Advanced Process Control (APC) allows companies to operate their facilities with greater safety, cost effectiveness, reliability and compliance with environmental factors. When jointly used with other unit-operation optimisation technologies, APC can prove to be extremely beneficial.

Optimisation is not a one-time event; it has to be a continuous effort to enhance operating performance in ever-changing conditions.

Yokogawa’s APC Suite delivers rich experiences of the Yokogawa-Shell alliance. With over 80 years of field-proven process control and instrumentation excellence, Yokogawa has established itself as a reliable system integrator with extensive project management, engineering, installation, commissioning and maintenance know-how. Committed to R&D, Yokogawa has earned for itself a solid reputation for delivering quality, reliable and revolutionary solutions.

Our strategic partner, Shell Global Solutions, also extends to you its expertise in APC technologies and operations. With more than 50 years’ experience in providing innovative services and technologies, Shell Global Solutions is continually helping customers improve business performance.

A cut above other packages available in the market, the Yokogawa APC Suite has also been tested in live plants aside from simulation testing in the R&D phase. Presently, our customers worldwide are enjoying the APC benefits and improved profitability from the Yokogawa APC solutions.
Easy Model Development for Advanced Process Control

In a typical model-based Advanced Process Control (APC) project, 25% to 50% of the implementation time is spent in the process testing and model identification phases. AIDA® is the Shell Global Solutions offline package for the estimation of linear dynamic process models required to implement a model predictive control application, such as SMOC®. It makes the intricate science of model identification available in an easy-to-use package and saves valuable project implementation time.

Confidence band from plots windows

Reasons to Use AIDA®

Some of its features include: Advanced Identification Technology - AIDA® is computationally fast. Its robust computation engine can process large datasets with unmeasured disturbance effects, and can identify models from both open- and closed-loop data.

Modeling Flexibility

Models can be obtained in two ways:
- Finite Impulse Response (FIR) fit followed by a parametric reduction
- Direct parametric fit of models to data

Flexible approach to model identification

Focus on Efficiency

AIDA® is designed to expedite the tasks performed during the course of a model identification analysis. AIDA® has a comprehensive reporting, project documentation, and "bookkeeping" functions.

Data Import

AIDA® includes a versatile data import capability, designed to work with a variety of formats. Plant data can also be retrieved directly from data historians via the Process Variable Retriever (PVR).

Data Analysis and Pre-processing

AIDA® has powerful trending capabilities. Data segmentation and bad data handling can be performed graphically. A wide variety of built-in calculations are also included.

Ease-of-use

An AIDA® workspace is a collection of process data, identification studies, and assembled models. It serves as a single-project archive and simplifies controller model maintenance. AIDA® is integrated with our process control software suite, sharing of objects between the various products, and also in its underlying modeling philosophy.

Incorporating Process Knowledge

Users can perform constrained model identification using prior process knowledge. This can include setting gain, time constants, and dead time within bounds.

Grey Box Modeling

The knowledge of cause-effect relationships can be incorporated during the process of model identification ("grey-box modeling").

Grey box modeling based on cause & effect structure and measure data regression

Unmeasured Disturbance Modeling

Rejecting unmeasured disturbances is one of the main functions of closed loop control. Unmeasured disturbances include measurement noise, sensor drift, changing ambient identification, some controller parameters (for example, Gains), are incorrectly estimated. This could result in overly aggressive control action. AIDA® allows factoring in unmeasured disturbance effects during model identification.

Fit Statistics

AIDA® provides statistical 95% confidence intervals for the estimated step responses and model parameters. Residual trends and goodness-of-fit tests, such as, residual auto- and cross-correlation analysis, can be used to check the quality of models.

Model validation and identification result

Model Validation and Selection

AIDA® can be used to build several different models and their predictions can be compared against actual data. Models are easily constructed by mixing and matching various identification results. Final models are exported to SMOC® for online configuration.
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**Graphical User Interface**

The AIDAPro interface includes tools for data collection, preprocessing, model identification, and model validation. It also features a comprehensive reporting and documentation system.
SMOC™ Pro is the Shell Global Solutions software package for the implementation of multivariable optimizing control strategies. SMOC™ Pro provides all the tools necessary to design, implement and maintain advanced multivariable controllers. This is to improve your plant stability and maximize plant profitability for the hydrocarbon processing and chemical industries.

Better control allows operation closer to "true" process limits

Applications
SMOC™ Pro has been successfully applied in over 800 projects worldwide on crude distillation, fluidized catalytic cracking, hydro cracking, lube oil, styrene, ethylene oxide/ethylene glycol plants and other major refinery and petrochemicals units.

