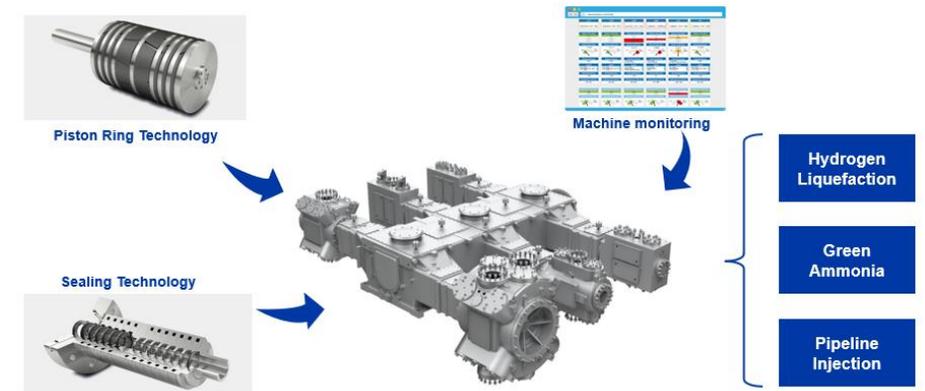


RUN-TIME OPTIMIZED COMPRESSORS FOR LH2, GREEN AMMONIA AND PIPELINE PROCESSES

Glasgow, May 2023
Edouard Blanquart

Key Take Aways

- **Process insights into hydrogen liquefaction, green ammonia and pipeline applications**
- **The importance having best fit Compressor System for these services**
- **How close collaboration with the operating company has more than doubled operational run-time between overhauls**
- **See how an effective monitoring and digitalization concept can substantially increase uptime while covering inherent operational safety risks**



