TECNICAS REUNIDAS

inprocess

# Dynamic Analysis of the Turboexpander Dew Point Unit with Aspen HYSYS

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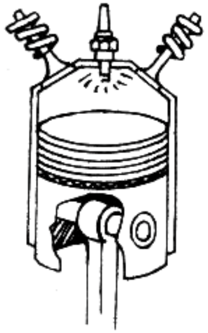
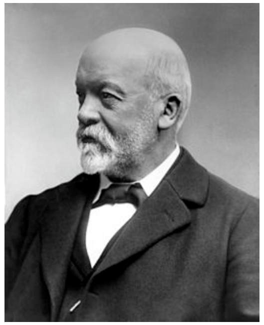
aspentech

# 00 Agenda

1. Tecnicas Reunidas and Project Background
2. Dew Point Unit & Dynamic Study Motivation
3. Study Scope
4. How to Model a TEX in HYSYS
5. Scenarios and Runs
6. Key Benefits

Is there a way to put more Oxygen into the cylinder of an engine?





Yes, with a compressor.
1885: Gottlieb Daimler patented Supercharger

What if I drive the compressor with a turbine using the exhaust gases?

# TURBO!

# 01

## TR Project Background

## 5th INTERNATIONAL DESIGN FIRM IN PETROLEUM MARKET (ENR, 2017)

UPSTREAM & GAS

DOWNSTREAM

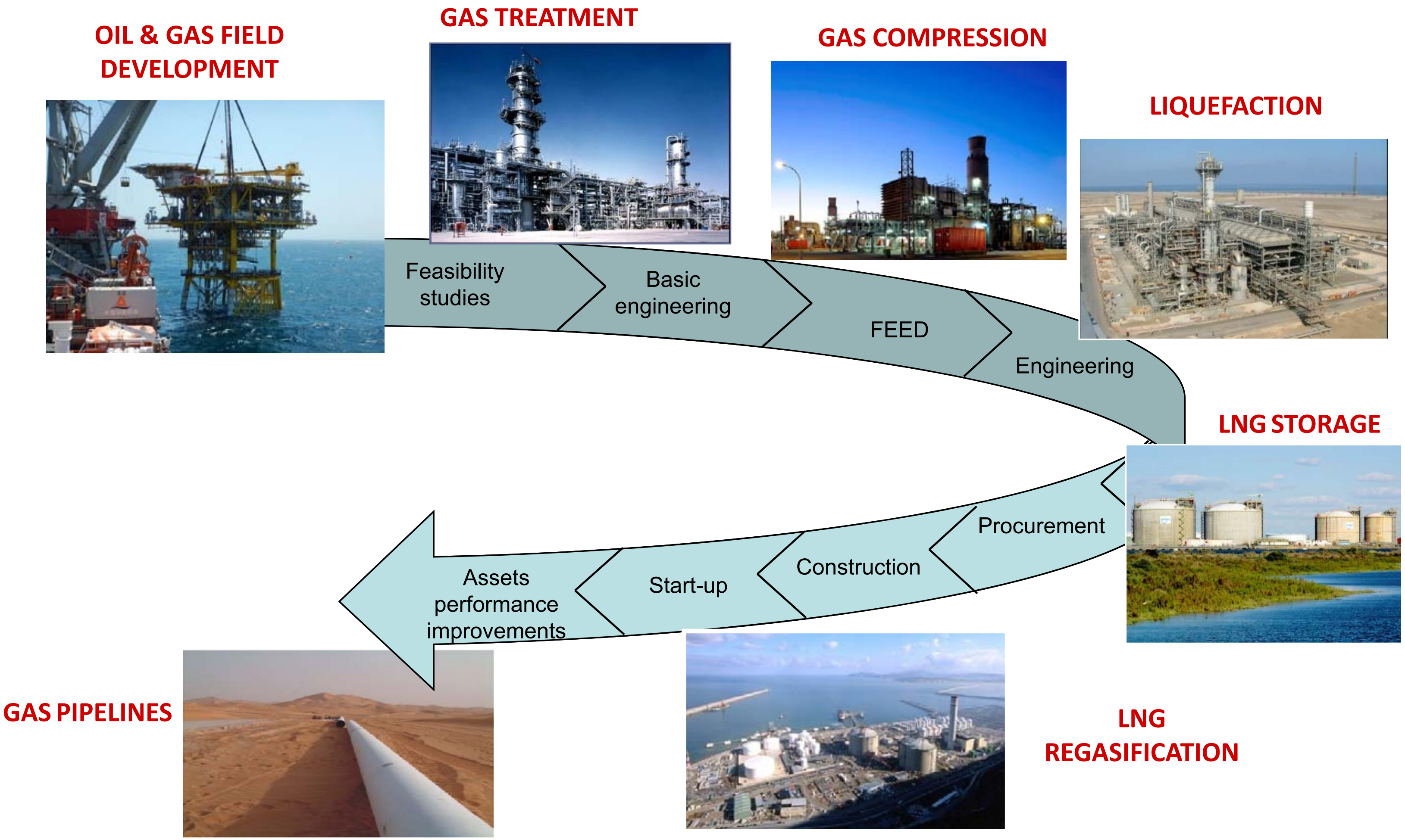
POWER

INFRASTRUCTURE & ENVIRONMENT

## TECNICAS REUNIDAS IN THE WORLD

+ 9,000 professionals from 70 different nationalities

# 01 | TECNICAS REUNIDAS - UPSTREAM



## 01 | TR Project Background

**Grass-Root Gas Plant Project:**

- 5+ billion standard m3 of gas
- 700,000+ barrels of condensates

- Development of 25+ wells and associated gas gathering systems over 150+ km of pipelines
- Gas Compression
- Hg / $H_2S$ / $CO_2$ removal units
- Gas Dehydration Unit
- Gas Dew Point Unit
- Treated Gas Export Pipeline
- Condensate Stabilization unit
- Residual Water Treatment Unit
- Associated Auxiliary Systems

