

# The AXO WELDING and GPIC Partnership

## A Benchmark in Realizing High Safety Standards and High On-Stream Figures

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*To operate in an ever-tougher and competitive market it is necessary to focus on the constant enhancement of the plant reliability and effectiveness through the application of Risk Based Maintenance and advanced materials and technology.*

*Keeping high standards in safety, reliability and on-stream figures in a urea plant through time is the result of a combination of factors, the most important of which are design, applied materials of construction, fabrication quality, planned investment, and the applied operation and maintenance procedures in the high pressure synthesis section.*

*This paper highlights the importance of a good partnership between the urea producer and suppliers who are equally motivated and concentrated on constant improvements to realize high standards in safety, reliability and on-stream figures in a urea plant.*

## 1. PREEMPTIVE APPROACH

For most of its history GPIC has had production costs significantly lower than sale prices, which turned into good profits.

Even during positive times, though, the attention of the Management has always been centered on the possibility that the future may be more difficult, and from the very beginning investing time and money in the constant improvement of the reliability, effectiveness and efficiency of its operations, as well as the education and competence of its human resources, has been a pillar of the Company Policy.

In maintenance, GPIC has always put in place a preemptive approach, trying whenever possible to predict the problems that may affect its operational results negatively and solve them beforehand.

Within this line of conduct, the findings of the inspections performed at each turnaround are analyzed and used to plan the actions of the next one in advance, not just in terms of the repairs that may be expected or the parts that may need to be replaced, but also to design the possible improvements and plan for the preventive actions that may be put in place, through a co-operation with some trusted contractors not limited to the plant shutdown but which continues during the on-stream time.

This article explains the work done jointly by GPIC and AXO WELDING in this direction, to prepare for and to carry out the works on the high pressure loop during seven turnarounds, between 2003 and 2018.

## 2. PROFILE OF GPIC

Gulf Petrochemical Industries Company – GPIC – is a world-class producer of ammonia, methanol and granular urea.

It was established in December 1979 as a joint venture equally owned by three major governmental institutions: the National Oil and Gas Authority (NOGA) from the Kingdom of Bahrain, Saudi Basic Industries Corporation (SABIC) from the Kingdom of Saudi Arabia and Petrochemical Industries Co. (PIC) from the State of Kuwait.

At its location in Sitra, Kingdom of Bahrain, GPIC runs a 1200 metric tons per day ammonia plant, a 1200 metric tons per day methanol plant and a 1700 metric tons per day urea plant. The urea plant was built by Mitsubishi Heavy Industries and it was commissioned in 1998.

GPIC has put in place solid and internationally recognized Quality, Safety, Health and Environmental Management Systems, certified per ISO 9001, ISO 14001, and ISO 18001, which earned it several international awards, among others the Sir George Earle Trophy from RoSPA, UK and the R.W. Campbell Award from the National Safety Council, USA for excellence in HSE management systems.

Mindful of the challenge posed by the global climate change, in 2010 GPIC commissioned the Middle East's first Carbon Dioxide Recovery plant, capable of capturing 450 metric tons per day of Carbon Dioxide from the reformer flue gas, substantially improving its carbon footprint.

GPIC considers itself a role model in the protection of the environment, and was the first industrial company to use practical demonstration projects to verify the environmental credentials of its operations. A fish farm, bird sanctuary, palm tree plantations and herbal garden have been established at GPIC site.

## 3. PROFILE OF AXO WELDING

AXO WELDING is an Italian company specialized in servicing, repairing, and modifying static urea equipment.

Founded in 2004, in this fourteen years it served urea plants in Canada, Venezuela, Italy, Spain, Kingdom of Saudi Arabia, Malaysia, China, Bangladesh, Argentina, Iraq, India, and Vietnam. It is a qualified contractor of world-class companies such as PETRONAS, YARA, SABIC and many others. Its relationship with GPIC dates almost to its inception.

AXO WELDING offers a deep knowledge of the materials employed, of the manufacturing and welding techniques, and of the specific problems of the high-pressure section of urea plants.

Today, in addition to the core business of urea, AXO WELDING has diversified into a group of five companies based in Italy and Germany which operate in different industries such as offshore oil and gas, chipboard panels manufacturing, design and construction of storage tanks, design and construction of sluice, radial and flap gates for water canalization, and several others.

## 4. GPIC UREA PLANT

After a selection process, GPIC chose Mitsubishi Heavy Industries from Japan as the General Contractor and SNAMPROGETTI (now SAIPEM) from Italy as the licensor of the urea process technology.

All manufacturers of critical equipment – as well as the manufacturers of the materials in contact with the process fluid – were approved by the process licensor. The specifications applied in designing and manufacturing were state-of-the art for the time.

The layout of the high pressure section is that typical of SNAMPROGETTI / SAIPEM urea process, as outlined in the scheme in Figure 1.

Its main features at the time of commissioning were as follows:

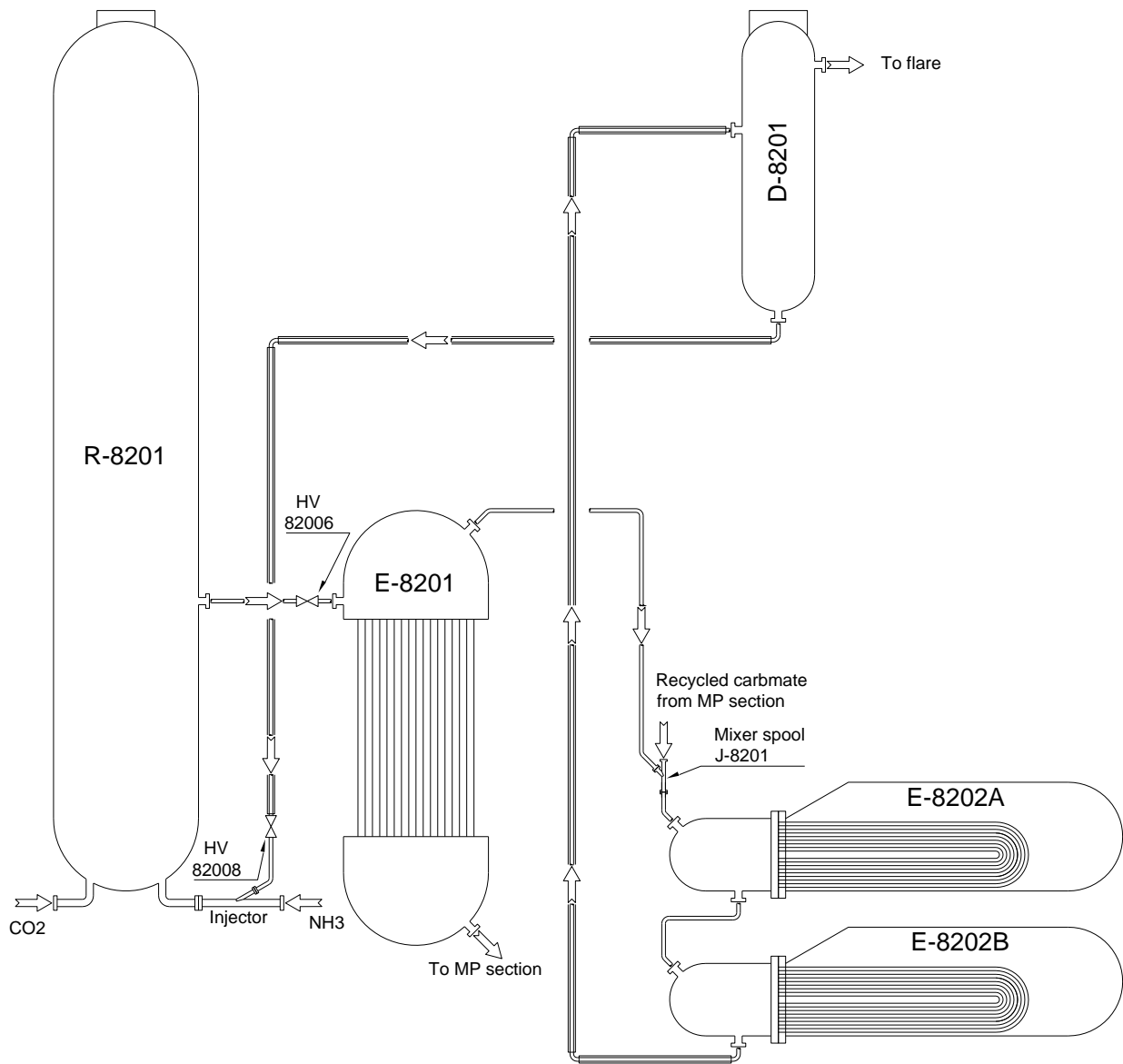
### Reactor R-8201:

- Equipment type: vertical pressure vessel
- Diameter: 2.011mm internal / 2.173mm external

- Height: 40m tangent line to tangent line
- Single-wall construction
- Material of construction, pressure shell: carbon steel (VdTÜV 440/1)
- Thickness of shell: 74mm
- Thickness of heads: 39mm
- Liner material: 316L Urea Grade
- Thickness of liner: 7mm
- Material of construction, overflow pipe: 316L Urea Grade
- Diameter / thickness of overflow pipe: Ø168.3mm / 7mm (fabricated from plate)
- Tray type: sieve tray
- Number of trays: 14
- Type of tray supports: double-gusset support as shown in Figure 2
- Material of construction, tray support: 316L Urea Grade
- Number of tray supports: 8 per tray
- Nozzle size: 6"

### **Stripper E-8201:**

- Equipment type: vertical tubular heat exchanger
- Stripper model: bimetallic
- Tube pitch: 33mm  $\Delta$
- Tube quantity: No. 1.832
- Tube length: 6m
- Tube diameter: 26.4mm o.d. / 21mm i.d.
- Tube thickness and material:  
1.7mm Zr inside / 2mm 25.22.2CrNiMo outside
- Tubesheet type: integral



**Figure 1:** high pressure loop

- Tubesheet material of construction: carbon steel + 10mm weld overlay 25.22.2CrNiMo
- Liner material: 25.22.2CrNiMo
- Liner thickness: 7mm
- Nozzle size: 6" (process nozzles)
- Passivation air: 70 Nm<sup>3</sup>/h

### **Carbamate condensers E-8202A/B**

- Equipment type: horizontal heat exchanger, kettle type with U-tube bundle

|                           | <b>E8202A</b> | <b>E8202B</b> |
|---------------------------|---------------|---------------|
| - Tube pitch:             | 23.8mm        | 23.8mm        |
| - Tube quantity:          | 1.044         | 418           |
| - Tube length (straight): | 12.000        | 6.000         |
| - Tube OD:                | 3/4"          | 3/4"          |

- Tube thickness: 14 BWG 14 BWG
- Tube material: 25.22.2CrNimo
- Nozzle size: 6" (process nozzles)

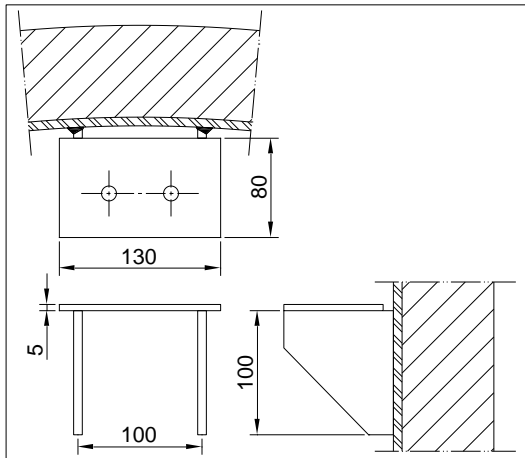


Figure 2: design of reactor tray supports

### Carbamate separator D-8201

- Equipment type: vertical pressure vessel
- Diameter: 1.400mm internal / 1.578mm external
- Height: 3.000mm tangent line to tangent line
- Single wall construction
- Material of construction: carbon steel SA516 grade 70
- Thickness of shell: 84mm
- Thickness of heads: 43mm
- Liner material: 316L Urea Grade
- Thickness of liner: 5mm
- Nozzle size: 6"

### Leak detection:

To fulfill the requirement of immediately detecting any leak that may find its way through the liner and corrode the pressure-containing shell – a very critical aspect in all urea high pressure equipment – the system implemented is a network of weep holes positioned near all liner welds, with the layout shown in figure 3.

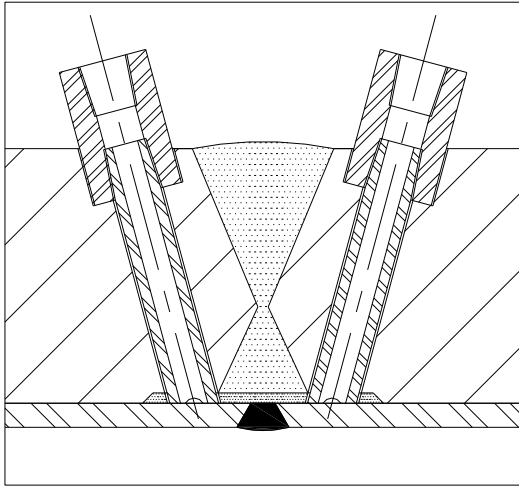
The weep hole network is the atmospheric pressure type, where the leak is driven towards the weep hole by the differential pressure between the process side and the atmosphere.

The number of weep holes is:

- 4 per each cylindrical course of liner
- 1 per each nozzle
- 2 per each section of liner on the heads
- 2 on the manways

## Piping

- Solution line R-8201 to E-8201:
  - Bare pipe
  - Pipe o.d.: 168.3mm (6")
  - Pipe thickness: 21.95mm (XXS)
  - Pipe material: 316L Urea Grade
- Gas line E-8201 to E-8202A and B:
  - Bare pipe
  - Pipe o.d.: 168.3mm (6")
  - Pipe thickness: 21.95mm (XXS)
  - Pipe material: 316L Urea Grade
- Condensate line E-8202A and B to D-8201:
  - Jacketed pipe
  - Jacket o.d.: 219mm (8")
  - Jacket thickness: 12.7mm (SCH 80)
  - Jacket material: carbon steel
  - Pipe o.d.: 168.3mm (6")
  - Pipe thickness: 21.95mm (XXS)
  - Pipe material: 316L Urea grade
- Condensate line D-8201 to HV-82008:
  - Jacketed pipe
  - Jacket o.d.: 219mm (8")
  - Jacket thickness: 12.7mm (SCH 80)
  - Jacket material: carbon steel
  - Pipe o.d.: 168.3mm (6")
  - Pipe thickness: 21.95mm (XXS)
  - Pipe material: 316L Urea grade
- Condensate line HV-82008 to R-8201:
  - Bare pipe
  - Pipe o.d.: 168.3mm (6")
  - Pipe thickness: 21.95mm (XXS)
  - Pipe material: 316L Urea Grade



