SAFEHR®
HEAT RECOVERY TECHNOLOGY
MUTUALLY INCREASING SAFETY AND HEAT RECOVERY
IN SULFURIC ACID PLANTS
UPDATE
PRESENTED AT THE
COBRAS – CONGRESSO BRASILEIRO DE ÁCIDO SULFÚRICO
FOZ DO IGUAÇÚ - BRASIL
OCTOBER 17TH , 2019
Clark
solutions

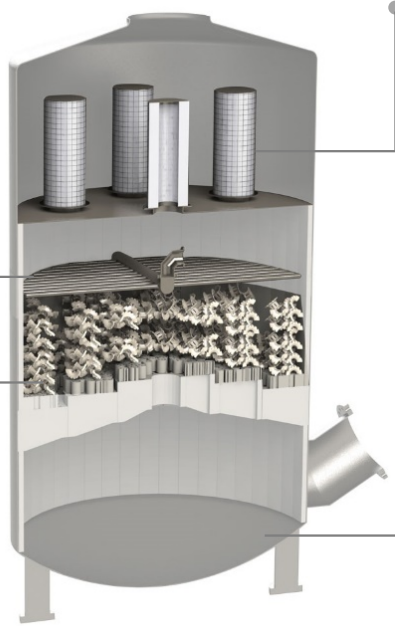
MANUFACTURING
SOME PRODUCTS

Liquid distributors

MaxiFlow®

Random Packing

MaxiSaddle® BPC



Mist Eliminators

FiberBed®

MaxiMesh®

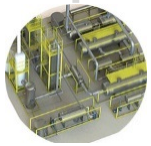
CSX™

High Silicon Sulfuric Acid Stainless Steel

ALWAYS INNOVATING

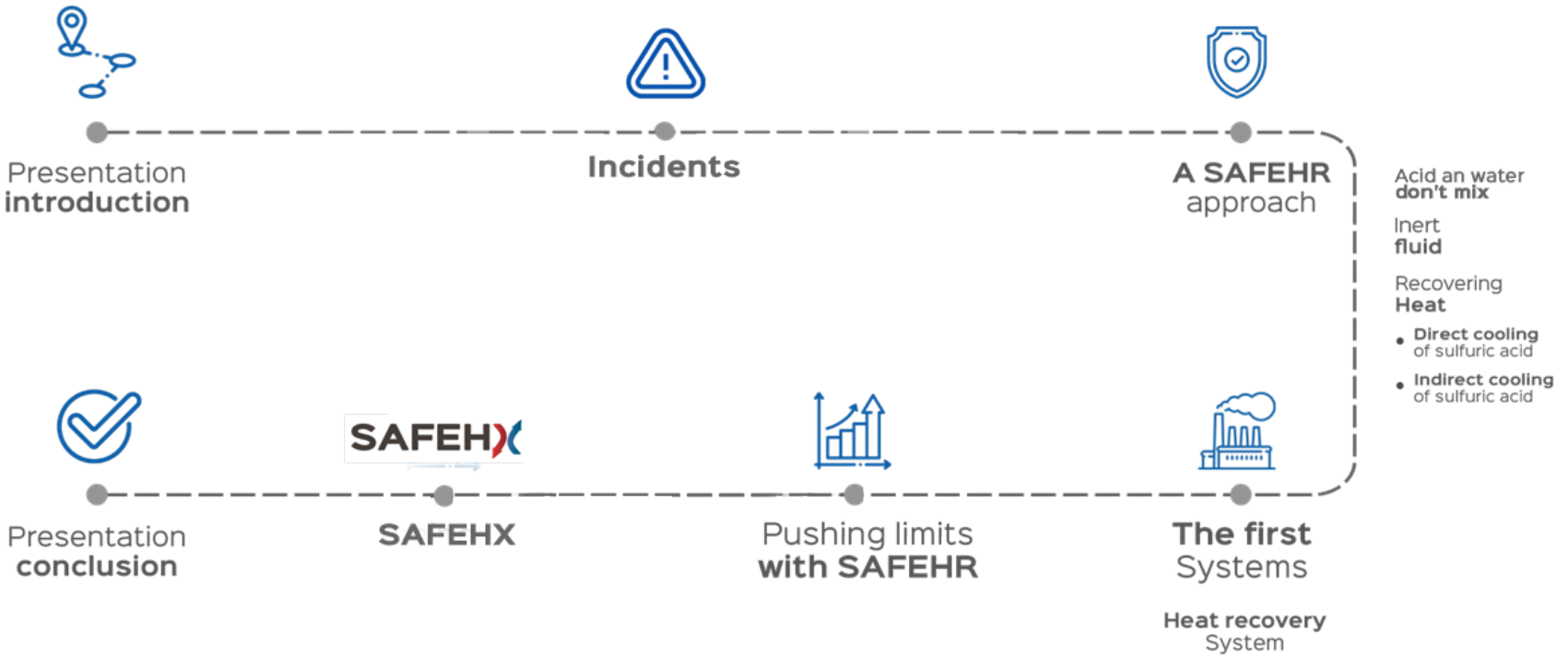
SAFEHR HEAT RECOVERY TECHNOLOGY

Dry Seal Device



Modular Plants **Sulfuric Acid**

SUMMARY


Presentation
introduction
Incidents
A SAFEHR
approach
Acid an water
don't mix
Inert
fluid
Recovering
Heat
Direct cooling
of sulfuric acid
Indirect cooling
of sulfuric acid
Presentation
conclusion
SAFEHX
SAFEHX
Pushing limits
with SAFEHR
The first
Systems
Heat recovery
System

SUMMARY

Presentation
introduction

THE CHALLENGE

NORMAL OPERATION

LEAK SITUATION

Leaks eventually happen.

Auto-catalytic effect

Once a leak starts, acid and water start mixing, dilution and heating take place, acceleration the corrosion and leakage

Hydrogen Release

Metal corrosion releases hydrogen. The longer the leak is undetected, the more hydrogen is released.

Water Contamination

Cooling and BFW Water contamination add to costs and shut down period

Plant Shutdown

Depending on seriousness, plant can be down for days or weeks. Besides production loss, major equipment may need repairs.

SUMMARY

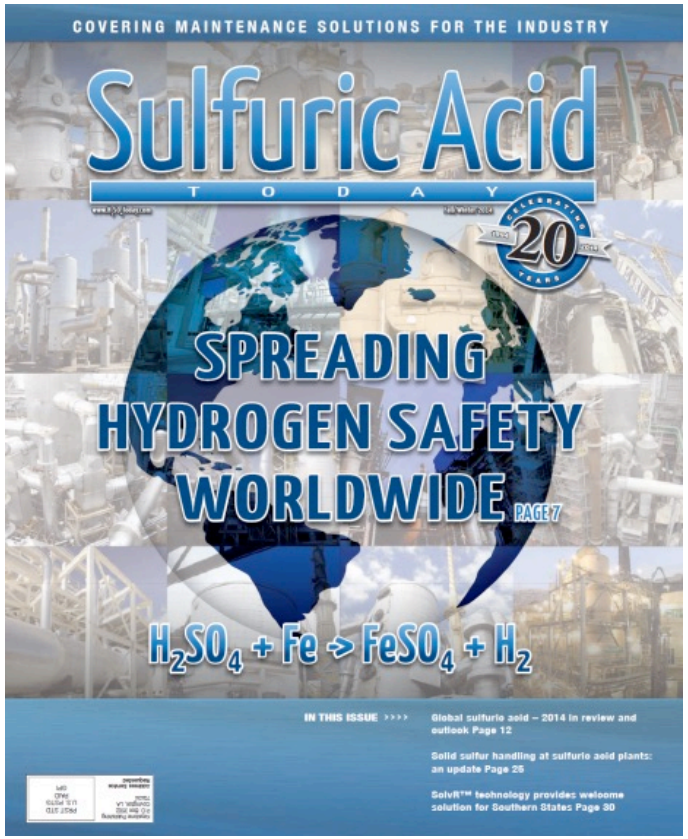
Presentation
introduction

SUMMARY

Incidents

HYDROGEN SAFETY

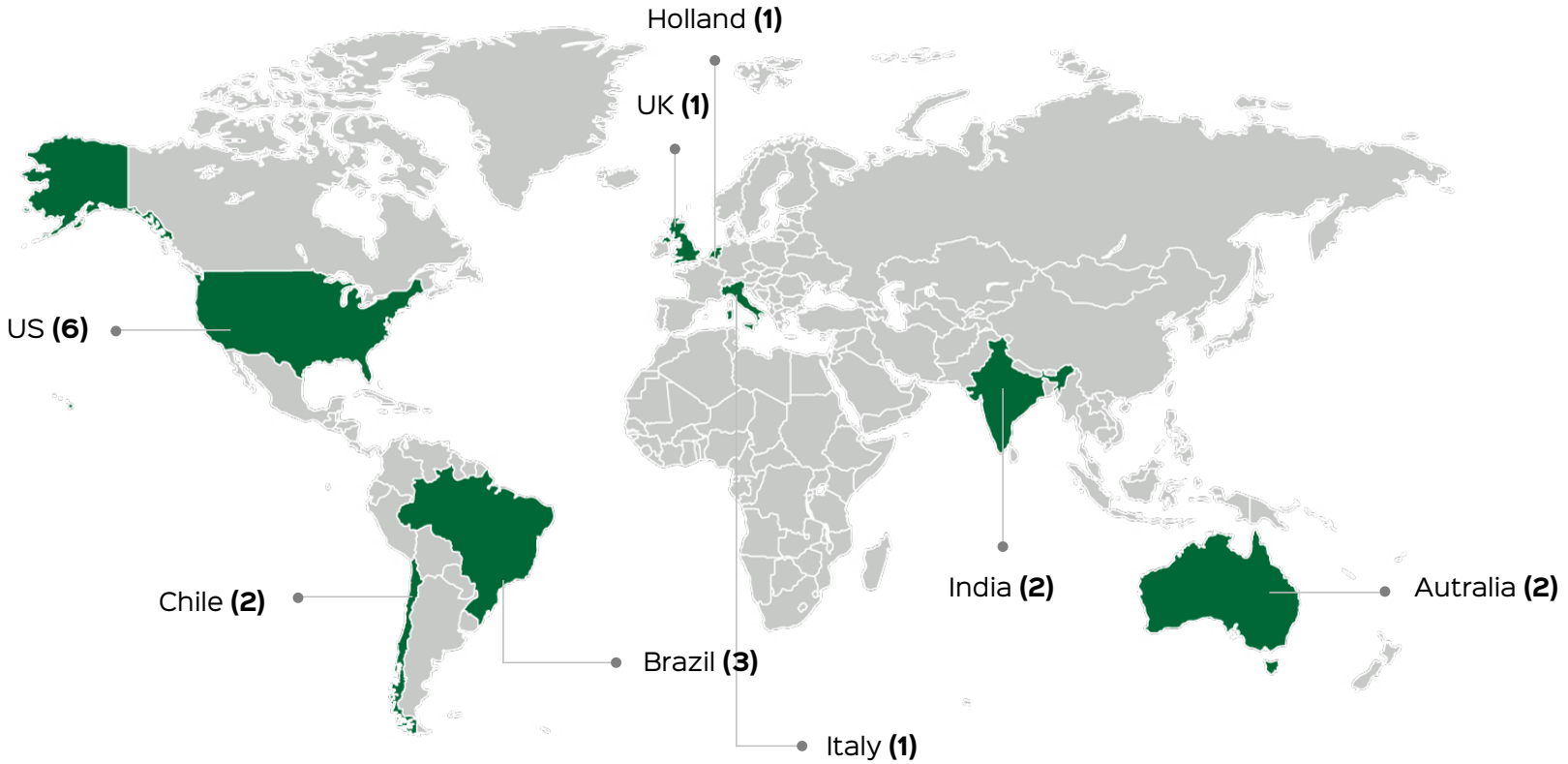
Hydrogen Safety is a major concern in the modern sulfuric acid industry



** Courtesy Sulfuric Acid Today, Kathy Hayward*

HYDROGEN SAFETY

Some reported hydrogen incidents with collateral damages...



