

A photograph of two industrial workers, a man and a woman, wearing white hard hats, safety glasses, and large earplugs. They are dressed in blue work jackets with red accents. They are standing in an industrial setting with various pipes, valves, and machinery. The man is on the left, looking towards the right, and the woman is on the right, looking towards the left. The background shows a complex network of pipes and equipment, with a red structure visible on the right side.

AVEVA

BROCHURE

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# Engineering Services for Dynamic Simulation

While plants may be designed to operate at steady state, transient operations drive up the cost, time, and risk. Dynamic phenomena often define the limits of safety systems. AVEVA's experienced dynamic simulation services team can help you solve problems throughout the lifecycle of the project, from design to controls engineering, startup, and ongoing operation.



## Introduction

AVEVA's engineering services program, based on AVEVA™ Dynamic Simulation (formerly DYNASIM), delivers both operating and design recommendations, as well as a complete simulation model. AVEVA Dynamic Simulation is a state-of-the-art, field-proven dynamic process simulation program. AVEVA Dynamic Simulation's process plant modeling environment covers the entire lifecycle of the plant, from simulation through system checkout, operator training and start up.

Our engineering services program offers an unparalleled combination of industry experience, process simulation knowledge and best in class technologies, enabling customers in all process industries to realize significant benefits in these four key areas:

- Capital cost savings
- Decreased time to market
- Improved safety
- Improved availability

## Dynamic Simulation for Process Design

AVEVA's Lifecycle Modeling concept is based on the use of dynamic simulation tools throughout the lifecycle of a project, from design, controls engineering, startup and ongoing operation. Engineering services address process engineering and design, verifying equipment and controls design and evaluating startup and shutdown procedures using dynamic simulation.

## Why use Dynamic Simulation for Process Engineering?

**Reduce equipment costs:** Many plant design parameters are based on transient operating conditions. Dynamic simulation accurately simulates transient events to predict the conditions that set equipment mechanical design temperatures and pressures.

**Evaluate first of a kind plants:** These plants often have unforeseen process, control and relief problems. Dynamic simulation can be used as a process design tool to reveal these problems early in the design phase to avoid costly modifications during or after startup.

**Design and validate control strategy:** Test the control strategy as defined on the control narrative and Piping and Instrumentation Diagrams (P&ID) before the plant goes online to avoid costly troubleshooting and tuning efforts in the field. Compressor systems and complex fractionation systems are good examples.

**Test heat integration:** Complex designs with tight heat integration may need supplemental heat for startup. Dynamic simulation can validate the process design to determine if adequate startup heat is available.

**Analyze flare and relief systems for hazop:** AVEVA Dynamic Simulation can be used for safety studies to validate relief system design as a result of a Hazop analysis.

## Lifecycle modeling

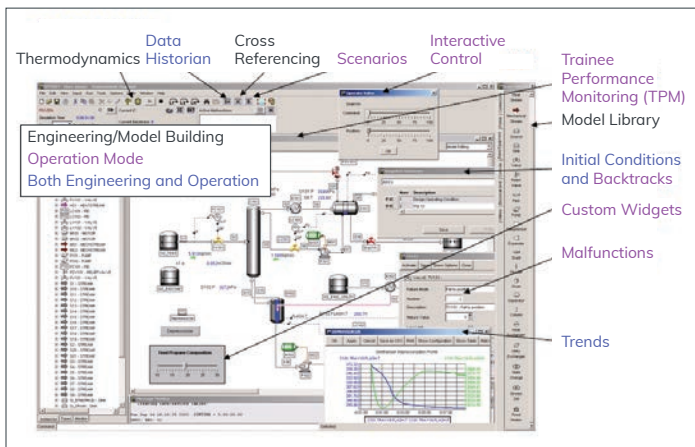


## AVEVA Dynamic Simulation decision support simulators

The AVEVA Dynamic Simulation graphical interface can easily be set up as a decision support simulator. The graphical interface allows easy execution by individuals who are not trained in building dynamic simulation models.

