Paradeep Phosphates
MANGALORE UNIT

adventz

Operational Experience with High-Pressure Equipment in a Stamicarbon Urea Plant

PPL Mangalore

S. Girish -Chief Manufacturing Officer
Shakuna Udupa – Jt. GM-Process Technology and Engineering
Nagaprasanna Bhat - Chief Manager Engineering & Inspection

1st Revamp 1999-2001 (Phase 1 & 2)

Major revamp after 24 years of Operation, 5.8 million tonnes of Urea production, Revamp split into two annual turnarounds

Urea Reactor (V1201)	• Relining with improved MOC : SS 25-22-2 Sieve trays replaced with high efficiency trays
HP Carbamate condenser and HP stripper	• Liquid distribution system modification
CO_2 Compressors	• 3rd stage moisture separators replaced with new design cyclone separator.
Automation	• DCS system installed • N/C meter.
LP carbamate condenser	• New condenser installed in series with existing to share condensation load of LP Section & to reduce vent losses.
LP Scrubber V1203	• Replacement with new modified design.
Urea hydrolyser section	• Vertical reflux condenser, tank and cooler • Replacement of internals - modified trays in desorption column & urea hydrolyser.
Evaporation Section	• Introduction of Pre evaporator • Vacuum ejectors replaced - higher capacity
Prill Bucket	• Bucket modification to improve product quality

Outcomes of 1st Revamp

Capacity Increase	• **1030 to 1290 tpd**
Improved reliability	• **Improvement in Material of construction of critical equipment**
Energy Efficiency	• **Reduction in Evaporator steam consumption**
Improvements in product Quality	• **Improvements in Prill Bucket**
Improvements in Process Control	• **Driven by Automation & DCS**

2nd Revamp - 2006

MP Scrubbing system	• MP scrubbing was introduced • MP Scrubber, MP Condenser, Level Tank, MP Carbamate Pumps and MP Flush pumps.
HP Stripper Replacement:	• MOC changed to Safurex® Infinity.
HP Carbamate Pump	• New Centrifugal pump with higher capacity.
H_2 Converters	• New 1+1 H2 converters & new downstream CO_2 Cooler at CO_2 Compressor discharge
LP Scrubber	• Relocation of LP Scrubber from Prill Tower top to 20 m elevation.

Improvements in

- Safety
- Reliability

High-Pressure Stripper

The High-Pressure (HP) stripper is one of the most critical proprietary high-pressure equipment in Urea plant.

- Efficient Carbamate decomposition, minimizing recycle
- Ensures energy efficiency
- Enhances overall urea conversion efficiency and stabilizes the high-pressure synthesis loop

Adopting continuously evolving HP Stripper metallurgy emphasizes PPL's focus on corrosion resistance, reliability, and long-term performance.

BC.05

1976 – 2006
30 years
7.9 million tonnes Urea
0.262 mmtpa

Safurex infinity

2006 – 2025
20 years
7.5 million tonnes Urea
0.373 mmtpa

Safurex Star

Commissioned in Jan 2026

BC.05 Stripper : 1976 - 2006

Design and Fabrication Details:

- Vessel manufacturer: Rheinstahl, Germany
- Year of fabrication: 1974
- Tube MOC: Stamicarbon specification BC.05
- Tube manufacturer: Sandvik, Sweden (Type 2RE69)
- Tube dimensions: 32 mm OD × 3.5 mm wall thickness
- Number of tubes: 1,680
- Tubes plugged by end of service : 87

Performance:

- Average Production: 0.262 million t/y
- Cumulative: 7.9 MMT
- Progressive corrosion over time
- By 2004:
  - 39 tubes plugged
  - Additional 48 Plugged.
- Thickness:
  - Avg: 2.26 mm
  - Min: 1.45 mm
- Corrosion rate: 0.05 mm/year
- Reached end of design life → Replaced in 2006

Safurex Stripper : 2006 - 2025

Design and Fabrication Details:

- Vessel manufacturer: Schoeller-Bleckmann Nitec, Austria
- Year of fabrication: 2005
- Tube dimensions: 31 mm OD × 2.5 mm wall thickness