Data as of 2015

HYDROGEN SAFETY

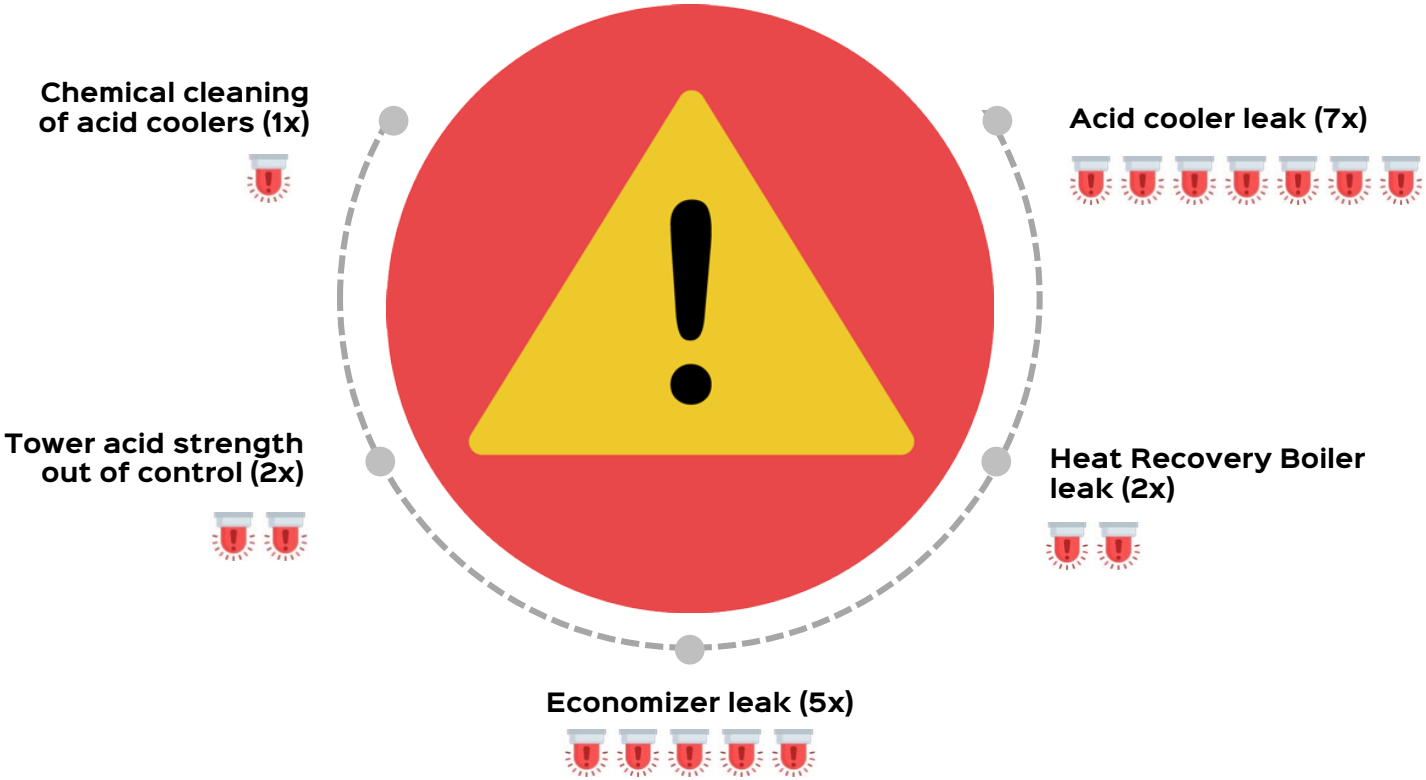
2014
USA

InterPass Absorption Tower
Hydrogen Incident

** Source: Sulfur Conference 2011/2014 – Hydrogen Safety in the Sulfuric Acid Industry*

MAJOR HYDROGEN INCIDENTS CAUSES

CAUSES
MAJOR HYDROGEN INCIDENTS



SUMMARY

Incidents

SUMMARY

A SAFEHR approach

Acid an water **don't mix**

Inert **fluid**

Recovering **Heat**

- **Direct cooling** of sulfuric acid
- **Indirect cooling** of sulfuric acid

INDIRECT COOLING OF SULFURIC ACID
BASIC ARRANGEMENT

WHAT HAPPENS ON
A FAILURE SITUATION?

EXPANSION VESSEL

ACID-FLUID HEAT EXCHANGER

LIQUID-LIQUID COALESCER

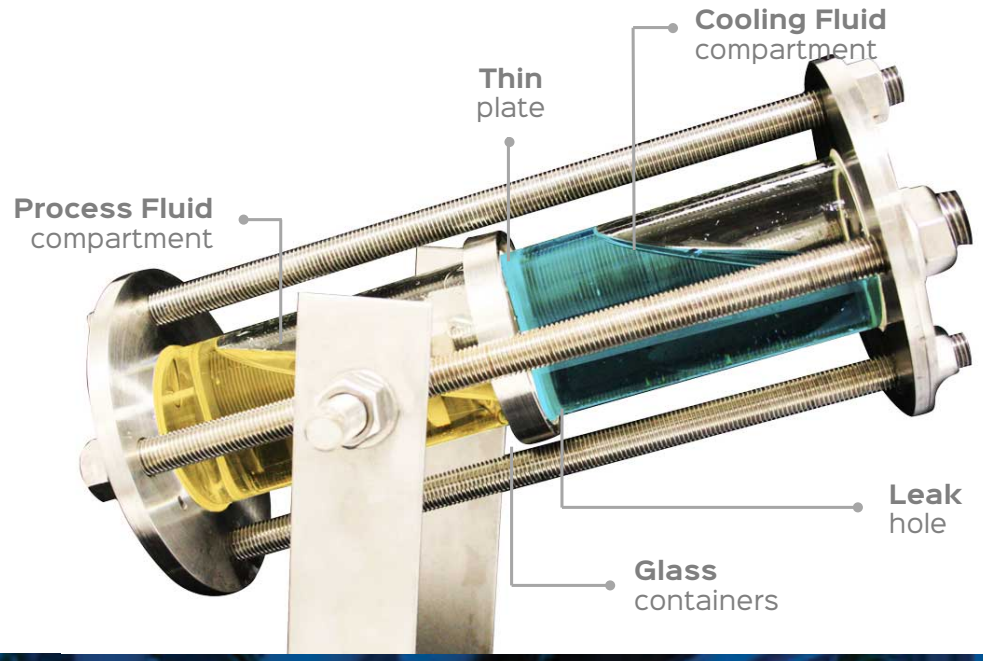
INERT FLUID PUMP

WATER-FLUID HEAT EXCHANGER

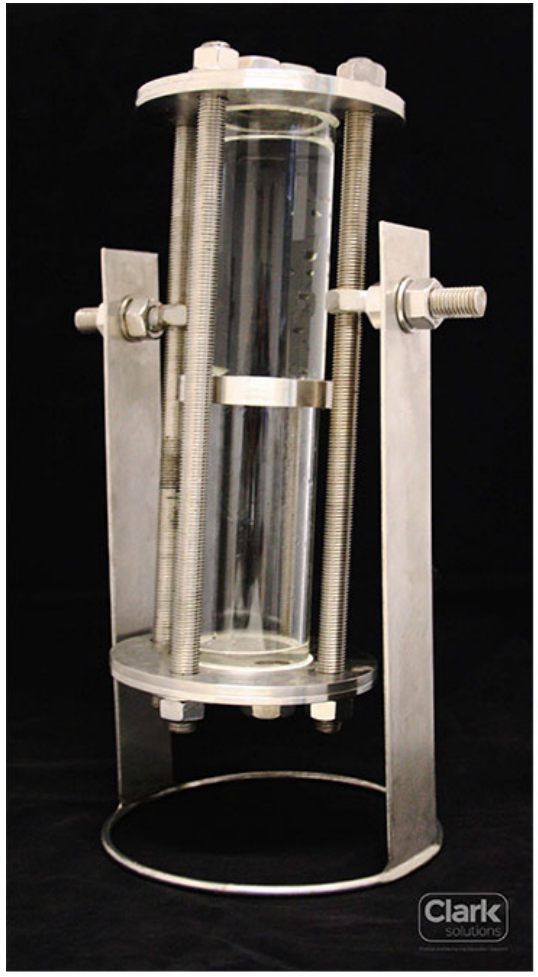
INDIRECT COOLING OF SULFURIC ACID
FAILURE SITUATION

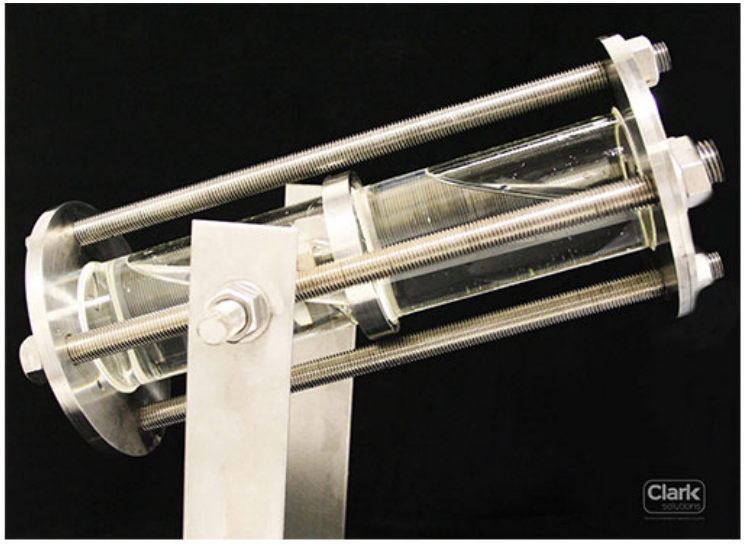
Device to measure corrosion rate at dynamic conditions.

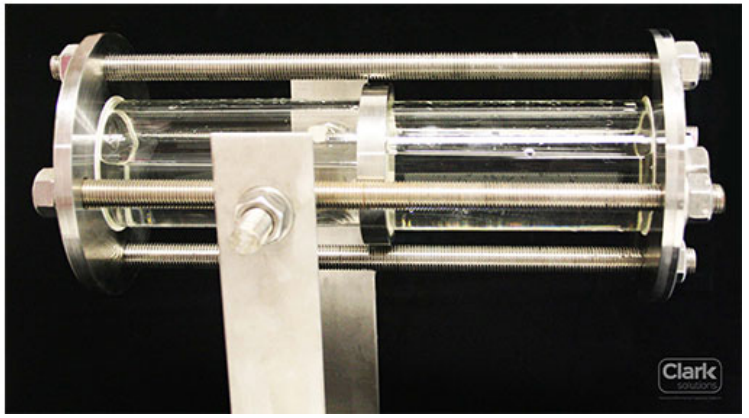
How to measure the corrosion rate at the dynamic leak area?



