Industrial Process Control and Engineering Training Courses

Many new technicians, operators and engineers enter the chemical plant control rooms every year. Responding to the needs of the industry all over the world, PiControl Solutions LLC has developed practical, proven and effective training courses on several industrial process control and engineering topics. PiControl Solutions LLC is a process control, engineering software vendor and industrial training company. PiControl develops and provides software for advanced process control (APC), PID tuning, OPC and training for both industry and colleges.

In Europe, Middle-East and Africa (EMEA region) PiControl is represented by Yazzoom BVBA, a software development, process control and R&D services company with headquarters in Belgium. Yazzoom realizes process improvements through data mining on production data, computer modelling, advanced process control and training services. For more information, please visit www.yazzoom.com or send an email to Info@Yazzoom.Com.
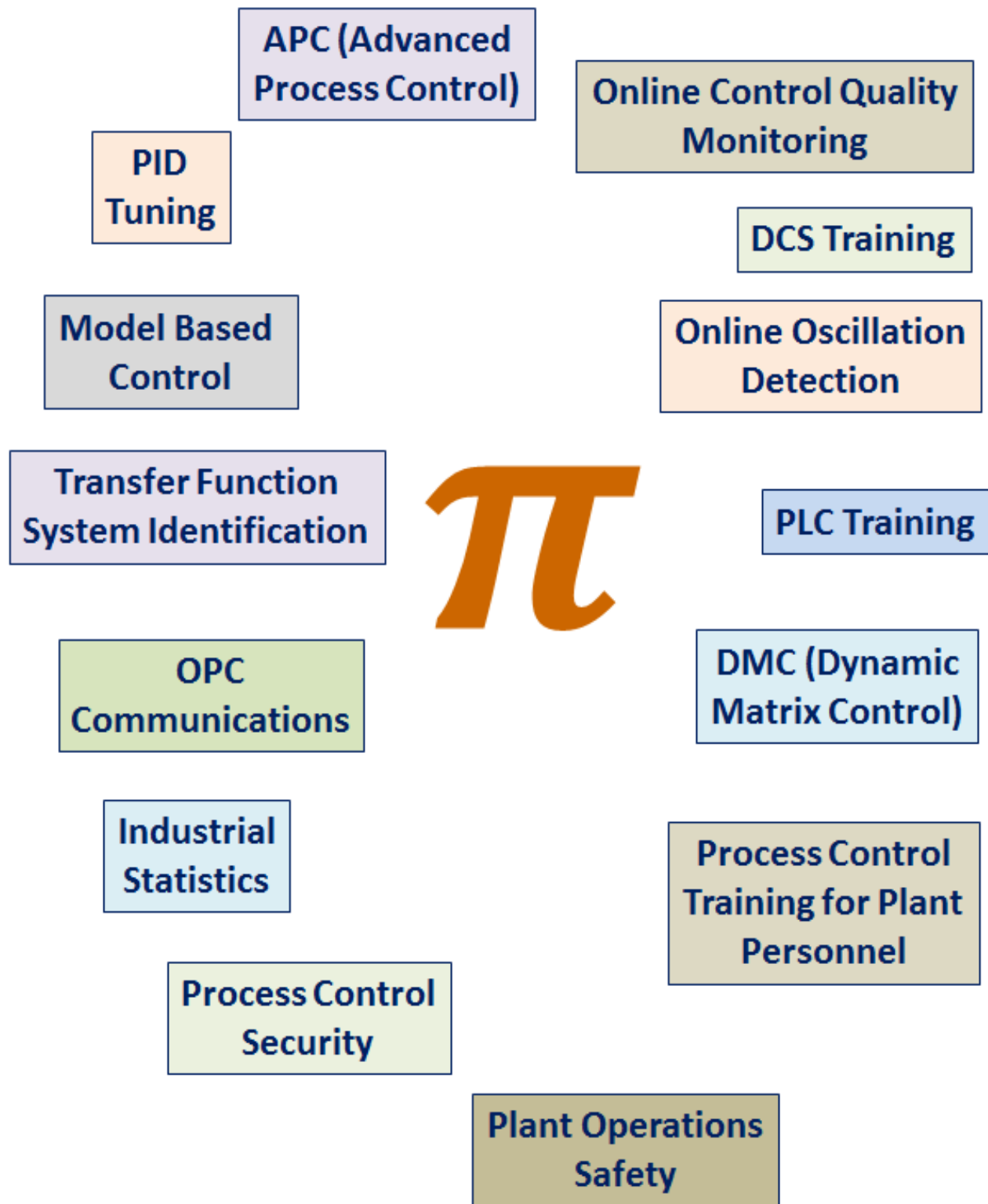
Yazzoom/PiControl offers the training courses using three different convenient options– Classroom, Online (Live) and Self-Paced (using computer-based training Software modules).

The courses are very practical; they avoid unnecessary and complicated academic material and are aimed at fast learning and immediate application. The courses will benefit operators, technicians, engineers, supervisors, managers - both new and experienced, and also students.

Unlike other training techniques, our new approach is far simpler, more effective and easier to learn and master. The simplicity and ease of use of the training products are because of PiControl's powerful and user-friendly software user interface and modern training approach.

A complete list of all training courses and their description are shown on the following pages.

Software, Training, Services

APC (Advanced Process Control)

Online Control Quality Monitoring

PID Tuning

DCS Training

Model Based Control

Online Oscillation Detection

Transfer Function System Identification

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PLC Training

OPC Communications

DMC (Dynamic Matrix Control)

Industrial Statistics

Process Control Training for Plant Personnel

Process Control Security

Plant Operations Safety

COURSE LIST

Classroom and Online

PID100:   PID Tuning Certification and Primary Process Control

APC200:   Advanced Process Control, PID Tuning and Beyond

MON300:   Control Quality Performance Monitoring and Adaptive Control

DCS400:   DCS Training for Control Room Operators

OPC500:   Industrial OPC Software for Communications and Control

SEC600:   Process Control Software and Hardware Security

MPC700:   DMC Maintenance

STA100:   Industrial Statistics, SQC and SPC

STA200:   Transfer Function Dynamics Identification

PLT100:   Industrial Safety – Plant Operations and Process Control

Self-Paced CBT (Computer-based Training) Software

CHE100C: Basic Chemical Technology and Stoichiometry

CHE200C: Material Balances

CHE300C: Thermodynamics - Gases, Vapors and Liquid

CHE400C: Energy Balances

CHE500C: Industrial Process Control - Primary and Advanced Process

Course Times and Format Options (Online, Classroom and Self-Paced CBT

The classroom courses are conducted at your plant site, training center or at our training facility or in a hotel or some alternate training venue. Local times every day are typically 8:30 AM to 4:30 PM with one hour lunch break.

