16th STS-AIChE
Southwest Process Technology Conference

- Keep Distillation System On Spec at Max Rates
- Charles D. Herzog
- Retired Chemical Engineer

Sept 22-23, 2025, University of Houston

16th STS-AIChE Southwest Process Technology Conference

Speaker Bio

Charles Herzog is a retired chemical engineer from the petrochemical and oil refining industries. His experience includes process design, plant startups, test runs, and process control. He was a pioneer in ethylene plant advanced process control in the 1980s, and was awarded a patent for the ‘Heat and Material Balance Method of Distillation Process Control’ in 2004. Charles graduated from Rice University with B.A. and M.Ch.E. degrees and was a professional engineer in Texas.

Charles was a soccer referee for 25 years and enjoys his long-time hobbies of piano, cycling, and chess in retirement.

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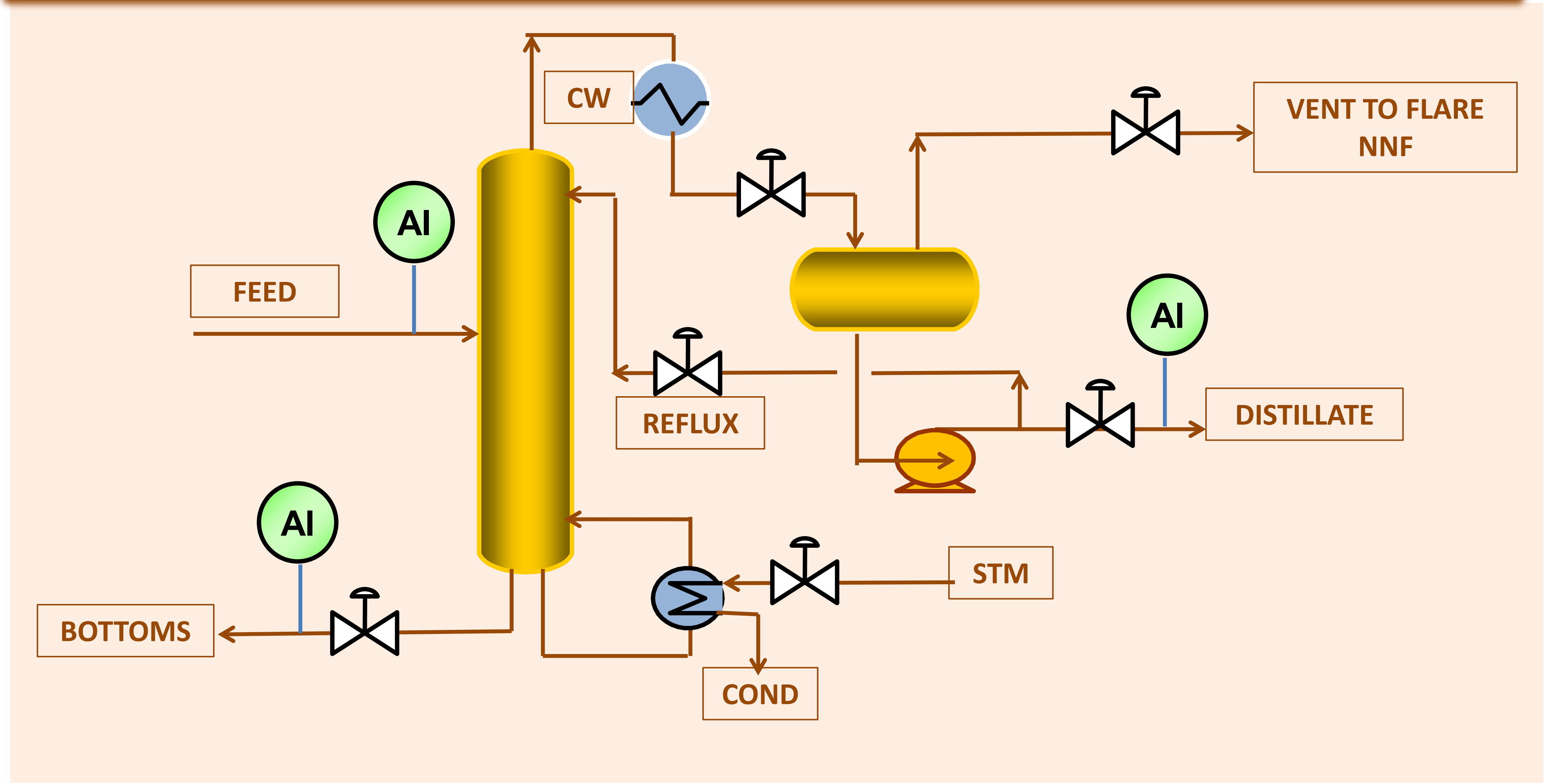
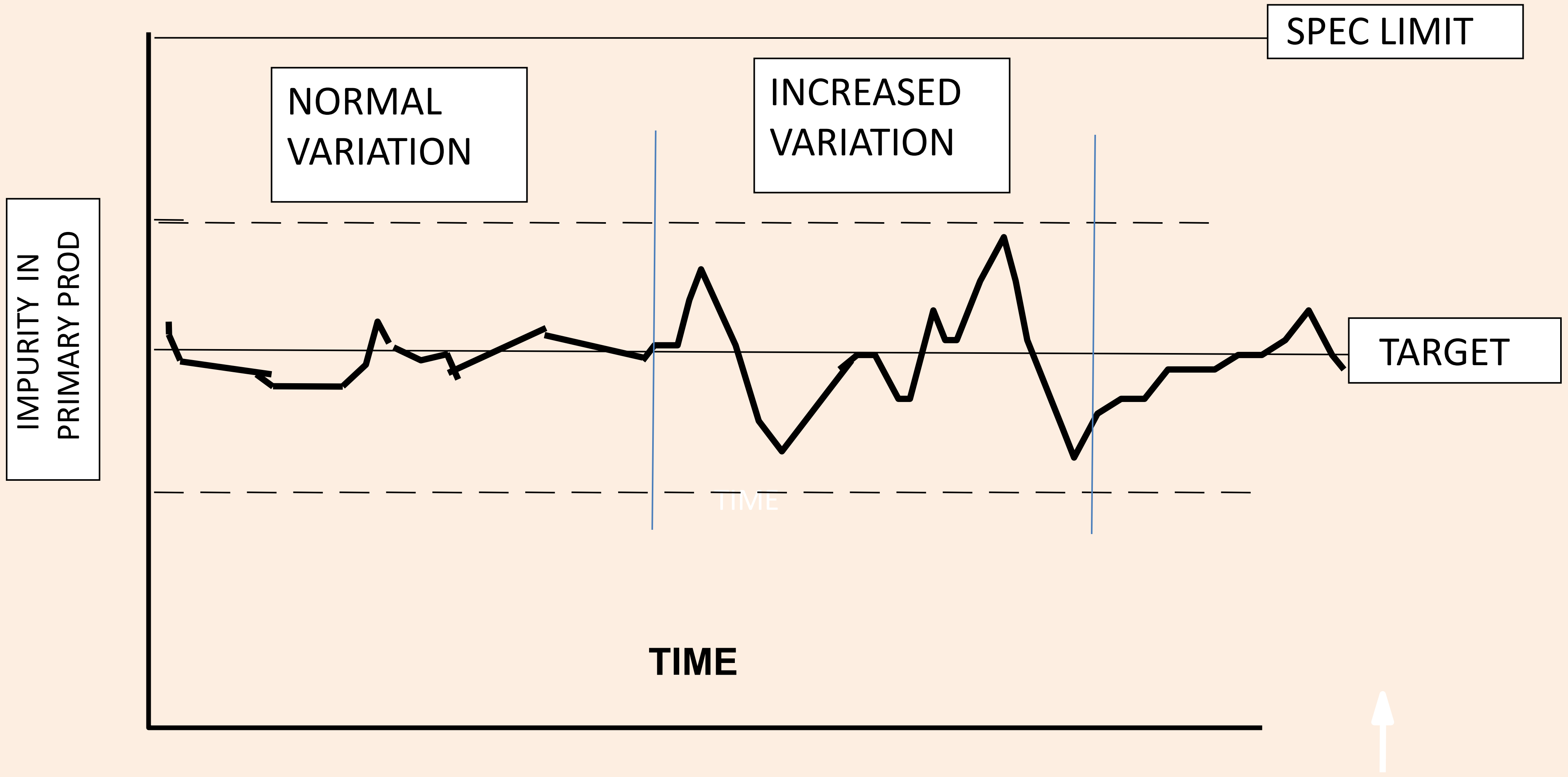
Typical Distillation System



Overall Strategic Plan

- Evaluate current process variation and operating target
- Adjust operating target if necessary
- Apply heat and material balance control to reduce variation
- Stay on-spec at max rate by taking load **off** the system
- Fine tune system at normal rate, then increase feed