**Figure 3:** leak-detection weep holes

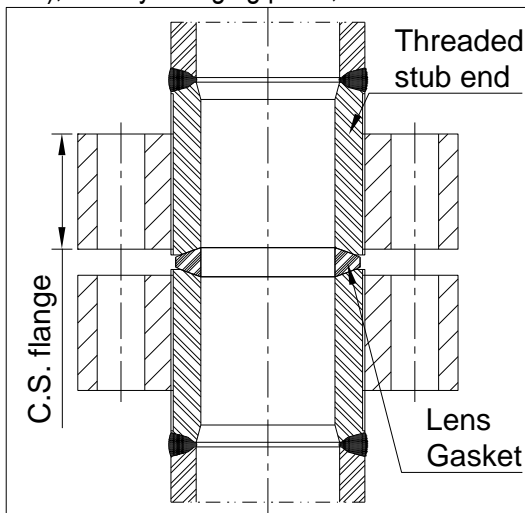
### **Flanged connections**

All flanged connections of the high pressure process piping, and all connections of the piping to a nozzle of the equipment in the high pressure loop, are of the lens-gasket type shown in figure 4.

This type of flanged connection has a number of advantages useful in urea high pressure process lines:

- The gasket is metallic, and it can be made from a corrosion resistant urea grade material
- The internal diameter of the gasket matches the internal diameter of the nozzle, creating a smooth internal profile and thus avoiding vortices or other disturbances to the flow of fluid, which may start localized corrosion
- The gasket seat is contained within the thickness of the nozzle itself and the flange can be in carbon steel, with a considerable reduction of cost.

Lens-gasket connections are installed on pipe by welding a threaded nozzle (also called a threaded stub end), usually a forging piece, to the end of the pipe. The flange is loose and it is screwed on the nozzle.



**Figure 4:** lens-gasket type connection

## **5. RESULTS OF THE FIRST INSPECTIONS**

The equipment was inspected a first time right before commissioning in November 1997, then again in 1998 after one year in operation, in order to release the guarantees. In 1999, due to a problem in the medium pressure decomposition section, the plant was shut down briefly, providing a chance for a third inspection, and finally in 2000 the first scheduled turnaround took place. All inspections included a visual examination and the measurement of the liner thickness and of the ferrite content of the liner welds.

In spite of the great deal of dedication that GPIC, the Main Contractor, and the Process Licensor put in the procurement process, in the reactor these first four inspections evidenced a worrisome corrosion phenomenon that, albeit in an initial status, showed a marked progression rate over time. The corrosion affected:

- The liner welds, mostly in the heat affected zone but in some instances also in the weld bead at the location of the start / stop points.
- The welds joining the tray supports to the liner.
- The tray support cleats and gussets.
- The welds joining the overflow pipe brackets and the liner.
- The longitudinal weld of the overflow pipe.
- The welds of the trays.

## 6. TURNAROUND 2003:

5 years since commissioning

Table 1 shows the risk analysis and the consequent plan of action carried out in preparation for turnaround 2003

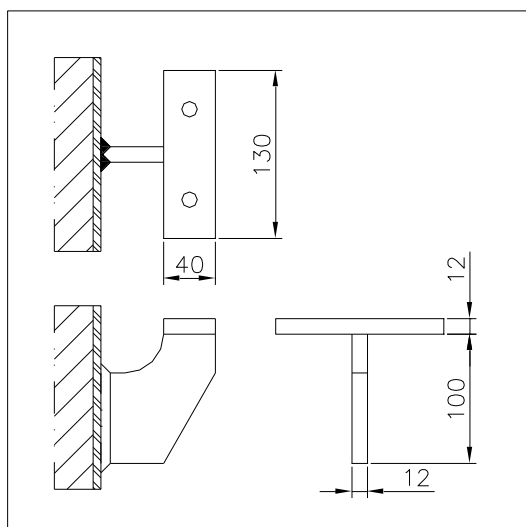
| Table 1: risk analysis and action plan for turnaround 2003 |   |   |   |  |   |
|--|---|---|---|--|---|
| Equipment  | Item  | Problem or hazard to prevent  | Aim of preventive action  | Detail of preventive action  | Notes   |
| Urea Reactor   | R-8201  | Stress and fatigue of personnel during inspection and maintenance activities  | Provide a better method to access, evacuate and transport material and equipment  | - Install a 1.500Kg electric hoist on top of reactor<br>- Supply a load-tested manbasket.  | Mounted on dedicated, specifically designed structure |
|  |   |   | Improve the environmental conditions inside the reactor   | Install a chiller-blower unit to blow cool air from the bottom nozzles   |   |
|  |   | Difficult or impossible monitoring of the work inside the reactor by operational and safety personnel on duty outside | Guarantee that reactor inside-to-outside communication is always working and that it does not suffer from interference with other groups of workers | Install a dedicated cable intercom system  |   |
|  |   |   | Guarantee that the inside of the reactor is fully visible from the top  | Install a specific illumination system   |   |
|  |   | Corrosion on liner plates   | Increase reliability of equipment and on-stream time  | Install new liner strips over the existing liner at the location of tray #1 through tray #12<br>Each liner strip is equipped with No. 2 new weep holes | Material upgraded to 25.22.2CrNiMo                    |
| Knife line corrosion in the HAZ of liner welds             | Increase the general safety and reliability of the equipment by reducing the risk of a leak | Repair No. 8 circumferential welds and No. 2 longitudinal welds   | Welding process: manual GTAW<br>Filler material: 25.22.2CrNiMo  |  |   |



| Table 1: risk analysis and action plan for turnaround 2003 |      |   |   |  |                                    |
|--|------|---|---|--|------------------------------------|
| Equipment  | Item | Problem or hazard to prevent  | Aim of preventive action  | Detail of preventive action  | Notes                              |
|  |      | Welds of tray supports and overflow pipe brackets suspected to be partial penetration. Some corners of the tray supports are difficult to see and inspect | Increase ease of inspection to increase the chance of spotting possible problems early.<br>Increase general safety of equipment by making sure that a leak does not happen at the location of tray supports | - The new liner strips are inclusive of tray supports of new design.<br>- Install new brackets for overflow pipe         | Material upgrade to 25.22.2CrNiMo  |
|  |      | Design of welds of solution outlet nozzle and NH3 and CO2 inlet nozzles may not guarantee that a leak is immediately detected through a weep hole         | Increase the general safety of the equipment by insuring that any leak is immediately spotted   | Install cover strips around solution outlet nozzle, NH3 and CO2 inlet nozzles.<br>Each strip is monitored by a weep hole | Material upgraded to 25.22.2CrNiMo |

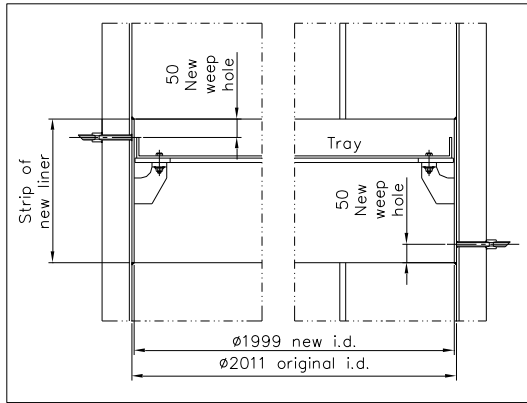
On the light of the findings of the first four inspections, in planning turnaround 2003 the focus was totally on improving the reactor, with the main concern being the corrosion process in progress. Addressing the corrosion on the tray supports was a matter of extreme urgency, because a leak in the welds between the supports and the liner might not reach the leak detection system with potentially catastrophic consequences. On the other hand there was also a need to rectify the liner welds and to stop (or significantly slow down) the rapid progress of the corrosion, and to do all that within the time-window of the turnaround.