PiControl is very flexible and selects training options, venues and locations to best fit the customer need.

Online sessions are based on using GoToMeeting online software. You can join in from any location anywhere in the world. Broadband internet with at least 1 MBPS speed or higher is required.

Online session times are typically 6:30 AM – 8:30 AM USA CDT for the courses ending in the letter "X) and 10:30 PM to 12:30 AM for the course names ending in the letter "Y". All times indicated are USA CDT (Central Time). Times for online courses can be adjusted to best suit customer needs. Please email us at Info@PiControlSolutions.Com and tell us your needs/requests.

Self-Paced CBT (computer-based training) is using software that you install on your computer and then you go through all chapters, sessions and take tests and quizzes. The CBT comprises of several chapters, lab sessions and tests. This is great for people who are currently very busy and are having a difficult time to participate in a classroom or online course with fixed times.

PID100:
PID Tuning Certification and Primary Process Control

Duration:	**2 Days (Classroom) or 3 Days (Online)**
Audience:	**DCS Technicians, Plant Operators, Instrument Engineers, Process Engineers, Managers and Process Control Engineers.**
Prerequisites:	**Control room experience as technician, operator or engineer is desirable, but not required.**
Course Material:	**Software Products used in Course - Pitops, Simcet and Training Slides.**

Course Description:
This course addresses needs of control room operators, DCS technicians, process control engineers, applications engineers and anyone else responsible for PID tuning in the plant. Many new personnel enter the control room these days; there are numerous types of processes and different DCS and PLC systems.

This course starts with the basics of process control, explains the PID equation in the time domain and then trains using three powerful PID tuning, real-time simulation/ optimization and grading software products.

In a remarkably short 2-day time, students learn to optimally tune PIDs and make process changes on distillation columns, reactors, tanks, compressors, flow controllers, heat exchangers using modern real-time simulator software.

The software also has automatic grading capability, so at end of the course, the software generates a report card on the PID tuning skills of each attendee.

Learning Outcomes:
After completing the course, attendees will be able to tune PIDs in any DCS/PLC, troubleshoot problems, dampen/eliminate oscillations, improve controller performance, all of which helps maximize rates, directly increasing the plant's bottom-line profits.

Through practice on a real-time PID tuning simulator, attendees will gain tremendous confidence in PID tuning on live DCS/PLC's in actual operating plants. This confidence that would otherwise have taken several years on the job now can be achieved in just two days. Attendees will also learn many important and practical concepts about DCS/PLC operations.

Day 1:
Introduction to Industrial Process Control
Process Control Terminology and Definitions
Manipulated Variables, Controlled Variables, Disturbance/Feedforward Variables
Process Control Dynamics and Process Transfer Functions
Open Loop Dynamics
PID Equation in Time Domain and Laplace Domain
PID Examples in Time Domain with Calculation Illustrations
Process Control Schematics
Positional and Velocity Forms of PID Equation
PID Simulations using Pitops and Simcet

Advanced Forms of PID Algorithms
Simulating Noise and Process Disturbances
Filter Action and Filter Time Constant
Estimating Correct Filter Time Constant in DCS or PLC
Hands-On Lab (Practical) Sessions Using Real-Time PID Simulator Software

Day 2:
Optimal Tuning Theory and Calculations
Error Criteria for PID Tuning and Quantifying Control Quality
Typical PID Tuning Parameters for Various Types of Processes
Optimal Tuning using Pitops Simulator with Disturbances, Noise and Setpoint Changes
Estimating Process Dynamics from DCS Trends and Operator Knowledge
Transforming Process Operating Information into Controller Tuning
DCS Attributes and Features
Controller Modes
PV Tracking
Importance of Derivative Action, When to Use/Not To Use Derivative
Estimating Derivative Tuning Parameter Scientifically
Procedures for conducting Step Tests in the Plant
Continue Hands-On Lab (Practical) Sessions Using Simulator Software
Cascade Control Basics
SP/OP Tracking, Bumpless Transfer
Timed Tests using Training Simulator for Testing

APC200:
Advanced Process Control, PID Tuning and Beyond

Duration:	**3 Days (Classroom) or 5 Days (Online)**
Audience:	**Process Control Engineers, Advanced Process Control Engineers, Instrument Engineers, Lab Technicians, DCS/PLC Technicians, Managers and Supervisors.**
Prerequisites:	**PID100 (2 day course), 2-year or 4-year degree in engineering or operations. A few months of plant/ engineering experience is desirable, but not required.**
Course Material:	**Software Products used in Course - Pitops, Simcet and Training Slides.**

Course Description:
The DCS and PLC have many powerful features that still remain under-utilized. This course shows you how to tune PIDs and build powerful optimizing controllers inside the DCS or PLC. During the course, we use several industrial process control software products - Pitops, Simcet, Process Control CBT and ACSSI.

The course assumes that attendees have completed PID100 course (PID100 is a prerequisite for this APC200 course).

Attendees use real time-series plant data and identify multivariable closed-loop/open-loop dynamics. Then they build various control schemes all inside Pitops software – cascade, constraint override, maximizing and minimizing constraint controllers, selectors, model-based controllers, dead-time compensators and many others.

This course is designed more for engineers but also will offer tremendous value to operators, technicians and supervisors. PiControl software products used in this course are so very easy to use that the course can be comfortably followed by even new and inexperienced technicians. This course also covers advanced functions of PID controllers in more detail.