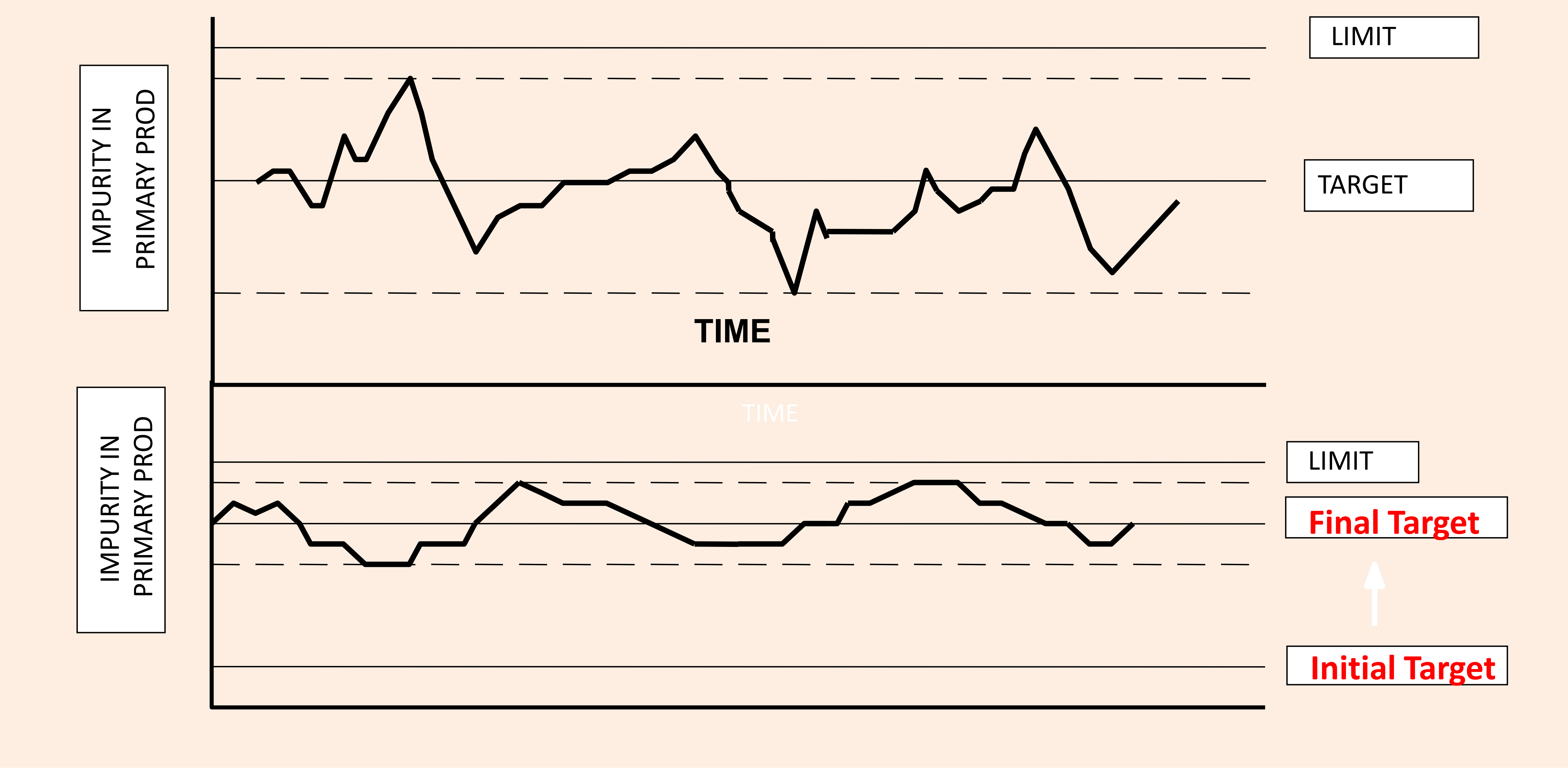
Use Excel to Plot Analyzer Data on Graph



Identify Causes of Increased Variation

- Identify periods of normal operation
- Identify shorter periods with increased variation
- Correlate increased variation with outside events:
  - **Feed rate or feed composition change**
  - Rainstorm or rapid drop in ambient temperature
  - Other ‘typical’ disturbance that occurs in your unit

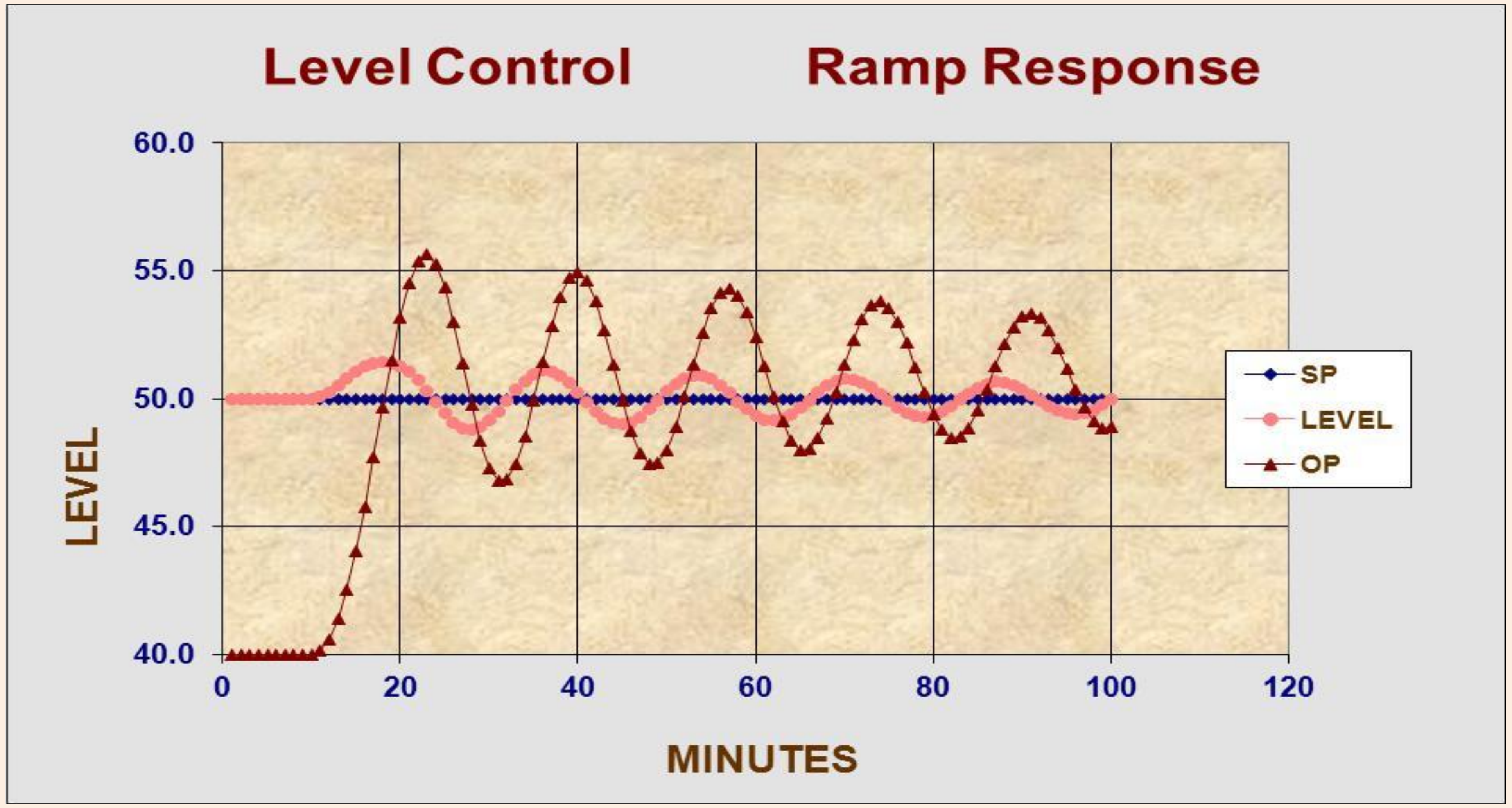
Reduce Maximum Variation to Achieve Success