# 02 Dew Point Unit & Dynamic study Drivers

# 02 | Dew Point Unit & Dynamic Study Motivation

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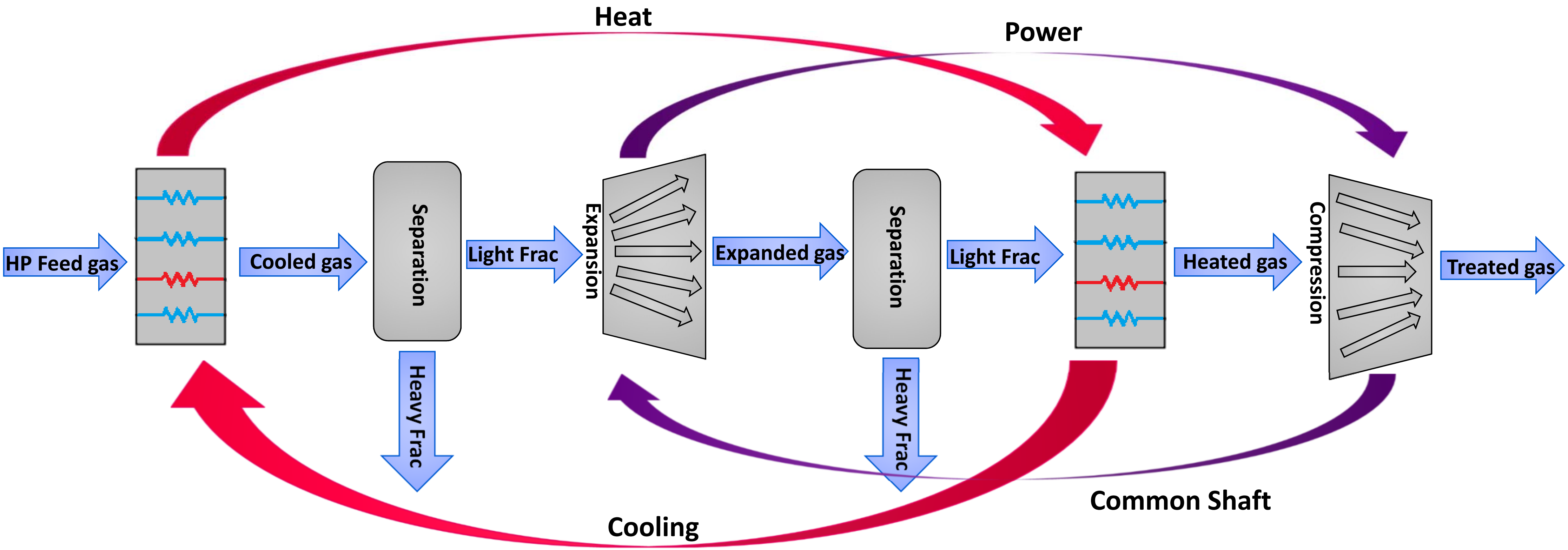
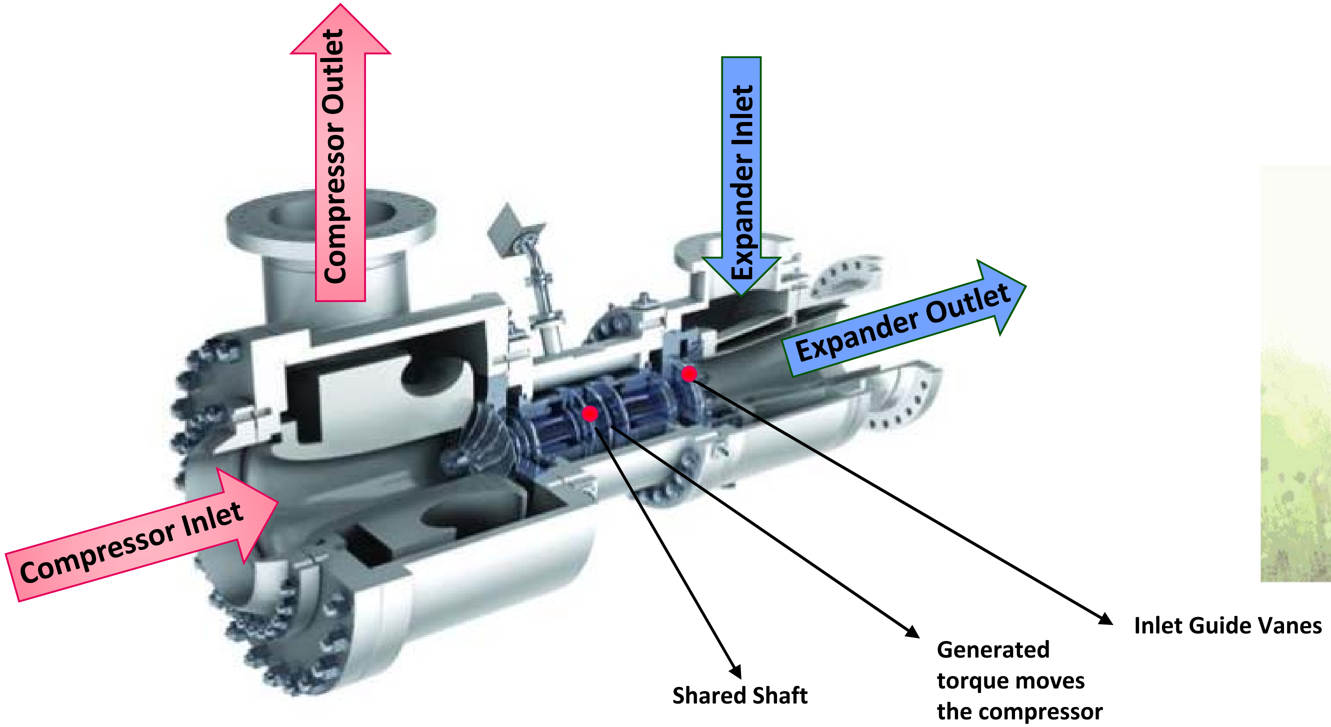
## Dew Point Unit Objective → Achieve Required Hydrocarbon Dew Point
## How? → Condensing Heavy Fractions
## Means → Expander-Recompressor System



**A Turboexpander is a rotating machine in which a high pressure gas is expanded to produce work that is used to drive a centrifugal compressor. It is the core of the process.**




