Round Table Discussion

We have a leak...
Do we need to stop the plant?
• Introduction

• Cases: We have a leak !… Do we need to stop the plant ?
  1. Leak in a weld-o-let
  2. Leak in weld of a NH3 pipeline
  3. Leaking flange connection
  4. Leaks in valves

• Conclusions
AmmoniaKnowHow.com & UreaKnowHow.com

Internet platforms to exchange technical information within the nitrogen fertilizer industry with the target to improve the Safety and Performance of nitrogen fertilizer plants

>12,000 Members representing all nitrogen fertilizer plants worldwide

Catalyzing Safety & Performance

E-library

Biweekly a Technical paper
Special Thanks to:

Prem Baboo, Dangote Fertilizers, Nigeria
Dan Cojocaru, AmmoniaKnowHow.com, UK
Jo Eijkenboom, UreaKnowHow.com, the Netherlands
Majid Mohammadian, OCI, The Netherlands
Giel Notten, NTT Consultancy, The Netherlands

Note:
Cases are modified to serve better the workshop character of the AICHE Round Table discussions
One of the conclusions of our AICHE2018 presentation “Lessons Learned from Urea Plant Incidents”

• In case of a leak, stop the plant

Reaction from the audience:
More easy said than done …
What if you are running the plant!
How to assess the risks of a leak?
What can we learn from earlier cases?
AICHE 2019:
Round Table Discussion Cases

We have a leak...
Do we need to stop the plant?
Introduction
Why easily leaks occur in urea plants?

Corrosion challenges
- A urea plant continuously fights against corrosion (due to presence of ammonium carbamate)
- Passive corrosion reduces wall thicknesses continuously
- Between two parts a crevice exist and crevice corrosion may occur

Sealing challenges
- A limited number of special urea grade materials can only be applied
- Hardness figures do not always differ a lot
- More attention required to properly seal two parts
Leaks in High Pressure Piping, Valves & Accessories

Some general remarks

• A relative high number of safety incidents occur with high pressure 316L UG carbamate lines and NH$_3$ and CO$_2$ carbon steel feed lines.

• Many failure modes exist when using standard materials like 316L UG and carbon steel.

• Many welds of piping systems are made in the field instead of shop.

• Welds in low pressure parts of feed lines are typically considered a lower risk level.

• Piping systems are typically difficult to inspect and to reach.

• Applying higher alloy material solves most / all failure modes.
1. Leak in weld-o-let

Liquid flow from Reactor to HP Stripper

8"

Pinhole leak

1½"

Thermowell

316L UG materials
Line of events

- On February 9, 2000 operators note a leak in the weld-o-let of a temperature measurement in the line from the urea reactor to the CO₂ stripper in a Stamicarbon technology urea plant built in 1976.
- The plant was running stable at 100% load.
- Weld-o-let was 24 years in operation.
- Turnaround is scheduled after 2 months....
1. Leak in weld-o-let

Liquid flow from Reactor to HP Stripper

Pinhole leak

Thermo well
Round Table Discussion

We have a leak...!

Do we need to stop the plant?
Let's start with a Risk Assessment

- Weld-o-let was 24 years in operation
- 316L UG materials, not an optimal design (many welds)
- Temperature 184 °C, Pressure 140 bars
- Process medium is liquid (gas phase would be much more risky)
- First leak in this plant
- No previous similar cases known in the industry…but what is known?
- Leak looks like a pinhole, no signs of a crack
- No previous corrosion inspections were done
- Expected corrosion rate for liquid carbamate is 0.01 mm/year, wall thickness is 5.0 mm…after 24 years still minimum 4.76 mm should be available against calculated minimum of 4.0 mm
- Turnaround is scheduled after 2 months….
Round Table Discussion

We have a leak...

Do we need to stop the plant?
Round Table Discussion

We have a leak...
Do we need to stop the plant?
Can we stop the leak with a clamp?
Risk Assessment

Carbamate Liquid at 184 °C after 24 years....
Has this weld-o-let really a dead zone, resulting in higher corrosion rates?
1. Leak in weld-o-let

Dead zone?

L/ID = 175 / 38 = 4.6 << 10

Assume 2X higher corrosion rate resulting in a minimum wall thickness of 4.52 mm against 4.0 mm as calculated minimum.
Round Table Discussion

We have a leak...
Do we need to stop the plant?
Can we stop the leak with a clamp?
Risk Assessment

What if 316L was used instead of 316L UG?

