Module 8A

LEAK DETECTION SYSYEMS FOR LOOSE LINERS IN HIGH PRESSURE EQUIPMENT

Leak detection systems

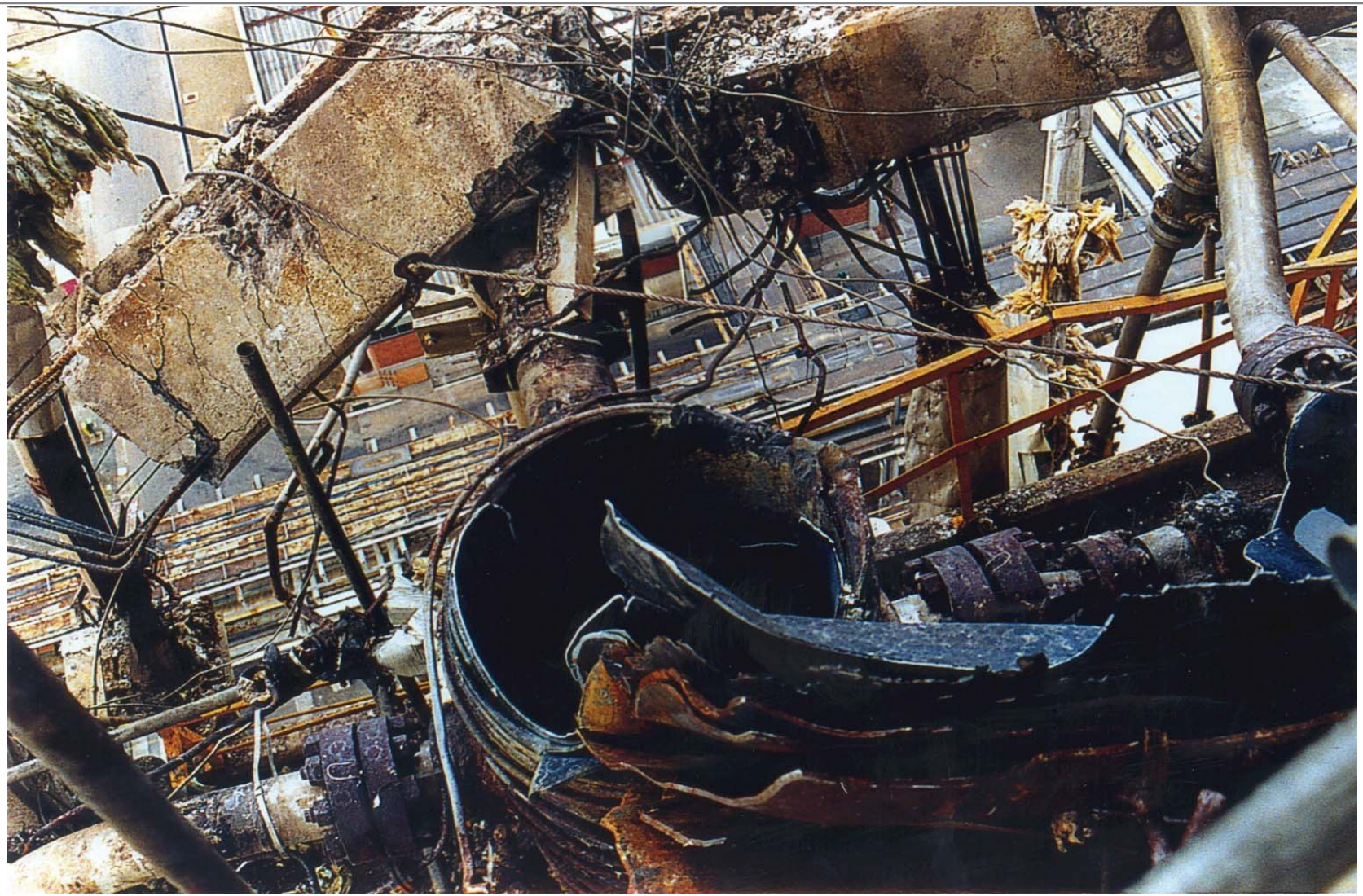
Leak Detection Systems:

- ✓ Loose liners in HP equipment (holes)
- ✓ HP heat exchanger tubes and tube-tubesheet connections (conductivity)
- ✓ HP valves (holes)
- ✓ HP flange connections (hole of insulation)

UreaKnowHow Leak Detection System

Content

1. Incidents



Today still too many accidents (ruptures, explosions) of high-pressure equipment items in the urea industry do occur...