https://www.youtube.com/watch?v=AS5CBlzCfRI

# 02 | Dew Point Unit & Dynamic Study Motivation

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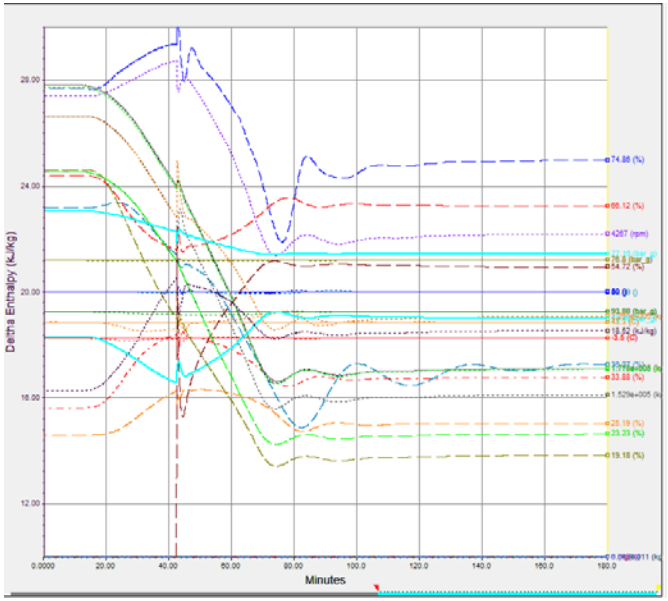
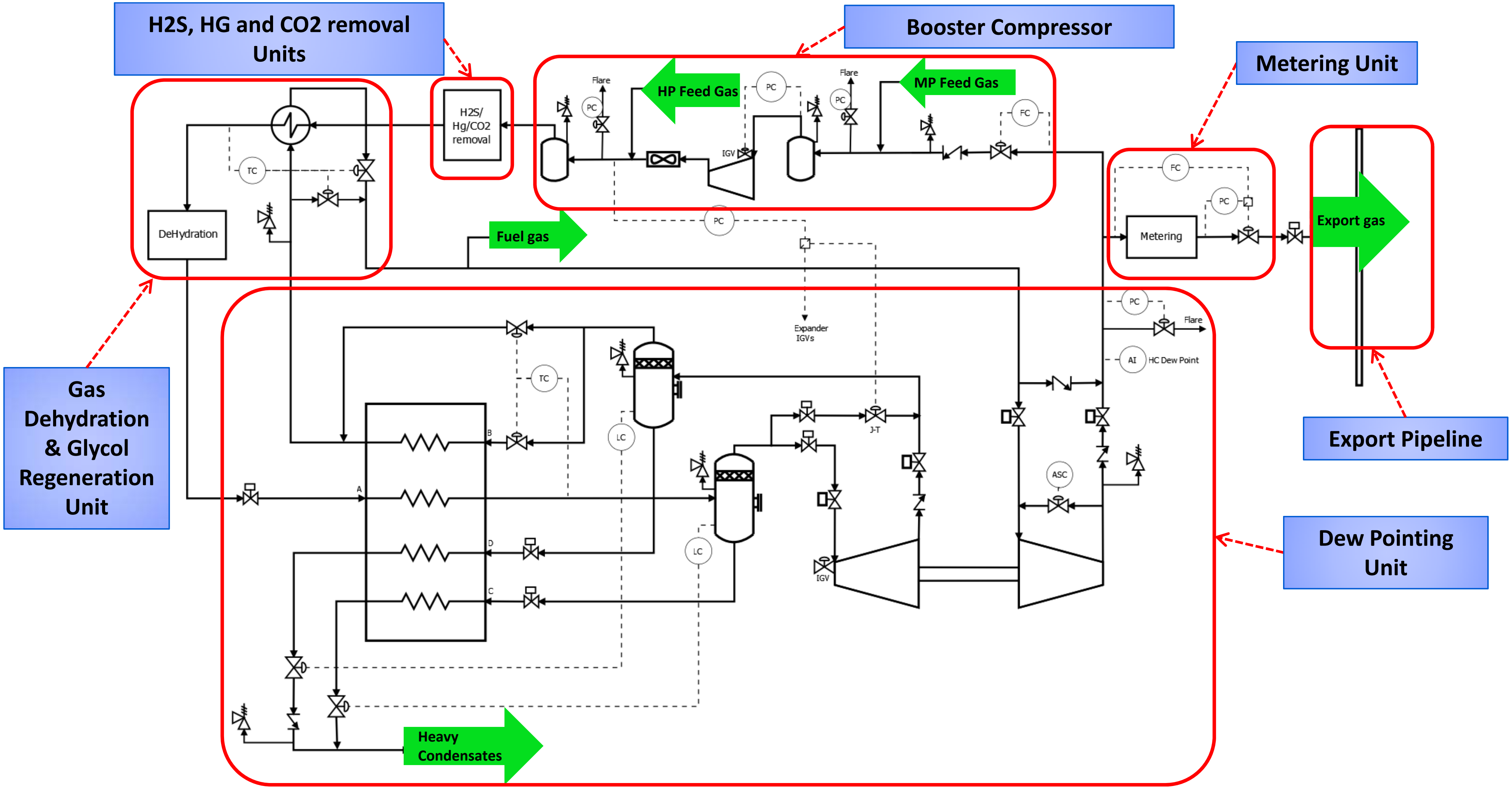
**Dynamic Study Objective → Validate the design of the Dew Point Unit**

**How? → Evaluating the dynamic response of the system through a set of 8 operating scenarios for different conditions (Summer, Winter, Gas Feeds), checking:**

- **Adequacy of overpressure protection system**
- **Adequacy of material selection based on maximum and minimum design metal temperature**
- **Adequacy of re-compressor antisurge protection**
- **Ensure operability of the unit within specifications under different upset scenarios**

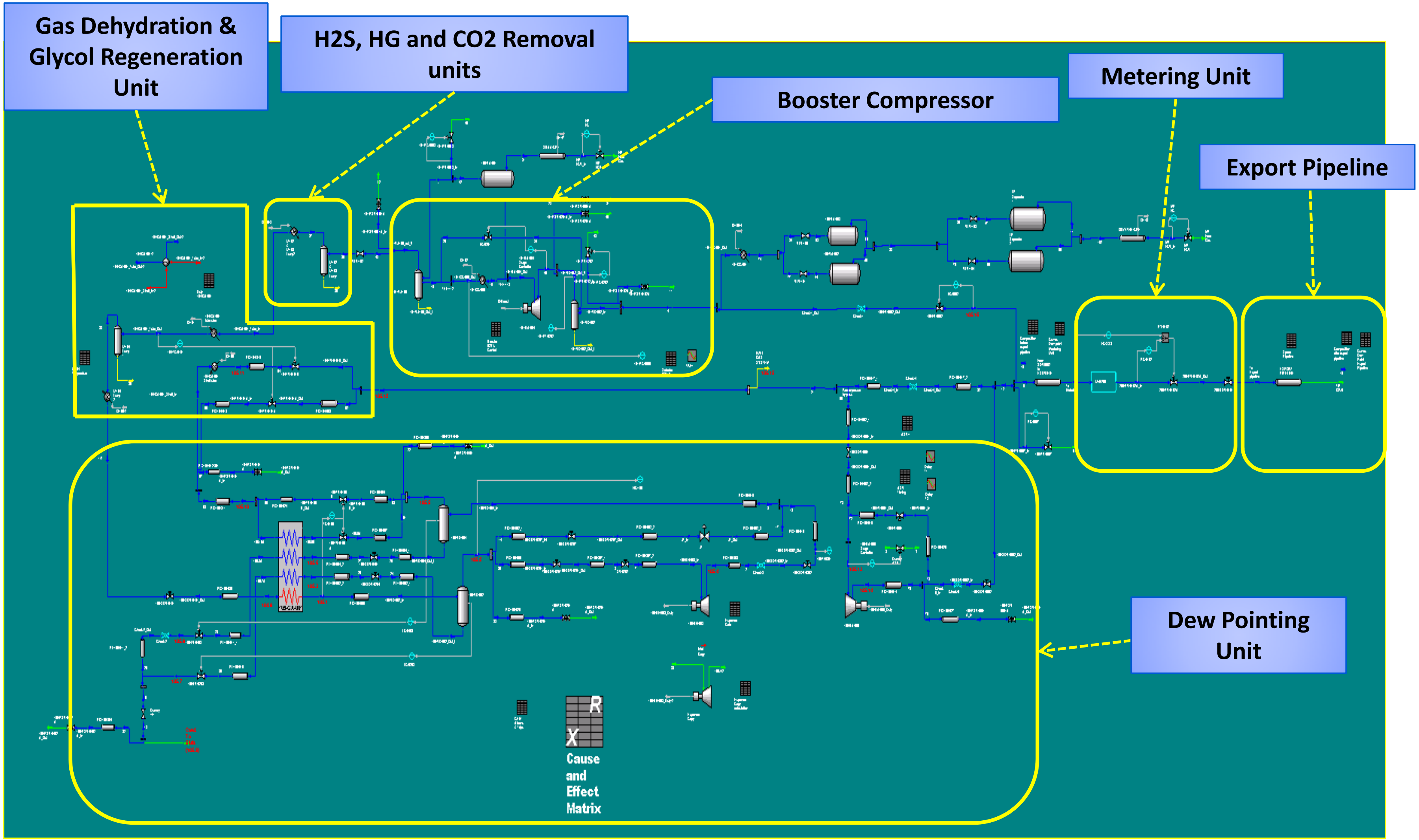


# 03 Study Scope


H2S, HG and CO2 removal Units
Booster Compressor
Metering Unit
Gas Dehydration & Glycol Regeneration Unit
Export Pipeline
Dew Pointing Unit
HP Feed Gas
MP Feed Gas
Fuel gas
Export gas
Heavy Condensates
H2S/ Hg/CO2 removal
DeHydration
Metering
Flare
Expander IGVs
HC Dew Point
J-T
IGV
TC
PC
FC
LC
AI
ASC