Who are we? From engineering workshop to global market leader

Engineering workshop founded in Basel



1844 | 1883

Safe compression of oxygen in the steel industry



1935

Liquefaction and transport of natural gas



1971

Use of LNG as fuel for maritime carriers



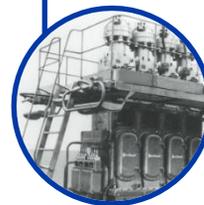
2013

1878



Production of fertilizers

1920



Production of plastics

1951

1969

1982



Oil-free hydrogen compression for bottle filling

2001

2006



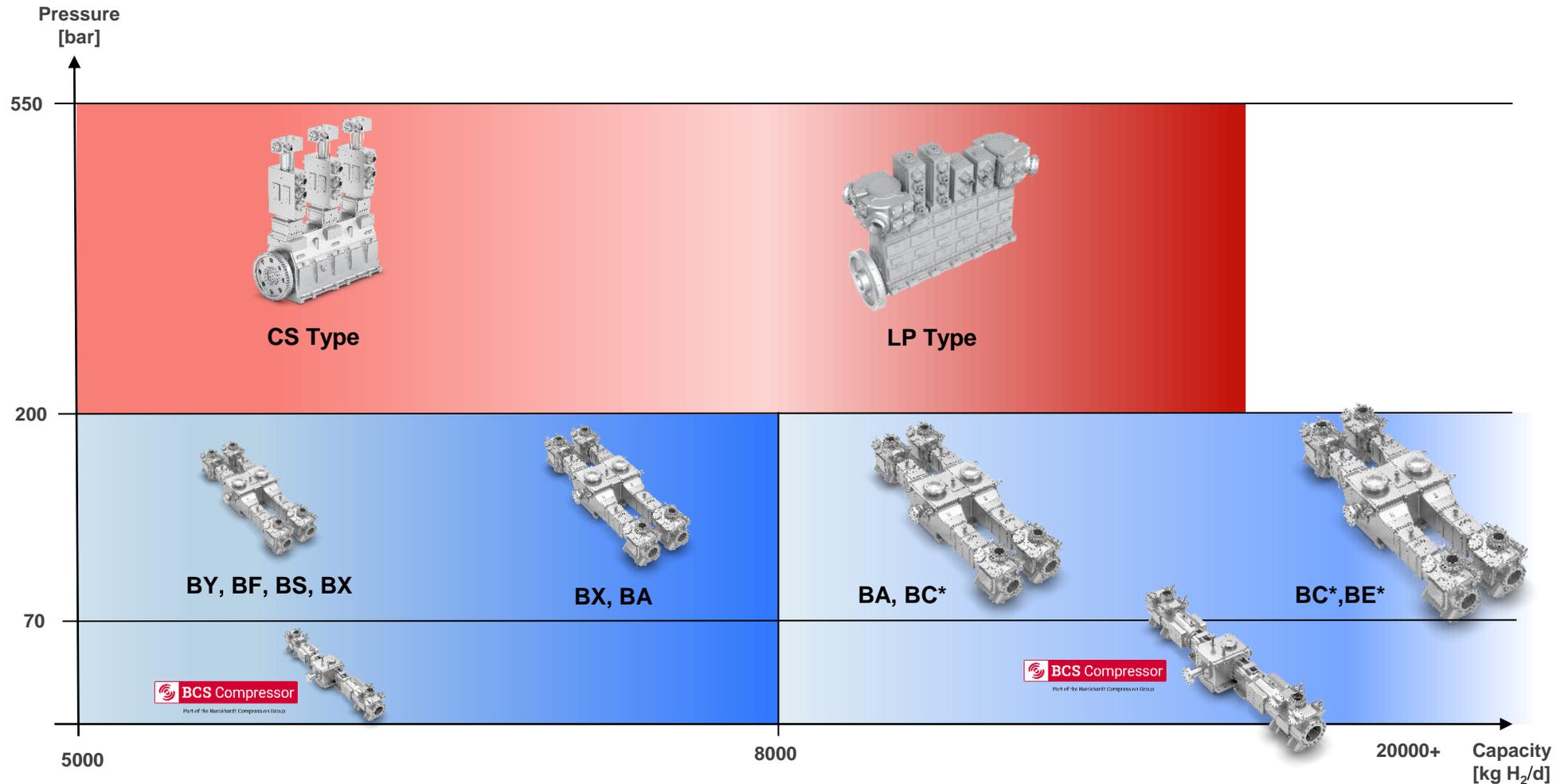
550 bar oil-free for H₂

2021

2'732 qualified employees around the world



Oil-Free Compressor Solutions at Medium Pressure for H₂ Liquefaction, Green Ammonia and Pipelines

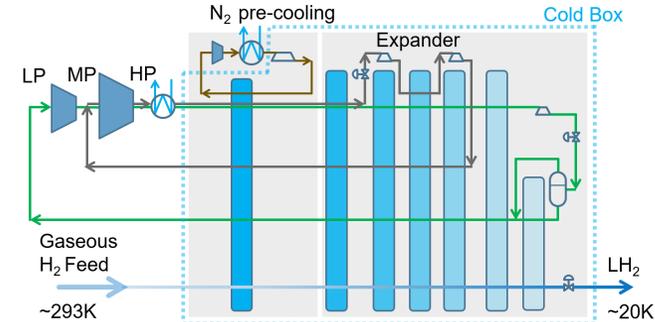


Approximate assignment above, effective compressor sizing will be customized based on customer needs (capacity and pressure)

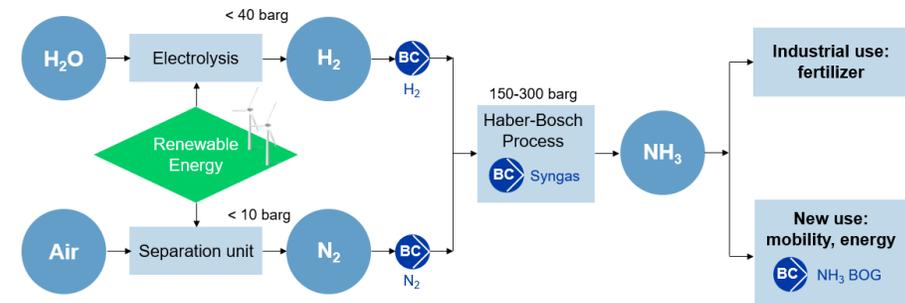
* Lubricated cylinders with oil removal system