Some features for the development of decision support simulators include:

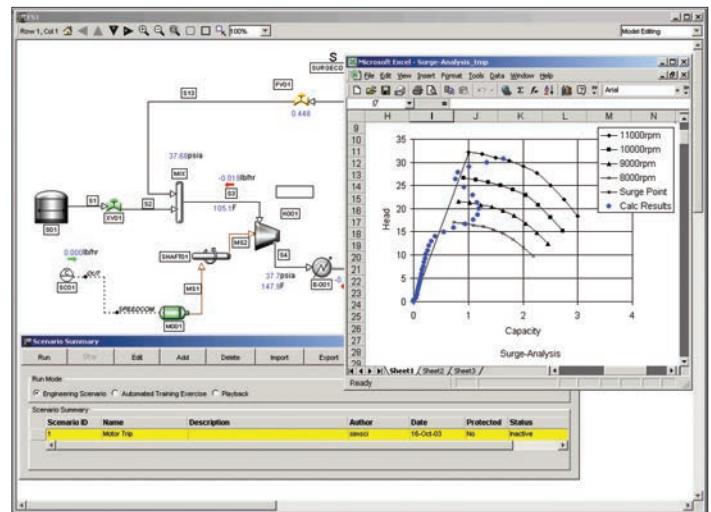
- The ability to drag-and-drop widgets directly on to the flowsheet for easy operation of the simulation. These widgets include sliders, buttons, dials, indicators and check boxes.
- Multiple flowsheet capability so dynamic models match plant PFDs or Piping and Instrumentation Diagrams (P&IDs) for easy navigation.
- Password protected access modes for Administrator, Engineer, Instructor and Operator, so only the appropriate individuals can make changes to the simulation.
- Preconfigured malfunctions in most equipment models.
- Link to Microsoft® Excel® for data collection and visualization.
- Remote functions for the operation of controls, valves and motors.
- Trainee performance monitoring to give a numerical score based on maintaining key process parameters between a low and high operational band.



## Compressor surge analysis

Dynamic simulation can be used to test and validate compressor surge control systems to keep a large centrifugal compressor out of surge, especially during startup and shutdown. In some instances, dynamic simulation can be used to model startup and determine proper throttle valve positions and startup horsepower requirements, as well as evaluate performance using hot gas bypass or cold gas bypass designs.

**Benefits:** Prevent damage to multi-million dollar machinery.



## Compressor startup analysis

Compressors with large constant speed motors may have insufficient horsepower to start under all operating conditions. For example, a hot restart of a compressor may not be possible at settle-out pressure, unless the compressor discharge pressure is reduced. This may delay compressor restart to depressure downstream equipment, increase flaring, or require motor cooldown periods after a failed motor start. Dynamic simulation with detailed motor startup torque curves can be used to determine the appropriate motor size while avoiding overdesign.

**Benefits:** Improve plant availability and reduce flare emissions.



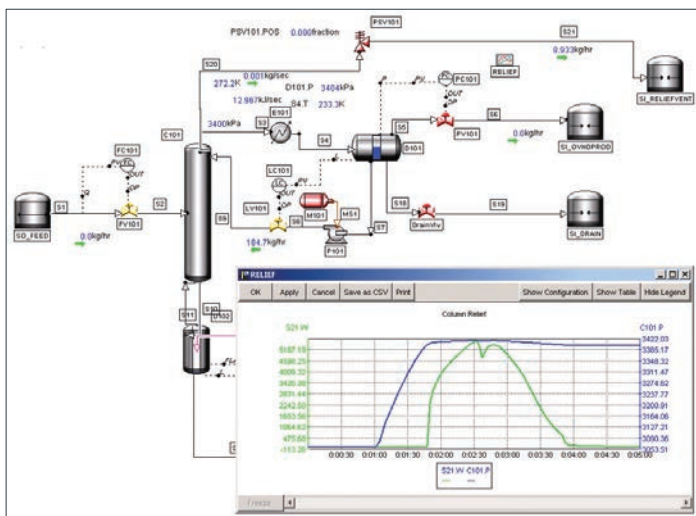
## Column control strategy selection

Dynamic simulation can be used for difficult distillation and fractionation control system problems. Sophisticated control systems can be designed and validated using dynamic simulation. Also, transient vapor and liquid profiles can be used to confirm tray designs. Dynamic simulation is particularly useful where product quality constraints are tight, blending of off-spec products may be difficult, or frequent feed variations are expected.

