



HONEYWELL / UOP PSA PROCESS BASICS

JM AMERICAS HYDROGEN & SYNGAS TECHNICAL TRAINING SEMINAR



WILLIAM BLASKO
SENIOR OFFERING MANAGER
HONEYWELL UOP - UPT HYDROGEN

7 November 2024

Honeywell
UOP

PSA APPLICATIONS / EXPERIENCE LIST

13% Ethylene Off-Gas

No. of Units: 151
Feed Pressure: .4 – 640 psig
Feed Flow: 0.08 – 188,385 MMSCFD

40% Steam Reformers

No. of Units: 465
Feed Pressure: 15 – 928 psig
Feed Flow: 0.12 – 344 MMSCFD



22% Specialty Applications

No. of Units 255
Ammonia Plants
Coke Oven Gas
Gasification
Methanol Off-Gas
Misc Off-Gas
Partial Oxidation/Syngas

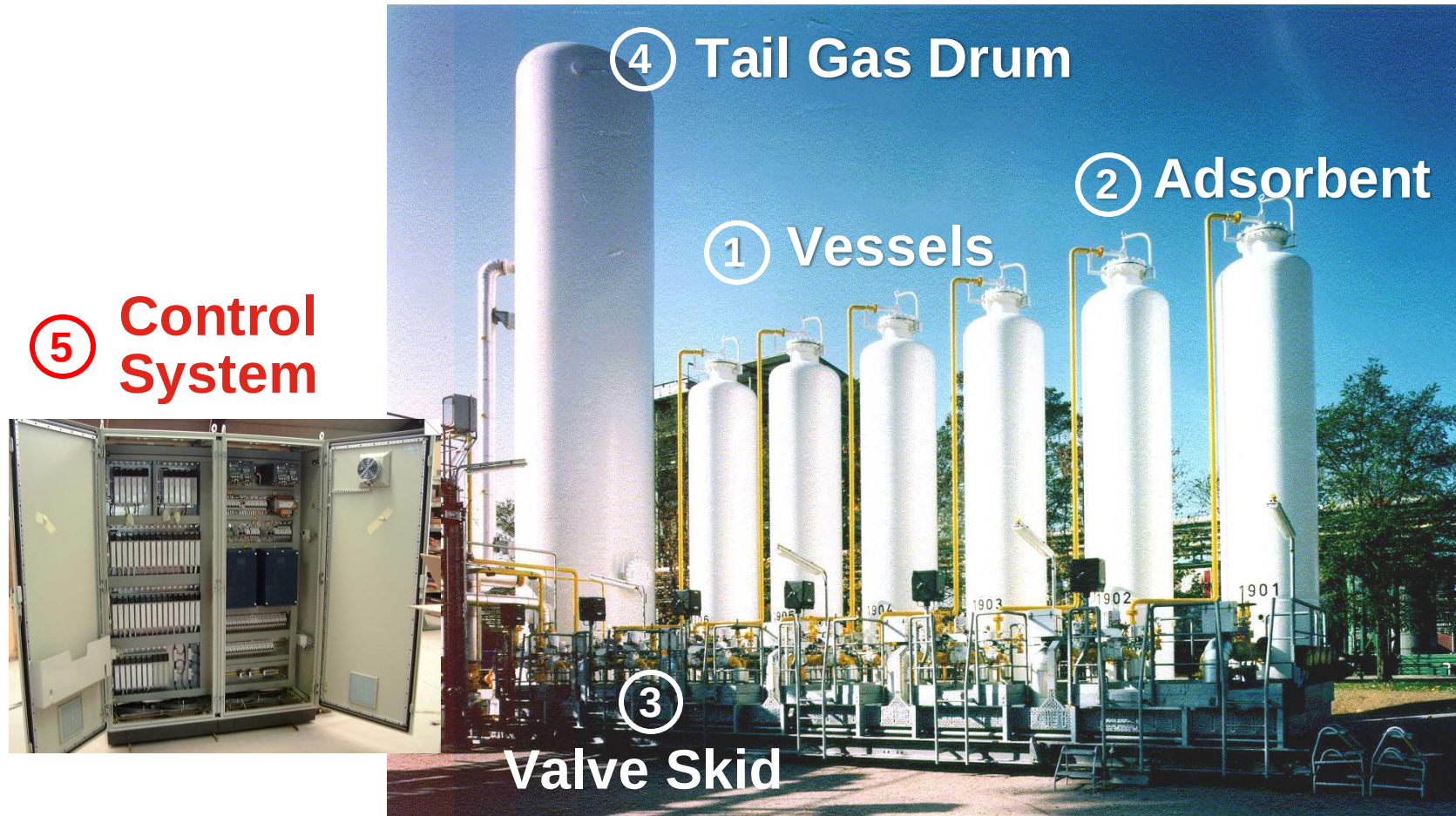
25% Refinery Streams

No. of Units: 288
Feed Pressure: 20 – 670 psig
Feed Flow: 0.05 – 203 MMSCFD



> 1,180 Polybed PSA Units UOP Supplied Worldwide

COMPONENTS OF A PSA SYSTEM



⑥ UOP Service and Support



PSA Equipment / Modular Supply

AGENDA

I. Basics of Adsorption

II. Basics of PSA Process

III. PSA Process Animation / Process Steps

IV. Effect of Operating Conditions

An aerial night photograph of a large industrial facility, likely a refinery or chemical plant. The scene is illuminated by numerous artificial lights, creating a warm yellow glow against the dark blue and purple twilight sky. In the foreground, several large, cylindrical storage tanks are visible, some with ladders and walkways. The middle ground is filled with a complex network of pipes, structural steel, and smaller tanks. In the background, tall distillation columns and other industrial structures are visible, with city lights in the distance. A prominent red banner with white text is overlaid in the center of the image.

BASICS OF ADSORPTION

CONCEPTS OF ADSORPTION

ADSORPTION

Preferential partitioning of substances from the gaseous or liquid phase onto the surface of a solid substrate

ADSORBENT

Solid substrate upon which the adsorption process takes place

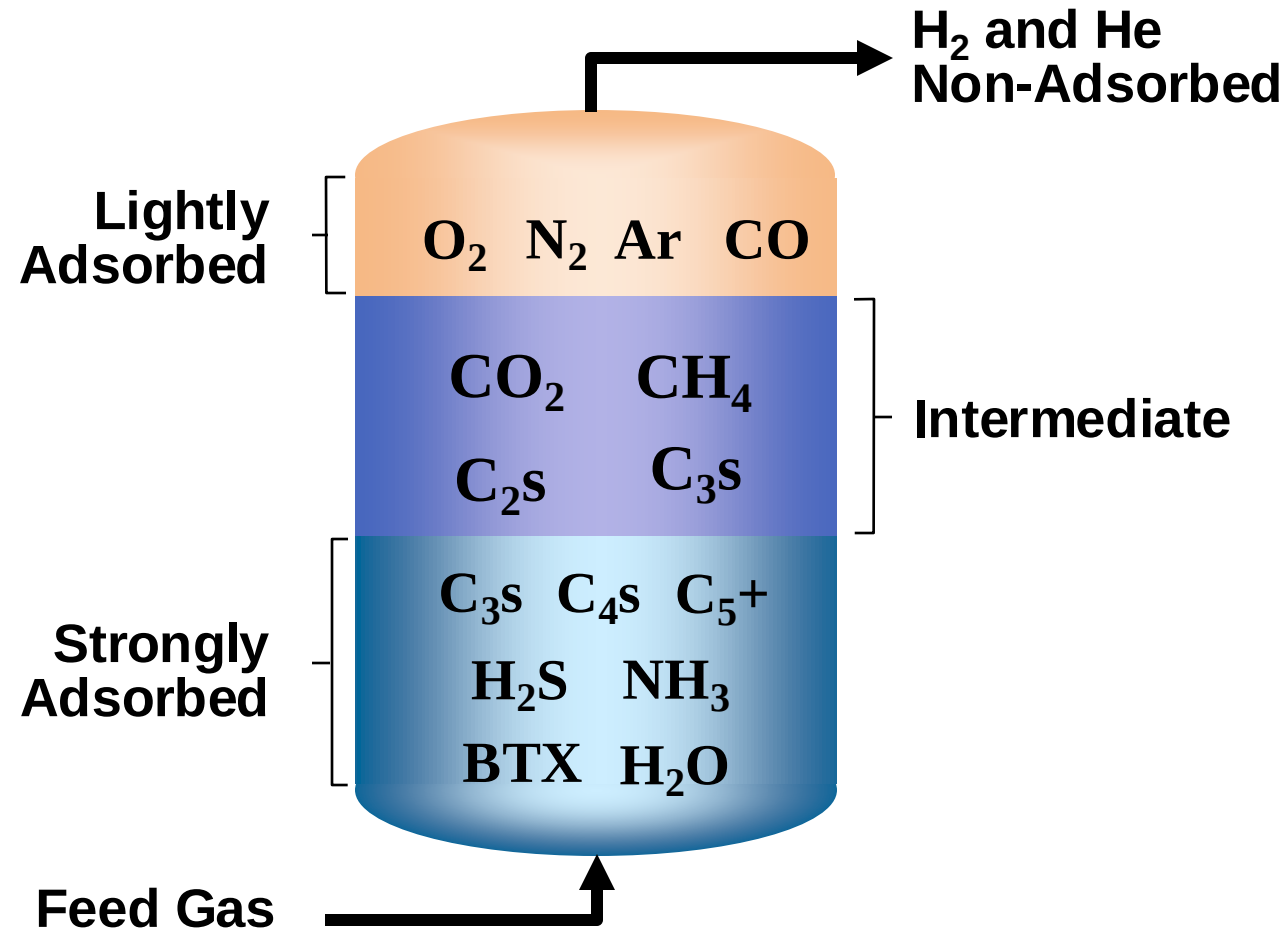
LOADING

Quantity of adsorbed material per mass unit of adsorbent

ISOTHERM

Quantity of adsorbed material per mass unit of adsorbent

ADSORPTION SELECTIVITY



Impurities are Removed Down to Any Level Required by the Customer

ADSORBENT PROTECTION

Avoid

- ❌ Liquids
- ❌ Major feed changes
- ❌ New feed components
- ❌ Crushing / drilling
- ❌ Lifting



