The X-files of a depropanizer

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OPTIMIZE™ 21

VIRTUAL EXPERIENCE

The Future Starts with Industrial AI

May 18 - 20, 2021

inprocess

Agenda

- **Who we are**
- **The Truth Is Out There**
- **Study highlights**
  - One condenser and a half
  - Column tray hydraulic constrains
  - Multivariable inferential for APC
- **Future work & conclusions**

Who we are

Inprocess in brief

independent from any ICSS or simulation software provider

our **core business** is Process Simulation

keen to **share its knowledge** with clients

2006

founded in Barcelona by domain experts

48 countries

worldwide presence

50+

simulation engineers

250+

years experience

400+

executed projects

320+

training courses

Mission: Deliver the value of Process Digital Twins to achieve Operations Excellence

Lifecycle Modelling and OTS projects

Simulation Lifecycle	Feasibility Studies	Dynamic Simulation Studies (DSS) Validation of Control	Operational Procedures Early OTS	DCS check-out	OTS Operator Training System	Plant start-up support	Operations & Maintenance support with the Digital Twin
Plant Lifecycle	Conceptual Design, Basic Engineering (FEED) and Detailed Engineering (EPC)					Commissioning & start-up	Operations & Maintenance

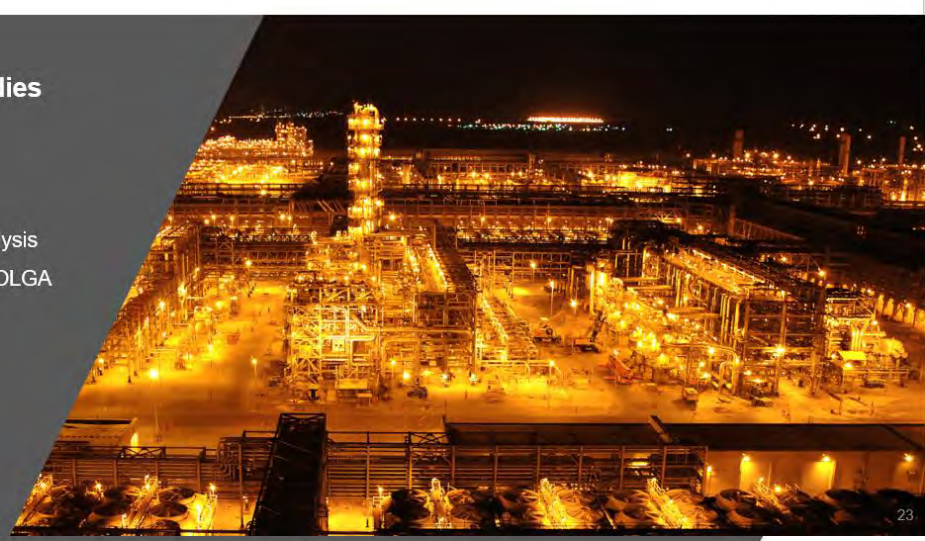
Lifecycle Modelling

- Feasibility studies. Selection of alternatives
- Dynamic simulation studies before plant construction
- Validation of control philosophy
- Operational procedures development/enhancement
- Process trainer - Emulated OTS - Early OTS
- DCS check-out
- OTS for operators' initial and continuous training
- Support during commissioning and start-up
- Operations & Maintenance support (Digital Twin)

Process Simulation projects

Process Simulation Studies

- Steady State Analysis
- Dynamic Simulation Studies
- Integrated Flare Systems Analysis
- Flow Assurance Studies with OLGA
- Utilities Network Models
- On-line models
- Operations Staff Training
- O&M Support



Training & Knowledge Transfer

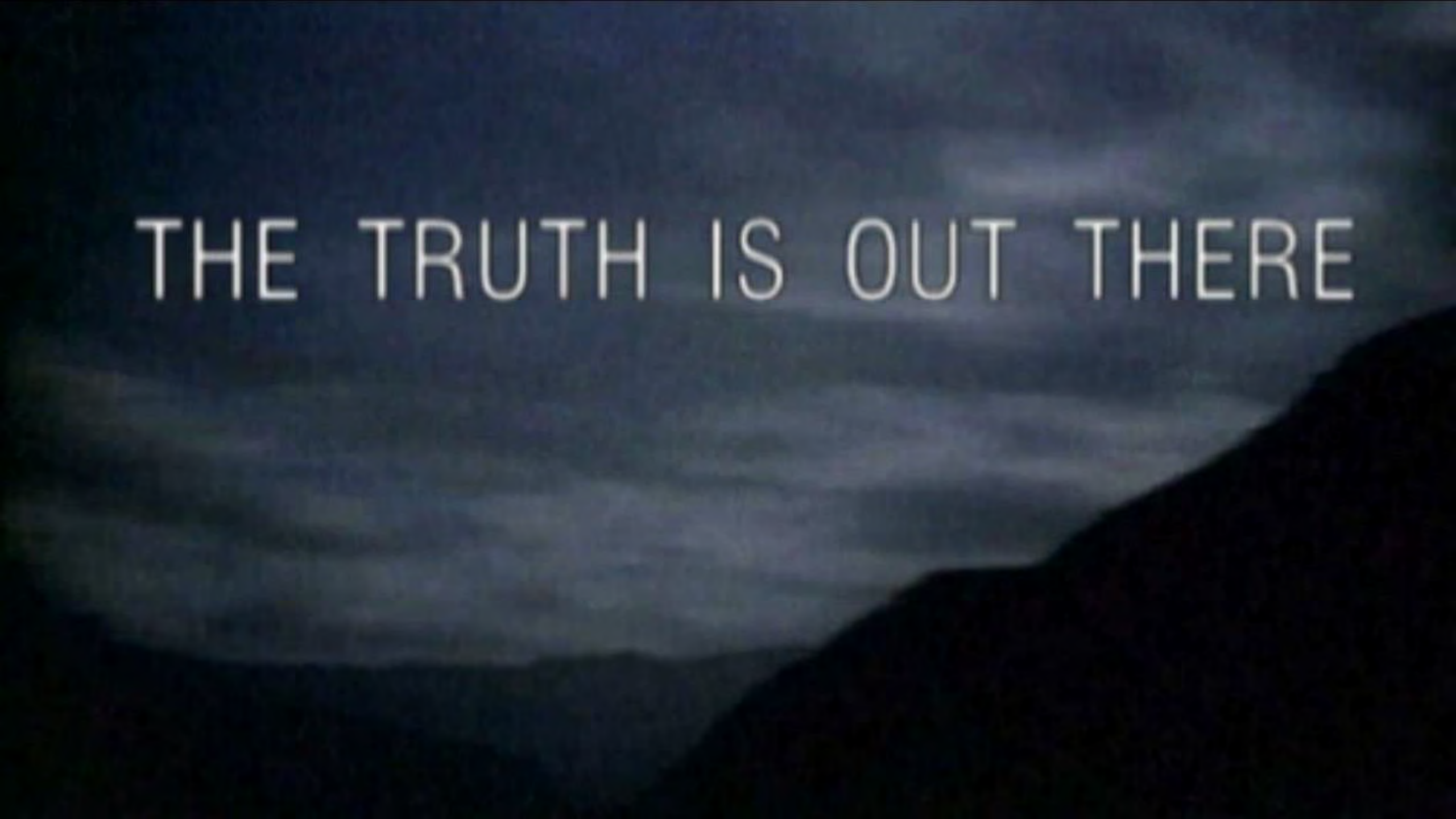
Training / Knowledge Transfer

- Process simulation courses
- Technology courses
- Knowledge Improvement Program – KIP
- Training for plant operators / technicians

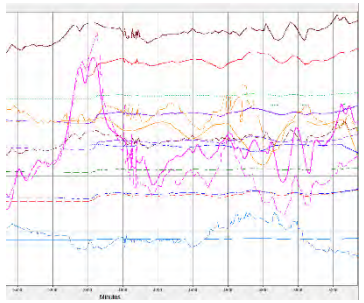
Applications & Software Development

Applications / Software Development

- **IIS**: Inprocess Infrastructure Suite
- **IPSV**: PSVs database
- **ITOP**: Inprocess Training for OPerators
- **ICOM**: Inprocess Competence Management System
- **IFLOW**: to link process simulators with OLGA®
- **IPSA**: Pressure Swing Adsorption simulator
- **OTS Web Access:** e-learning options
- Extensions for process simulators

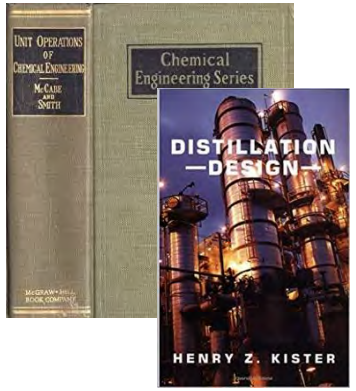

THE TRUTH IS OUT THERE

Finding the Truth with Industrial HI



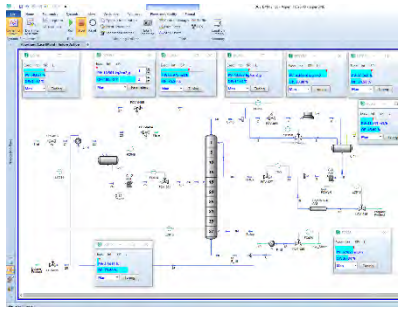
The Process Data

Plant sensors provide vast data sets of what is “Out There”. With the right visualization tool an experienced eye can make clever use of it.