# 03 | Study Scope

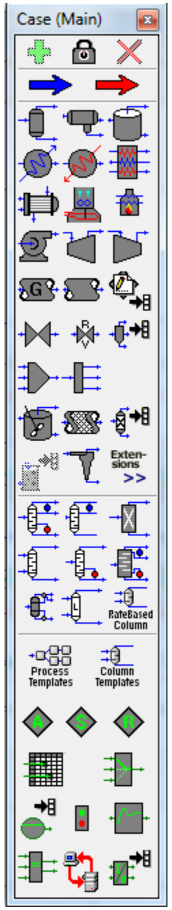


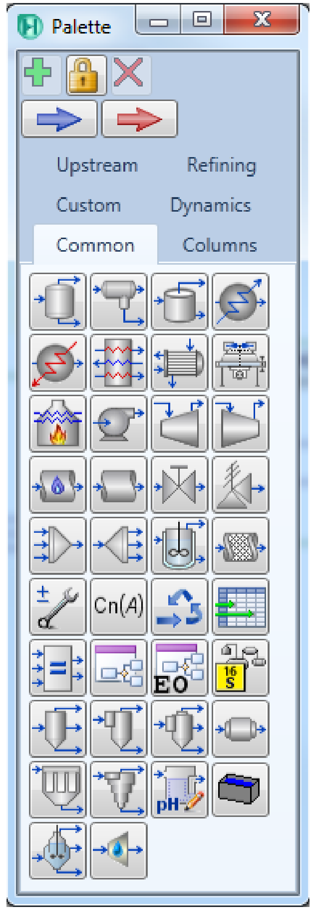


# 04

## How to model a TEX in HYSYS

# Have you ever seen a TEX object in the HYSYS objects palette?



**Standard HYSYS expander block has some limitations when an expander with IGVs has to be modelled:**

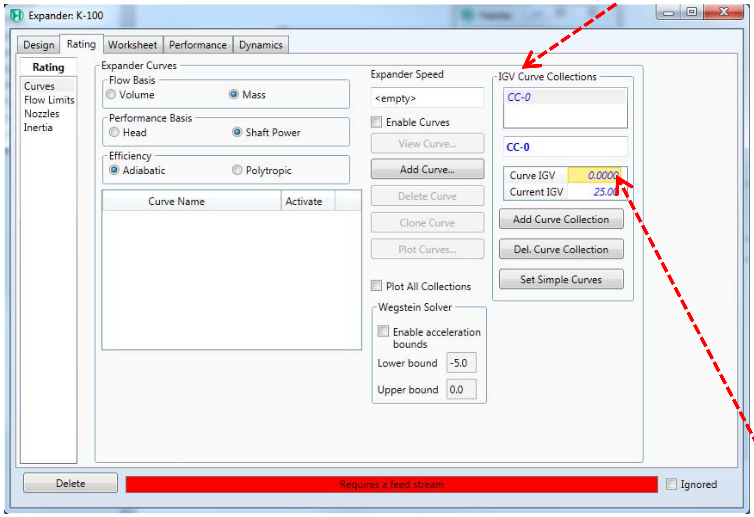
1. **The power curve interpolation is conditioned by a defect (in v7.3) that causes peaks and fluctuations. This defect has been corrected in v9.0.**

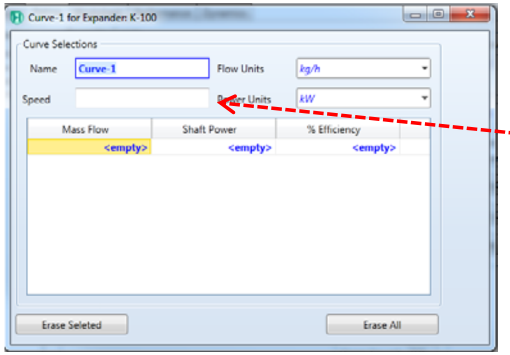
2. **The way that HYSYS expects to use the IGV position for the Power vs Flow and Efficiency vs Flow curves does not match with the Expander manufacturer curve data.**

# 04 | How to model a TEX in HYSYS

## HYSYS INTERFACE

**When a HYSYS expander with multiple IGV curves is defined, HYSYS expects an IGV curve collection for every IGV position**