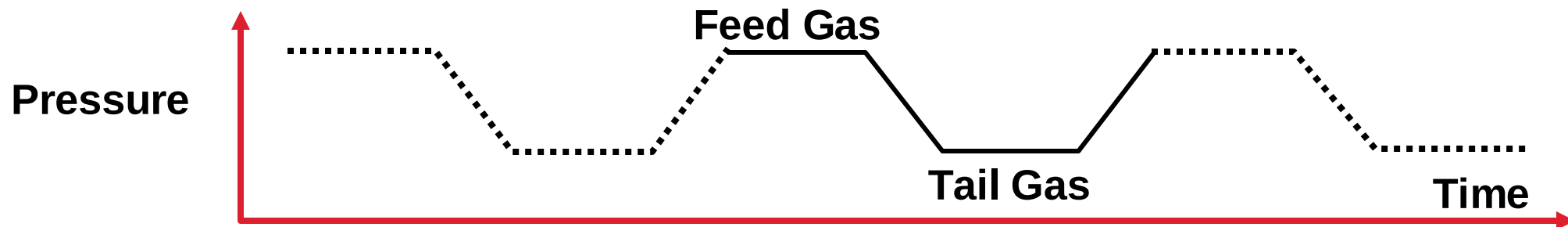
An aerial night photograph of a large industrial complex, likely a refinery or chemical plant. The facility is illuminated by numerous yellow and white lights, creating a stark contrast against the dark sky. In the foreground, several large, cylindrical storage tanks are visible, some with ladders and walkways. To the left, a cluster of spherical storage tanks is situated. The background features a complex network of pipes, structural steel, and tall distillation columns. A city skyline is visible in the far distance under a twilight sky with soft pink and blue hues.

BASICS OF PSA PROCESS

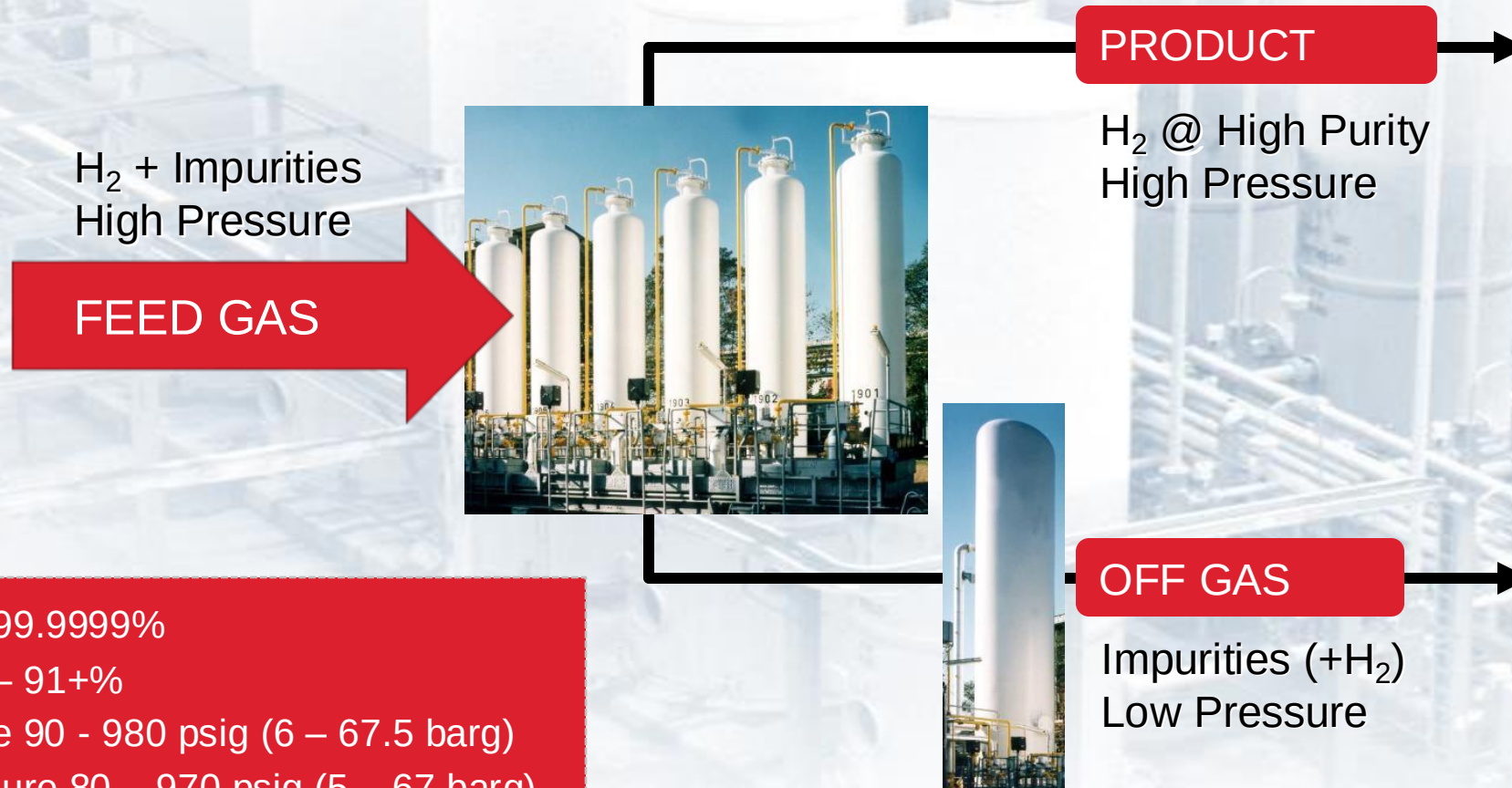
PSA BASIC PRINCIPLES

Ability of adsorbents to adsorb more impurities at high pressure than at low pressure