The Laws

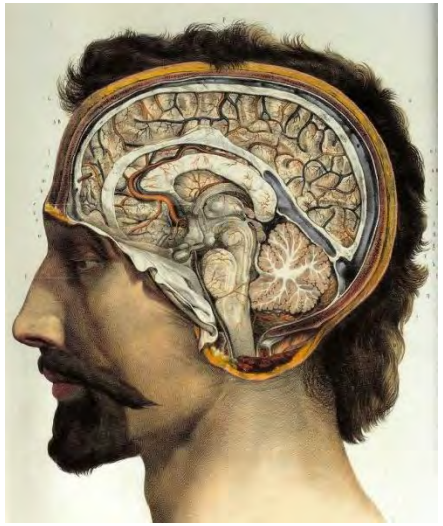
Hundreds of “Data Scientists” worked hard along the centuries to discover the laws of how matter behaves. Those laws still last today.



The Calculator

Process simulation is only a macro-compilation of physics, chemistry and thermodynamics laws smartly coded in an interactive computer application

Industrial
Human
Intelligence

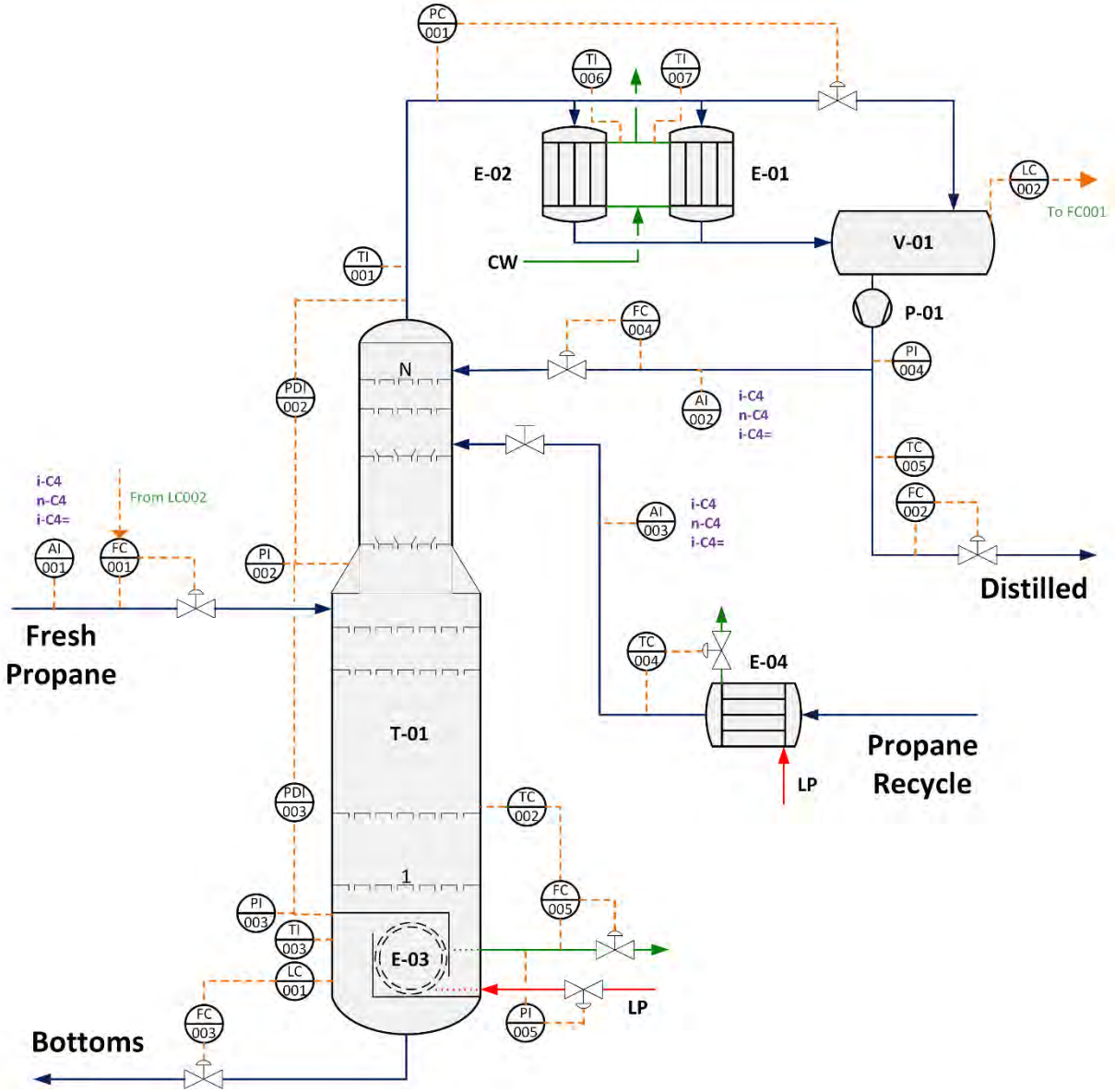


The Engineer

A combination of skills in chemical engineering, process control, plant operation coupled with plant data visualization, process simulation, programming and some common sense.

The Truth

Study scope



Plant background

- The column purify the propane by removing de C4s and heavies through the bottom
- The column is controlled by a DMCPlus controller which control C4s impurities at the top and minimize propane at the bottom
- The plant is being revamped to increase capacity in 25%