**Benefits:** Reduce plant commissioning time and reduce off spec production.

## Column relief load analysis

Conventional methods for calculating column relief loads are very conservative and can lead to overly expensive flare systems or unnecessary flare or flare header replacements during unit revamp and debottlenecking projects. Also, refiners may have insufficient plot space because they are confined by the flare radiation radius or are restricted by government permits. Dynamic simulation provides an alternative to conventional calculation methods and provides substantially lower relief loads.



For fractionation towers with wide boiling ranges: flare load reductions (up to 50%) are possible as dynamic simulation accounts for the limited inventory of light components and the sensible heat required to boil off the heavier components. Dynamic simulation also provides a realistic calculation of the reboiler pinch at elevated pressures using the time-dependent feed

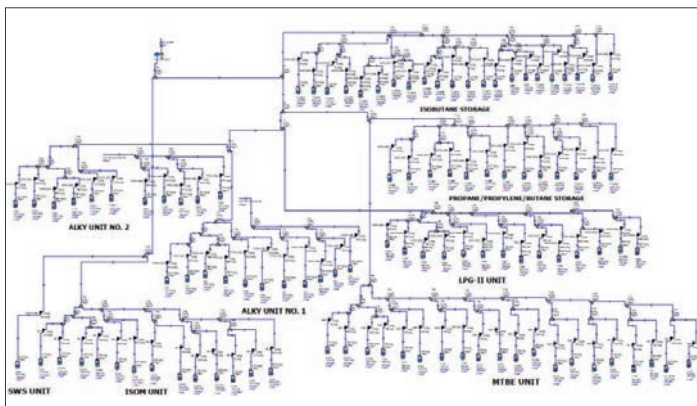
composition. Dynamic simulation is consistent with API RP-521 methods. Dynamic simulation provides a safe and documented alternative to conventional relief load calculations methods resulting in substantially lower calculated relief loads.

**Benefits:** Save relief and flare system capital expenditures – up to several million dollars.

## Flare system studies

Dynamic simulation can evaluate the effect of vessel and flare header packing. Packing is the pressurization of the flare system, particularly the blowdown and knockout vessels within a unit. Packing may reduce the calculated backpressures in the flare – particularly for depressuring or staged relief loads.

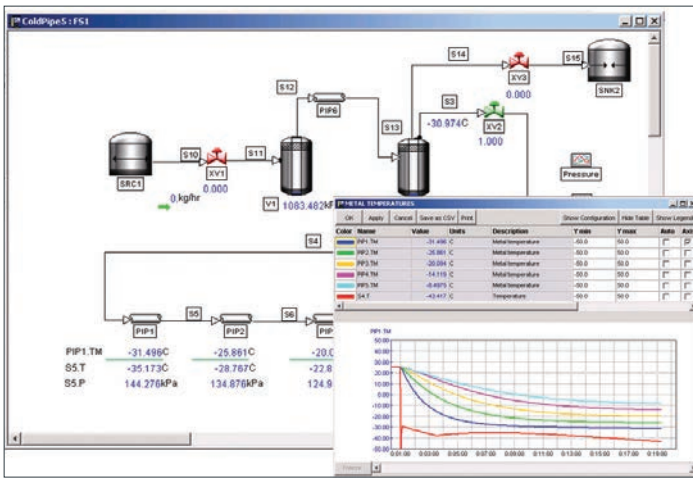
**Benefits:** Relief and flare system capital expenditures – up to several million dollars.