SMOC™ Pro can be used to safely push a unit towards its constraints, maintain key operating variables at desired targets, while maximizing the profit function with all available operating handles.

Refinery Case Study:
At a European refinery, the Fluid Catalytic Cracking Unit (FCCU) was constrained by the Catalyst Circulation Rate (CCR). This constraint was not only holding back the throughput in the FCCU, but also restricted the overall refinery capacity. A SMOC™ Pro controller was commissioned to alleviate this constraint and increase unit throughput. The controller achieved an impressive improvement of around 1 ton/min in CCR, raised the unit throughput and met all the performance guarantees. It also exceeds the 95% average uptime required by the client.

Summary of SMOC™ Pro Features
- Parametric models
- Grey box modeling (via intermediate variables)
- Robust unmeasured disturbance model
- Powerful scenario-based simulation environment
- Optimization via bilinear QP or external targets
- Dynamic constraint handling
- Easy to use graphical model builder
- Updatable models for use in blending applications

SMOC™ Pro Offline
The dynamic models used by a SMOC™ Pro controller can be built either in a matrix format using a Microsoft Windows based package (AIDA™) and/or a flow sheet using the Graphical Model Builder (GMB) available in the SMOC™ Pro offline package. Offline configuration tools are also provided to design, test and build SMOC™ Pro controllers. The SMOC™ Pro offline package generates the on-line controller implementation file. SMOC™ Pro offline package features a powerful simulation environment to test the controller behavior. Scenario based simulations can be used to test tuning, robustness to model errors and optimization performance.

SMOC™ Pro Online
The SMOC™ Pro online package includes the online controller engine, and tools for signal validation, controller initialization, mode shedding, and a standard operator and engineer interface. SMOC™ Pro online controller interfaces to variety of OPC compliant DCS platforms.

SMOC Graphical Model Builder (GMB)
Stabilize Your Plant and Maximize Its Profit

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SMOC™ Graphical Model Builder (GMB)
Predict Product Quality for Better Control

Inferred measurements are calculations used to predict the current value of a critical product property when it is not measured online or only measured infrequently.

**ROEPro**

Robust Quality Estimator is the Shell Global Solutions technology for design and implementation of inferred measurements for process monitoring and control. An **ROE™** inferred measurement is typically calculated using selected process variable such as temperature, pressure, and flow. The **ROE™** technology is used extensively in many refineries and chemical sites around the world. Typical applications in the hydrocarbon industry include:

- ASTM boiling point temperatures
- Cold properties
- Flash point
- Reid Vapor Pressure (RVP)
- Road Octane Number (RON)
- Impurity content in various streams
- Melt index for polymerization processes

**Reasons to Use ROEPro**

**ROE™** uses a unique online model calibration technique to make the predicted property value accurate and robust. It has a greatly expanded ability to perform intermediate calculations and include them as model inputs. Users can develop cascaded predictors and calculations within a single application, and can validate laboratory results prior to model calibration through an interactive data entry display.

**ROE™** includes a blending rules library and tools for tank quality estimation for use in various blending applications. It can also linearize non linear models, such as blending rules, and pass updated gains to an online SMOG™ controller model.

**ROEPro Configurations**

As an analyzer predictor, **ROE™** gives an early prediction of an analyzer signal to boost the performance of your multivariable predictive control application. It makes the control scheme robust against varying dead time, uncertain dynamics, and process non-linearity. As a virtual analyzer, **ROE™** can be used as a replacement for an online analyzer, when it is not economical or when it is not technically feasible. Feedback from laboratory results is continuously used to keep the **ROE™** internal prediction model accurate.

**ROEPro Off-line Package**

The **ROE™** offline package is a Microsoft Windows-based graphical package for the easy design and maintenance of inferred measurements. To create inferred measurements, users can select data analysis options ranging from multivariable regression to advanced modeling techniques such as Partial Least Squares (PLS) and neural networks. The **ROE™** offline package also includes a configuration wizard for generating the online implementation file.

**ROEPro Simulation Tool (RQESimPro)**

**RQESim™** is an intuitive, user-friendly offline simulation package for testing the performance of **ROE™** applications. It provides process control engineers the ability to tune **ROE™** applications created, using the **ROE™** offline package. **RQESim™** provides troubleshooting tool for existing **ROE™** applications. When used as a maintenance tool, **RQESim™** can monitor model update frequency, prediction errors, Quality Measurement Indicator (QMI) spike filtering and other tuning parameters in the application.

**ROEPro On-line Package**

**ROE™** online package is a stand-alone product, but is fully integrated with our other Advanced Process Control products. **ROE™** online package includes all the functionalities required for the robust and reliable online implementation of inferred measurements, such as online model calibration from analyzer and laboratory measurements. The **ROE™** online package has been rolled out on many major DCS platforms and is OPC compliant.