Is a Cr content of 15.3% instead of the spec of min 16.5% (1976) or min 17.0% (2019)

indeed too less?

Corrosion rate can be 4X higher than normal to still have sufficient wall thickness available.
Round Table Discussion

We have a leak...
Do we need to stop the plant?
Can we stop the leak with a clamp?
Risk Assessment

What if X-ray shows following result?

1. Leak in weld-o-let
Round Table Discussion

We have a leak...

Do we need to stop the plant?

Can we stop the leak with a clamp?
1. Leak in weld-o-let

Decision: Lets stop the leak with a clamp
1. Leak in weld-o-let

Decision: Let's stop the leak with a clamp

While measuring up the clamp... … the weld-o-let ruptured !!
Chemical accident in the urea plant of a fertilizers industry - failure of weldolet resulting in death of four persons.

There was a chemical accident in the Urea Plant at xxxx on 9.2.2000. An 8" dia high pressure pipe line housing a weldolet was connected between autoclave (urea reactor) of 108MT capacity and the stripper to carry ammonium carbamate (Urea Solution). The pressure of pipe line was of the order of 141kg/cm2 and the temperature of 180 C. The Solution had contained 29% of ammonia, 18% carbon di oxide and 32% of urea. The parameters such as temperature and pressure are required to be maintained at the same level throughout the pipe line for effective transfer urea solution. For this purpose pressure gauges and thermocouples were introduced at regular intervals and the readings were recorded.

On 9th February 2000, a substantial quantity of ammonium carbamate solution leakage was noticed at the weldolet joint of the pipeline. A maintenance manager along with two operators, an engineer and two contract workmen were trying to plug the leakage by providing a proper clamping. In the process, the weldolet joint gave way resulting in sudden release of pressurized hot ammonium carbamate solution. As a result, the personnel on the job.....
Consequences

- 4 people died
- 5 people injured
- Plant was unplanned shut-down for 2 months
1. Leak in weld-o-let

Weld-o-let connection to pipeline according design
Corroded areas at HAZ’s of weld-o-let

1½”

Failed at this position

Corroded areas

Corroded areas at HAZ’s of weld-o-let
1. Leak in weld-o-let

Significant Corrosion in HAZ
1. Leak in weld-o-let

Intergranular corrosion in HAZ
Causes

• Inferior material quality: Cr content 15.3% while min. required Cr content in 316L UG material is 17.0%

• Insufficient refreshment of carbamate solution in T-joint will increase the corrosion rate … even with 316L UG material!

• Note: In this plant all other high pressure weld-o-lets were inspected and several ones needed replacement
Lessons Learned

- Strict control of quality of materials of construction applied in High Pressure section of urea plant is required by a.o. PMI
- Choose higher alloy materials for High Pressure piping like 25-22-2 or (super)duplex, especially for the accessories
- Apply a proper design (min. welds, min. dead zone)
- High-pressure piping including accessories have to be included in regular inspection programs to ensure the integrity (e.g. X-ray weld-o-lets)
1. Leak in weld-o-let

Decision: Let's stop the leak with a clamp
1. Leak in weld-o-let

Is this safe to operate for 2 months?
1. Leak in weld-o-let

Is this safe?

How to assure no crevice is present?

What is the risk of a crevice in a carbamate line?
Summary

- From outside a leak can look like a possible single point local corrosion issue, but from inside more corrosion areas may be present
- Perform a proper Risk Assessment
- Assure you know all the possible failure modes
- Include any possible NDT assessments
- Applying a clamp on carbamate lines to stop a leak is dangerous and should not be done
2. Leak in weld of NH3 line

Leak in weld
Line of events

- In first week of September 2007 the operator noticed a leak in the weld joint of an elbow in the common suction line of HP NH₃ pumps in a 2530 mtpd Snamprogetti urea plant built in 2005
- 8” carbon steel line, schedule 20
- Design temperature and pressure: -45 °C and 43 bars
- The line was only 2.5 years in operation
2. Leak in weld of NH3 line
Round Table Discussion

We have a leak...
Do we need to stop the plant?
Round Table Discussion

We have a leak...
Do we need to stop the plant?
Can we stop the leak with a clamp?
 Lets start with a Risk Assessment

- Line was 2.5 years in operation
- Carbon steel pipeline
- Leak looks like a crack
- No previous corrosion inspections were done
- Turnaround is scheduled after 6 months
- First leak in this plant
- But many related failures reported in the industry…
Previous incidents carbon steel NH₃ lines

