Guidelines for Dynamic Modeling of Column Startup

Chemstations, Inc.

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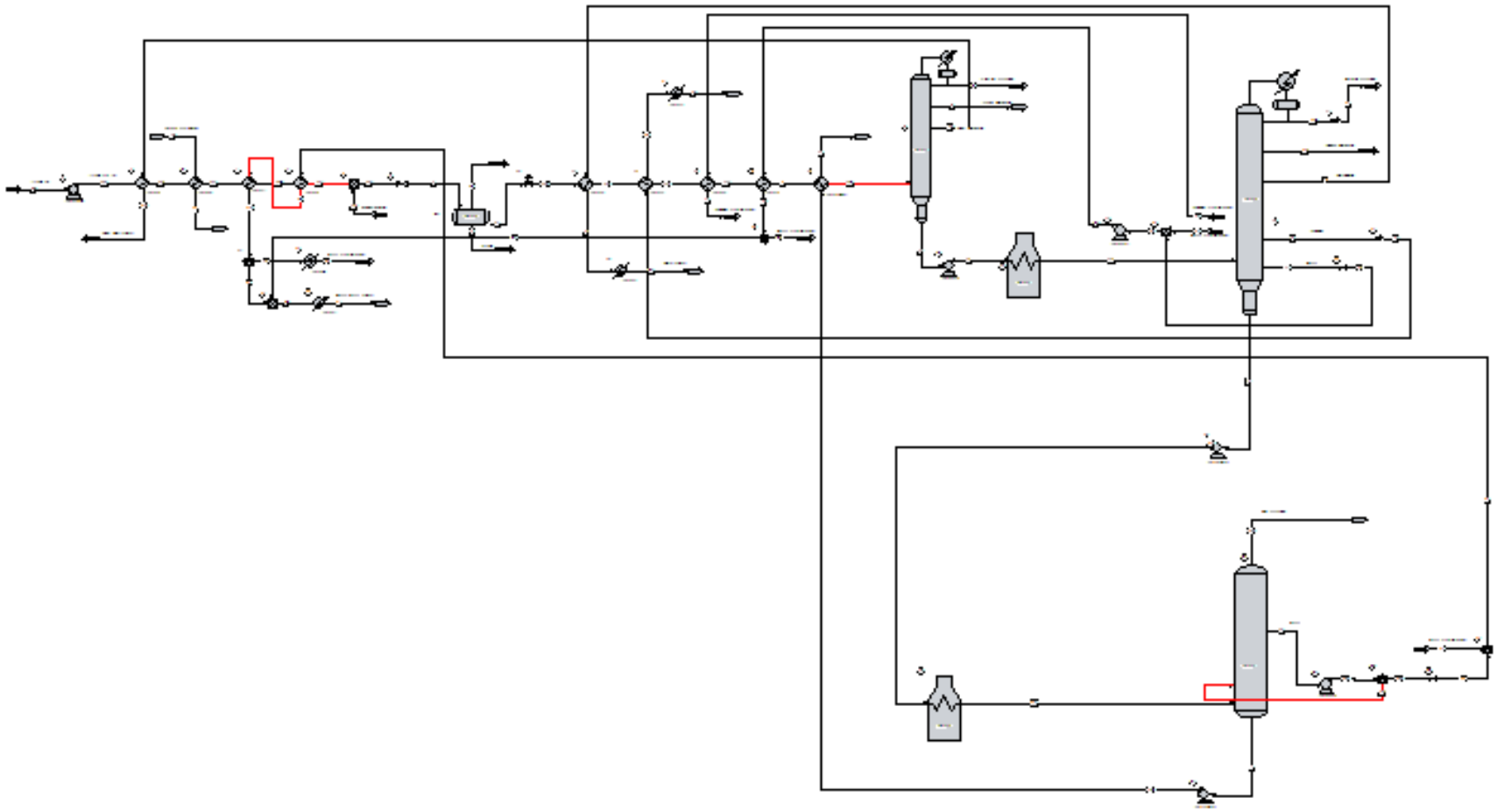
Agenda

- Background of case study
- Determining scope of model
- Simulation Guidelines
- Case Study
- Summary

Background of Case Study

- Customer – Calumet Montana Refining, LLC
- Had existing steady-state model of entire facility
- Shared P&IDs, PFDs, procedures, & process data from previous start-up
- New crude unit being built & would like accurate simulation of startup conditions

Original Steady State Simulation



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Goals of Case Study

- Simulate crude unit only
- Model existing tower startup
- Compare to historical startup data
- Determine if dynamic simulation could be used as tool to predict startup performance of new crude unit

Determining Scope of Model

Use operating procedure to determine sequential steps & model targets:

1) Crude charge introduced to tower at increasing temp & flow rate
2) Target level reached in overhead accumulator
3) Reflux system placed in service
4) Stripping steam introduced to tower
5) Product streams reach specification

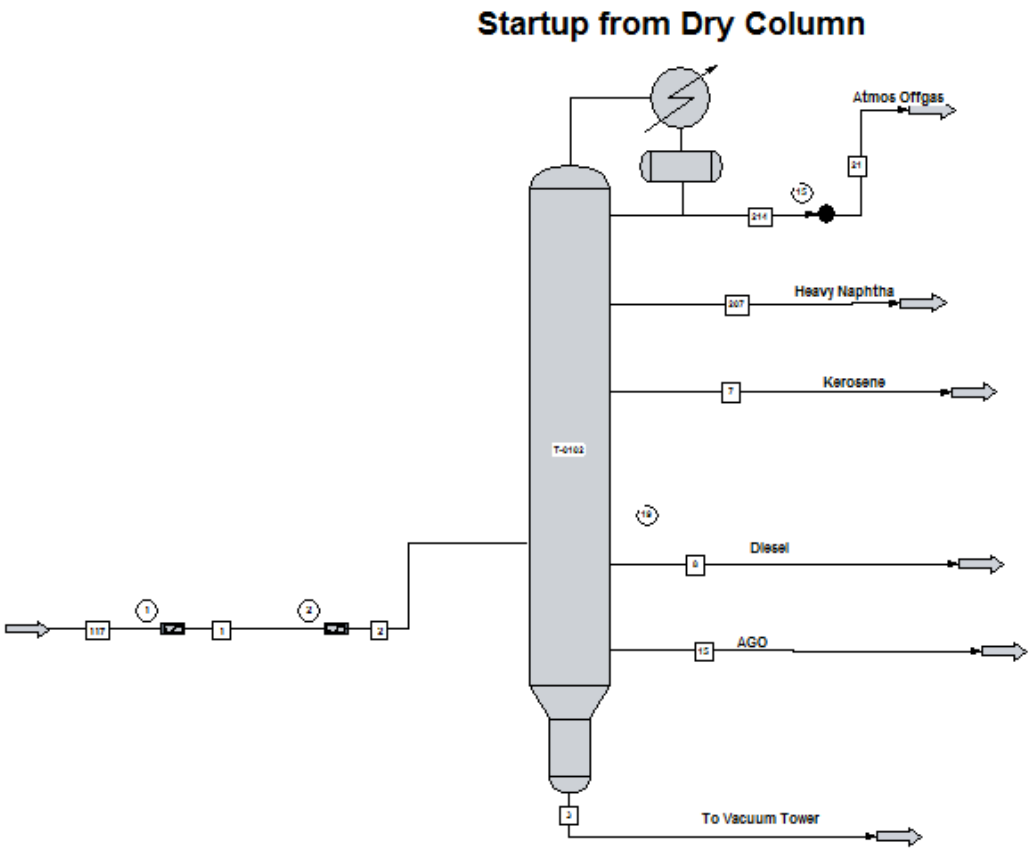
Simulation Guidelines

- Start with a simple model
- Get model to converge
- Validate results
- Add complexity as required to reach desired engineering solution

Start with a Simple Model

- Crude tower only
- Change to dynamic simulation mode
- Pumparounds/side strippers not in service
- Crude Heater modeled as temp & flow ramps
- Use actual data & equipment parameters
  - Feed temps & flows from actual data
  - Accumulator dimensions & condenser setpoints
  - # trays, feed stage, etc.

