

PETRONAS TECHNICAL STANDARDS

Advanced Process Control Implementation Guide

PTS 20.00.20.39

JULY 2011



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PTS Circular 2011 – 1	PETRONAS 
PTS No:	20.00.20.39
PTS Title:	Advanced Process Control Implementation Guide

This revision of **20.00.20.39 – Advanced Process Control Implementation Guide (July 2011, Revision 1)** has been updated to incorporate PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards. All updates in the document are highlighted in *italic* font.

The previous version of this PTS **20.00.20.39 (Dec 2008)** will be removed from PTS binder / e-repository from herein onwards.

This PTS also includes PETRONAS Lessons Learnt and PETRONAS Best Practice for the subject matter Advanced Process Control Implementation Guide.

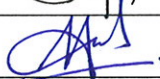
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Revision History

Rev No.	Reviewed by	Approved by	Date
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PREFACE

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1 INTRODUCTION

1.1 OBJECTIVE

The objective of this document is to provide a standard guideline for implementing Advanced Process Control applications, specifically Multivariable Predictive Controllers and Inferentials in PETRONAS operating units. It is intended for use by PETRONAS and Vendor when preparing to embark on an Advanced Process Control project in the plants and also during the operation and maintenance of the system.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by PETRONAS, the distribution of this document is confined to companies forming part of or managed by PETRONAS, and to Contractors and Manufacturers/Suppliers nominated by them.

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1.3 DEFINITIONS

1.3.1 General Definitions

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier/Vendor** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word “**shall**” indicates a requirement.

The word “**should**” indicates a recommendation.

1.3.2 Specific Definitions

Controlled Variables (CV)

Dependent variables that are to be controlled to targets and/or kept within constrained limits.

Dependent Variable

The observed result of the independent variable being manipulated.

Disturbance Variables (DV) or Feed Forward Variables (FF)

Independent variables (measurable) that affect the process which are not manipulated in the controller.

Independent Variable

It is the variable representing the value being manipulated or changed.

Multivariable Predictive Controller (MPC)

A MPC application manipulates several setpoints and/or valve positions simultaneously to achieve its control objectives. It employs a model predictor containing dynamic models of the process which predicts the process behavior in the future and responds accordingly to actual or anticipated moves in the process.

Manipulated Variables (MV)

Independent variables that are manipulated to achieve desired results (the results are typically a controlled variable). This may be in the form of a setpoint to a control loop or may be an output sent directly to a control valve.

Inferential

It is a technique of utilising secondary variables in a process to estimate the value or 'property' of the primary or key variable, e.g. utilising properties such as temperatures and pressures to estimate product composition. This technique provides an instantaneous/real-time value of the key variable. It is also known as Quality Estimator (QE), Inferred Property (IP).

Time constant (τ)

Time for the process to reach 63.2% of its final value after a manipulation of valve affecting the process.

Time to steady state (TTSS)

Time taken for the process to settle after a change in an independent variable. Typically, it is four (4) times the time constant, τ .

1.3.3 Abbreviations

APC	Advanced Process Control
ARC	Advanced Regulatory Control
BLC	Base Layer Control
CV	Controlled Variable
DCS	Distributed Control System
DV	Disturbance Variable
FAT	Factory Acceptance Test
FCCU	Fluid Catalytic Cracking Unit
FF	Feedforward
IRC	Intermediate Regulatory Control
MPC	Multivariable Predictive Controller
MV	Manipulated Variable
PFD	Process Flow Diagram
P&ID	Piping and Instrumentation Diagram
PVO	Product Value Optimisation
RVP	Reid Vapour Pressure
SAT	Site Acceptance Test
SPC	Statistical Process Control
SRM	<i>Step Response Model</i>

1.4 PROCESS UNDERSTANDING

The backbone of any successful MPC applications is a clear understanding of the process. This is necessary in order to develop a good representation of the process and to formulate plant step test strategy. Process knowledge in this context refers to:

- i) *Understanding the objective of the process*
- ii) *Understanding the key economic drivers of the process*
- iii) *Understanding the process flow (or the means by which the process objective is met)*
- iv) *Understanding process steady state (typically at maximum/target production)*
- v) *Understanding process dynamic stability*
- vi) *Understanding control points, constraints and disturbances*
- vii) *Understanding the process handles*

The process knowledge should be obtained by

- in-depth discussion with process technologists and operations personnel, production/economic planners and instrument personnel
- reference to similar plant/process technology
- reference to design basis documents/manuals, PFDs, P&IDs, DCS schematics, operation philosophy and controller narratives documentation
- running process steady-state simulator of the plant, if available

Refer to Appendix A for a typical list of queries.