Already 21 incidents leading to 17 fatalities and 55 people injured

Risk Assessment:

• Atmospheric Corrosion: minor issues
• Corrosion from inside due to carbon dioxide: unknown
• Erosion issues: unknown
• Vibration issues: yes, some limited vibrations
• Weld failures: unknown, welds were limited inspected

NDT inspections show no significant integrity issues
Round Table Discussion

We have a leak...
Do we need to stop the plant?
Can we stop the leak with a clamp?
Decision: Let's stop the leak with a clamp
2. Leak in weld of NH3 line

Line of events

• The leak was sealed on line by means of a clamp
• 4 months later, on 4\textsuperscript{th} January 2008 the weld joint started again leaking through the clamp
Round Table Discussion

We have a leak...

Do we need to stop the plant?
Round Table Discussion

We have a leak...
Do we need to stop the plant?
Can we stop the leak by re-injecting sealing component in the clamp?

2. Leak in weld of NH3 line
2. Leak in weld of NH3 line

Line of events

Online sealing compound was re-injected to stop the leak, which was executed successfully.
However 2 weeks later, on 17th January 2008 at 04.40 hours the weld joint fully snapped off and caused a heavy ammonia leak...
2. Leak in weld of NH3 line

Line of events

- Immediately emergency shut down was initiated
- And HV was closed to isolate large ammonia hold up
- Level 1 emergency was declared, all affected area was cordoned off and cleared of any workforce present
- Luckily nobody had received any ammonia exposure
Causes

- Fatigue cracking due to vibrations in combination with corrosion from inside and outside
- Is the sealing component suitable for low temperatures?
- Additional stresses on weld due to (re-)injection of sealing compound
Summary

- Assure proper weld quality for all NH₃ lines
- Perform stress analysis on critical piping
- Assure perfect conservation
- Apply stainless steel materials as CO₂ contamination and/or backflow can cause corrosion from inside to carbon steels
- In case of leaks with any signs of cracks, stop the plant
- Do not install clamps on ammonia pipe lines
3. Leaking flange connection

Flange leak in High Pressure carbamate line
Round Table Discussion

We have a leak...!
Do we need to stop the plant?
Round Table Discussion

We have a leak...!
Do we need to stop the plant?

Or can we choose between:
1. Hot torqueing?
2. Apply a flush and monitor leak?
3. Let it crystallise and stop the leak?
3. Leaking flange connection

Is it Safe?
3. Leaking flange connection

When applying a flush, how to assure integrity of bolts?
An Important Case

• A flange connection is sometimes leaking urea/carbamate solution
• Normally a steam flush is applied
• But when the leak is too large, in order to limit NH$_3$ gasses, a cold condensate flush is applied
• Condensate/NH$_3$/carbamate mixture is dripping on the below insulated high pressure stripper
• The mixture enters the insulation and the carbonate causes Stress Corrosion Cracking of the carbon steel pressure bearing wall!
During annual turnaround of our urea plant, cracks were noted in CS multilayers of two strippers. An in-depth analysis is presented of the failures and corrective actions taken to repair the strippers and prevent such failures in the future.

Rashtriya Chemicals and Fertilizers Ltd., Thal, India

It can be concluded that the failures of two strippers were due to stress corrosion cracking as a result of seepage of ammoniacal solution through the damaged insulation in combination with residual stresses in layers of the shell.

Avoid carbamate dripping on high pressure equipment
4. Leaks in valves
A leak from a stuffing box
A leak from a stuffing box can cause corrosion of the spindle
Round Table Discussion

We have a leak...

Do we need to stop the plant?
Prevention measures for leaks along stuffing boxes:

- Check minimum tightening force during pressure test (bubbles from foam)
- Retighten with half turn before feed in carbamate
- Pre-press packing rings
- Use proper materials: higher alloy stems and proper dimensions and quality packing rings
- Apply a stuffing box flush system (UKH/BHDT)
Mitigation measure for leaks along stuffing boxes:
- Further retighten packing rings
- Flush with steam to remove solids and keep stem possible to move

Flush with steam
4. Leaks in valves

A leak from the bonnet
Case: Leaking drain valve

316L UG materials
Round Table Discussion

We have a leak...

Do we need to stop the plant?
Line of events

- On May 1, 2017 operators note a leakage of the valve body of the drain valve in the drain line from the reactor in a Stamicarbon PoolCondenser urea plant started up in 2007
- A leak was noted from the threaded bonnet connection to the valve body...
- The plant was running stable at 105% load
- The drain valve was 10 years in operation and was passing somewhat (quite normal)
Round Table Discussion

We have a leak...