Simplified Flowsheet



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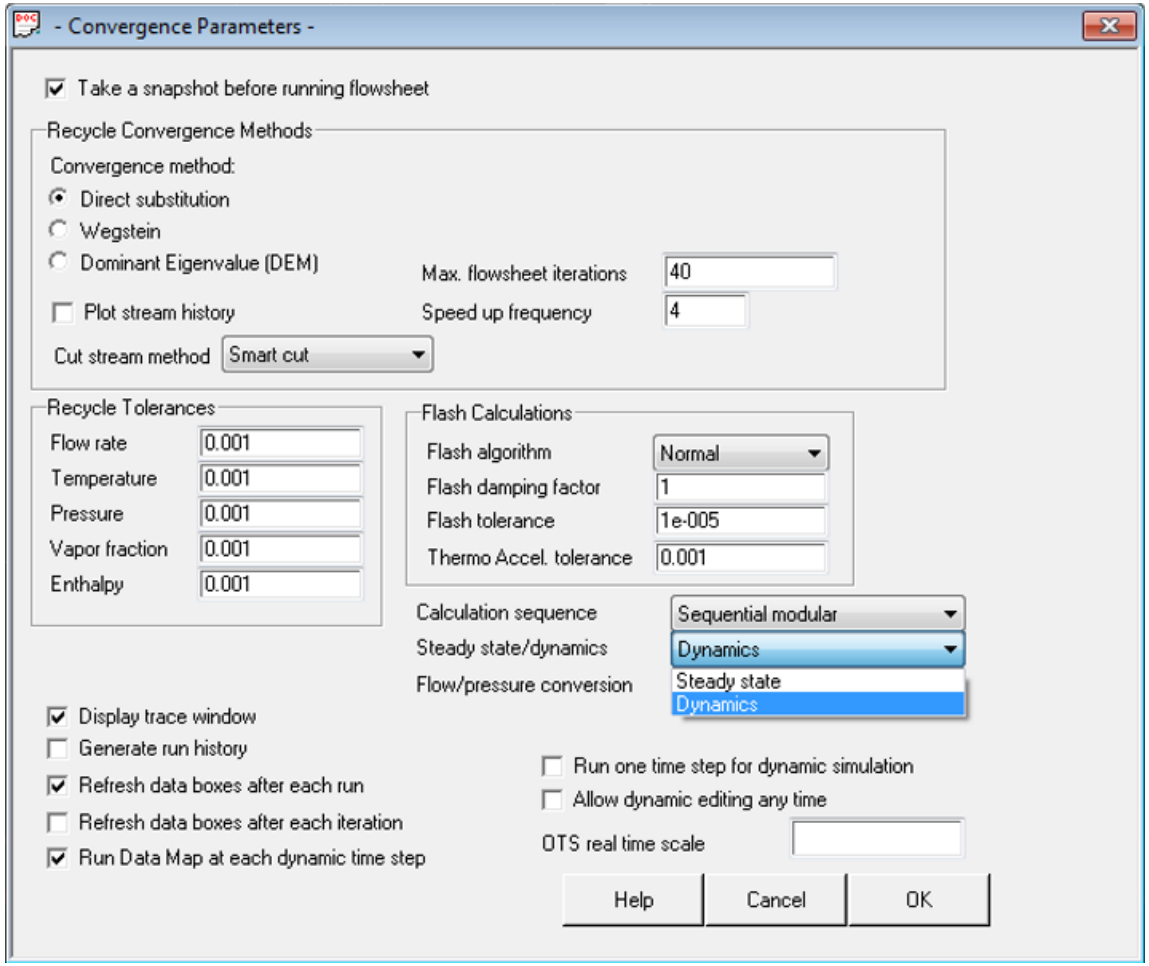
Change to Dynamic Simulation Mode



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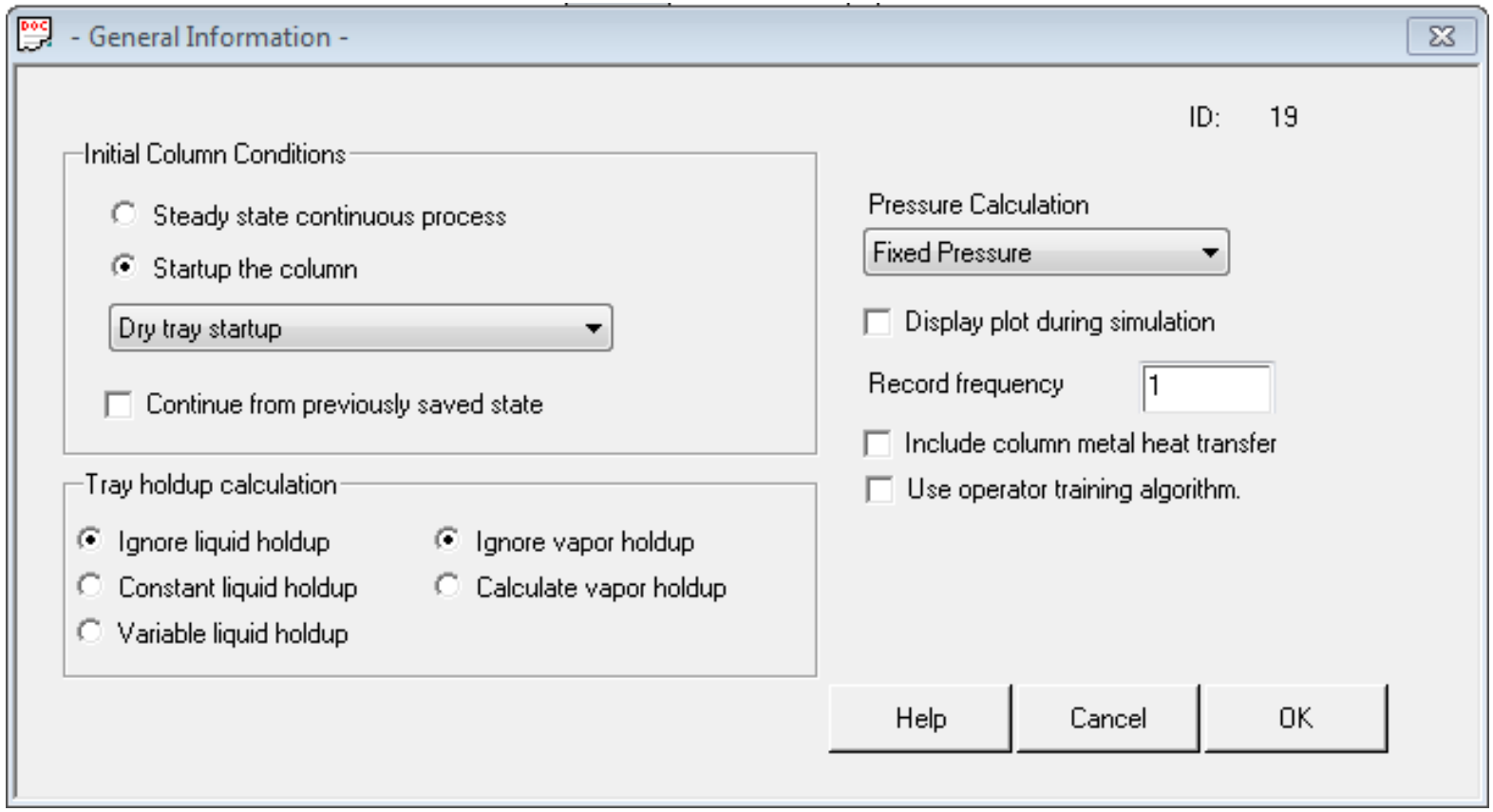
Startup Conditions



