Risk Register of a Urea Reactor:
Learn also Why... instead of only What...

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1. Introduction

UreaKnowHow.com: Largest independent network in the nitrogen fertilizer industry to exchange technical information with the target to improve Safety and Performance of all nitrogen fertilizer plants worldwide.

Now also AmmoniaKnowHow.com is online!
Safety Risks of Urea Reactors

- High pressures
- High Temperatures
- Various kinds of corrosion phenomena
- Crystallization risks
- Large volumes
- Release of ammonia in case of a leak

High Demands on Integrity is crucial for a Safe & Reliable urea plant
Typical design of Urea Reactors

- Carbon steel pressure bearing wall
- Protective layer consisting of a loose liners and/or overlay welding
- Several trays and a down comer as internals only
Integrity of carbon steel pressure bearing wall can be threatened by:

- Carbamate corrosion due to damage of protective layer with a corrosion rate of 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
21 serious incidents (integrity of carbon steel threatened)
During last 25 year every 3 years such an incident happened in one of the 500 urea plants worldwide
Leading to totally 21 casualties, 55+ people injured inside and 90+ people injured outside the plant
In 40% a failing leak detection system was one of the causes
In 25% specific corrosion failure modes of carbon steel occurred (inside & outside)

Source: UreaKnowHow.com Urea Incident Database
Please 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 nearly unavoidable
Why an Open Source Global Risk Register?

To further reduce incidents, we believe the Urea Industry needs to share more safety related information.

An Open Source Risk Register based on shared safety knowledge can fulfil the need of increased safety in operation.

A Risk Register is a list of possible hazards plus ...
Of each hazard the Risk Register shows:

- Possible causes
- Possible consequences
- Project phase during which the hazard is applicable
- Equipment part
- Hazard reference document
- Risk ranking before Prevention and Mitigation steps
- Prevention steps to reduce likelihood
- Mitigation steps to reduce consequences
- Risk ranking after Prevention and Mitigation steps
Open Source Global document with possible input from all Members

3. Introduction Risk Register

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Hazard Type</th>
<th>Comments</th>
<th>Project Unmitigated Risk Ranking</th>
<th>Indicative Risk Management for Significant and High Risks</th>
<th>Project Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Process</td>
<td></td>
<td>Major Moderate 11</td>
<td>Perform risk assessment</td>
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<tr>
<td>2</td>
<td>Commissioning</td>
<td>Why oil film formed inside the tank/After repair</td>
<td>Catastrophic Moderate 12</td>
<td>New Procedure Improvement or pressure relief system</td>
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<td>3</td>
<td>Process</td>
<td>The tank was in operation?</td>
<td>Catastrophic Moderate 12</td>
<td>Perform risk assessment Improvement or pressure relief system</td>
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<tr>
<td>4</td>
<td>Operation</td>
<td>Commissioning procedure was followed?</td>
<td>Major Moderate 11</td>
<td>Burner management system New Operating Procedure</td>
<td></td>
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<tr>
<td>5</td>
<td>Operation</td>
<td></td>
<td>Moderate Moderate 9</td>
<td>Improved operation procedure</td>
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<tr>
<td>6</td>
<td>Procurement</td>
<td></td>
<td>Moderate Unlikely 6</td>
<td>Change alkaline filmming agent</td>
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<tr>
<td>7</td>
<td>Process</td>
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<td>Moderate Unlikely 6</td>
<td>Improved WPV quality</td>
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<td>8</td>
<td>Process</td>
<td>What was the cause of the pressure drop?</td>
<td>Moderate Moderate 9</td>
<td>Modified the gas flow path Improve the pressure relief system</td>
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<tr>
<td>9</td>
<td>Process</td>
<td></td>
<td>Moderate Moderate 9</td>
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Risk Register:

- **Intolerable Risk**: Risk is unacceptable where elimination of the hazard or implementation of additional risk reduction measure(s) is a must.
- **High Risk**: Risk is tolerable where elimination of the hazard or implementation of additional risk reduction measure(s) should be considered with the ALARP principle.
- **Moderate Risk**: Risk is tolerable where implementation of additional risk reduction measure(s) should be considered with the ALARP principle.
Case: Risk Register of a typical Urea Reactor

- Carbon steel pressure bearing wall

- 316L Urea Grade protective layer (loose liner and overlay welding)

- Leak detection system for loose liner: passive - only tubes (refer to picture)
43 hazards are identified (so far)

- Operation, 33
- Commissioning, 5
- Construction, 2
- Engineering, 1
- Maintenance, 2
Risk ranking before (#b) and after (#a)
Prevention and Mitigation steps

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Category</th>
<th>Likelihood</th>
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<tr>
<td></td>
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</table>
No Mitigation steps are identified: One can only reduce the likelihood of the incidents.

The Prevention steps lead to 39 recommendations related to a specific project phase like design, fabrication, commissioning, operational and maintenance.

In the Risk Register the recommendations are directly connected to the hazard so One Also Learns Why Instead Of Only What.
Top 3 recommendations for an existing 316L UG Reactor:

1. Install an active, vacuum based, leak detection system with a reliable and accurate ammonia detector. Vacuum because:
   - It detects the maximum liner area (also around clips and other failure modes like condensation corrosion, fatigue cracks, clogged groove etc.)
   - It can be applied in every design (also in case no grooves, one hole, clogged, etc.)
   - It avoids risks of liner bulging

2. Perform corrosion inspections during turnarounds by qualified and experienced inspectors with a frequency depending on age of reactor and previous inspection findings.

3. Make use of skillful and experienced welders during repair jobs and apply higher alloy materials.
1. Several safety risks threaten Urea Reactors
2. A significant number of serious incidents with Urea Reactors still occur in the industry
3. A leak in the protective layer is nearly unavoidable
4. The Open Source Urea Reactor Risk Register targets to increase Safety and Knowledge in the industry
5. 39 Recommendations are provided, which can reduce significantly the likelihood of these incidents
6. The Risk Register Learns also Why... Instead of only What...