**Refinery Case Study:**

At a European refinery, a toluene/benzene splitter column had a stringent specification on the amount of toluene impurity in the benzene product. The specification limit was frequently exceeded, and the product had to be reprocessed, leading to a reduction in overall unit throughput. The online analyzer used to measure the impurity had a significant delay in detecting changes in the quality of the product. This was due to its location in the process and the analyzer sampling frequency. The advanced control application, as a result, was not robust in rejecting process disturbances. The controller was modified to include an **ROE™** analyzer predictor of the benzene product quality. This allows for an estimation of the benzene quality without waiting for the delay of the on-line analyzer. The right figure shows the improvement in performance of the controller after the **ROE™** predictor for benzene quality was included in the control loop. Incorporating the **ROE™** inferred measurement in the control application led to a record production that year for the unit, despite a major planned plant shutdown in the refinery.

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MDPro is the Shell Global Solutions software suite for monitoring all base level and commercially available multivariable control systems. It also features off-line applications that can be used to perform advanced diagnostics on all single output and multivariable control loops, and another for analyzing PID loops only. MDPro technology is being used extensively in many refineries and chemical sites around the world.

Control Performance Monitoring
It is generally recognized that Advanced Process Control (APC) generates large economic benefits. The achieved benefits are a direct function of the control system utilization and of its actual performance. Base layer controls, instruments and analyzers must also perform correctly to ensure high APC utilization and profit.

Reasons to Use MDPro
Following is a partial list of features that make MDPro the tool of choice for monitoring controller performance:
- Any type of commercially available multivariable controller can be monitored.
- Multiple input data formats and historian systems are supported, for example, PI, InfoPlusX, ExaQuantum, PHD, and IP21.
- Fast calculation and data handling allows a large number of loops to be analyzed in a short period of time.
- Diagnostic measures and statistics, such as, closed loop speed of response, can be compared with user-defined benchmarks.
- The technology and the user interface are easy to use and understand, and comprehensive on-line help is included.
- Loop reports can be shared using standard MS Windows applications.
- Automatic, exception-based performance reports distribution via e-mail.
- PID tuning is available based on the desired response time.

MDPro Performance and Benefits Statistics
PONC (price of non-conformance) is the lost opportunity cost associated with process or controller downtime. PONC is the difference between the maximum daily benefit and the realized daily benefit.

- % Uptime: The amount of time that a particular controlled variable (CV) is “on control” during the day.
- % In-service: The amount of time during the day that a CV was operational or available for control.
- % In-compliance: The amount of time during the day that a CV was on control and within a pre-specified tolerance of its set point or set range.

MDPro Offline Package
The MDPro offline package can be used to analyze the performance of single-input, single-output controllers and multivariable controllers. The MDPro Offline package uses statistical methods to extract the essential control performance information from a loop’s set point, process value and output trends. This saves the control engineer from the inefficient and time consuming process of viewing hundreds of raw data trends in detail.

MDPro Online Package
The MDPro online is a client/server system for monitoring plant wide controller performance. It has been designed to operate on a typical business network, as shown in the figure below.

A wide variety of summary reports are available:
- Location summary: A summary of control performance for the entire facility, with uptime, compliance and in service statistics presented for each process unit.
- Bad actors: Two lists of the worst performing CVs in the facility ranked by consecutive days of not meeting objectives. The first list applies to CVs that are in-service, and the second list applies to CVs that are out-of-service (sample in the figure below).
- Unit escalation: A list of the controlled variables in a unit that are not meeting user defined control performance objectives.
- On-demand reports: Customizable summary reports consisting of all control performance and benefits statistics over a user-defined time period.
- Refinery Case Study: A Canadian 100-kbpd refinery estimated annual benefits of $100,000 by increased %compliance and %uptime through using MDPro.

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COAST is an advanced process control algorithm developed by SHELL OIL based on their long experience of plant operation. Among them following algorithms are implemented in CENTUM CS 3000 as an optional function:
• Shell Surge Volume Controller (ZSSVC)
• Furnace Pass/Coil Balance (ZBALACE)
• Column Tray Loading (ZCTL)
• Measurement Validation Comparison (ZMVC)

Types of COAST Control Blocks
COAST Control Blocks include Shell Surge Volume Controller, Furnace Pass/Coil Balance, Column Tray Loading, and Measurement Validation Comparison.