## Cryogenic depressuring for minimum metal temperature specification

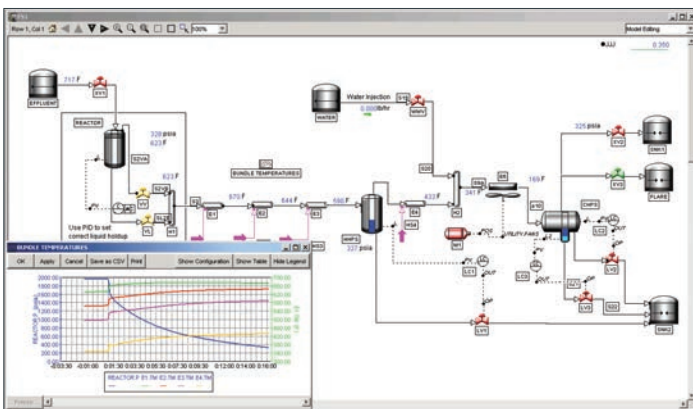
Dynamic simulation can be used to calculate the mean metal temperature as a function of time during depressurization for gas processing and LNG applications, where the vessel and outlet piping can reach extreme cold temperatures. In most cases, the mean metal temperature is considerably less severe than the fluid temperature and may alleviate expensive metallurgy and design choices.

**Benefits:** Avoid use of stainless steel metallurgy for savings up to \$1 million U.S. dollars.



## Hydroprocessor depressuring for feed/Effluent heat exchanger design

Heat exchangers in feed / effluent service for high-pressure hydrocrackers and other hydroprocessors must be designed for the temperatures associated with reactor depressurization. During depressurization, the feed is stopped and cooling is unavailable for the reactor effluent. One conventional steady-state method of calculation predicts that the heat exchanger temperature will rise instantaneously to the reactor outlet temperature. Accordingly, the design temperature and pressure for the entire heat exchange train may be specified the same as the reactor outlet condition. Alternatively, dynamic simulation can minimize heat exchanger design temperatures by accounting for the heat capacitance of the metal in the piping and tube bundles. The simulation giving the fluid temperatures corresponding to the actual pressure at every point in time provides a coincident pressure and temperature trajectory. Mean metal temperatures can be determined from this temperature profile.

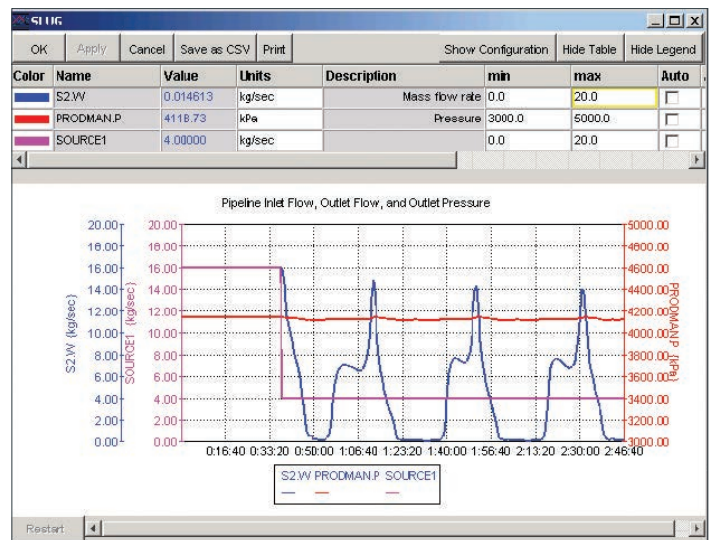


**Benefits:** Reduce feed / effluent exchanger and reactor effluent air cooler capital costs, avoid additional piping thermal expansion loops, and eliminate the need for secured power. Calculated savings up to \$4 million U.S. dollars.

## Integrated pipeline/Topsides modeling

Dynamic simulation can be integrated with a subsea pipeline simulator (such as Scandpower's OLGA 2000) to study the interaction of the pipeline with the topsides. For example, the impact of slugging on topsides operation can be analyzed.