Key Improvements:

- Material: Safurex® Infinity (BE.06)
- No. of Tubes : 1,840 (from 1680)
- Wall thickness: 2.5 mm (from 3.5)
- Improved heat transfer

Performance:

- On-stream: ~6000 days
- Average Production: 0.373 million t/y
- Cumulative: 7.5 MMT

HP Stripper End-of-Life Management (2022–2025)

During the June 2022 inspection, Stamicarbon B.V. reported the following observations:

- Average tube wall thickness: 1.35 mm
- Minimum measured wall thickness: 1.10 mm
- Average corrosion rate since installation: 0.07 mm/year

Recommendation:

- Plug 300–350 tubes
- Replace within 3 years

⚠️ Risk: Capacity reduction & accelerated corrosion

⚠️ Maintained low stripper tube heat load to limit corrosion; no leaks or plugging until replacement (Dec 2025)

Original Design of Liquid Divider Assembly

Liquid Divider: Importance

- Ensures uniform liquid distribution
- Direct impact on:
  - Corrosion rate
  - Tube life
  - Stripping efficiency
- Liquid divider assembly consists of two main components,
  - Liquid divider head
  - Gas tube
- Liquid divider head manufactured in two parts and joined by welding.
- Three liquid distribution holes drilled through the weld at: 0°, 120°, and 240°.

Problem Areas:

- Weld seams
- Heat-affected zones (HAZ)

Inspection History (2008–2014)

- **TA 2008** Liquid divider assemblies were smooth and free from corrosion.
- **TA 2009** 7 liquid divider assemblies found corroded and replaced.
- **TA 2010** 2 assemblies replaced as a precautionary measure.
- **TA 2012** 11 assemblies with pinholes (some with leakage) replaced.
- **TA 2014**
  - All liquid divider assemblies installed in May 2006 exhibited moderate to severe corrosion.
  - During testing based on Stamicarbon Delta-P test method, 13 liquid divider assemblies were found leaking.
  - The most severely affected ferrules were replaced using 50 available spare assemblies.

2012 : Weld seam corrosion / HAZ corrosion.

2014: Corrosion on external and internal weld seam

Corrosion mechanisms identified:

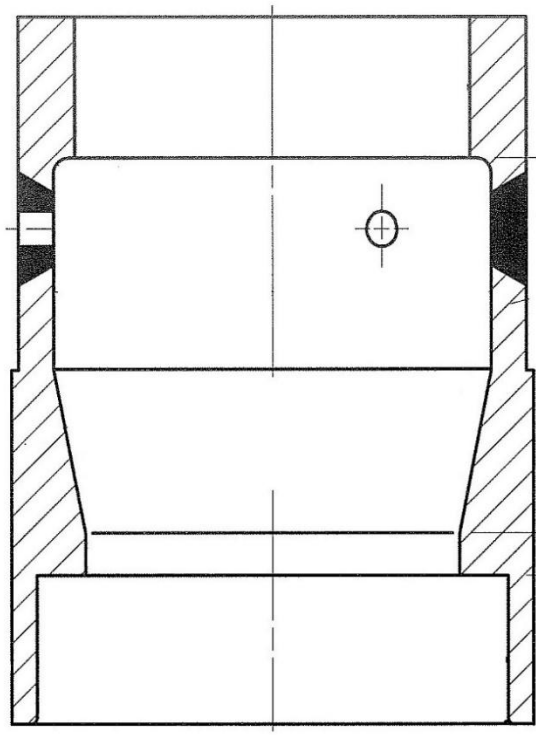
- Uniform corrosion of weld seam
- Corrosion at weld end craters
- Selective attack of HAZ
- Pinhole formation
- Corrosion at weld between divider and gas tube
- Enlargement of liquid holes from 2.3 mm → 2.4–2.5 mm