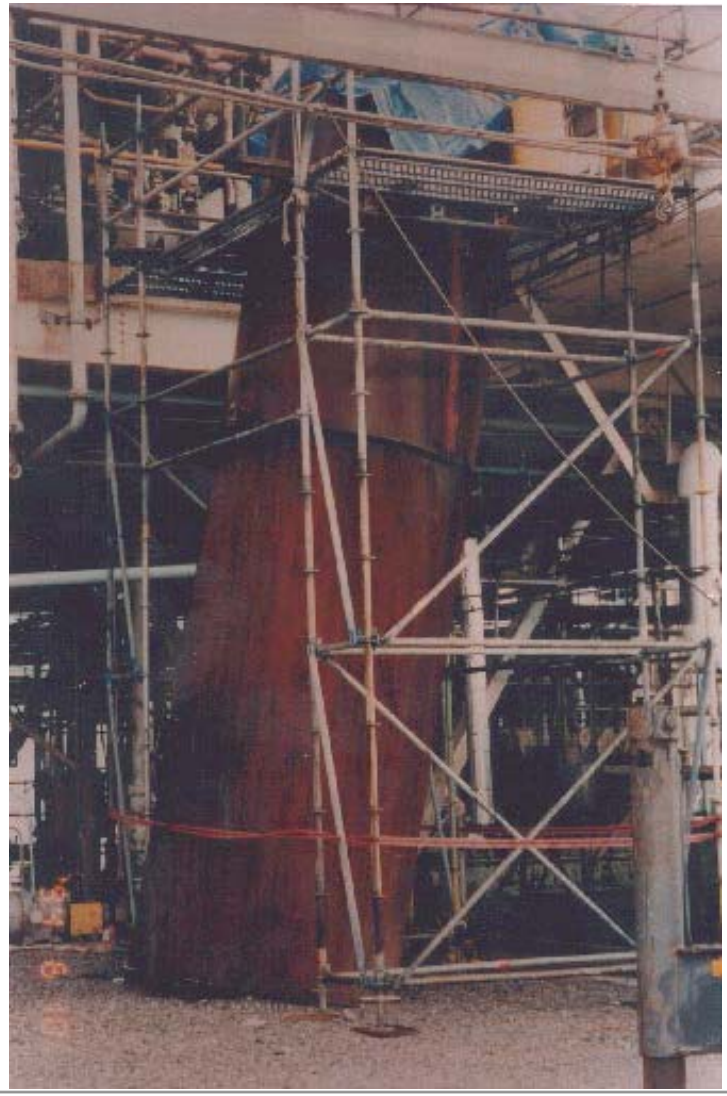
UreaKnowHow.com Incident database

- ✓ Totally 24+ serious incidents (integrity of carbon steel 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
- ✓ In 50%, a failing leak detection system was one of the causes

Source: UreaKnowHow.com Urea Incident Database

as per December 2017

1. Incidents



50% of incidents are caused by
failing leak detection systems

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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]

Ammonia leak

Carbamate leak

Risk Register of a typical Urea Reactor

Assumptions:

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

As per today already
45+ Safety Hazards identified

2. Risk Register Urea Reactor

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

Consequence §	Category	Likelihood: Rare	Unlikely	Moderate	Likely	Almost Certain
	Catastrophic	26a ←		26b		
	Major	11a ←		11b		
	Moderate					
	Minor	2a ←		2b		
	Insignificant	4a ←			4b	

75% of the hazards can be prevented by a proper leak detection system

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2. Risk Register Urea Reactor

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.

2. Risk Register Urea Reactor

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 !

