



Engineering Procedure

SAEP-363

25 January 2006

Pipeline Simulation

Model Development and Support

Document Responsibility: Process & Control Systems Department

Saudi Aramco Desktop Standards

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Previous Issue: New Next Planned Update: 25 January 2009

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Primary contact: Habis, Ayman Mazin on 966-3-8730674

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1 Scope

This procedure establishes general guidelines governing development and support of; 1) pipelines simulation models; 2) associated hydraulic analysis studies; and 3) technical reviews of models developed by Saudi Aramco engineers and engineering design contractors. It provides Saudi Aramco engineers and engineering design contractors with guidelines describing the minimum requirements to develop and document pipelines simulation models for existing and new facilities.

2 Applicable Documents

To ensure compliance with the appropriate Saudi Aramco and International Standards and Codes for pipelines, the following Engineering Standards shall be reviewed during model development. These Standards encompass hydraulic analysis, surge analysis, over pressure protection of pipelines, design pressure, materials, operating conditions, maximum allowable operating pressure and maximum allowable surge pressure.

2.1 Saudi Aramco References

Saudi Aramco Engineering Standards

<i>SAES-L-100</i>	<i>Basic Criteria for Pressure Piping Systems</i>
<i>SAES-L-310</i>	<i>Design of Piping Systems Inside Plant Area</i>
<i>SAES-L-410</i>	<i>Design of Transportation Piping In Hydrocarbon Service</i>
<i>SAES-L-132</i>	<i>Material Selection of Piping Systems</i>
<i>SAES-J-600</i>	<i>Pressure Relief Devices</i>
<i>SAES-J-605</i>	<i>Surge Relief Protection Systems</i>

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 Reports

<i>SAER-5437</i>	<i>Guidelines for Conducting HAZOP Studies</i>
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Saudi Aramco Contracting Manual

2.2 International Standards and Codes

ANSI/ASME Code "Process Piping" Chemical plant and petroleum refinery pipeline for in-plant piping

ANSI/ASME B16.5 Pipe Flanges and Flanged Fittings

ANSI/ASME B31.4 Liquid Petroleum Transportation Piping Systems for Cross-Country Liquid Pipelines

ANSI/ASME B31.8 Gas Transmission and Distribution Piping Systems

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 pipeline simulation models, and notify him that he shall comply with the requirements.
- 3.1.4 The engineering design contractor shall utilize one of the approved pipelines simulation packages that are defined in the Saudi Aramco Recommended Pipeline Simulation Software Vendor List.
- 3.1.5 At the completion of studies, the engineering design contractor shall submit an electronic copy of the completed simulation models and supporting documentation to P&CSD/Pipelines & Simulation Unit. P&CSD/P&SU shall be responsible for adding the new models to the Simulation Model Library for ongoing support and maintenance.

3.2 Model Fidelity

The following are considered to be minimum requirements to develop pipeline

simulation models.

3.2.1 Model Objective

The objective of the model will determine the extent of the pipeline system to be modeled and the accuracy of data required during model build and model validation steps. The following categories represent a summary of the main objectives considered when developing pipeline simulation models.

- (a) Models for Design of Pipeline Systems – Models are developed to support construction of new pipeline systems. These models shall be constructed using established equipment and pipeline design data, fluid property data, and soil thermal properties. The sophistication of the model improves with time as it is used initially for hydraulic analysis, then surge analysis, and finally controls system design.
- (b) Models for Operational Analysis – New developed models or existing models for existing pipelines systems are used to study specific operational problems. These models, depending on the nature of the study, could be used without modification. Alternatively, the models could be modified to support; 1) re-validation of the model following acquisition of new pipeline operating data; 2) an expansion to the pipeline system; or 3) a change to the operating philosophy.

3.2.2 Model Scope

The model shall include all major equipments. Dynamic models must include major control systems. 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) steady state analysis; 2) dynamics analysis; 3) isothermal analysis; and 4) thermal analysis. Some models may incorporate more than one of these attributes.

3.2.3 Data Requirement

The following list identifies data that shall be collected before a steady state model or a dynamic model is developed:

- (a) Bulk parameters for fluid physical properties data: density, viscosity, true vapor pressure, bulk modulus. Alternatively, for compositional analysis, the fluid composition shall be defined.