Do we need to stop the plant?
Round Table Discussion

We have a leak...
Do we need to stop the plant?
If not, we have two options...
4. Leaks in valves

Option 1: Atmospheric pressure in drain line

- Passing drain valve.
- Leak from bonnet stopped.
- Pressure in drain line is atmospheric.
- Bleed valve is dripping and monitored.
- HP Flush.
Option 1: Atmospheric pressure in drain line

- Synthesis pressure
- Atmospheric pressure

- Some passing of drain valve
- No leak from bonnet
- Force on thread of bonnet connection
Option 2: Pressurised drain line by condensate

Passing drain valve minimum. Leak from bonnet

Pressure in drain line is 140 bars

bleed valve is closed

Option 2: Pressurised drain line by condensate
4. Leaks in valves

Option 2: Pressurised drain line with condensate

- Minimum passing of drain valve
- Leak from bonnet, mostly water will be leaking
- Less force on thread of bonnet connection
Round Table Discussion

We have a leak...
Do we need to stop the plant?
We choose Option 1 or 2?
Line of events

- The drain valve experienced passing…wrenching was tried to solve this problem but without success…
- The bleed valve was opened and the bleed valve outlet was under monitoring (Option 1).
- Due to opening of the bleed valve the leak from bonnet stopped and the amount of solution passing the valve was dripping from the bleed valve
- At the end of the shift the situation was the same and seemed stable
Line of events

• The night shift continued monitoring the drain valve and bleed valve
• When the operator checked the situation after a few hours, he heard an abnormal sound from the drain line
• When the operator turned around, he saw a big flow coming out of the bleed valve
• One tried to close the drain valve further but no change in the flow coming out of the bleed valve
• After a few minutes the bonnet detached from the drain valve and the solution from the reactor came out
Line of events

- 4 people got injured
- Plant had an emergency shut down
- The repair took 5 days
4. Leaks in valves

Causes

Thread of bonnet and valve body showed erosion/corrosion
Lesson Learned

A leak along a threaded connection is very dangerous
4. Leaks in valves

A leak from a weep hole
Round Table Discussion

We have a leak...

Do we need to stop the plant?
Why some valves have a weep hole?
Sealing rings avoid crevices in which active corrosion can occur
4. Leaks in valves

Weep hole is a leak detection!
Leaking weep hole

One possible Cause:
Wrong installation of sealing ring set

Wrong maintenance procedure
did lead to leaking weep holes in multiple valves
We just started up the plant after a turnaround...
Round Table Discussion

We have a leak...

Do we need to stop the plant?
Round Table Discussion

We have a leak...

Do we need to stop the plant?

Or can we stop the leak by injecting a polymer?
One decides to stop the leaks by injecting a polymer.

Is it safe?
4. Leaks in valves

Prevention measures

- Avoid threaded bonnet connections
- Assure leak detection holes to detect possible corrosion of threads or valve body connecting parts
- Crevices (depth/width > 10) in valve design require sealing rings with leak detection holes
- Apply higher alloy (25-22-2, super duplex) materials
- Purchase from qualified and experienced vendors
- Involve qualified and experienced maintenance companies / people
Mitigation measures

- In case of a leak along a threaded connection, shut down the plant
Conclusions

• Perform a proper Risk Assessment
• Assure you know all the possible failure modes
• Search for similar cases in the industry (AICHE, FIORDA)
• Perform all possible NDT inspections
• Never clamp carbamate lines
• Never clamp carbon steel ammonia lines
• In case of a crack, stop the plant
• In case of leak along a threaded connection, stop the plant (e.g. bonnet connections in valves, reciprocating pumps)
Related concluding remarks

- Leaks in urea plants are typically non-explosive, toxic, erosive, corrosive (possible CO₂ contamination of NH₃) and solids may form.
- Is installing a clamp the best solution? Or better just add a flush?
- Realise that the installation of clamps may create other risks (injection pressure, other forces on leak area).
- Clamps should always be considered a temporary solution and develop a procedure to check its integrity during installation.
- Most leaks can be prevented (design, choice of materials, installation quality (flanges), inspections, maintenance).
- Apply zero tolerance for leaks in urea plants.
Round Table Discussion

We have a leak...
Do we need to stop the plant?

THANK YOU!