Learning Outcomes:
At the end of the course, attendees will be able to study a process and its P&IDs and talk to the right people in the plant or control room and then design and build powerful controllers in the DCS/PLC. Attendees will become skilled in PID tuning, feedforward implementation, and parameter specification for all types of controllers in the DCS/PLC.

Further, using scientific process control methods and software products they will be able to calculate tuning and other DCS parameters precisely, thus eliminating guesswork and generating precise, optimized control action.

The course also trains attendees how to be careful while activating and commissioning new control schemes, avoiding mistakes and starting up a control chain in the right sequence.

This course is all you will ever need to use the full potential of the DCS or PLC and build powerful new controllers to stabilize plant operation, push against economic, market, process and equipment constraints. Attendees will also learn when to use traditional advanced control and when to use multivariable model-predictive control, a very practical and useful skill.

Day 1:
Process Control Hierarchy
Advanced Process Control (APC) Options and Strategies
Need for Automatic Process Control
Benefits of Process Control
How to Maximize Throughput and Minimize Utilities using APC
Feedforward Control Theory and Calculations
Feedforward Lab Session using Pitops
Decoupler Strategies
Advanced Cascade Control
Cascade Control Lab Session Illustrating an AC-TC Triple Cascade
Cascade Control Tuning Guidelines
Constraint Override Selector Control Procedures and Calculations
How to build correct DCS Configuration for Long Chain Control Schemes
Startup and Chain Activation Procedures in the DCS
Practical Rules and Tips for PID and APC Schemes

Day 2:
Model-based Control
Bias Update for Automatic Control
Closed-Loop Dynamics
GC-based Online Correction, PV Sample Hold
Using Rigorous Models for Closed-Loop Advanced Control with PID Integration
Dead-Time Compensation
Internal Model-Based Control and Lab Session Internal Model-Based Control
Identifying Process Dynamics based on Operator Experience and Knowledge
Identifying Process Dynamics based on DCS Trends and Historical Data
Continue Lab (Practical) Sessions on System Identification and Tuning Optimization

Day 3:
Identification of SISO Closed-Loop Process Transfer Functions
Multi-Input Closed-Loop Transfer Function Identification
Identifying Process Dynamics based on analyzing actual Time-Sampled Data
Lab Session using Pitops to identify first and second order transfer functions using real plant data
Use Pitops to identify multivariable transfer functions using real plant data in closed-loop mode
Model-Predictive Control
When to use PID, Cascade PID, Advanced Regulatory, DMC, RMPCT, Rule-Based Control
Identifying, Debugging and Troubleshooting PID Tuning and Process Control Problems
Online PID/APC Control Quality Monitoring and Reporting
Online Oscillation Detection and Online Control Sluggishness Detection
PID Control Quality Alerting to Smartphones for Improved Proactive Maintenance

MON300:
Control Quality Performance Monitoring and Adaptive Control

Duration:	**2 Days (Classroom) or 3 Days (Online)**
Audience:	**Process Control Engineers, Advanced Process Control Engineers, Instrument Engineers, Lab Technicians, DCS/PLC Technicians, Managers and Supervisors.**
Prerequisites:	**2-year or 4-year degree in engineering or operations and/or a few months of plant/ engineering experience is desirable, but not required.**
Course Material:	**Software used: Apromon and Pitops. Also custom training slides.**

Course Description and Objectives:

Chemical plants can have anywhere from about 50 PIDs in small plants to over 2000 PIDs in large refineries and integrated petrochemical complexes. In addition to simple PIDs, there are cascades, override controllers, model-based controllers and multivariable controllers.

As time goes by, even well tuned PIDs and other controllers can slowly start to deteriorate. As deterioration progresses, process oscillations can start with small amplitudes and can grow large over time costing the plant significant monetary and/or quality losses. Or conversely, PIDs could become sluggish because of changes in process and operating conditions, once again causing the control quality to deteriorate.

This course covers the technology and application of a control performance monitoring software (Apromon) that identifies poorly controlling PIDs (includes single, cascade, override and complex PIDs). Apromon runs online using OPC and calculates several control criteria and generates control quality reports. Integrated with Apromon is a novel, breakthrough algorithm called TAD (True Amplitude Detection) that accurately isolates oscillating or sluggish controllers. This course shows how to improve and maintain the plant's primary and advanced control system and increase the plant's profits.

This course explains how to identify control problems in an online/real-time manner and take immediate corrective action using online adaptive control. The course also shows how to implement true adaptive control inside the DCS by connecting the control quality monitoring software using OPC technology to the DCS/PLC and by designing special DCS/PLC-resident logic for triggering automatic control action.

Learning Outcomes:

At the end of the course, attendees will be skilled in understanding process control quality monitoring criteria and statistics. They will be skilled in the application, installation and use of real-time software products for process control quality monitoring at any plant.

Attendees will also be skilled on the application of online adaptive control technology using the control quality monitoring software and then linking it with closed-loop DCS based-adaptive control schemes. Using the knowledge, attendees on their own can build closed-loop adaptive control schemes at their plant inside the DCS/PLC using OPC connectivity.

Attendees will be able to significantly improve control quality at their plants, move the plant more stably and reliably in the direction of increasing profits with fewer shutdowns and fewer abnormal events. The plant will also see a reduction in the number of alarms and a reduced need for operator intervention.

Day 1:
Modern process control in plants
Process interactions because of mass balance and heat balance integration
Potential for process cycling and sustained oscillations
Causes of process oscillations
Pitops simulations illustrating different oscillation cases
Pitops simulations illustrating excessive control valve movement
Pitops simulations illustrating sluggish control
Definition of various process control quality performance criteria
Explanation of special new terms – crimp, cheat, vacillation, rope length etc.
Component breakdown of PID contributions
Use of process control monitoring software - Apromon-Excel
Run example cases on Apromon-Excel
More explanation of process control quality performance monitoring criteria

Day 2:
Conduct what-if studies on example using Apromon-Excel
Adjust and understand oscillation tuning parameters
Set up online OPC servers to simulate real-plant environment
Use of Apromon-OPC
Run example cases on Apromon-OPC
Implement Apromon-OPC using OPC simulation server
More explanation of process control quality performance monitoring criteria
Procedure and tips on implementing Apromon-OPC in a plant environment
Need for detection of online oscillation in an industrial process
Need for detection of sluggish control in an industrial process.
Precise determination of oscillation
Practical challenges of detecting oscillations reliably
Understanding of true amplitude detection) algorithm
Setting up Apromon-OPC and configuring it in online/real-time mode
Implementing online adaptive control using DCS, Apromon and a OPC server-based computer