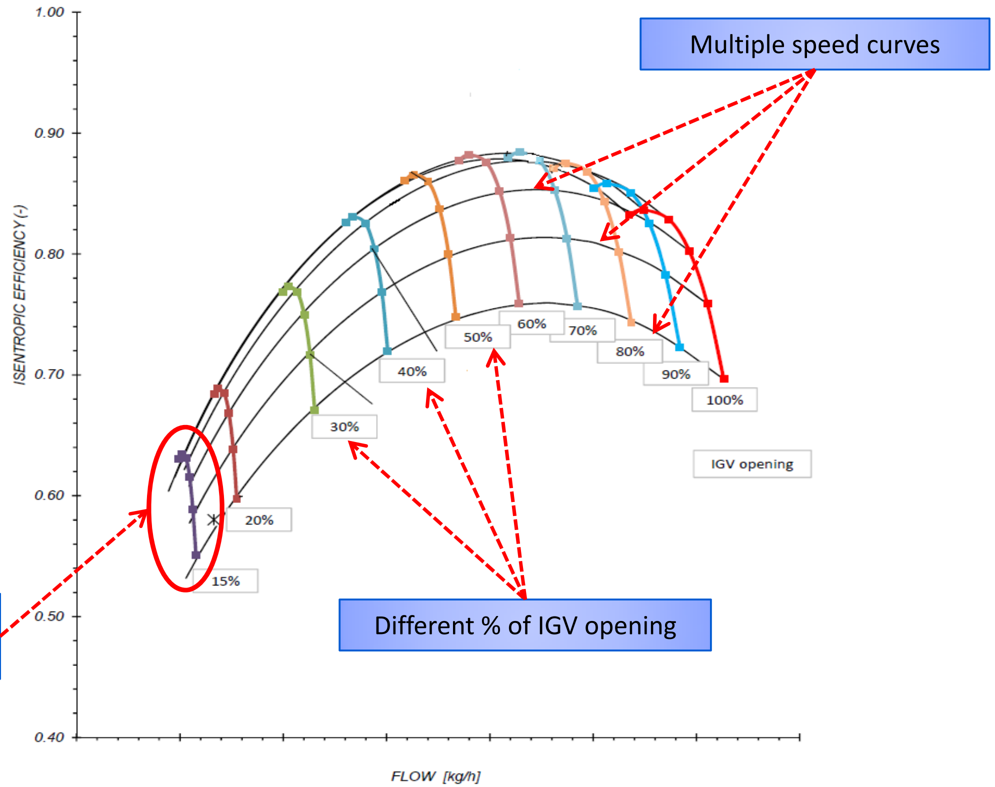




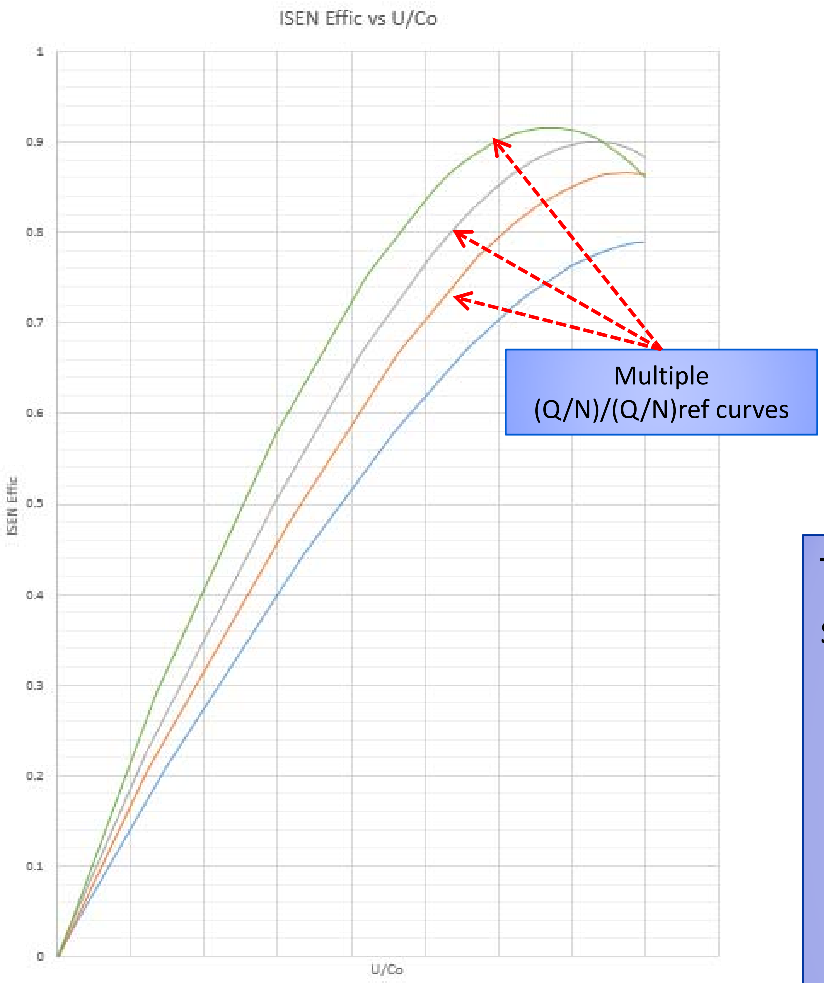
Single IGV position & multiple speed curves

## MANUFACTURER DATA

**For every IGV position there is a collection of points (no curves) for every speed for the Eff. vs Flow and Power vs Flow maps**




*Note: These curves do not represent any actual performance data. They had been randomly generated to represent the concept.*




*Note: These curves do not represent any actual performance data. They had been randomly generated to represent the concept.*

**Because of the mentioned limitations, the expander was simulated using the manufacturer Isentropic Efficiency vs U/Co curves and the flow for every IGV and rpm combination.**

**U/Co is a dimensionless parameter defined as:**

- **Tip speed (U [m/s])**
- **Isentropic spouting velocity (Co[m/s]): where Co=$\sqrt{2000 \cdot \Delta H}$**

**(Q/N) is the flow coefficient where:**

- **Q= Expander Vol flow [m3/s]**
- **N= shaft speed [rpm]**

**(Q/N)ref is the reference flow coefficient**

The API 617 7th Ed. Chapter 4 (Expander-Compressors) Section 5 specifies the TEX vendor data :

**5.2.1.1.2** Predicted curves provided for expander-compressors shall include the following:

a. Expander power vs. flow.
b. Compressor power vs. flow.
c. Compressor head and pressure ratio vs. flow for at least 4 speed lines from 70% – 110% of normal speed.
d. Expander *U/C* vs. efficiency.

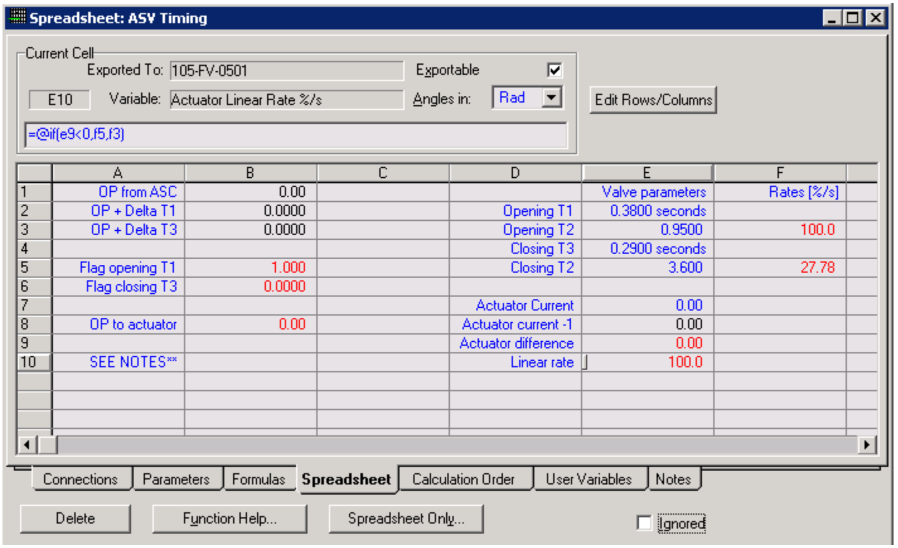
The compressor curves shall indicate the complete operating range.

But it should also specify to supply the <u>actual position of the IGV</u> in the Power vs. Flow curves

# 04 | How to model a TEX in HYSYS

**Some critical valves require additional modelling details for accurate representation of fast transients.**

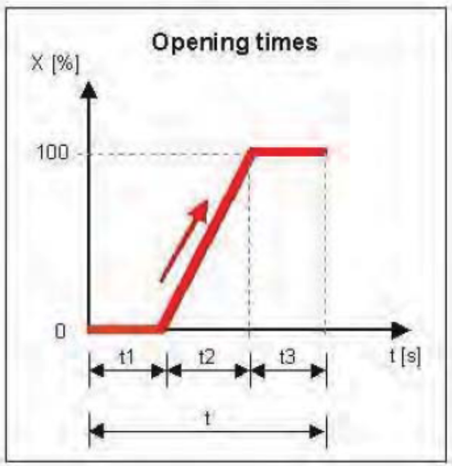
**This was implemented using standard HYSYS features with additional spreadsheets and blocks, but it would be convenient additional flexibility in HYSYS current valve actuator.**

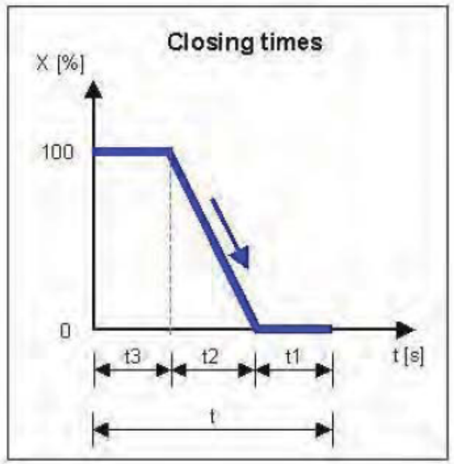



**Closing and opening times**

| | | | dp = 0 bar | dpmax = 95 bar |
|---|---|---|---|---|
| **Opening times** | | | | |
| Venting delay time at 0 % | t1 | [s] | 0.11 | 0.056 |
| Venting time | t2 | [s] | 0.28 | 0.25 |
| Venting delay time at 100 % | t3 | [s] | 0.051 | 0.08 |
| Total time (t1+ t2 + t3) | t | [s] | 0.44 | 0.38 |
| **Closing time** | | | | |
| Filling delay time at 100 % | t3 | [s] | 2.9 | 5.5 |
| Filling time | t2 | [s] | 36.8 | 52.4 |
| Filling delay time at 0 % | t1 | [s] | 36.3 | 23.3 |
| Total time (t1+ t2 + t3) | t | [s] | 76 | 81.2 |