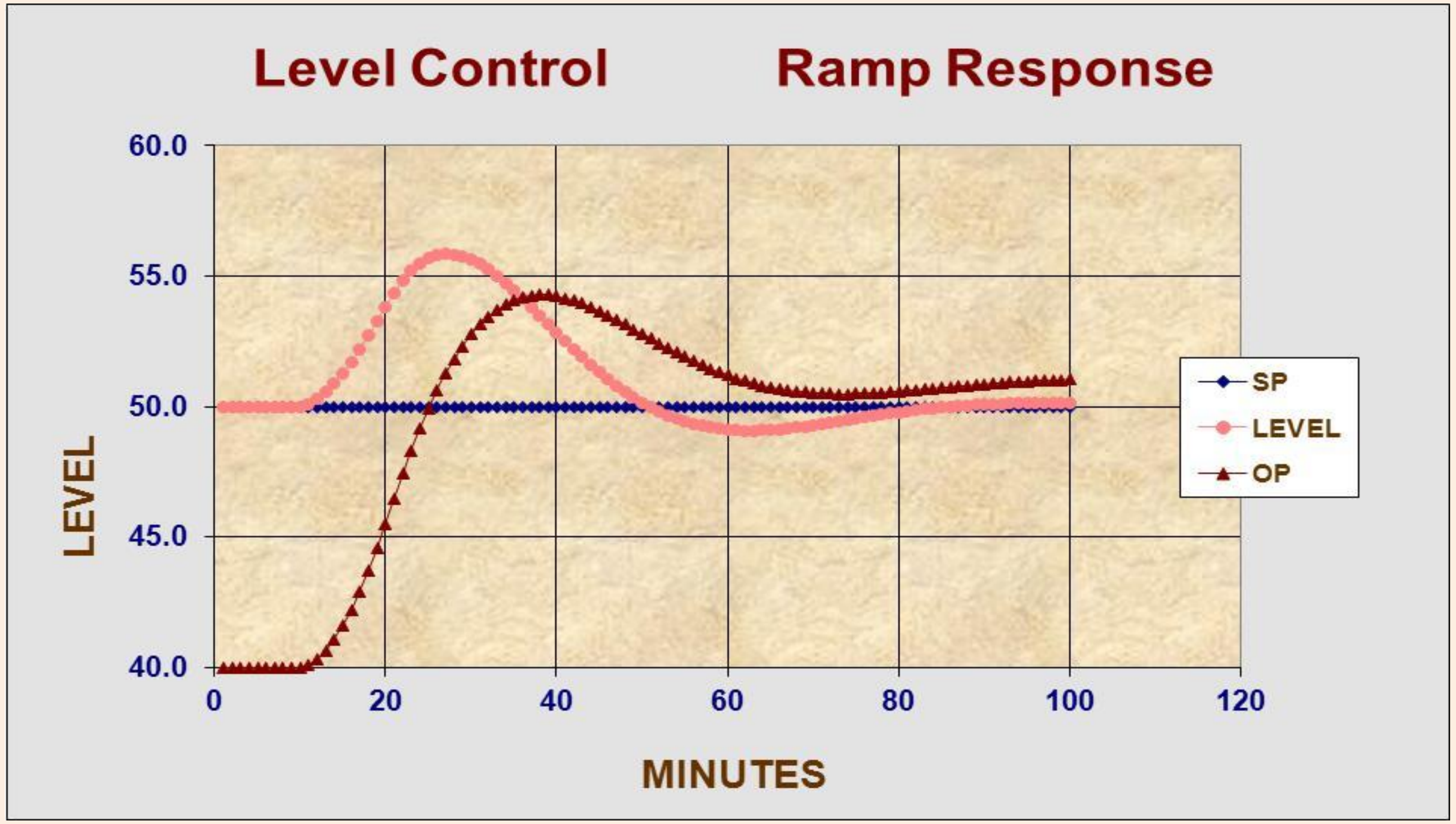
Fix Upstream Sources of Unsteady Feed Rate

- Feed rate changes occur in all units
- Level controllers must respond correctly
- **Tune upstream level control for steadier feed**
- Plant process engineers must learn how to tune controllers

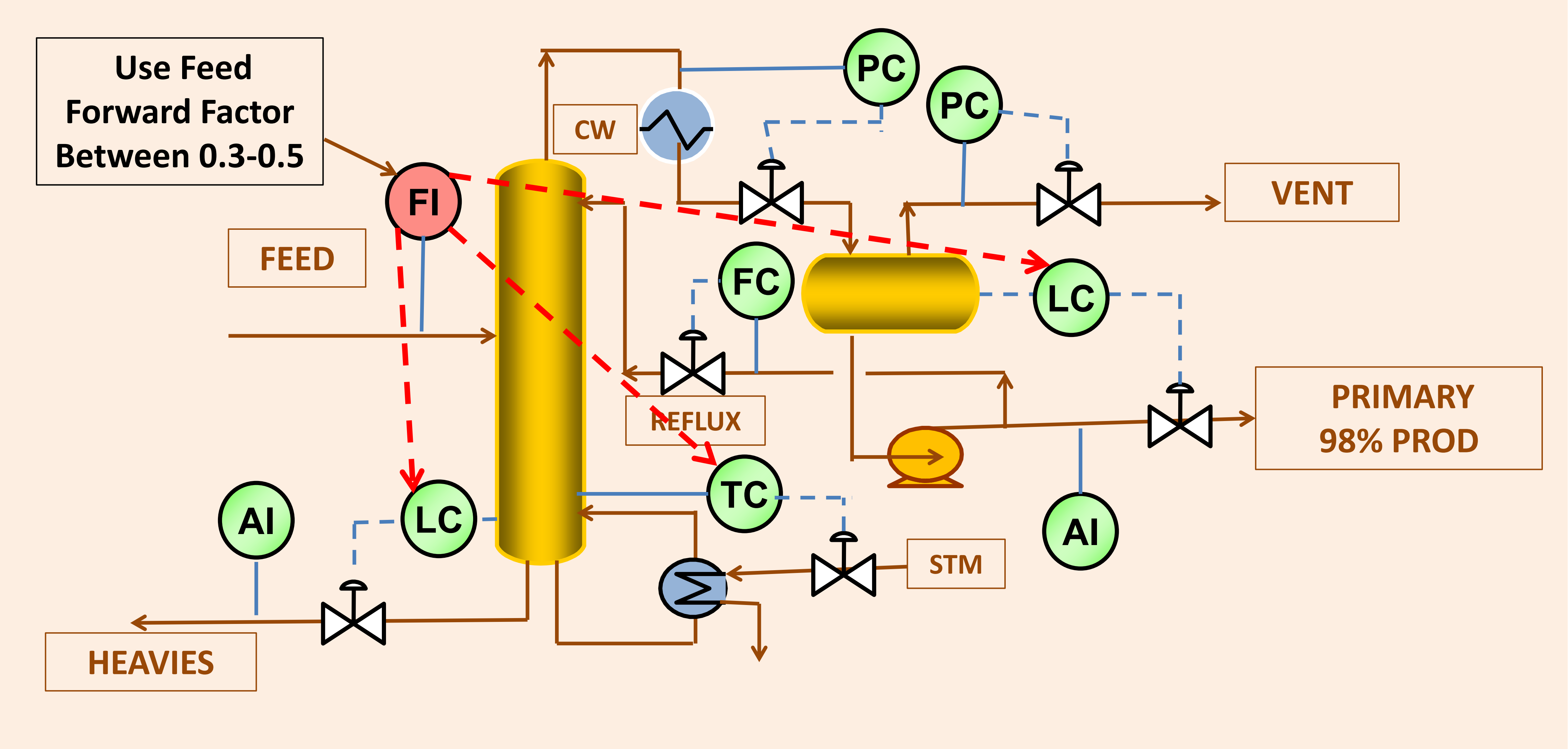
Level Controller Needs Tuning



Tuning Improves Performance

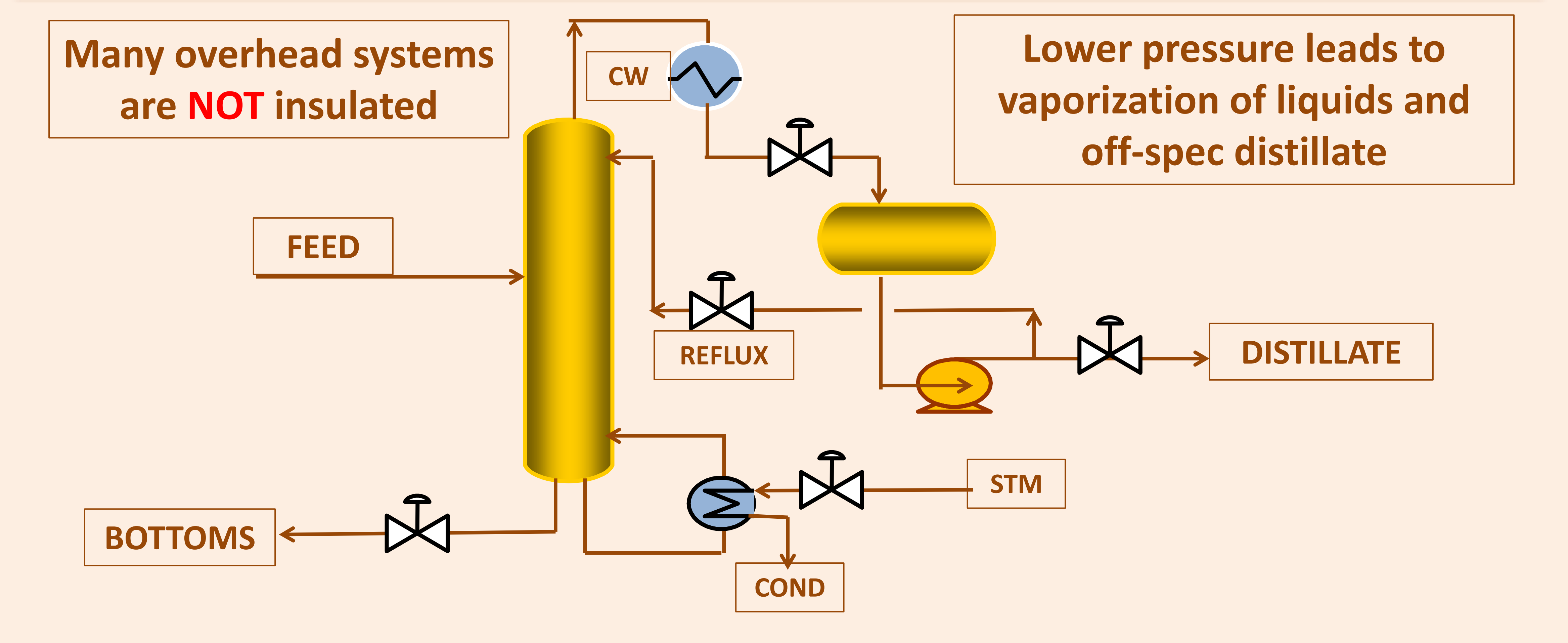


Adding Feed Forward to Primary Controls Reduces Controller Error and Simplifies Tuning