Scope of the study

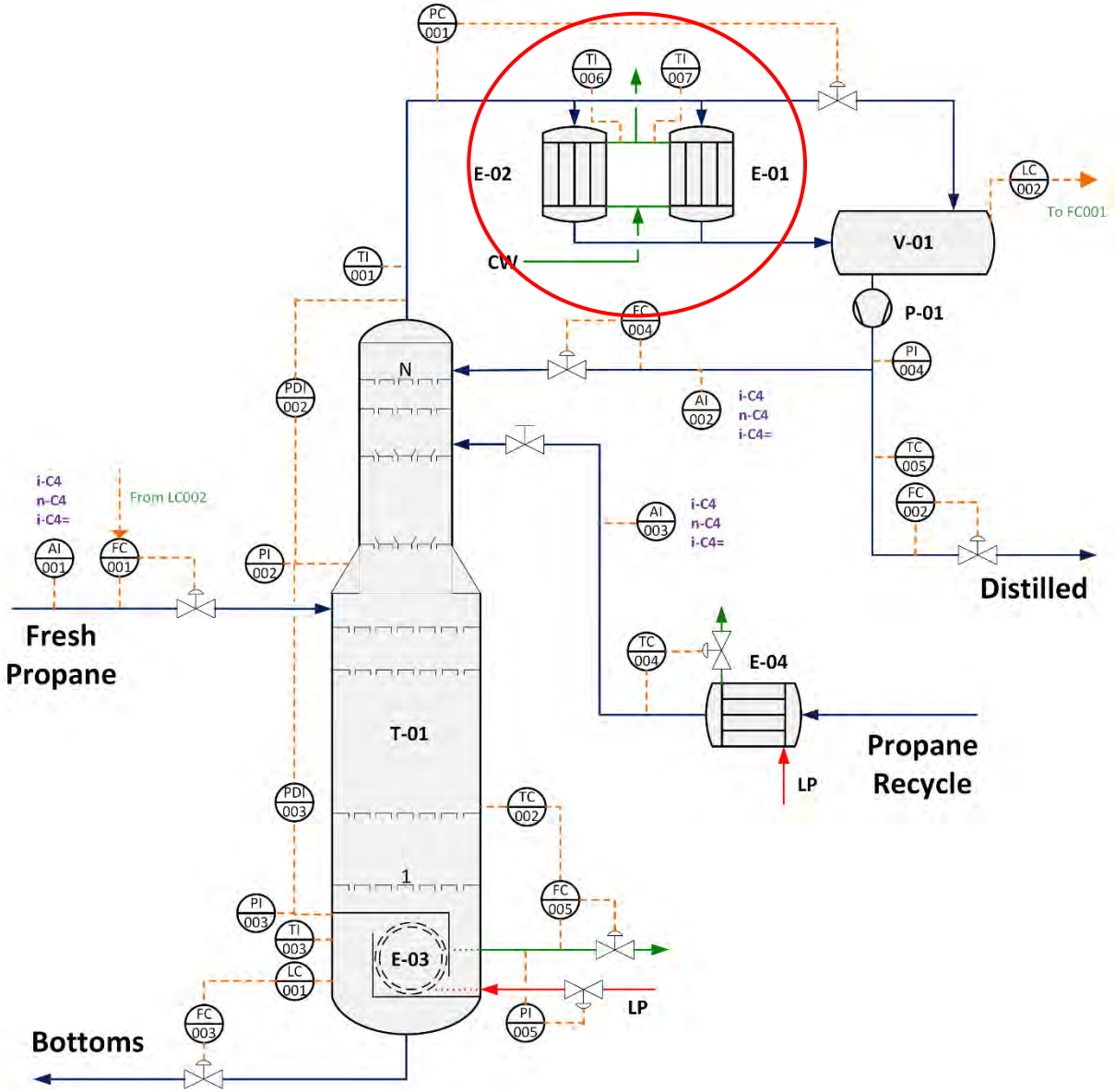
- Develop a HYSYS steady state and dynamic model calibrated to current plant conditions
- Study the current and future column conditions for all equipment involved:
  - Column hydraulics constrains
  - Condenser and reboiler duty requirements
  - Alternative feed tray locations
  - C3 inferential and APC gains
- Custom HYSYS training with the built models

Study highlights

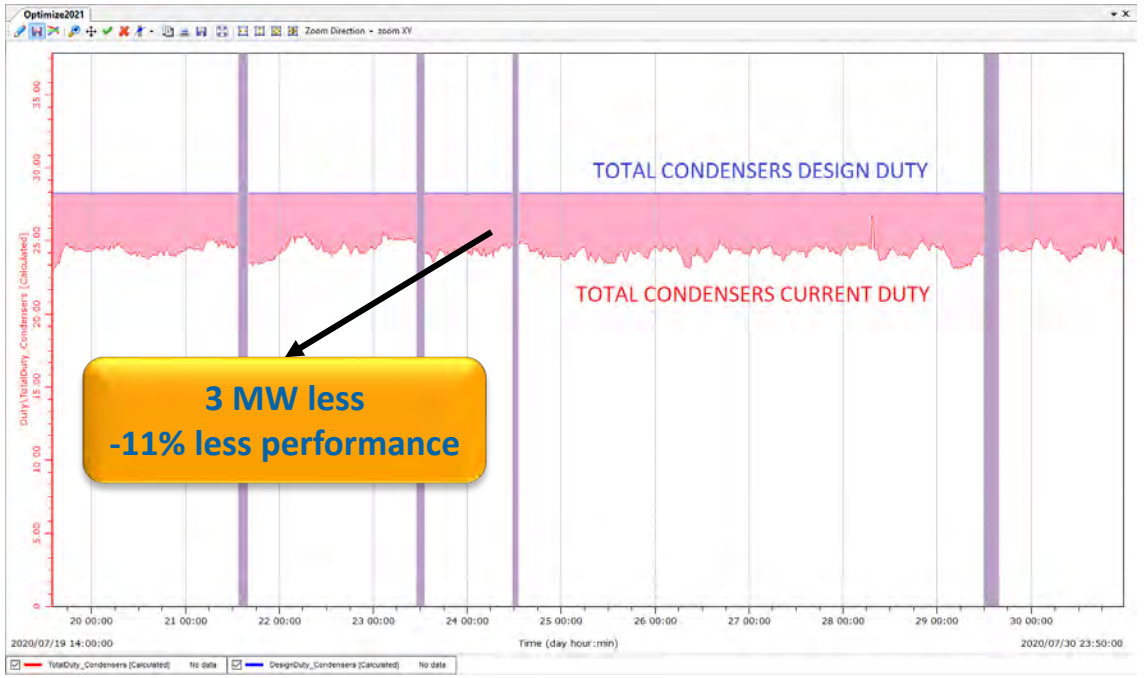
- **Condenser:** How is it possible that an exchanger gives less duty. This section is about how to detect a performance problem in plant equipment.
- **Tray hydraulics:** A review of how to use the HYSYS/AspenPlus Tray Sizing Utility and its benefits in a real plant.
- **Multivariable inferential:** This section explains how a HYSYS model can be useful to make an inferential that depends on more variables than pressure and temperature.

One condenser and a half

Depropanizer condensers issue

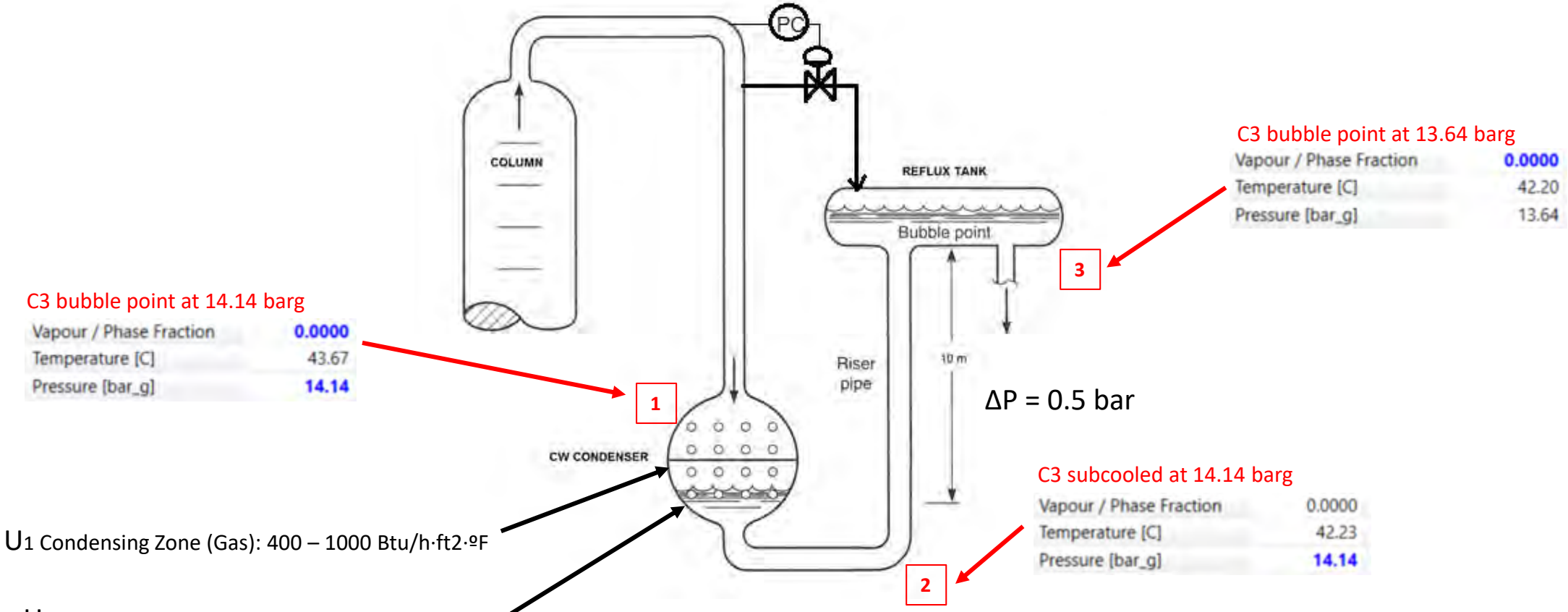


- Initially there was only one condenser and during a previous revamp a smaller condenser was added to supply the extra cooling capacity required



