Adsorption Assembly	Eight-column pressure swing adsorption (PSA) configuration	Comparative column studies, cycle sequence optimization, and breakthrough curve analysis.
Feed Gas Compatibility	Nitrogen / Ethylene / Ethane mixture (nominal ratio 80 / 10 / 10)	Multi-component gas separation, selective adsorption, and binary/ternary gas mixture thermodynamics.
Process Control Hardware	12-channel slot module compatible with multi-signal inputs (monitoring up to 24 channels)	Instruction on process control loops, sensor calibration, and industrial data acquisition systems.
Flow & Pressure Control	Mass flow meters, high-precision pressure sensors, and 5L/10L buffer tanks	Dynamic mass balance calculations, pressure swing cycle adjustment, and system stabilization studies.
User Interface	15.6-inch industrial-grade touchscreen terminal	Real-time parameter visualization, trend plotting, and human-machine interface (HMI) operation.
Physical Dimensions	≥ 2200 mm × 1120 mm × 1800 mm (L × W × H) on adjustable casters	Spatial awareness in pilot plant design, industrial footprint utilization, and laboratory safety management.

Multi-Component Gas Pressure Swing Adsorption Pilot Plant For Unit Operations Education

Item Number: LPK-CBPA

Introduction

Multi-component gas pressure swing adsorption pilot plant designed for unit operations education. Features four-tower configuration, IoT touchscreen control, dual regeneration, and real-time breakthrough curve analysis for engineering training with safety interlocks and mobile frame simulates industrial PSA processes.

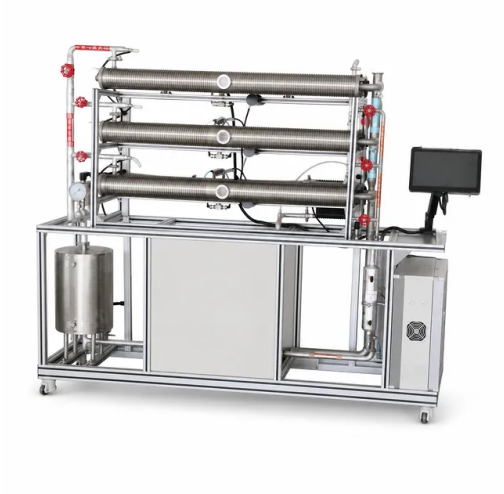
Learn More

Parameter	Specification
Process Configuration	Four-tower adsorption system with multi-valve routing
Applicable Gas Mixtures	Ethylene/Ethane, Carbon Dioxide/Nitrogen, etc.
Regeneration Modes	Thermal purging, vacuum desorption
Control Interface	15.6-inch IoT-compatible industrial touchscreen
Analytical Instruments	Dual online carbon dioxide gas analyzers
Safety Features	Pressure relief valves, buffer vessel, system interlocks
Structural Frame	Mobile aluminum alloy profile frame with lockable casters
Overall Dimensions	≤ 2200 mm × 580 mm × 1800 mm (L × W × H)

Educational Experimental Module	Core Learning Objectives	Textbook Concept / Terminology
Breakthrough Curve Determination	Measure concentration profiles over time to determine adsorbent saturation capacity.	Mass Transfer Zone (MTZ), Breakthrough Point, Adsorption Capacity
PSA Cycle Optimization	Analyze the effect of cycle times, pressure levels, and step sequences on product purity.	Pressure Swing Adsorption Cycle, Desorption, Purge Step
Adsorbent Regeneration Study	Compare thermal swing regeneration against vacuum desorption in terms of energy and recovery.	Thermal Regeneration, Vacuum Desorption, Sorbent Aging
Multi-Component Selectivity	Evaluate separation factors for different gas mixtures under varying feed compositions.	Adsorption Isotherms, Selectivity Coefficient, Co-adsorption

Three-Tube Heat Transfer Educational Pilot Plant For Unit Operations Training

Item Number: LPK-BHTT



Introduction

Three-tube heat transfer pilot plant for studying convective heat transfer enhancement and condensation. Allows comparison of smooth, corrugated, turbulent tubes, verifying empirical correlations. Ideal for chemical engineering education with safety and closed-loop steam recovery.

Learn More

Parameter	Specifications
Tube Configurations	Smooth Tube, Corrugated Tube, Turbulent Flow Tube
Measured Variables	Flow rate, wall temperatures, inlet/outlet temperatures, system pressure
Frame Material	High-strength aluminum alloy support frame with locking industrial casters
Maximum Dimensions	$\le 2200 \text{ mm} \times 580 \text{ mm} \times 1880 \text{ mm}$ (Length $\times$ Width $\times$ Height)
Water Management	Closed-loop steam condensate recovery system
Safety Instrumentation	Physical safety water seal, pressure transmitter, digital overpressure alarm

Experimental Module	Key Engineering Concepts Covered	Associated Terminology in Classic Textbooks
Convective Heat Transfer Correlation	Dimensional analysis, Nusselt, Reynolds, and Prandtl numbers, turbulent flow in pipes	Forced convection in pipes, empirical heat transfer equations (*Unit Operations of Chemical Engineering* / *Transport Processes and Unit Operations*)
Vapor Condensation Analysis	Filmwise vs. dropwise condensation, condensation on horizontal tubes, thermal resistance	Condensation of single vapors, film condensation (*Unit Operations of Chemical Engineering*)
Overall Heat Exchanger Performance	Overall heat transfer coefficient (K_o), fouling factors, log mean temperature difference (LMTD)	Heat exchange equipment design, heat transfer coefficients (*Chemical Engineering Design*)

Ethylbenzene Dehydrogenation Educational Unit Operations Pilot Plant

Item Number: LPK-SREB

Introduction

Ethylbenzene dehydrogenation educational pilot plant replicates industrial styrene production, offering hands-on experience with fixed-bed reactors, catalyst activation, regeneration, automated process control. Designed for university chemical engineering labs, it enables study of gas-solid catalysis, catalyst deactivation, steam regeneration, and safety interlocks.