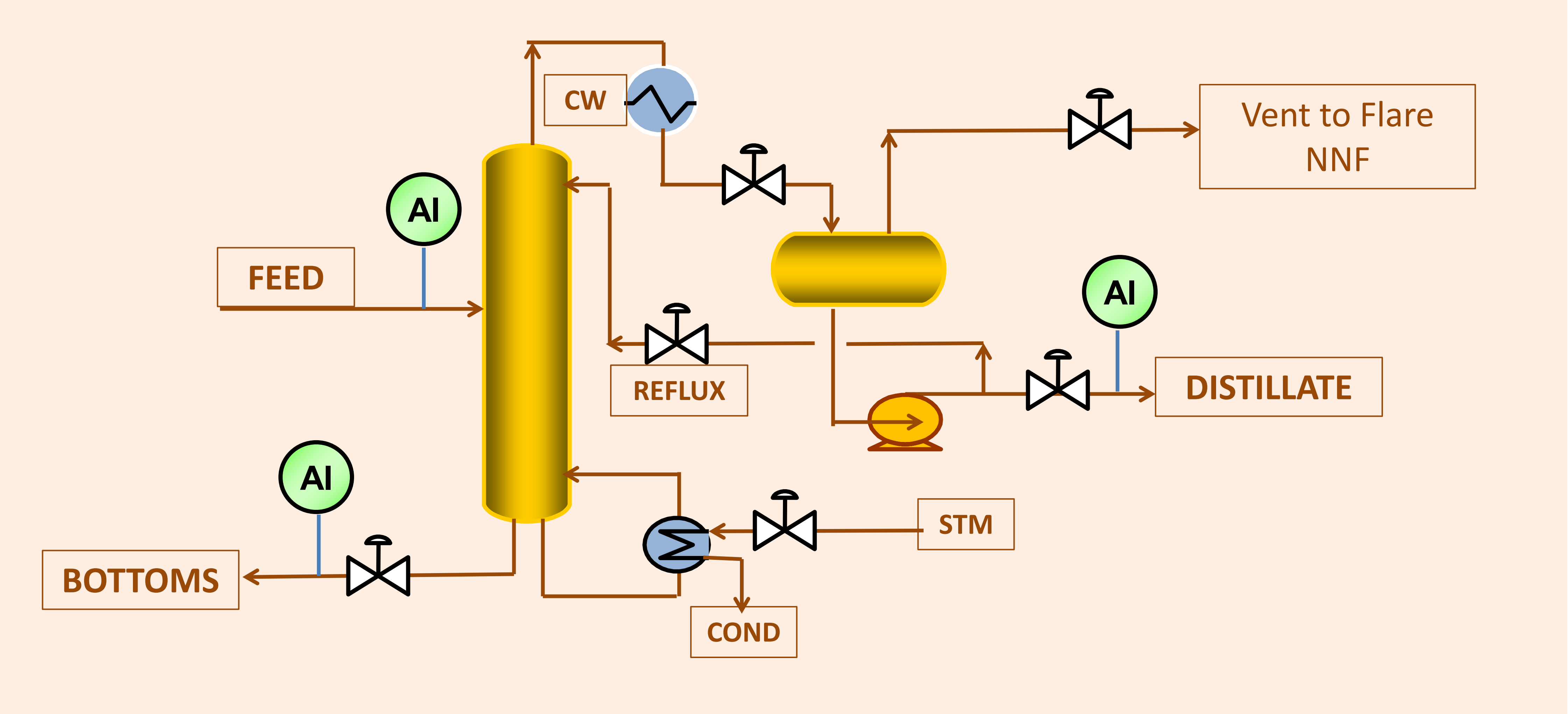


Reduce Effects of Rainstorm with Insulation

Rain on Overhead Piping Causes Sudden Pressure Decrease



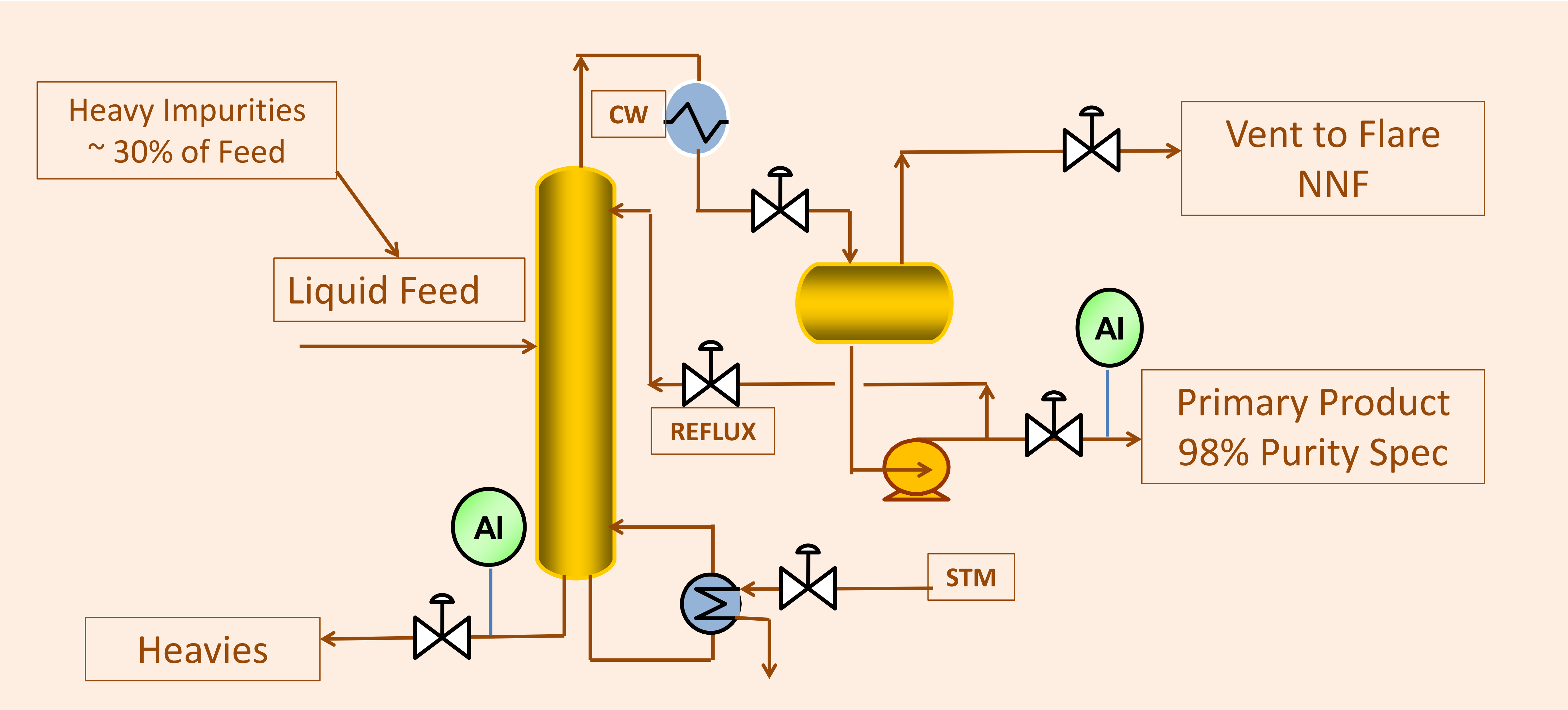
Design Control System for Max Rates



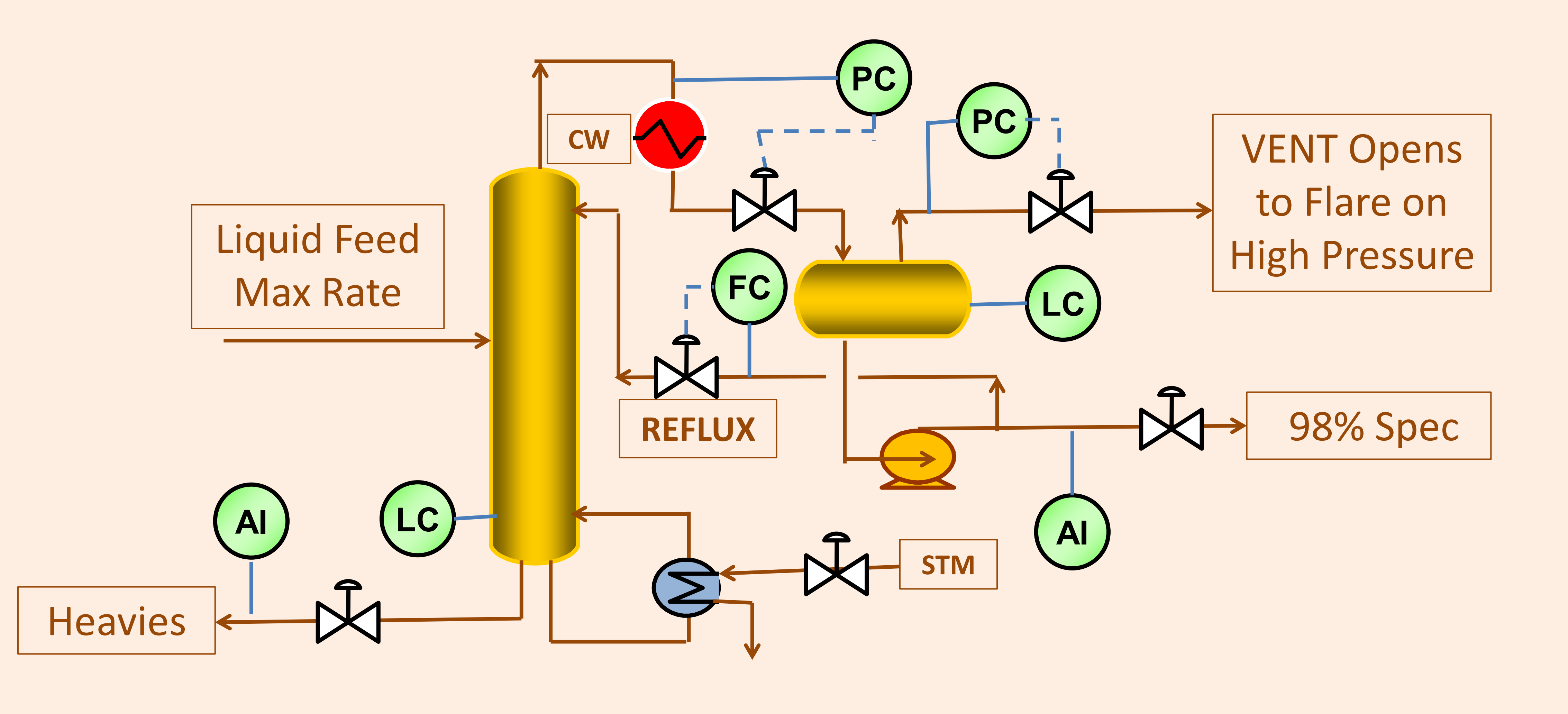
Equipment Constraints Affect Distillation

- Condenser
- Reboiler
- Hydraulic Capacity of Trays
- Reflux Pump (not as common as the others)

Example: Constrained LPG Distillation System



Condenser Becomes Constrained in Afternoon
How to Control Pressure and Remain On-Spec?



Degrees of Freedom

With No Active Constraints – Everything is controlled

Independent Variables	Dependent Variables
• Condenser Area	• Pressure
• Reflux Rate	• Heavies in Distillate
• Reboiler Duty	• Lights in Bottoms
• Distillate Rate	• Reflux Drum Level
• Bottoms Rate	• Bottoms Level