2. Risk Register Urea Reactor

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 nearly unavoidable

2. Risk Register Urea Reactor

Gas phase leak

- CO_2 and NH_3 gases flashing forming carbamate solids below 60ºC

Liquid phase leak without urea

- Carbamate flashes forming CO_2 and NH_3 gases
- No carbamate solids above 60ºC

Liquid phase leak with urea

- Carbamate flashes forming CO_2 and NH_3 gases
- No carbamate solids above 60ºC
- BUT urea solids are present below 133ºC and also above

133ºC urea partly decomposes into NH_3 and HNCO but also forms biuret, triuret etc. with even higher melting points

3. Various Leak Detection Systems

Passive systems

- ✓ Checking for vapors
- ✓ Checking the smell of NH_3
- ✓ NH_3 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…

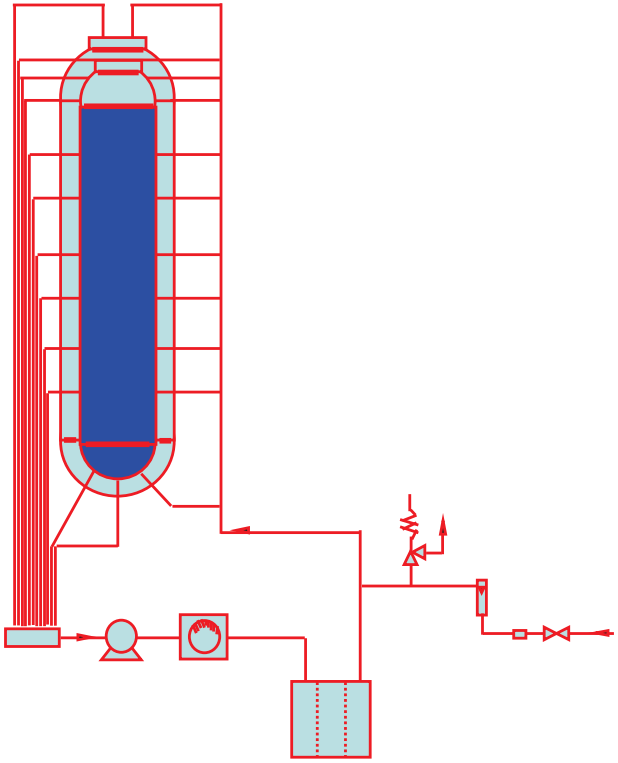
Conclusion: Unreliable detector and takes too long

A reliable detection ?

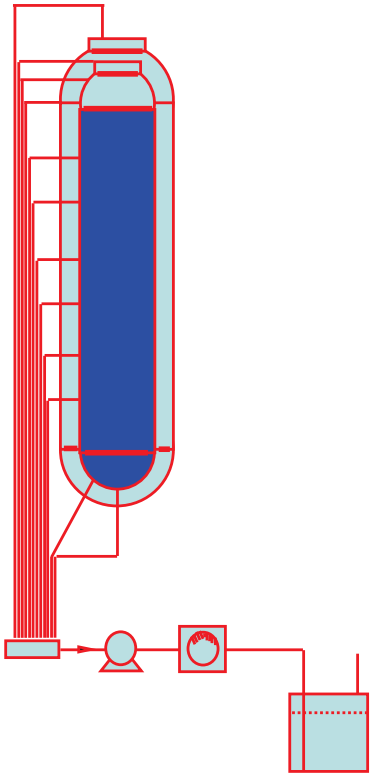
Clogging can occur quickly with a mixture carbamate and urea