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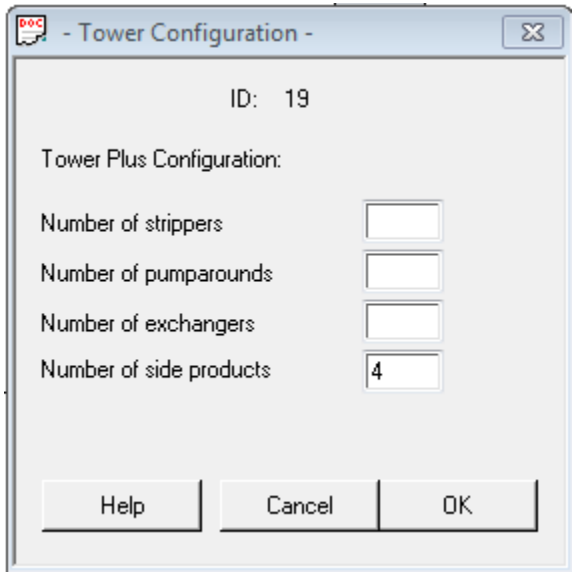
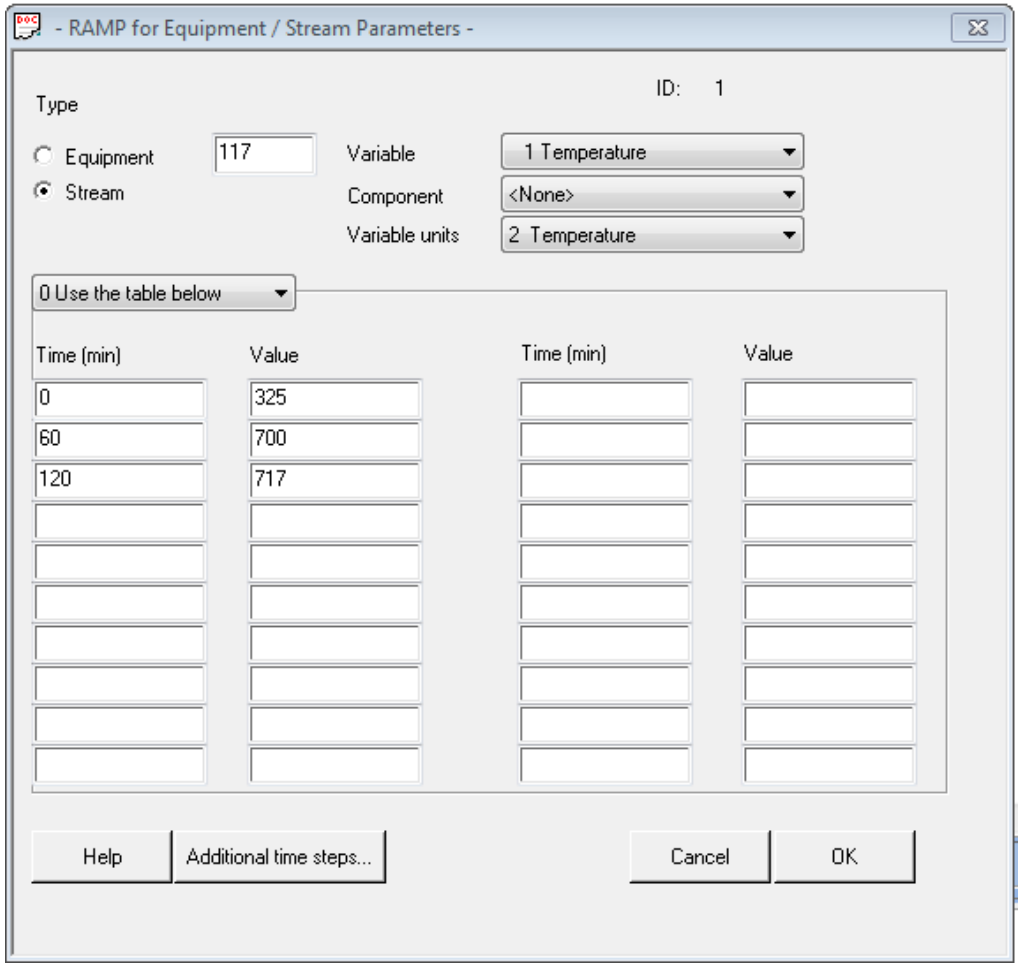
Tower & Feed Configuration





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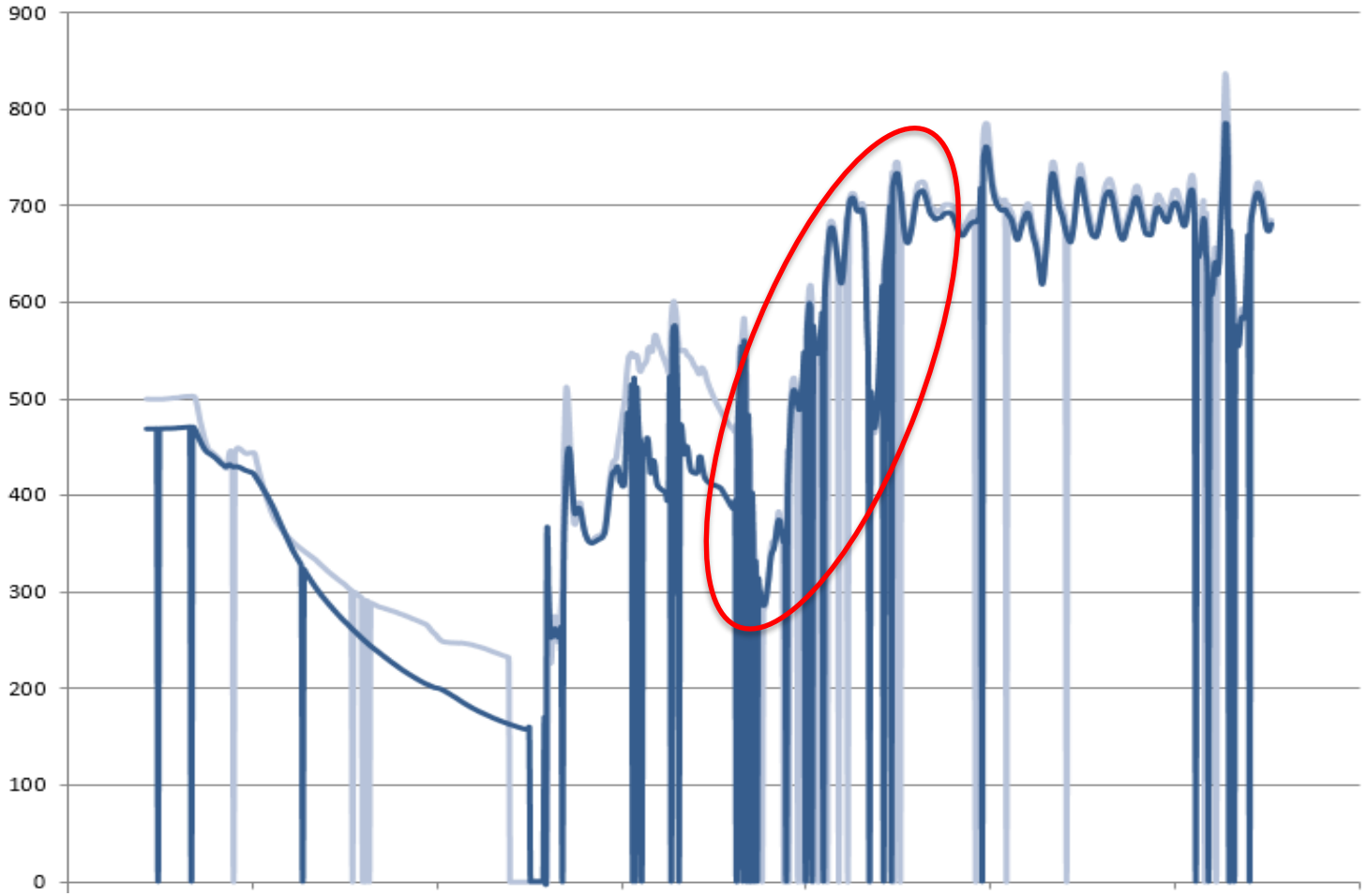
Actual Data Determined Ramp Settings