'Pressure Swing' cycle



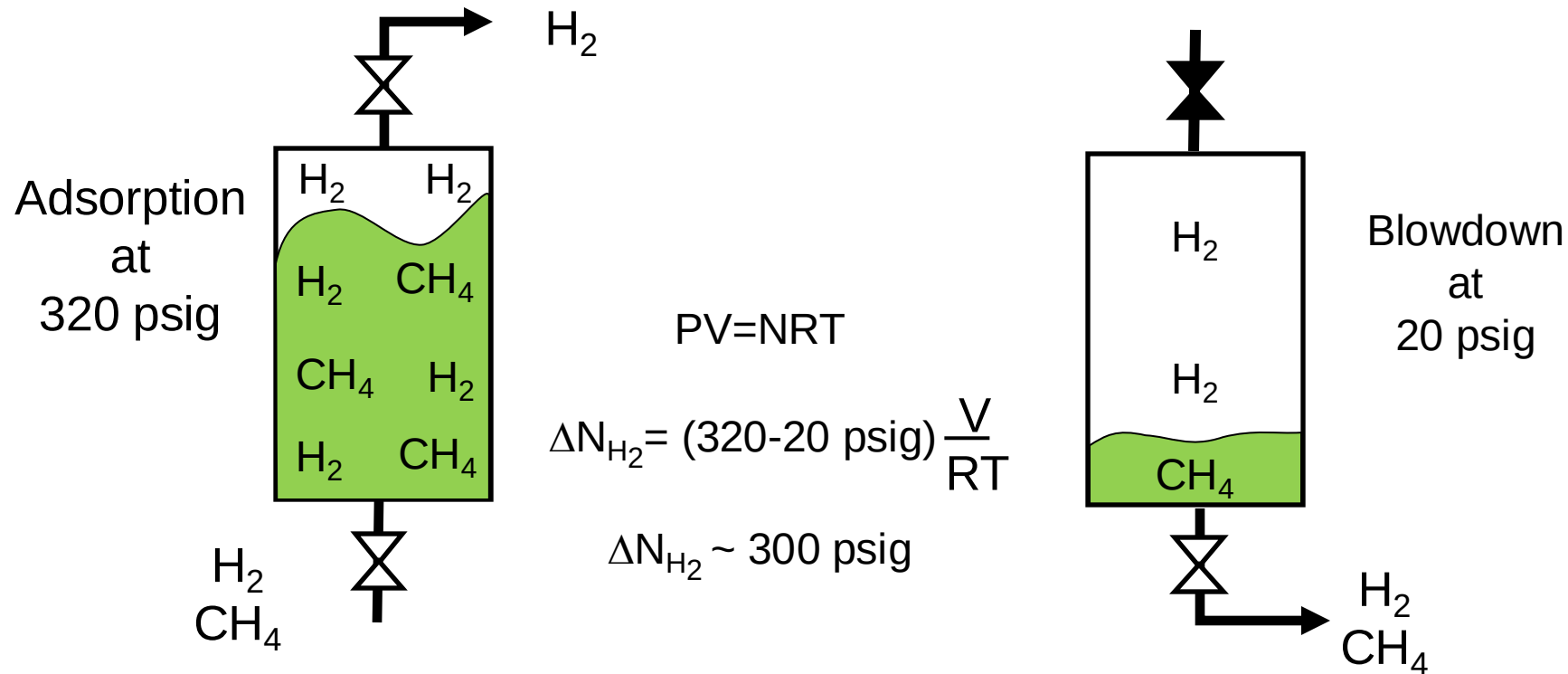
PSA BASIC FLOW DIAGRAM



H₂ Purity 99.9 – 99.9999%
H₂ Recovery 80 – 91+%
H₂ Feed pressure 90 - 980 psig (6 – 67.5 barg)
H₂ Product pressure 80 – 970 psig (5 – 67 barg)

PRESSURE EQUALIZATIONS

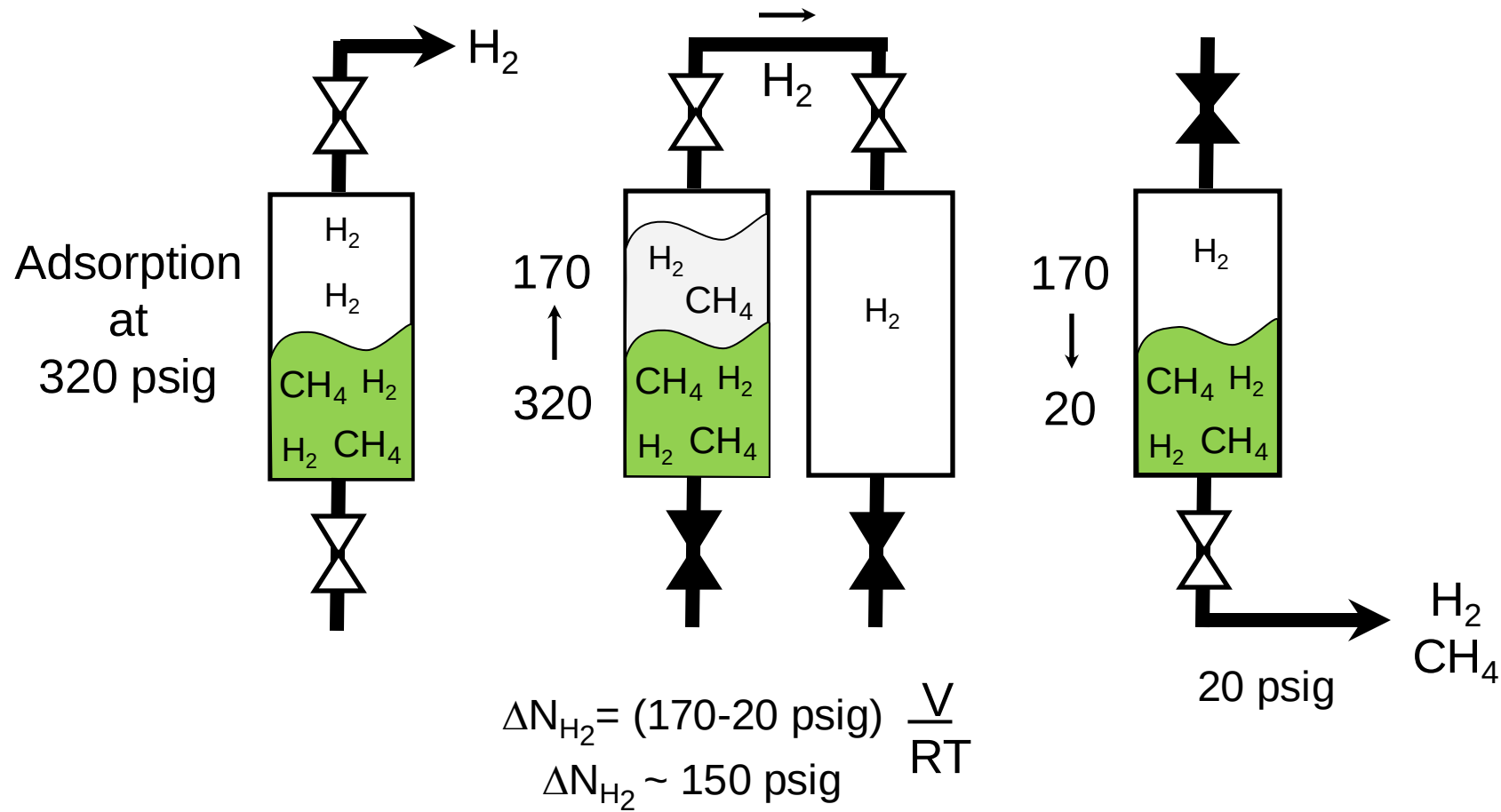
In its simplest form, the PSA process could consist of only two steps:
Adsorption and Blowdown



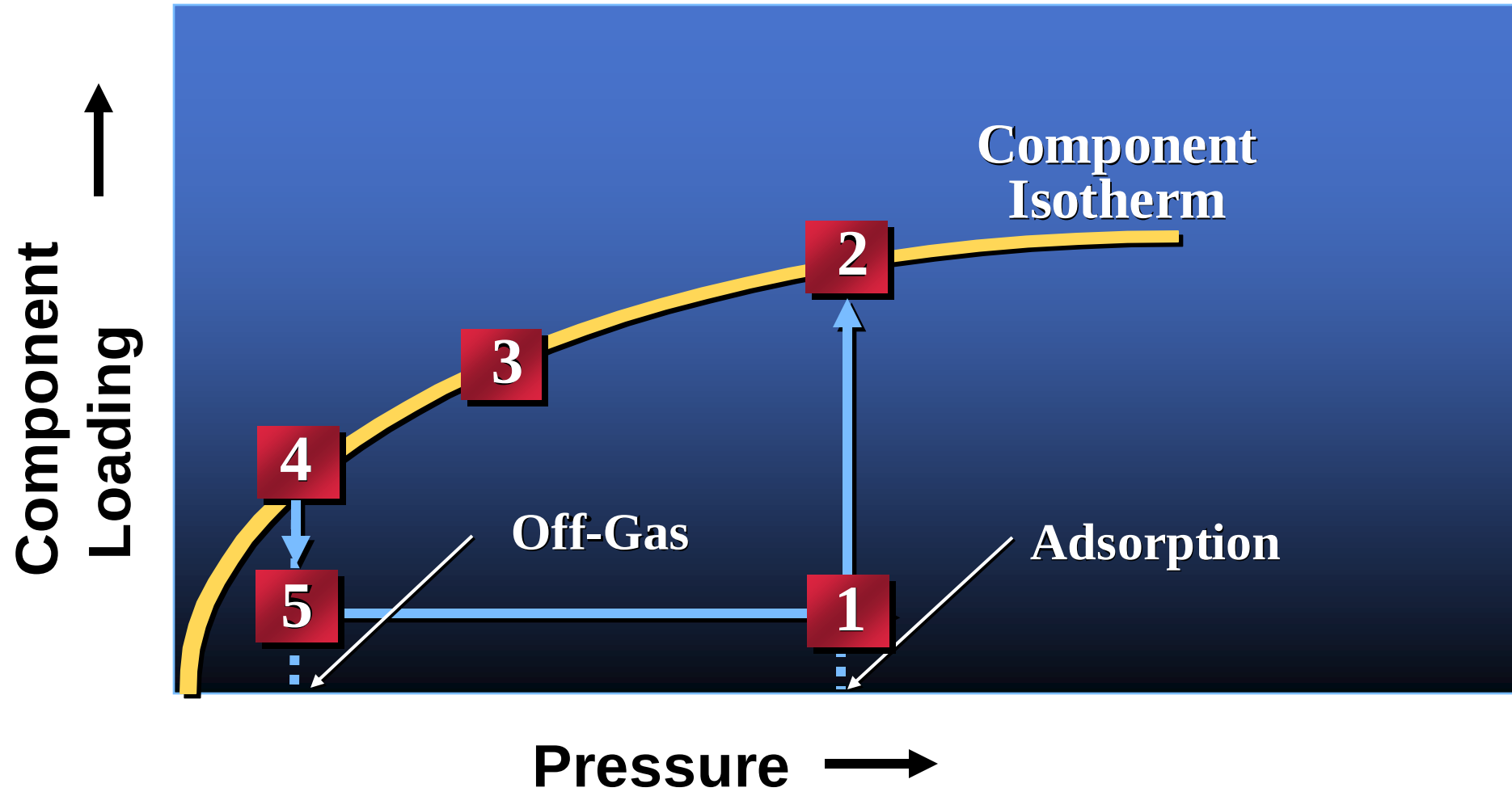
Hydrogen Lost Due to Large Pressure Fluctuations