Active systems

Pressurized system
circulating inert gas
behind loose liner

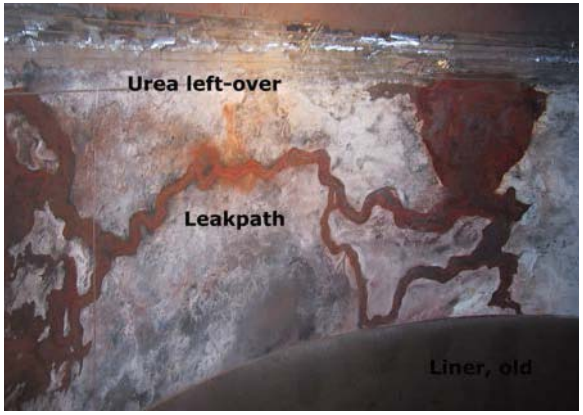


Vacuum system
pulling vacuum
behind loose liner



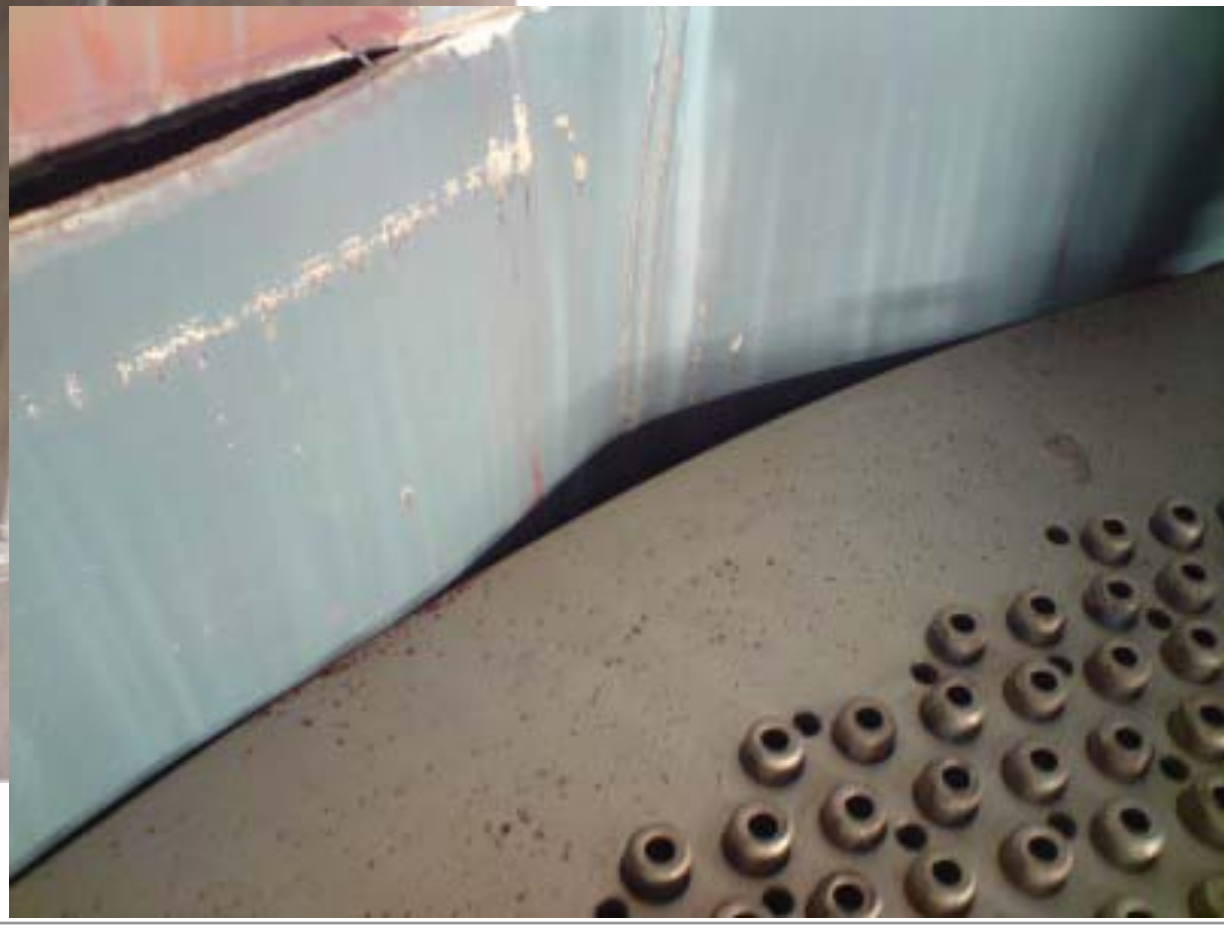
UreaKnowHow.com prefers vacuum system because:

- ✓ It detects the maximum liner area (also around clips and monitors other failure modes like condensation corrosion, fatigue cracks, clogged groove etc.).
- ✓ It can be applied in every design reactor, also in case
  1) no grooves are present
  2) one hole is present in the liner compartment
  3) clogged situations



- ✓ It avoids risks of liner bulging and damage
- ✓ A vacuum system allows larger distances between high-pressure equipment items (for example with twin urea lines or UAN plant)
- ✓ Failing pressurised active systems are reported

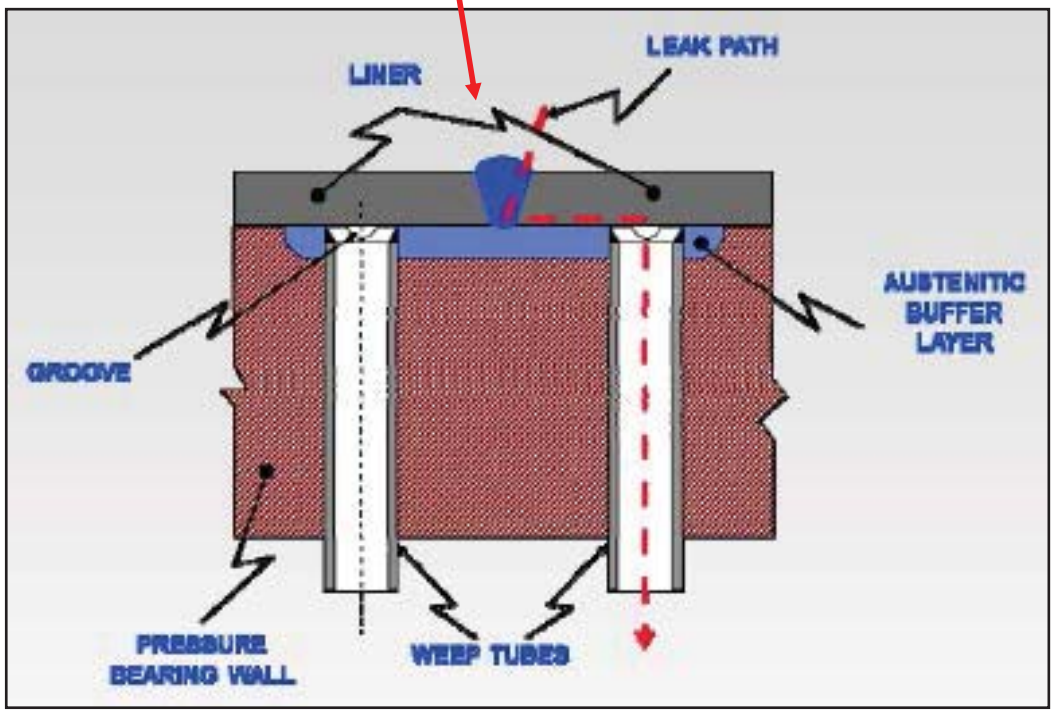
3. Various Leak Detection Systems

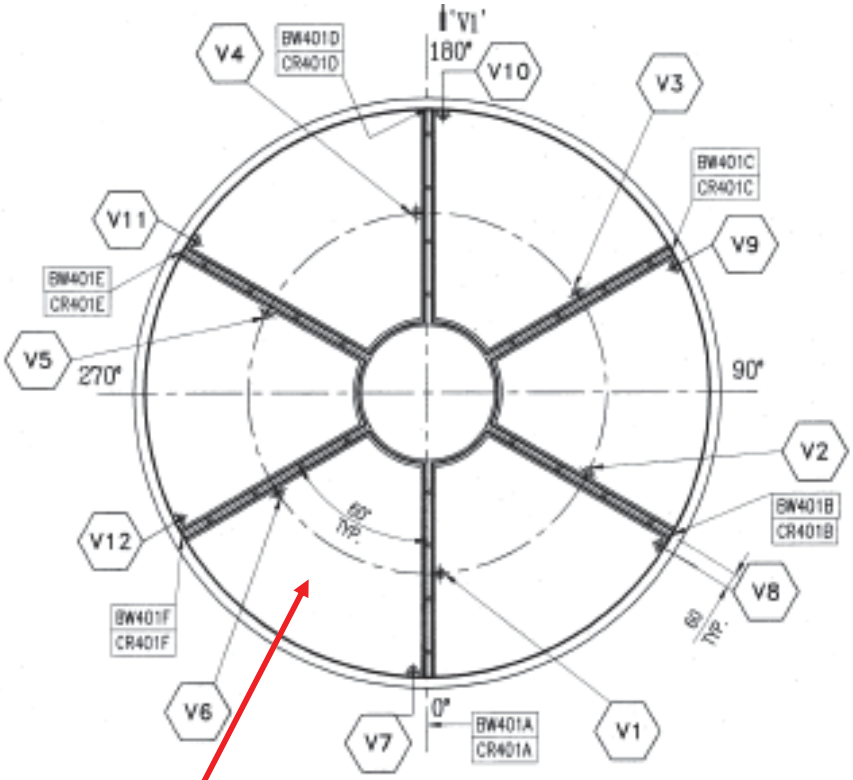


Liner bulging happens easily and often

3. Various Leak Detection Systems

Fixed weld connections of liner to carbon steel are assumed to be most critical…



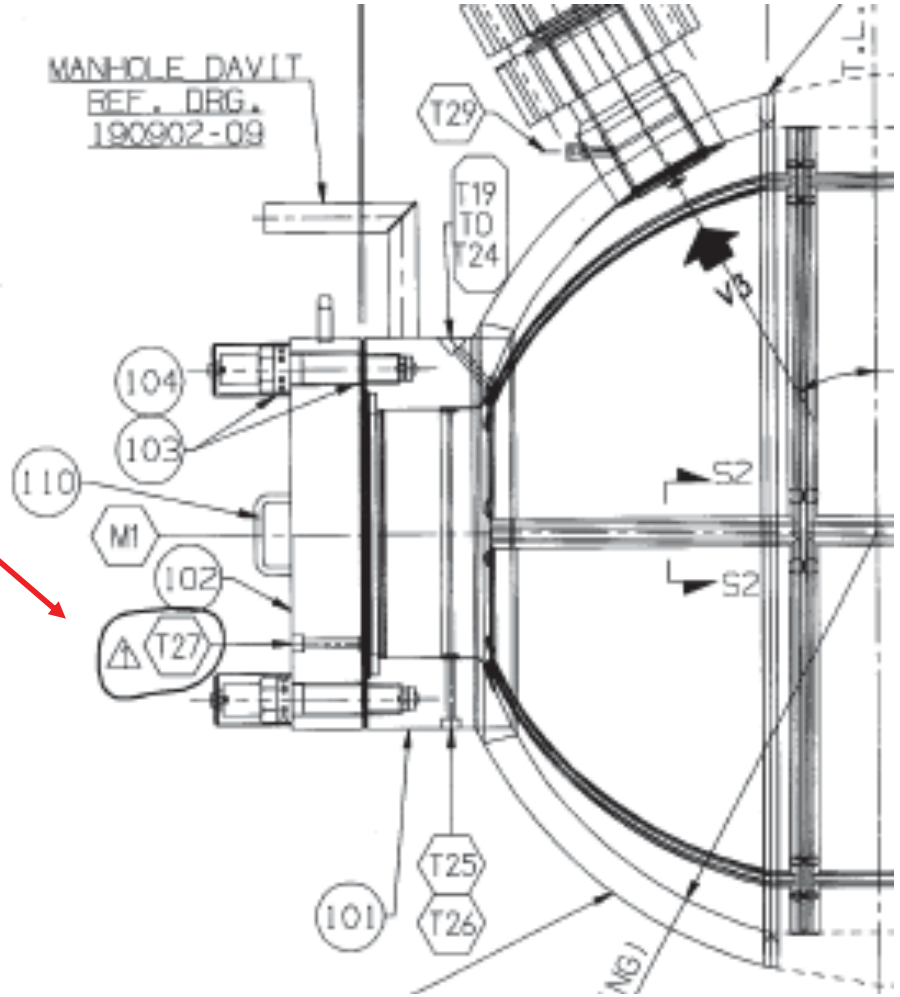


…But clip welds, cold spots (condensation corrosion), etc. can also lead to leaks in liner