Learn More

Equipment Feature / Component	Specifications & Capabilities	Key Academic Concepts & Textbook Reference
Reactor Configuration	Fixed-bed tubular reactor; open-type programmable heating furnace with rapid disassembly mechanisms.	Heterogeneous Catalysis, Gas-Solid Reactions, Catalyst Deactivation (*Unit Operations of Chemical Engineering*)
Control & Interface System	Industrial-grade all-in-one PC; real-time PID temperature control, flow monitoring, and safety interlocks.	Process Control, System Dynamics, Automated Data Acquisition (*Chemical Engineering Design*)
Reactant Feed & Preheating	High-precision liquid metering pumps, integrated steam generator, and vaporizing preheater.	Mass Balance, Vapor-Liquid Equilibrium, Multiphase Flow (*Transport Processes and Unit Operations*)
Product Recovery & Separation	High-efficiency condenser and gas-liquid separator for sampling and mass balance calculations.	Fractional Condensation, Phase Separation, Material Balances (*Unit Operations of Chemical Engineering*)
Structure & Dimensions	Heavy-duty anodized aluminum alloy frame on lockable casters; dimensions $\le 1480 \text{ mm} \times 580 \text{ mm} \times 1780 \text{ mm}$.	Pilot Plant Layout, Industrial Safety Standards, Mechanical Design (*Chemical Engineering Design*)

Plate Column Hydrodynamics Tray Demonstration Educational Pilot Plant

Item Number: LPK-BMT

Introduction

Advanced transparent educational pilot plant for chemical engineering labs demonstrates plate column hydrodynamics with industrial sieve bubble cap serrated valve trays for visual observation of gas-liquid contact pressure drop measurement and operational limit analysis including flooding weeping entrainment

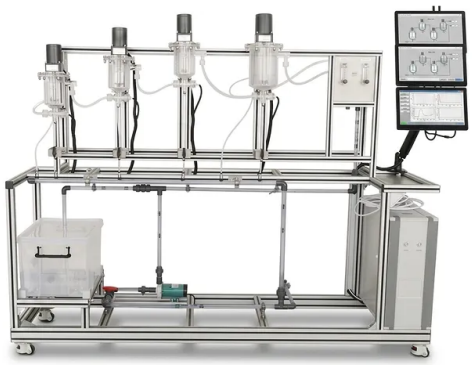
Learn More

Parameter	Description / Specification
Frame Material	High-quality anodized aluminum alloy with heavy-duty caster wheels
Max Dimensions	2200 mm × 580 mm × 1925 mm (Length × Width × Height)
Column Construction	High-transparency acrylic / polycarbonate cold-model column
Included Tray Designs	Sieve tray, Bubble cap tray, Serrated tray, Valve tray
Measurement Devices	Multi-tube differential manometer board, gas rotameter, liquid rotameter
Safety and Drainage	Integrated bottom water seal and easy-access liquid reservoir with drainage valve
Fluid Circulation	Low-noise air blower and industrial-grade water pump

Experimental Module	Measurable/Observable Parameters	Connected Textbook Concept
Tray Geometry Comparison	Structural differences, bubbling active area, downcomer layout	Column Internals and Tray Design Selection
Single-Plate Pressure Drop	Liquid level, air flow rate, differential pressure	Plate Column Hydraulics and Flow Resistance
Operational Limits Analysis	Flooding velocity, weeping thresholds, mist entrainment	Column Capacity Limits and Operating Windows
Water Seal Operations	Gas bypass prevention, bottom liquid level stability	Column Bottom Design and Safety Seals

Multi-Stage Stirred Tanks In Series Residence Time Distribution And Mixing Performance Determination Educational Pilot Plant

Item Number: LPK-DFCL



Introduction

Explore residence time distribution and mixing performance in series stirred tanks with this educational pilot plant. Real-time conductivity sensors, interactive 3D simulation, and industrial-grade PC for chemical engineering lab training. Customizable to curricula.

Learn More

System Component / Parameter	Technical Description	Related Academic & Textbook Concepts
Reactor Configuration	Four transparent stirred tank reactors (CSTRs) in series with variable-speed electric agitators.	Multiple CSTRs in series, fluid mixing, and backmixing behavior.
Tracer Injection System	Pulse tracer injection system with online, real-time conductivity sensors.	Pulse input method, tracer response technique, and concentration profiles.
Data Acquisition & UI	Industrial panel PC, real-time data logging, and automatic curve plotting software.	Residence Time Distribution (RTD) function, $E(t)$ curve calculation, and variance analysis.
Fluid Circulation	Corrosion-resistant circulation pump, precise rotameters, and integrated feed tank.	Volumetric flow rate, space velocity, and reactor space-time calculations.
3D Virtual Platform	Interactive 3D modeling with guided procedures and grading synchronization.	Virtual laboratory practice, safety training, and pre-laboratory evaluation.