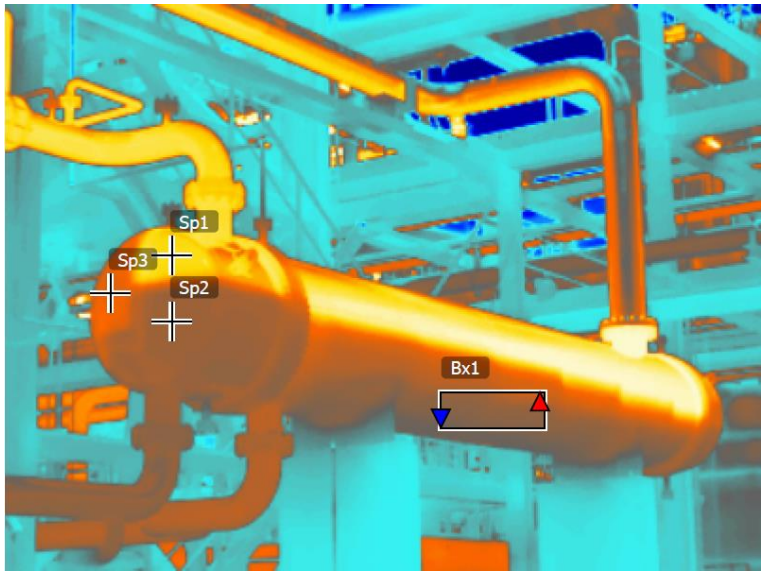
The current Duty was back-calculated with HYSYS and a small VBA macro with one year historical data

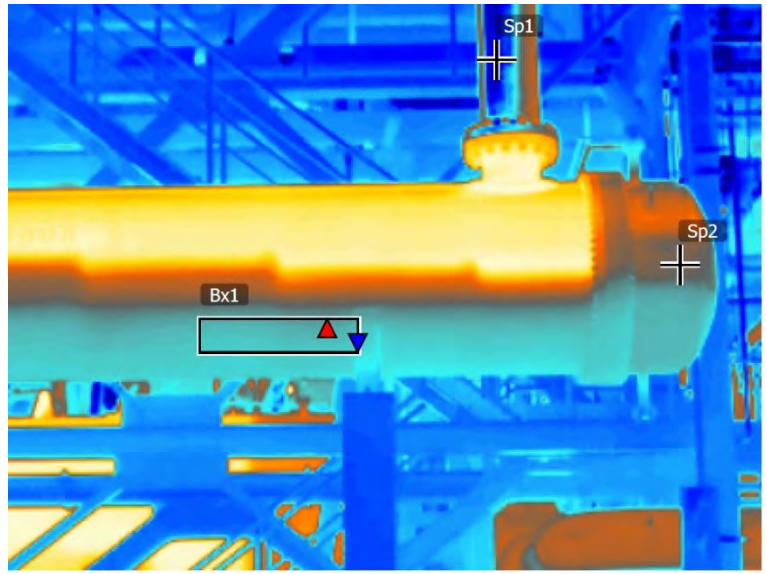
How these condensers works?

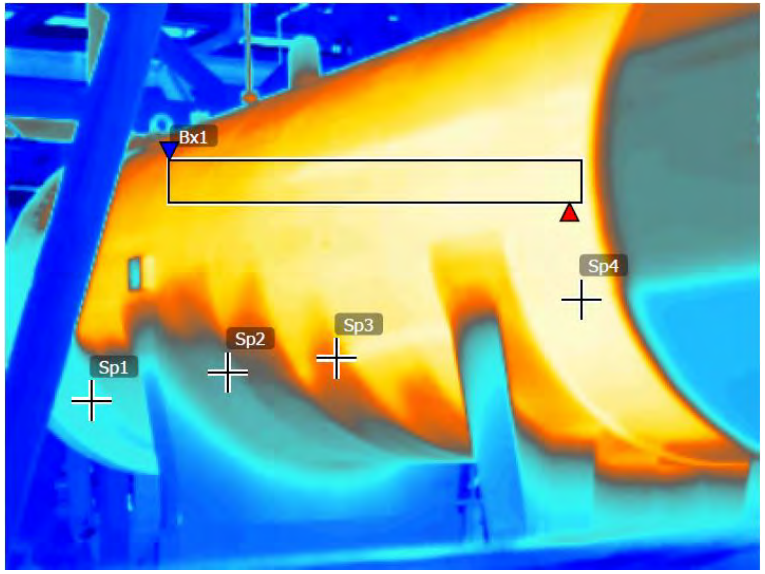


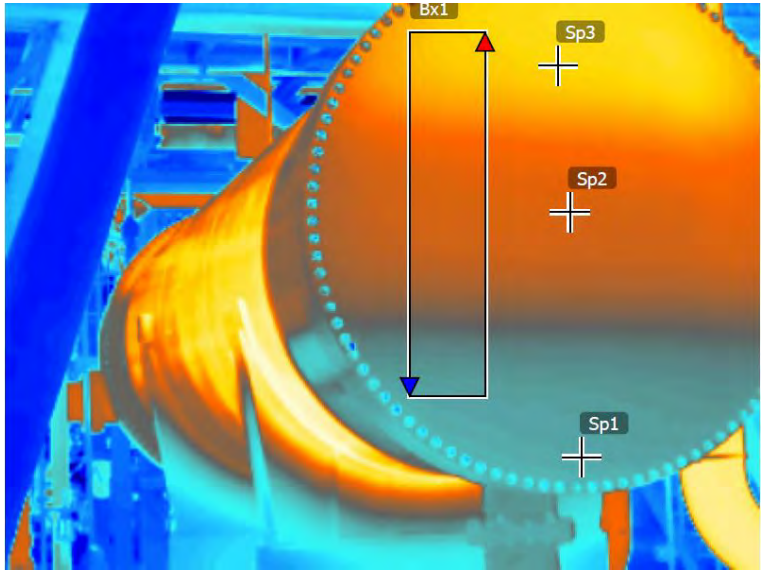
- **The liquid propane inside the shell could partially cover some of the tubes, losing condensing capacity. But, it is required some coverage of the tubes to achieve at least 1.5ºC subcooling, needed for the 10 m elevation of the reflux tank.**
- **Therefore, a small liquid level is needed, but no more because it will lose duty capacity due U difference.**

