



Engineering Procedure

SAEP-364

25 January 2006

Process Simulation

Model Development and Support

Document Responsibility: Process & Control Systems Department

Saudi Aramco Desktop Standards

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1 Scope

This procedure establishes a framework within Saudi Aramco for acquiring, developing and properly documenting steady state process simulation models for new and existing facilities. The procedure will provide guidelines describing the minimum requirements for process simulation models development and also define the minimum acceptable supporting documentation.

2 Applicable Documents

To ensure compliance with the appropriate Saudi Aramco and International Standards and Codes for process vessels and equipment, the following Engineering Standards shall be reviewed during model development. These Standards encompass pressure vessels, distillation columns, relief systems, compressors, pumps and in-plant piping, design pressure, materials, and operating conditions.

- Saudi Aramco Recommended Process Simulation Software Vendor List

Saudi Aramco Engineering Procedures

<i>SAEP-302</i>	<i>Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement</i>
<i>SAEP-303</i>	<i>Engineering Reviews of Project Proposal and Detail Design Documentation</i>
<i>SAEP-1610</i>	<i>Preparation of Functional Specification Documents</i>

Saudi Aramco Engineering Standards

<i>SAES-C-001</i>	<i>Process Design of Trays and Packing</i>
<i>SAES-D-001</i>	<i>Design Criteria for Pressure Vessels</i>
<i>SAES-D-100</i>	<i>Design Criteria of Atmospheric and Low-Pressure Tanks</i>
<i>SAES-D-109</i>	<i>Design of Small Tanks</i>
<i>SAES-E-004</i>	<i>Design Criteria of Shell and Tube Heat Exchangers</i>
<i>SAES-E-006</i>	<i>Design Criteria of Double Pipe Heat Exchangers</i>
<i>SAES-E-007</i>	<i>Design Criteria of Air-Cooled Heat Exchangers</i>
<i>SAES-E-014</i>	<i>Design Criteria of Plate and Frame Heat Exchangers</i>

<i>SAES-E-015</i>	<i>Design Criteria of Electric Heat Exchangers</i>
<i>SAES-F-001</i>	<i>Design Criteria of Fired Heaters</i>
<i>SAES-G-005</i>	<i>Centrifugal Pumps</i>
<i>SAES-G-006</i>	<i>Positive Displacement Pumps - Controlled Volume</i>
<i>SAES-G-007</i>	<i>Submersible Pumps and Motors for Water Well and Offshore Service</i>
<i>SAES-K-402</i>	<i>Centrifugal Compressors</i>
<i>SAES-K-403</i>	<i>Reciprocating Compressors</i>
<i>SAES-K-501</i>	<i>Steam Turbines</i>
<i>SAES-K-502</i>	<i>Combustion Gas Turbines</i>
<i>SAES-L-100</i>	<i>Applicable Codes and Standards for Pressure Piping Systems</i>
<i>SAES-L-140</i>	<i>Thermal Expansion Relief in Piping</i>
<i>SAES-L-310</i>	<i>Design of Plant Piping</i>

3 Instructions

3.1 General Requirements

- 3.1.1 Any conflicts between this standard and other applicable Saudi Aramco Engineering Standards (SAESs) or industry standards, codes, and forms shall be resolved in writing through the Manager, Process & Control Systems Department of Saudi Aramco, Dhahran.
- 3.1.2 Direct all requests to deviate from this standard in writing to the Company, who shall follow internal company procedure SAEP-302 and forward such requests to the Manager, Process & Control Systems Department of Saudi Aramco, Dhahran.
- 3.1.3 PMT shall provide a copy of this Engineering Procedure to the engineering design contractor involved in the development of process simulation models and instruct him that he shall comply with the requirements in this Procedure.
- 3.1.4 The engineering design contractor shall utilize one of the approved process simulation packages, defined in the Saudi Aramco Recommended Process Simulation Software Vendor List.

- 3.1.5 At the completion of studies, the engineering design contractor shall submit an electronic copy of the completed models and supporting documentation to P&CSD/P&SU. P&CSD/P&SU shall be responsible for adding the new models to the Simulation Model Library and for ongoing support and maintenance.

3.2 Process Model Applications

The purpose of the model will determine the extent of the process system to be modeled and the accuracy of data required during model development and model validation steps. The categories listed below, represent a summary of the rationale considered when developing process simulation models. The categories can be incorporated together under a single banner known as the "Process Model Life Cycle".