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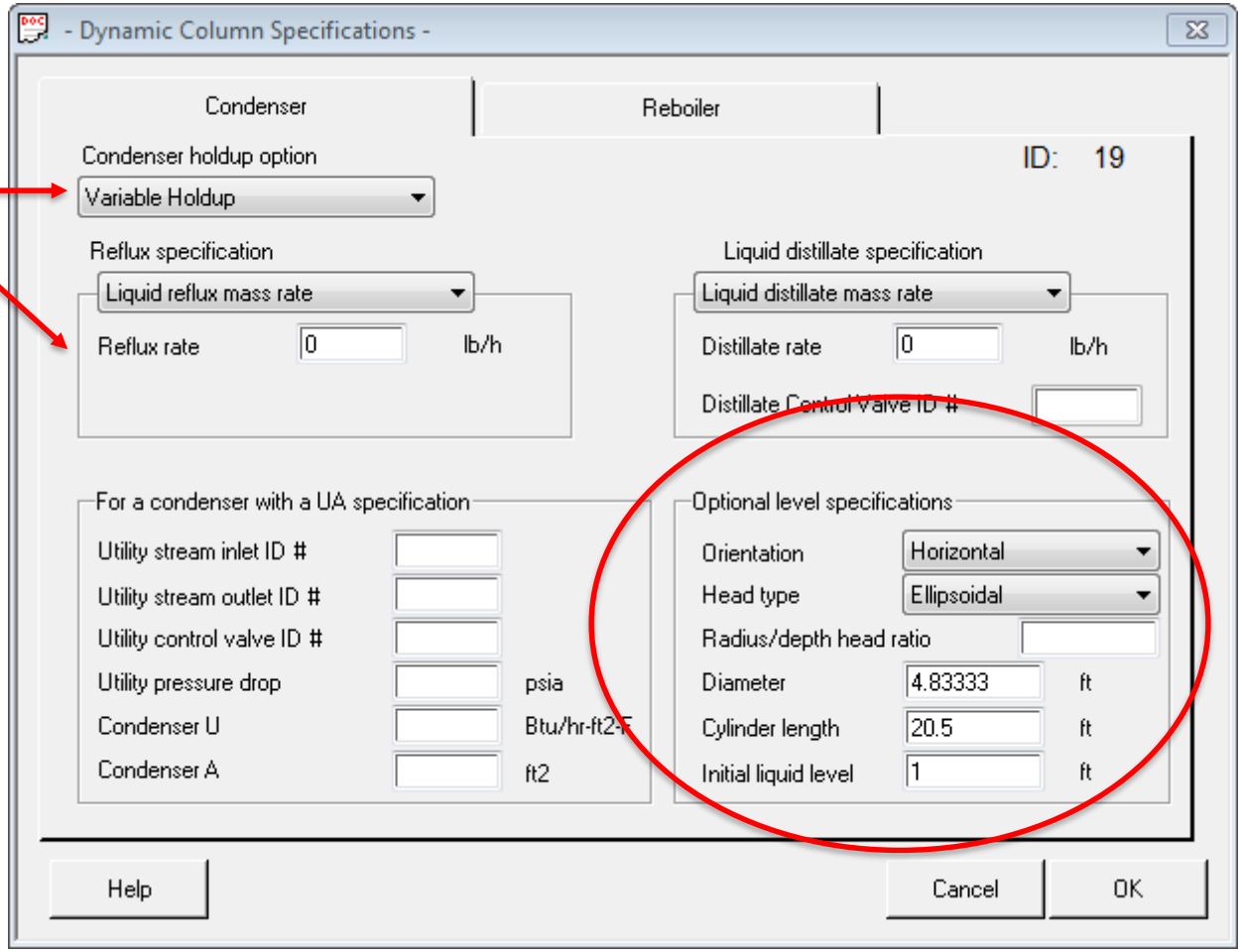
Scope of Model

1) Crude charge introduced to tower at increasing temp & flow rate 
2) Target level reached in overhead accumulator
3) Reflux system placed in service
4) Stripping steam introduced to tower
5) Product streams reach specification

Accumulator Dimensions & Reflux

Set reflux to zero initially



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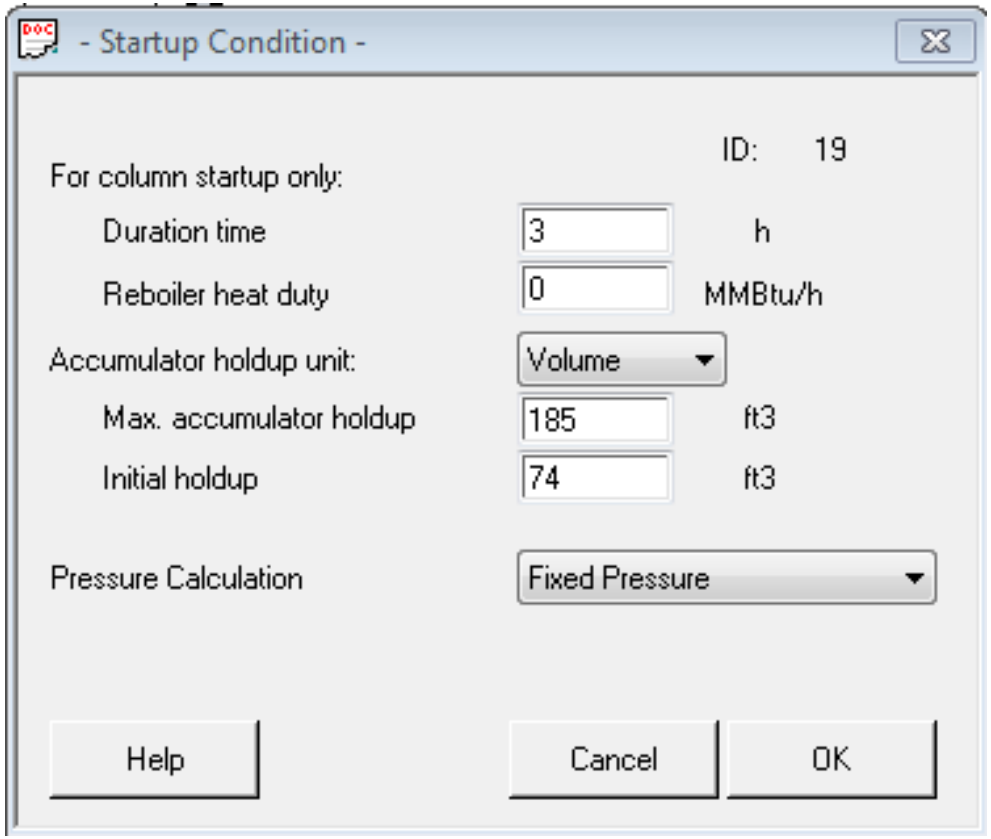
Accumulator Level Target Specification



