AMMO LASER Leak Detection System

#1 Safety Measure with a Guaranteed Pay Back
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Today still too many accidents (ruptures, explosions) of high-pressure equipment items in the urea industry do occur...
UreaKnowHow.com Incident database

✓ Totally 24+ serious incidents (integrity of carbon steel pressure bearing wall threatened)

✓ During last 25 year every 3 years such an incident happened

✓ Leading to totally 21 casualties, 55+ people injured inside and 90+ people injured outside the plant

A failing leak detection system was the #1 main cause

Source: UreaKnowHow.com Urea Incident Database as per December 2017
1. Incidents

A failing leak detection system was the #1 main cause.
Safety Risks of Urea High Pressure Equipment

- High pressures
- High Temperatures
- Various kinds of corrosion phenomena (inside and outside)
- Crystallization risks
- Large volumes
- Release of toxic ammonia in case of a leak
1. Incidents

- Ammonia leak at ... plant kills two workers [2016]

- A Carbamate leak leads to a toxic ammonia cloud
Risk Register of a typical Urea Reactor

Assumptions:
✓ Carbon steel pressure bearing wall
✓ 316L Urea Grade protective layer (loose liner and/or overlay welding)
✓ Leak detection system for loose liner: passive system (refer to picture)

As per today already 45+ Safety Hazards identified

Most Urea Reactors currently in operation are “protected” like this
### Risk Register Urea Reactor

#### Risk ranking before (#b) and after (#a) Prevention and Mitigation steps

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Category</th>
<th>Rare</th>
<th>Unlikely</th>
<th>Moderate</th>
<th>Likely</th>
<th>Almost Certain</th>
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<tr>
<td>Catastrophic</td>
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<td></td>
<td></td>
<td>26b</td>
<td></td>
<td></td>
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<tr>
<td>Major</td>
<td>11a</td>
<td></td>
<td></td>
<td>11b</td>
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<td>2a</td>
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<td></td>
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<tr>
<td>Insignificant</td>
<td>4a</td>
<td></td>
<td></td>
<td></td>
<td>4b</td>
<td></td>
</tr>
</tbody>
</table>

75% of the risks can be prevented by a proper leak detection system.
Top 4 recommendations for safeguarding a reactor:

1. Install an active, vacuum based, leak detection system with a reliable and accurate ammonia detector (protect loose liner, break before leak)

2. Perform regular walking tour inspections to identify leak in overlay weld (leak before break)

3. Perform corrosion inspections during turnarounds by qualified and experienced inspectors with a frequency depending on age of reactor and previous inspection findings (protect loose liner and overlay weld)

4. Make use of skillful and experienced welders during repair jobs and apply higher alloy materials
Integrity of carbon steel pressure bearing wall can be threatened by:

- Carbamate corrosion due to damage of protective layer with (corrosion rate 1000 mm/year):
  - An early and reliable detection is a must
  - In case of a leak, stop the plant
- Stress corrosion cracking behind loose liner when water and contaminants are present
- Stress corrosion cracking from outside when water and contaminants are present
Cracks in carbon steel behind liner caused by presence of water!

Never flush with steam or condensate
Do realise
Typical lifetime of the 316L Urea Grade protective layer of a urea reactor is 20-30 years

While
Typical lifetime of a urea plant is 40-50 years

Thus
Every urea reactor will finally operate close to the end of lifetime conditions of the protective layer

Meaning that at a certain moment a leak in the protective layer is unavoidable
Gas phase leak
- CO₂ and NH₃ gases flashing forming carbamate solids below 60°C

Liquid phase leak without urea
- Carbamate flashes forming CO₂ and NH₃ gases
- No carbamate solids above 60°C

Liquid phase leak with urea
- Carbamate flashes forming CO₂ and NH₃ gases
- No carbamate solids above 60°C
- BUT urea solids are present below 133°C and also above 133°C urea partly decomposes into NH₃ and HNCO but also forms biuret, triuret etc. with even higher melting points

An early reliable and accurate leak detection is thus very important
Typical Design for Urea HP Pressure vessels

✓ Pressure bearing part: carbon steel
✓ Corrosion resistant layer (in contact with process)
Where leak detection is required?

On those locations where a gap exists between the stainless steel alloy protection and the carbon steel pressure bearing parts.

A very high risk for catastrophic corrosion is a reality (break before leak scenario).

Examples:

 ✓ Behind loose liners
 ✓ Behind an overlay welded or explosive cladded multi wall or multi layer pressure wall
 ✓ HP heat exchanger tubes and tube-tubesheet connections
 ✓ Behind sleeves in nozzles (lined nozzles)
For a loose liner the following is valid:

✓ Fixed liner connections are most critical

✓ Passage way along fixed liner welds typically are present creating a network of small longitudinal and lateral grooves

✓ Connected to preferably minimum two leak detection holes per liner compartment

*Liner compartment is that part of a lining which is comprised between fixed weld connections*

*For multi wall or multi layer vessels, leaking fluids should be prevented to find their way between the layers*
The quality of these fixed liner connections cannot be checked by NDT (Non Destructive Testing) methods.
Stamicarbon design:
Passageways (grooves) along fixed liner connections in carbon steel

LDS = leak detection system
Snamprogetti design:
Passageways (grooves) along fixed liner connections in austenitic buffer layer
4. Various Leak Detection Systems

**Passive systems**

- Checking for vapors
- Checking the smell of NH₃
- NH₃ Reagent (color change)
- Checking of bubbles in a dipped vessel filled with oil
- Conductivity
- Infrared

All systems wait for leak to show up at the detector, while clogging can already occur...