Residence Time Distribution And Reactor Flow Characteristics Determination Educational Pilot Plant

Item Number: LPK-RTDRF

Introduction

This versatile educational pilot plant is designed for comprehensive study of residence time distribution and reactor flow characteristics, featuring multiple CSTRs in series, a tubular reactor, variable recycle loop, and automated real-time data acquisition, perfect for hands-on chemical engineering education.

Learn More

Parameter / Module	Technical Specification / Description	Educational Focus
Reactor Array	Four transparent CSTRs in series and one vertical tubular reactor	Multi-stage mixing versus plug flow behavior
Tracer Injection System	Pulse tracer method with inline conductivity monitoring	Measurement of stimulus-response curves
Recycle Capability	Adjustable circulation loop with variable circulation ratio (R)	Study of backmixing and transition from plug flow to mixed flow
Frame & Mobility	High-quality aluminum alloy frame with lockable casters; dimensions $\le 2200 \text{ mm} \times 580 \text{ mm} \times 2280 \text{ mm}$	Industrial-type equipment layout and space efficiency
Data Acquisition	Digital sensors linked to a dedicated control terminal with real-time software analysis	Data logging, curve fitting, and parameter calculation (N parameter)
Customization Scope	Tailor-made software dashboards and adjustable hardware configurations	Adaptation to specific departmental research or teaching needs

Laboratory Session	Measured Parameters & Phenomena	Textbook Concept / Terminology
RTD in CSTRs in Series	Pulse response, determination of vessel count parameter (N)	Tanks-in-Series Model, Perfect Mixing, Non-Ideal Flow
RTD in Tubular Reactors	Influence of fluid velocity on tracer dispersion	Plug Flow Reactor (PFR) Model, Axial Dispersion Model
Backmixing with Recycle	Effect of variable circulation ratio (R) on RTD curves	Recycle Reactors, Intermediate Flow Patterns, Backmixing Degree

Two Phase Flow Pattern Velocity Resistance Measurement Educational Pilot Plant

Item Number: LPK-TSFR

Introduction

Benchtop educational pilot plant for university labs studying gas-liquid two-phase flow patterns, velocity, and resistance across circular, square, and rectangular conduits. Features 15.6-inch touchscreen, 5G connectivity, differential pressure sensors, safe water-air operation. Supports chemical engineering curricula.

Learn More

Parameter	Specification / Detail
Experimental Geometries	Circular, square, and rectangular conduits
Material Construction	High-transparency acrylic glass for test sections; corrosion-resistant alloys and polymers for fluid circulation loops
Control & Interface	15.6-inch integrated touchscreen console
Connectivity	5G / Bluetooth enabled for remote monitoring and cloud data storage
Safety Features	Real-time differential pressure monitoring, low-voltage control circuits, automatic pressure-relief protocols
Working Fluids	Water and air (non-toxic, low-maintenance)

Experimental Module	Academic Focus	Core Concepts Addressed	Textbook Alignment
Two-Phase Flow Regime Mapping	Multiphase Fluid Dynamics	Transition boundaries between bubbly, slug, plug, and churn flow regimes.	*Unit Operations of Chemical Engineering*
Frictional Resistance & Drag Analysis	Momentum Transfer	Pressure drops in smooth vs. obstructed conduits; calculation of friction factors and head loss.	*Transport Processes and Unit Operations*
Conduit Geometry Comparison	Fluid Mechanics	Effects of non-circular cross-sections on hydraulic diameter and Reynolds number calculations.	*Unit Operations of Chemical Engineering*
Instrumentation Calibration & Design	Process Control & Piping Design	Differential pressure transmitter calibration, rotameter operations, and sizing of industrial piping lines.	*Chemical Engineering Design*

Supercritical High-Gravity Flash Evaporation Educational Unit Operations Pilot Plant

Item Number: LPK-HGDS

Introduction

Bench-scale integrated teaching system for advanced separation and mass transfer, combining supercritical high-gravity flash evaporation with heating, chemical reaction, and material collection, featuring modular design, Stainless Steel 316L construction, transparent visualization, touchscreen control, and safety systems for chemical engineering education.

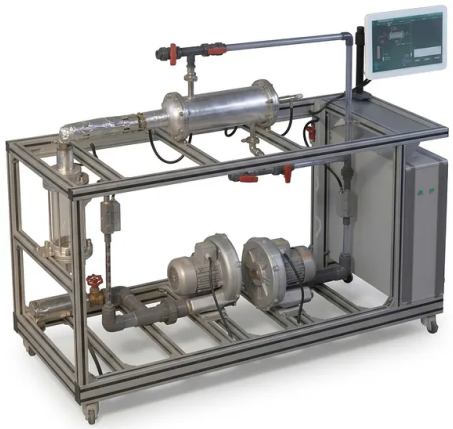
Learn More

Component / Parameter	Specification / Description
Primary Structural Material	Stainless Steel 316L and High-Borosilicate Glass
High-Gravity Device	Motor-driven with magnetic coupling for leak-free, high-shear mixing
Control Interface	15.6-inch industrial touchscreen with 5G/Bluetooth connectivity
Safety Mechanisms	Over-temperature and over-pressure automated shut-offs
Fluid Delivery	Integrated precision liquid metering pumps with feedback control
Material Circulation	Closed-loop collection and recycling system for sustainable chemical usage