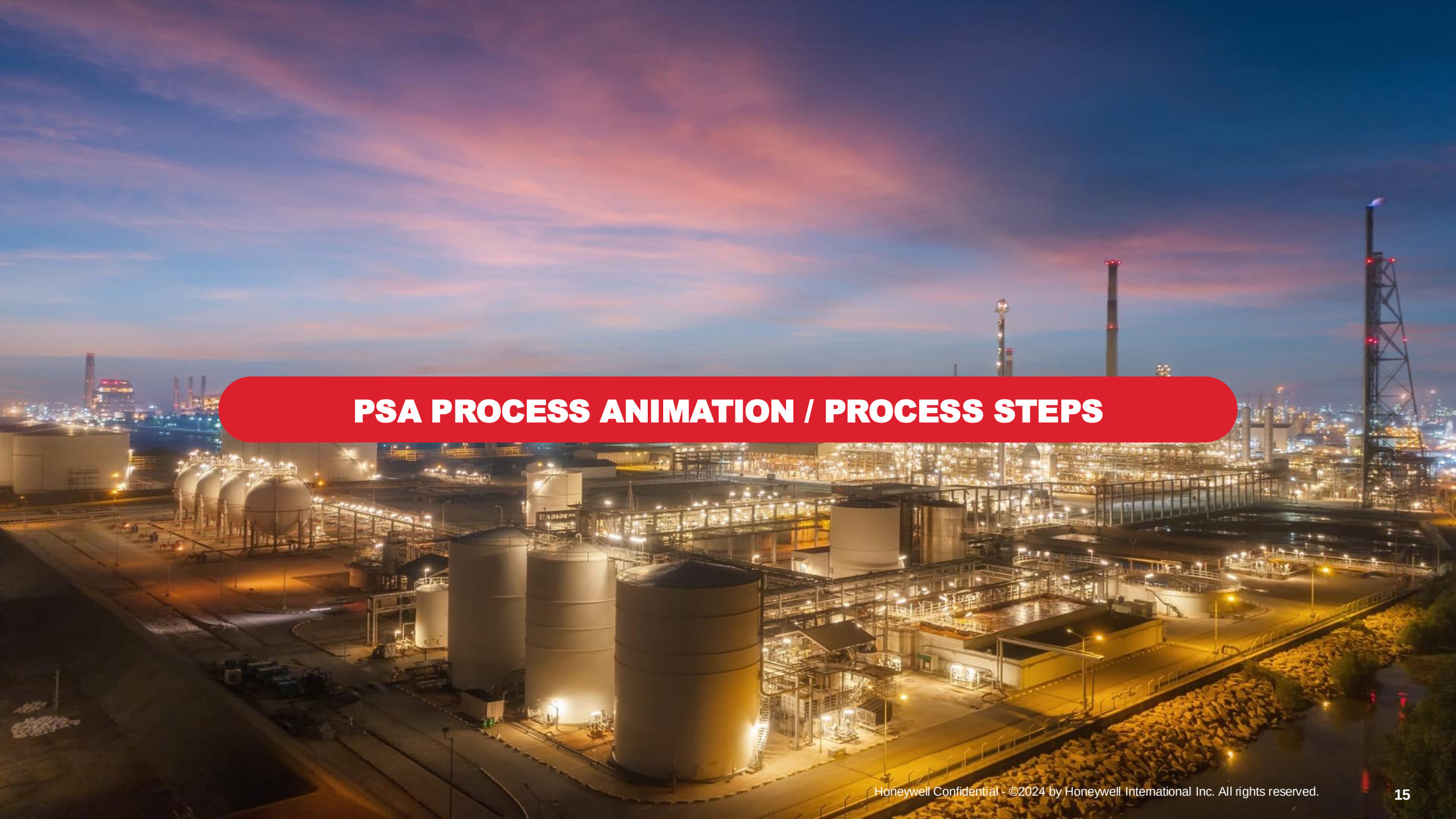
PRESSURE EQUALIZATIONS

Co-current depressurization increases hydrogen recovery



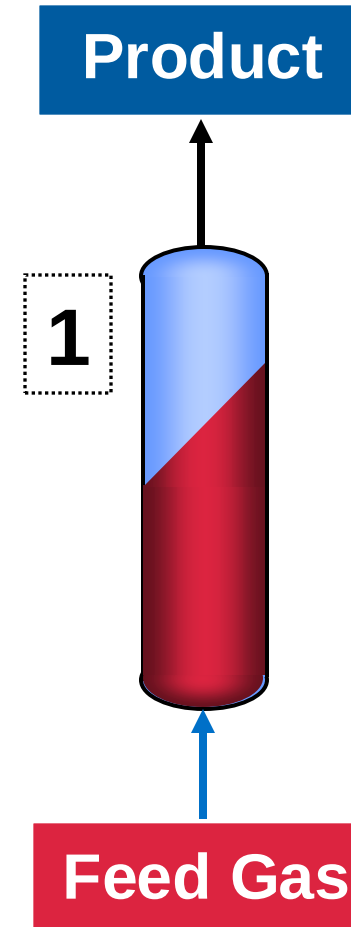
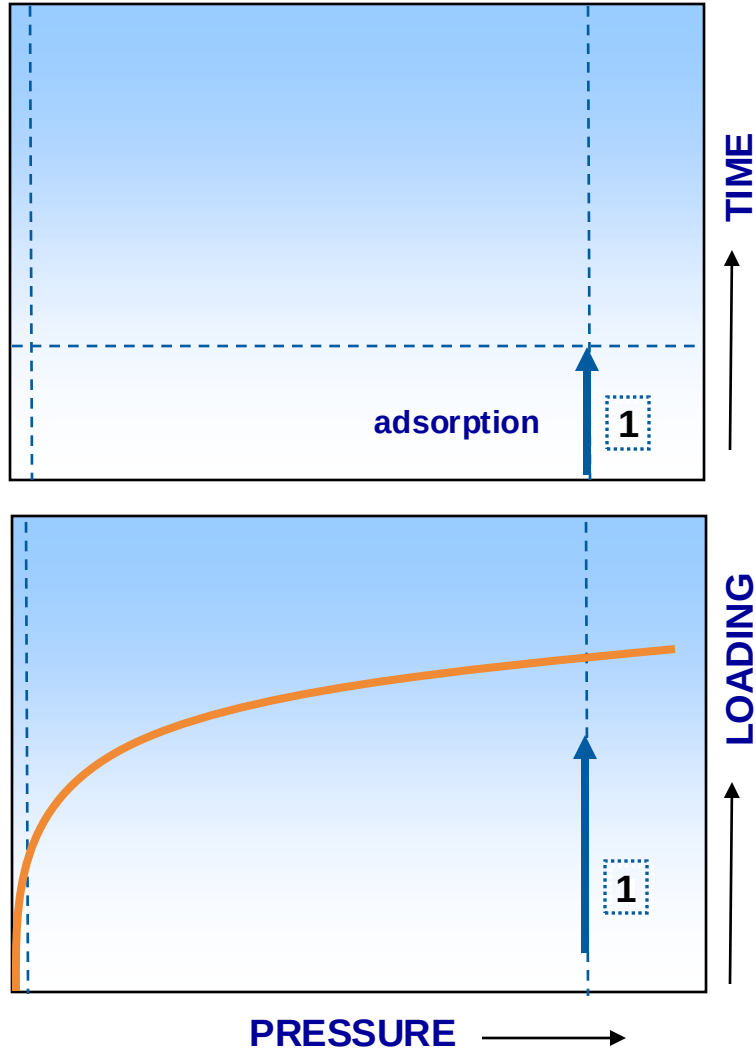
PSA CYCLE