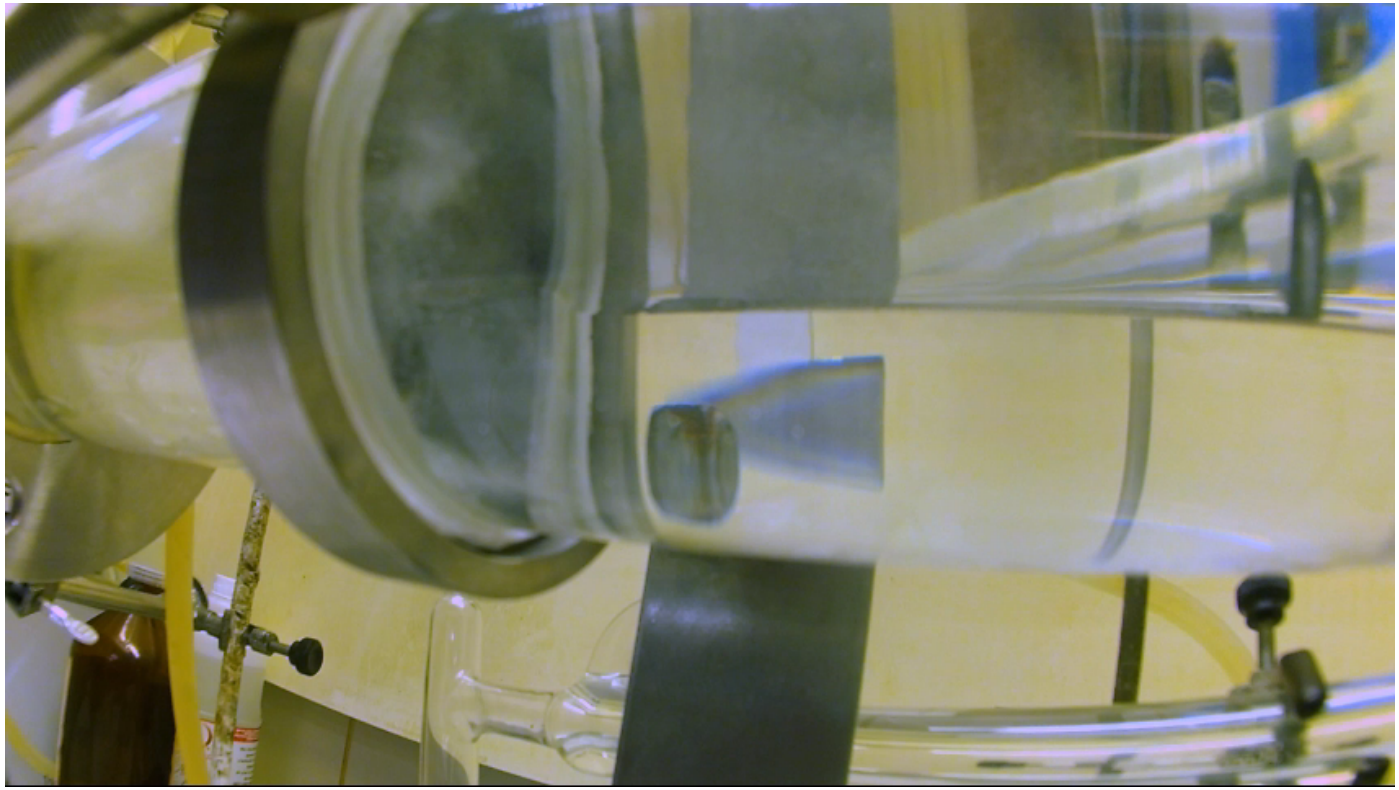
INDIRECT COOLING OF SULFURIC ACID







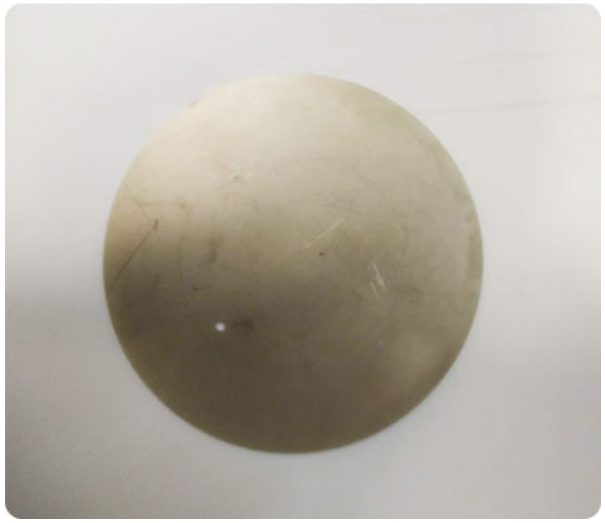
INDIRECT COOLING OF SULFURIC ACID



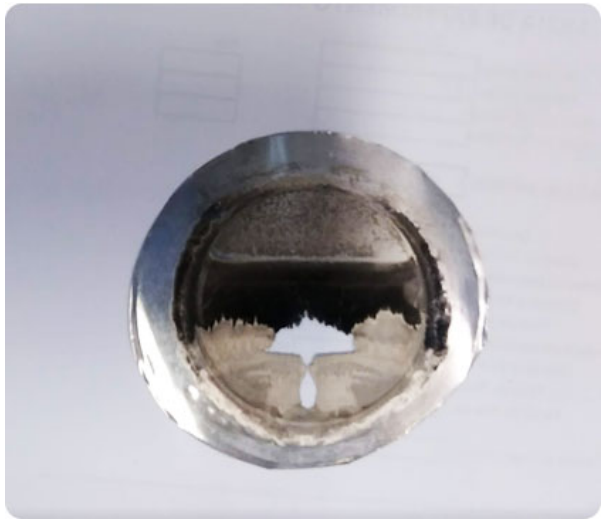
INDIRECT COOLING OF SULFURIC ACID

INDIRECT COOLING OF SULFURIC ACID

SS 316L



Time:
0 min

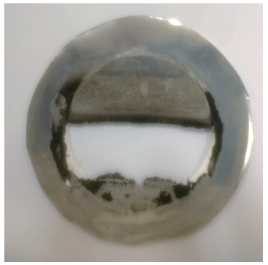


Time:
40 min

Time:
120 min

INDIRECT COOLING OF SULFURIC ACID

Table 1
Sulfuric Acid Corrosion Progression on Leaking Hole
(tests realized at ambient temperatures)

Fluid Pair	Conditions	Results	Images
Water 98% Sulfuric Acid	2mm hole 120 min test Start at ambient temperature Peak temperature 66 °C 316L Stainless steel	Corrosion rate >145 mm/year	

SUMMARY

A SAFEHR approach

Acid an water **don't mix**

Inert **fluid**

Recovering **Heat**

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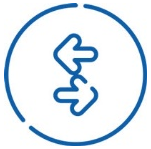
INERT FLUID

SAFEHR® INERT FLUID FAMILY
CHARACTERISTICS

Inert to acid and water



Good heat transfer properties

Non-Toxic

Stability

Low Vapor Pressures

Substantial density difference between fluid and water/acid

Non-flammable

Safe to handle

SAFEHR® INERT FLUID FAMILY
“D” FAMILY ACID/WATER IMMISCIBILITY

Sulfuric acid +
Inert fluid

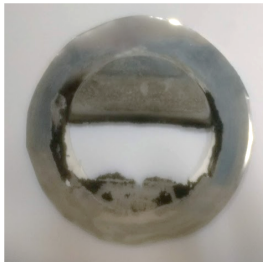
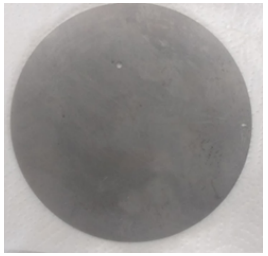
Inert fluid
+ Water

Sulfuric acid +
Inert fluid + Water

SAFEHR® INERT FLUID FAMILY
“D” FAMILY SAFETY, FLAMABILITY, TOXICITY

INDIRECT COOLING OF SULFURIC ACID

Table 2
Sulfuric Acid Corrosion Progression on Leaking Hole
(tests realized at ambient temperatures)

Fluid Pair	Conditions	Results	Images
Water 98% Sulfuric Acid	2mm hole Start at ambient temperature Peak temperature 66 °C 316L Stainless steel	Corrosion rate >145 mm/year	
D-20 Inert Fluid 98% Sulfuric Acid	2mm hole 72 hours test duration Start at ambient temperature 316L Stainless steel	Corrosion rate: nil Mass lost: nil	

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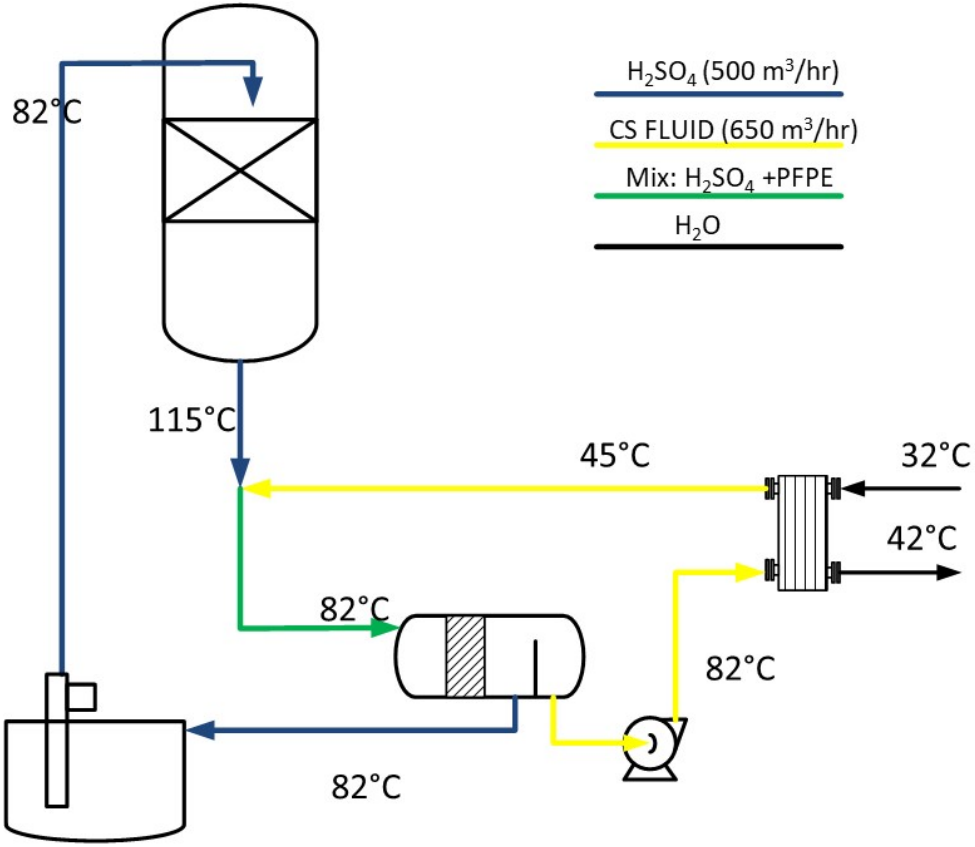
DIRECT COOLING OF SULFURIC ACID
2013 PATENT



DIRECT COOLING OF SULFURIC ACID
2013 PATENT DRAWBACKS

TECHNOLOGY FOUND FEASIBLE BUT:

AVERAGE FLUID TEMPERATURE

- *Increases heat transfer equipment size*
- *Reduces heat recovery possibility*

BUILD UP OF FLUID IN ACID SIDE

- *Coalescer efficiency*

LARGE VOLUME OF FLUID

- *Large equipment and vessels*

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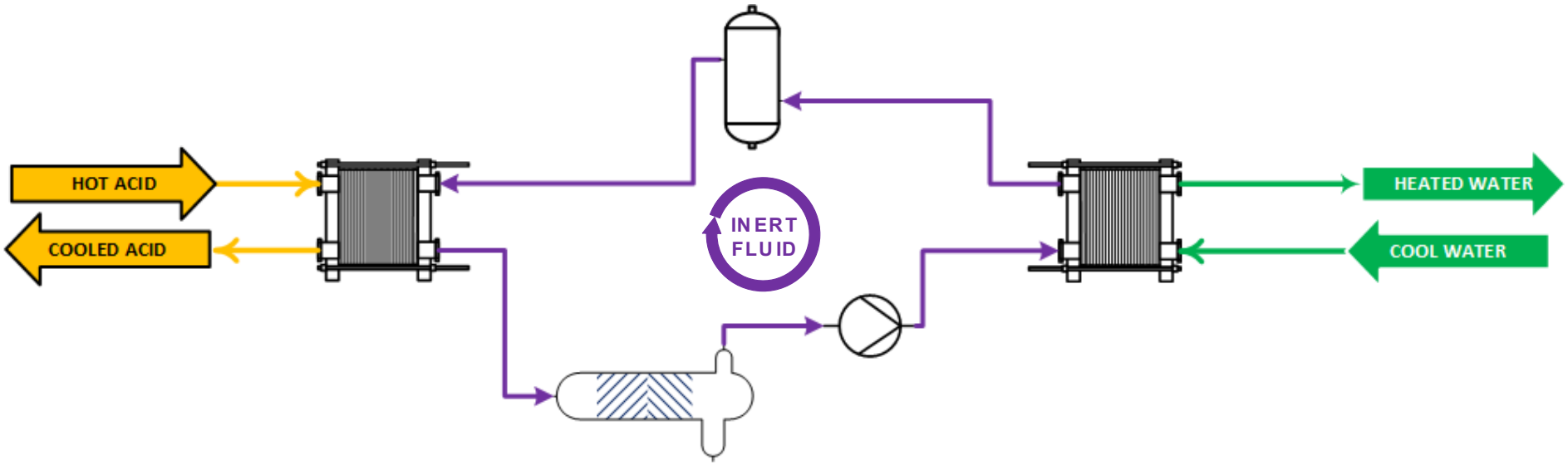
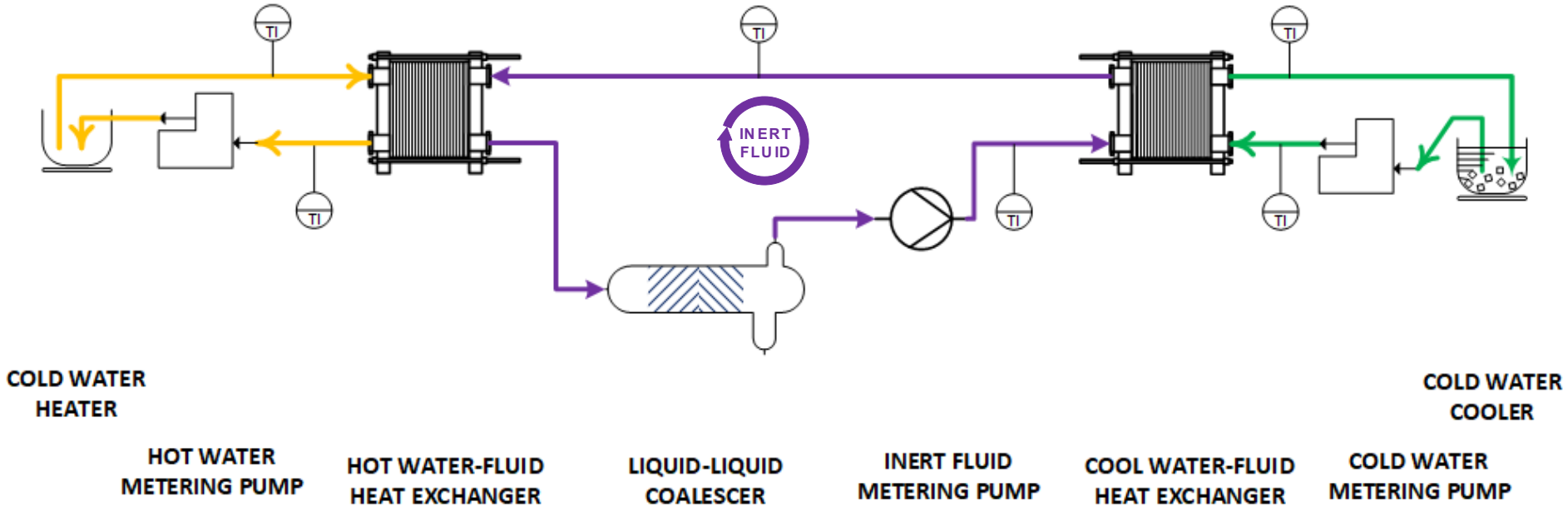
BASIC ARRANGMENT