Experimental Module	Key Educational Concepts Covered	Classic Textbook Alignment
Flash Distillation and Vapor-Liquid Equilibrium	Thermodynamic equilibrium, throttling processes, phase separation efficiency, and material balances.	*Unit Operations of Chemical Engineering* & *Transport Processes and Unit Operations*
High-Gravity Mass Transfer	Centrifugal separation field dynamics, mass transfer coefficients, residence time distribution, and process intensification.	*Chemical Engineering Design* & *Unit Operations of Chemical Engineering*
Supercritical Fluid Operations	High-pressure phase behavior, supercritical solvent properties, and thermodynamic phase envelopes.	*Transport Processes and Unit Operations*
Process Control and Automation	Closed-loop PID control, sensor calibration, real-time data acquisition, and safety interlock design.	*Chemical Engineering Design*

Shell And Tube Heat Exchanger Heat Transfer Coefficient Determination Educational Pilot Plant

Item Number: LPK-LGHR



Introduction

LABPARK's shell and tube heat exchanger pilot plant enables students to investigate heat transfer coefficients, LMTD, co-current vs counter-current flow, bridging theory and industrial practice. Customizable for chemical, mechanical, environmental engineering curricula. Ideal for unit operations and process engineering labs.

Learn More

System Component / Parameter	Technical Description	Educational & Experimental Objective
Shell and Tube Heat Exchanger	Stainless steel construction with a multi-tube bundle and shell baffles to promote turbulent flow.	Study of heat exchanger geometry, boundary layer resistance, and thermal contact area.
Fluid Circulation System	Variable-speed industrial pumps/blowers for precise flow control of hot and cold media.	Determination of the relationship between fluid velocity (Reynolds number) and convective heat transfer.
Data Acquisition System	High-precision temperature transmitters and electromagnetic/turbine flow meters.	Calculation of overall heat transfer coefficients (U) and verification of steady-state energy balances.
Control Console	Industrial all-in-one PC integrated into a robust, mobile aluminum profile chassis.	Hands-on experience with industrial automation, real-time data plotting, and sensor calibration procedures.

Experimental Module	Corresponding Unit Operations Concepts	Associated Academic Disciplines
LMTD Determination	Co-current vs. counter-current temperature profiles, LMTD correction factor computation.	Chemical Engineering, Mechanical Engineering
Heat Transfer Coefficient (U) Analysis	Convective heat transfer, conductive wall resistance, fluid flow rate dependencies.	Process Engineering, Food Engineering
Energy Balance Verification	Enthalpy changes in hot and cold streams, system heat loss estimation.	Environmental Engineering, Thermal Engineering

Agitation And Mixing Educational Unit Operations Pilot Plant

Item Number: LPK-JBJ

Introduction

This bench-scale educational pilot plant enables investigation of agitation and mixing characteristics through real-time torque, speed, and conductivity measurements, supporting power number, Reynolds number, and scale-up experiments for chemical engineering students with customizable impellers and interactive control for practical education.

Learn More

Parameter / Component	Specification
Agitation Vessel	Stainless steel construction equipped with removable baffles for flow pattern modification
Drive System	Variable speed motor with integrated control, speed range: 0–1000 RPM
Impeller Options	Standard configurations include Flat-Blade Turbine, Pitched-Blade Turbine, and Anchor types
Instrumentation	Real-time torque/power transmitter, photoelectric speed sensor, high-precision conductivity probe, and temperature sensor
Control & Acquisition	Integrated PLC with a color touchscreen HMI; data export capability via standard interface
Frame & Mobility	Corrosion-resistant aluminum alloy profile skid with heavy-duty locking casters

Experimental Module	Measurable Parameters	Associated Academic Concepts	Reference Textbook Alignment
Agitator Power Determination	Speed (n), Power (N), Fluid density (ρ), Fluid viscosity (μ)	Power Number (N_p), Reynolds Number (Re), dimensional analysis	*Unit Operations of Chemical Engineering / Transport Processes and Unit Operations*
Mixing Time & Efficiency	Conductivity vs. time, impeller speed, baffle configuration	Blending effectiveness, concentration homogenization, tracer dynamics	*Unit Operations of Chemical Engineering*
System Characterization & Scale-Up	Impeller geometry, vessel-to-impeller ratio, baffle effects	Scale-up criteria, power-per-unit-volume, flow vs. shear characteristics	*Chemical Engineering Design / Transport Processes and Unit Operations*

Continuous Sieve-Plate Distillation Pilot Plant For Unit Operations Laboratory Education

Item Number: LPK-BDIS

Introduction

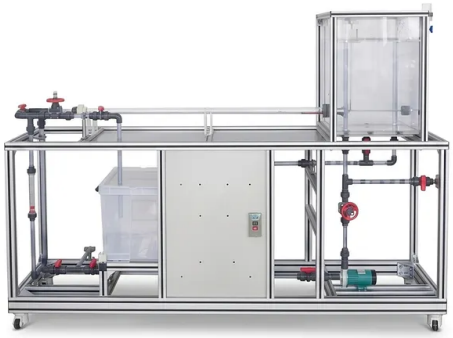
Integrated pilot-scale teaching system for continuous sieve-plate distillation studies. Visual demonstration of tray hydraulics, flexible feed positions, and automatic reflux control for hands-on unit operations education in engineering labs. Designed for higher education engineering laboratories.

