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WELDED PLATE-BLOCK HEAT EXCHANGERS IN AMINE SYSTEMS AND SWS

REFCOMM® BUDAPEST
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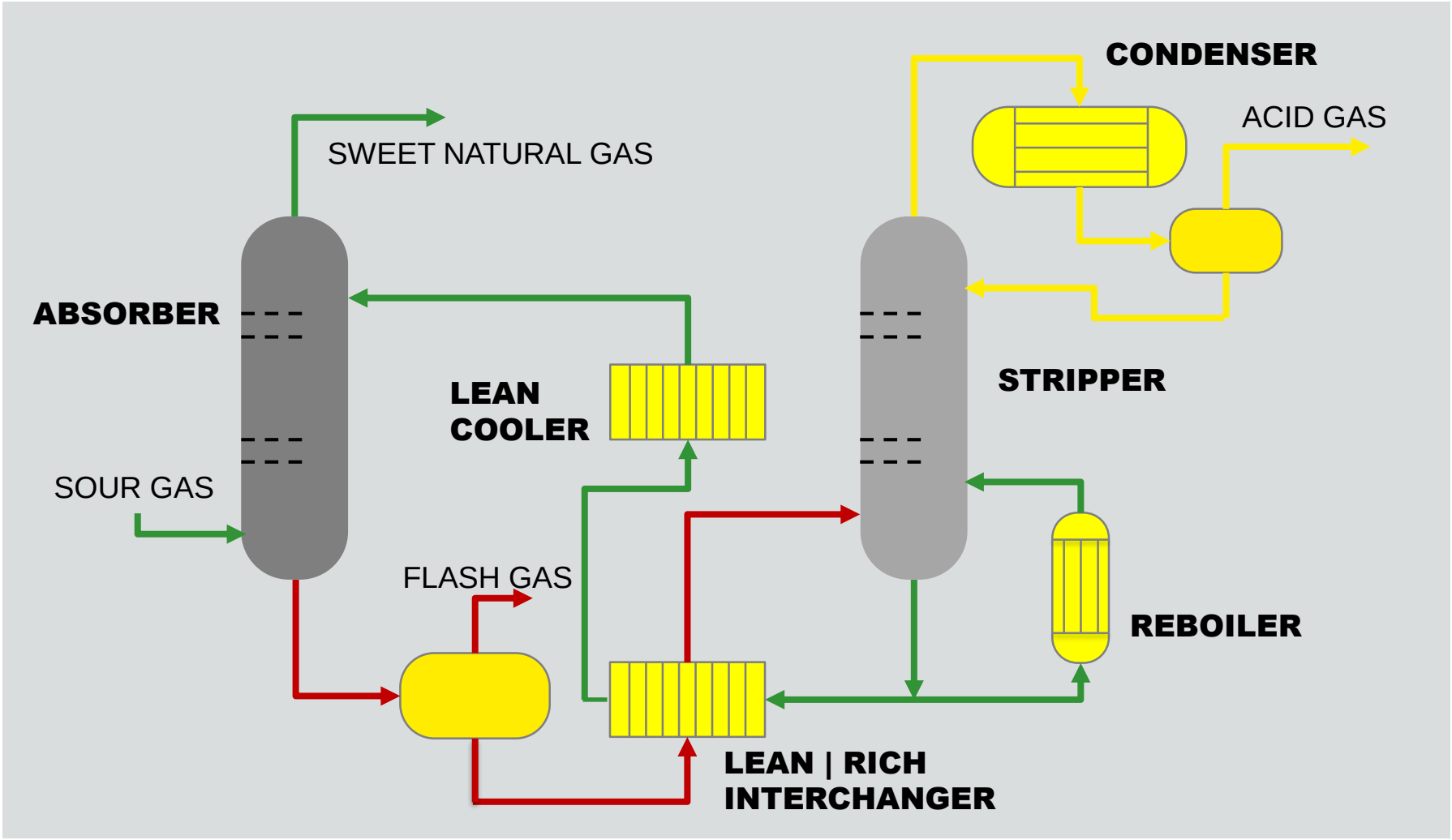
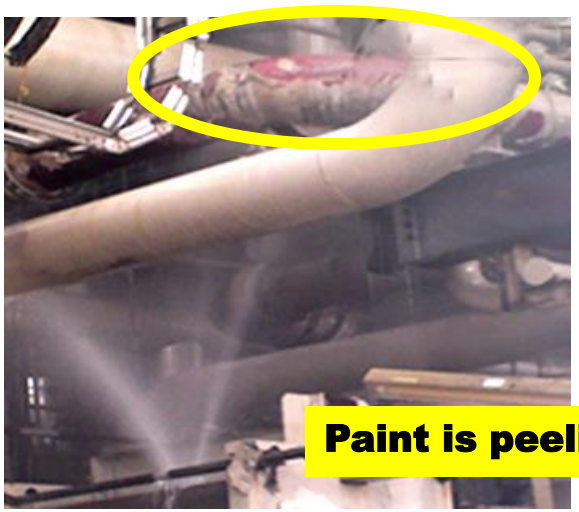