Grooves in an austenitic buffer layer do not avoid contact carbamate – carbon steel

3. Various Leak Detection Systems

Liner compartment
with only one hole



A vacuum system is best solution for liner compartments with only one leak detection hole

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Requirements for a State-of-the-Art leak detection system

- ✓ Active vacuum based leak detection system
- ✓ Reliable and accurate ammonia detector
- ✓ DCS alarm in case of not proper functioning
- ✓ Probability of Failure of demand max 0.01 to reach E-5 risk factor

Further requirements for quick and easy locating of leak

- ✓ To distinguish false air leaks from real liner leaks
- ✓ To dilute the leak to avoid clogging
- ✓ 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

The UreaKnowHow Leak Detection System

Features of UreaKnowHow Leak Detection System

- ✓ An active, vacuum based leak detection system
- ✓ With the most accurate and reliable ammonia detector
- ✓ Meeting the Probability of Failure on Demand requirement of maximum 0.01.
- ✓ Dilute the leak to avoid clogging
- ✓ 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

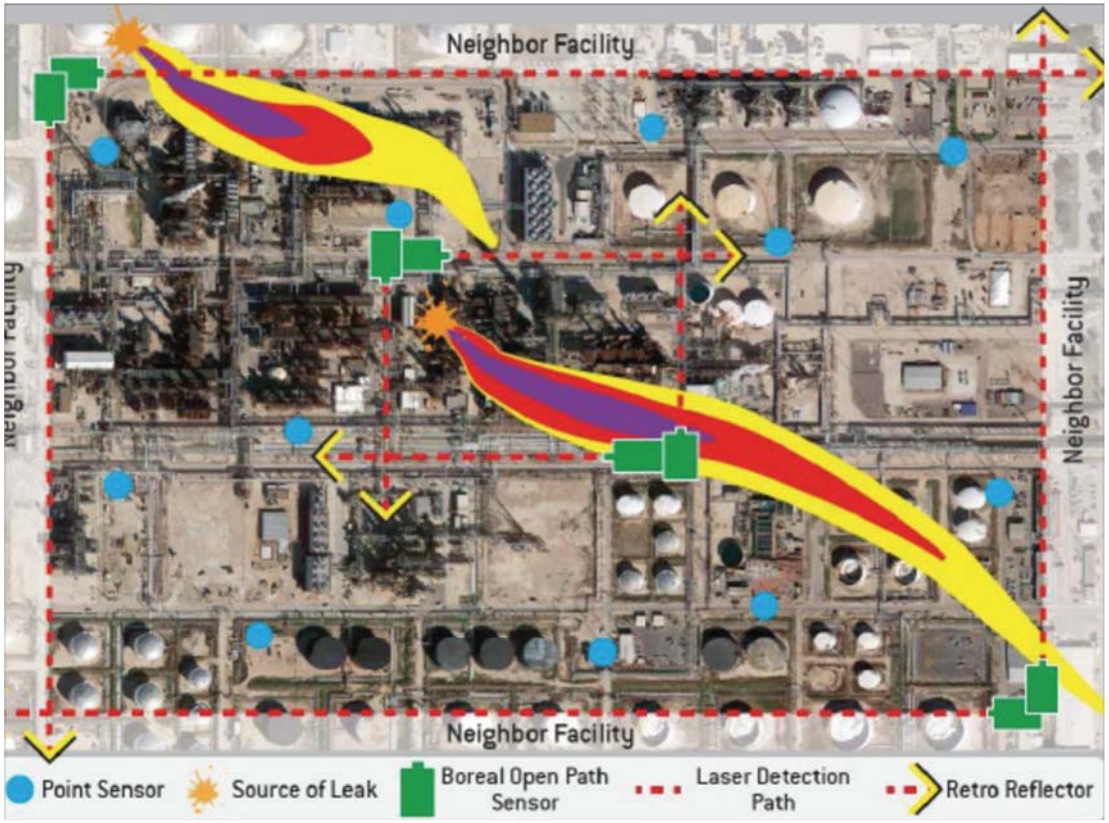
Benefits Boreal Ammonia Detector

- ✓ Safe
- ✓ Very accurate
- ✓ NH_3 specific
- ✓ Self calibrating
- ✓ No maintenance
- ✓ No consumables
- ✓ No memory effect
- ✓ No saturation effect
- ✓ Provides alarm when not functioning