Learn More

System Component / Feature	Technical Specifications	Associated Unit Operations & Educational Concepts
Distillation Column	Sieve-plate type with a single overflow downcomer; integrated observation sight glasses.	Vapor-liquid equilibrium (VLE), tray hydraulics, weeping, flooding, and plate efficiency.
Reflux Control System	Automatic reflux ratio control; configurable for continuous total and partial reflux.	Operating lines, minimum reflux ratio, and the McCabe-Thiele graphical method.
Feed System	Minimum of three configurable feed entry points along the column height.	Feed tray location, feed quality (q-line), rectifying and stripping section dynamics.
Chassis & Build	High-strength aluminum alloy structural frame with heavy-duty casters. Dimensions: ≤ 2200mm × 580mm × 2500mm.	Pilot plant safety, industrial equipment layout, and structural design.
Instrumentation & Control	Digital sensors, temperature probes, rotameters, and integrated DCS-ready software interfaces.	Process control, sensor calibration, data acquisition, and automated process monitoring.

Fluid Reynolds Number Demonstration Educational Unit Operations Pilot Plant

Item Number: LPK-BRE



Introduction

Visual fluid dynamics pilot plant for engineering education demonstrating laminar, transitional, and turbulent flow regimes via dye injection in circular conduits. Verifies Reynolds number transitions and teaches dimensionless analysis. Modular design with digital simulation software enhances hands-on learning

Learn More

System Feature / Module	Technical Details & Components	Educational Target & Textbook Mapping
Flow Regime Demonstration Module	Precision glass/acrylic test pipe with a micro-injection dye needle and reservoir.	Observation of laminar lines, transitional wave-like disturbances, and turbulent dispersion.
Stabilization Water Tank	Custom-designed constant-head tank with internal baffles to eliminate inlet turbulence.	Demonstrates the importance of steady-state inlet conditions in fluid mechanics experiments.
Flow Control & Measurement	Calibrated rotameter, needle control valves, and volumetric discharge measuring system.	Quantitative determination of flow rate, average fluid velocity, and calculation of experimental Re.
Chassis & Structural Frame	Industrial-grade aluminum alloy profile frame with lockable casters; Max dimensions: 2200mm × 580mm × 1780mm.	Demonstrates industrial piping and frame layout practices to engineering students.
Digital Simulation Software	Interactive 3D visualization and process animation of internal fluid pathways.	Complements hands-on trials by demonstrating structural features not easily visible from the exterior.

Gas Phase Mixing And Residence Time Distribution Determination Educational Unit Operations Pilot Plant

Item Number: LPK-RTD

Introduction

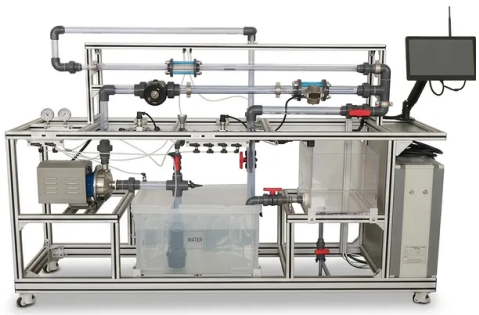
Integrated lab system for gas-phase mixing and RTD determination. Supports pulse and step tracer methods with dual CSTR and PFR reactors, industrial components, and PC data logging. Provides hands-on study of non-ideal flow and reactor behavior for university students.

Learn More

System Parameter / Module	Technical Specifications & Components	Associated Curricular Knowledge Points
Reactor Configurations	Kettle-type reactor (CSTR approximation) and tubular reactor (PFR approximation)	Ideal vs. non-ideal flow, reactor modeling, axial dispersion
Tracer Injection System	Pneumatic 4-way and 6-way switching valves; 316L/PTFE transport lines	Step input response, pulse input response, tracer mass balance
Monitoring Instrumentation	6 high-precision pressure sensors, thermocouple transmitters (TC), and analog-to-digital (AD) conversion modules	Sensor calibration, process variable monitoring, signal conditioning
Control Interface	Dedicated Windows-based workstation with integrated self-check and data logging software	Real-time data acquisition, automated system diagnostics
Physical Dimensions	Width: $\le$ 2200 mm, Depth: $\le$ 580 mm, Height: $\le$ 1600 mm	Industrial plant layout, laboratory space optimization
Structural Frame	Industrial aluminum alloy profile with heavy-duty adjustable leveling casters	Pilot plant safety, structural ergonomics, mobility

Centrifugal Pump Performance And Orifice Flowmeter Calibration Educational Pilot Plant

Item Number: LPK-LXBCD



Introduction

This versatile educational pilot plant enables engineering students to conduct centrifugal pump performance tests, orifice flowmeter calibration, and fluid mechanics experiments using a transparent flow loop, industrial HMI, and 3D virtual simulation for a comprehensive hands-on learning experience.