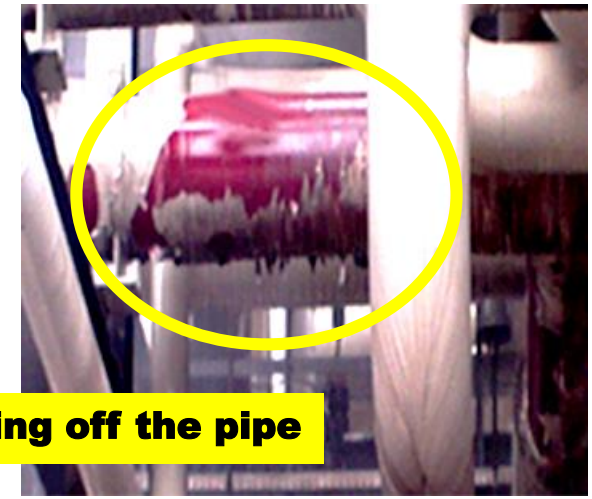
TECHNOLOGY CHOICE IN MANY AMINE SYSTEMS

- **SHELL & TUBE (S&THE) for:**
  - Regenerator Reboiler (Kettle or Themosyphon)
  - Overhead condenser (when water cooled)
    - Or Aircooler
- **PLATE & FRAME HEAT EXCHANGER (P&FHE) for:**
  - Lean Rich Amine Exchanger
  - Lean Amine Cooler (when water cooled)
    - Or Aircooler
- **P&FHE International standard API 667** (under development) replacing API 662 part 2
- Experience with P&FHE?

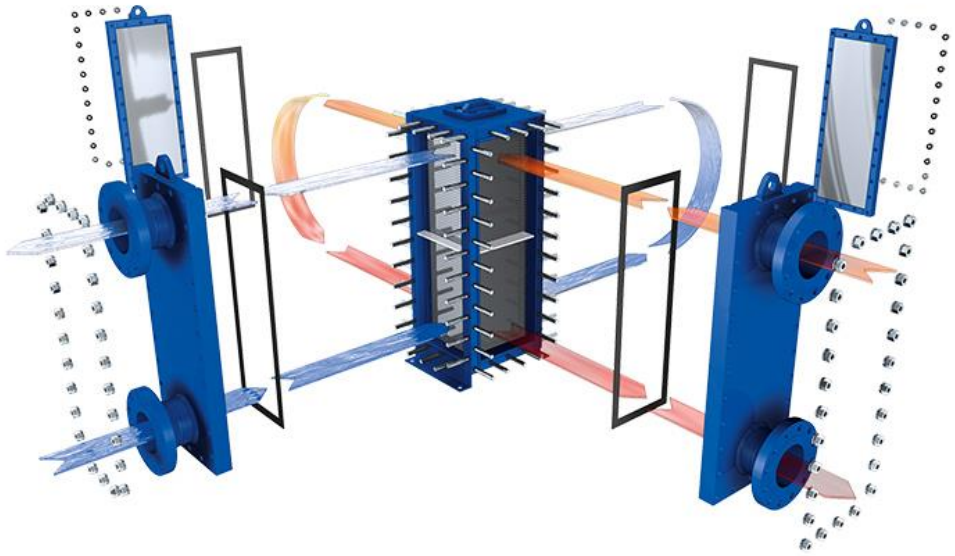
WHAT CAN GO WRONG WITH P&FHE IN AMINE SYSTEMS?