Conclusion: Unreliable and takes too long time
Clogging can occur quickly with a mixture of carbamate and urea.
4. Various Leak Detection Systems

**Active systems**

- **Pressurized system**
  - circulating inert gas behind loose liner

- **Vacuum system**
  - pulling vacuum behind loose liner
UreaKnowHow.com prefers vacuum system because:

1. It detects the maximum liner area (also around clips and other failure modes like condensation corrosion, fatigue cracks, clogged groove etc.)

2. It can be applied in every design reactor, also in case
   - no grooves are present
   - one hole is present in a liner compartment
   - clogged situations behind the liner

3. It avoids risks of liner bulging and damage. And assure also a detection during start-up and shut down phase.

4. A vacuum system allows larger distances between high-pressure equipment items (for example with twin urea lines)

5. It is possible to dilute the leak and avoid any risk of clogging

6. Failing pressurized systems are reported in the public domain
Fixed weld connections of liner to carbon steel are assumed to be most critical...

...But clip welds, cold spots (condensation corrosion), etc. can also lead to leaks in liner.
A vacuum system is best solution for liner compartments with only one leak detection hole.
4. Various Leak Detection Systems

Liner bulging happens easily and often
Requirements for a State-of-the-Art leak detection system

- Active vacuum based leak detection system
- Reliable and accurate ammonia detector
- DCS alarms in case of a liner leak, loss of vacuum pressure and in case of not proper functioning of the leak detection system
- The possibility to check for open circuits
- Dilute the leak to avoid clogging
- To distinguish false air leaks from real liner leaks
Further requirements for quick and easy locating of leak

- The possibility to identify the leaking liner circuit in order to minimize downtime to locate and repair the leak
- To have information about the leak size (in order to be able to select and prepare the right and most suitable method to pinpoint the leak to minimize the downtime to locate and repair the leak)
- To be able to introduce a leak detection tracer for pinpointing the leak
Additional Feature Ammonia Laser Analyzer

Can also be applied for continuous monitoring NH₃ emissions from e.g.:
- MP inert vent
- Stack
- Flare
- Prill tower
- Granulation stack
- Absorbers

Monitoring continuously NH₃ emissions will focus the operator attention to NH₃ emission reduction and will for sure reduce NH₃ consumption figures leading to a Guaranteed Pay Back Time.
Additional Feature Ammonia Laser Analyzer
Can also be applied for other applications like NH₃ leak detection in plant

Point sensor
and /or
Line sensor
Additional Feature
Ammonia Laser Analyzer

Can also be applied for other applications like leak detection from

- NH₃ storage tank
- NH₃ loading station
- NH₃ pumps
- NH₃ refrigeration compressor
Additional Feature Ammonia Laser Analyzer

Example: Continuous monitoring of the NH₃ emission trend from a prill tower inviting the operator to optimise the operating parameters in the evaporation section and melt temperature.
AMMO LASER Leak Detection System

#1 Safety Measure with a Guaranteed Pay Back
Description AMMO LASER Leak Detection System

- An active, vacuum based leak detection system
- With the most accurate and reliable ammonia detector
- The DCS operator will be warned in case there is
  - A lack of vacuum pressure
  - Clogging situation
  - Malfunctioning of the ammonia detector
  - And of course a liner leak is present
- The possibility to check for open circuits
- Dilute the leak to avoid clogging
- Distinguish false air and ammonia leaks from real liner leaks
Features Ammonia Laser Analyzer

✓ Safe
✓ Very accurate
✓ NH₃ specific
✓ Self calibrating
✓ No maintenance
✓ No consumables
✓ No memory effect
✓ No saturation effect
✓ Provides alarm when not functioning
Additional Feature AMMO Laser Analyzer:

Multi-channel feature, so same analyser can also be applied for continuous monitoring \( \text{NH}_3 \) emissions from e.g.:

- MP inert vent
- Stack
- Flare
- Prill tower
- Granulation stack
- Absorbers
- Tanks

Monitoring continuously \( \text{NH}_3 \) emissions will focus the operator attention to \( \text{NH}_3 \) emission reduction and will for sure reduce \( \text{NH}_3 \) consumption figures leading to a **Guaranteed Pay Back Time**
Manifold Cabinet: The core of the AMMO LASER Leak Detection System

AMMO Laser analyzer

Vacuum pumps (1+1)

Inlet from each HP equipment item
8. Conclusions

Features AMMO LASER Leak Detection System

1. Most reliable system available in the market
2. Distinguish false air and ammonia leaks from real liner leaks
3. Suitable for all designs of HP equipment, new or existing
4. No risks for bulging / damage of liner
5. No risks for clogging
6. Continuous detection for open leak detection circuits
7. No risks for corrosion of carbon steel
8. Best option for a clogged system after an earlier leak
Features AMMO LASER Leak Detection System

9. Most reliable and accurate NH₃ analyzer (self calibrating, no memory effect, no saturation, no consumables)

10. Failure safe design

11. Gives NH₃ leak rate and calculates leak size

12. Allows NH₃ leak test to locate the leak

13. Can be combined with up to 7 other NH₃ emission sources monitoring

14. A **Guaranteed Pay Back Time** resulting from shorter shut down periods as one can find the leak faster, knows the leak size and assured no damage to carbon steel

15. Plus **Guaranteed Pay Back Time** from lower NH₃ consumption figures
Features AMMO LASER Leak Detection System

16. One system for twin urea lines is feasible
17. Only part of leak detection circuit needs to be heated and insulated
18. No inert gas supply required and a low power requirement
19. Already four successful references since 2017
For more information, please contact:

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