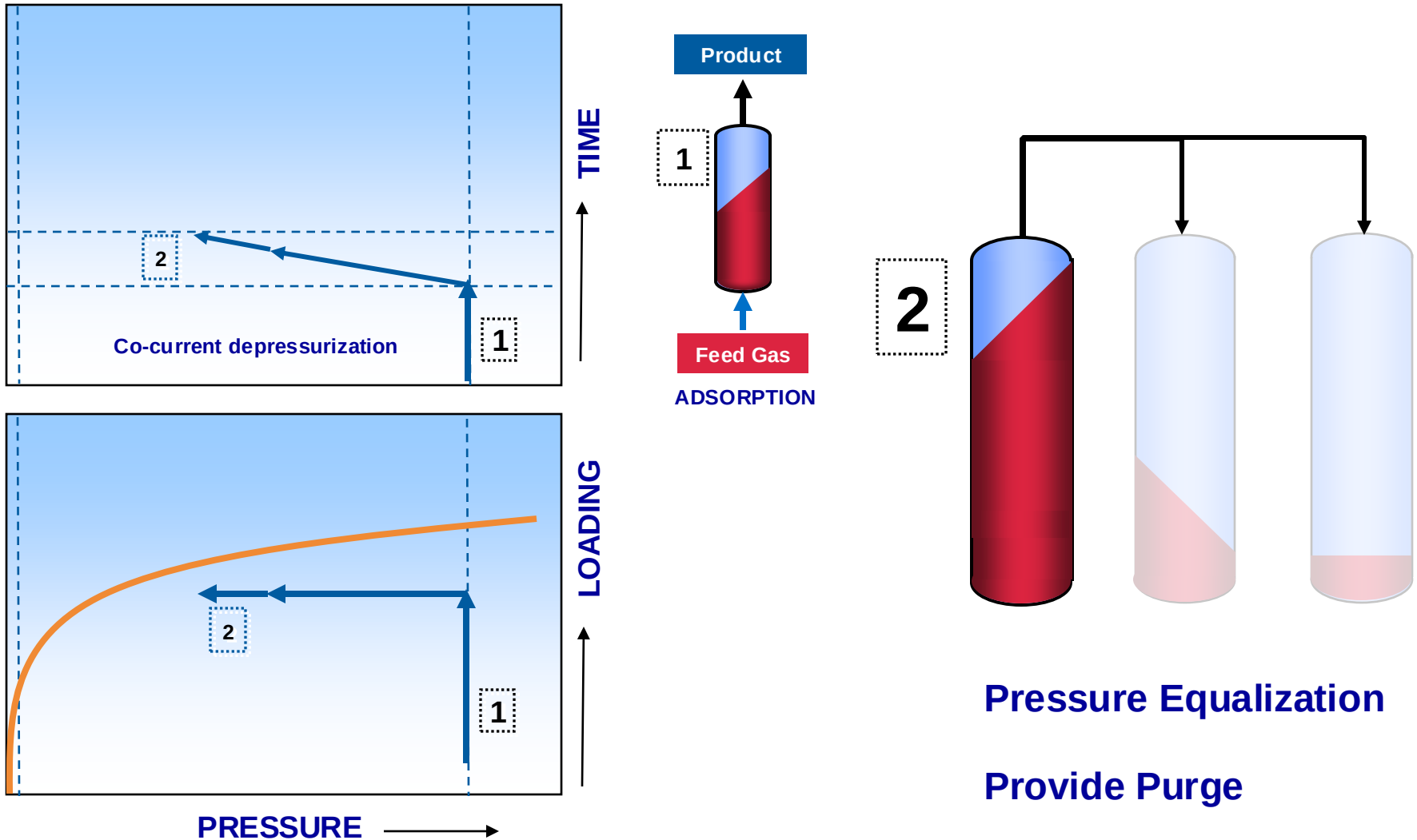
An aerial night view of a large industrial facility, likely a refinery or chemical plant. The scene is illuminated by numerous yellow and white lights, highlighting the complex network of pipes, walkways, and large cylindrical storage tanks. In the foreground, three large, white, horizontal storage tanks are prominent. The background shows more industrial structures and a city skyline under a twilight sky with soft pink and blue hues. A red banner with white text is overlaid in the center of the image.

PSA PROCESS ANIMATION / PROCESS STEPS

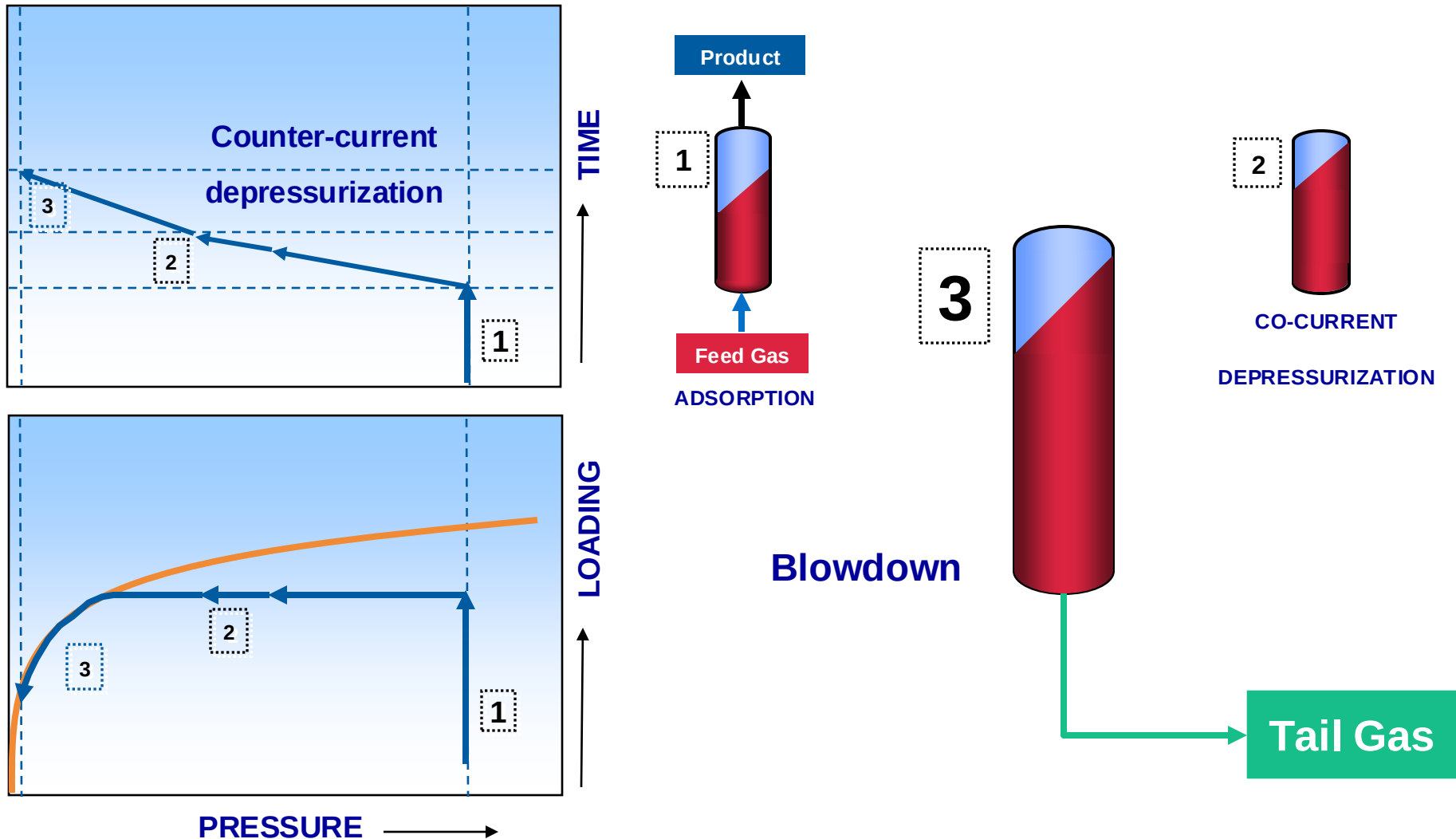
PSA PROCESS – STEP 1 (ADSORPTION)



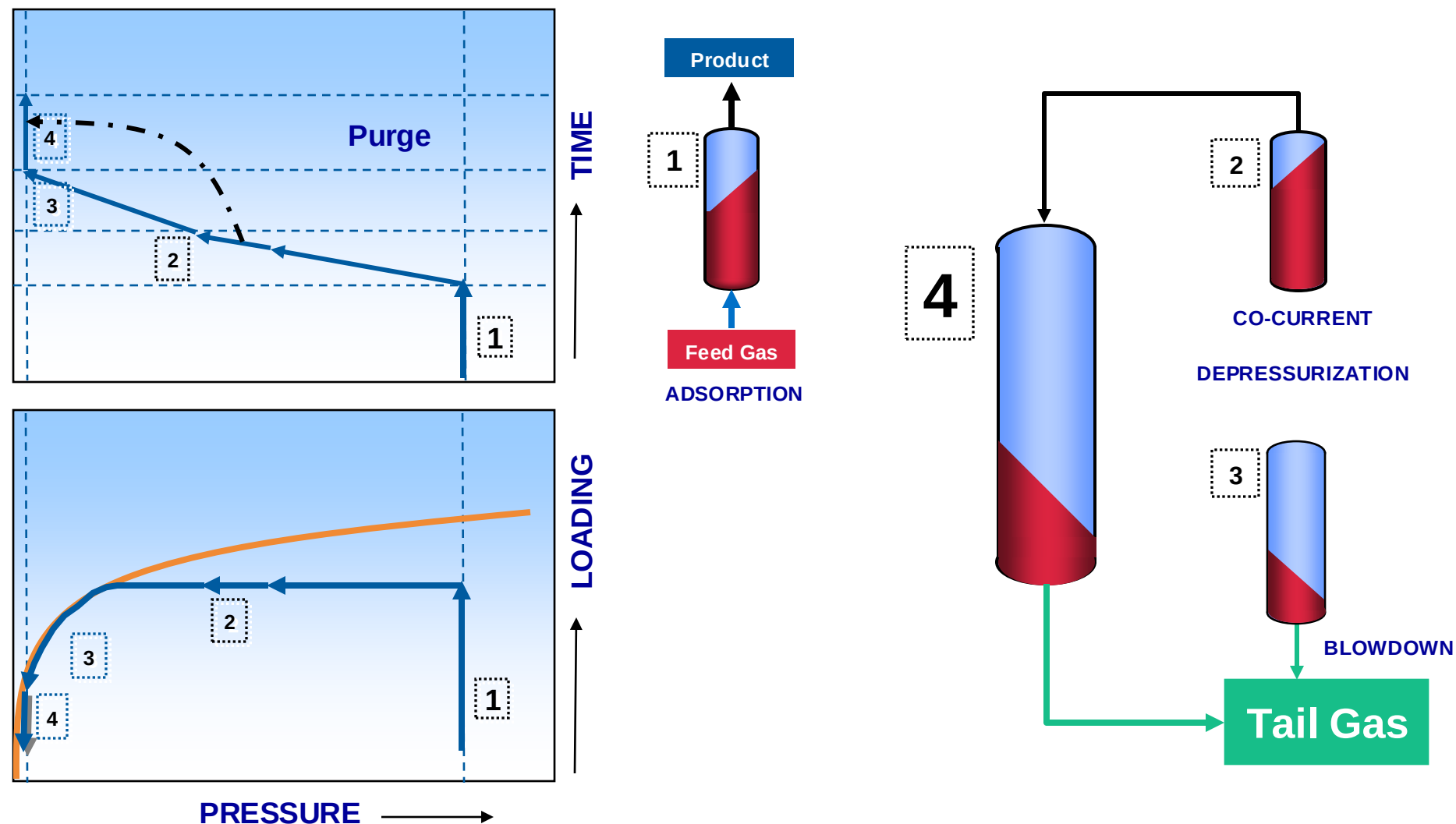
PSA PROCESS – STEP 2 (CO-CURRENT DEPRESSURIZATION)