- Purchase of wrong incompatible gaskets
- Wrong glueing:
  - Cold glueing was done although hot oven curing was required
- Many sites have experienced leakage issues with P&FHE





WELDED PLATE-BLOCK HEAT EXCHANGER: A ROBUST ALTERNATIVE

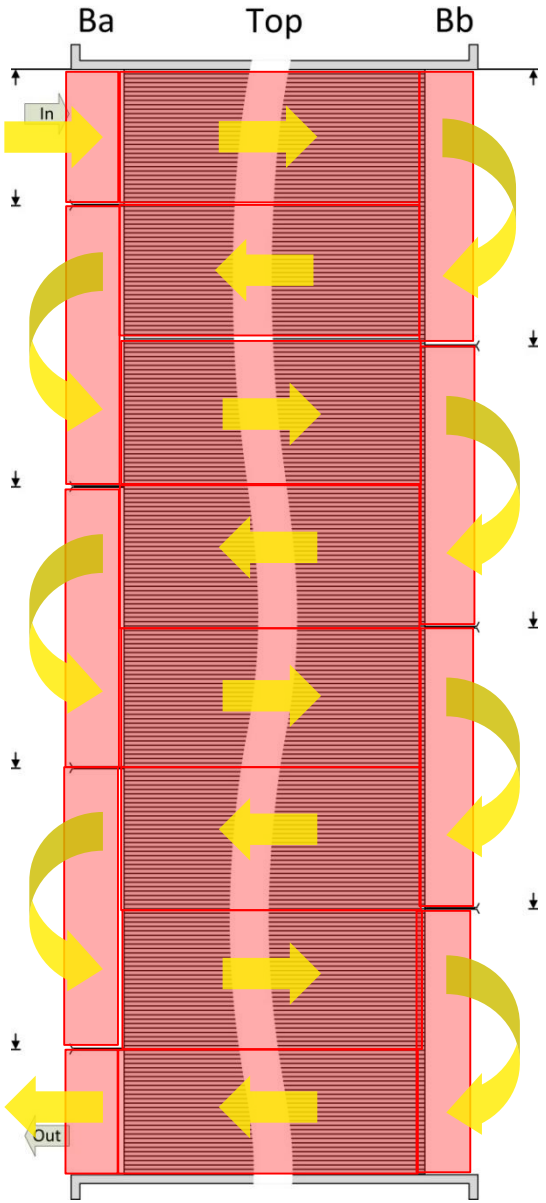


KELVION K°BLOC

- **Up to 350°C** design temperature
- **Up to 42 barg** design pressure
- **Up to 860 m²** HTA
- **Totally accessible** for inspections and maintenance
- **Compliant** to the main international PV Codes and Standards
- **API 810** under development

K°BLOC - BAFFLE

- Countercurrent flow approach by many cross passes
- Temperature approach down to 5 °C