Today is Focused on these Applications

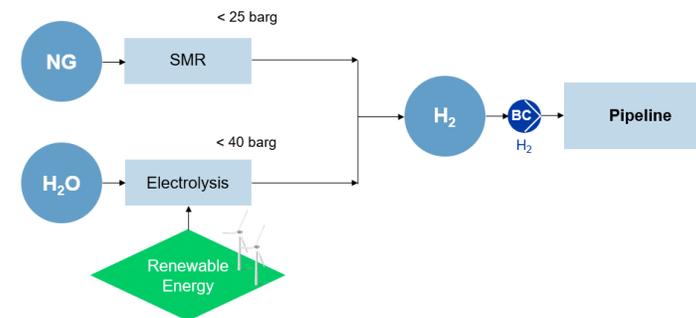
Hydrogen Liquefaction



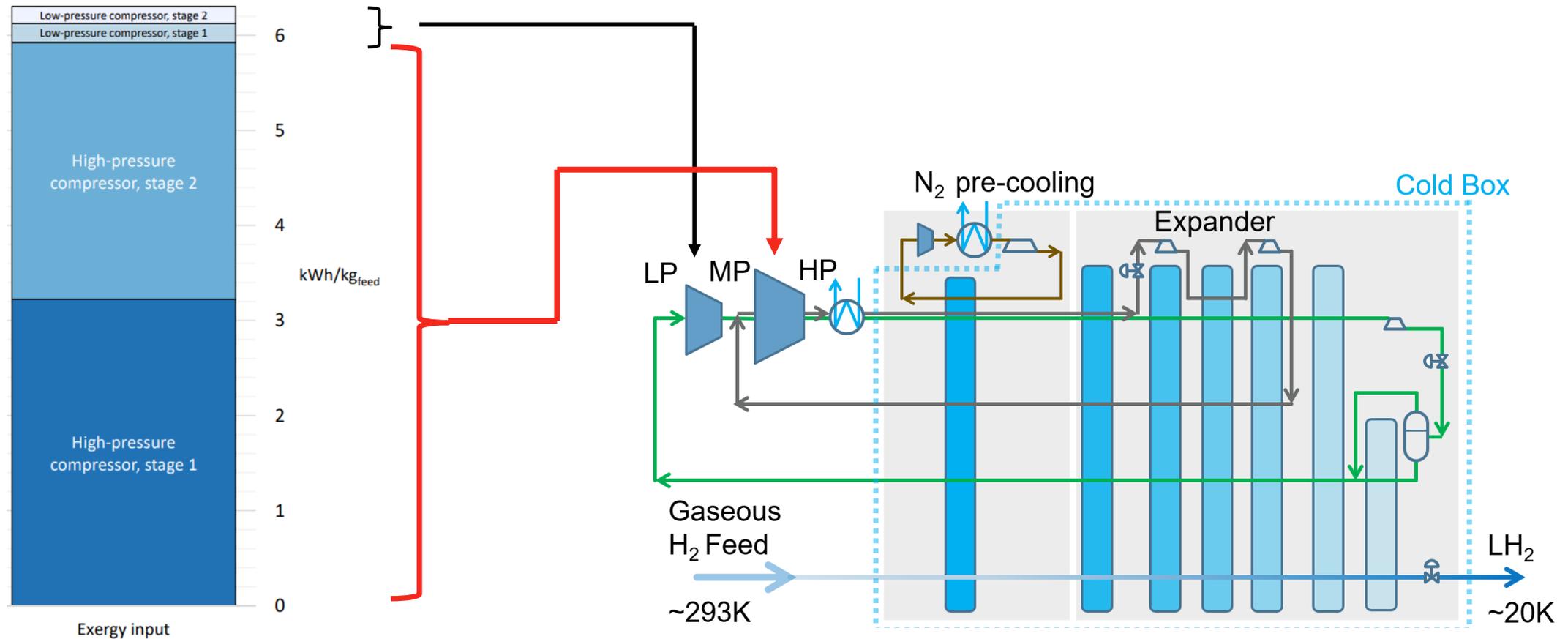
Green Ammonia Production



Pipeline Injection



LH2 Process Efficiency Depends on Compressor Design



- Reference: Berstad D et al., Dissecting the exergy balance of a hydrogen liquefier: Analysis of a scaled-up claudé hydrogen liquefier with mixed refrigerant pre-cooling, International Journal of Hydrogen Energy, <https://doi.org/10.1016/j.ijhydene.2020.09.188>

Hydrogen Liquefaction Plant References

- Hydrogen Liquefaction plant with 90 tpd LH2 capacity, located in South Korea.
- The order includes 3 large scale API618 compressors
- Motor power of 7.6 MW per compressor
- Operational start in 2023