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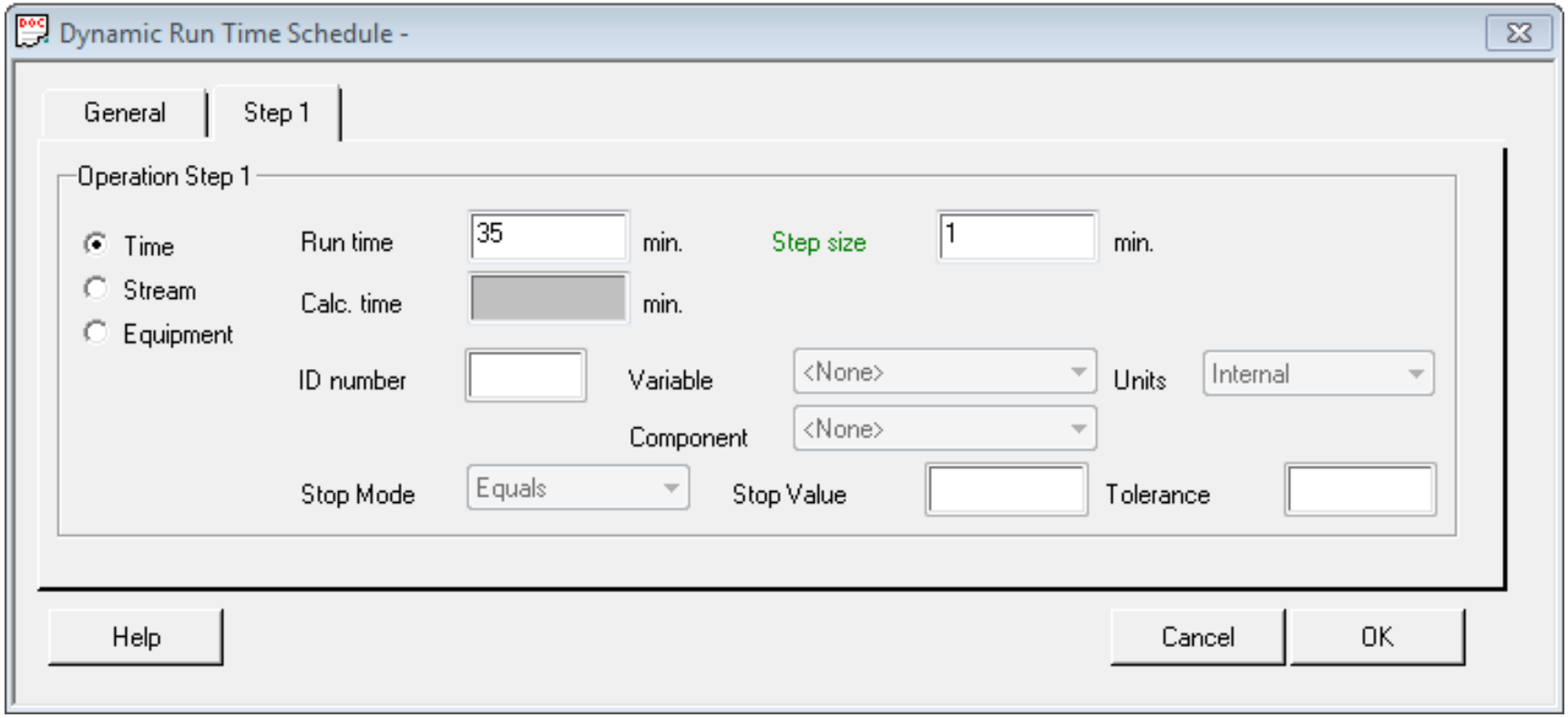
Get Dynamic Model to Converge

- Set initial run time based on actual data if available
- Modify step size:
  - If needed to assist with convergence
  - Depending on target parameter's rate of change
- Run one time step manually & view results
- Other convergence adjustments:
  - # of iterations
  - tolerances

Run Time Parameters



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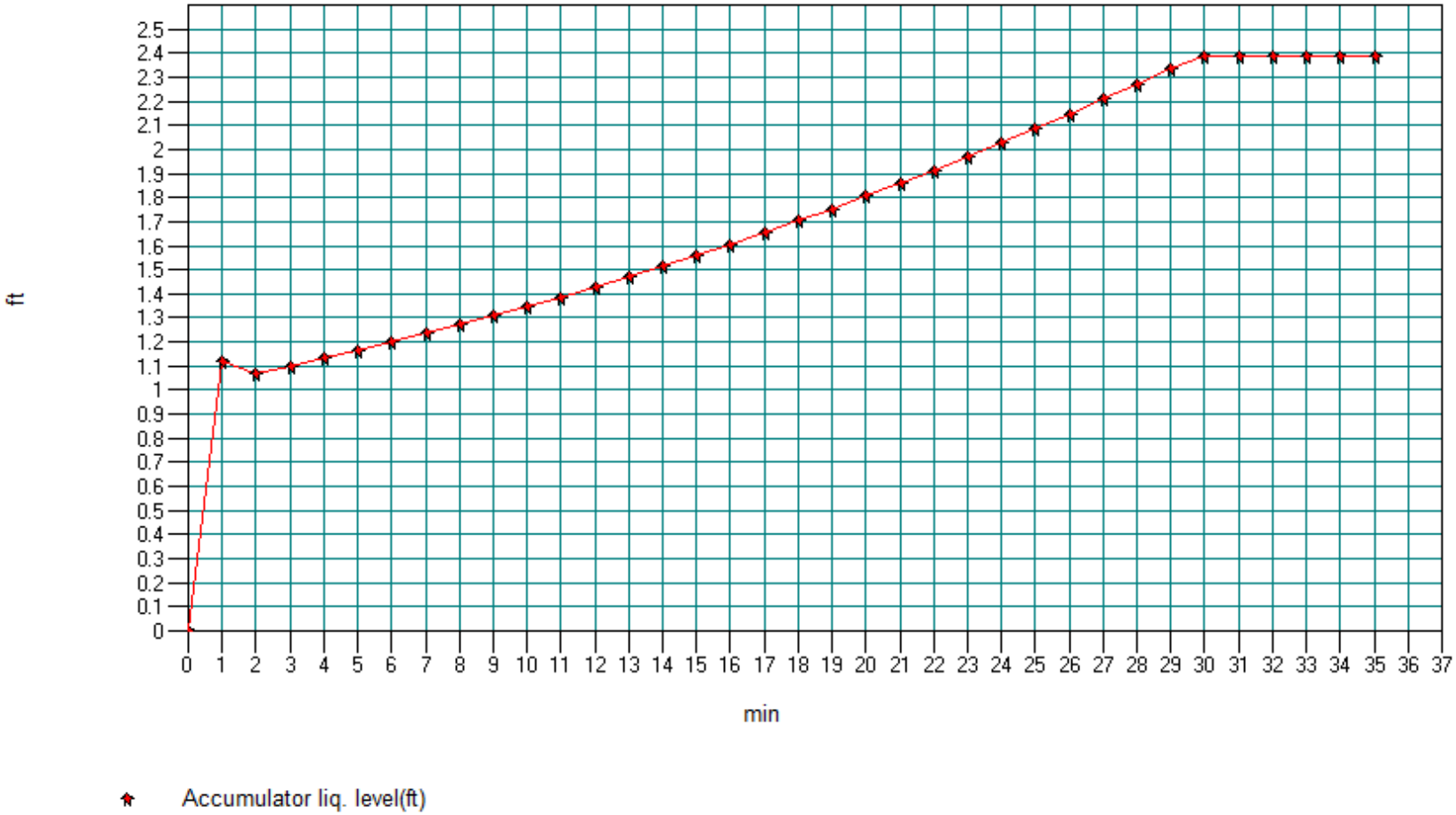
Accumulator Level Plot