Max Rates: One or More Variables Limited

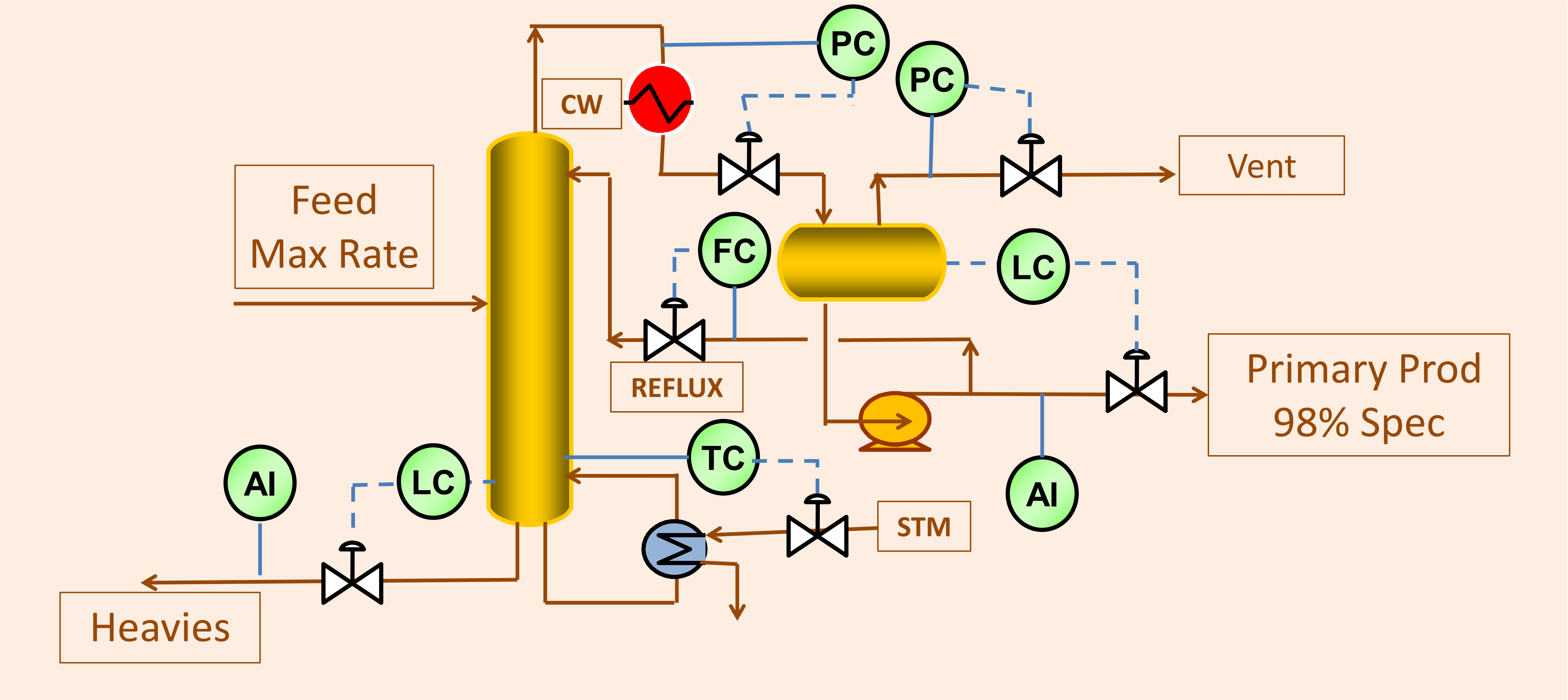
Active Constraint Causes Negative Degrees of Freedom
One of the Dependent Variables Cannot Be Controlled

Independent Variables	Dependent Variables
• **Condenser Area -- Limited**	• **Pressure**
• **Reflux Rate**	• **Heavies in Distillate**
• **Reboiler Duty**	• **Lights in Bottoms**
• **Distillate Rate**	• **Reflux Drum Level**
• **Bottoms Rate**	• **Bottoms Level**

Bottoms Product Composition is Sacrificed In Order to Control Pressure without Venting

Independent Variables	Dependent Variables
• **Condenser Area -- Limited**	• **Pressure**
• **Reflux Rate**	• **Heavies in Distillate**
• **Reboiler Duty**	• **Lights in Bottoms**
• **Distillate Rate**	• **Reflux Drum Level**
• **Bottoms Rate**	• **Bottoms Level**