Assembly of Piston Compressor Type 4BE at facilities in Winterthur

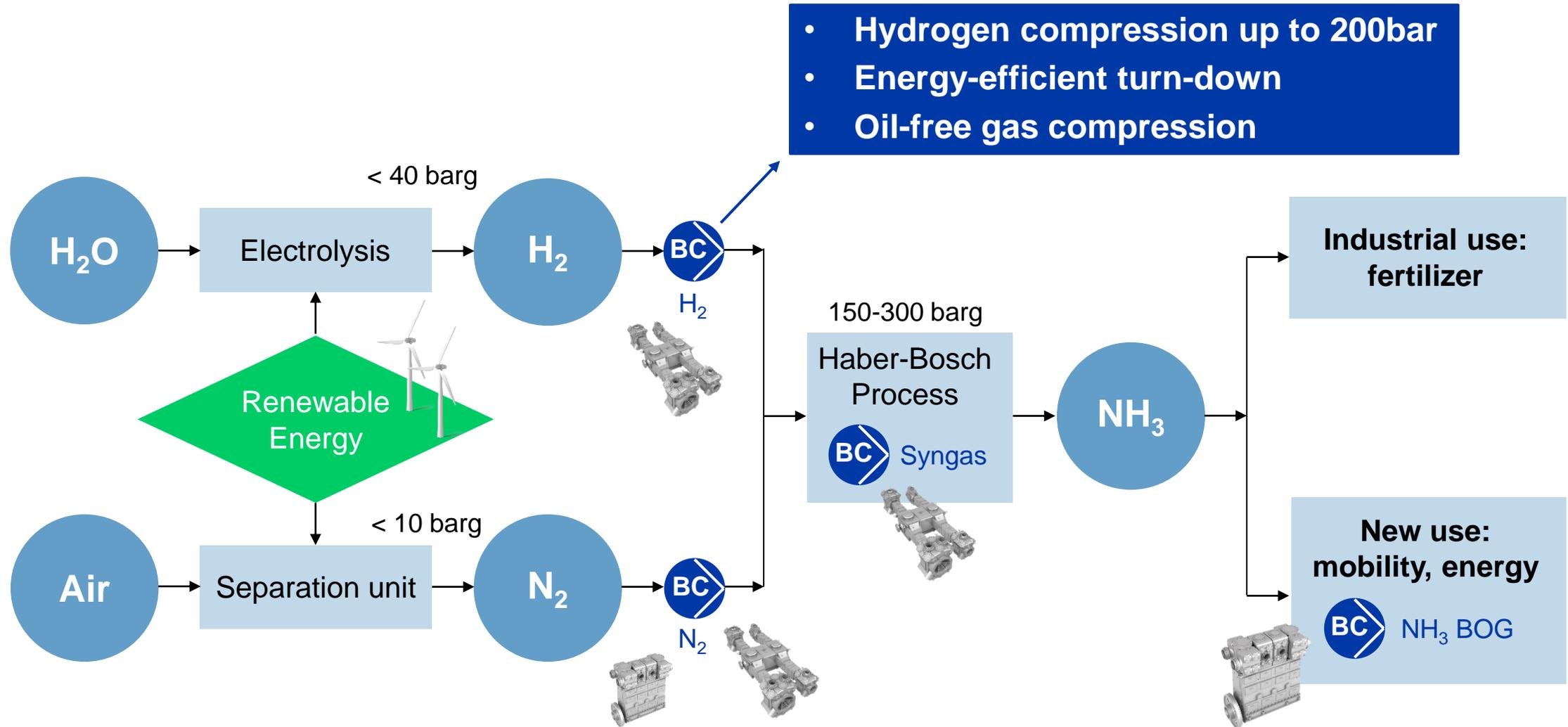
Hydrogen Liquefaction Plant References

- In total > 300 TPD LH2 Capacity operational or projects in execution
 - 300TPD is equivalent to approx. 700MW Electrolysis Capacity
 - majority are green H2 fed
 - 300TPD also equals a travel range of:
 - Truck 3,750,000km/day (@ 8kg/100km)
 - Car 37,000,000km/day (@ 0,8kg/100km)



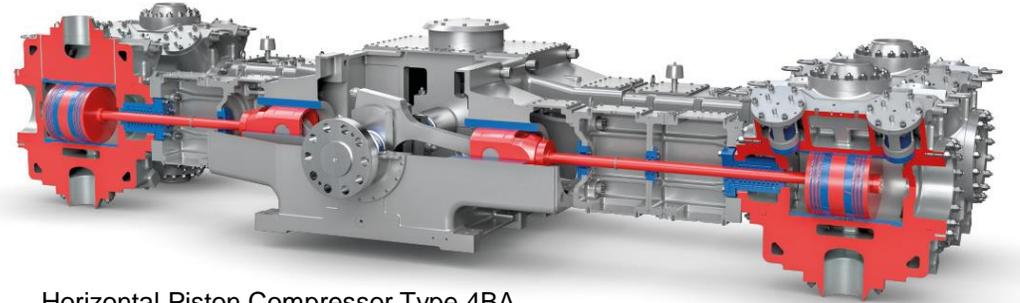
Assembly of Piston Compressor Type 4BE at facilities in Winterthur

Compression Requirements for Green Ammonia Production

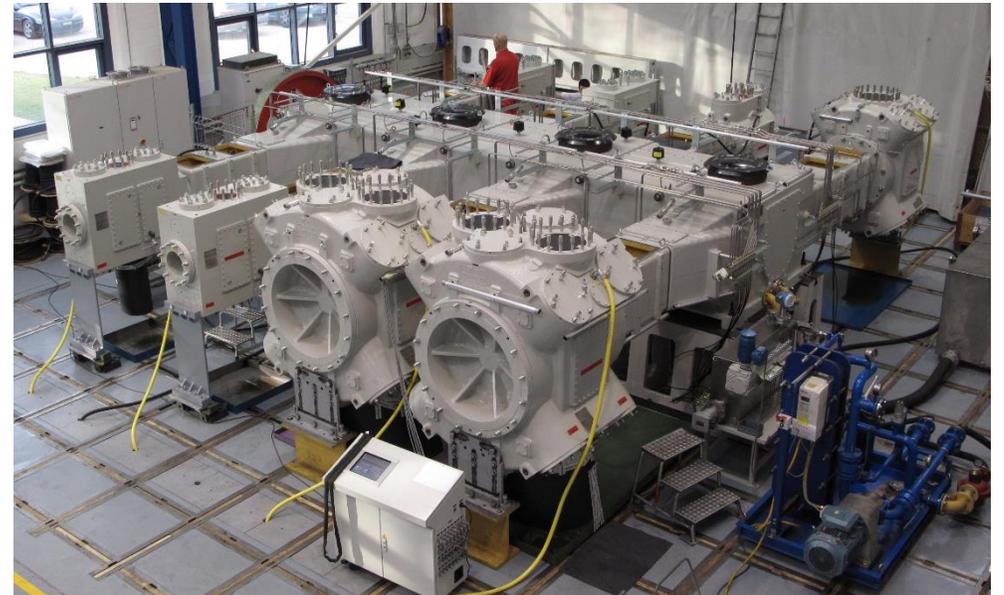


Horizontal Piston Compressors for Large Gas Volumes

- Oil-free design up to 200 bar
- Energy-efficient turn-down operation
- High availability and reliability: condition monitoring of compressor and wear parts allows planned overhaul
- Hydrogen references in operation for Ammonia production, hydrogen liquefaction and pipeline injection
- Achieving MTBO (Mean Time Between Overhaul) of up to 27'000 h