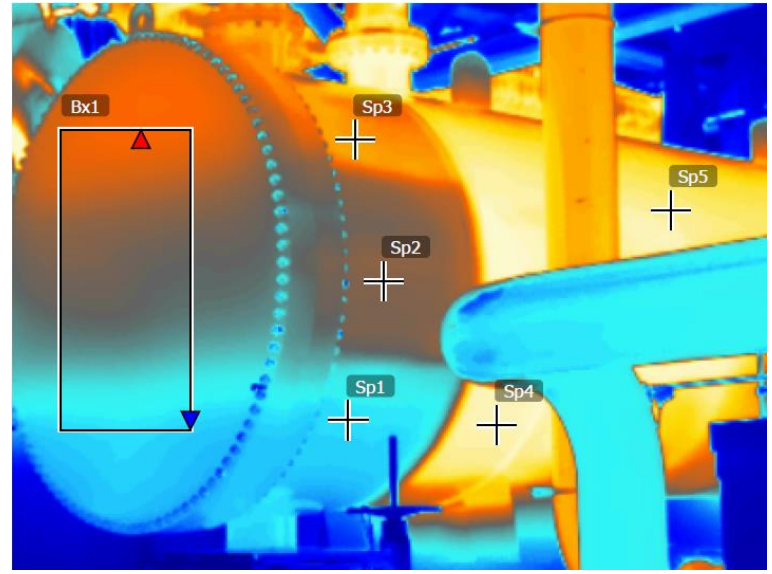
Thermographic of the condensers







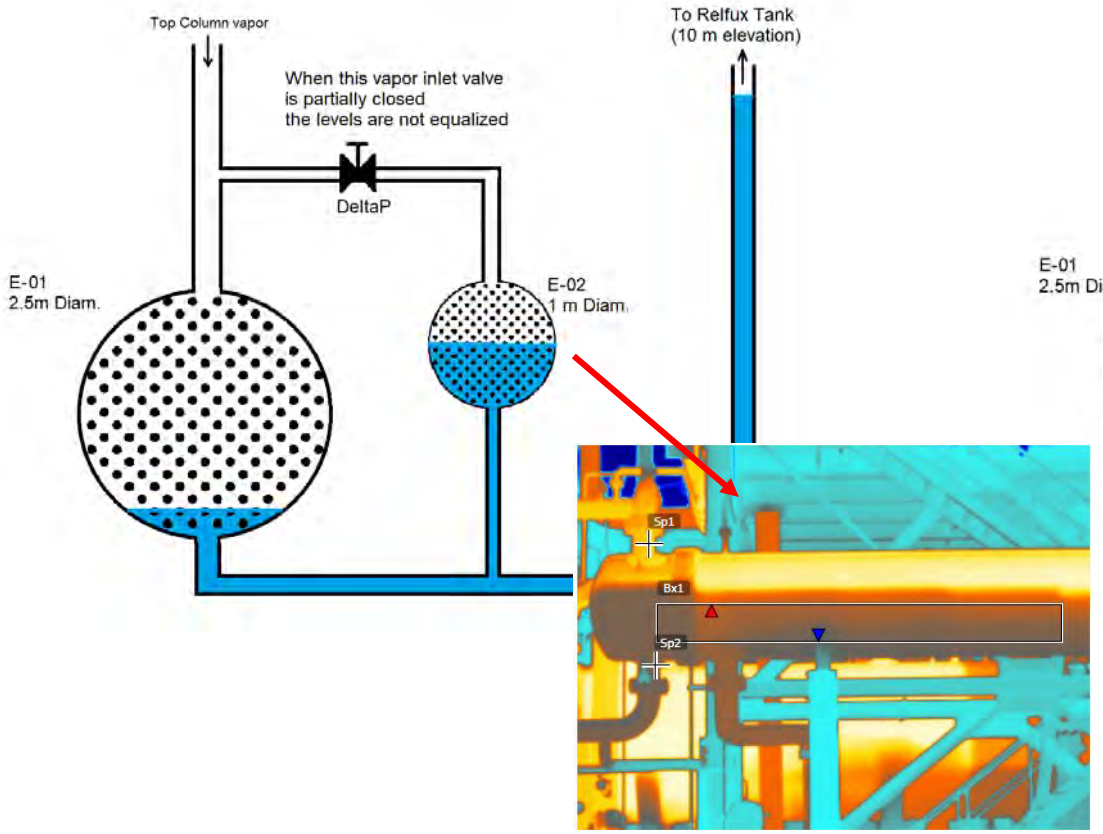




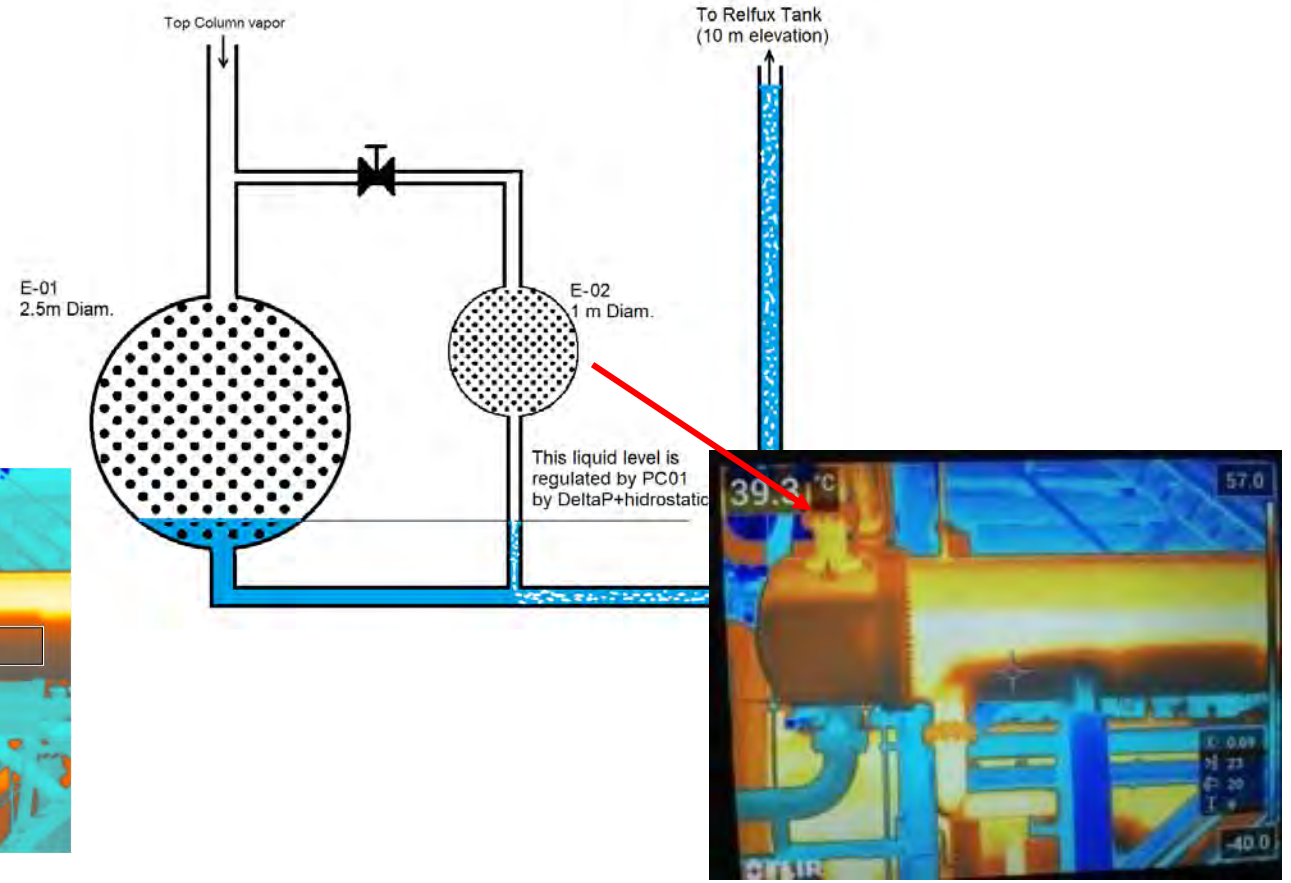
Effect of closing E-02 inlet gas valve

- **When the inlet valve is partially closed an extra ΔP is introduced, therefore the flow to the E-02 is reduced. This causes a lower pressure in the E-02 and the liquid rises covering some tubes, reducing its cooling capacity.**

Valve partially closed:



Valve open (E-02 gas blow by):



Replacing this condenser has a 6 months payback with the new production capacity

Column tray hydraulic constrains

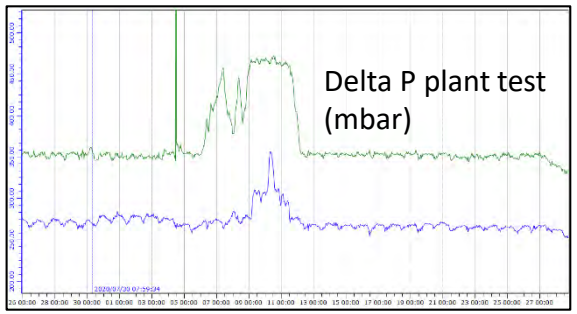
Column tray hydraulic constrains

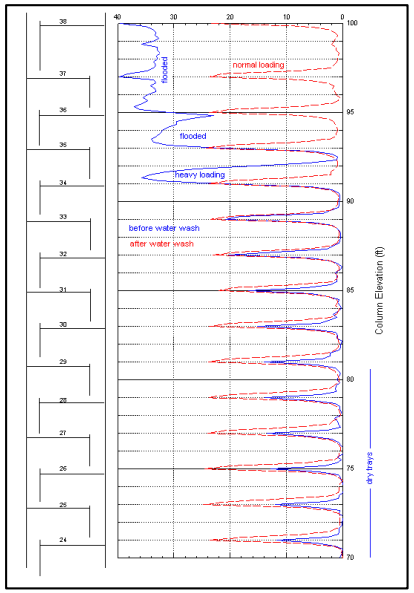
How do you know how close is your column to the hydraulic limits?

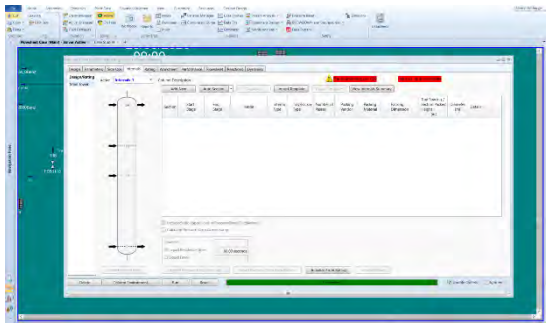
✓ Study of the column hydraulics

How to study?