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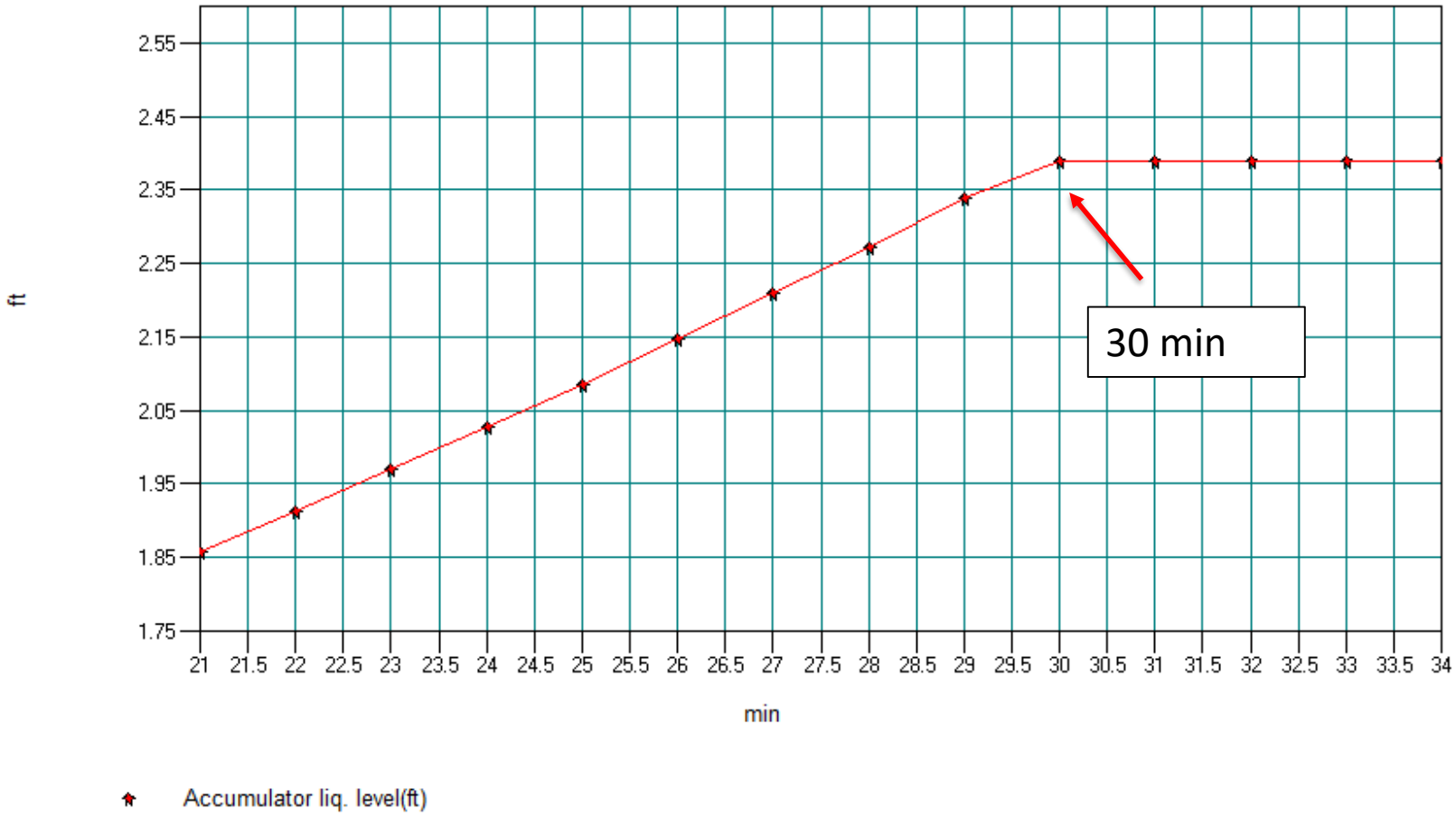
Accumulator Level Target Reached



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Scope of Model

1) Crude charge introduced to tower at increasing temp & flow rate 
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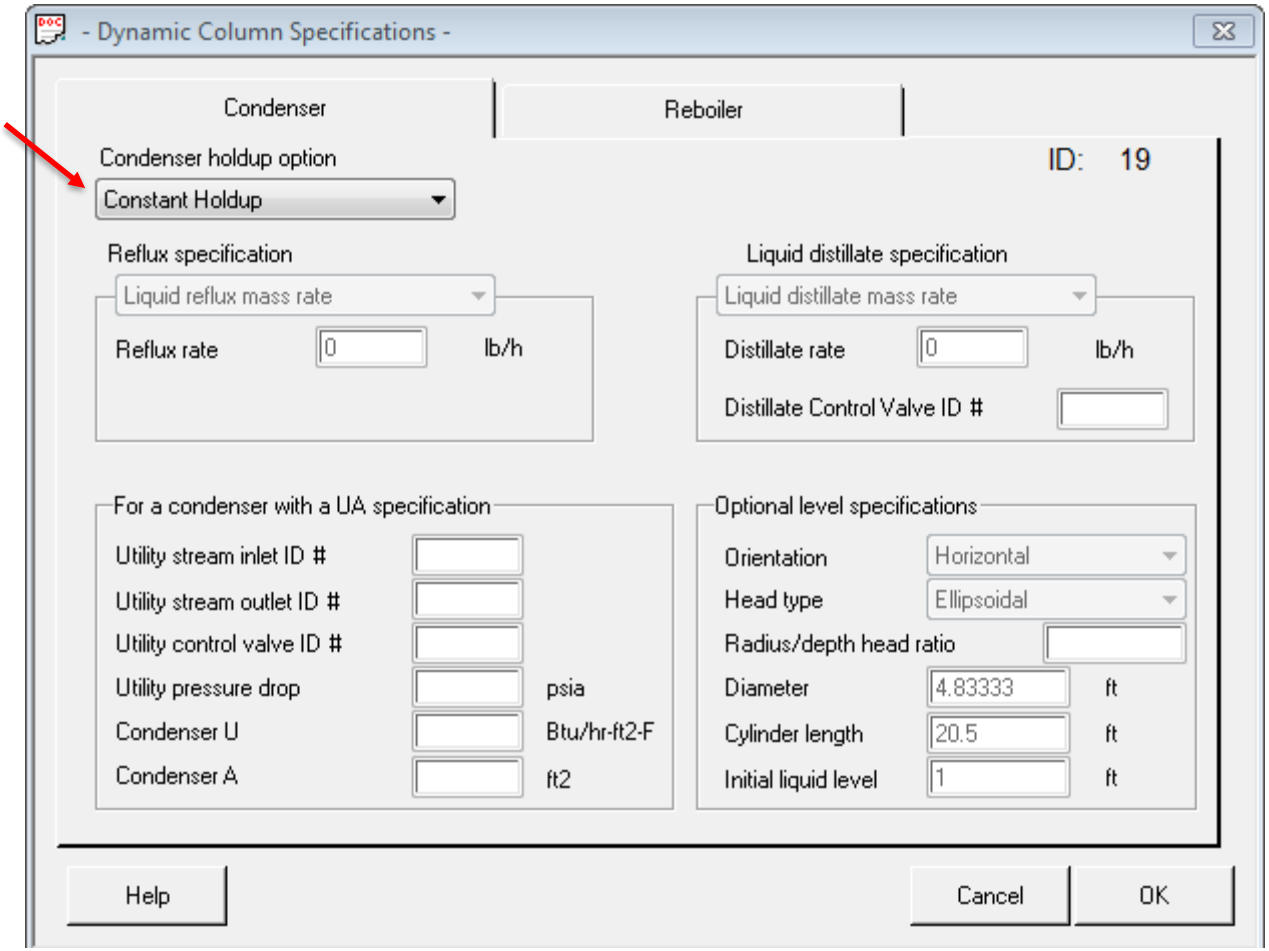
Place Reflux System In Service