**These and next numbers based on approximate to 1000 MTPD Acid Plant*

INDIRECT COOLING OF SULFURIC ACID
SETUP FOR HTC (U) ESTIMATION



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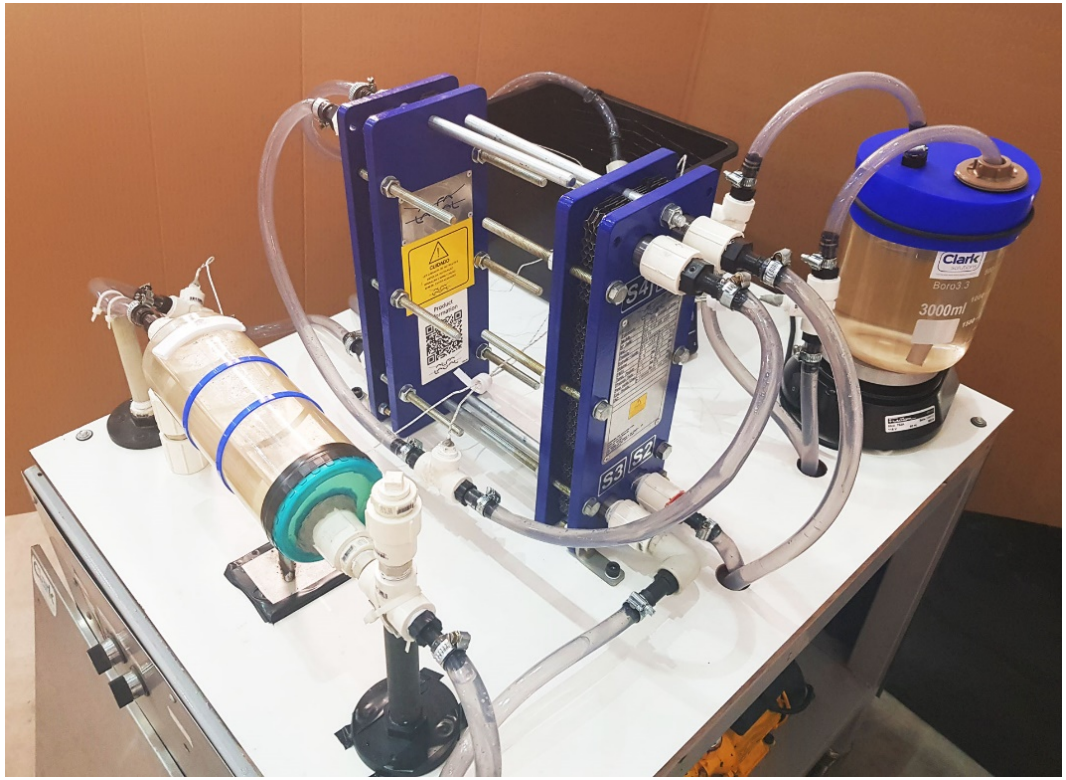


SAFEHR® APPROACH
APPLICATION AREAS

SAFEHR
HEAT RECOVERY TECHNOLOGY

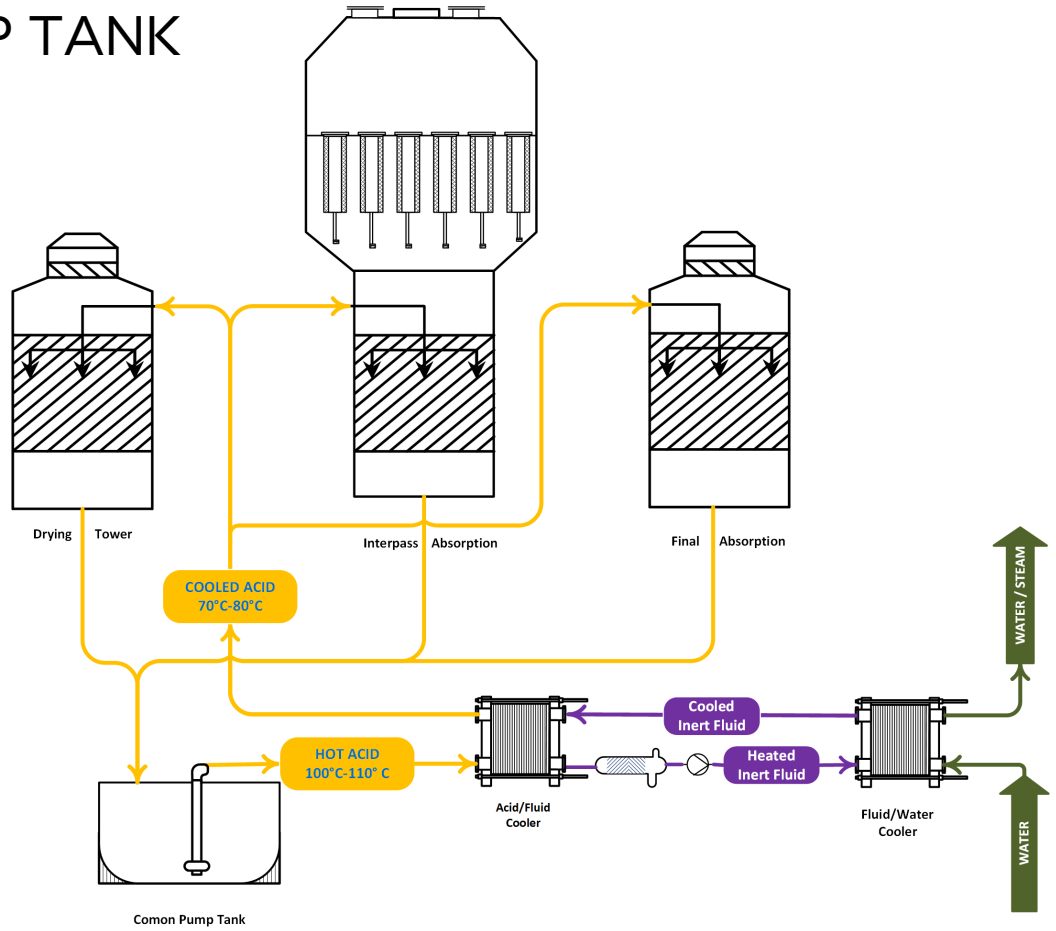
Increase Steam Generation

Reduce Safety Risks

RECOVERING HEAT OF HOT ACID

SAFEHR® APPROACH
COMMON PUMP TANK

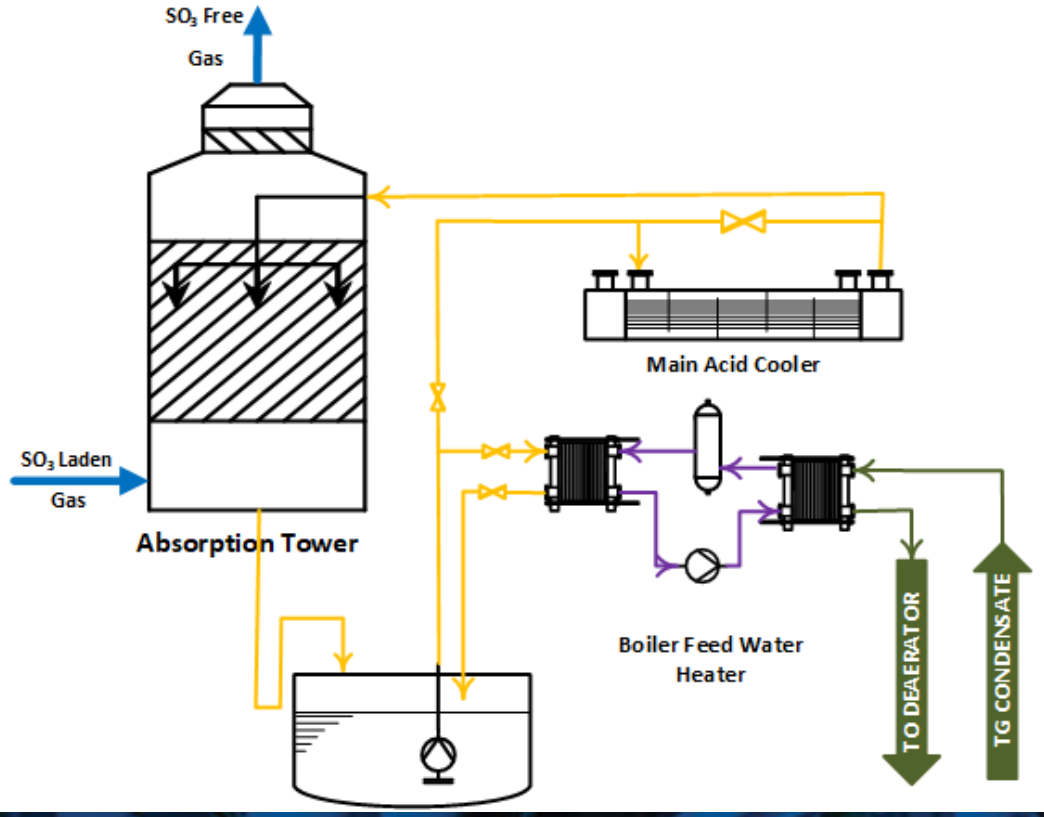
Commom pump tank



SAFEHR® APPROACH

BOILER FEED WATER HEATER

Safehr® can increase safety while maintaining/improving heat recovery.