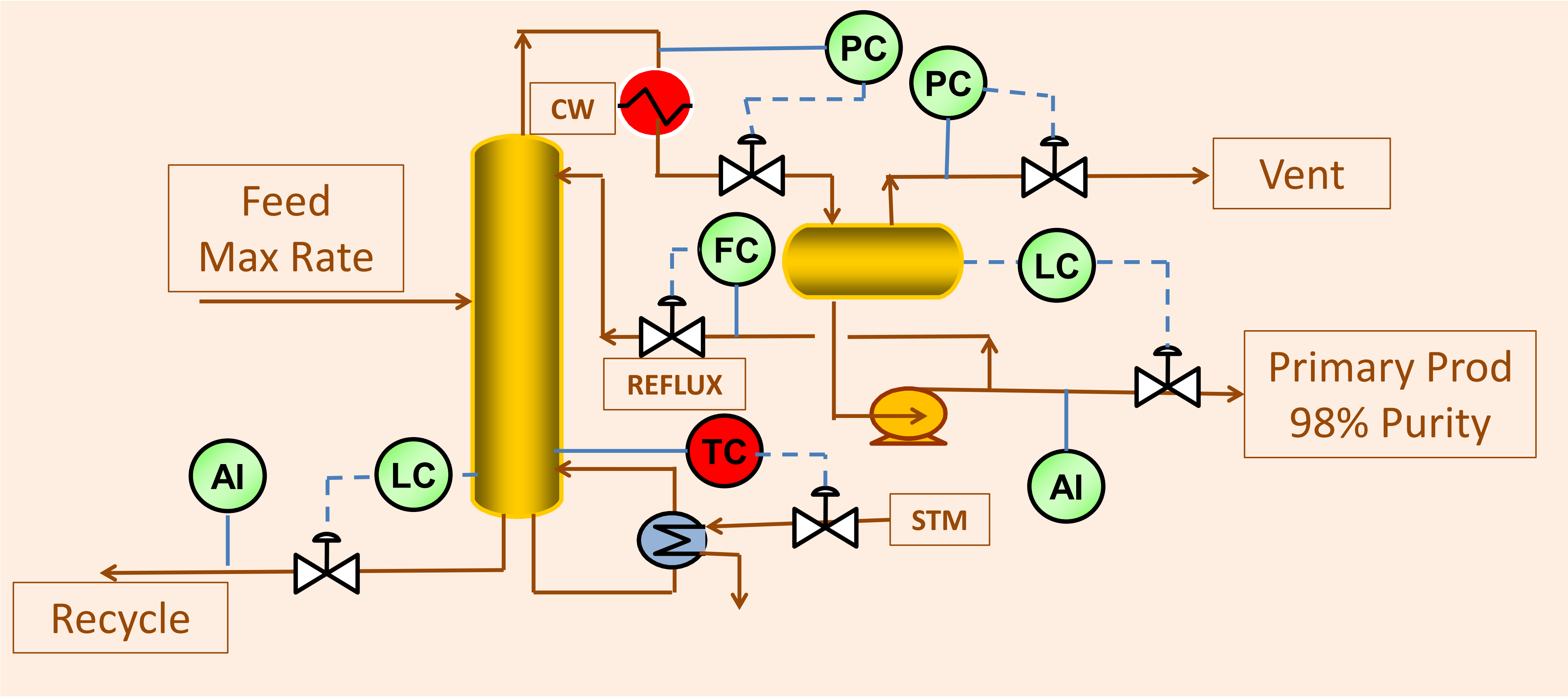
Typical DCS Control Strategy: Operator Increases Reflux to Purify Distillate



What's Wrong with the DCS Strategy Shown?

- Adding reflux for distillate purity adds load to condenser
- Bottoms TC controls composition of least important stream
- **Operator changes control strategy at max rates**
  - **Operator uses bottoms TC to manage the constraint**
  - **Requires constant attention to avoid venting**

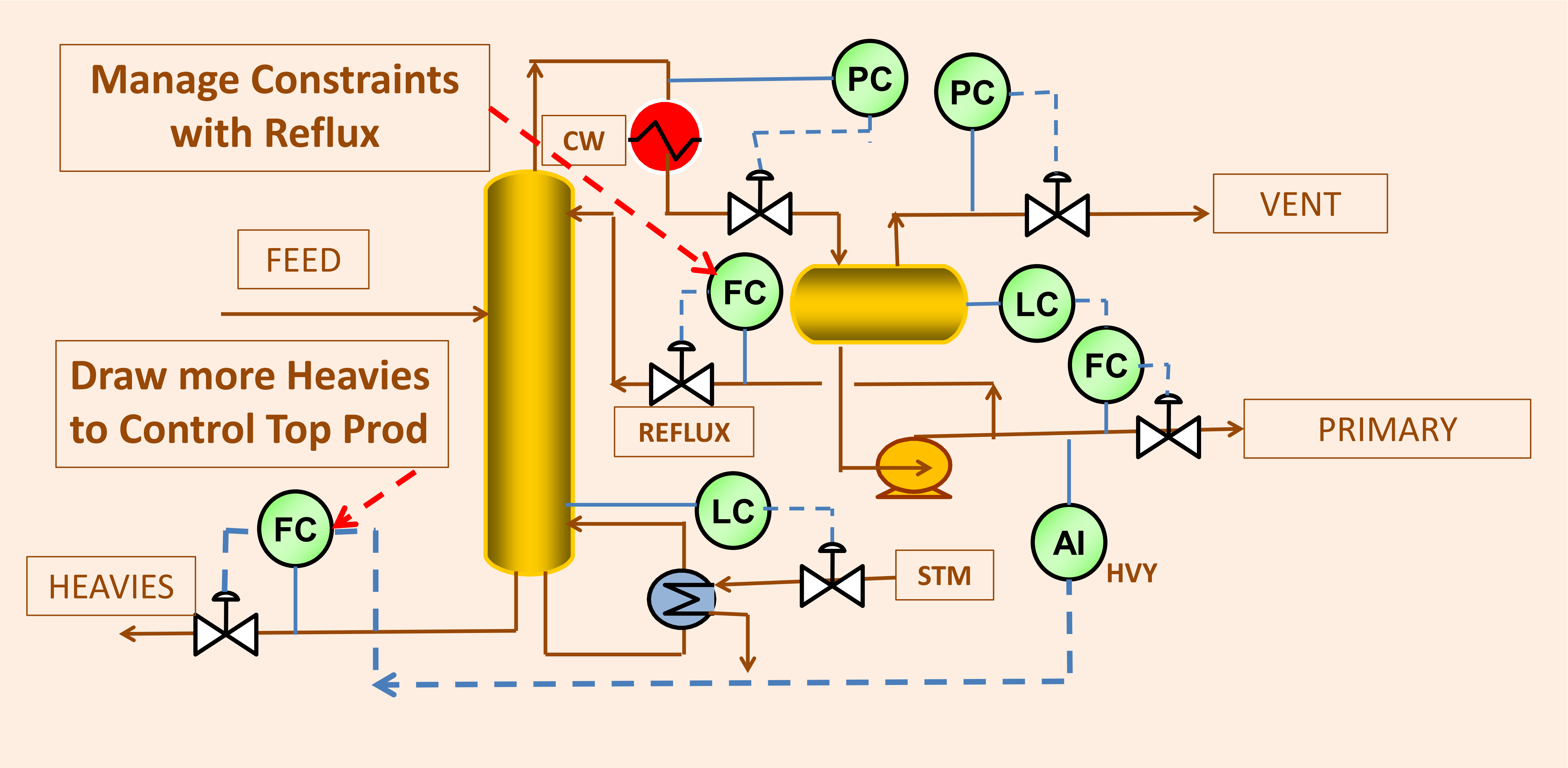
Must Cut Reboiler Duty (TC setpoint) to Control Pressure and Keep Primary On Spec



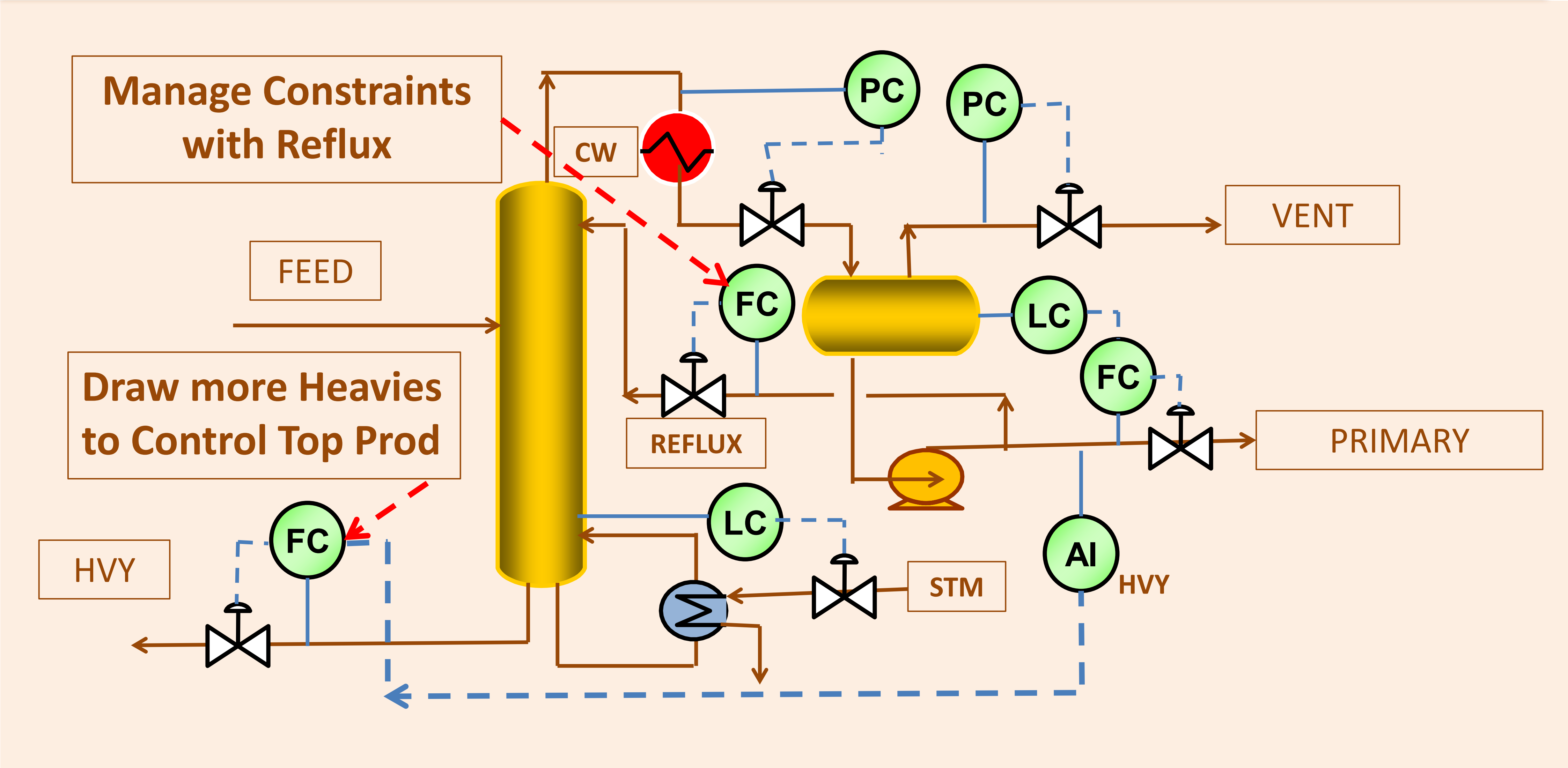
The Heat and Material Balance Method of Distillation Process Control