- (b) Pipeline data: pipeline elevation profile, length, diameter, wall thickness.
- (c) Equipment performance sheets for valves, pumps and compressors, open/close times for valves, start/stop times for pumps and compressors.
- (d) Ambient conditions (summer/winter temperatures), thermal conductivities for pipeline and soil and/or the overall heat transfer coefficient between pipeline and soil.
- (e) Operating conditions: pipeline inlet pressure and temperature, arrival pressure, maximum and minimum flow rates.
- (f) Units of measurements must be consistent.

3.2.4 Model Validation

When plant and pipeline operating data is available, the model shall be validated against a set of operating data within the known constraints of; 1) accuracy of plant measurements; 2) tolerance and convergence limitations within the simulator; and 3) the errors associated with simplifying assumptions made during model development.

Before the data can be applied to the model, it shall be necessary to evaluate the quality of the measurements caused by faulty instruments. If available, a software package shall be used to evaluate all elements of the data. The software package shall reconcile the data to identify faulty instruments and to eliminate or reduce measurement errors.

Following model validation, if it is determined that the model results are not within acceptable limits, tuning of specific parameters may be required to improve accuracy. Model parameters may only be changed, following discussion and agreement with P&CSD. P&CSD has accumulated experience from previous model validation exercises. Typically, the difference between pipeline model results and operating data can be less than 2%. If the discrepancies are greater than 2%, the design contractor shall submit explanations for the discrepancies to P&CSD and seek approval to use the model for studies.

3.3 **Documentation Requirements**

At the completion of the studies, documentation shall be developed containing, as a minimum requirement, the following sections:

- (a) An Executive summary that shall include a brief description of the problem under investigation, background, objective, proposed solution; tool used and concluding remarks.

- (b) A system description of the pipeline and processes and study objectives.
- (c) A description of the model including a detailed description of the simulation software components being utilized.
- (d) A description of each scenario adopted for the study.
- (e) The methodology used to extract, reconcile, and filter the operating data.
- (f) Model drawings.
- (g) Tabulated results for each scenario.
- (h) Graphical results representing time plots and/or profile plots of critical variables to support conclusions established for each scenario.

The following sections provide a detailed description of requirements for the documentation.

3.3.1 Model Objective

Describe the purpose of the study and the role that simulation plays in addressing that purpose. The objective of the simulation must be clearly stated. The model shall be represented as a tool to help solve specific problems or answer specific questions rather than as an end product. The simulation package and version used to build the model shall be defined.

3.3.2 Work Scope

Describe the system under investigation. The level of detail, model boundaries, sources of feed...etc. This can be accomplished by referencing available documents. Major relevant system characteristics should be summarized in the report that describes the simulation.

3.3.3 Study Assumptions

In order to understand the model and its limitations, all assumptions shall be identified. Discuss the limitations of the model's representation of the actual system and the impact those limitations have on the results and conclusions presented.

3.3.4 Property Packages

Describe the thermodynamics packages that were utilized to define the fluid properties. Flow and pressure drop correlations must also be described.

3.3.5 System Drawings (PFD's, P&ID's and Model Sketches)

Provide the modeled system process flow diagrams and Process Instrumentation Diagrams. Also provide the simulation schematic used to build the model and compare the simulation model with the overview and actual process to highlight differences.

3.3.6 Model Results Analysis

Present the calibration criteria, procedure, and results. Describe the source of the observed data to which model results are compared. Explain the appropriateness of using these data for model comparisons and the basis for any adjustments made to actual observations when making the comparisons. It is important to report and use as many types of data as possible for successful calibration of the model.

3.3.7 Results Analysis Profiles and Trends

Provide results analysis in profiles (specific variable vs. length of pipeline) and trends (specific variable vs. time) for all the evaluated cases.

4 **Responsibilities**

Responsibilities for pipeline 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 for all hydraulic analysis, surge analysis, or pipeline control system studies during DBSP, Project Proposal, and Detailed Design phases of a project. P&CSD proactively works with Project Management on pipeline design; reviews all related pipeline models; and provides guidance during each design stage. It is P&CSD responsibility to approve and endorse the pipeline models.
- 4.2 P&CSD is custodian of the Pipeline 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.