Horizontal Piston Compressor Type 4BA



Horizontal Piston Compressor Type 8BA

Oil-Free H₂ Horizontal Piston Compressor

Achieved Mean Time Between Overhaul (MTBO) of 27'000 h

Compressor Profile

Location
Germany

Duty
PSA recycle compressor

Gas
H₂/CO mixture

In operation since
2002

Suction pressure
0.3 bar g

Discharge pressure
65 bar g

Capacity
7'383 Nm³/h (90 kg/h)

Motor power
1'450 kW



Piston Compressor Type 6B5XC oil-free, six cranks, 5 stages

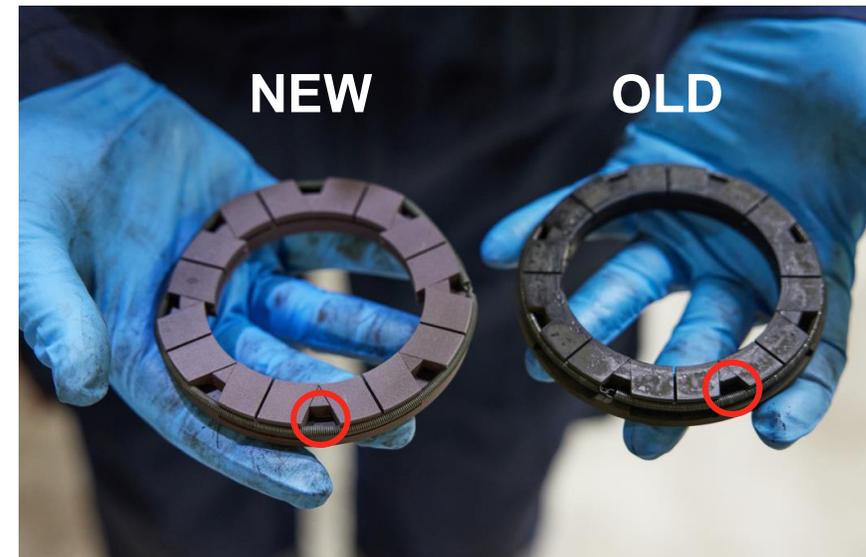


Condition After 27'000 Operating Hours of Redura® and Persisto® Rings & Packings

- 05/2017: Installation of Redura® Packing with Persisto® material during upgrade of 6B5X
- 09/2020: Replacement of piston- and packing rings
- Rings and sealings still in good condition after 27'000 operating hours



Piston rings with some wear reserve left after 27'000 h operation



Significant reserves left before meeting the wear limit

The Challenge of Omitting the Lubricant in Reciprocating Compressors → Sealing Systems

Lubricated sealing systems

- Well referenced 
- Available for high pressure 
- Long MTBO / low wear 
- Good sealing performance 
- Contamination of process gas 



Non-lubricated sealing systems

Challenges:

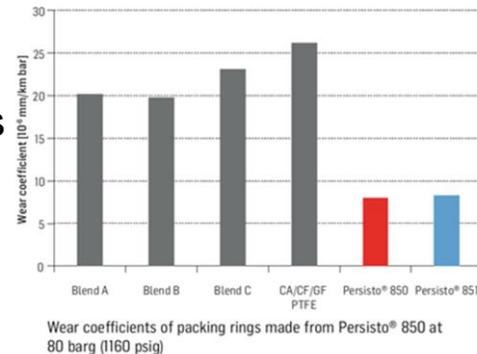
- Increased friction coefficient
 - Friction power = Cooling power
 - Increased temperature
 - Reduced material strength
- Challenge to seal



Burckhardt Compression – Technology Leader for Non-lubricated Sealing Systems

Ring Materials – PERSISTO®

- Internal laboratory
- Dedicated test compressors (for more than 20 years)
- In house production of materials and rings



Tribology

- Broad experience with different coatings
- In-house grinding capabilities
- Optimized friction partners
- Premium suppliers



Sealing Element Design

- Proprietary, superior ring design
- Broad portfolio of proven and innovative ring designs
- Specifically developed for H₂