Liquid Divider Modified Design

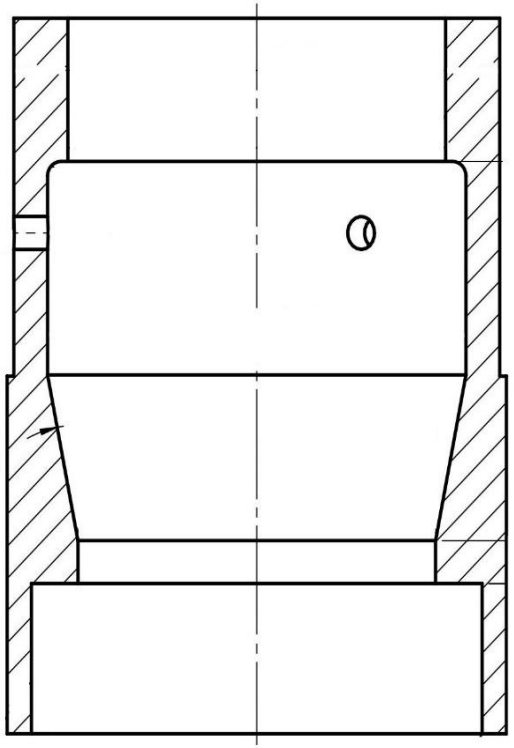
TA2015:

- All liquid divider assemblies were replaced with a modified design.
- Weld within the liquid divider head was eliminated.
- Liquid divider head manufactured as a single piece and welded directly to the gas tube.

Original Design



Modified design



Inspection History (2017–2020)

TA 2017

- Etching was observed in the Heat Affected Zone (HAZ)

TA2018

- Liquid divider surfaces were roughened.
- Gas tubes exhibited selective corrosion at the welds
- Liquid distribution hole diameters increased significantly, generally ranging from 2.50 mm to 3.20 mm, with some holes measuring up to 3.7 mm.

Due to the poor condition of the 2015-installed assemblies, liquid divider assemblies removed earlier were reused during 2018, 2019, and 2020 to maintain operability.

Liquid Divider Assembly

2018

2019

2020

Adoption of HIP Liquid Divider Technology

In 2022, all liquid divider assemblies were replaced with Safurex DEGREE® Hot Isostatic Pressed (HIP) liquid divider assemblies.

Key Advantages of HIP

- Homogeneous microstructure
- No welds
- Superior corrosion resistance

TA 2023:

- Virtually no corrosion observed.
- Liquid distribution hole diameter: 2.28 – 2.34 mm.
- Distribution holes remained round and free from deformation.

TA 2025:

- Continued good condition of the HIP liquid divider assemblies.
- No significant corrosion or deformation observed during operation.

Confirmed excellent reliability (2023 & 2025)

Based on this successful performance, HIP liquid divider assemblies were installed in the new HP stripper

Liquid Divider Assembly

2022

2023

2025

HP Stripper made of Safurex® Star

Design and Fabrication Details:

- Vessel manufacturer: Lointek, Spain
- Year of fabrication: 2025
- Tube Material: Safurex® Star (BE.06)
- Tube Dimensions: 31 mm OD × 2.5 mm thickness
- Number of Tubes: 1,980

Upgrades in the New HP Stripper (2025)

Tube Upgrade and Capacity Enhancement

- Stripper tubes have been upgraded to Safurex® Star, and the total number of tubes has been increased to 1,980 (from 1840)
- Design supports urea production capacity of 1,425 MTPD, compared to 1,350 MTPD from the existing HP stripper.

Enhanced Venting Arrangement:

- Additional vent nozzles have been provided at the mid-section of the stripper to facilitate effective venting of inert gases.

Manway Improvements:

- Manway cover liners were upgraded with overlay welding, enhancing integrity and corrosion resistance while eliminating the need to disconnect and reinstall the leak detection monitoring system during turnarounds.

Improved Operating Pressure:

- Designed to operate at 15.5 bar steam pressure on shell side, resulting in improved stripping efficiency and overall energy performance.

Radar-based level measurement system

- New stripper is equipped with a radar-based level measurement system, building on the successful operational experience of radar level measurement in the existing stripper.
- Notably, PPL Mangalore was the first urea plant worldwide to replace radioactive level measurement with radar technology, resulting in a significant improvement in operational safety and reliability.