Switch to maintain level & adjust reflux rate



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Scope of Model

1) Crude charge introduced to tower at increasing temp & flow rate ✓
2) Target level reached in overhead accumulator ✓
3) Reflux system placed in service ✓
4) Stripping steam introduced to tower
5) Product streams reach specification

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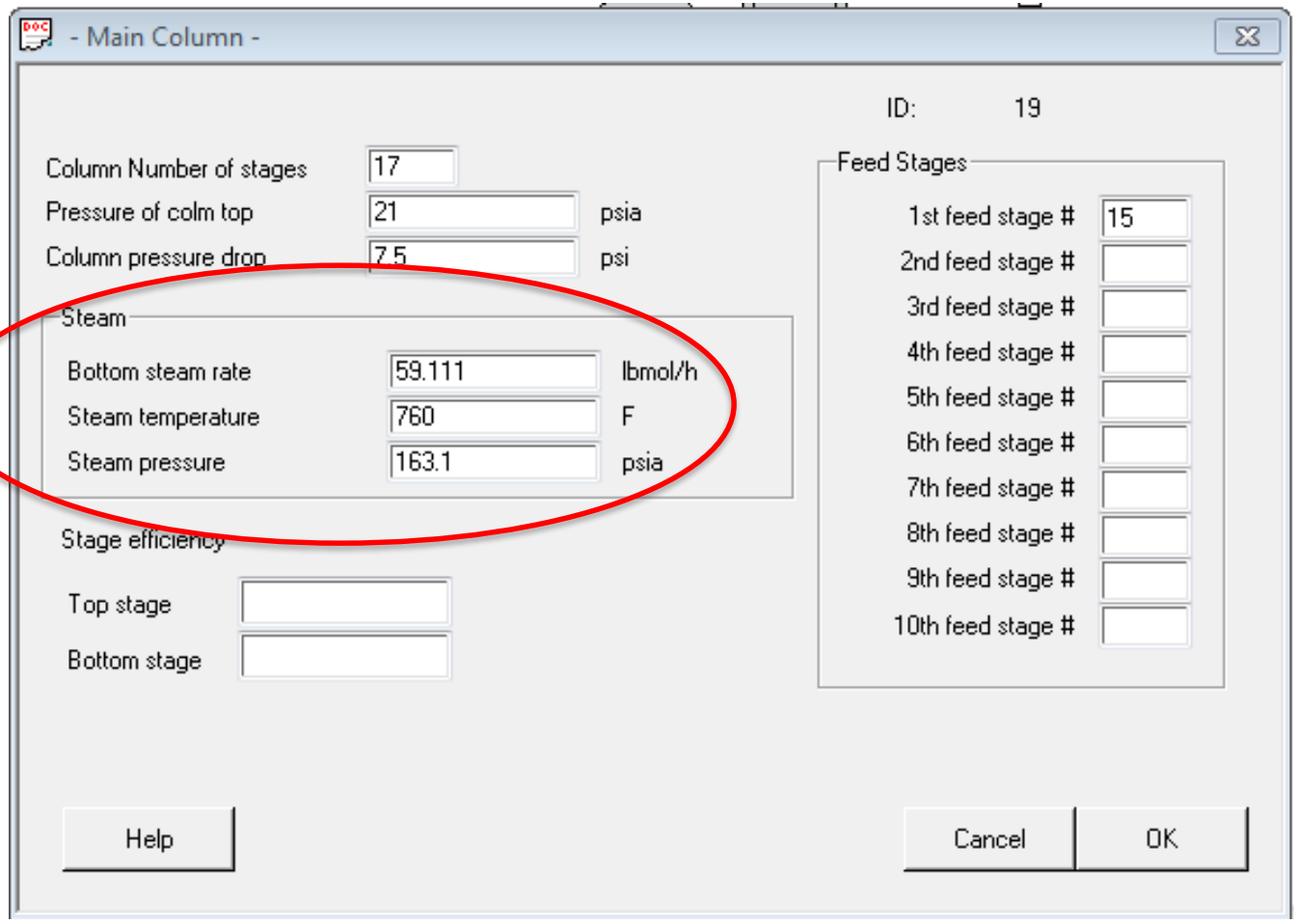
Start Stripping Steam to Tower