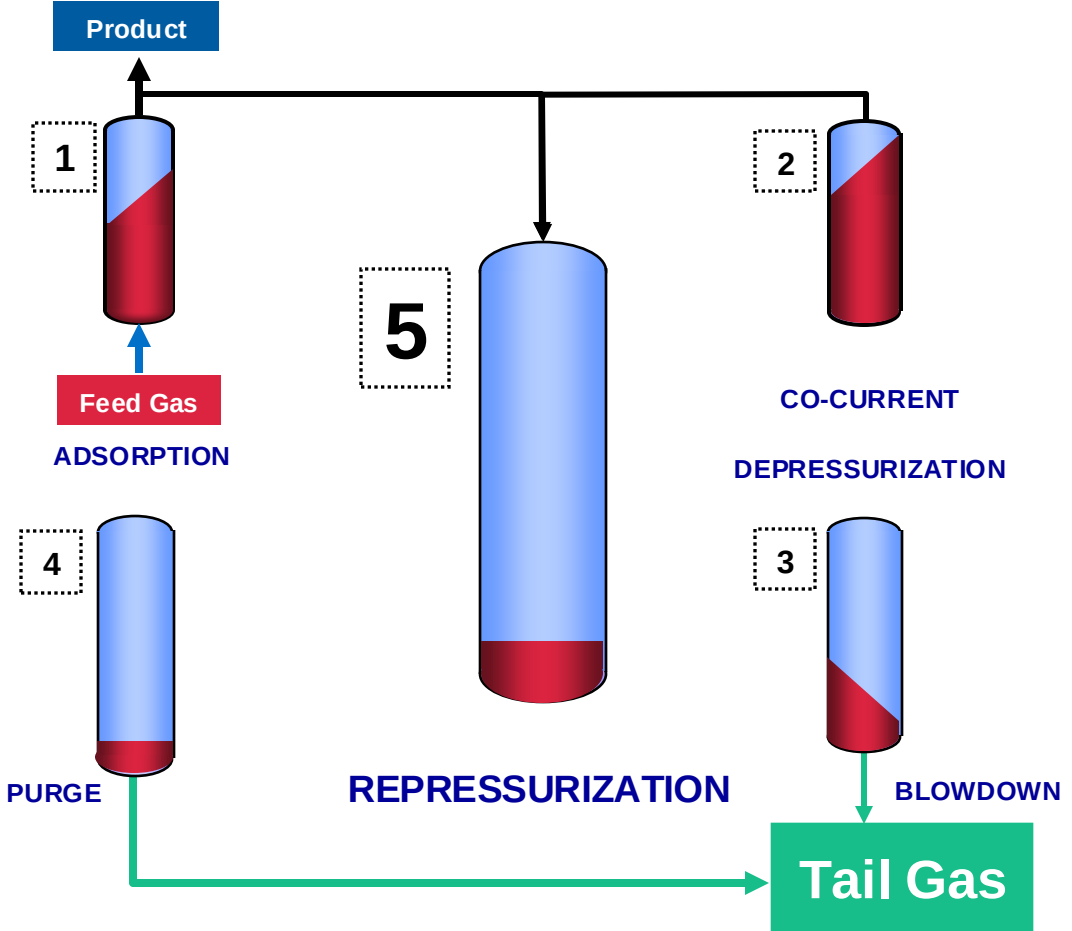
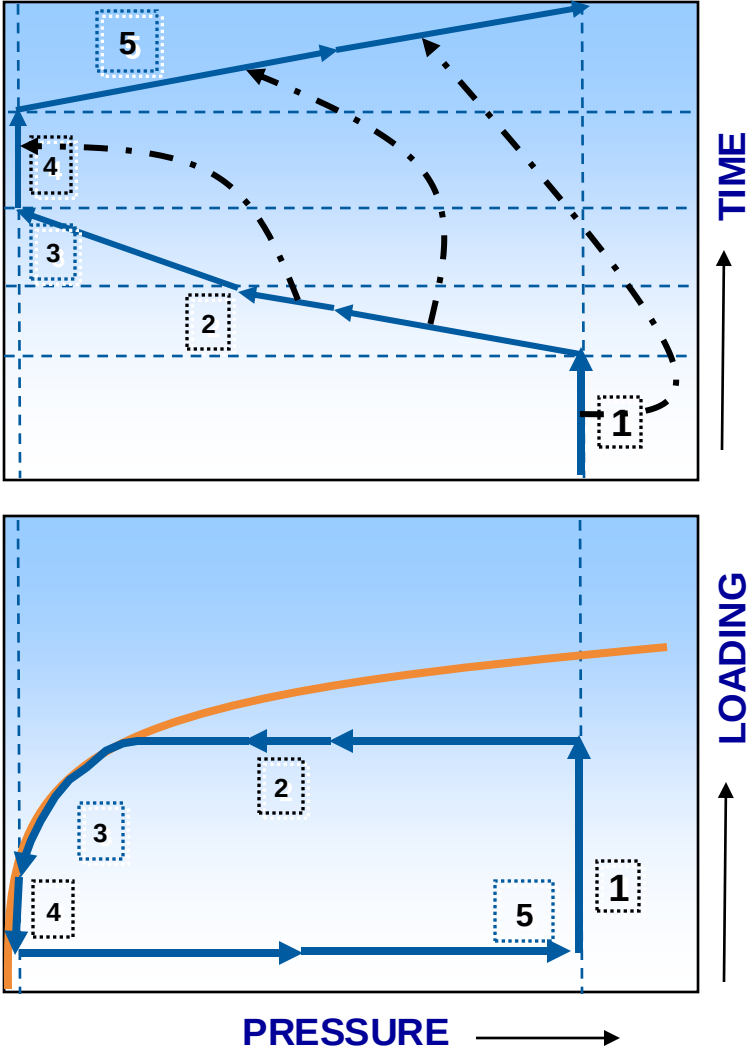
PSA PROCESS – STEP 3 (COUNTER-CURRENT DEPRESSURIZATION)



PSA PROCESS – STEP 4 (PURGE)