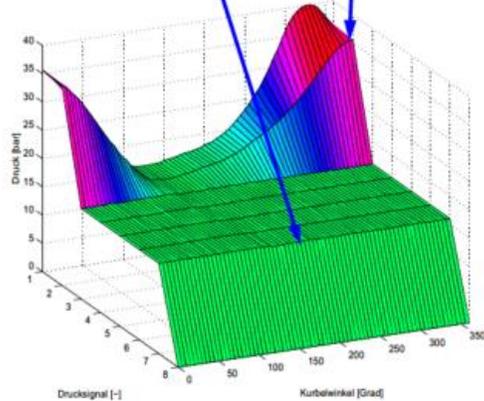
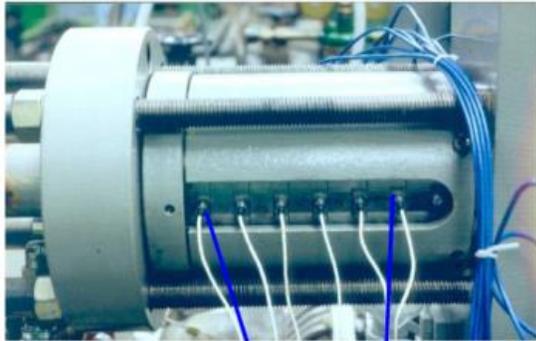
System Configuration – REDURA®

- BC is the inventor of the heterogenous sealing system REDURA

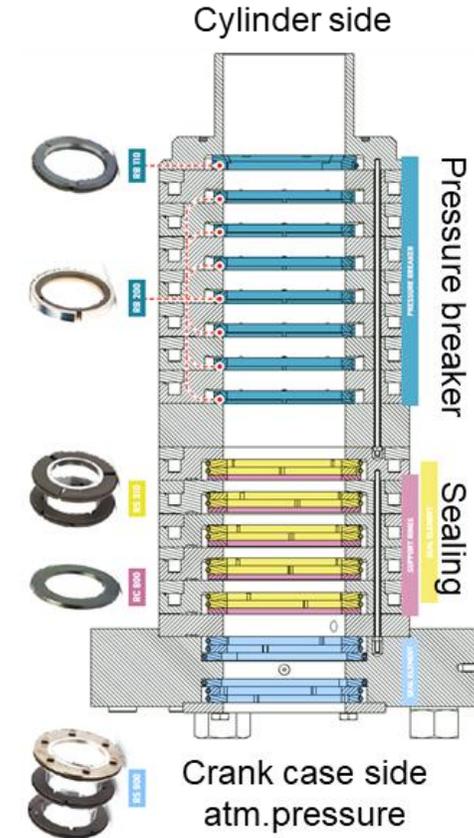
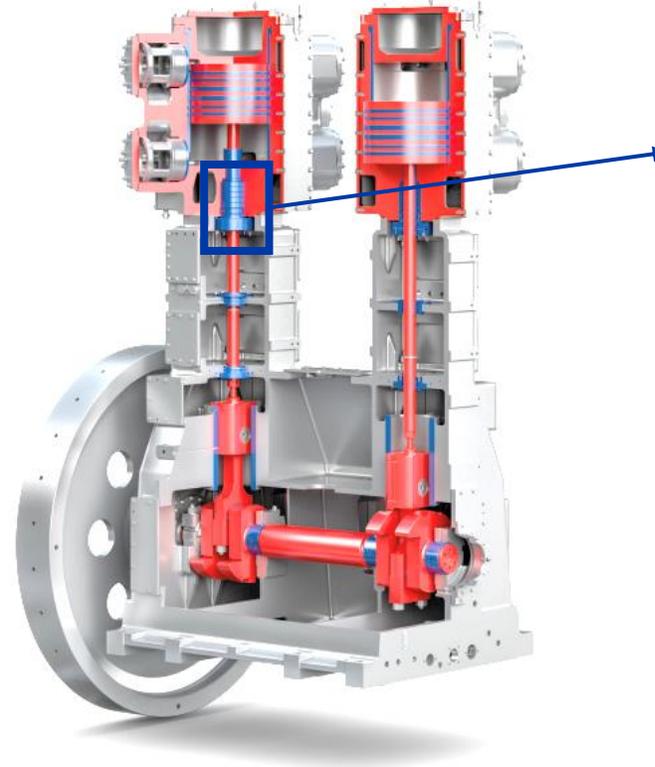


The Sealing System is Key for Achieving the highest Reliability & Availability of Oil-Free Hydrogen Compressors