Learn More

Module / System Component	Description & Functionality
Fluid Circulation Loop	Includes a durable centrifugal pump, a transparent suction/discharge piping network, regulating valves, and storage reservoirs.
Measurement Suite	Integrated electronic pressure transmitters, differential pressure sensors, electromagnetic flowmeters, and digital temperature sensors.
Centrifugal Pump Analysis	Measurement of flow rate (Q), head (H), shaft power (N), and overall efficiency (η) to plot characteristic curves at constant rotational speeds.
Flowmeter Calibration	Calculation of the discharge coefficient (C_0) of an orifice plate flowmeter and analysis of its variation in relation to the Reynolds number (Re).
Control Interface	Industrial touch-screen HMI and PLC system supporting automatic data logging, manual overrides, and system safety interlocks.

Discipline	Core Textbook Reference	Associated Unit Operations & Concepts
Chemical Engineering	*Unit Operations of Chemical Engineering*	Fluid statics and dynamics, friction loss in pipes, pump characteristic curves, Net Positive Suction Head (NPSH), and orifice meter calibration.
Bioprocess & Food Engineering	*Transport Processes and Separation Process Principles*	Momentum transfer in fluids, fluid flow measurement, power requirements for pumping Newtonian fluids, and pipeline system curves.
Process Plant Design	*Chemical Engineering Design*	Piping system sizing, selection of pumps and flow control valves, instrumentation diagrams, and process control loop configuration.

Comprehensive Heat Transfer Coefficient Determination Educational Unit Operations Pilot Plant

Item Number: LPK-BHTC

Introduction

Advanced industrial-grade educational pilot plant for comprehensive heat transfer coefficient determination. Enables quantitative convective heat transfer analysis, evaluates double-pipe and shell-and-tube exchanger configurations, and includes digital data acquisition. Customizable for engineering curriculum. Ideal for engineering unit operations labs.

Learn More

Specification Parameter	Detail Description
Structure Frame	High-grade aluminum alloy framework with locking industrial casters for mobility and stability.
Footprint Dimensions	$\le$ 2200 mm (L) × 580 mm (W) × 1800 mm (H).
Smooth Tube Exchanger	Stainless steel outer shell with a high-conductivity smooth red copper inner tube.
Threaded Tube Exchanger	Stainless steel outer shell with an internally threaded red copper inner tube for turbulent boundary layer disruption.
Shell-and-Tube Exchanger	Industrial-geometry multi-pass shell-and-tube configuration with a stainless steel shell.
Steam Generation Unit	Automated electric steam boiler equipped with pressure sensors, safety liquid seal, and automatic pressure release.
Data Acquisition	Digital temperature transmitters, turbine flowmeters, and pressure sensors linked to a centralized control panel.

Experimental Module	Targeted Engineering Fields	Core Concepts & Classic Textbook Alignment
Convective Heat Transfer Correlation	Chemical Engineering, Mechanical Engineering	Determination of $Nu = A \cdot Re^m \cdot Pr^{0.4}$ correlation parameters; evaluation of Reynolds number (Re) and Prandtl number (Pr) effects on Nusselt number (Nu) as covered in ***Unit Operations of Chemical Engineering***.
Enhanced Heat Transfer Evaluation	Chemical Engineering, Food Engineering	Comparative study of heat transfer coefficients (α_i) in smooth versus threaded tubes; boundary layer interruption and pressure drop trade-offs as discussed in ***Transport Processes and Unit Operations***.
Steam Condensation Analysis	Environmental Engineering, Thermal Engineering	Measurement of external steam condensation film-heat transfer coefficients (α_o) and overall thermal resistance, directly referencing heat transfer topics in ***Unit Operations of Chemical Engineering***.
Shell-and-Tube Performance Testing	Chemical Engineering, Process Design	Calculation of overall heat transfer coefficient (K_o) and Logarithmic Mean Temperature Difference (LMTD) correction factors; practical evaluation of industrial exchanger geometries as outlined in ***Chemical Engineering Design***.

Packed Bed Absorption Educational Unit Operations Pilot Plant

Item Number: LPK-TLXS

Introduction

Study gas-liquid absorption, pressure drop, flooding, and mass transfer coefficients with this pilot plant. Transparent packed column, industrial touchscreen, real-time sensor data, automated analysis. Investigate two-phase flow, loading points, column efficiency. Comprehensive data logging and assessment software included.

Learn More

Educational Module	Technical Specifications & Capabilities	Textbook & Curriculum Alignment
Fluid Dynamics & Hydraulics	• Transparent packed column with industrial-grade packing. • Variable-speed gas blower and liquid pump. • Differential pressure transmitters for bed pressure-drop measurement.	• **Two-Phase Flow in Packed Beds:** Loading and flooding point determination. • **Pressure Drop Correlation:** Dry vs. irrigated packing pressure drop curves. • Directly corresponds to column hydraulics concepts in *Unit Operations of Chemical Engineering* and *Transport Processes and Unit Operations*.
Mass Transfer Determination	• Liquid distribution system with adjustable spray density. • Liquid and gas sampling ports. • High-accuracy flow meters for liquid and gas streams.	• **Absorption of Dilute Gases:** Determination of volumetric mass transfer coefficients ($K_Y a$). • **Column Efficiency:** Calculation of Height of a Transfer Unit (HTU) and Number of Transfer Units (NTU). • Aligns with mass transfer theories in *Unit Operations of Chemical Engineering*.
Process Control & Automation	• Industrial all-in-one touch screen interface. • Digital sensors for flow, pressure, and temperature. • Automated data logging and parameter calibration.	• **Plant Instrumentation & Control:** Introduction to sensor calibration, signal transmission, and data analysis. • **System Design & Integration:** Practical evaluation of control loops as discussed in *Chemical Engineering Design*.