To fulfill all these requirements GPIC decided to begin a relining project and – at the same time – to replace all tray supports. The material of the new liner and supports would be improved to 25.22.2CrNiMo – which has proven to have a much lower corrosion rate at the process conditions of SAIPEM reactor – and the design of the new supports would be changed to that shown in figure 5, in order to make it easier to inspect them.



**Figure 5:** design of new tray supports

The relining project would be carried out in phases, with only a part of the reactor surface being covered at each turnaround. To begin with, then, in 2003 No. 12 strips of new liner were installed at the location of tray #1 through tray #12. The strips of new liner were fabricated complete with new supports and to guarantee leak detection, No. 2 new weep holes were made for each strip. Figure 6 illustrates the scheme of installation of the new strips of new liner.



**Figure 6:** scheme of installation of new liner strips

The planned modification required an extensive amount of work to be carried out inside the reactor, a potentially dangerous environment where the hazards typical of a confined space sum up with the hazards of working at height. The solution adopted to address this HSE issue consisted in:

- A new way to transport personnel and materials in and out of the reactor by means of an electric hoist and manbaskets,
- A specially-designed aluminum platform to support the personnel at the working elevation
- the use of a powerful chiller/blower unit connected to the bottom nozzles to guarantee a constant air exchange and a comfortable working environment.
- A cable-intercom system to guarantee good communication between the workers inside the reactor and those on top and outside it.
- A specifically procured, low-voltage illumination system based on a number of lamps attached to a single cable.

Figure 7 shows the inside of the reactor as seen from the top manway, after the implementation of the actions.



**Figure 7:** work in progress inside the reactor

## 7. TURNAROUND 2005

7 years since commissioning

Table 2 shows the risk analysis and planned actions for turnaround 2005

| Table 2: risk analysis and action plan for turnaround 2005 |        |  |  |  |   |
|--|--------|--|--|--|---|
| Equipment  | Item   | Problem or hazard to prevent   | Aim of preventive action   | Detail of preventive action  | Notes   |
| Urea Reactor   | R-8201 | The top hoist, which was willingly oversized in order to guarantee an abundant safety factor in comparison with the actual load that it carries, is strong enough to damage the internals and possibly endanger the personnel working inside | Reduce the power of the hoist without reducing its SWL                                     | Install a load-limiting device in top hoist.   | Working by direct measurement of load through a load cell                               |
|  |        | Corrosion on liner plates  | Increase reliability of reactor and on-stream time.  | Install new liner strips over the existing liner at tray #13 and #14. Each strip is equipped with No. 2 new weep holes | This is the completion of the action started in 2003. Material upgrade to 25.22.2CrNiMo |
|  |        | Knife line corrosion in the HAZ of liner welds<br>Corrosion in the weld bead of liner welds  | Prevent leaks.<br>Increase the general safety and reliability of the equipment.            | Perform extensive repair program of liner welds.   | Welding process: manual GTAW<br>Filler material: 25.22.2CrNiMo                          |
|  |        | Corrosion on base material and welds of overflow pipe  | Prevent a reduction in the production volumes consequent to a bypass in the overflow pipe. | Replace 100% of overflow pipe.   |   |
| Urea Stripper  | E-8201 | Initial corrosion in the Tube-Tubesheet (TTS) welds of bottom tubesheet, located in the Heat Affected Zone (HAZ) on the tubesheet side (weld overlay)  | Prevent leaks.<br>Increase the reliability of the equipment.                               | Perform weld repair of tube-to-tubesheet welds.  | Welding process: manual GTAW<br>Filler material: 25.22.2CrNiMo                          |
| HP Piping  | N/A    | Corrosion on the sealing surface of the flanged joints (metal, lens gasket type)   | Prevent leaks.   | Cut and replace some of the pipe's threaded stub ends as per inspection findings                                       | Material upgrade to 25.22.2CrNiMo   |

### Reactor R-8201

The planning of Turnaround 2005 was still very much focused on the reactor. The work started in 2003 proceeded with:

- the installation of new strips at tray #13 and #14
- an extensive scope of repair of the welds of the liner, which consisted in grinding the corroded area to a maximum depth of 2mm and making an overlay bead using 25.22.2CrNiMo weld material.
- The complete removal and replacement of the overflow pipe

On the HSE front, three years after its installation the top hoist was upgraded with the addition of a safety system which limited its maximum capacity.

The hoist chosen for the installation on top of the reactor has a Safe Working Load of 1.5 tons, which is 3-4 times higher than the maximum load that will be moved in the reactor according to the working procedures in place. The reason for this choice is that the hoist is used for lifting personnel, and so we would prefer to add a further safety factor (ratio between the nominal Safe Working Load and the load that the hoist is actually capable of lifting) to what the machine is already built with. As a result, we have a very powerful machine which will not break down while lifting a worker, but on the other hand we also have a machine that – should the hook get entangled into some element into the reactor – is capable of creating damage and possible danger for the persons working inside.

The upgrade installed is based on a load cell positioned in the central pulley, which measures in real time the actual load on the hook and automatically stops the lifting movement when a maximum load (which can be set) is exceeded.

## Stripper E-8201

During Turnaround 2005 we started the first repair on the bimetallic stripper.

The repair consisted in a careful grinding – made by pencil grinder – and re-welding of the tubesheet weld overlay in the space between the tubes and of the tube-to-tubesheet welds, at the bottom tubesheet.

## High pressure piping

GPIC inspection checked the condition of the threaded stub ends. They marked those where the corrosion progress was too advanced to guarantee a good operation without leaking until the next turnaround, and a team from AXO WELDING was dedicated to cut and replace them with new pieces.