<u>**DCS400**</u>**:**
DCS Training for Control Room Operators

Duration:	**1 Day (Classroom) or 2 Days (Online)**
Audience:	**Plant Operators, Process Engineers, DCS technicians, Instrument Engineers and Supervisors**
Prerequisites:	**Some control room exposure is desirable, but not required.**
Course Material:	**DCS screens and slides**

Course Description and Objectives:
Many new and inexperienced control room operators enter plants every year. This course is aimed at training both new and experienced operators. The course focuses not only on the mechanics of how to use the DCS but also covers many of the intricate details necessary for skilled and high quality operation.

In this course, we teach the operator many important DCS operational details, including DCS tag attributes, parameters and fields, how to start up complex control schemes, the meaning of SP tracking, PV tracking, windup and many other topics. We cover procedures for how to detect control problems and tackle them quickly and effectively. We also cover PID tuning. The operators learn DCS graphics and how to navigate from the various screens. We also teach how to modify and improve DCS graphics using typical configuration methods. The course helps to prevent careless mistakes that could potentially cause shutdowns and encourages safe habits. The operators also learn to fully utilize features like trending, event monitoring, history and other advanced features that can make the operators' time more effective.

Learning Outcomes:
At the end of the course, operators will be skilled on all basic, advanced and practical concepts on DCS operations. They will understand DCS tag attributes and variables. They will know how to activate control schemes correctly, troubleshoot process and control problems and also tune PIDs. They would have learnt tag ranges, tuning parameters, alarm system, alarm limits, rate of change limits, trending in the DCS, event history, logs, reports and security. The course also teaches safety and important good habits recommended for operators. This course is a must for any operator or technician and will be of great value to engineers and supervisors too.

<u>**Day 1**</u>**:**
Analog input, output and regulatory tag details, parameters and attributes
Digital input, output and regulatory tag details, parameters and attributes
Continuous control programs
Discrete control programs
PID equation- how it works
PID parameters, nonlinear control, gap action, special forms of PID
Long chains of control tags, cascade chains, chain startup procedure
Preventing mistakes when entering data into DCS, use of clamp functions
Event history
Trending system
Alarm rationalization, management and enforcement
Troubleshooting common problems
Smart messaging and advisory
Interlocks and Permissives
Sequence and rule-based controllers
Safety and reliability in the control room

<u>**OPC500**</u>**:**
Industrial OPC Software for Communications & Control

Duration:	**2 Days (Classroom) or 3 Days (Online)**
Audience:	**Process Control Engineers, Application Engineers, Analyzer Technicians, DCS technicians, Instrument Engineers and Supervisors.**
Prerequisites:	**None**
Course Material:	**OPC training slides, various OPC software products - PiBridge, PiConect, PiLims, PiLogger, Chromatiqx and OPC explorers, OPC browsers, OPC Tunneling concepts.**

Course Description and Objectives:
OPC (OLE for Process Control) is now the latest, most modern and powerful communications protocol for the industry. Using OPC, many data transfers can be quickly and effectively facilitated. In addition, many powerful, custom applications can be developed and implemented on an OPC server-based computer connected to the DCS.

This course shows you how to use OPC for many important DCS connected applications, e.g.: bringing online data from gas chromatographs into the DCS, allowing operator entered data on a operator HMI screen to get downloaded into the DCS.

This course also shows you how to connect two independent OPC servers together easily with special software. The course covers how to pull/push data to and from DCS/PLC to host computers. It teaches how to use signal processing and validation for increasing safety and reliability in chemical processes.

The course teaches how to conceive, design and implement new process control, advanced control and communications-related applications using OPC, level-3 computers and DCS/PLC.

Learning Outcomes:
At the end of the course, attendees will clearly understand important concepts about OPC and its use in the industry.

Attendees will be able to connect any OPC server together, transfer data two-way to DCS/PLC, perform custom calculations directly on an OPC-server and then talk to the DCS, decipher, troubleshoot and solve OPC problems.

Attendees will understand COM, DCOM, DA, HDA, UA, AE and all commonly used OPC concepts.

Attendees will have the skills and knowledge to develop new applications using OPC, save costs using modern OPC technology and implement new APC and primary control schemes faster and with lower costs.

<u>**Day 1**</u>**:**
History and Vision behind OPC technology
Basic Concepts of OPC
OPC Specifications
Benefits of OPC Solutions
Connection Parameters in OPC Servers
Configuration of OPC Clients

OPC Redundancy
OPC DA and HDA
OPC Client and Server Architecture
OPC Tunneling Technology
Windows Security
OPC options and industry vendors
XML Overview
COM and DCOM
Troubleshooting DCOM Problems
Systematic Detailed Procedure for Correctly Setting DCOM Configuration
OPC Diagnostics

Day 2:
SCADA applications using OPC
OPC Alarms and Events
Server-Client-Server (SCS) OPC Applications
OPC UA (Unified Architecture)
PiBridge OPC Client Connector
Connecting different OPC servers together
PiConect Human-to-Excel/DCS Interface
Building powerful custom process applications using OPC
Converting any Excel spreadsheet from office/control room and make it online using OPC
Online Analyzer Signals in Chemical Processes
Online Signal Validation using PiControl's Chromatiqx Product
Using validated signals for closed-loop advanced process control
Laboratory Information Management Systems (LIMS)
Using OPC as a modern, new method for implementing LIMS
Overview of PiLIMS Laboratory Data Information Management System
Fast Data Monitoring for Debugging Process Problems and Equipment Shutdowns
OPC Product PiLogger for Fast Data Monitoring
Expert-System Rule-Based Advisory using OPC
Additional Industrial Applications using OPC
Online process optimization using OPC
Fieldbus, Ethernet, OPC comparisons
Practical industrial communications case studies

SEC600:
Process control software and hardware security

Duration:	**1 Day (Classroom) and 2 Days (Online)**
Audience:	**Process Control Engineers, Supervisors, Managers, DCS/PLC Technicians/Operators and Laboratory Technicians.**
Prerequisites:	**None**
Course Material:	**Training slides and hand-outs.**

Course Description and Objectives:
Modern-day process control systems need to be secured and protected against unauthorized personnel, hackers and potentially malicious attackers. Plant and process data must be protected from competitors or contractors having temporary access to the control systems. Viruses, worms etc., can infect and bring-down an entire process control network if the control system is not adequately and appropriately protected. User IDs, access control for new employees, leaving employees, contractors etc. need to be properly implemented and enforced. Control room access, magnetic card access, DCS/PLC access etc., need to be properly enforced in the modern control room and process control environment. This course is a must for process control management and staff in order to protect data, protect the entire control system and ensure safe and reliable operation.