1.5 TECHNOLOGY UTILISATION IN PETRONAS

There are many APC providers in the market and most are comparable with one another. Two APC providers shall be utilised, i.e.

<u>Vendor</u>	<u>APC Technology</u>
i. Honeywell	Profit Controller / Robust Multivariable Predictive Control Technology (RMPCT)
ii. Yokogawa	Shell Multivariable Optimising Controller (ExaSMOC)

Exceptions apply to specialised applications, such as in highly non-linear processes.

The following is the list of sites in PETRONAS that has APC applications installed:

<u>Operating Unit</u>	<u>APC Provider</u>
PETRONAS Penapisan (Melaka) Sdn. Bhd.	Honeywell
PETRONAS Penapisan (Terengganu) Sdn. Bhd.	Honeywell/Yokogawa
Aromatics Malaysia Sdn. Bhd.	Honeywell/Yokogawa
Malaysia LNG Sdn. Bhd. (1, 2 and 3)	Yokogawa
<i>PETRONAS Ammonia Sdn. Bhd.</i>	<i>Yokogawa</i>
PETRONAS Gas Berhad	Yokogawa
<i>PETRONAS Methanol Labuan Sdn. Bhd.</i>	<i>Yokogawa</i>
Ethylene Malaysia Sdn. Bhd.	AspenTech
<i>OPTIMAL Group of Companies</i>	<i>AspenTech</i>
<i>Petlin (Malaysia) Sdn. Bhd.</i>	<i>AspenTech</i>
MTBE/Polypropylene Malaysia Sdn. Bhd.	Invensys, Axens, Dow

2 PERSONNEL INVOLVEMENT FROM SITE

An APC project requires involvement from APC engineers, production/economic planners, operations personnel, process technologists, instrumentation/systems engineers and others. They may not be involved full-time but their input is crucial for the success of the project.

The following table lists the typical roles and responsibilities during each project phase:

Project Phase	Main Responsibility	Supporting Role
Feasibility studies	Experienced APC leader	APC engineer, production/economic planner, operations personnel, process technologists, instrument/systems engineer
Controller basic design	APC leader	APC engineer, operations personnel, process technologists
Base layer performance review and improvement work	APC engineer, instrumentation/systems engineer	APC leader, operations personnel, field technician, process technologists,
Inferential model building (if any) or validation	APC engineer	APC leader, <i>chemists</i>
Plant pre-test	APC leader, APC engineer, operations,	Field technician, instrumentation/systems engineer, production/economic planner
Final controller design	APC leader	APC engineer, production/economic planner, operations personnel, process technologists
Plant step test	APC leader, APC engineer, operations	Operations personnel, <i>chemists</i> , instrumentation/systems engineer,
Dynamic model identification	APC engineer	APC leader
Dynamic model review (during FAT)	APC leader, APC engineer,	Operations personnel, process technologists
Controller building	APC engineer	APC leader
Off-line simulation and tuning (during FAT)	APC engineer	APC leader, operations personnel, process technologists
On-line installation	APC engineer	APC leader, instrumentation/systems engineer,
Commissioning and tuning	APC leader	APC engineer, operations personnel,
Site Acceptance Test (SAT)	APC leader	APC engineer, operations personnel, instrumentation/systems engineer,
Operator training	APC engineer	APC leader
Performance test run / Project wrap-up / post commissioning review	APC leader, APC engineer	Production/economic planner, operations personnel, process technologists
Monitoring and Maintenance	APC leader, APC engineer	Operations personnel, process technologists

APC Leader, and APC engineers are involved at each and every phase of the project. At the end of the project implementation, they will produce operator training material, maintenance guidelines and references to ensure the APC can be maintained properly.

APC Leader roles during the following stages are:

Phase	Roles
<i>Feasibility studies</i>	• Conduct feasibility study to quantify benefits of implementing APC • Conduct APC readiness assessment • Design a preliminary control matrix
<i>Controller basic design</i>	<i>Lead the development of preliminary controller design to determine the MVs, CVs and DVs as well as the operating envelope</i>
<i>Base layer performance review and improvement work</i>	• Lead the performance review of base layer controls • Lead rectification work on base layer controls
<i>Inferential model building (if any) or validation</i>	• Identify the necessary lab data/analyser and verify their accuracy • Lead inferential model development or validation
<i>Plant pre-test</i>	<i>Lead pre-test</i>
<i>Final controller design</i>	<i>Finalise controller design</i>
<i>Plant step test</i>	<i>Lead the development of steptest methodology</i>
<i>Dynamic model identification</i>	<i>Lead the dynamic model identification phase</i>
<i>Dynamic model review (during FAT)</i>	<i>Lead the dynamic model review</i>
<i>Controller building</i>	<i>Lead the controller building exercise</i>
<i>Off-line simulation and tuning (during FAT)</i>	<i>Lead offline simulation and tuning exercise</i>
<i>On-line installation</i>	<i>Lead installation works</i>
<i>Commissioning and tuning</i>	<i>Lead the controller commissioning and tuning exercise</i>
<i>Site Acceptance Test (SAT)</i>	<i>Lead the testing of the controller on-site</i>
<i>Operator training</i>	<i>Develop training material and conduct operator training</i>
<i>Performance test run / Project wrap-up / post commissioning review</i>	• Conduct performance test or conduct post-implementation review to quantify benefits • Close-out project by finalising APC documentation (As-built documentation)
<i>Monitoring and Maintenance</i>	• Ensure APC is monitored according to PTS 20.00.20.10 for sustainable benefits • Define appropriate maintenance strategies for site to implement

APC Engineer roles during the following stages are:

Phase	Roles
Feasibility studies	- Gather data for feasibility study - Assist in conducting APC readiness assessment
Controller basic design	Selection of MVs, CVs and DVs
Base layer performance review and improvement work	- Gather data for performance review of base layer controls - Conduct analysis for performance review - Assist rectification work on base layer controls
Inferential model building (if any) or validation	- Check accuracy of lab data/analyser - Develop inferential model or conduct validation in any existing model
Plant pre-test	Conduct pre-test to gather information on process dynamics and to finalise controller design
Final controller design	Consolidate information from APC team to finalise controller design
Plant step test	Develop step test methodology
Dynamic model identification	Gather data to conduct dynamic model identification
Dynamic model review (during FAT)	Conduct dynamic model review
Controller building	Build offline controller
Off-line simulation and tuning (during FAT)	- Develop scenarios for offline simulation - Conduct offline simulation and tuning for the controller
On-line installation	- Install controller into an online system (APC server) - Define necessary configuration works on DCS system (coding for watchdog, shed manager) - Define required graphic modification - Check communication between DCS and APC controller is healthy
Commissioning and tuning	- Develop procedure for controller commissioning - Fine-tune APC controller
Site Acceptance Test (SAT)	Develop SAT procedure
Operator training	Assist in developing training material and in conducting operator training
Performance test run / Project wrap-up / post commissioning review	- Develop procedure for performance test-run (if necessary) - Consolidate information during performance test or during post-implementation review to quantify benefits - Prepare APC documentation (As-built documentation)
Monitoring and Maintenance	Prepare templates for continuous monitoring of APC health as per PTS 20.00.20.10 for sustainable benefits

Operations roles during the following stages are:

Phase	Roles
Feasibility studies	Feedback on process operations and constraints
Controller basic design	Selection of MVs, CVs and DVs
Base layer performance review and improvement work	Feedback on controller performance
Plant pre-test	- Recommend step size, make step changes and monitor plant <i>Ensure sampling is carried out and time-stamped correctly</i>
Final controller design	Finalise selection of MVs, CVs and DVs
Plant step test	- Recommend step size, make step changes and monitor plant <i>Ensure sampling is carried out and time-stamped correctly</i>
Dynamic model review (during FAT)	Verify model against actual plant behaviour
Off-line simulation and tuning (during FAT)	Verify control action against normal operating practise
SAT	<i>Verify model against actual plant behaviour, Verify control action against normal operating practise</i>
Operator training	Attend and understand operation with APC
Performance test run / Project wrap-up / post commissioning review / <i>Monitoring and Maintenance</i>	Monitor and feedback on controller performance

Process technologists involvement is typically as follows:

Phase	Roles
Feasibility studies	Feedback on process operations, constraints, design basis
Controller basic design	Advise selection of MVs, CVs and DVs
Base layer performance review and improvement work	Feedback on controller performance and provide control philosophy
Final controller design	Finalise selection of MVs, CVs and DVs
Operator training	Attend and understand of operation with APC

Production/economic planners involvement is typically as follows:

Phase	Roles
Feasibility studies	- Setting of economic objectives - Providing economic variables and other data for benefits estimation
Controller basic design	Provide feedback where optimisation issues are involved
Plant pre-test	<i>Advise window for pre-test</i>
Plant step test	<i>Advise window for step test</i>
Performance test run / Project wrap-up / post commissioning review (SAT) /	<i>Advise window for step test</i>