- Experimental approx.
- Gamma Ray Scanning
- AspenPlus v11/HYSYS v12 tray sizing utility





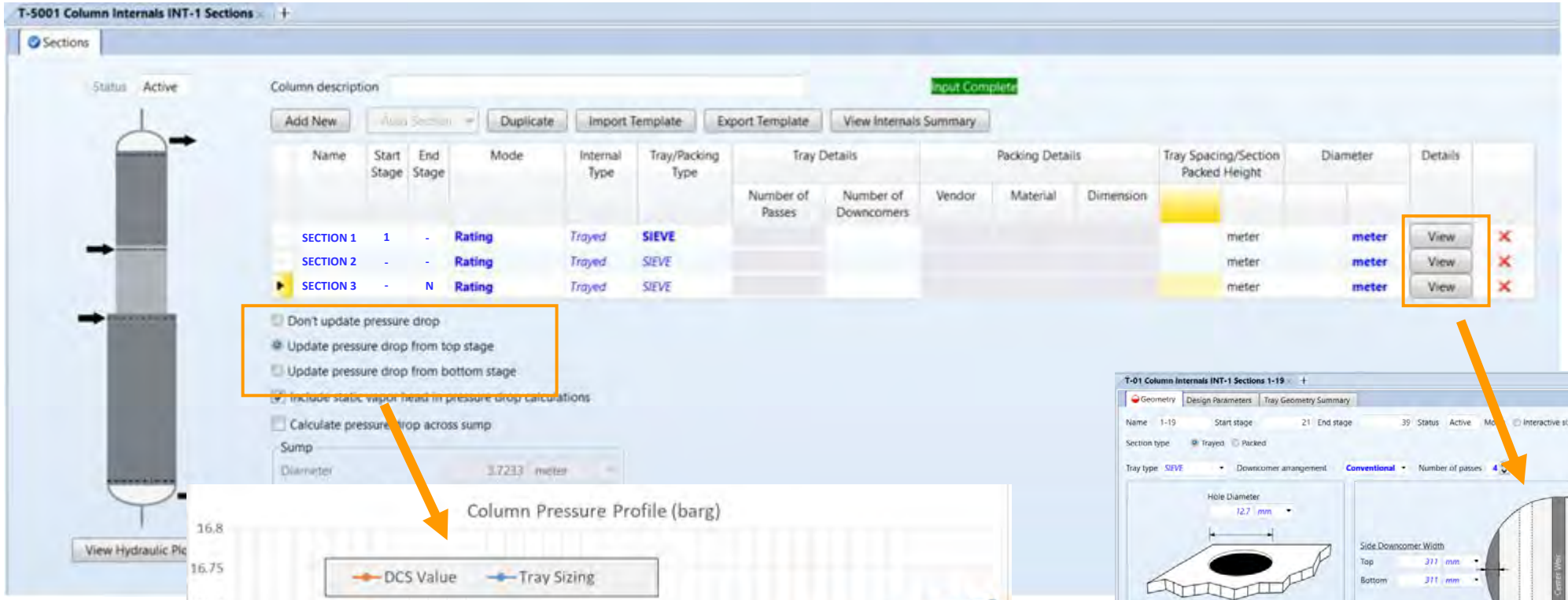


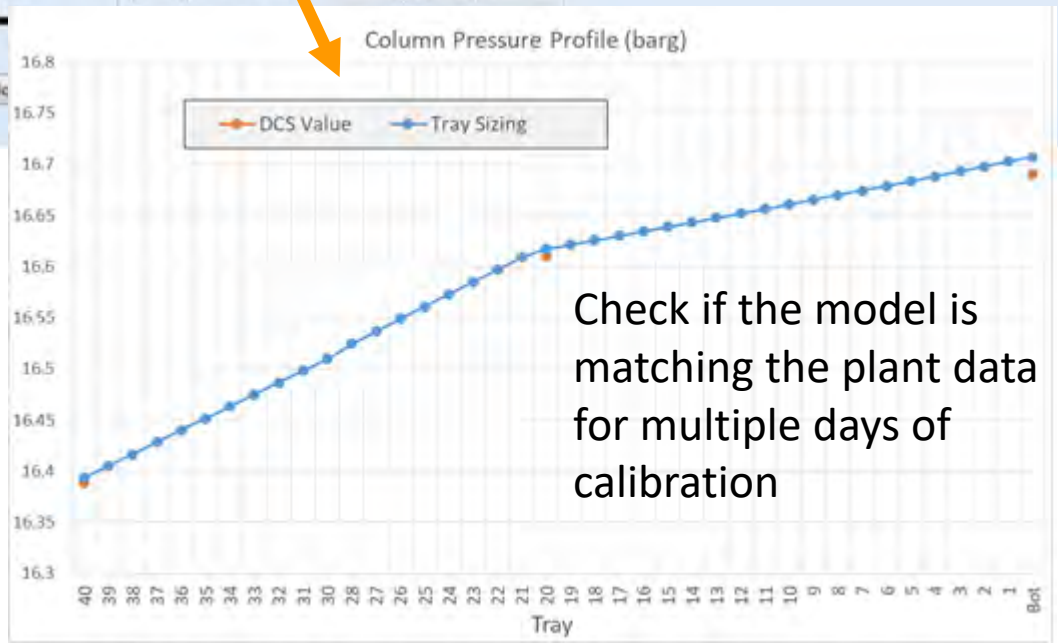
Disclaimer: Gamma Scan image is just an example, and it doesn't correspond to the real column

Why simulation?