**Legend**



# 04 | How to model vertical vessels with head

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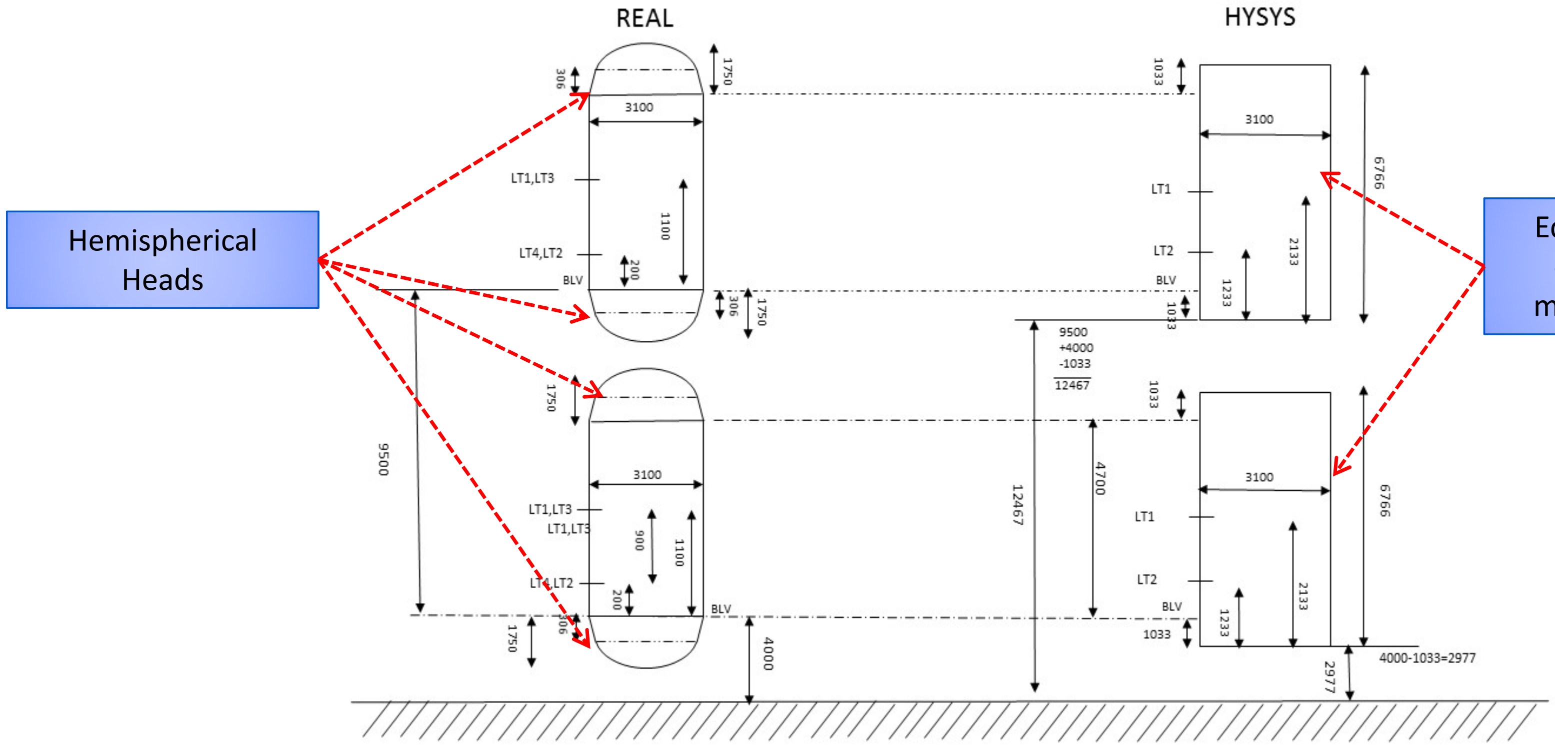
**Vessels were modelled as flat cylinders since HYSYS cannot accommodate an hemispherical head for vertical vessels → height has been kept as a free degree for HYSYS to match volumes, elevations and level taps.**



# 05 Scenarios list and results

## 05 | Scenarios list and results

**Inprocess developed 8 scenarios for several normal and upset conditions (summer, winter, gas feeds), including:**

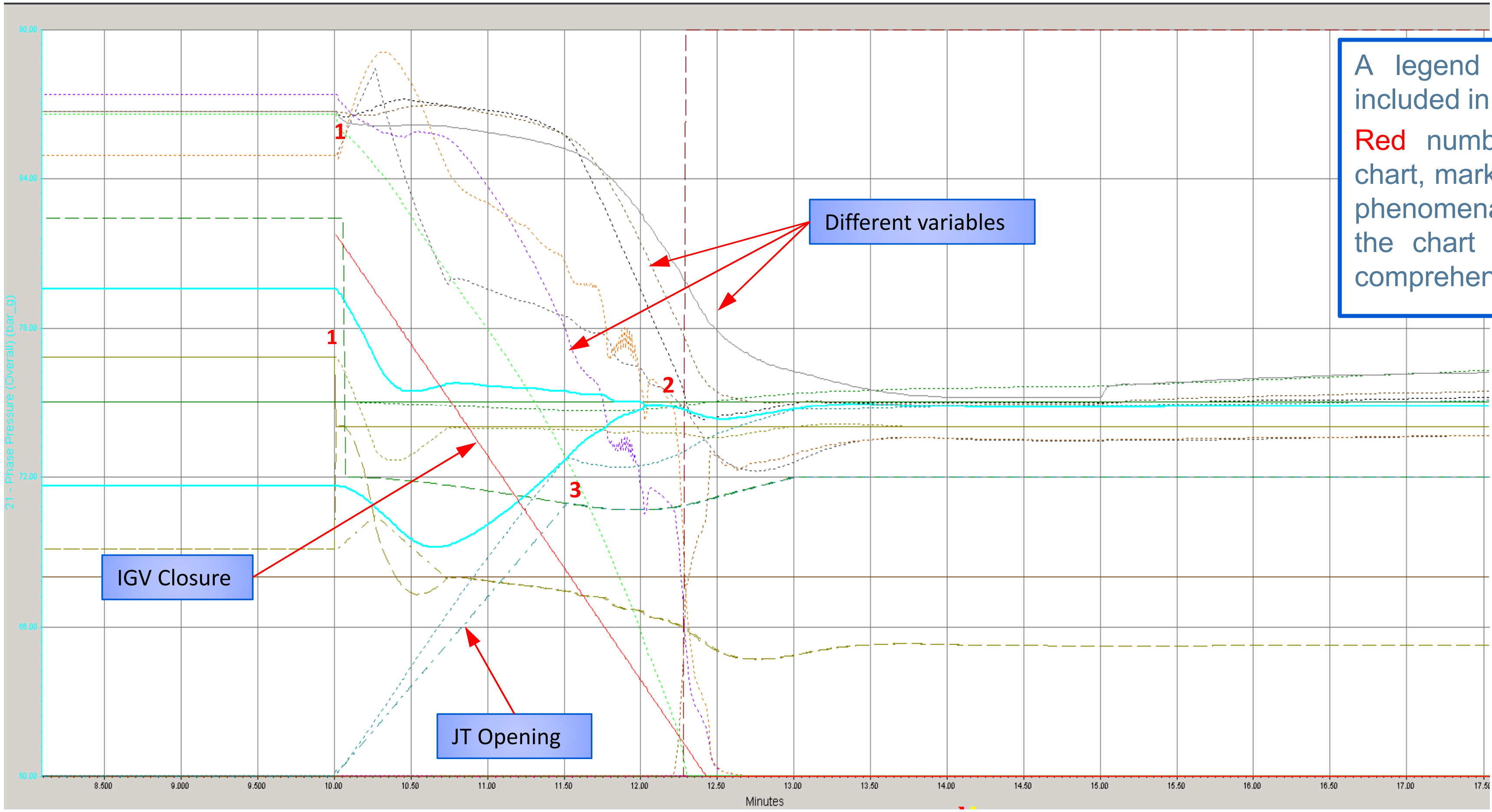
- **To JT mode with recycle and partial export**
- **To JT mode without recycle**
- **Turndown (40%)**
- **Sudden Valve closure at export pipeline**