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Scope of Model

1) Crude charge introduced to tower at increasing temp & flow rate ✓
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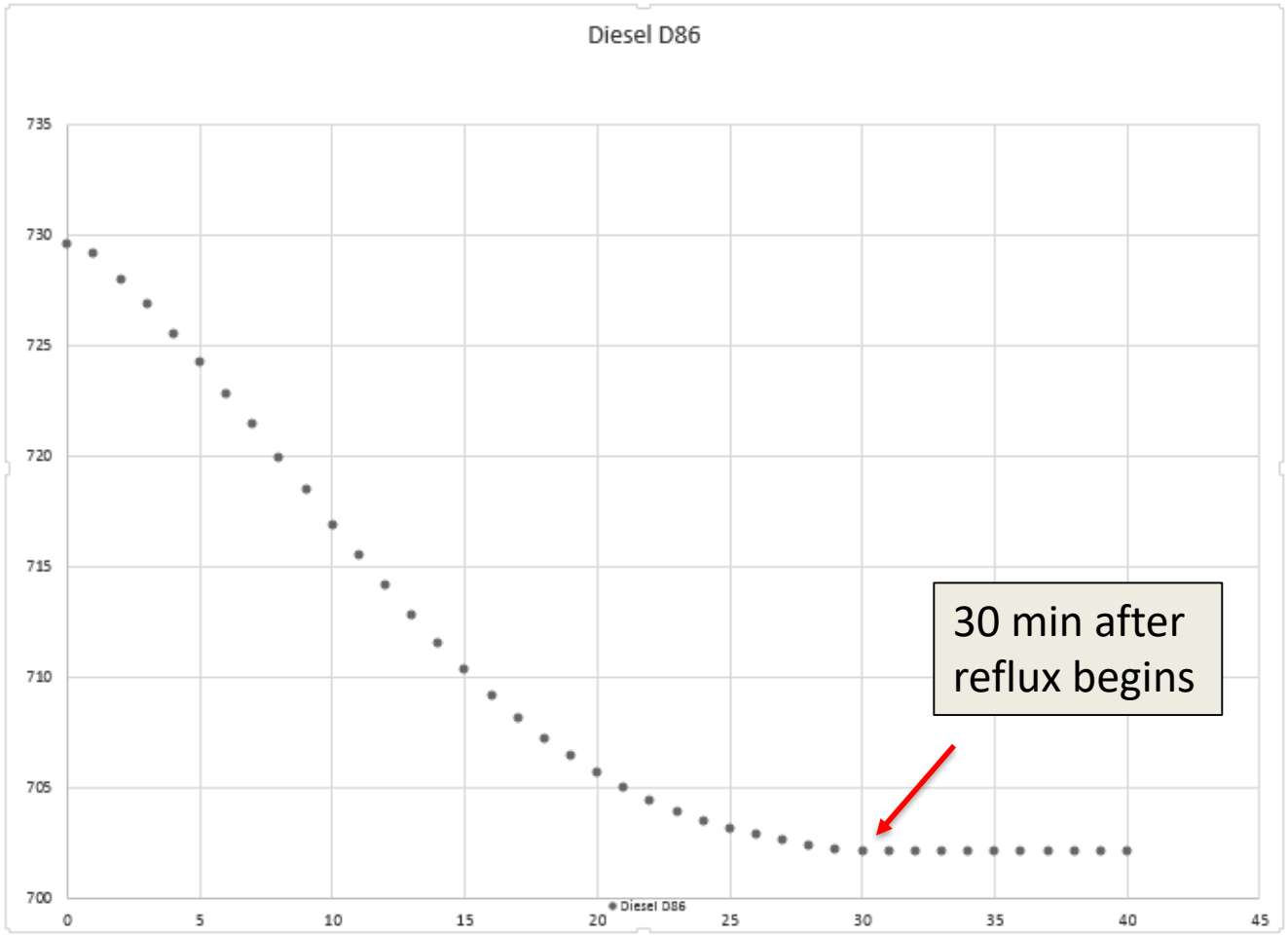
Product Stream Reaching Specification



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Scope of Model

1) Crude charge introduced to tower at increasing temp & flow rate ✓
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Validating Results

- Time to reach accumulator level:
  - Model → 30 min
  - Actual → 20 min
- Time to side product specs after reflux begins:
  - Model → 30 min
  - Actual → 40 min

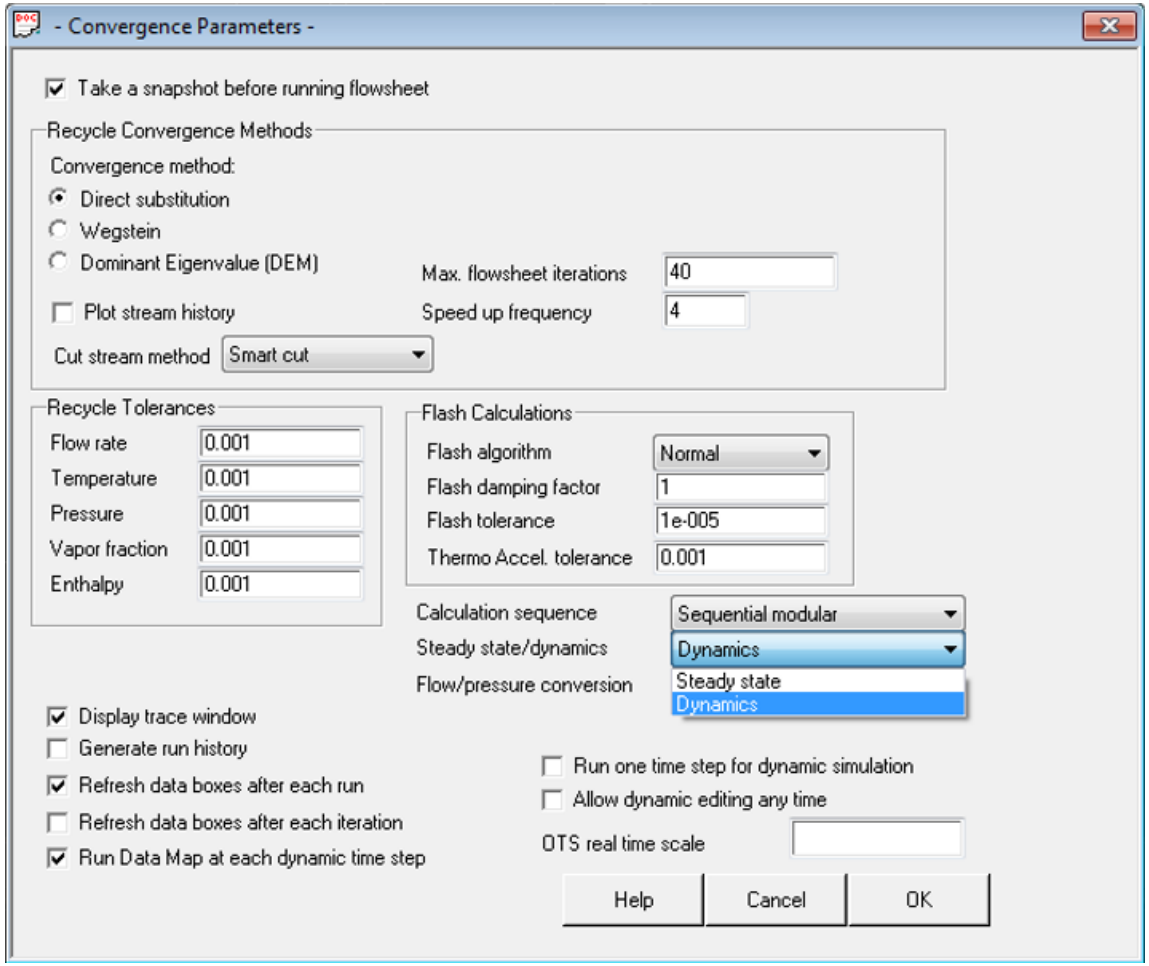
Further Validation of Results

- Compare to additional sets of startup data
  - Is the delta between the model & actual consistent?
- Add complexity as required to get desired results
  - How close is close enough?

Add Complexity As Required

- Fired heater
- Reflux/distillate control valves
- Pumparounds/side strippers
- Relief valve studies
- Additional upstream / downstream units

Switch Back to Steady State Model



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Review Simulation Guidelines*

- Start with a simple model
  - Fix what you can, i.e. pressures, etc.
  - Ignore what you can, i.e. utilities, etc.
- Get model to converge
- Validate results
- Add complexity as required to reach desired engineering solution
  - more detail may not be better!
  - i.e. don't add utilities controls systems to flowsheet just because they're on the P&ID

* True for steady state & dynamic simulations!

Special Thanks

Ron Colwell, PE – Engineering Manager

David Fleming – Senior Process Engineer

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Calumet Montana Refining processes Canadian heavy crude oil to produce gasoline, middle distillates and asphalt which they market primarily into local markets in Washington, Montana, Idaho and Alberta, Canada.

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