Learning Outcomes:
This course helps the attendees to understand all important process control system security concepts. It will help to staff the control systems team correctly to ensure that control systems security is properly enforced at the plant. The course helps to generate security forms that can be used to get signatures from various staff members for facilitating securities enforcements. Forms you get from the course can be directly used immediately at the plant. The course provides all information necessary to make the plant control system safe and secure.

Day 1:
Process control system security
Password, user IDs and handling of shared passwords
Passwords, user accounts and automatic password expiration
Protecting non-24-hour manned process control consoles
Annual logon ID access review and control
Control room access controls, DCS/PLC configuration access controls
Engineer, supervisor and operator security
Preventing unauthorized access
Protecting proprietary data and intellectual property, attorney reviews
Sharing control room with different competing technologies
Satisfying licensor requirements regarding patents and proprietary technology
Virus patches and updates
Remote access security and control, remote process control support and monitoring
Developing securities and control forms for management approval – Break Out session
Developing the required management approval authority for security and controls
Protecting proprietary data from offices and control rooms
Developing teams to manage process control systems and audits
How to conduct formal process control audits to ensure control system reliability

MPC700:
DMC Maintenance

Duration: **2 Days (Classroom) and 3 Days (Online)**
Audience: **Process Control Engineers, DCS Technicians and Supervisors.**
Prerequisites: **Knowledge of primary process control, PIDs etc. and preferably a few months of plant experience especially on a DCS.**
Course Material: **Training slides and DMC software.**

Course Description and Objectives:

This course trains on the use of DMC (dynamic matrix control) software. It starts from the fundamentals: the history behind DMC, the need for DMC, how DMC is superior when used right and where other control methodologies could be more appropriate. The course covers how to conduct step tests and identify DMC models, designing and building the DMC controller, startup and commissioning. The course also covers DMC maintenance, how to modify and improve DMC models after years of operation or after significant process changes. It covers automated step testing, PRBS and other new techniques.

Learning Outcomes:

At the end of the course, attendees will be equipped with the skills to design, maintain and troubleshoot DMC controllers. They will be able to use the modern 3G closed-loop dynamics identification technology to improve DMI models using Pitops-TFI. They will have the skills to observe plant trends and troubleshoot the DMC controller and discuss with operations and control engineers on how to improve the control.

Day 1:

History of DMC, benefits of DMC, areas where DMC is vastly superior
Applications where DMC should not be used, alternate control methodologies
DMC software product overview, different modules and building procedure
DMC algorithm overview – how it works – prediction, correction and time shift
Conducting step tests, rules for conducting good tests
Getting DMI models, techniques and procedures for getting good models
Eliminating models and relationships that can harm control quality
Building the DMC controller, running in prediction mode

Day 2:

LP algorithm, LP versus SQP, determining correct LP costs to ensure stable LP solution
Using DMC to locally optimize the process operations
Practical examples to illustrate DMC design and optimization
DMC LP optimizer and Turbo-Max online nonlinear optimizer
DMC controller maintenance
Using Pitops TFI to improve DMC models using short-duration closed-loop data
Effect of small gain models, how to reduce/eliminate cycling and instability
Prediction error feedforward
Adaptive gains, nonlinear control challenges and how to overcome them
DMC Web-server and remote access
Online maintenance examples to improve DMC operation and monetary benefits
Advanced DMC tips and procedures

STA100:
Industrial Statistics, SQC AND SPC

Duration:	**3 Days (Online Only)**
Audience:	**Process Engineers, Research Engineers, Laboratory Personnel, Analyzer Technicians, Instrument Engineers and Supervisors.**
Prerequisites:	**None**
Course Material:	**Training slides and various statistical software products.**

Course Description and Objectives:
Train engineers, technicians and supervisors on the latest statistical tools, methods and practices. Apply statistical methods to analyze process and plant data. Understand statistical quality control, statistical process control, six sigma and related topics. Understand customer quality needs and implement monitoring and statistical methods to improve control.

Learning Outcomes:
At the end of the course, attendees will understand all practical concepts on statistics. They will be able to apply statistical principles and theory to their practical plant data and control problems. They will be able to use modern statistical tools and apply them to actual plant data. The knowledge will help directly to improve statistical control at the plant and achieve more customer satisfaction.

Day 1: (8:30 AM to 4:30 PM)
Analyze, interpret and present data in a meaningful way and Descriptive statistics
Histograms, Pareto charts, Scatter Plots, Confidence Intervals, T-tests and F-tests.
Sampling strategies, transformations, power and sample size calculations
Analysis of variance (ANOVA), Non-parametric tests and Regression
Determine when a real problem exists and if process improvements, changes are required
X and mR, Xbar and R, c, u, np, p, CUSUM and EWMA charts
Capability indices Cp, Cpk, Pp and Ppk, Time series plots, Trend analysis and Decomposition

Day 2: (8:30 AM to 4:30 PM)
Moving averages and other smoothing methods
Statistical hypothesis tests - equivalence testing
One-way analysis of variance and confidence intervals showing their application to validation
Problem definition, selecting responses and factors
Scoping studies, Screening designs, Taguchi methods, fractional and full factorial designs
Response surface methodology (RSM)
Product design, semantic scales, questionnaire design
Factor analysis and Principal components analysis (PCA)

Day 3: (8:30 AM to 4:30 PM)
Gauge repeatability and reproducibility studies
Gauge linearity and bias studies and attribute agreement analysis
Estimate relationships between independent variables and dependent variables
Understand and explain relationships among variables and use them to predict actual responses
Understand product and system lifetimes. Product reliability and failure modes
Manufacturer's methods to inform warranty periods
First-time failure rates, terminal failure rates, non-repairable devices, repairable systems, test plans and the Weibull distribution.