SAFEHR® APPROACH
HEAT RECOVERY SYSTEMS

HEAT RECOVERY TOWER

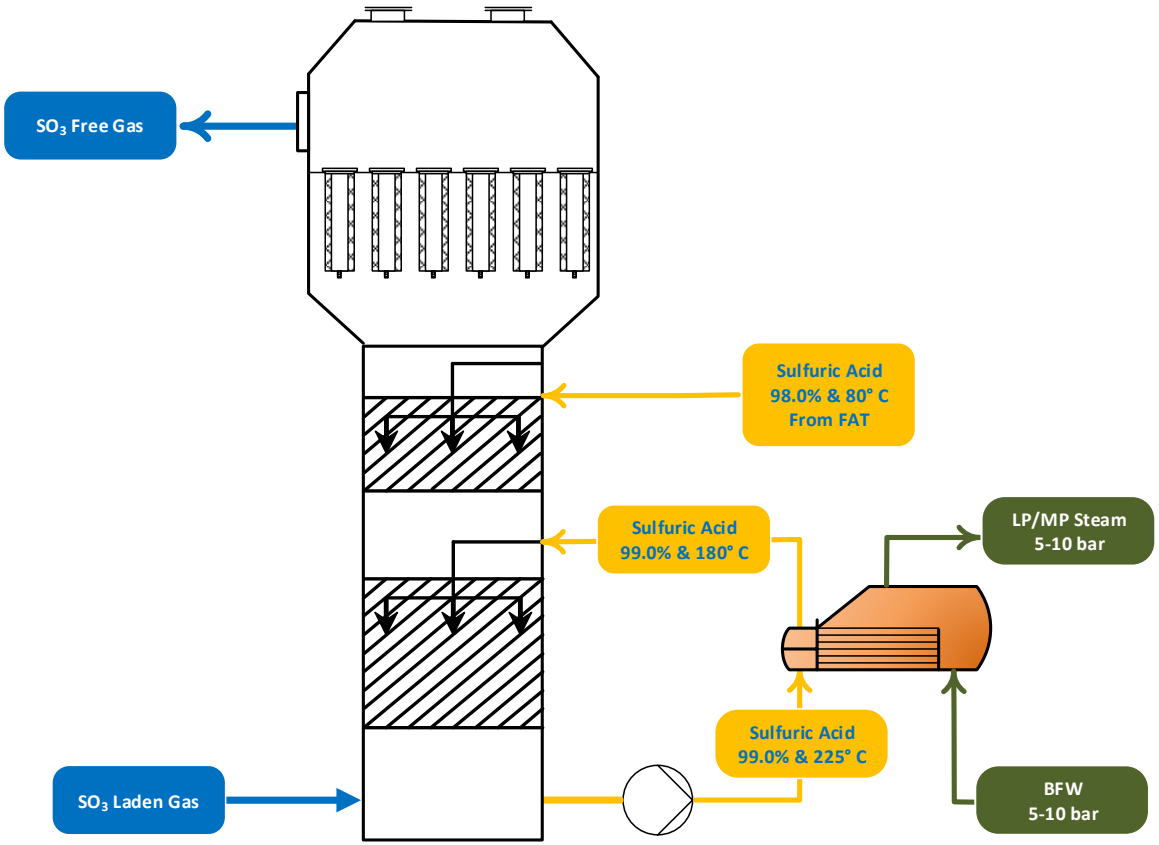
Double deck absorption tower.

Benefits

Heat Recovery≈ 50GJ/h
Cooling Water M/U Reduction≈ <90%

Risks

- Boiler Corrosion/Failure
- H_2 Generation/Explosion
- Site Shutdown
- Acid / Energy Production Loss
- Equipment damage



SAFEHR® APPROACH
HEAT RECOVERY SYSTEMS

VENTURI ABSORBER

Venturi absorber followed by conventional tower.

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Heat Recovery≈ 50GJ/h
Cooling Water M/U Reduction≈ <90%

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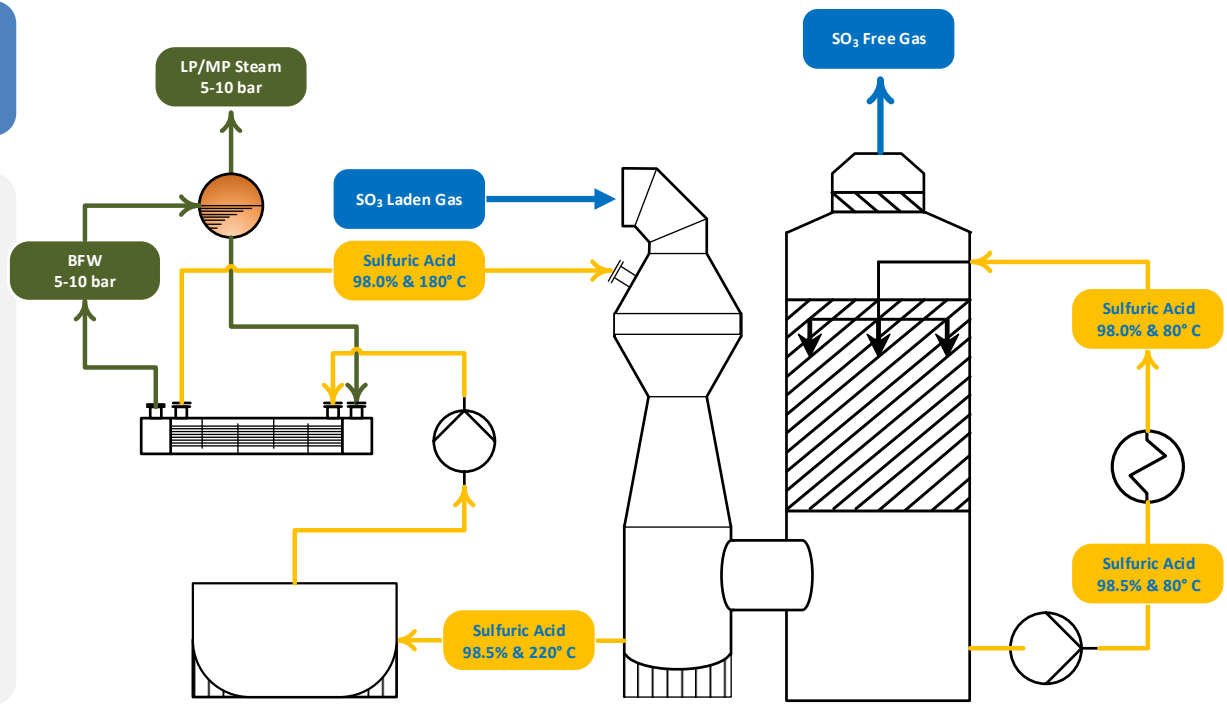
- Heat Exchanger Corrosion/Failure
- H_2 Generation/Explosion
- Energy Production Loss
- Equipment damage

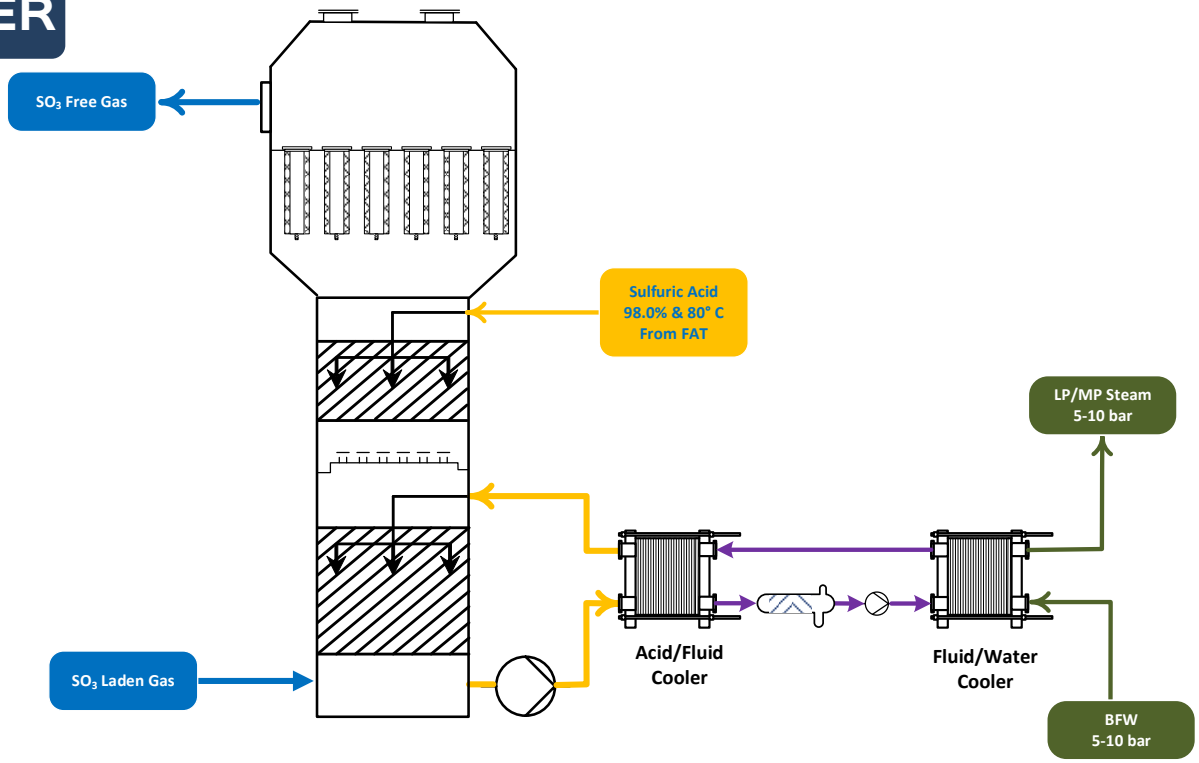


SAFEHR® APPROACH
HEAT RECOVERY SYSTEMS

SAFEHR can be used in replacement to a heat recovery boiler...to inscrease safety...

HEAT RECOVERY TOWER

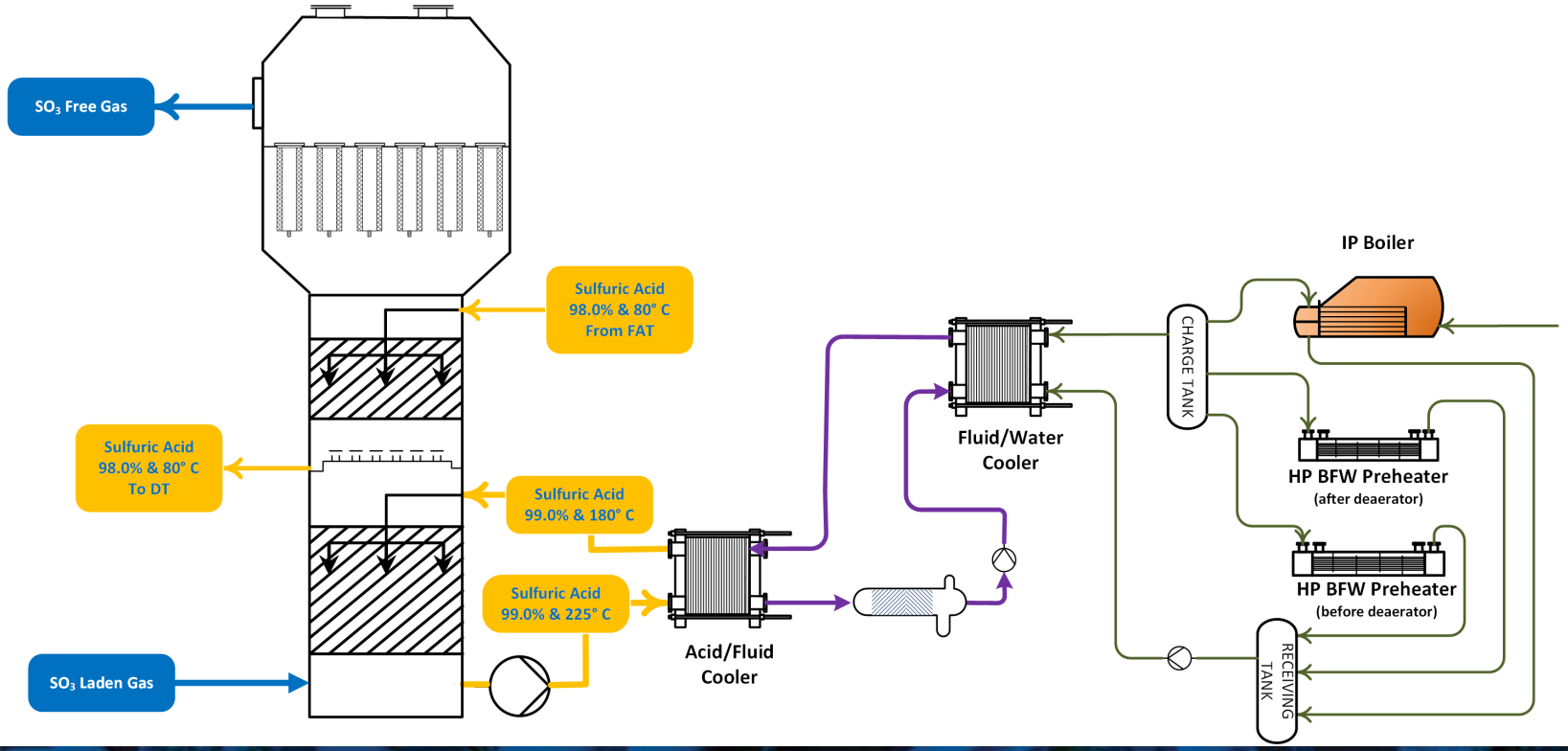
Safehr® eliminates acid/water
Pressure boiler