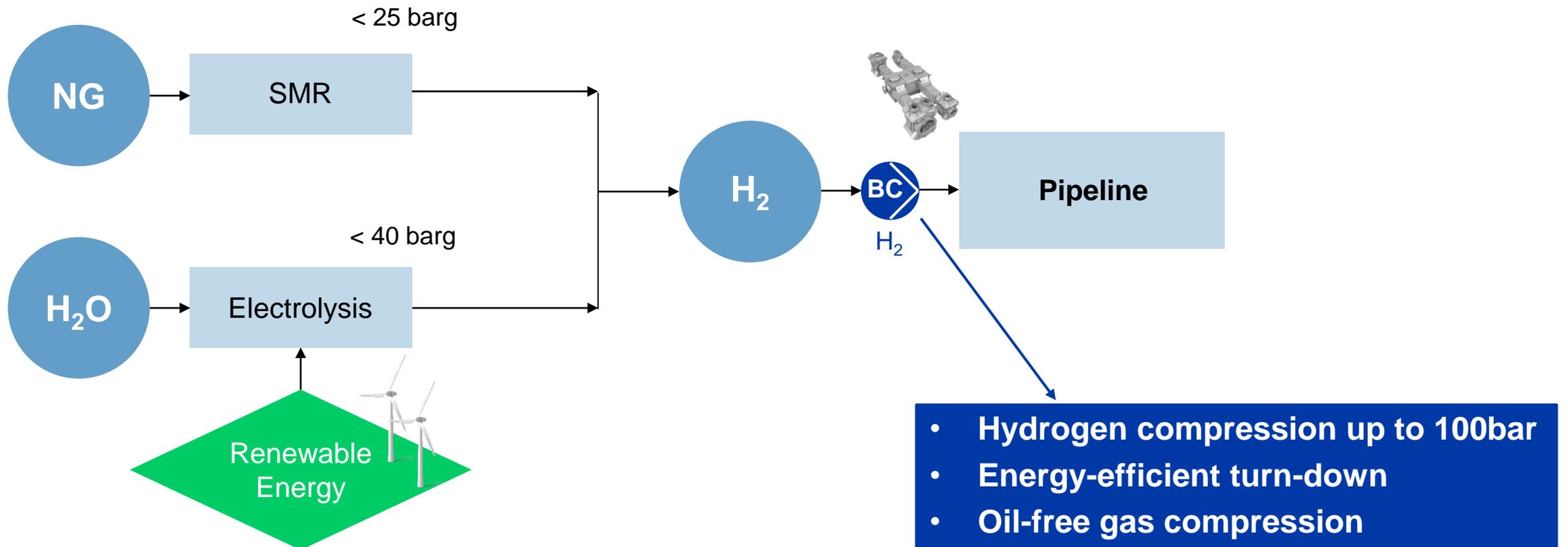
Heterogeneously designed sealing systems based on the Redura® principle, achieving stable sealing efficiency and long lifetime of sealing rings:



Measured pressure signals



Compression Requirements for Pipeline Injection



Case Study: Three Oil-Free H₂ Piston Compressor Units for Pipeline Injection in the Netherlands

Compressor Profile

Location

Botlek, Netherlands

Duty

H₂ Pipeline Injection

Gas

Hydrogen from PSA

In operation since

2011

Suction pressure

22.5 bar g

Discharge pressure

101 bar g

Capacity (per unit)

68'000 Nm³/h (6'052 kg/h)

Motor power (per unit)

4800 kW



Piston Compressor Type 6BA

Optimization of Process for Improved Availability

Situation at beginning: repeated short life-time < 8'000 h of packings first stage, second stage good performance

1) Impurities in gas feed to compressor

Dismantled packing rings for investigation at BCAG: PSA adsorber material detected in rings (abrasive particles)

Experience from other compressors, installed downstream a PSA helped to understand the negative effect of such highly abrasive particles.

→ additional filtration step upstream the compressor



Optimization of Components & Monitoring for Improved Availability

2) Ring design

Existing penguin-type rings were damaged mechanically not only due to particles but also due to extensive dynamic pressure profiles. Good understanding of static & dynamic pressure profiles was the basis to develop different types of ring design.