Absorption And Desorption Educational Unit Operations Pilot Plant

Item Number: LPK-BABD-C

Introduction

Dual packed column absorption and desorption pilot plant for chemical engineering education, offering real-time mass transfer coefficient measurement, durable mobile frame, industrial touch-screen interface, and customizable design for varied laboratory curricula, enabling hands-on study of gas absorption and stripping.

Learn More

Parameter	Description / Specification	Educational / Operational Value
System Columns	Packed absorption column and packed desorption column	Supports side-by-side study of absorption and stripping mechanisms.
Frame Material	High-quality industrial aluminum alloy with locking casters	Ensures durability and allows flexible laboratory floor plan layouts.
Dimensions	≤ 2200 mm × 580 mm × 2300 mm (L × W × H)	Compact footprint suitable for standard university teaching laboratories.
Control Unit	Industrial touch-screen all-in-one PC	Exposes students to professional Human-Machine Interfaces (HMI).
Data Handing	Real-time online data display and automated software calculation	Enhances data accuracy and reduces manual calculation errors during lab sessions.

Experimental Module	Key Unit Operation / Physical Concept	Academic Textbook Reference
Absorption Column Dynamics	Gas absorption in packed towers, determination of volumetric mass transfer coefficients ($K_y a$), liquid film resistance.	*Unit Operations of Chemical Engineering*
Desorption & Stripping	Solute removal from liquid phases, mass transfer driving force, counter-current flow patterns.	*Transport Processes and Separation Process Principles* (formerly *Transport Processes and Unit Operations*)
Hydrodynamics of Packed Columns	Pressure drop measurement, determination of flooding and loading points, spray density effects.	*Chemical Engineering Design*

Educational Compression Refrigeration Performance Determination Unit Operations Pilot Plant

Item Number: LPK-SRDE

Introduction

This educational pilot plant for compression refrigeration performance determination offers dual COP evaluation, regenerative cycle comparison, and calorimeter calibration. Customizable for curriculum integration, it features environmentally conscious design. Supports thermodynamic mapping on pressure-enthalpy diagrams and synchronous monitoring with centralized instrumentation.

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Parameter	Specification / Details
Structure	Industrial-grade aluminum alloy frame with heavy-duty lockable casters for mobility
Overall Dimensions	≤ 1480 mm × 580 mm × 1780 mm (L × W × H)
Core Components	Hermetic refrigeration compressor, water-cooled condenser, calorimeter (heater), regenerator (heat exchanger), expansion valve
Instrumentation	High/low-pressure gauges, electronic temperature sensors, digital power meters, flow control valves
Working Fluid	Environmentally compliant secondary heat transfer fluid
Safety Features	Overpressure protection, electrical leakage protection, and overload protection

Experimental Module	Learning Objectives	Academic Concepts & Textbook Reference
Compressor COP Determination	Calculate electrical power input and heat absorption to evaluate compressor performance.	Vapor-Compression Cycles, Work of Compression (*Unit Operations of Chemical Engineering*)
Overall Unit COP Analysis	Measure cumulative energy inputs and cooling outputs under varying load conditions.	Coefficient of Performance, Energy Balances (*Transport Processes and Unit Operations*)
Regenerative Cycle Performance	Compare system metrics when routing refrigerant through the regenerator versus direct expansion.	Heat Recovery, Refrigerant Subcooling (*Chemical Engineering Design*)
Calorimeter Calibration	Determine the thermal loss factor of the heater vessel to correct experimental COP values.	Heat Leakage, Thermal Insulation, Steady-State Heat Transfer (*Unit Operations of Chemical Engineering*)
Pressure-Enthalpy Analysis	Construct and analyze thermodynamic cycles using real-time pressure and temperature data.	Saturated and Superheated Vapor States (*Transport Processes and Unit Operations*)

Crude Benzene Hydrogenation Educational Unit Operations Pilot Plant

Item Number: LPK-CBJQ

Introduction

Advanced pilot plant for higher education, enabling hands-on study of crude benzene hydrogenation and gas-liquid catalytic reactions. Triple-stage reactor system with precision flow and temperature control, AI-driven PID, remote monitoring, and comprehensive safety interlocks. Customizable for curriculum integration.