- Easy
- Fast
- Extrapolate to other conditions

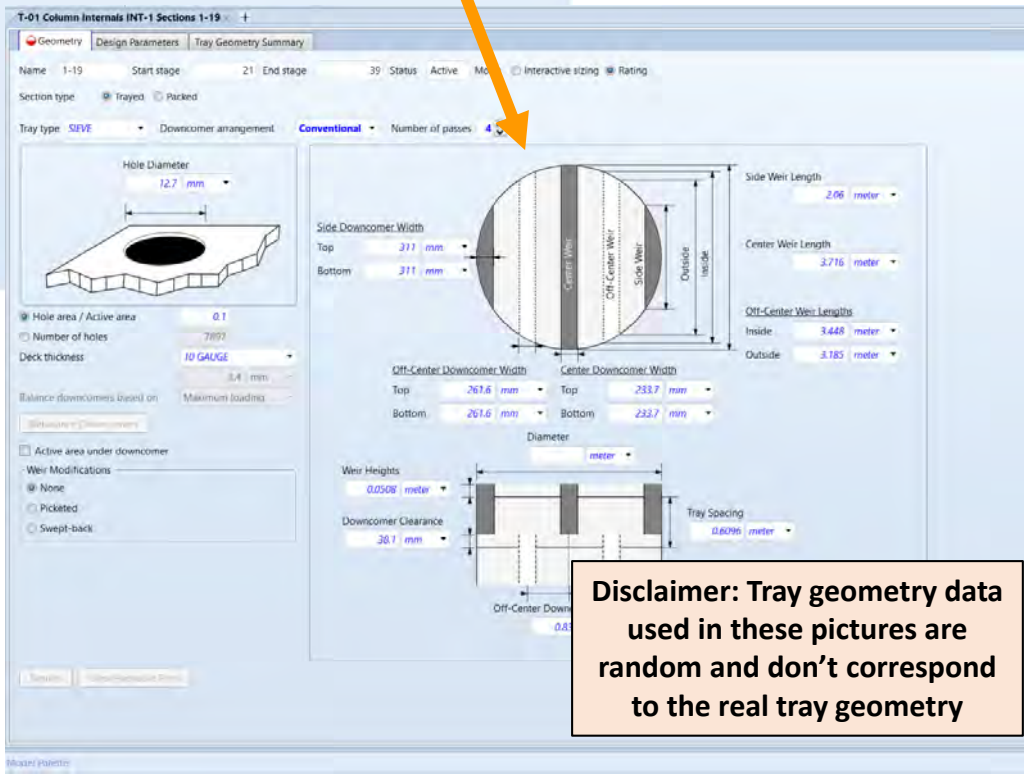
Tray sizing utility





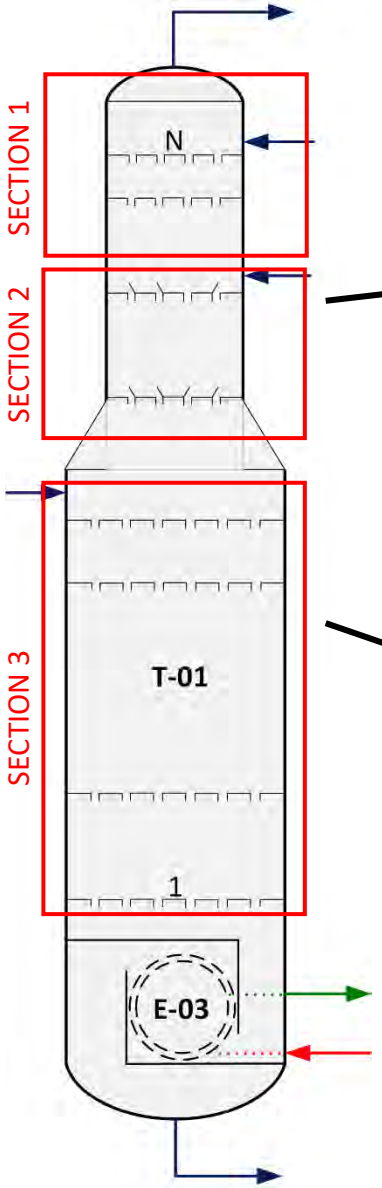
Check if the model is matching the plant data for multiple days of calibration

Update all the internal geometry.



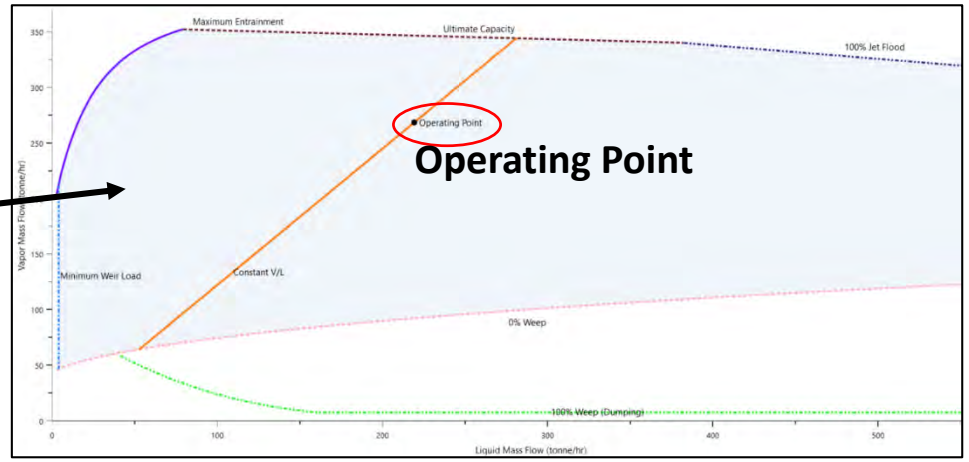
Disclaimer: Tray geometry data used in these pictures are random and don't correspond to the real tray geometry

An example

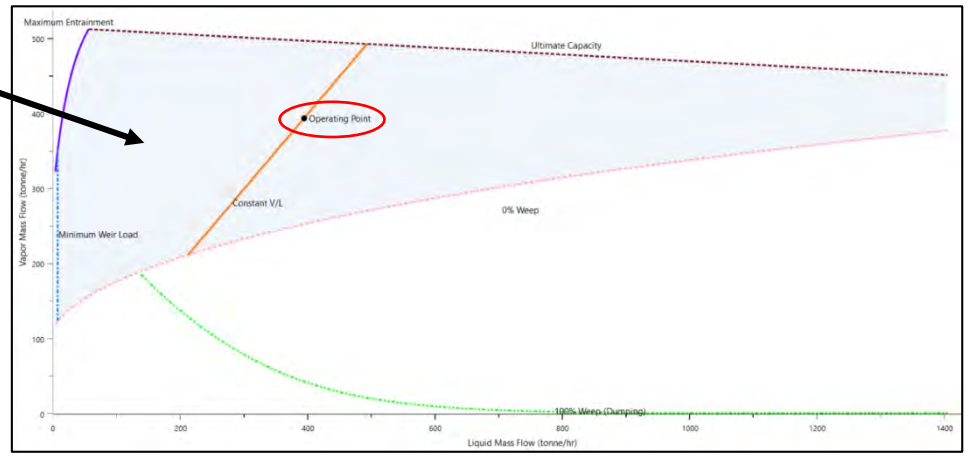


+25% inlet flow

NORMAL OPERATION

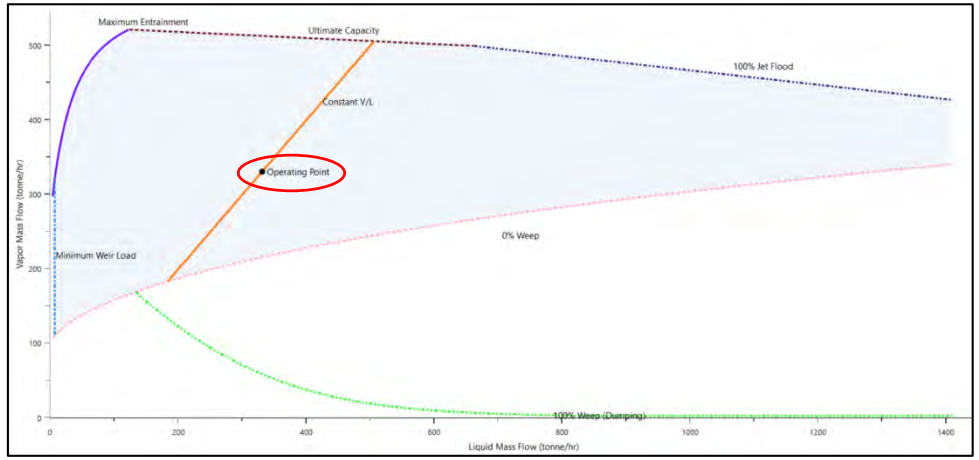


Operating Point



REVAMP OPERATION

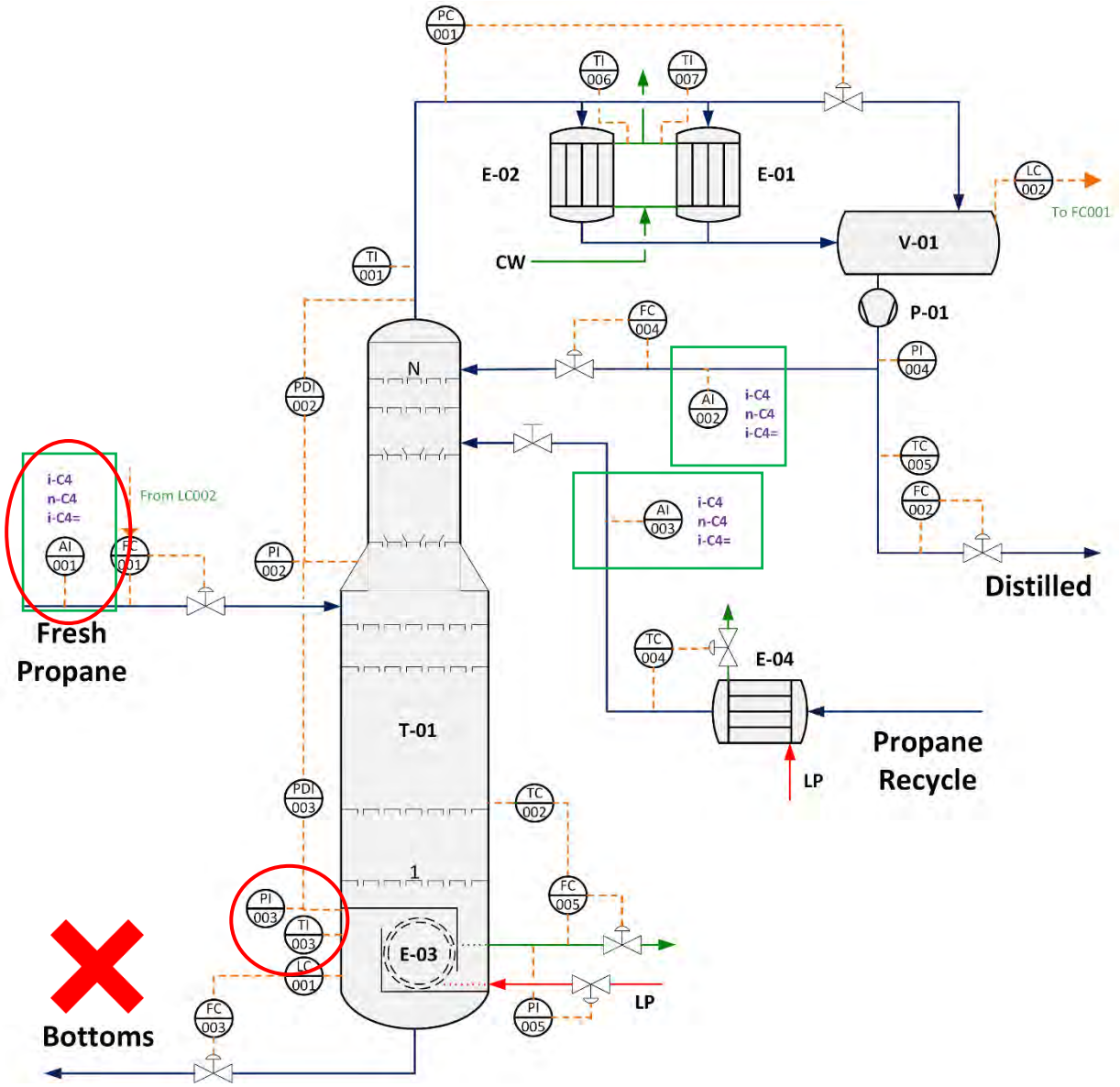
100% Jet Flood!!!