STA200:
Transfer Function Dynamics Identification

Duration:	**2 Days (Online Only)**
Audience:	**Process Control Engineers, Process Engineers, Research Engineers, Laboratory Personnel, Instrument Engineers and Supervisors.**
Prerequisites:	**None**
Course Material:	**Training slides and Pitops-TFI software product.**

Course Description and Objectives:
Identification of transfer functions using industrial process data is both an art and a science. Industrial data comprises of fast noise, drifts and disturbances; these result in special challenges while trying to accurately estimate the transfer function parameters. We use the most modern, advanced and sophisticated 3G dynamics identification technology (Geometric, Gradient and Gravity components) to isolate fast and slow disturbances to accurately determining the true transfer function. The technique used works remarkably well even for multivariable inputs using closed-loop data. Another unique feature is the successful transfer function identification with relatively short-duration data (where other techniques are commonly unsuccessful). The new method used in the course is far simpler and more powerful than other currently practiced methods. It can be easily learnt and applied by new personnel without advanced educational degrees or prior experience.

Learning Outcomes:
At the end of the course, attendees will be able to identify multivariable (multi-input) transfer function parameters using closed-loop data, open-loop data or a mixture of both. Attendees will learn skills to help isolate disturbances and identify the true transfer functions. The skills will be useful in all fields dealing with transfer functions – chemical, mechanical, electrical and industrial engineering, all branches of science (particularly chemistry), medical fields, population studies, statistics and related fields. The modern techniques are both revolutionary and novel; they produce successful results even with challenging data sets comprising of significant levels of complex, unknown and unmeasured disturbances.

Day 1:
Transfer function definition
Fast and slow processes
Different methods of characterizing process dynamics
Characterizing high order transfer function models
Step response coefficient models
ARMA models
Pros and cons of various dynamic models
Open loop step tests, closed-loop tests, gradual changes in input

Day 2:
3G disturbance rejection technology- Geometric, Gradient and
Gravity options Isolating noise from process data
Dead time estimation tips
Model prediction and correction procedures
Industrial examples using real plant/process data
Identification examples using many real and simulated conditions
Zooming on the real transfer function in cases of multiple solutions
Practical tips for successful closed-loop transfer function identification

PLT100:
Industrial Safety—Plant Operations and Process Control

Duration: **2 Days (Online Only)**
Audience: **Operators, Technicians, Engineers, Supervisors and Managers.**
Prerequisites: **None**
Course Material: **Training slides and hand-outs.**

Course Description and Objectives:
Despite advances and improvements on safety in modern-day plant operation, injuries, illnesses and fatalities on-the-job still happen. The course covers most common areas of safety related to plant operation, startup, commissioning and maintenance. A unique aspect of the course is that it also discusses how process control schemes and strategies may be used to increase operational safety. The course also aims at increasing safety awareness and reducing both on-the-job and off-the-job safety-related incidences.

Learning Outcomes:
After completion of the course, attendees will be familiar with important safety concepts relevant to chemical plants. They will be more aware of hazards and will be more cognizant of imminent dangers. Course attendees are likely to operate and work safer than ever before and contribute to improved company safety records. This course is a must for operators, technicians, engineers and managers.

Day 1: (8:30 AM to 4:30 PM)
Industrial safety, working safely with chemicals
Safe handling of pressurized gases
Welding safety
Electrical and lighting safety
Material handling
Machine shop safety
Powered hand operated tools
Back safety, correct lifting technique
Asbestos awareness, ammonia, H_2S, and other hazards
Asphyxiation dangers
Blood-borne pathogens
Fire safety, different types of fires and fire extinguishers
Hazard communications
Hazardous materials transportation

Day 2: (8:30 AM to 4:30 PM)
Lock-out and Tag-out procedures
Material safety data sheets
Office ergonomics
Personal protective equipment
Scaffolds
Slips, trips and falls, fall protection
Forklifts
DOT training
Using DCS/PLC control schemes and advisories for increased safety
Incorporating safety in design of process control strategies and online closed-loop advisories

CHE100C:
Basic Chemical Technology and Stoichiometry

Duration:	**Self-Paced Training Software**
Audience:	**Control Room Operators, Process Engineers, Technicians, Application Engineers, Instrument Engineers and Supervisors.**
Prerequisites:	**None**
Course Material:	**CBT (computer-based training) software**

Course Description and Objectives:
This course is an excellent refresher for process engineers, control engineers and managers – those who took college classes but now need a refresher to review and remember important concepts. This course is also an excellent introduction and knowledge-booster for operators and technicians who want to learn more about the academic theory and principles of basic chemical technology and stoichiometry.

Learning Outcomes:
Master the concepts of basic chemical technology and stoichiometry. Use the knowledge to perform calculations and interact more intelligently during design and troubleshooting meetings at the plant. The knowledge and skills will be of immediate value and use on the job in the control room or a design office.

Course Chapters:
1. Basic Information and Stoichiometry
2. Units, Dimensions, and Conversions
3. Dimensional Homogeneity and Analysis
4. Dimensionless Groups and Analysis
5. Pressure and Temperature
6. Process and Process Units
7. Mass, Density, Volume and Mole
8. Chemical Equations and Stoichiometry

CHE200C:
Material Balances

Duration:	**Self-Paced Training Software**
Audience:	**Control Room Operators, Process Engineers, Technicians, Application Engineers, Instrument Engineers and Supervisors**
Prerequisites:	**None**
Course Material:	**CBT (computer-based training) software**

Course Description and Objectives:
This course is an excellent refresher for process engineers, control engineers and managers – those who took college classes but now need a refresher to review and remember important concepts. This course is also an excellent introduction and knowledge-booster for operators and technicians who want to learn more about the academic theory and the principles of material balances.