3.2.1 Models for Design

Models shall be developed to support construction of new plants.. These models are constructed using conceptual design data and basic engineering relationships such as mass and energy balances, phase and chemical equilibrium, and reaction kinetics. The extent of the model improves with time as it is used initially for a non-rating case, then a rating case, and finally, if required, controls systems design and analysis. During this life cycle development, the model may transition from a steady state basis, to a model that is used to study process dynamics.

3.2.2 Models for Operational Analysis

Existing models that were developed for design purposes, and are available within a simulation model library, can be re-used to study operational problems in the plants. These models, depending on the nature of the study, could be used without modification. However, if plant data is available, the models shall be validated against plant operating data. This is an exercise that shall be repeated if significant deviations occur between the plant and the model due to elapse of time and/or changes to the plant process. The validated models shall support studies associated with; 1) trouble-shooting; 2) an expansion or change to the process system; or 3) a change to the operating philosophy.

3.2.3 Models to Support Planning

Use validated process simulation models to support the economics and planning functions by generating input data for linear programming (LP) models in common use by Planners and Schedulers. The LP programs help to create economic plans and schedules that enable refineries and/or

petrochemical plants to run at maximum efficiency. The rigorous process model improves the quality of the data used by the LP program to develop plans that vary in length, but are typically weekly, monthly, or yearly.

3.2.4 Proprietary Models to Support New Technology Evaluation

Simulation studies can aid the evaluation of new technologies. Under this category, it may be necessary to collaborate with the simulation vendor to modify the simulator to enable the new process to be evaluated. A study will help to identify the benefits of the new technology before a capital procurement program is established. It may be necessary to modify the software license agreement to account for the addition of this new capability and to protect the intellectual property of Saudi Aramco.

3.2.5 Models to Support Online Applications

Use the steady state process model in an on-line environment to improve the monitoring of plant variables or to optimize plant operations. An additional benefit is that the accuracy of the process model is continuously enhanced. Following each scan of process measurements, the on-line model is automatically updated by adjusting model parameters that are shown to have changed from previous scans. The real time model determines that the change is warranted by using sophisticated error detection and elimination techniques on process measurements.

3.3 **The Scope and Fidelity of the Process Model**

The model shall include all major process equipment. Model boundaries shall be established such that boundary constraints do not affect the accuracy of the solution. Depending on the problem definition, models shall be developed to support; 1) design; 2) operational analysis; 3) planning; 4) customized models; 5) new technology evaluation; 6) online applications.

3.4 **Data Required to Support Model Development**

The following list includes, but not limited to, data that shall be collected before a process model is developed:

3.4.1 Specify the chemical components in the process. If modeling includes production facilities, use crude assays to define components.

3.4.2 Identify the Unit operations in the process and collect the critical modeling parameters for each Unit operation.

- 3.4.3 Identify the process streams.
- 3.4.4 Establish the thermodynamic models to represent the physical properties of the components and the mixtures.
- 3.4.5 Establish component flow rates and thermodynamic conditions of feed streams such as temperature and pressure.
- 3.4.6 Collect design and performance sheets for major pieces of equipment to be included in the model.
- 3.4.7 Units of measurements must be consistent.

During model development, there will be a constant interaction between the extent of the model and the increasing quality and quantity of data required to support it. The completed model will reflect a trade-off between model accuracy and the cost to develop it.

3.5 Model Development Guidelines

General guidelines can be followed that will lead to building successful models in every instance. The technique of process modeling is enhanced by the following:

- 3.5.1 Good definition of the process application.
- 3.5.2 Define the essential features of the model.
- 3.5.3 Establish basic assumptions that characterize the system.
- 3.5.4 Enhance the model in a series of modeling steps until satisfactory results are reached.

3.6 Model Validation

A difference between model results and plant measurements can be attributed to modeling assumptions that simplify the process and the accuracy and repeatability of instruments. Model validation can be conducted in two phases. The first validation exercise can be conducted against an existing design-case model if it exists. There should be good agreement between the existing model and the new model. Differences should be less than 2% on heat and material balances and the compositions of the streams. The second validation exercise can be conducted against the plant operating data. Differences between model results and plant data will be dependent on the process being modeled and the accuracy of the instruments. On a relative basis, differences between measured

pressures and temperatures shall be less than differences between measured flows and measurements from analyzers providing compositions of streams.