**Benefits:** Validate impact of slug induced transients that might reduce or stop production.

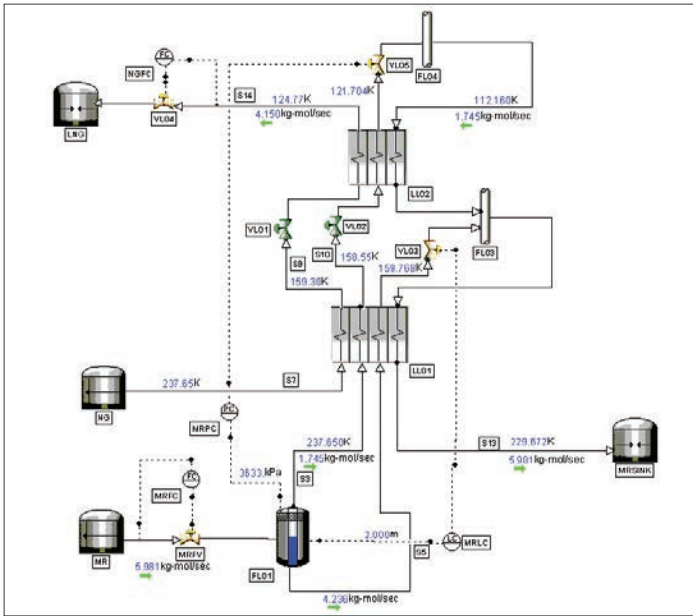


## Cryogenic exchanger stress analysis

Dynamic simulation can be used to model spiral wound and plate fin heat exchangers. AVEVA Dynamic Simulation has a rigorous multi-stream exchanger model that can be used to calculate metal temperature dynamics.

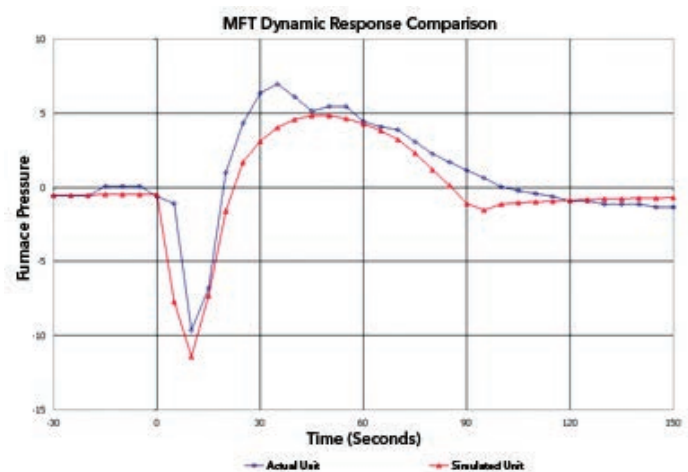
This analysis can be used to determine the thermal stress on the exchanger to determine if mechanical failure can result during startup or other severe transient conditions.

**Benefits:** Verify transient operating conditions to prevent damage to expensive heat exchangers.



### Boiler draft studies for FGD retrofits

A Flue Gas Desulfurization (FGD) retrofit will affect a power plant's controllability and may expose it to an unplanned shutdown or mechanical damage during upset conditions. Dynamic simulation is a valuable design tool for FGD retrofit process and control design. In particular, Dynamic simulation can assess the possibility of boiler implosion due to continued operation of an induced draft fan, seconds after a master fuel trip. Dynamic simulation can also assess controllability issues associated with parallel units using a shared FGD system. Dynamic simulation provides the required information to make important design decisions that can significantly improve the controllability and safety of the boiler and FGD system.



**Benefits:** Avoid unnecessary boiler stiffening for conversion of forced draft to balanced draft operation (costing in excess of several million U.S. dollars). Develop MFT control logic which prevents implosion damage to a boiler.

### Refinery steam systems analysis

The process dynamics and controls system design for refinery steam systems, cogeneration plants, integrated gasification and combined cycle (IGCC) and conventional power plants are often evaluated with dynamic simulation. The reliability of the steam system is crucial to refiners as the loss of steam can shutdown the entire refinery – costing lost production. Typical systems are combined-cycle facilities where the gas turbine exhaust gas is used to generate steam in a heat recovery steam generator (HRSG) which is then provided to a steam turbine and process steam users. Dynamic simulation can be used to validate control systems, check control valve sizes and response times, and provide initial controller tuning parameters. Dynamic simulation can also be used to insure that after a gas turbine or boiler trip, the backup steam systems such as HRSG supplemental firing and auxiliary boilers can produce additional steam quickly enough to maintain steam to the process users.

**Benefits:** Design and verify steam system process and controls to avoid refinery wide shutdown because of loss of steam supply, saving several million U.S. dollars in lost production.