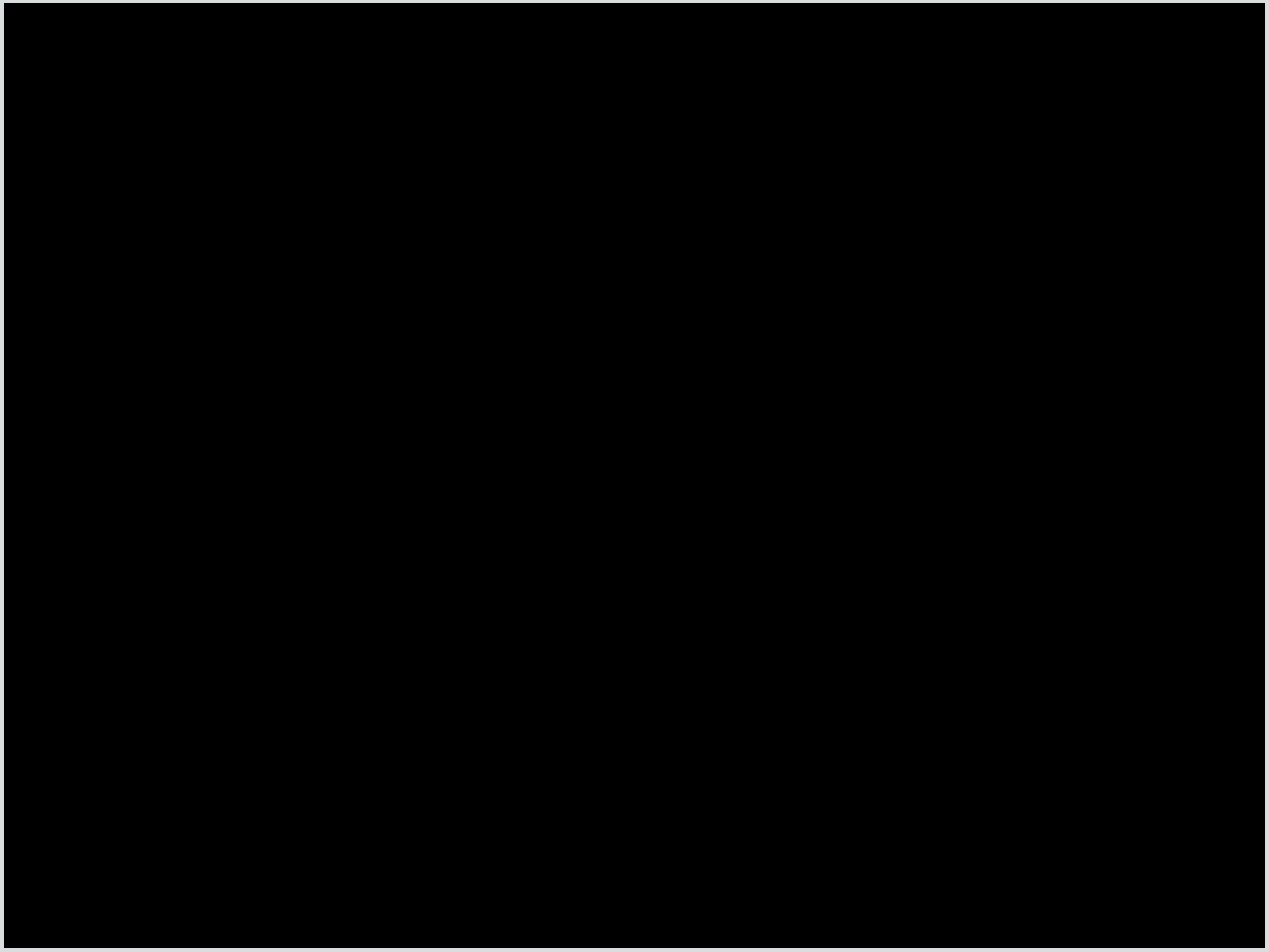
K°BLOC – STD PLATES MATERIAL

DIN	AISI	TRADE NAME
1.4306	AISI 304L	
1.4404	**AISI 316L**	
1.4547	**AISI S31254**	**SMO 254**
1.4539	AISI 904L	
2.4068	AISI N02201	Nickel 201
2.4602	AISI N06022	Alloy C22
2.4675	AISI N06200	Alloy C2000
2.4819	**AISI N10276**	**Alloy C276**
3.7025	**AISI B265 Gr1**	**Titan Gr.1**

REFINERY IN USA

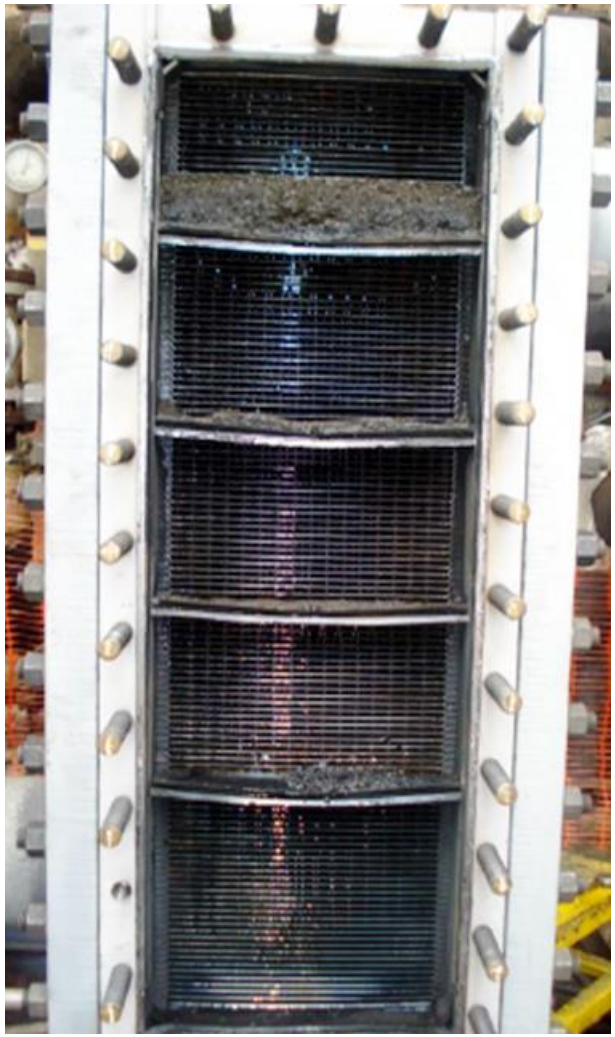
- Refinery in USA
- 3 units BT50-250
- with AISI304L plates
- Lean-rich
  Amine Exchanger
- Design P: 13.8 barg
  (200 PSIG)
- Design T: 177°C
  (350°F)