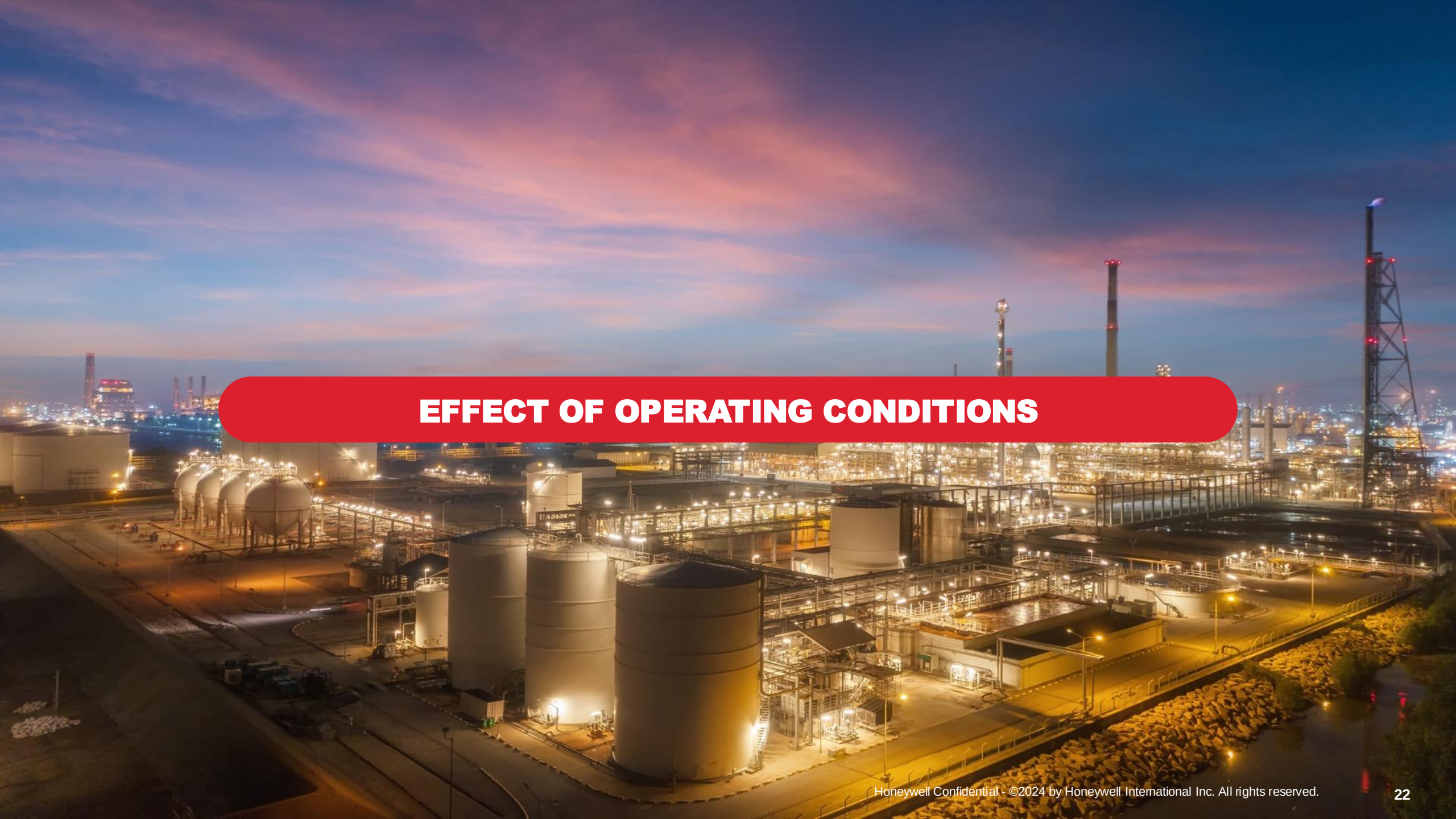
PSA PROCESS – STEP 5 (REPRESSURIZATION)



DESIGNED FOR RELIABILITY

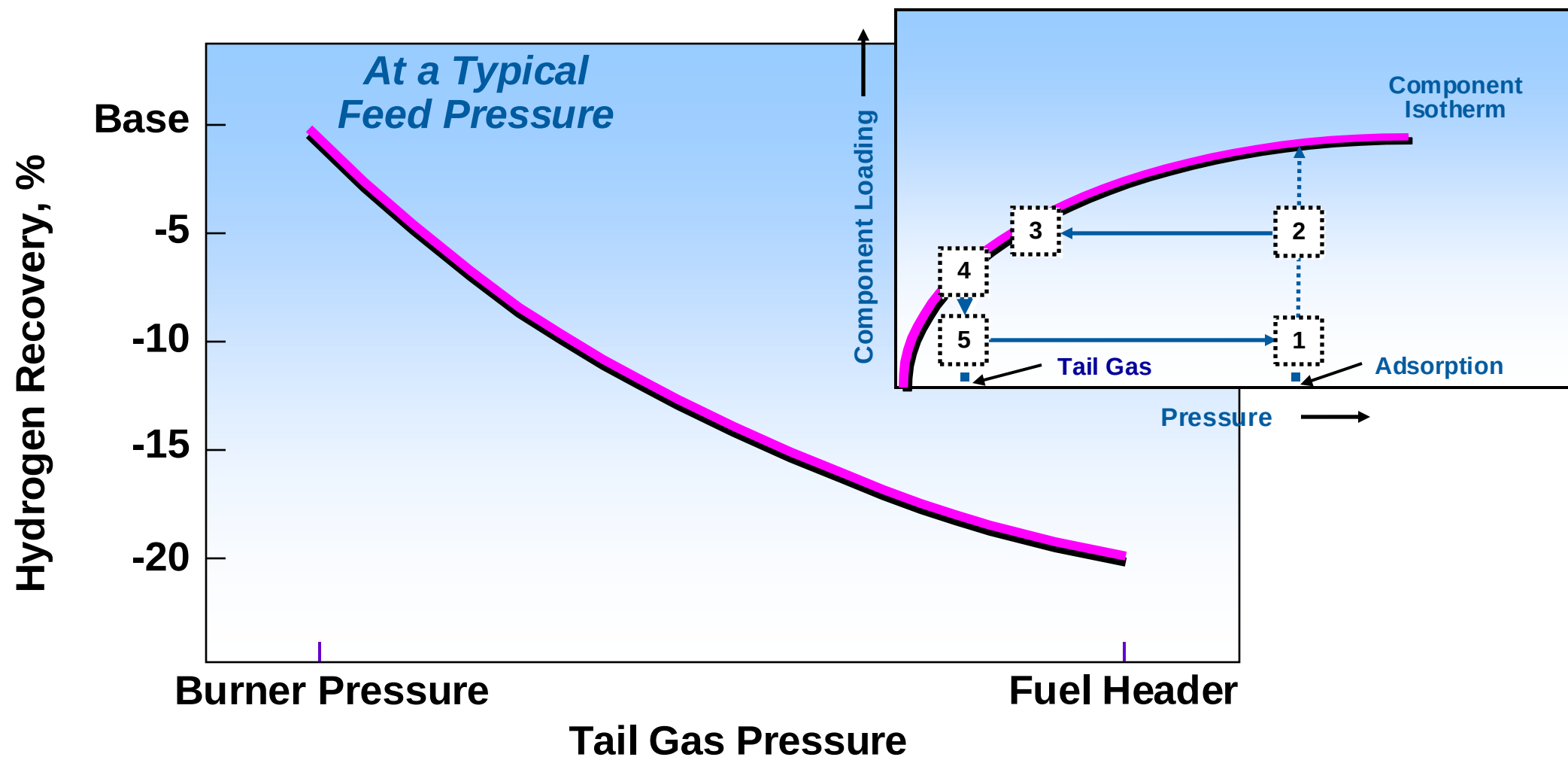
- Over 99.95+% on-stream factor
- Component selection
- Back-up operating mode(s)
- No single component failure will shut the unit down
- Automation



An aerial night photograph of a large industrial facility, likely a refinery or chemical plant. The scene is illuminated by numerous yellow and white lights, highlighting the complex network of pipes, walkways, and large cylindrical storage tanks in the foreground. In the background, several tall distillation columns and other industrial structures are visible against a dark sky with a hint of twilight colors. A red banner with white text is superimposed over the middle of the image.