- Product purity achieved by component material balance
- Heat balance achieved by level control of secondary product
- Constraints managed by a ‘loading variable’ (heat or reflux)
- Control strategy **continues to work** at max rates
- Secondary product composition sacrificed if necessary

Improve Purity by Taking Load Off the System



Calculate Bottoms Draw by Material Balance
Use Reflux as a Loading Variable to Manage Constraints

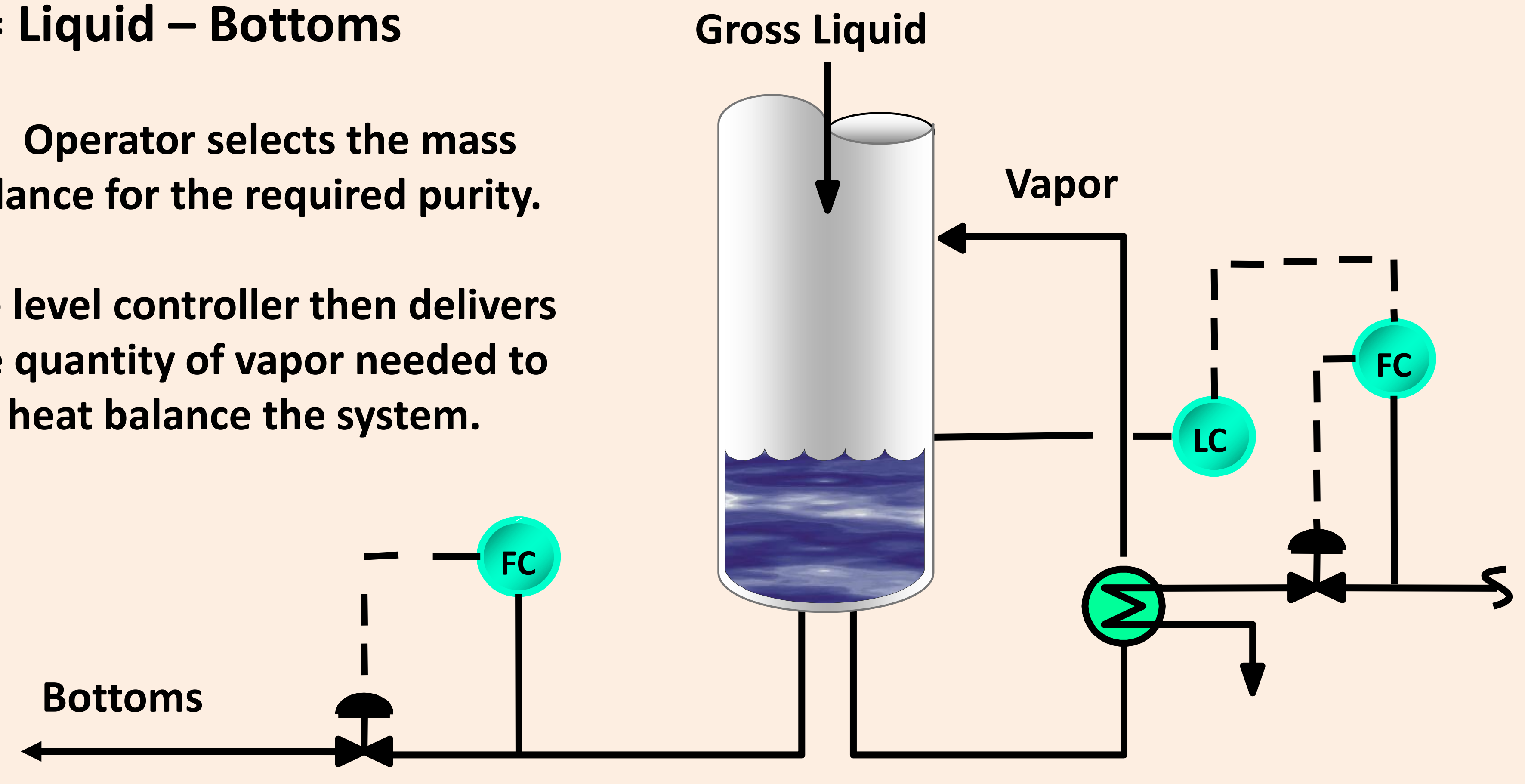


Use Bottom Level to Enforce Heat Balance

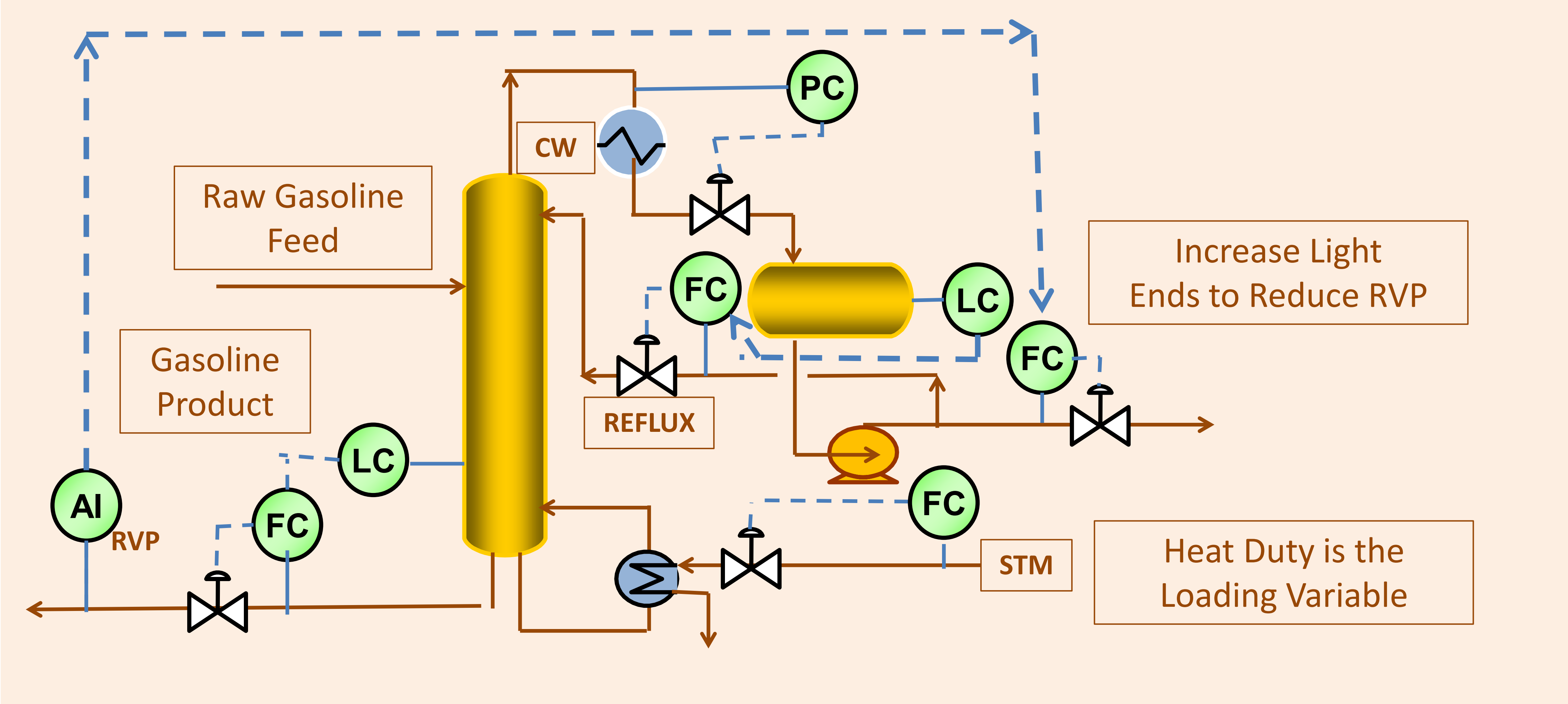
Vapor = Liquid – Bottoms

Operator selects the mass balance for the required purity.