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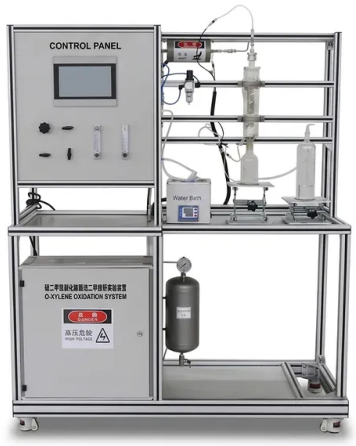
Component/Feature	Technical Specification	Curriculum & Textbook Mapping
Reactor System	Triple-stage series (deoxygenation, 1st stage, 2nd stage) in 316L Stainless Steel; Max pressure: 10 MPa	Multiphase Reactor Design, Heterogeneous Catalysis, Kinetics of Series Reactions
Flow Management	Mass flow controllers for H_2 and N_2 (Range: 0–1000 mL/min; Accuracy: ±0.5%)	Fluid Flow, Gas-Liquid Mass Transfer, Stoichiometric Flow Calculations
Thermal Control	PID-driven automatic temperature control; Programmed temperature ramping	Process Dynamics and Control, Heat Transfer in Jacketed Reactors
Safety Systems	Hydrogen gas leak sensors, automatic over-limit shutdown, 304 SS safety enclosure	Process Safety Management, Hazardous Operation (HAZOP) Studies
Control Interface	Dual-mode control (Local touchscreen + Cloud/Web remote monitoring platform)	Industrial Instrumentation, Distributed Control Systems (DCS), Remote Process Monitoring

O-Xylene Oxidation To Phthalic Anhydride Educational Unit Operations Pilot Plant

Item Number: LPK-COPA



Introduction

Explore our bench-scale educational pilot plant for o-xylene oxidation to phthalic anhydride, featuring a fixed-bed tubular reactor with visual observation, precise temperature control, and safety systems, ideal for chemical engineering hands-on training and industrial simulation, designed for university unit operations.

Learn More

Parameter	Specification
Reactor Type	Fixed-bed tubular reactor
Reactor Material	High-temperature resistant glass (up to 500°C)
Reactor Dimensions	Inner Diameter: 20 mm
Operating Pressure	Atmospheric pressure
Temperature Control	Integrated modular program control with ±1°C accuracy
Safety Systems	Thermocouple sensors, pressure gauges, over-temperature alarm, 5L buffer tank
Auxiliary Equipment	Preheater, air filtration system, product trapping device
Frame Material	Industrial-grade aluminum alloy
Dimensions	1480 mm × 580 mm × 1800 mm

Educational Module	Key Concepts & Transport Phenomena	Relevant Textbook Concepts
Heterogeneous Catalysis & Kinetics	Catalyst bed activation, gas-solid reaction kinetics, space velocity, conversion rate, and product selectivity.	Solid-catalyzed reactions, rate equations, and catalyst deactivation in *Elements of Chemical Reaction Engineering*.
Fixed-Bed Reactor Heat Transfer	Radial and axial temperature profiles, heat dissipation in exothermic packed beds, and prevention of thermal runaway.	Heat transfer in packed beds and heat exchangers in *Unit Operations of Chemical Engineering* and *Transport Processes and Unit Operations*.
Process Control & Instrumentation	Feedback loop configuration, PID temperature control, flow rate monitoring, and safety interlock systems.	Instrumentation, process control loops, and safety systems in *Chemical Engineering Design*.
Mass Transfer & Phase Separation	Gas-phase reactant distribution, product condensation, trapping efficiency, and mass balance calculations.	Gas-solid mass transfer and condensation processes in *Unit Operations of Chemical Engineering*.

Orifice And Venturi Flowmeter Calibration Educational Pilot Plant For Fluid Mechanics Laboratory

Item Number: LPK-LLBD

Introduction

Enhance fluid dynamics education with the Orifice and Venturi Flowmeter Calibration Educational Unit Operations Pilot Plant, featuring transparent orifice and Venturi meters, industrial sensors, touchscreen interface for real-time data analysis and automatic coefficient calculations in engineering student laboratories.

Learn More

Component / Parameter	Specification / Detail
Flow Measurement Devices	Transparent Orifice Plate Flowmeter; Transparent Venturi Flowmeter
Piping & Construction	High-transparency, corrosion-resistant PVC/acrylic conduit system mounted on a durable stainless steel/aluminum profile frame
Circulation System	Stainless steel centrifugal pump with a transparent water reservoir
Instrumentation & Sensors	Electronic differential pressure transmitters, turbine/electromagnetic flowmeters, and pressure sensors
Control & Interface	Industrial touch-screen all-in-one PC with integrated data acquisition hardware
Software Capabilities	Real-time data plotting, automatic calculation of C_0, C_v, and Re, and an integrated instructor examination manager

Experimental Module	Key Pedagogical Objectives	Curriculum & Textbook Reference
Orifice Plate Characterization	Measure differential pressure across the restriction; calculate the orifice discharge coefficient (C_0) and analyze its variation as a function of the Reynolds number (Re).	*Unit Operations of Chemical Engineering* • Flow of Incompressible Fluids • Head Meters / Orifice Meters
Venturi Meter Characterization	Determine the Venturi discharge coefficient (C_v); analyze pressure recovery characteristics and compare energy loss against the orifice plate.	*Transport Processes and Separation Process Principles* • Fluid Dynamics and Flow Measurement • Venturi Meter Theory
Reynolds Number & Flow Regime Study	Correlate frictional losses, flow velocity, and fluid properties to identify laminar, transitional, and turbulent regimes.	*Unit Operations of Chemical Engineering / Chemical Engineering Design* • Fluid Flow Phenomena • Pipe and Fitting Friction Losses
Industrial Instrumentation & Control	Learn the calibration procedures for industrial transmitters, signal transmission, and computer-aided data acquisition.	*Chemical Engineering Design* • Process Control and Instrumentation Schemes

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