## 8. TURNAROUND 2007

9 years since commissioning

| Table 3: risk analysis and action plan for turnaround 2007 |        |   |  |  |  |
|--|--------|---|--|--|--|
| Equipment  | Item   | Problem or hazard to prevent  | Aim of preventive action   | Detail of preventive action  | Notes  |
| Urea Reactor   | R-8201 | Corrosion on the sealing surface of the manway cover and on the liner of the manway neck                | Prevent leaks<br>Increase the equipment safety and reliability                 | Replace gasket seat and nozzle liner on top manway   | Material upgrade to 25.22.2CrNiMo                              |
|  |        | Corrosion of liner plates and liner welds   | Increase reliability of equipment and on-stream time.                          | Install new liner on top dome and above tray #1  | Material upgrade to 25.22.2CrNiMo                              |
|  |        | Knife line corrosion in the HAZ of liner welds  | Prevent leaks<br>Increase safety and reliability of equipment                  | Perform extensive repair of welds of original liner  | Welding process: manual GTAW<br>Filler material: 25.22.2CrNiMo |
|  |        | Thinning out of sieve trays due to corrosion  | Prevent the loss of production volume due to decreased conversion of carbamate | Procure and install sieve trays No. 4, 5, 8, 9, 10, 11, 12, 13 and 14 (9 Nos)                                  | Material upgrade to 25.22.2CrNiMo                              |
| Urea Stripper  | E-8201 | Corrosion in the area of the bottom tubesheet weld overlay which has not been covered by the TTS welds. | Prevent leaks<br>Increase safety and reliability of the equipment              | Repair bottom tubesheet: manual GTAW recharge of tubesheet weld overlay in between the tube-to-tubesheet welds | Welding process: manual GTAW<br>Filler material: 25.22.2CrNiMo |

| Table 3: risk analysis and action plan for turnaround 2007 |      |  |                          |  |                                   |
|--|------|--|--------------------------|--|-----------------------------------|
| Equipment  | Item | Problem or hazard to prevent   | Aim of preventive action | Detail of preventive action  | Notes                             |
| HP Piping  | N/A  | Corrosion on the sealing surface of the flanged joints (metal, lens gasket type) | Prevent leaks            | Inspect the threaded stub-ends, identify cut and replace the corroded ones | Material upgrade to 25.22.2CrNiMo |

## Reactor R-8201

For T/A 2007 the planned scope of work on the reactor included:

- The replacement of the stainless steel ring that forms the seat of the manway gasket (see figure 8)
- The relining of the top dome and the area above tray #1
- The replacement of some trays

Figure 9 shows the principle of the relining job: the new liner is applied in tiles – or strips – small enough to be introduced into the manway  $\text{\O}500\text{mm}$ . The tiles are welded on the existing liner and the leak detection is guaranteed by two features:

- One new weep holes is drilled through the reactor wall
- A gap is left into the weld of each tile, then this gap is covered by a cover pad
- The weld of the strip installed in 2003 is carved into, to produce a gap which is then covered by a cover pad

The presence of gaps in the weld provide a way for a possible leak to get to the nearest weep hole

## Stripper E-8201 and High pressure piping

The job performed on the bimetallic stripper and the piping was similar to what we did in 2005