STANDARD SYSTEMS

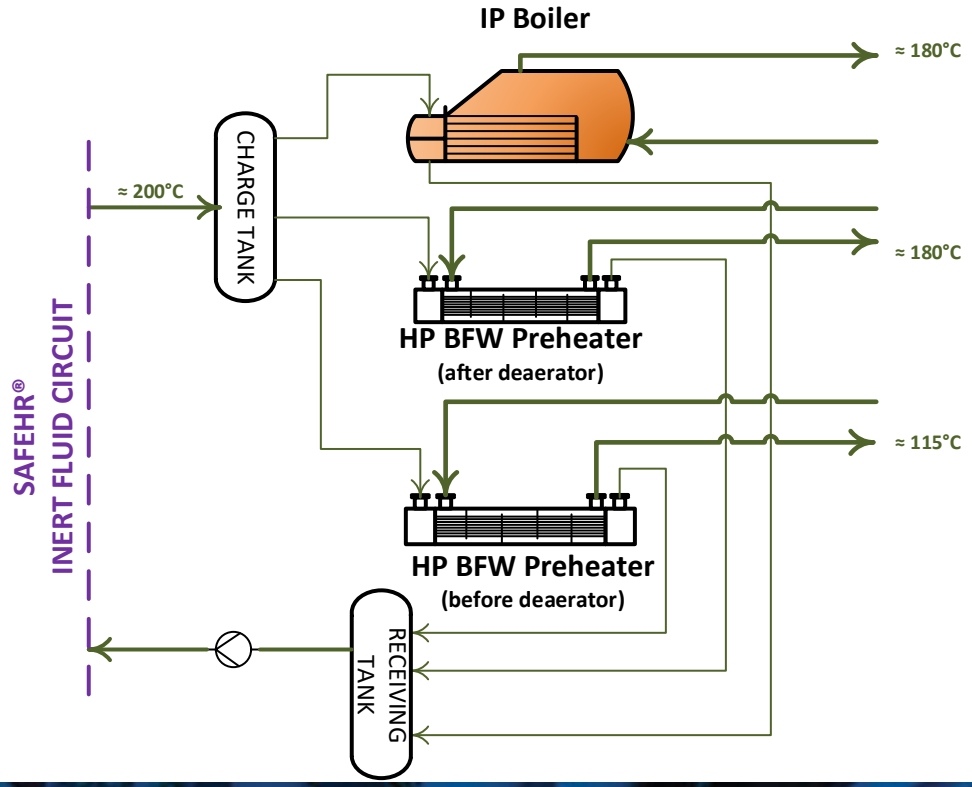
SAFEHR® APPROACH
HEAT RECOVERY SYSTEMS

With Safehr® boost in the heat recovery to LP/MP Steam and to HP steam!



SAFEHR® APPROACH
HEAT RECOVERY SYSTEMS

Up to 70% of Energy shifted to HP Steam...



SUMMARY

A SAFEHR approach

Acid an water **don't mix**

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- **Direct cooling** of sulfuric acid
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SUMMARY

of sulfuric acid

- **Indirect cooling** of sulfuric acid

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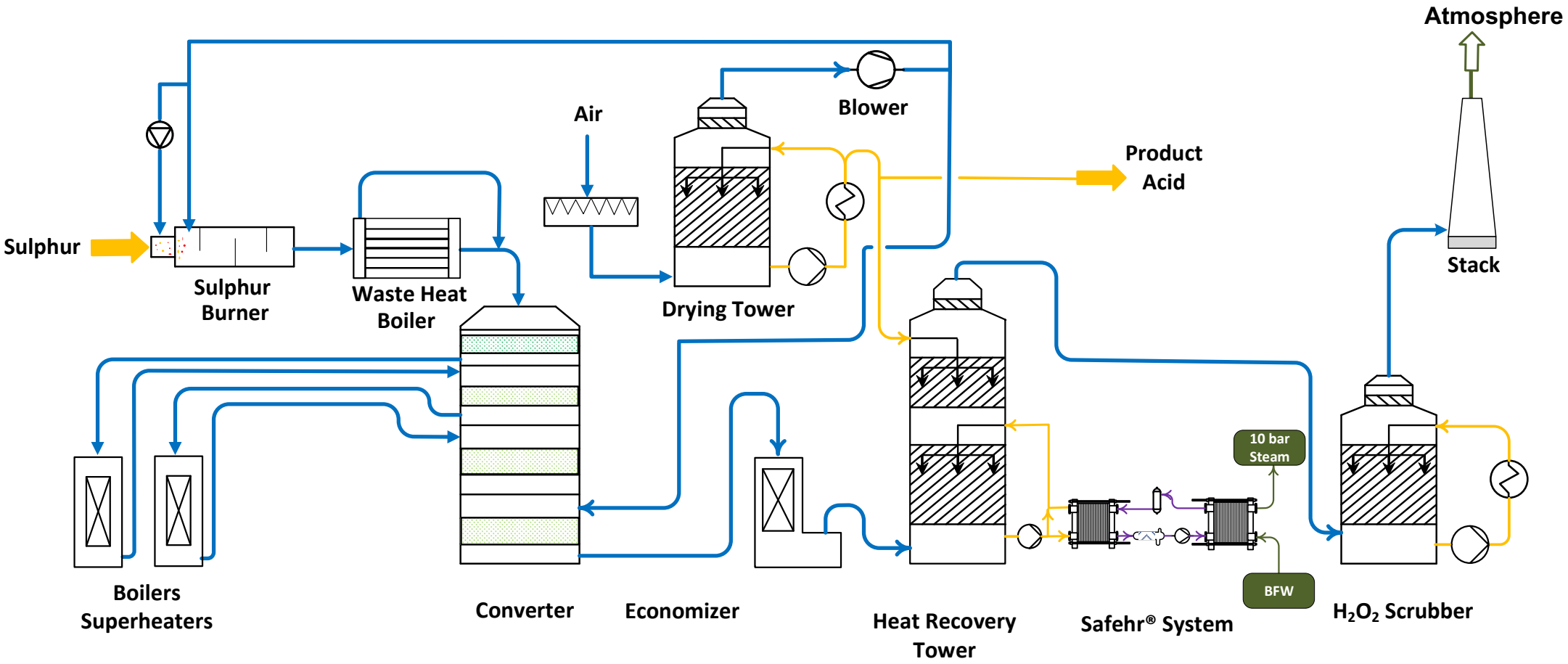
The first
Systems

Heat recovery
System

SAFEHR HEAT RECOVERY SYSTEM

Schematic diagram of first plant designed with SAFEHR Heat Recovery System...



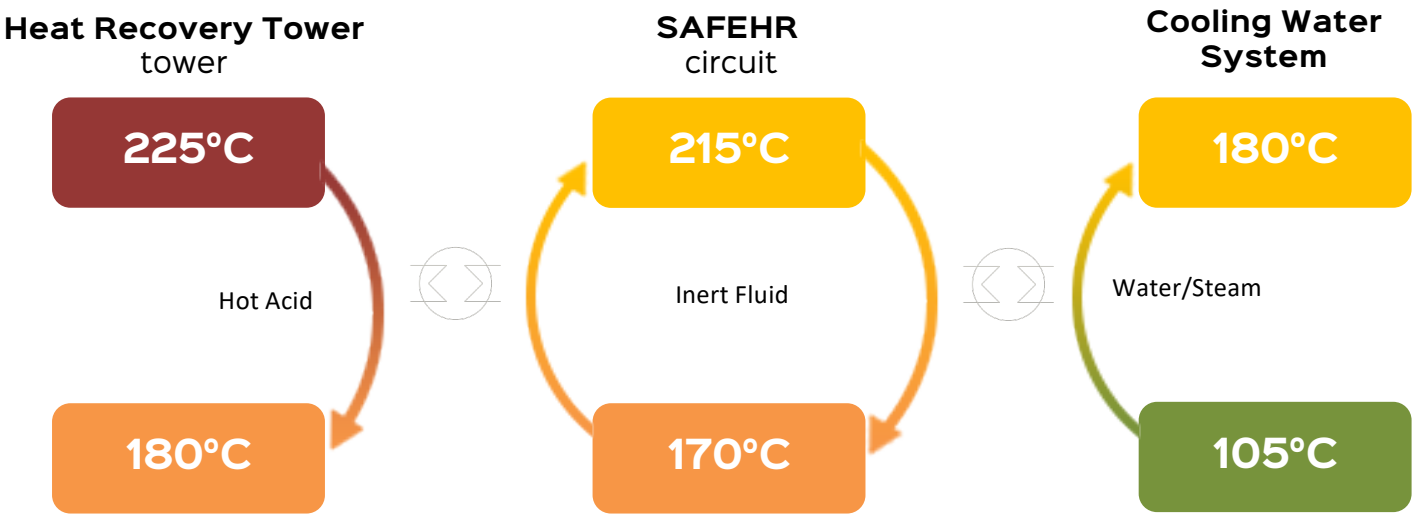
SAFEHR® HEAT RECOVERY SYSTEM

Heat Exchangers typical temperature approach for

SAFEHR®

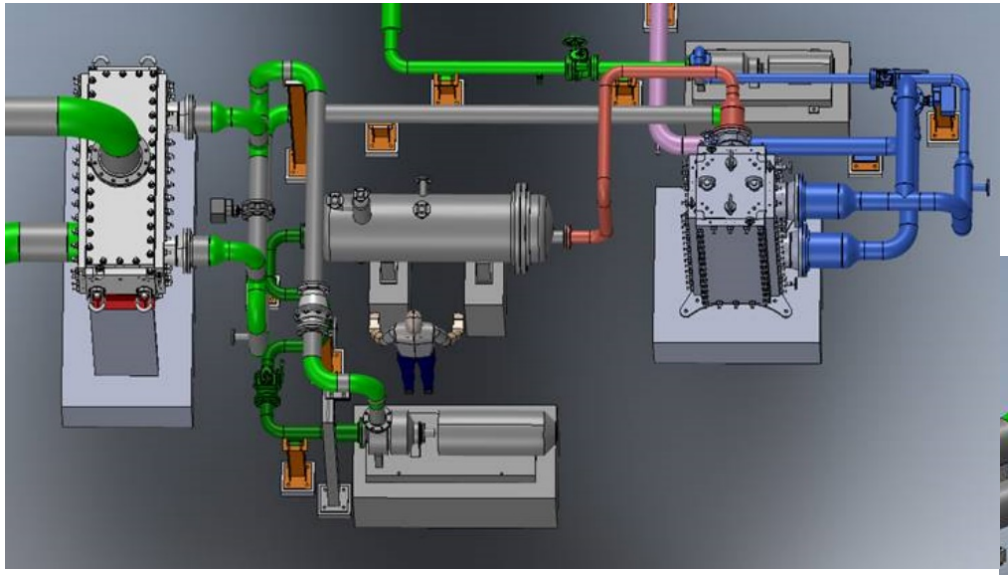
ON A

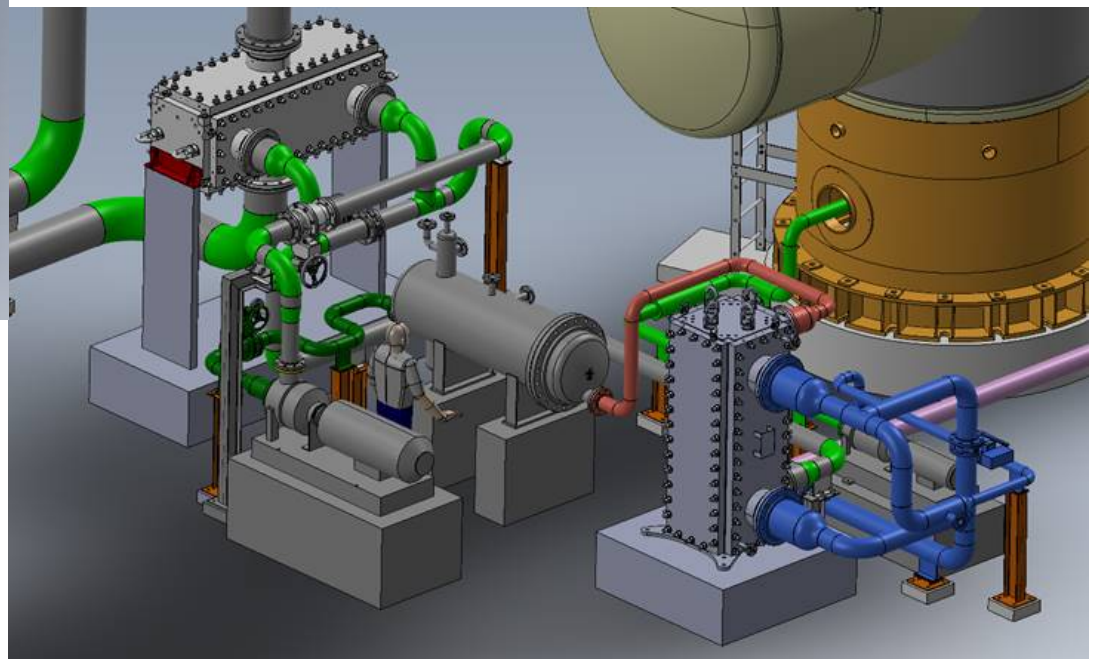
HEAT RECOVERY SYSTEM



Temperatures on a Heat Recovery application may vary according to steam pressure levels