BOREAL BOREAL EUROPE BV

Benefits Boreal Ammonia Detector:

Can also be applied for other applications like NH_3 leak detection in plant



Boreal Laser can be:

Point sensor

and /or

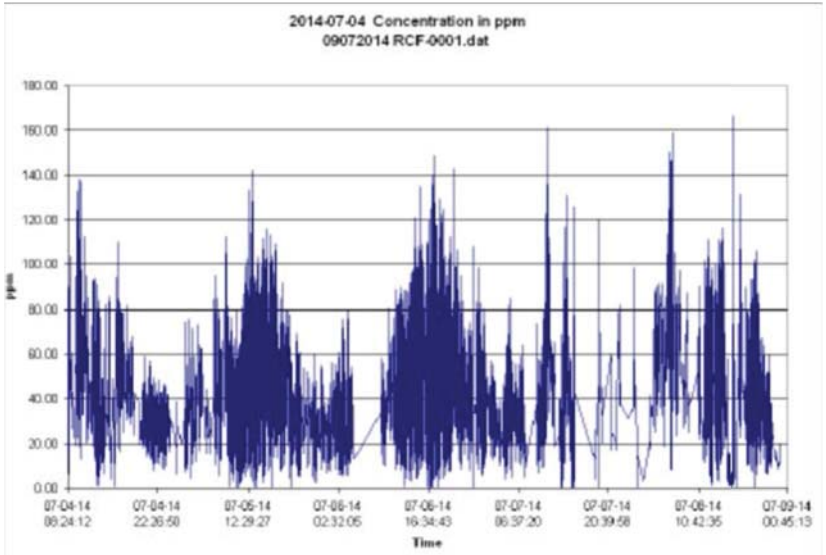
Line sensor

Benefits Boreal Ammonia Detector:

Can also be applied for other applications like NH_3 storage tank, NH3 loading leak detection

Benefits Boreal Ammonia Detector:

Can also be applied for other applications like NH_3 emission prill tower, granulation or melt plant stack, Flare, absorbers, etc.



5. UreaKnowHow Leak Detection System

References

- ✓ 2016, Dakota Gas, USA (in operation)
- ✓ 2015, Pardis 3, Iran (in operation)
- ✓ 2015, Lordegan, Iran (under construction)

6. Conclusions

- ✓ Too many incidents with High Pressure Urea Equipment still occur in the industry
- ✓ In 50% a failing leak detection system was one of the causes
- ✓ Many Safety Hazards threaten High Pressure Urea Equipment
- ✓ The Risk Register for a 316L UG Urea Reactor identifies 45 safety hazards of which 75% can be prevented by operating a proper leak detection system
- ✓ During its lifetime a leak in the protective layer is nearly unavoidable

6. Conclusions

The UreaKnowHow Leak Detection System offers:

- ✓ Suitable for all designs of HP equipment, new or existing
- ✓ No risks for bulging / damage of liner (vacuum)
- ✓ No risks for clogging (dilute leak)
- ✓ No risks for corrosion of carbon steel (no moisture)
- ✓ Best option for a clogged system
- ✓ Most reliable and accurate NH3 detector (self calibrating, no memory effect, no saturation)
- ✓ Failure safe design

6. Conclusions

The UreaKnowHow Leak Detection System offers:

- ✓ Continuous detection for open connections of leak detection circuits
- ✓ Gives NH_3 leak rate and calculates leak size
- ✓ Detection of false leaking air
- ✓ Allows NH_3 leak test to find leak
- ✓ Can be combined with other NH_3 detection applications
- ✓ Pay back time resulting from shorter shut down periods as one can find the leak faster and reduction of NH_3 losses

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