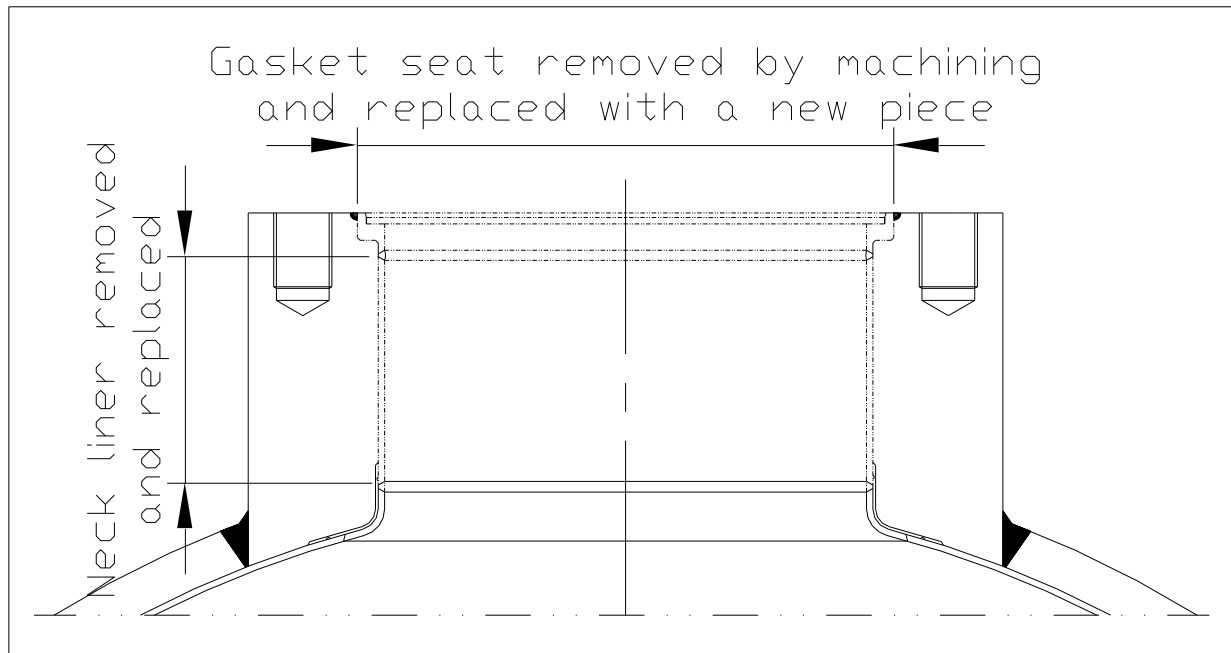


Figure 8: scheme of relining of manway

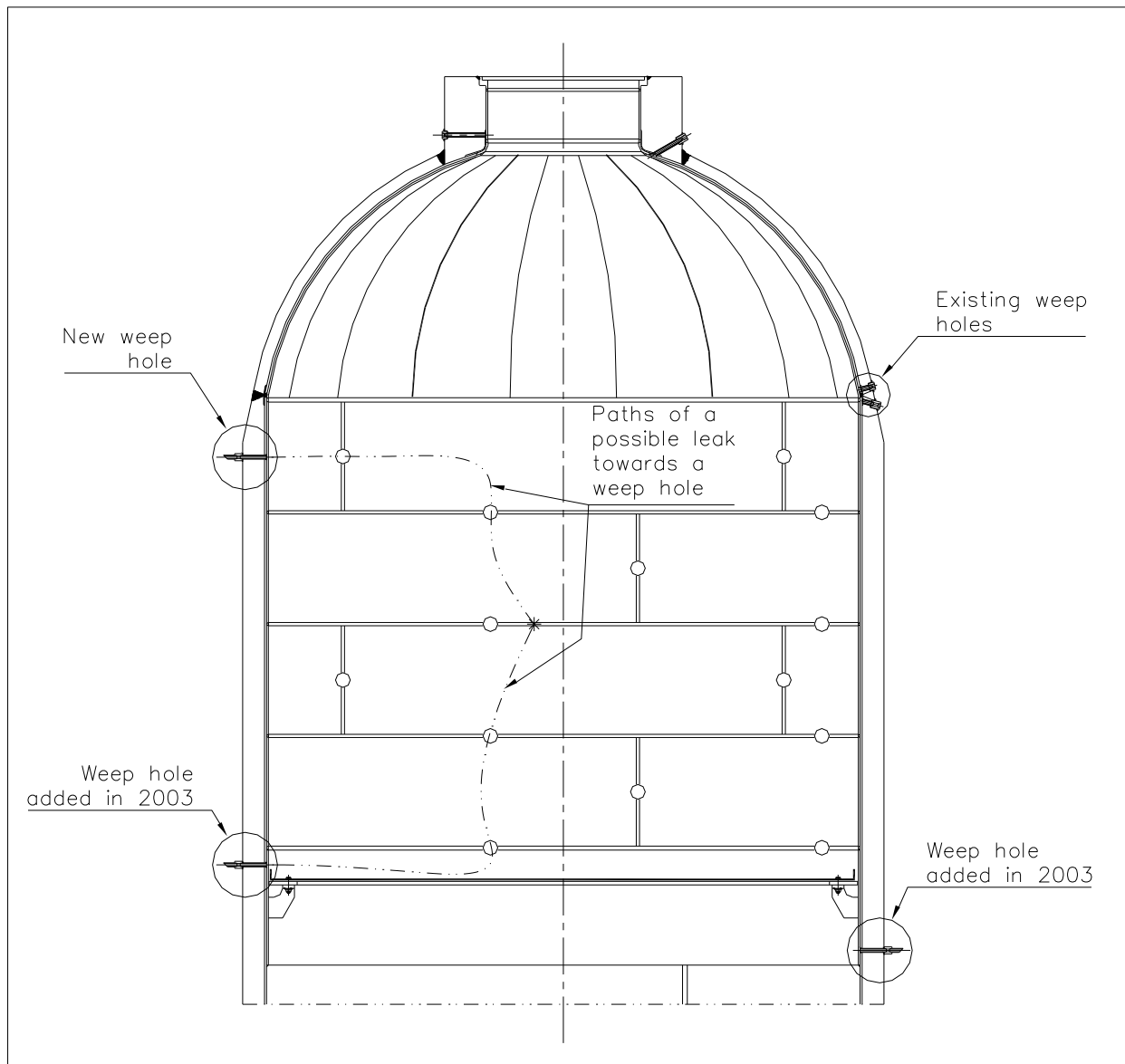


Figure 9: scheme of reactor relining

## 9. TURNAROUND 2009

11 years since commissioning

Table 4: risk analysis and action plan for turnaround 2009

| Equipment     | Item   | Problem or hazard to prevent   | Aim of preventive action   | Detail of preventive action   | Notes  |
|---------------|--------|--|--|---|--|
| Urea Reactor  | R-8201 | Corrosion of liner plates  | Increase reliability of equipment and on-stream time.                            | Install new liner between tray #1 and tray #5                           | Material upgrade to 25.22.2CrNiMo                              |
|               |        | Knife corrosion in the HAZ of liner welds and general corrosion of liner welds | Prevent leaks<br>Increase safety and reliability of equipment                    | Repair welds of original liner in the area not covered by the new liner | Welding process: manual GTAW<br>Filler material: 25.22.2CrNiMo |
| Urea Stripper | E-8201 | Production bottleneck  | Increase the production volumes and improve the general reliability of the plant | Replace 25.22.2CrNiMo bimetallic stripper with new, Omega Bond unit     |  |

| Table 4: risk analysis and action plan for turnaround 2009 |                    |  |  |   |  |
|--|--------------------|--|--|---|--|
| Equipment  | Item               | Problem or hazard to prevent   | Aim of preventive action   | Detail of preventive action   | Notes  |
|  |                    | Loss of production due to malfunctioning of new unit                             | Rehabilitate the old stripper in order to keep is as a backup                    | Extensive repair of tube-to-tubesheet welds at bottom tubesheet and liner of bottom channel of replaced bimetallic stripper   | Welding process: manual GTAW<br>Filler material: 25.22.2CrNiMo |
| Carbamate condensers                                       | E-8202A<br>E-8202B | Corrosion of tubesheets  | Prevent leaks<br>Increase safety and reliability of equipment                    | Inspect tubesheet, identify and repair areas of possible corrosion attack   | Welding process: manual GTAW<br>Filler material: 25.22.2CrNiMo |
| Carbamate separator  | D-8201             | Knife line corrosion in the HAZ of liner welds                                   | Prevent leaks  | Repair and rehabilitation of liner welds  | Welding process: manual GTAW<br>Filler material: 25.22.2CrNiMo |
| HP piping  | N/A                | Production bottleneck  | Increase the production volumes and improve the general reliability of the plant | Modified piping to suit the new Omega-Bond Stripper:<br>Raised elevation of vapor outlet line by 164mm<br>Raised elevation of solution inlet line R-8201 to E-8201 by 170mm<br>Changed diameter of part of solution inlet line R-8201 to E-8201 from 6" to 8"<br>Replaced No. 2 thermowells for temperature probe | Material upgrade to 25.22.2CrNiMo                              |
|  |                    | Corrosion on the sealing surface of the flanged joints (metal, lens gasket type) | Prevent leaks  | Replace stub ends as per inspection findings  | Material upgrade to 25.22.2CrNiMo                              |

In 2009 the plant had been running for 12 years and – while the reactor had an ongoing plan – in order to keep up the reliability of the high pressure loop other equipment needed some attention. In addition, GPIC wanted to increase the volumes of production of urea.

Based on these premises, GPIC decided to replace the stripper with a new unit – based on SAIPEM Omega Bond technology – that would grant a higher production volume thanks to the higher corrosion resistance and the process nozzles 8” in diameter, while those of the old unit were 6”.

To exploit in full the new nozzle size, obviously, the connecting piping needed to be updated too. For this reason, starting from T/A 2009, GPIC begun the replacement of the high pressure piping.

Since the old bimetallic stripper was still far from the end of its operational life, after the turnaround a team of welders from AXO WELDING and inspectors from GPIC rehabilitated it through an extensive scope of repair of the bottom tubesheet and the liner, then the equipment was safely stored to be used as a backup unit.

Also, from 2009 on, weld repair of corroded areas was extended to all equipment of the high pressure loop, with special care being dedicated to the carbamate condensers.

## 10. TURNAROUND 2012

14 years since commissioning

| Table 5: risk analysis and action plan for turnaround 2012 |                    |   |  |   |   |
|--|--------------------|---|--|---|---|
| Equipment  | Item               | Problem or hazard to prevent  | Aim of preventive action   | Detail of preventive action   | Notes   |
| Urea Reactor   | R-8201             | Corrosion of liner plates   | Increase reliability of equipment and on-stream time.  | Install new liner between tray #5 and tray #10  | Material upgrade to 25.22.2CrNiMo                                     |
|  |                    | Knife line corrosion in the HAZ of liner welds and general corrosion of liner welds | Prevent leaks<br>Increase safety and reliability of equipment  | Repair welds of original liner in the area not covered by the new liner   | Welding process: manual GTAW<br>Filler material: 25.22.2CrNiMo        |
|  |                    | Corrosion of the manway cover liner   | Prevent leaks  | Recharge by welding and re-machine cover  | Welding process: manual GTAW<br>Filler material: 25.22.2CrNiMo        |
| Carbamate condensers                                       | E-8202A<br>E-8202B | Corrosion of tubesheets   | Prevent leaks<br>Increase safety and reliability of equipment  | Inspect tubesheet, identify and repair areas of possible corrosion attack   | Welding process: manual GTAW<br>Filler material: 25.22.2CrNiMo        |
| Carbamate separator  | D-8201             | Knife line corrosion in the HAZ of liner welds                                      | Prevent leaks  | Repair and rehabilitation of liner welds  | Welding process: manual GTAW<br>Filler material: 25.22.2CrNiMo        |
| HP Piping  |                    | Production bottleneck<br>Corrosion of piping material                               | Increase the production volumes and improve the general reliability of the plant<br>Bring the piping up-to-level with the increased size of the new stripper | Replace HP lines:<br>Solution outlet line R-8201 to E-8201<br>Liquid outlet line D-8201 outlet nozzle to HV-82008 upstream flange (jacketed line) | Diameter increased from 6" to 8"<br>Material upgrade to 25.22.2CrNiMo |
|  |                    | Corrosion on the sealing surface of the flanged joints (metal, lens gasket type)    | Prevent leaks  | Replace stub ends as per inspection findings  | Material upgrade to 25.22.2CrNiMo                                     |

Debottlenecking of the high pressure piping was an extensive part of the work in 2012, with the replacement of the bare solution outlet line that connects reactor R-8201 to stripper E-8201 and the jacketed line that brings the recycled carbamate fluid from carbamate separator D-8201 to valve HV-82008.