The level controller then delivers the quantity of vapor needed to heat balance the system.



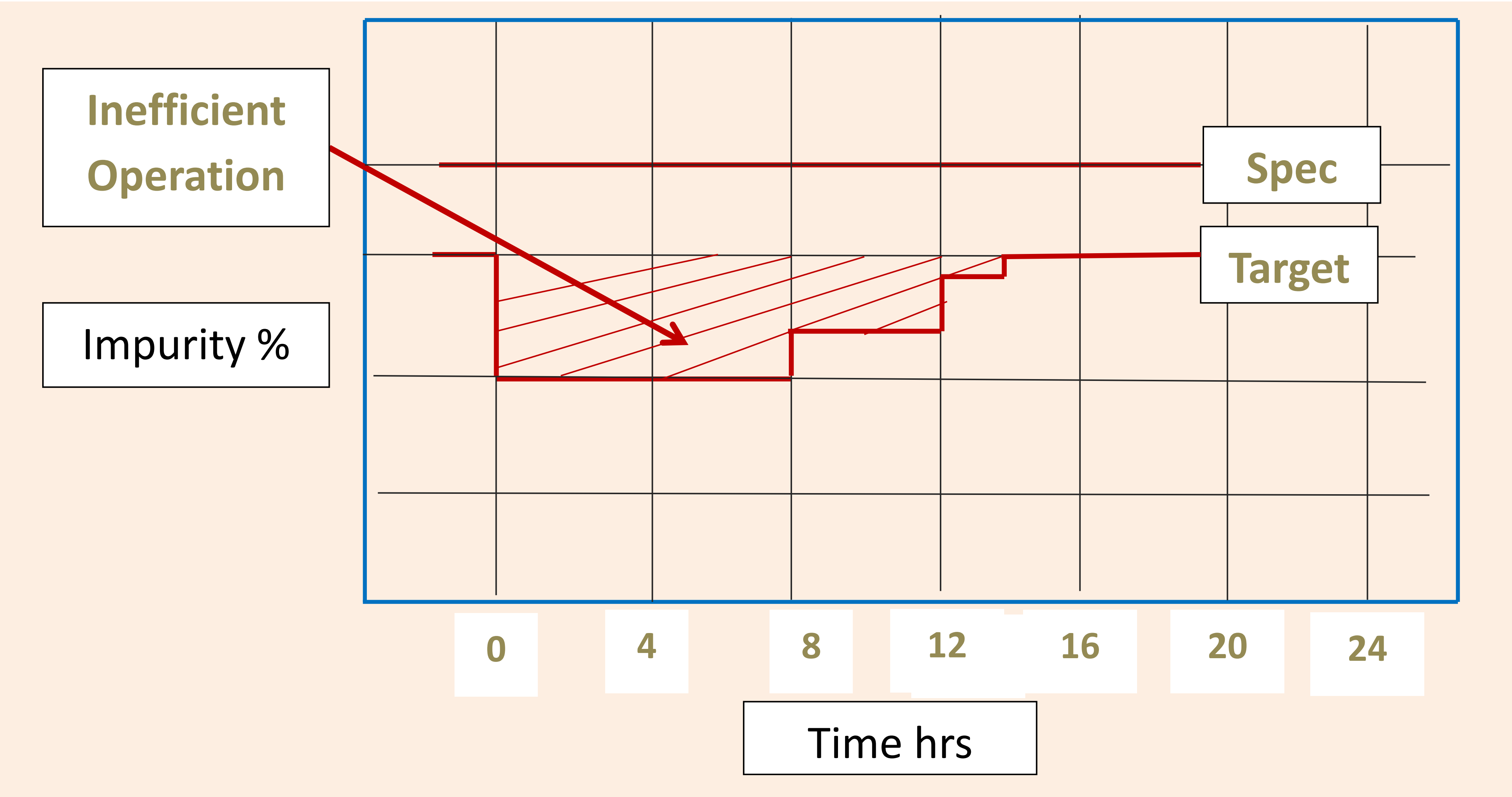
FCC Debutanizer—Bottoms is Primary Product



Stay On Spec during Analyzer Calibrations

- Critical product analyzers are calibrated weekly
- Calibrations usually take 4 – 6 hours
- Move away from the spec limit prior to calibration ??
  - Leads to reduced capacity and shifts the entire system
- Develop a process model that tracks the analyzer
  - Ok, but good models take time and need maintenance
- **Add redundant analyzer at next turnaround (or now)**

Typical Analyzer Calibration Timeline



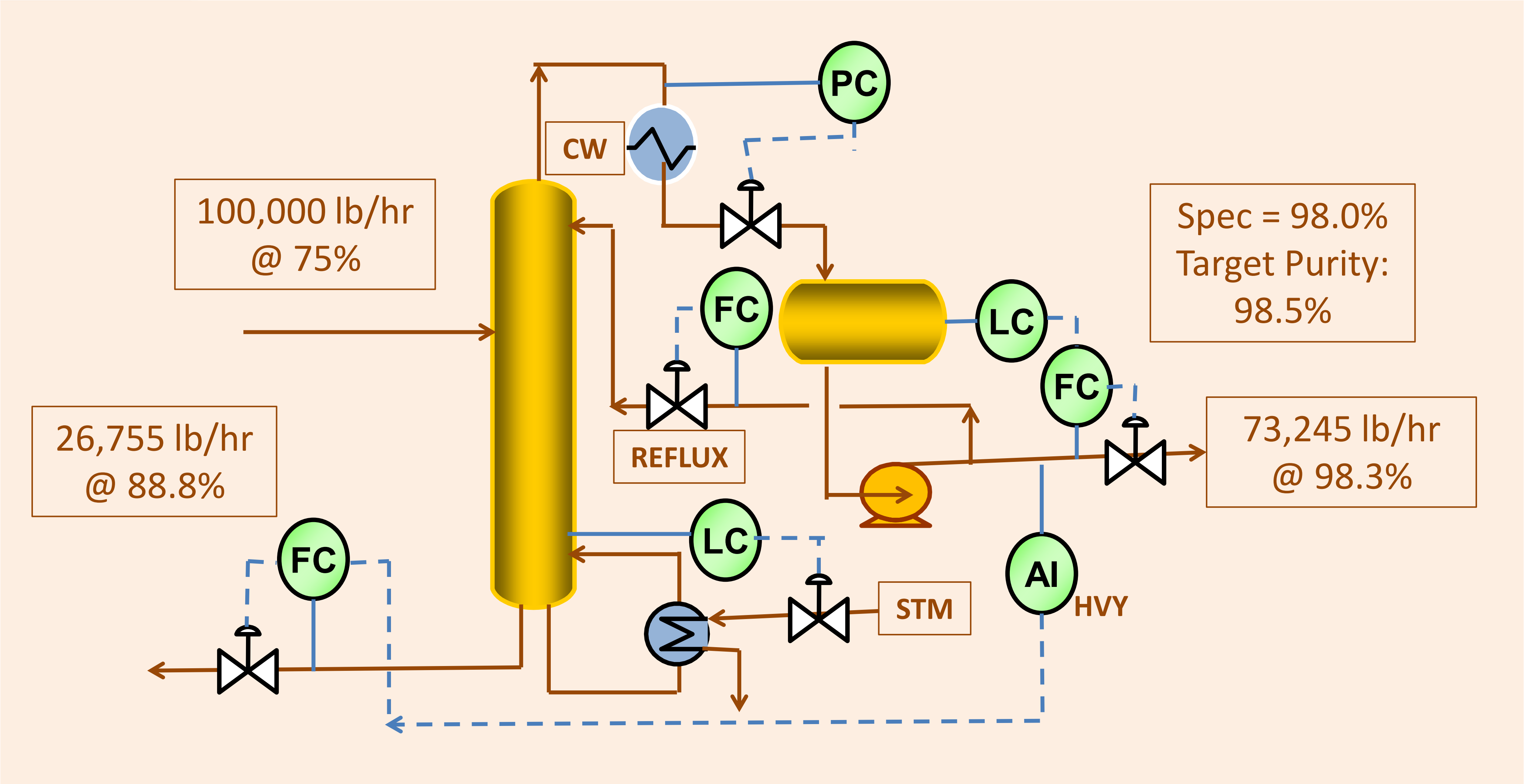
Thank You!

Example Problem

- Overhead product spec = 98.0%
- Initial purity = 98.3%
- Target purity = 98.5%
- Feed = 100,000 lb/hr @ 75% purity
- Ovhd = 73,245 lb/hr
- Btms = 26,755 lb/hr

Objective: Calculate Change to Bottoms Draw

Initial Conditions – Binary Feed Mixture



Final Conditions
Increase Bottoms Draw by 167 lb/hr (0.6%)