3.7 Model Robustness

To run new cases effectively, the simulator shall be capable of solving new cases by altering process variables in an existing converged solution. The ability of the simulator to reach a converged solution within reasonable time, following a change to process variable(s), is a measure of the robustness of the simulator. The robustness of a simulator is affected by:

- 3.7.1 The thermodynamic characterization of the system
- 3.7.2 The numerical solution
- 3.7.3 The sensitivity of the model
- 3.7.4 The complexity of the model

Simulators that reach a converged solution within reasonable time following a 5% step change, or greater, of process variable(s) shall be defined as robust.

3.8 Model Documentation

Documentation to support the process simulation model shall be provided at the completion of the study. This will enable Saudi Aramco to review the study objectives, the alternatives, the criterion by which the alternatives were compared, the evaluation of specific case scenarios, and the recommendations issued at the completion of the study.

The following are the minimum documentation requirement for both new and existing facilities.

3.8.1 Executive Summary

This section will include a brief description of the problem under investigation, background, objective, proposed solution; tools used and concluding remarks.

3.8.2 Model Objective

The purpose of the study and the role that simulation plays in addressing that purpose will be described in this section. The objective of the simulation study shall be clearly stated. The model shall be represented as a tool to resolve specific problems or answer specific questions rather than as an end product.

3.8.3 Work Scope

This section shall describe the system under investigation including a description of the model; the simulation software components utilized; process unit model assumptions; the modeling strategy; model boundaries; sources of feed; and interaction of the model with other units and plants. This may be accomplished by referencing previous studies but major relevant system characteristics shall be summarized.

3.8.4 Assumptions

In order to understand the model configuration, the underlying assumptions and limitations will be identified, and the impact those limitations have on the results and conclusions identified.

3.8.5 General Approach

3.8.5.1 Crude feed characterization

The feedstock characterization used for the simulation model and all bulk property curves, where applicable shall be defined.

3.8.5.2 Simulation Package

The simulator and version used to build the model shall be defined. Special requirements to run the simulator shall be described.

3.8.5.3 Property Package

The mathematical methods used and their appropriateness to the problem being solved shall be described. Simple references to readily available property packages and simulation techniques will be adequate to support decisions regarding modeling techniques adopted for the study.

3.8.6 Process Flow Diagrams

Provide model process flow diagrams to identify similarities and discrepancies between the plant and the process model.

3.8.7 Hierarchies (Sub-flowsheets)

Identify and describe all hierarchies, and sub-flowsheets, within the model.

3.8.8 Data Acquisition and Model Validation

Describe the source of the observed data, the methods used to extract it, reconcile and filter it, to support validation of the model. Explain the appropriateness of using these data for model comparisons and the basis for any adjustments made to actual observations when making the comparisons.

3.8.9 Case Studies

Describe how the model was used to support the study. Explain how each case supported the overall objectives of the study. Provide narrative describing results from each case study.

3.8.10 Model Results

Provide tabulated results for all streams including; mass, enthalpy, composition, temperature and pressure. The reporting units should be reported in both mass and mole based units.

3.8.11 Conclusion and Recommendations

This section shall concisely describe the results of the study and provide recommendations for future work.

3.8.12 Copies of Models and Supporting Documentation

Copies of all models and supporting documentation will be provided on Electronic media (CDROM or DVD) at the completion of the study at pre-defined major milestones during the project.

3.8.13 Model Developing Organization

This section should refer to the organization and individual engineer(s) who developed the simulation model. This information is needed for future consultations/developments.

4 Responsibilities

Responsibilities for process models that support either the Capital Procurement Program, or the P&CSD Pipeline Model Library, are noted below:

- 4.1 P&CSD provides technical guidance covering plant process design and analysis during; DBSP, Project Proposal, and Detailed Design phases of a project. P&CSD proactively works with Project Management on process related design issues; reviews all related process models; and provides guidance to PMT when
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required. It is P&CSD responsibility to approve and endorse the process models.

- 4.2 P&CSD is custodian of the Process Model Library. P&CSD is responsible for all model additions, model deletions, and model enhancements to the library. Models within the library may have been developed by P&CSD, Plant personnel, or by a Design Contractor. It is P&CSD responsibility to approve and endorse all models contained in the library.

Revision Summary

25 January 2006 New Saudi Aramco Engineering Procedure.