Learning Outcomes:
Master the concepts of material balances which are so critical and useful in the plant operation and process design. Use the knowledge to perform calculations and interact more intelligently during design and troubleshooting meetings at the plant. The knowledge and skills will be of immediate value and use on the job in the control room or a design office.

Course Chapters:
1. General Balance Equation
2. Material Balances without Chemical Reaction
   a. Distillation
   b. Mixing/Settling
   c. Drying/Evaporation
   d. Absorption
   e. Extraction
   f. Crystallization
   g. Adsorption
3. Material Balances without Chemical Reaction - With Recycle, Bypass, Purge
   a. Distillation
   b. Drying/Evaporation
   c. Combination of Units
4. Material Balances with Chemical Reaction
   a. Recycle
   b. Purge
   c. Multiple Equipments
   d. Combustion

CHE300C:
Thermodynamics - Gases, Vapors and Liquids

Duration: **Self-Paced Training Software**
Audience: **Control Room Operators, Process Engineers, Technicians, Application**
                             Engineers, Instrument Engineers and Supervisors
Prerequisites: **None**
Course Material: **CBT (computer-based training) software**

Course Description and Objectives:
This course is an excellent refresher for process engineers, control engineers and managers – those who took college classes but now need a refresher to review and remember important concepts. This course is also an excellent introduction and knowledge-booster for operators and technicians who want to learn more about the academic theory and principles of practical industrial thermodynamics.

Learning Outcomes:
Master the concepts on thermodynamics. Use the knowledge to perform calculations and interact more intelligently during design and troubleshooting meetings at the plant. The knowledge and skills will be of immediate value and use on the job in the control room or a design office.

Course Chapters:
1. Pure Components
   a. PVT Relations
   b. Ideal Gases
   c. Real Gases
   d. Vapor Pressure
2. Mixtures
   a. Ideal Gases
   b. Real Gases
3. Ideal Solutions
   a. Phase Rule
   b. t / P-x-y Diagrams
   c. Raoult's & Henry's Laws
4. Humidity And Saturation
   a. Air + Water System
   b. Air + Solvent System

CHE400C:
Energy Balances

Duration:	**Self-Paced Training Software**
Audience:	**Control Room Operators, Process Engineers, Technicians, Application Engineers, Instrument Engineers and Supervisors**
Prerequisites:	**None**
Course Material:	**CBT (computer-based training) software**

Course Description and Objectives:
This course is an excellent refresher for process engineers, control engineers and managers – those who took college classes but now need a refresher to review and remember important concepts. This course is also an excellent introduction and knowledge-booster for operators and technicians who want to learn more about the academic theory and principles of energy balances.

Learning Outcomes:
Master the concepts on energy balances which are so critical and useful in process design and plant operation. Use the knowledge to perform calculations and interact more intelligently during design and troubleshooting meetings at the plant. The knowledge and skills will be of immediate value and use on the job in the control room or a design office.

Course Chapters:
1. Heat Effects
    a. Without Phase Change
    b. With Phase Change
    c. With Water & Steam
2. General Energy Balance Equation
    a. First Law of Thermodynamics
    b. Application To Processes
    c. Mechanical Energy Balance
3. Energy Balances With Reaction
    a. Enthalpy of Formation
    b. Enthalpy of Reaction
    c. Enthalpy of Combustion
    d. Adiabatic Flame Temperature
    e. Application To Processes
4. Enthalpy of Solution & Mixing
5. Application To Processes

6. Heating Values of Fossil Fuels
    a. Coal
    b. Petroleum
    c. Gas

Industrial Process Control - Primary and Advanced Process Control (APC)

Duration:	**Self-Paced Training Software**
Audience:	**Process Control Engineers, DCS/ PLC Technicians, Operators, Process Engineers, Contact Engineers, Supervisors, Managers, Project Engineers**
Prerequisites:	**None**
Course Material:	**CBT (computer-based training) software**

Course Description and Objectives:

Process control courses in universities are still to academic and the training is not adequate for the industrial control room environment. This course covers the practical industrial aspects of process control like no other textbook or course available currently. What would take a typical engineer or technician numerous years of hands-on experience in the control room now can be mastered by this modern, powerful CBT in just a amazing span of a few hours. This course will benefit both new and experienced engineers, operators, supervisors, managers, professors and students. It covers modern industrial process control theory - both primary process control and advanced process control (APC) and can be used by both technicians and engineers without need for advanced math and other background or skills.

Learning Outcomes:

After completion of the course, the students will understand the concept of DCS and PLC architectures and networks. They will understand process control schematics, basic process control theory, system identification, step testing, dynamics characterization. The course teaches PID control, cascade control, feedforward control, constraint control, override control, model-based control, model-predictive control, and other forms of APC (Advanced Process Control). The course teaches how to design and implement primary and advanced process control schemes inside a DCS or a PLC. It teaches skills on when to use PID and APC and when to use a DMC (dynamic matrix control) or other forms of multivariable model-predictive control. It teaches how to design and implement closed-loop controllers in the practical control room environment. It also teaches concepts typically not covered in universities and concepts that take a long time to learn on one's own on-the-job time and effort. The course helps to convert both new and experienced personnel into skilled process control experts in a remarkably short time.

Course Chapters:

Part I: Primary Process Control (Study Time » 25 Hrs.)