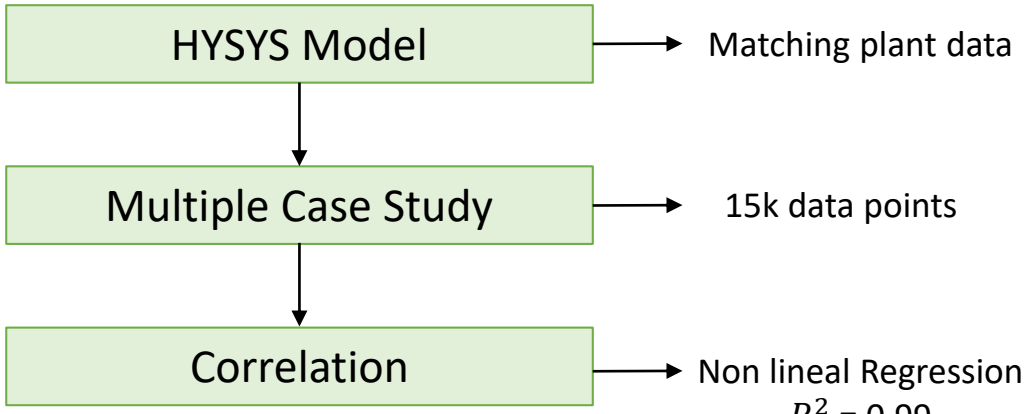
- These operation maps are better for APC Controlled Variable hydraulic limits than column DP!
- The hydraulic study showed that this column could compromise the revamp capacity

Multivariable inferential for APC

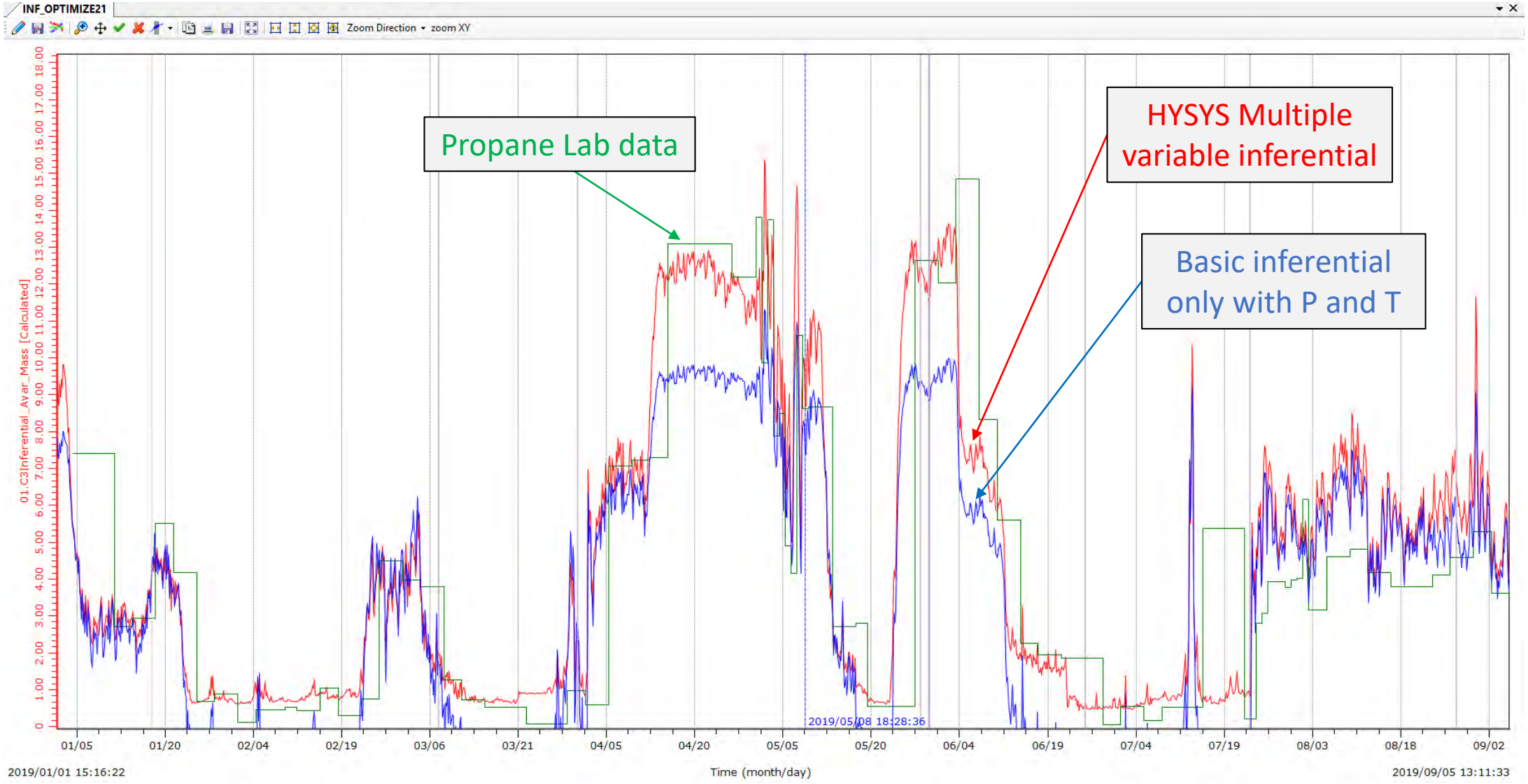
Multivariable inferential for APC



- The bottom of the column does not have an online analyzer. The DMCPlus cannot operate optimally if it does not have the bottom propane as a controlled variable.
- The main variables that affect the propane at the bottom are the equilibrium pressure and temperature, but also the C4s in the inlet.
- The inferential was not only a linear correlation with P and T. Therefore, it was done in HYSYS a multiple Case Study and fitted with a multivariable non-linear correlation.



Inferential vs. Lab data for 9 months



The graphic shows the unbiased inferential (just explicit formula without lab correction)

Future work & conclusions

Ongoing work and future

Dynamic Study → OTS & Online Digital Twin → Additional features

- Finding the truth. Main constrains and limits of the system
- Review the instrumentation and its reliability
- Dynamic model: Developed and tested with plant data

- Connection with the plant real time database
- Online dynamic model reflecting current plant conditions
- Building OTS on top of the developed models

- Equipment anomaly detection and diagnosis
- Online Analyser backup
- Tray operating map and hydraulic constrains
- Real Time Optimizer

Conclusions

- Building simulation models (steady state and dynamics) of existing plants is a very different task than building a simulation model for a new plant. Reality vs ideality.
- Plant engineers are often busy and it is difficult to do an in-depth simulation study.
- A simple simulation study can reveal false myths or hidden plant issues that it has been happening for a long time.
- Performing simulation studies over a running plant have a direct payback:
  - Improving energy consumption
  - Improving DMCPlus performance (inferential, CV limits, gains…)
  - Reveal equipment issues
  - Find production maximization ways

Current trend → **Digital Transformation departments are making use of the process simulation tools as an integral component of their new applications**

Thank you!

Q&A

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