HYDROBLASTING K°BLOC



ULTRASONIC BATH CLEANING

- Tank filled with cleaning/degreasing solution (typically aqueous based)
- Transducers create ‘ultrasonic waves’ in the liquid medium (20 – 50 KHz)
- Cavitation ‘bubbles’
- Cleaning occurs due to two separate actions:
  - Dissolution of the contaminant in the solution through the continuous removal of any saturated solvent layer
  - Displacement and removal of loosely held contaminants
- Equipment is removed and rinsed to remove any loose residue and cleaning agent



SPARING PHILOSOPHY – PUTTING SPARE UNIT ONLINE

EXAMPLE: INSTALLATION OF 3 x 50% (2 ONLINE, 1 SPARE)

- Because of fouling performance decreases.
- Operation decides to put 3rd unit online. What happens?

UA FACTOR

- OHTC goes down, Reynolds decreases with factor 2/3 and film coefficient decreases roughly with factor (2/3)^0.7 = 0.75
- Area increases factor 3/2.
- U*A is increased with 3/2 * 0.75 = 1.125, or an improvement of 12.5%

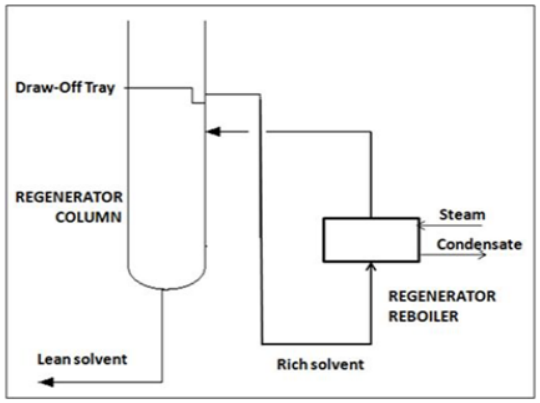
SHEAR STRESS

Assuming turbulent flow, the pressure drop goes down with a factor (2/3)^2 = 0.44 and therefore also your shear stress goes down with factor 0.44

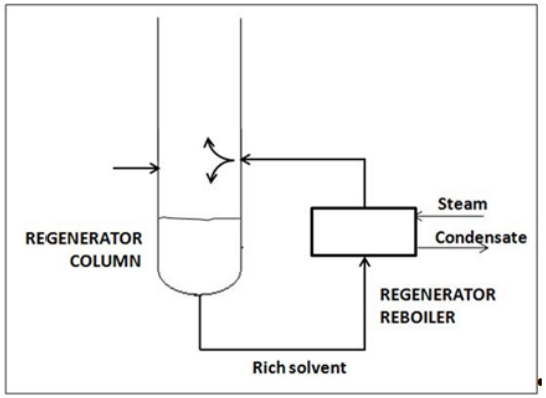
RESULT: **increased fouling rate ▶ soon performance will be even worse**

WPBHE AS AMINE REBOILER

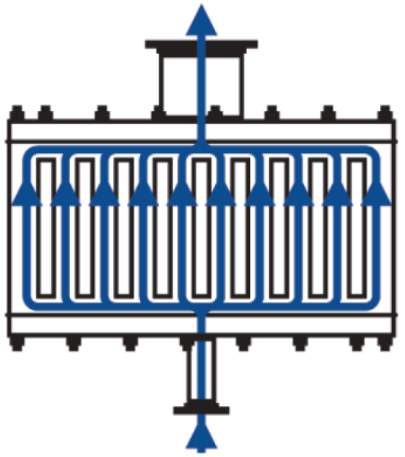
- Block placed horizontally
- Channels vertical
- Thermosyphon principle
- Minimum turndown ~ 50%