**In order to make the information independent and to manage the results data, several strip charts were developed:**

- **Key variables & controls (33 tags):** All controllers and key variables
- **CEM Matrix (22 tags):** All Cause& Effects limits and current values
- **PCs to flare (12 tags):** All pressure controllers that vent to the flare header
- **PSVs (64 tags):** All PSVs settings and lift positions
- **Dew Point at metering unit (15 tags):** Dew point specification and envelope at the metering unit
- **Dew Point at export pipeline (15 tags):** Dew point specification and envelope after the export pipeline
- **Hydrates Formation (7 tags):** Hydrate formation limit and current temperature

# 05 | Scenarios list and results

## An example of report Key variables & Controllers strip-charts:



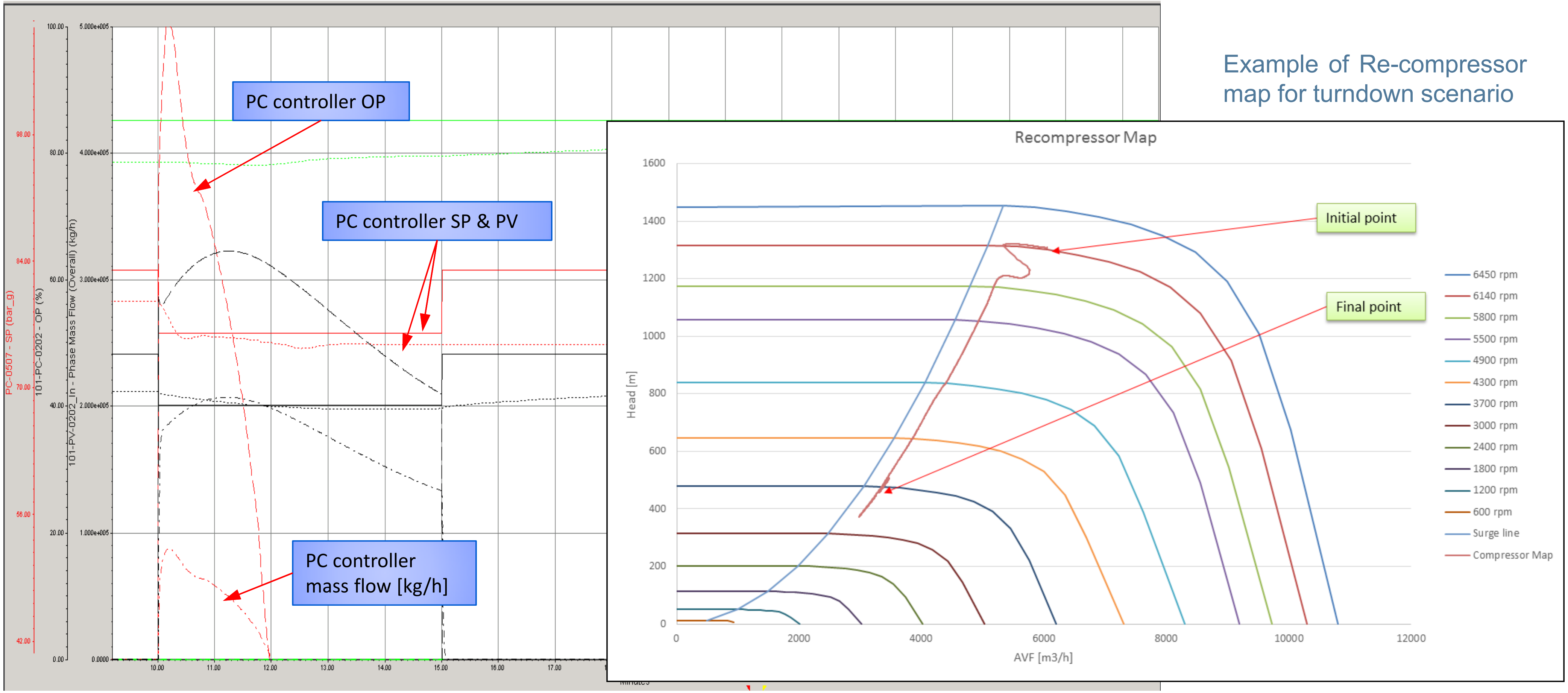

A legend for each strip chart is included in the report.

Red numbers are shown in the chart, marking the relevant events or phenomena that are explained after the chart to improve the scenario comprehension.