The job was performed in two phases: the prefabrication of the spools took place in GPIC workshop before the plant shutdown and the installation of the same spools on site was carried out during the 19 days turnaround.

In the reactor, the relining was extended to the elevation of tray #10 and the manway cover was recharged by welding and machined at GPIC machine shop, to remove some corrosion that appeared on the cover liner. Carbamate condensers and carbamate separators were subject to inspection and repair



## 11. TURNAROUND 2015

17 years since commissioning

| Table 6: risk analysis and action plan for turnaround 2015 |                    |   |   |   |  |
|--|--------------------|---|---|---|--|
| Equipment  | Item               | Problem or hazard to prevent  | Aim of preventive action                                      | Detail of preventive action   | Notes  |
| Urea Reactor   | R-8201             | Corrosion of liner plates   | Increase reliability of equipment and on-stream time.         | Install new liner between tray #11 and tray #14   | Material upgrade to 25.22.2CrNiMo                              |
|  |                    | Knife line corrosion in the HAZ of liner welds and general corrosion of liner welds | Prevent leaks<br>Increase safety and reliability of equipment | Repair welds of original liner in the area not covered by the new liner                               | With filler material 25.22.2CrNiMo                             |
| Carbamate condensers                                       | E-8202A<br>E-8202B | Corrosion of tubesheets   | Prevent leaks<br>Increase safety and reliability of equipment | Inspect tubesheet, identify and repair areas of possible corrosion attack                             | Welding process: manual GTAW<br>Filler material: 25.22.2CrNiMo |
| Carbamate separator  | D-8201             | Knife line corrosion in the HAZ of liner welds                                      | Prevent leaks   | Repair and rehabilitation of liner welds  | With filler material 25.22.2CrNiMo                             |
| HP Piping  | N/A                | Recurrent leak from flange of valve HV-82008 (recycled carbamate inlet line)        | Improve the general reliability of the plant                  | Re-align the valve by identifying and correcting the geometrical error in the piping spool downstream | Material upgrade to 25.22.2CrNiMo                              |
|  |                    | Corrosion on the sealing surface of the flanged joints (metal, lens gasket type)    | Prevent leaks   | Replace stub ends as per inspection findings  | Material upgrade to 25.22.2CrNiMo                              |

HV-82008 is the recycled carbamate check valve, positioned between carbamate separator D-8201 and reactor R-8201. This valve had had problems of leaks from the downstream flange practically since the plant commissioning. A measurement of the spools downstream the valve evidenced a dimensional error. We solved the leak problem by replacing them with new spools that we fabricated on site

## 12. TURNAROUND 2018

20 years after commissioning

| Table 7: risk analysis and action plan for turnaround 2018 |        |   |  |  |                                    |
|--|--------|---|--|--|------------------------------------|
| Equipment  | Item   | Problem or hazard to prevent  | Aim of preventive action   | Detail of preventive action                                | Notes                              |
| Urea Reactor   | R-8201 | Corrosion of liner plates   | Increase reliability of equipment and on-stream time.                | Install new liner between tray #14 and bottom tangent line | Material upgrade to 25.22.2CrNiMo  |
|  |        | Knife line corrosion in the HAZ of liner welds and general corrosion of liner welds | Prevent leaks<br>Increase safety and reliability of equipment        | Small repairs on the reactor bottom                        | With filler material 25.22.2CrNiMo |
|  |        | Corrosion of solution outlet nozzle N1  | Increase safety and reliability of equipment and on-stream time.     | Removed and replaced existing N1 nozzle.                   | Material upgrade to 25.22.2CrNiMo  |
|  |        | Corrosion of elbow of overflow pipe   | Prevent a reduction in the production volumes consequent to a bypass | Removed and replaced elbow                                 |                                    |

| Table 7: risk analysis and action plan for turnaround 2018 |         |  |  |   |   |
|--|---------|--|--|---|---|
| Equipment  | Item    | Problem or hazard to prevent   | Aim of preventive action   | Detail of preventive action   | Notes   |
| Carbamate condenser  | E-8202A | Corrosion of tubesheet   | Prevent leaks<br>Increase safety and reliability of equipment  | Inspect tubesheet, identify and repair areas of possible corrosion attack   | Welding process: manual GTAW<br>Filler material: 25.22.2CrNiMo                              |
| Carbamate condenser  | E-8202B | End of operational life  | Increase reliability of plant  | Replace equipment with new unit   | Cut outlet spool from old unit and re-used.<br>Cut and adapted jacketed inlet process line. |
| Carbamate preheater  |         | Corrosion of tubesheet   | Prevent leaks<br>Increase safety and reliability of equipment  | Inspect tubesheet, identify and repair areas of possible corrosion attack   | Welding process: manual GTAW<br>Filler material: 25.22.2CrNiMo                              |
| Carbamate separator  | D-8201  | Knife corrosion in the HAZ of liner welds and cover                              | Prevent leaks  | Repair and rehabilitation of liner welds  | With filler material 25.22.2CrNiMo  |
| HP Piping  |         | Production bottleneck.<br>Corrosion of piping material                           | Increase the production volumes and improve the general reliability of the plant<br>Bring the piping up-to-level with the increased size of the new stripper | - Replace vapor outlet line from stripper E-8201 to carbamate condenser E-8202A.<br>- Replace parts of mixer spool J-8201<br>- Replace of bottom spool piece of stripper E-8201 | Diameter increased from 6" to 8"<br>Material upgrade to 25.22.2CrNiMo                       |
|  |         | Corrosion on the sealing surface of the flanged joints (metal, lens gasket type) | Prevent leaks  | Replace stub ends as per inspection findings  | Material upgrade to 25.22.2CrNiMo   |

## Reactor R-8201

With turnaround 2018 the internal surface of the reactor has been covered by a new liner of upgraded 25.22.2CrNiMo material from the gasket seat of the top manway down to the bottom tangent line. The only part of the original 316L Urea Grade liner that is still in contact with the process fluid is the bottom dome.

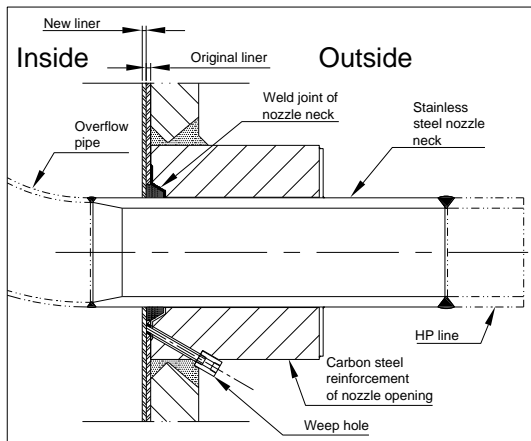
Although the surface of the new liner appears bright and rough, the actual loss of thickness has been negligible, even in the first strips – those installed in 2003, which have been in operation for 15 years.