→ MP Rings best choice for this specific case



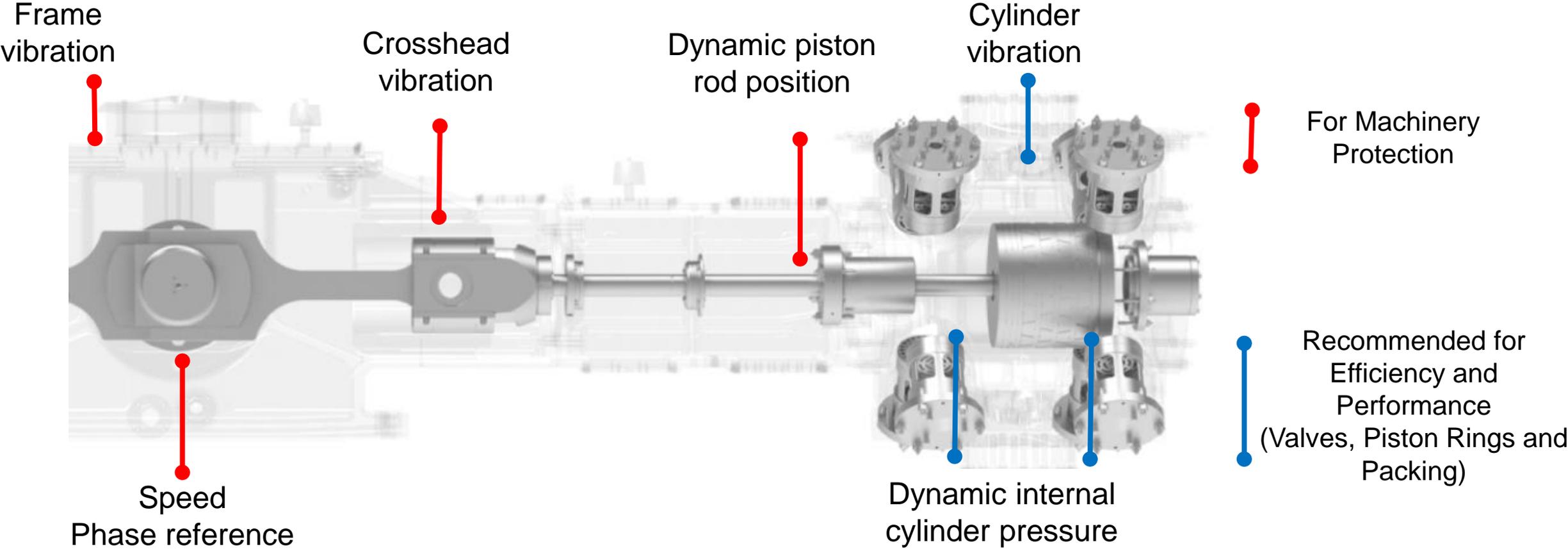
3) Machine Monitoring

Advanced machine monitoring system PROGNOST NT was installed, which helped to better understand and predict when and where next maintenance will be required.



Achieved 16'000 – 20'000 hours MTBO (Mean Time Between Overhaul)

Recommended Sensor Positions



Process data from DCS: e.g. suction/discharge temperatures and pressures

Our Compression Solutions Enable a High Reliability and Availability for your Hydrogen Processing



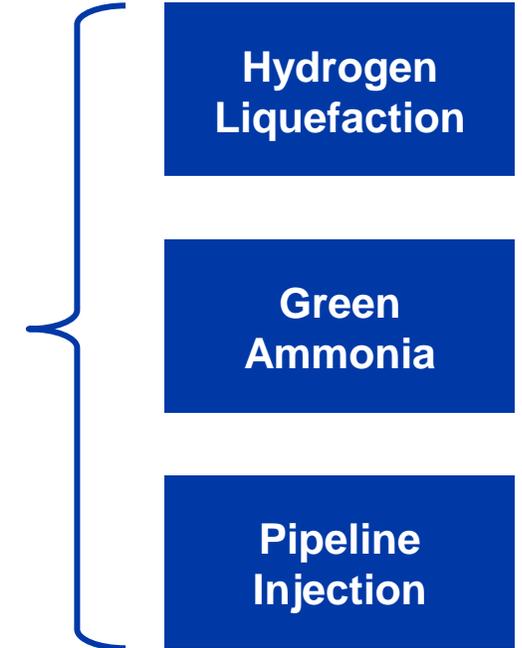
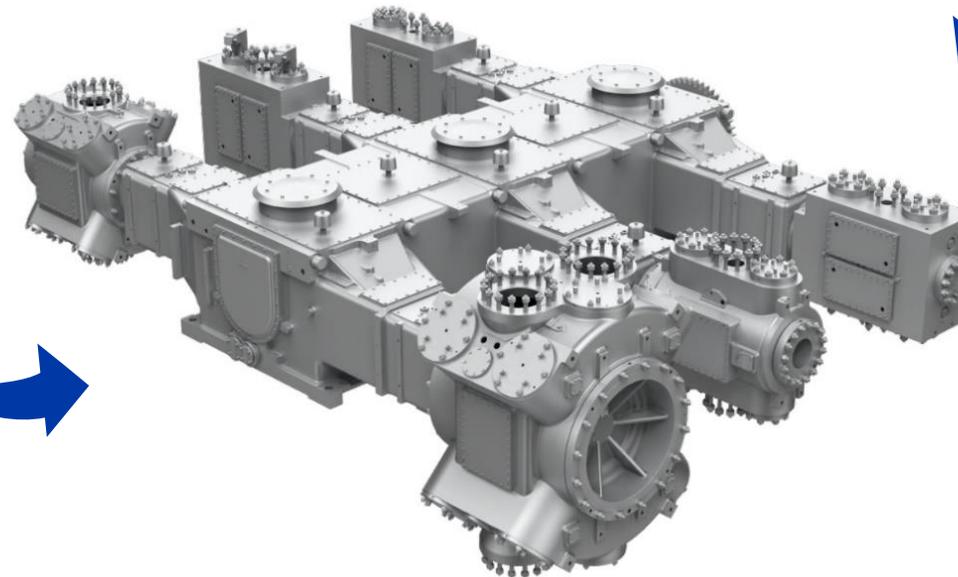
Piston Ring Technology



Machine monitoring



Sealing Technology



THANK YOU!

Edouard Blanquart
Sales Manager UK & FR

Burckhardt Compression
Franz-Burckhardt-Strasse 5
8405 Winterthur, Schweiz

Edouard.blanquart
@burckhardtcompression.com

Follow us on

 LinkedIn – Burckhardt-compression

 YouTube - burckhardtcompr

 Twitter – BurckhardtCompr



Burckhardt Compression

Compressors for a Lifetime™