### Refining example: Dynamic Simulation for a delayed coker main fractionator

#### 1. Delayed coker main fractionator control strategy for coke drum switch

Dynamic simulation can be used to design and validate the delayed coker main fractionator control system. Delayed coker main fractionators experience dramatic changes in coke drum vapor rates during a typical coke drum switch operation. These changes impact column operation and product qualities which may lead to off specification products. AVEVA Dynamic Simulation can be used to develop a control strategy which maintains product quality during a switch to improve product qualities by providing a test bed for control strategy changes.





As a first step, a dynamic model of the main fractionator should be developed and validated against actual plant data. This validation includes comparing simulated and actual product flow rates and fractionator tray temperatures as a function of time during the coke drum switch. After the dynamic model is validated, alternative control system designs can be evaluated.

One option may be to explore the use of feed forward control on coke drum vapor rate, measured by the pressure drop from the coke drum to the fractionator flash zone, to change product draw rates.

The result of the study will include a final report with graphical results showing model validation, results of the control strategies implemented and recommendations on control strategy modifications.

## 2. Delayed coker main fractionator relief load reduction

Delayed cokers have a major contribution to the total flare system load. Delayed coker main fractionators may also require substantial investment in column relief system, due to their high calculated relief loads and low operating pressure. Typical calculations methods assume the full energy content of the coke drum vapor is applied to a fluid composition on a tray near the top of the column, which can lead to an overestimation of the actual relief load for the following reasons:

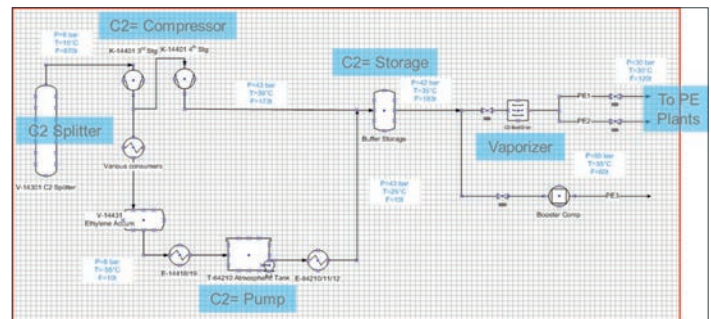
- The coke drum vapor rate decays after the feed heater charge pump is tripped. Calculating how the coke drum vapor rate decays with time after a power failure is critical for predicting the relief rate. The coke drum will continue to produce vapor even after feed to the drum is stopped, due to the continuing reaction of the liquid inventory in the drum.

However, the vapor rate will decay exponentially based on the initial amount of unreacted liquid within the drum. This coke drum decay rate can be determined from actual plant data for a typical coke drum switch.

- There is limited light ends inventory inside the column. Dynamic simulation considers the inventory of volatile C2 components in the column and the additional sensible heat that must be added to boil off heavier components once the lighter material is relieved. There are other considerations such as the possibility of continued cooling in the overhead air cooler.

## Highly integrated plant complex

Engineering studies via dynamic simulation can be used to verify the adequacy of C2 storage, export pump, vaporizer design, as well as, the control system. Major disturbances on the ethylene header can be modeled to assure that an upset will not cause shutdown to PE units. Sample scenarios for reliability and safety include (1) Trip of C2= compressor, (2) Lost of C2= demand (trip of PE unit), and (3) Changes in C2= demand during grade transition in PE unit. A recommendation for optimum control performance, in terms of header pressure measurement location or controller tuning and design, can be made.





## Other application areas

### Depressurizing analysis

- Estimate the lowest possible temperature during depressurization
- Determine depressurization strategies that meet safety/design standards

### Flare gas recovery furnace operation

- Determine the control strategy to operate flare-gas recovery furnace in emergency situations
- Determine FG header pressure, Maximize heating value

### Determining safety system design for flare/relief scenario

- Determine safety system setpoints (e.g. cut off steam supply in tower reboiler when tower pressure rises beyond certain value)

## High Integrity Pressure Protection System (HIPPS) design

- Meet safety constraint fast but do not constrain operating window

For more information on AVEVA Dynamic Simulation, please visit:  
[aveva.com/en/products/dynamic-simulation](https://www.aveva.com/en/products/dynamic-simulation)