SAFEHR® HEAT RECOVERY SYSTEM





3D of SAFEHR **Heat Recovery System**

THE FIRST PLANT

Round Production Numbers for 150 MTPD Capacity		
Consumption		
Sulphur (ton/day)	50	
Energy (kW)	450	
Dilution Water (m^3/h)	0.9	
Cooling water (m^3/h)	70	
Production		
Sulfuric Acid (ton/day)	150	
Steam Generation Ratio (ton/ton)	1.9-2.0	@ 10 bar

SUMMARY

of sulfuric acid

- **Indirect cooling** of sulfuric acid

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h SAFEHR

The first
Systems

Heat recovery
System

SUMMARY

AFEHX

SAFEHX

Pushing limits
with SAFEHR

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Heat rec
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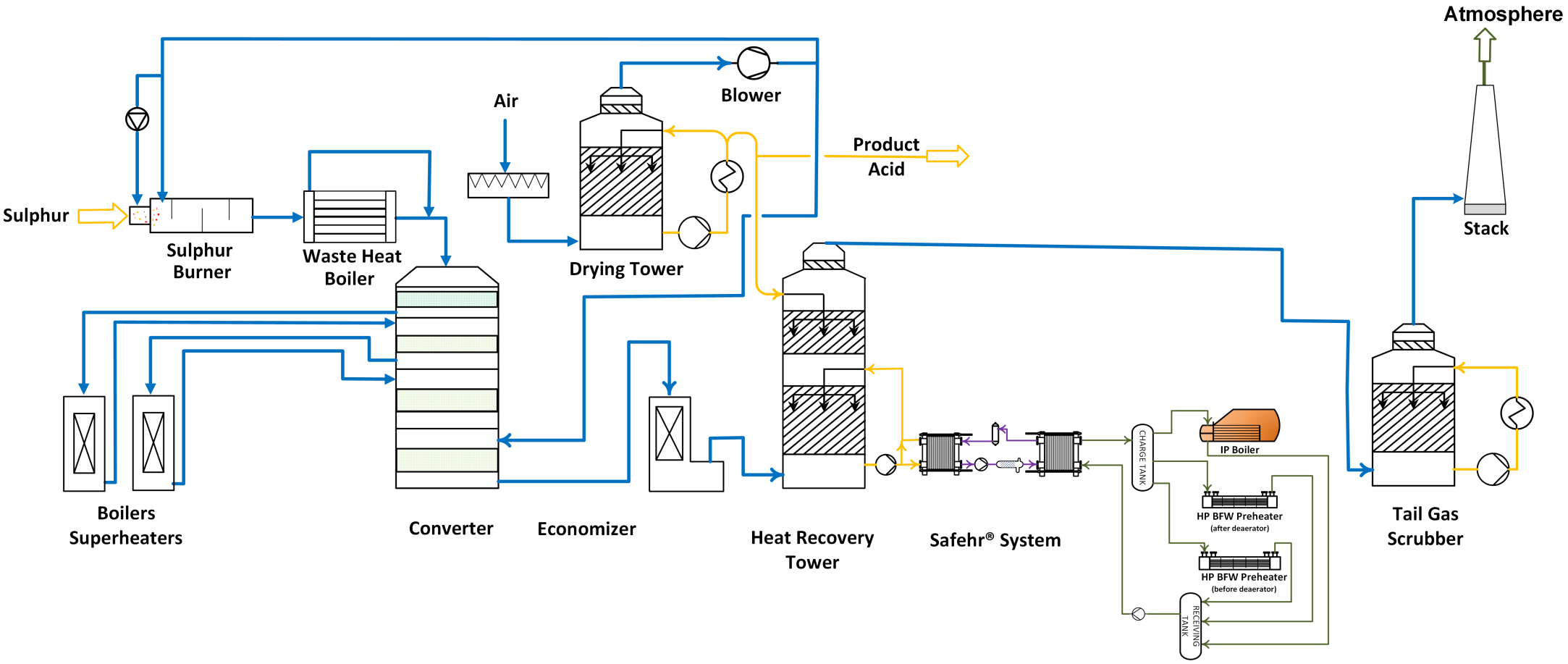
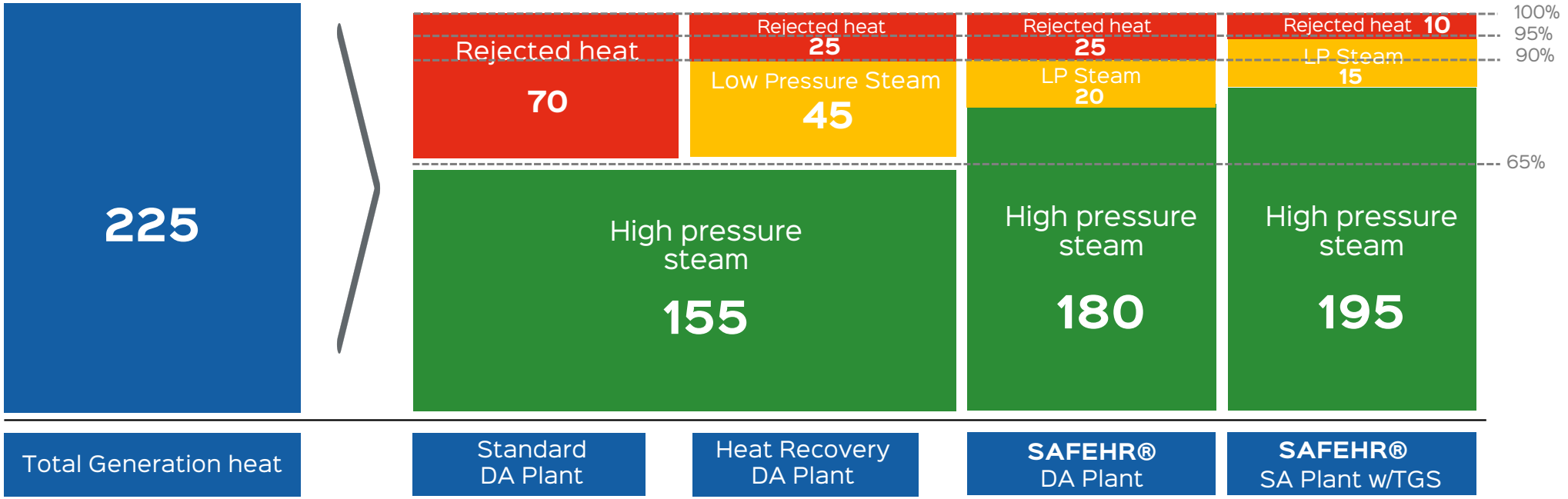
SAFEHR HEAT RECOVERY SYSTEM

Single absorption with Heat Recovery and Tail Gas Scrubbing will push energy generation limits...



SAFEHR PERFORMANCE

Single Absorption Plants with Tail Gas Scrubber and Safehr produce even more steam..



Energy breakdown in different plant configurations (all values in GJ/h)

* Pro-rated figures for sulphur burning plant, 3/1 IPA, 1000 MTDP

SUMMARY

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SAFEHX

Pushing limits
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SUMMARY

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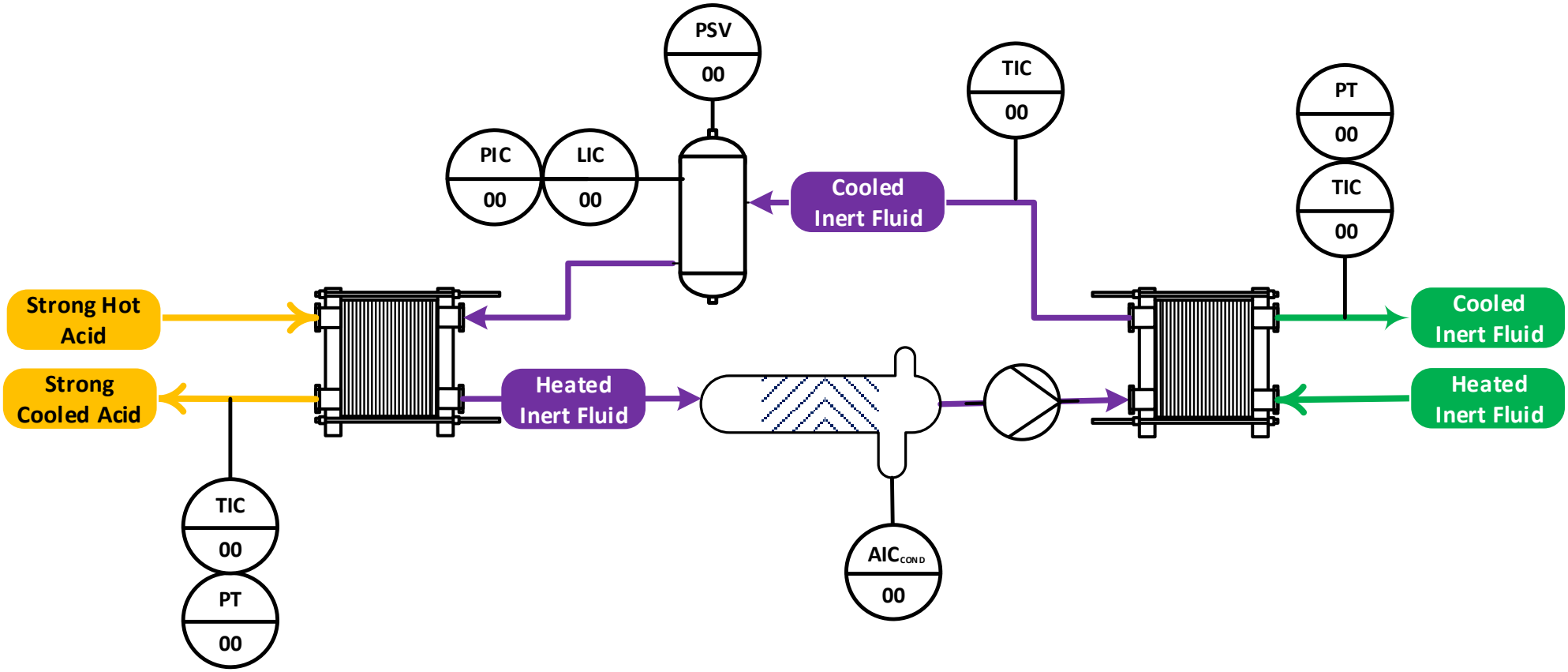
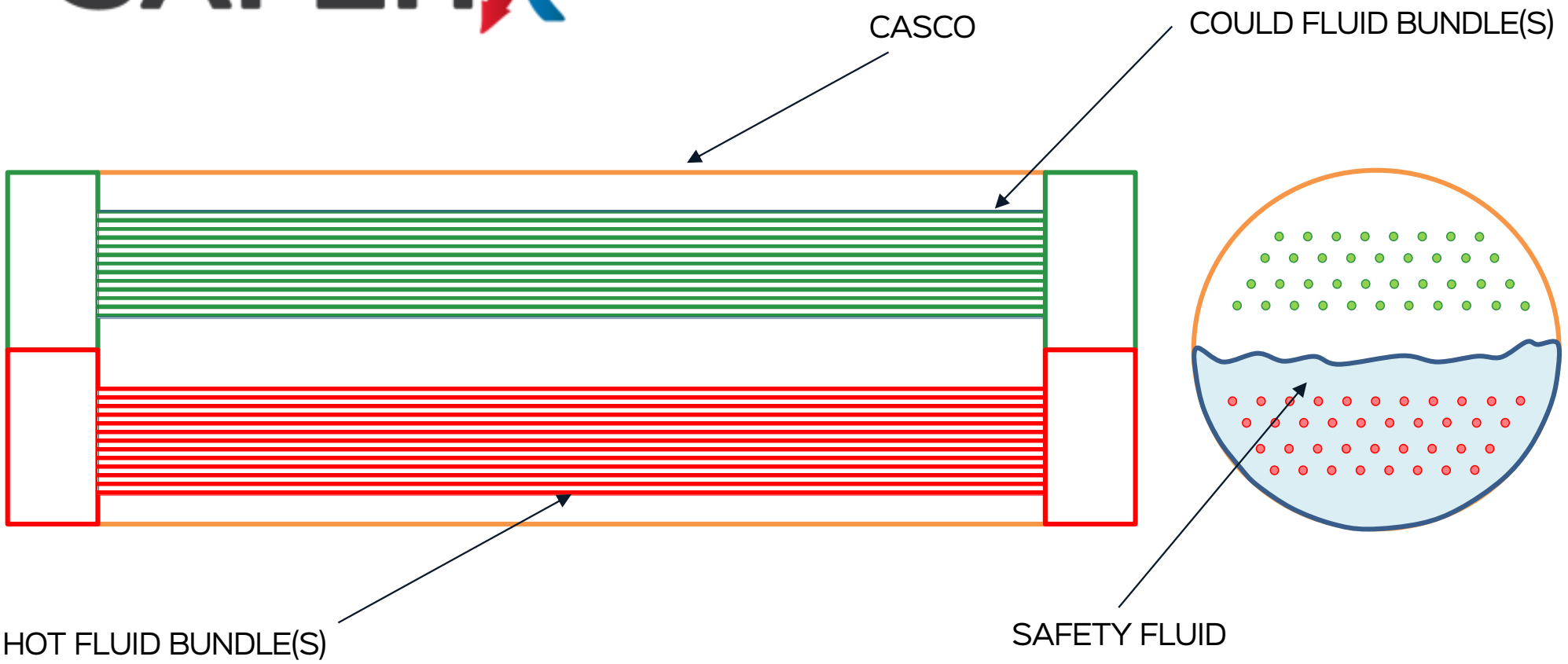
INDIRECT COOLING OF SULFURIC ACID
EQUIPMENT AND INSTRUMENTATION