1) Overview of Modern Industrial Process Control
   a. Overview
   b. Need For Process Control
   c. Distributed Control System
   d. Choice of DCS or PLC
   e. Laboratory Information Management System (LIMS)
   f. Safety Interlocks and Shutdowns
   g. Permissives

2) Process Control Variable Definitions
   a. Controlled Variables (CV)
   b. Manipulated Variables (MV)

  c. Process Variable (PV)
  d. Setpoint (SP)
  e. Process Dynamics
  f. Transfer Function
  g. Transfer Function Parameters
  h. Linear and Nonlinear Processes
  i. Identifying Process Dynamics
  j. Dynamics Identification Procedure
  k. Dynamics Identification With Multiple Inputs
  l. Rules For Conducting Pulse Tests

3) Primary Control and The PID Algorithm
  a. Manual Control
  b. Automatic Control
  c. The PID Algorithm
  d. Sign of the three terms
  e. Offset
  f. Primary Control

4) PID Algorithm - Additional Options and Parameters
  a. Process Noise
  b. Filter Time Constant
  c. Direction of Control Action
  d. Direct and Reverse Action
  e. Other Forms of The PID Algorithm
  f. Nonlinear PID
  g. Output Sponge PID
  h. Split Range PID
  i. PID Faceplate
  j. PID Detailed Screens

5) Cascade PID Algorithm
  a. Level-To-Flow Double Cascade
  b. Temperature-To-Temperature Double Cascade
  c. TC-FC Double Cascade
  d. AC-TC-FC Triple Cascade
  e. AC-TC-QC-FC Quadruple Cascade

6) Override Control Strategies
  a. Dual Level Control
  b. Dual Temperature Control
  c. Low Level Override Constraint Control
  d. Distillation Reflux Flow Override
  e. Compressor Override Controls
  f. High and Low Override Constraint Control
  g. Maximization of Production Rates
  h. Need For Constraint Override Control Strategies

7) PID Modes and PID Activation Procedure
    a. PID Controller Modes
    b. Summary of Different PID Modes and States
    c. How To Change PID State
    d. Ranges of A PID Controller
    e. Setpoint Tracking and Output Initialization
    f. The "Track" Flag
    g. Bumpless Transfer
    h. Cascade Chain Activation Sequence
    i. Chain Activation Sequence For A Constraint Override Loop
    j. PV Tracking
    k. How To Enable PV Tracking
    l. Benefits of PV Tracking
    m. When To Use PV Tracking
    n. PV Tracking In Case of Master PIDs

8) PID Tuning Procedures and Control Quality
    a. Open-Loop and Closed-Loop Mode
    b. Engineering Units of PID Tuning Parameters
    c. PID Tuning Procedures
    d. Effect of Range Change on PID Tuning Parameters
    e. Advanced Control PID Control
    f. PID Tuning and Control Quality
    g. Comparison of The Criteria

9) Process Control Schematics

Part II: Advanced Process Control (Study Time » 30 Hrs.)

10) Disturbances, Feedforwards and Decouplers
    a. Disturbance
    b. Feedforward Control
    c. Feedforward and Feedback Control Examples
    d. Feedforward Strategy Implementation In DCS or PLC
    e. LEAD and LAG Action
    f. Final Steady State Value From Feedforward
    g. Cases where Feedforward Control may not be effective
    h. Distillation Column Feedforward

11) Process Signal Filtering and Control Valve Checkout
    a. Signal Noise
    b. Effect of excessive noise on control quality
    c. Filter Constant
    d. When To Use Filtering
    e. Selecting Filter Constant
    f. Optimal Filtering
    g. Adding Filtering During PID Tuning
    h. Impact of Noise Band on Open-Loop Test Procedure
    i. Identifying Valve Problems

    j.   Effect of Noise on PID Control Action

12) Dead Time Compensation and Model-Based Control
    a.   Dead Time in Control Loops
    b.   Effect of Dead Time On Control Quality
    c.   When Dead Time Is Really Harmful In A Control Loop
    d.   Methods to combat dead time
    e.   Dead Time Compensation Implementation in DCS or PLC
    f.   Model-Based Control
    g.   Pure Transfer Function-Based Models
    h.   Rigorous Predictive Models
    i.   Steps In Implementing A Rigorous Model-Based Control Scheme

13) Control Schemes Using Discrete Signals
    a.   Continuous Signals
    b.   Discrete Signals
    c.   PV Sample Delay
    d.   Discrete Signals
    e.   Distillation Control With PV Sample Delay
    f.   Distillation Cascade Control With PV Sample Delay
    g.   Analyzer Multiplexing
    h.   Inferential Model-Based Control
    i.   Spike Rejection ii) Frozen Value Check
    j.   PID Scan Time

14) Model Predictive Control and Rule-Based Control
    a.   Types of Process Control Strategies
    b.   Characterizing Process Dynamics In MPC
    c.   Control Matrix
    d.   MPC Algorithm
    e.   Feedback Correction
    f.   Rate of Change
    g.   Multivariable MPC System
    h.   Priority of Controlled Variables
    i.   Local Optimization
    j.   When To Use MPC and When To Use TAC
    k.   When To Use MPC and When To Use TAC
    l.   Analyzing the criteria to select TAC or MPC
    m.   Benefits Due To Advanced Control
    n.   Pros and Cons of MPC Versus TAC
    o.   Operating Zones
    p.   Rule-Based Control and Fuzzy Control
    q.   Types of Advanced Control Tools

15) Handling Nonlinearities
    a.   Linearity
    b.   Valve-To-Flow Nonlinearity
    c.   Gain Scheduling
    d.   Valve Characterization

e. Constraint Control
f. Reflux-To-Product Impurity Nonlinearity
g. Average Temperature Control

Part III: Lab Session (Study Time » 20 Hrs.)

16) Lab Sessions (Practical Exercises)

The various simulation exercises will be conducted with PITOPSÔ industrial process control software. This software accompanies this training module and can be used in a variety of ways. PITOPS^{TM} software consists of two modules - PITOPS-PID and PITOPS-TFI.

PID stands for PID Control Tuning and Design.

TFI stands for Transfer Function Identification.

PID module simulates PID controllers, cascade PIDs, feedforward loops and Dead Time Compensator. Various other features are provided for primary and advanced control tuning and design. TFI module identifies transfer functions using time-series plant data. The following nine lab sessions will be conducted using the PITOPS-PID module and tenth session using PITOPS-TFI module.

1. Configure a transfer function and study open-loop response.
2. Configure a PID loop, simulate a setpoint change, tune the PID.
3. Add random noise to the previous simulation.
4. Configure external disturbances.
5. Tune a Temperature Control PID (TC).
6. Tune a Level Control PID (LC).
7. Tune a cascade PID.
8. Configure Disturbance and Feedforward transfer function.
9. Configure a Model-based Dead-time compensator.
10. Identify a transfer function using simulated plant data.

Guidelines and Recommendations