Once-through type reboiler

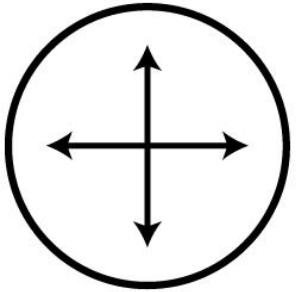


Recirculating type reboiler



ADVANTAGES WPBHE AMINE REBOILER

- Smaller footprint



- Smaller holdup volume leading to:
  - Lower operating weight than S&THE
  - Lower amine inventory
  - Shorter residence time, hence less amine degradation

- Lower weight than S&THE and therefore easier handling in maintenance activities

- Lower CAPEX than S&THE (~ 50%)

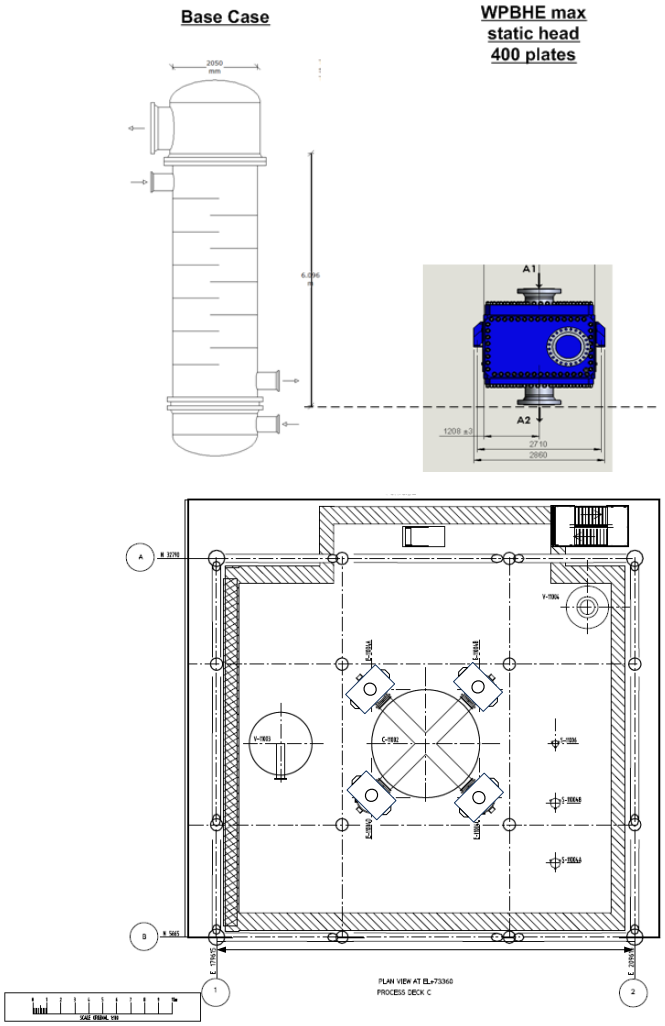
WPBHE REBOILER – SOME GUIDELINES

- **WPBHE** can work on higher vapor quality than S&THE –
  up to 15% (w/w) outlet quality is very feasible
- Make sure vendor provides sufficient review data
  - Pressure drop breakdown
  - Amine recirculation rate
  - Area
  - Plate grouping
  - etc.
- Asses all design cases and simulate these in their process-controlled condition
  - What is the steam pressure in min. turndown and clean condition?
  - What are the thermosiphon flow regimes in this condition?
- Combination of steam pressure and steam level control is advised