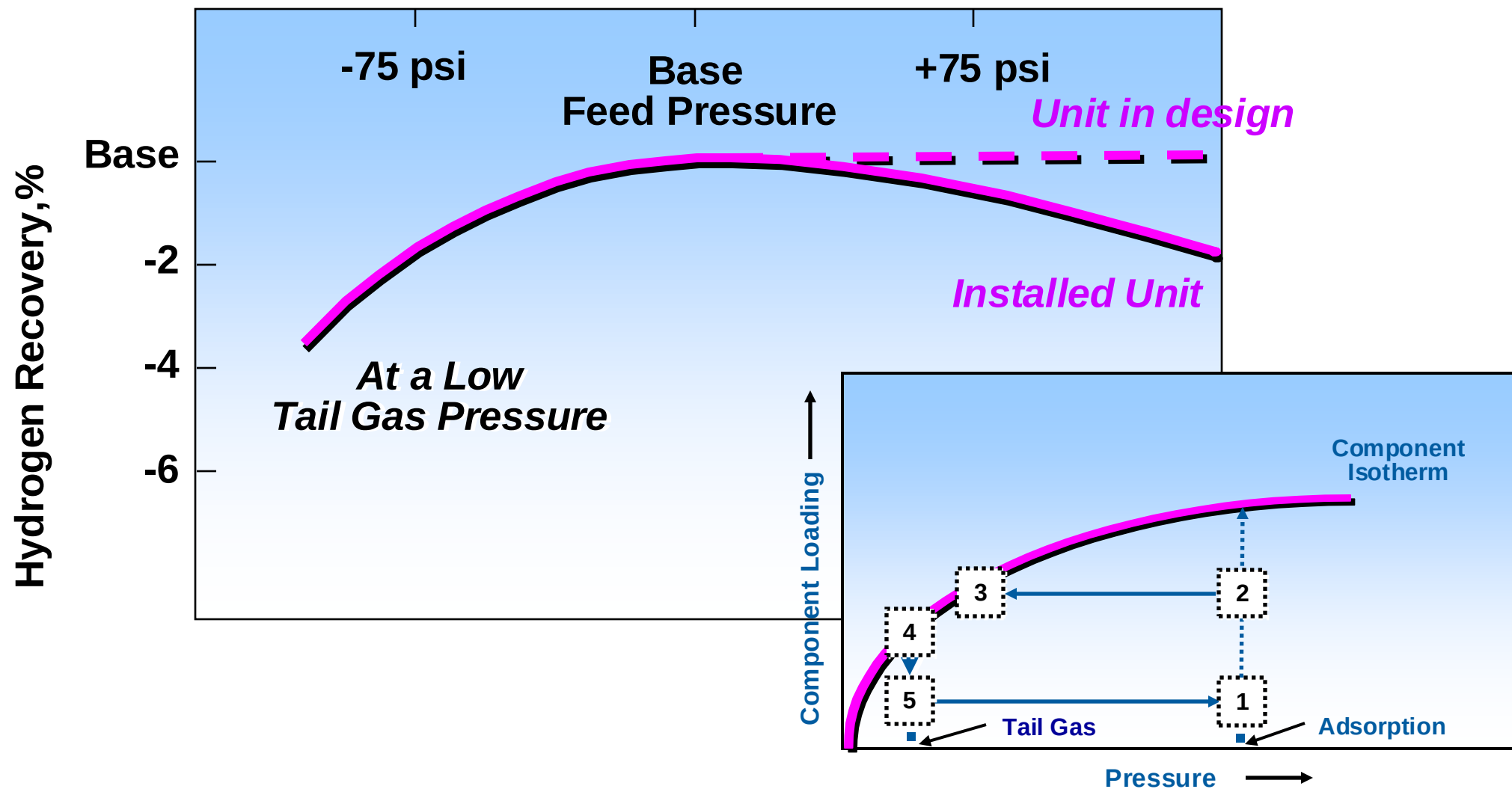
EFFECT OF OPERATING CONDITIONS

EFFECT OF TAIL GAS PRESSURE

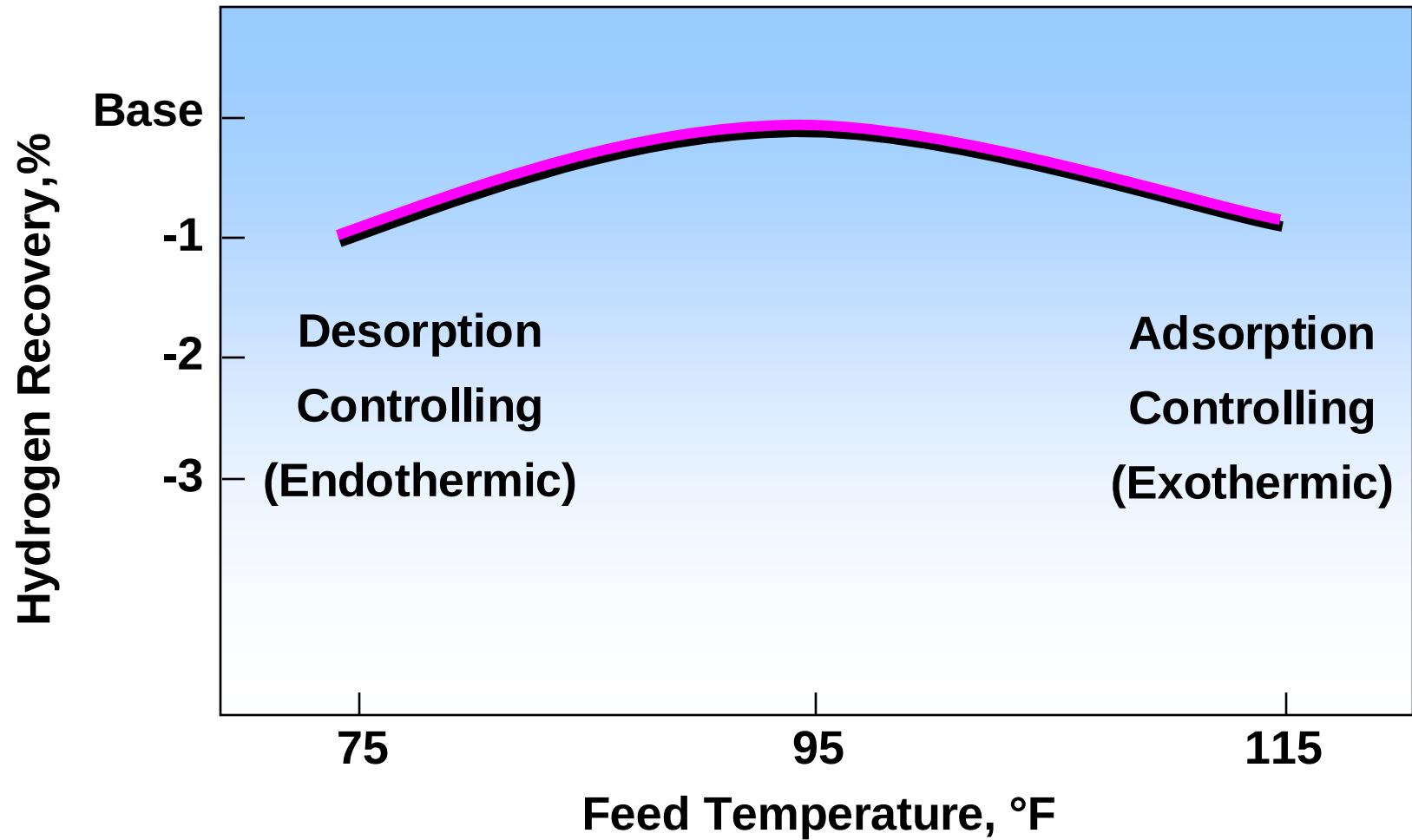


Tail Gas Pressure had the Greatest Impact on Product Recovery

EFFECT OF FEED GAS PRESSURE



EFFECT OF FEED GAS TEMPERATURE



GENERAL POLYBED™ PSA RELATIONSHIPS

Increase In:	Unit Size	H ₂ Recovery
Tail Gas Pressure	↑	↓
Feed Pressure	↓	↑↓
Product Purity (99% to 99.9%)	↑	↓
Feed Temperature	↑↓	↑↓
Feed Purity (75% to 80%)	↓	↑
Cycle Time	↑	—
Feed Flow	↑	—

TYPICAL SMR PSA DESIGN

Capacity MMSCFD (M Nm3/hr)	System	H ₂ Recovery	Relative Cost
5 (6)	4 / 5 / 6 Bed	80-83	100
20 (22)	5 / 6 Bed	83-87	200
60 (67)	8 / 10 Bed	87-90	400-500
100+ (112+)	10 / 12+ Bed	88-90	500-600

Maximize Recovery Through Pressure Equalizations

SUMMARY: THE PSA ADVANTAGE

Approaches 100%
Impurity Rejection

Minimal
Pre-treatment
Required

High Purity
Hydrogen Product

Low Pressure Drop
to Hydrogen Product

Increased Run Time
for Hydroprocessing
Units

Avoids Downstream
Catalyst Poisoning

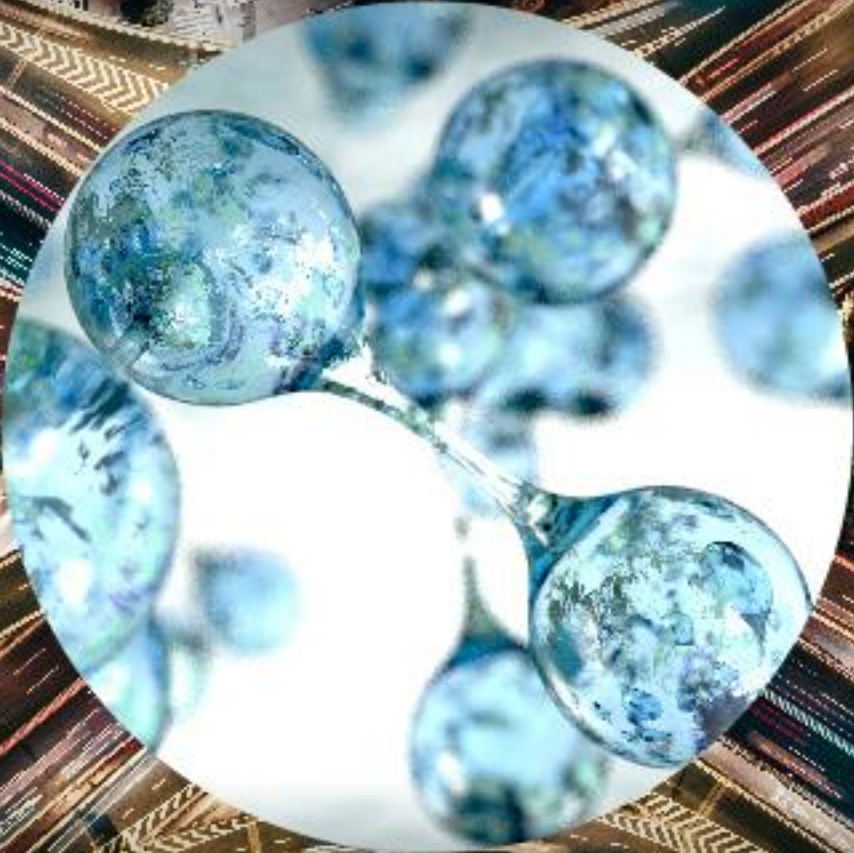
High Reliability
(>99.95%
On-Stream)

Attractive
Economies of Scale



THANK YOU

UOP

A circular inset image showing several small, blue and white globes of the Earth, arranged in a cluster. This graphic serves as the letter 'O' in the 'UOP' logo.

Honeywell
UOP