For completeness of information, it must be said that in June 2013 a leak was caused by a pinhole in the weld of one of the cover pads of the liner strip of tray #4. After detection and repair no other negative events were recorded.

During this turnaround the most critical activity was the replacement of solution outlet nozzle N1, for which we followed this procedure:

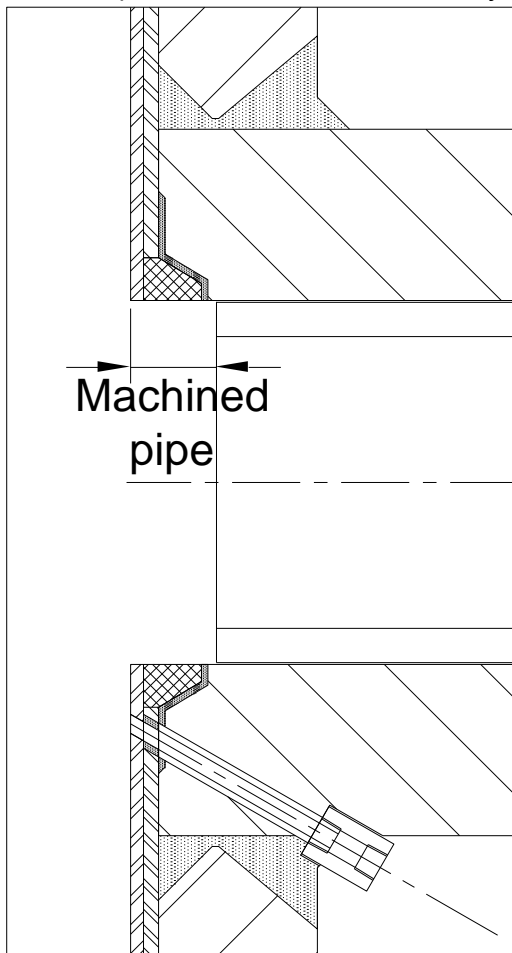
**Note:** The area around nozzle N1 had already been subject to relining. The initial layout was as shown in figure 10

1. Using a manual grinder, cut free the nozzle neck from the high pressure pipe outside the reactor and from the internal overflow pipe

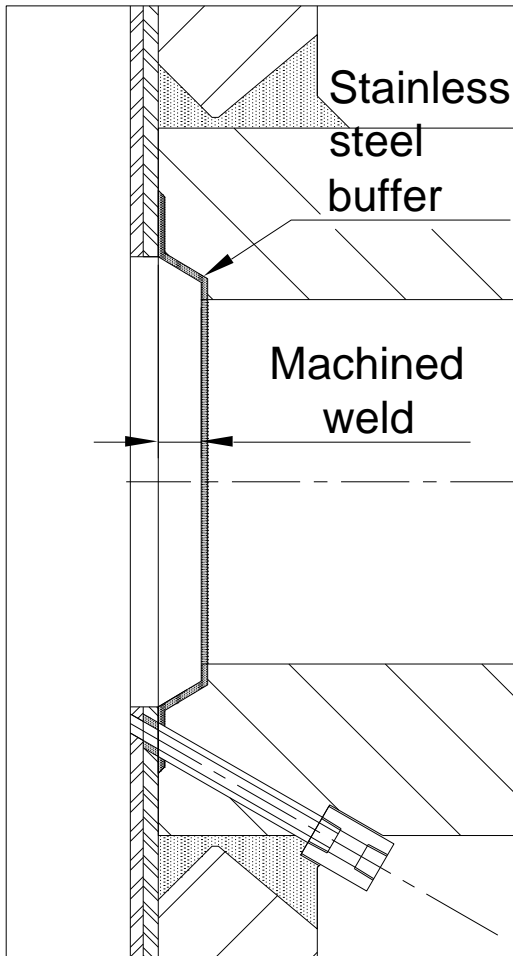


**Figure 10** initial layout of N1

2. Extend the weep hole through the thickness of the liner by manual drilling.
3. Cut the internal stub flush to the internal surface
4. Machine the pipe through the whole thickness of the weld joint (Figure 11)
5. Remove the nozzle and machine the weld joint, taking care not to remove the stainless steel buffer layer that separates the stainless steel weld joint from the carbon steel shell (Figure 12)



**Figure 11:** machined nozzle



**Figure 12:** nozzle N1 after removal of pipe and machining of weld

6. Insert new nozzle pipe and weld the pipe-to-shell joint

**Note:** the presence of a stainless steel buffer layer avoids the requirement for a Post Weld Heat Treatment which would otherwise be mandatory if the weld interested the carbon steel shell directly.

**Note:** since volumetric NDE (RT or UT) of the joint was not feasible, PT inspection was performed on each weld layer.

7. Grind the weld flush with the liner surface
8. Add a new layer of lining in the form of a ring surrounding the nozzle, to protect the weld from contact with the process fluid.
9. Leak detection of the welds of the additional liner is guaranteed by the extended weep hole.

The modified layout after the replacement is shown in Figure 13

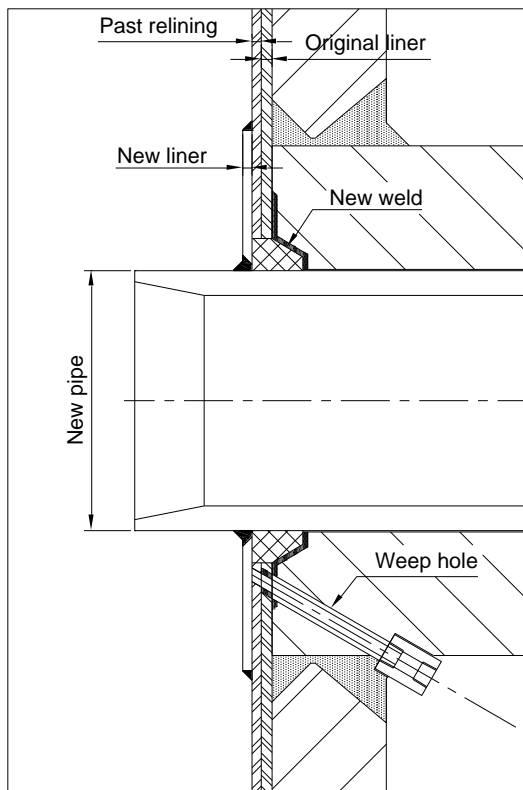


Figure 13: final layout of nozzle N1

## Carbamate condenser E-8202B

During turnaround 2018 carbamate condenser E-8202B was replaced with a new equipment

### High pressure piping

The modification works on the high pressure piping were quite extensive, having concerned the complete replacement of the vapor outlet line that connects stripper E-8201 to the carbamate condensers, the modification of the connection lines to suit the new carbamate condenser, the rehabilitation of spool J-8201 (which mix the solution from E-8201 with that coming from MP loop) and the replacement of several threaded stub ends.

## 13. CONCLUSION

In the course of 15 years and 7 turnarounds, GPIC and AXO WELDING have carried out an extensive program of modifications, replacements and improvements, which were related to mostly – if not all – the critical parts of the high pressure synthesis section, the very heart of its urea plant.

Methodic planning, careful attention to detail, excellent co-operation and communication between the parties involved, thorough preliminary safety analysis of each job and reliance on expert and skilled personnel has brought outstanding records of on-stream time, while all the workers involved in the projects – especially those who performed the most hazardous tasks, at the end of each turnaround always got back to their families safe and in good health.