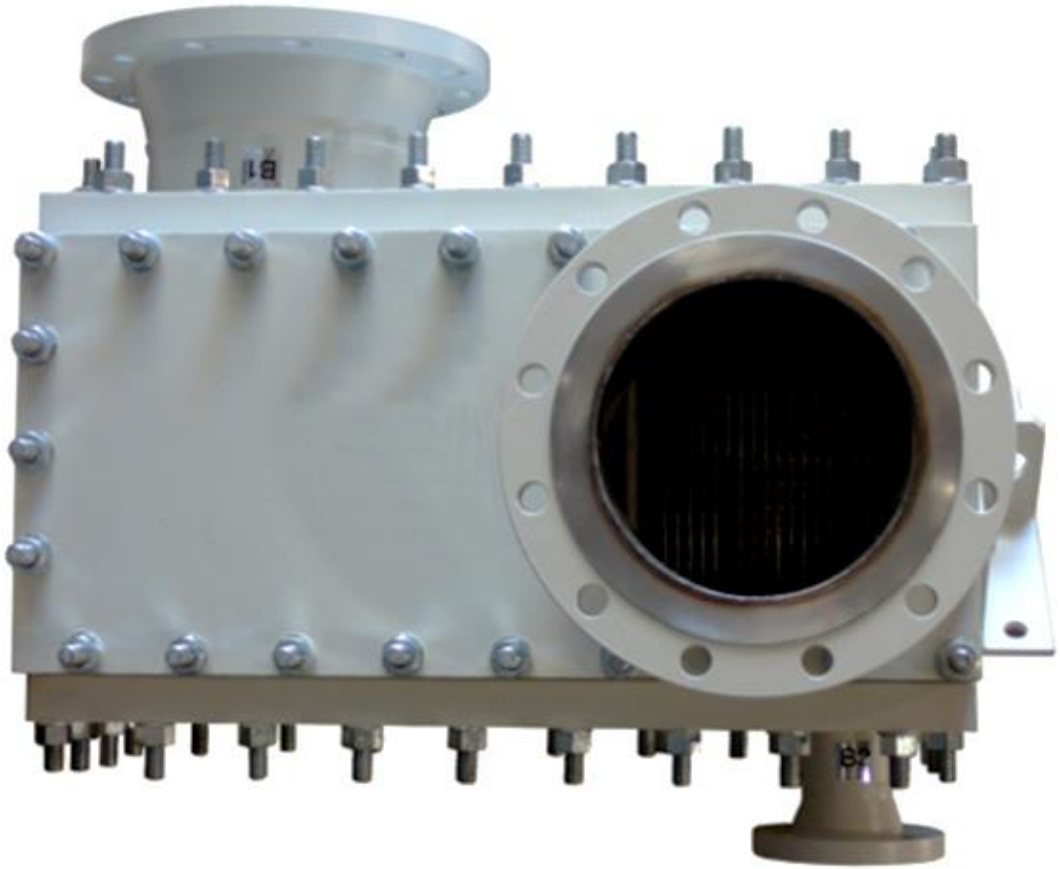
BUSINESS CASE FOR FLOATING APPLICATION

INFLUENCE ON TOPSIDES MODULE WHEN REPLACING S&THE BY A WPBHE REBOILER
(Unfortunately capacity data cannot be shared)

	BENEFITS
Weight	~50 % reduction in equipment wt. vs S&T. Total module wt. savings of 250 tons
CAPEX	~50% reduction (FOB). Savings of ~$7M module cost (EDM 2014)
Installed vol. size	~30% reduction
O&M	Increased options for equipment lifting e.g.: • Lifting options include blue sky access & lifting by means of pedestal crane (current) • Move with local beams over the deck towards the 'maintenance ally'
Performance	Lower likelihood of fouling due to less residence time and hence solvent degradation and higher velocities.



REFINERY IN BULGARIA



- Installed beginning 2015
- BT-75-150H
- Heat transfer area of **126,5 m2**
- Plate material **316L.**
- Capacity is **7.04 MW**
- Overall heat transfer coefficient is **2449 W/m2.K**

INITIAL PROCESS DESIGN – KEY VALUES

- Typical Heat Transfer Coefficients for WPBHE

Service	OHTC (W/m2.K)
Lean / Rich Amine Exchanger	2000
Lean Amine Cooler	1200
Condenser	1500
Reboiler	2000

- CAPEX of WPBHE approx. factor 3-4 of P&FHE
- Maximum heat transfer area WPBHE 860 m2 per unit
- L/R Exchanger dP 3 bar for reaching 75 Pa shear stress
- Min temp. approach 10 °C
- Reboiler – define max. skin temperature solvent degradation

TOPICS FOR INTERNATIONAL STANDARDS

- Maximum temperature difference process steams (100 C°)
- Temperature changes max. 60 °C per hour
- Maximum velocity head
- Fouling margin guidelines
- Shear stress guidelines
- Welding requirements
- Nozzle load requirements
- Testing and inspection requirements

TO SUMMARIZE...