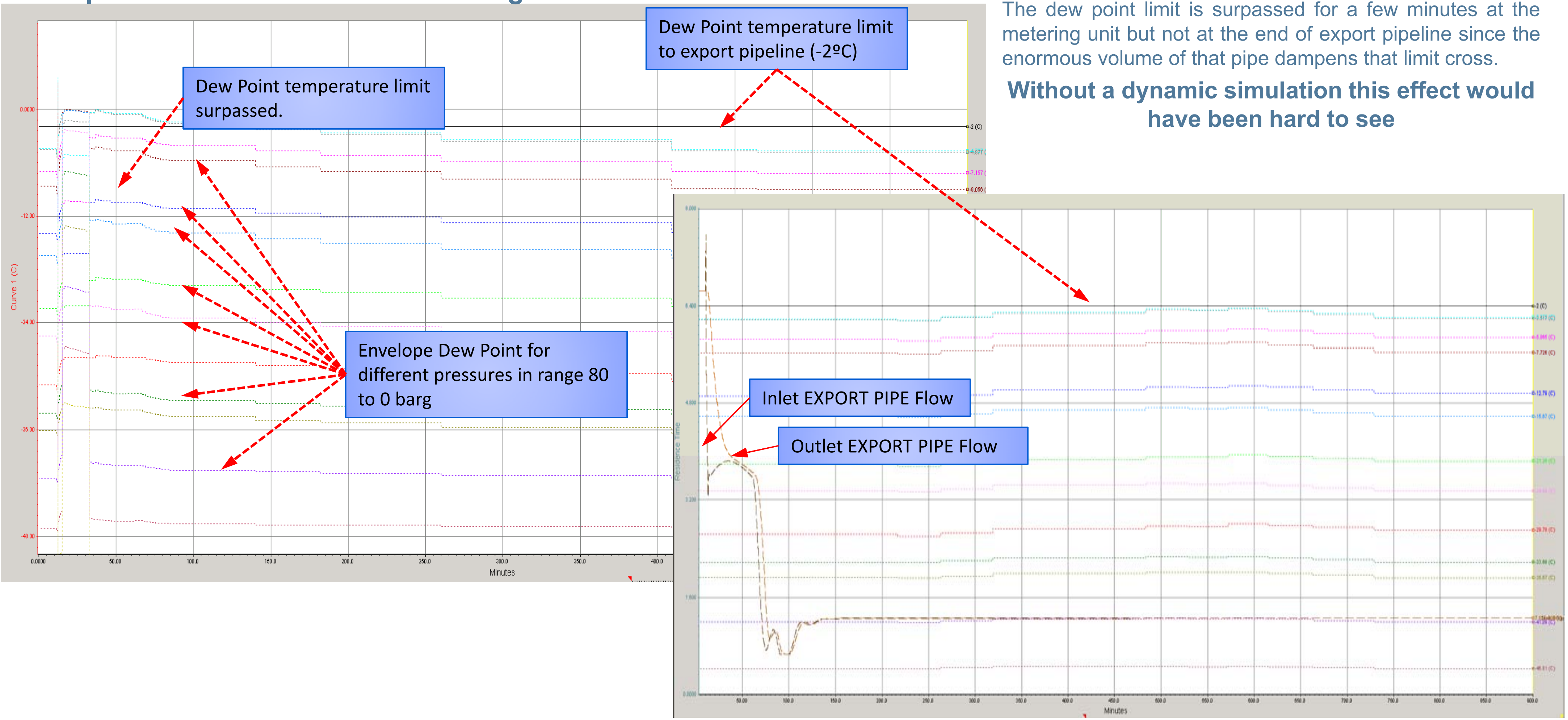
# 05 | Scenarios list and results

**Example of PCs to Flare strip-chart:** Certain sequences require the operator to change SetPoints of Pressure Controllers to Flare in other to avoid trip conditions

Example of Re-compressor map for turndown scenario



## Example of Dew Point chart at metering unit:




The dew point limit is surpassed for a few minutes at the metering unit but not at the end of export pipeline since the enormous volume of that pipe dampens that limit cross.

**Without a dynamic simulation this effect would have been hard to see**

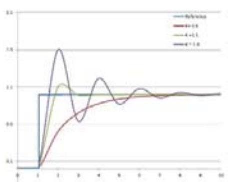
# 06

## Key benefits

## 06 | Key Study Benefits

- **Adequate Equipment Sizing:** Most of the scenarios confirmed the right sizing of the equipment but certain cases revealed some issues (valve saturation, trip condition, off-spec, etc). Most of them were solved by re-setting or ramping setpoints, changing sequences or tuning the controllers

- **Understanding the Dynamics of the System:** The transients gave a precise information of the available time before off-spec or trip conditions are reached, allowing to optimize certain procedures, alarm and SP settings and increase the reliability and availability of the unit



- **PID Tuning optimization:** The PIDs tuning was revised several times since scenarios required a more or less aggressive actions. A single set of tuning was provided to satisfy all scenarios

- **Optimization of Operating Procedures:** When export gas is cut, the plant works in recycle and a detailed procedure was tuned to bring the unit back online
- **Hazop:** The Dynamic model allowed TR to check those limits established during the HAZOP meetings, an impossible action to do without a dynamic model.

## 06 | HYSYS Key Benefits

- **Consistency:** TR uses HYSYS in steady state for the design of the plant. Inprocess developed a Dynamic HYSYS model based on design H&MB, consistent with TR design standards.

- **Flexibility:** Even though HYSYS does not have a TEX block, its enormous calculation capability and flexibility allowed Inprocess to develop a TEX model based on vendor performance data. The model includes, through the Event Scheduler, the control logic as well as the start/shutdown sequences of the TEX vendor.

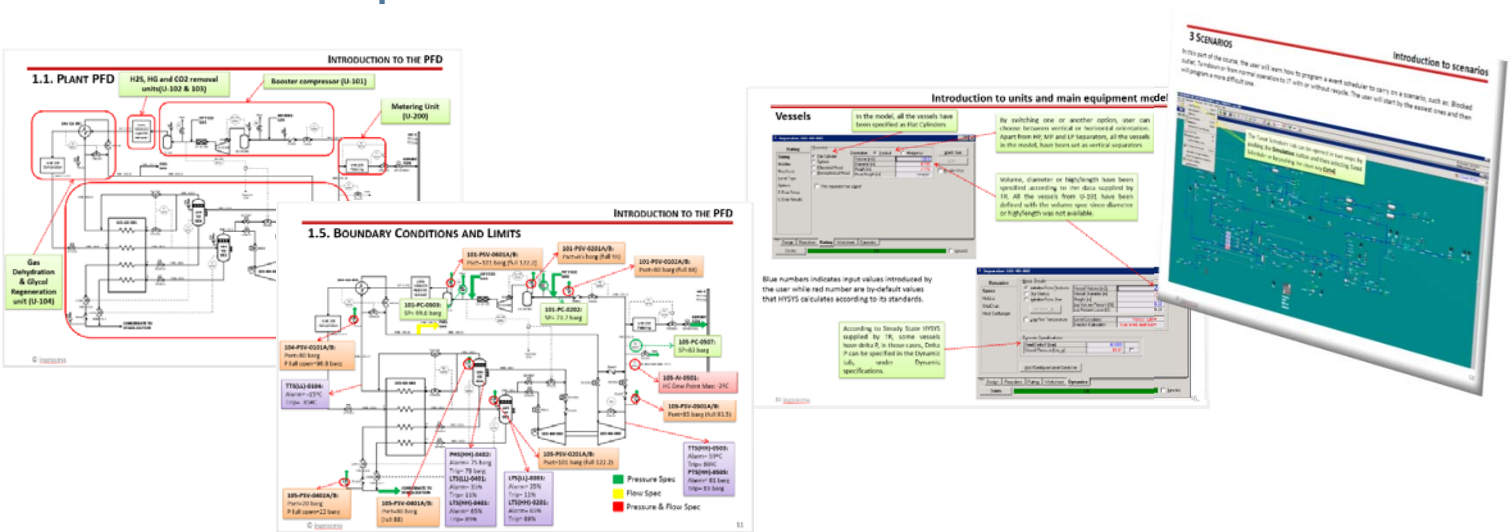
- **Complexity:** With complex processes (recycle, heat integration, shared shaft, etc) with multiple self interacting variables, it is very difficult to analyse the dynamic behaviour of the model. Following an adequate discipline when reporting and thanks to the powerful strip-charts from HYSYS, it was feasible to analyse all the dynamics affecting the process.

# 06 | Knowledge Transfer program

**Apart from the detailed report and dynamic models deliverables, a custom training course was included in the project scope, where TR engineers learnt how the model was built and how other scenarios could be developed by TR.**

**Custom course structure**

- **2 Days of basic HYSYS dynamic course: TR engineers were instructed in the basic skill to understand and know how to develop a dynamics HYSYS model.**
- **1 Day of the Dew Point Unit model usage: TR engineers were instructed specifically in the usage of the model, how the model was built, how to work with it and how to implement scenarios.**

# *Thank you and remember…*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