Manufacturing and Quality Control of the HP Stripper

Engineering & Code Compliance

- Design validation and approval of calculations, drawings, WPS & ITP
- Compliance with ASME Boiler and Pressure Vessel Code Section VIII.
- Alignment with licensor requirements of the Stamicarbon.

Material Integrity & Traceability

- Strict traceability for plates, forgings, tubes, and Safurex® components.

Critical Fabrication Controls

- Precision machining of tube sheets
- Buffer layer and corrosion-resistant weld overlays
- Shell fabrication through controlled rolling and seam welding

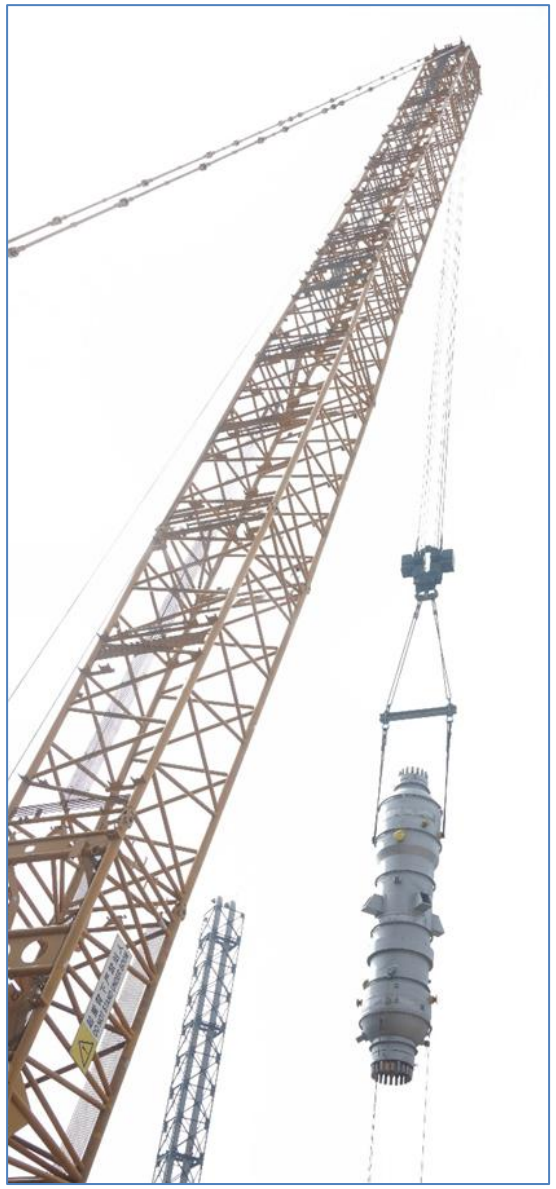
Assembly & Final Validation

- Tube bundle fabrication and tube-to-tube sheet welding.
- PWHT, dimensional inspection
- Hydrostatic and leak testing
- Extensive NDT

HP Stripper Erection and Commissioning

1. Controlled Lifting and Positioning:
   - Erection executed as per approved lifting plan and drawings.
   - Two-crane lifting method is used.
2. Equipment Alignment and Installation:
   - Vertical alignment maintained within 1 mm per 1 m tolerance.
3. Nozzle Fit-up and Welding:
   - Nozzle fit-up and welding performed by Safurex-qualified welders at site.
4. Testing, Internals Installation and Commissioning.

Erection of HP Stripper



Conclusion

- Long-term operating experience at Paradeep Phosphates Limited, Mangalore demonstrates the critical role of material selection, design evolution, and inspection-based decision making in ensuring the reliability of high-pressure urea equipment.

- The transition from welded liquid divider assemblies to HIP technology significantly enhanced corrosion resistance and operational reliability.

- Paradeep Phosphates Limited has consistently remained at the forefront of adopting advanced materials such as Safurex® Star and Safurex® Degree, along with modern technologies like radar level measurement systems, significantly enhancing plant reliability, operational efficiency, and safety.

THANK YOU

QUESTIONS?

THANK YOU