Operating sites have experienced leakages with Plate & Frame Heat Exchangers

Welded Plate-Block Heat Exchangers (WPBHE) are a more robust, gasket-free alternative

Number of references is growing

Best practices for cleaning WPBHE exists

International standards are being developed (API 810)

There is a business case for WPBHE as Amine Reboiler

CONTACT SLIDE

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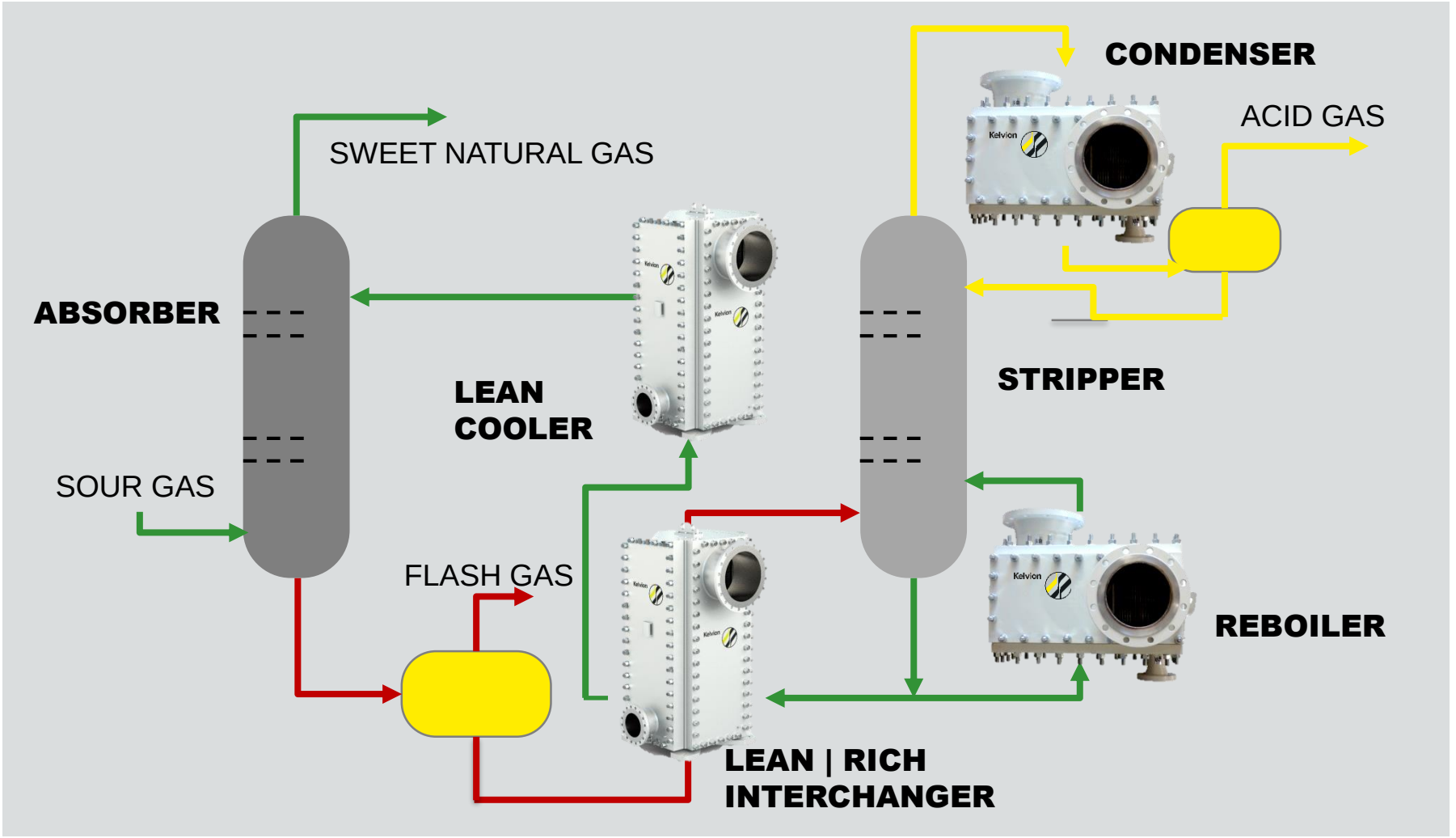

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