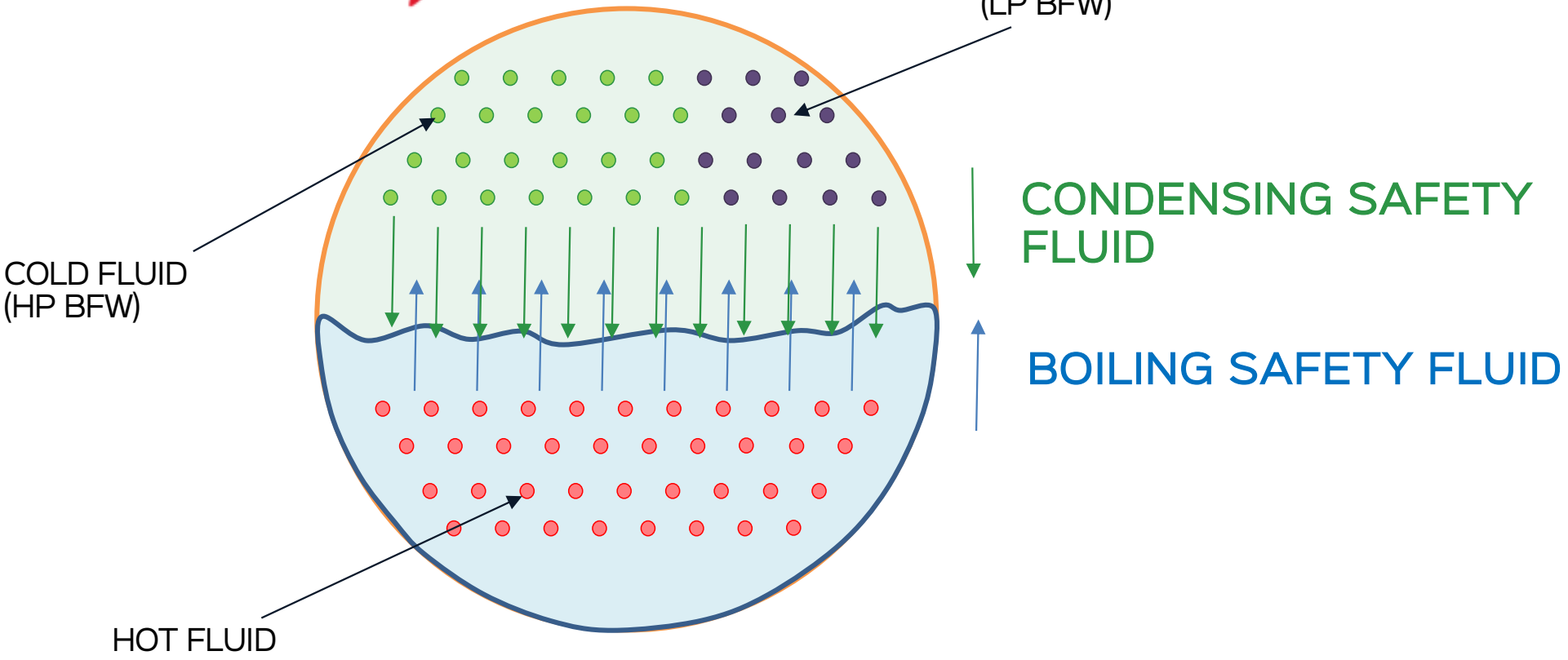
SAFETY HEAT EXCHANGER

SAFEHX patent pending



SAFETY HEAT EXCHANGER

SAFEHX patent pending



SAFEHX® HEAT EXCHANGER
SAFE HEAT RECOVERY SYSTEMS

HEAT RECOVERY TOWER

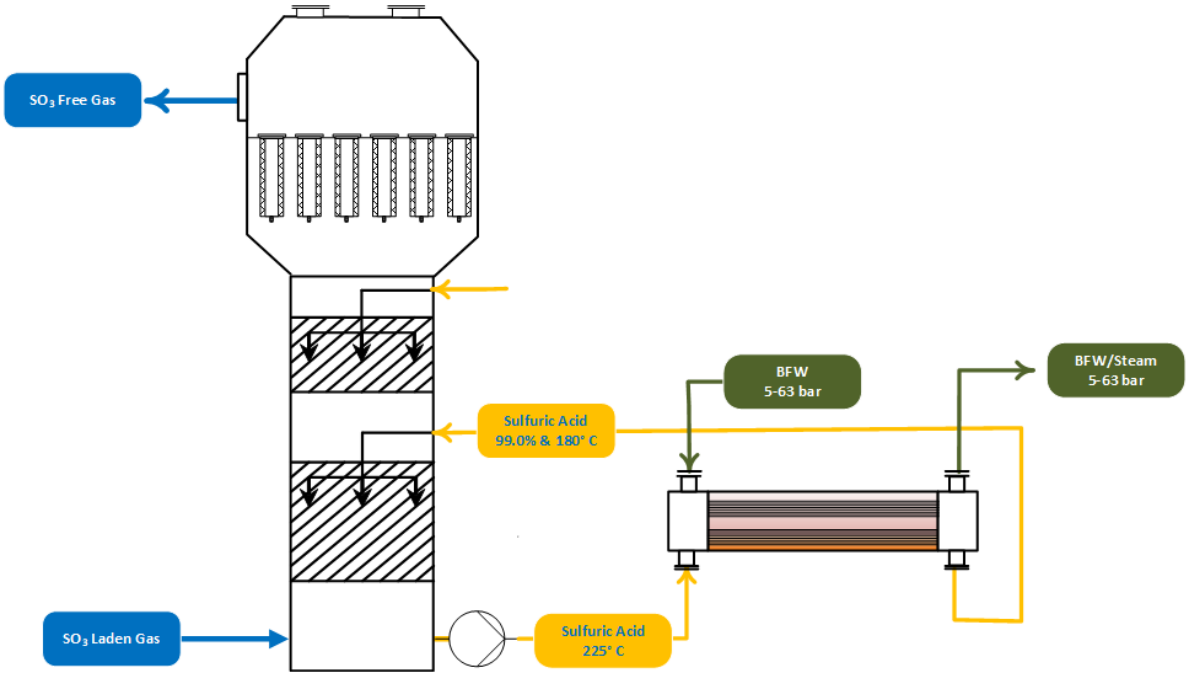
Double deck absorption tower.

Benefits

Heat Recovery≈ 50GJ/h
Cooling Water M/U Reduction≈ <90%

Reduced Risks

- Boiler Corrosion/Failure
- H_2 Generation/Explosion
- Site Shutdown
- Acid / Energy Production Loss
- Equipment damage



SUMMARY

WHAT'S NEXT?

Pushing limits
with SAFEHR

SAFEHX

SUMMARY

Presentation
conclusion

CONCLUSION

SAFEHR®

Enables safer operation and environment

Failure Safe

Leaks no longer cause emergency shut-down

No auto-catalytic effect

No auto-catalytic effect caused by leaks guarantee long life to equipment.

Energy

35+% lost energy recovered

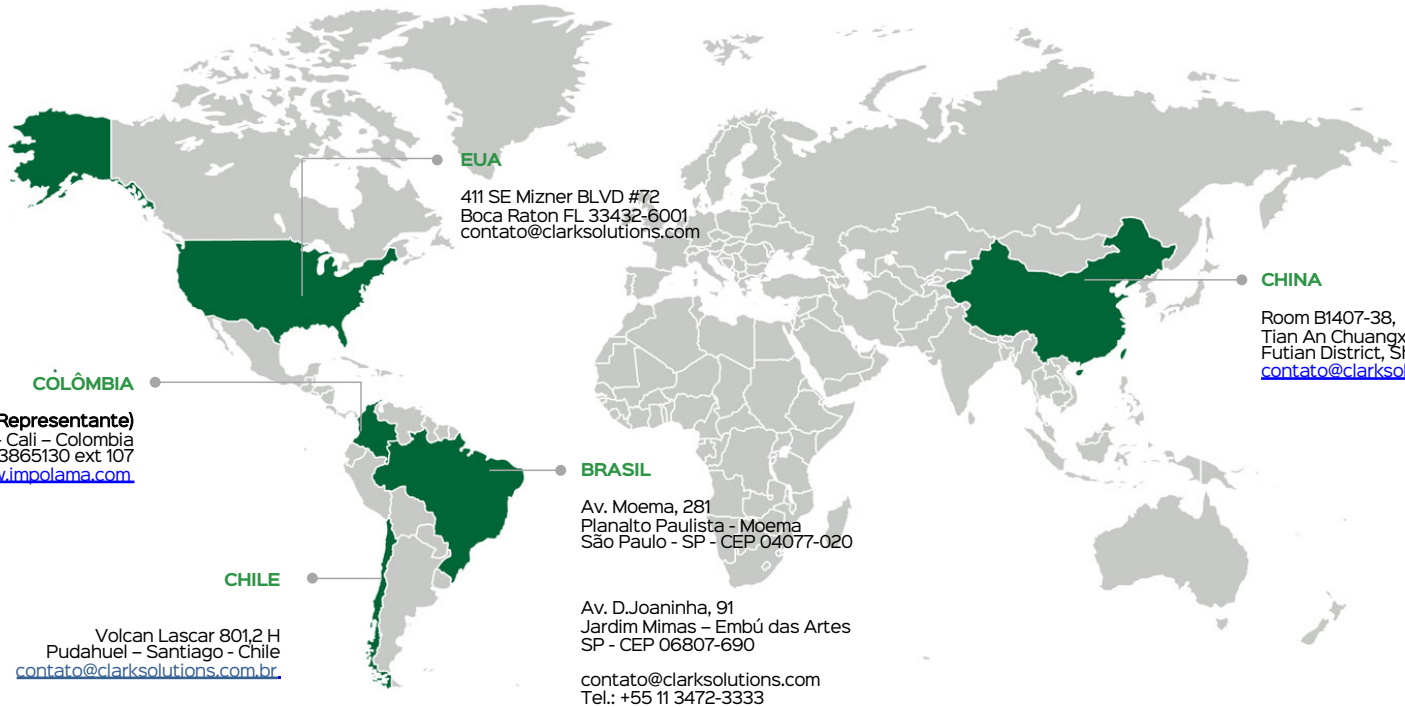
Cooling water

Reduced cooling water circulation
Energy can be shifted elsewhere

Make-up water

Reduced cooling water make-up and treatment

WHERE WE ARE



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