Shell Surge Volume Controller
The Shell Surge Volume Controller (hereinafter called the SSVC) steadily controls the liquid level in the surge vessel. The purpose is to minimize changes in the outlet flow/inlet flow. Though it controls volume, to an operator it appears to be a standard level controller. The algorithm is designed to work for horizontal cylindrical vessel or vertical vessels of constant cross-section.
The SSVC stabilizes the flow out of or into a vessel by allowing the vessel level to “swing” between high and low limits. This allows disturbances in the uncontrolled flow to be rejected. The controller also brings the level back to a set point during the periods of steady-state operation.

Furnace Pass/Coil Balancing
The Furnace Pass/Coil Balancing Algorithm (hereinafter called the ZBALACE) receives the desired total flow and distributes it among furnaces and cells as the result of balancing calculation. The ZBALANCE can cover up to two furnaces each with up to two cells (chambers). Each cell may have up to 16 passes (coils). Each pass may have up to 5 skin temperatures. As such, the ZBALANCE reads process data, i.e. pass flow, pass temperature, skin temperature etc. and executes balancing calculation so as to accomplish the common coil outlet temperature among individual passes within a furnace cell.

Column Tray Load Algorithm
The Column Tray Load (CTL) Algorithm (hereinafter called the ZCTL) provides the monitoring data of the one (1) tray of the column. When the user wants to see the operating data of another tray, another ZCTL shall be applied. The ZCTL receives four (4) measurement (liquid and vapor mass flow rates, column pressure and tray temperature) and provides eight (8) outputs as the result of execution of the ZCTL.

Measurement Validation and Comparison
The Measurement Validation and Comparison Algorithm (hereinafter called the ZMVC) contains two portions, i.e. “validation” and “comparison.” The ZMVC has two analog input terminals through which analog data are collected. The data may come through analog input cards, from other function blocks or through sub-system communication. The validation function may be applied to the data from each of the two terminals independently.

When two transmitters measure the same process variable, the ZMVC reads the two transmitter’s readings, and makes comparison. The comparison is realized through CUSUM calculation. Deviations between two transmitter’s readings above a reference value are continuously accumulated, and when the accumulated value (CUSUM value) exceeds a certain limit, an alarm results.
The ZMVC is one of the function blocks of the Field Control Station, similar to other function blocks such as PID controller, PVI indicator and so on. The operator can manipulate the ZMVC through a faceplate. Also for the engineer, configurations including the ZMVC can be made through CAD based engineering functions in the same manner as those for other function blocks.
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The ZCTL receives four (4) measurement (liquid and vapor mass flow rates, column pressure and tray temperature) and provides eight (8) outputs as the result of execution of the ZCTL.

Measurement Validation and Comparison

The Measurement Validation and Comparison Algorithm (hereinafter called the ZMVC) contains two portions, i.e. “validation” and “comparison.” The ZMVC has two analog input terminals through which analog data are collected. The data may come through analog input cards, from other function blocks or through sub-system communication. The validation function may be applied to the data from each of the two terminals independently.

When two transmitters measure the same process variable, the ZMVC reads the two transmitter’s readings, and makes comparison. The comparison is realized through CUSUM calculation. Deviations between two transmitter’s readings above a reference value are continuously accumulated, and when the accumulated value (CUSUM value) exceeds a certain limit, an alarm results.

The ZMVC is one of the function blocks of the Field Control Station, similar to other function blocks such as PID controller, PVI indicator and so on. The operator can manipulate the ZMVC through a faceplate. Also for the engineer, configurations including the ZMVC can be made through CAD based engineering functions in the same manner as those for other function blocks.
Benefits-oriented APC Suite for Your Processes

Advanced Process Control (APC) allows companies to operate its facilities with greater safety, cost effectiveness, reliability and compliance with environmental factors. When jointly used with other unit-operation optimisation technologies, APC can prove to be extremely beneficial. Optimisation is not a one-time event; it has to be a continuous effort to enhance operating performance in ever-changing conditions.

Yokogawa’s APC Suite delivers rich experiences of the Yokogawa-Shell alliance. With over 80 years of field-proven process control and instrumentation excellence, Yokogawa has established itself as a reliable system integrator with extensive project management, engineering, installation, commissioning and maintenance know-how. Committed to R&D, Yokogawa has earned for itself a solid reputation for delivering quality, reliable and revolutionary solutions.

Our strategic partner, Shell Global Solutions, also extends to you its expertise in APC technologies and operations. With more than 50 years’ experience in providing innovative services and technologies, Shell Global Solutions is continually helping customers improve business performance.

A cut above other packages available in the market, the Yokogawa APC Suite has also been tested in live plants aside from simulation testing in the R&D phase. Presently, our customers worldwide are enjoying the APC benefits and improved profitability from the Yokogawa APC solutions.