

UreaKnowHow Revamp Guide Part 2:

Reducing Ammonia Emission / Consumption Figures

V0, April 2019

Introduction

Today's name of the game is improving your competitive position. Figure 1 shows a typical cost price structure of the urea product.

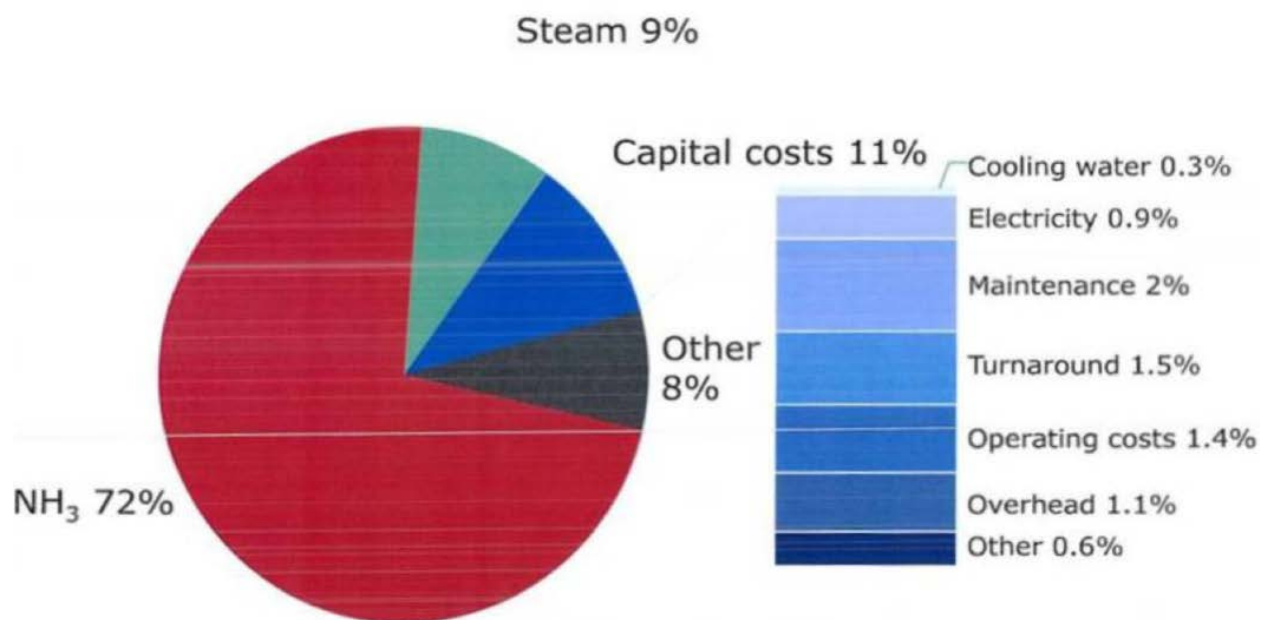


Figure 1: Typical urea cost price structure

From Figure 1 one can easily conclude that the costs for the ammonia feed is the most important factor determining the urea cost price.

It is therefore very important to pay attention to ammonia emissions, not only from environmental point of view but even more because of reducing the urea cost price position. For every 1 kg NH₃ per metric ton of urea above the stoichiometry ratio required for the overall urea formation reaction one loses in a typical modern size urea plant of 3000 mtpd thus 3000 kg/day or about 1000 ton NH₃ per year. Assuming an ammonia market price of 300 US\$/mt, this means a financial loss of 300.000 US\$/yr. Assuming a pay-back time of 3 years, this means **one is allowed to invest 1 mln US\$ for every 1 kg/mt NH₃ consumption reduction.**

How to measure ammonia consumption figures accurately ?

Best practice is to measure accurately the ammonia consumption figure in a urea plant is by measuring the ammonia emissions. This is also the typical procedure applied during a performance test.

Ammonia emissions from a urea plant can be divided by continuous and discontinuous emission points.

Continuous emission points are from the inert vents / absorbers, melt stack, flares, granulation stack and prilling towers, waste water streams plus the fugitive emissions from stuffing boxes, seals and flanges.

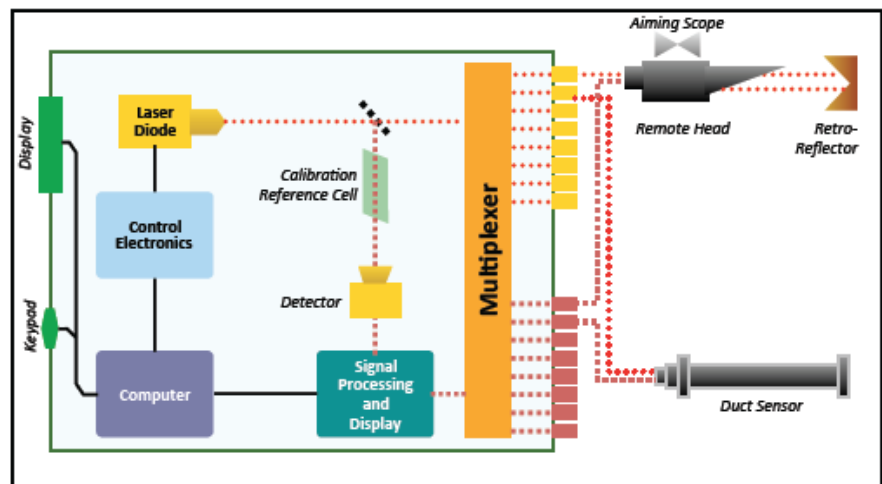
Discontinuous emission points are from blow off situations from safety valves, rupture discs, shut down and start up situations.

During a performance test, typically urea plants realize very low guaranteed ammonia consumption figures. But when one starts to maximize the plant loads, ammonia emissions increase as absorbers get overloaded. Also aging of the plant will increase ammonia emissions as corrosion phenomena cause small leakages from safety valves for example.

In those situations, it makes sense to measure accurately and continuously the ammonia emissions in order to be able to minimize the ammonia consumption figures.

Together with [BOREAL](#), UreaKnowHow.com has developed solutions to measure economically, accurately and continuously the ammonia emissions from inert vents and stacks. These are based on a tuneable diode laser, which is specific for ammonia, is self-calibrating and does not require any maintenance. One laser can measure up to eight ammonia emission points making it a very economical solution (refer to Figure 2).

Figure 2: One laser with up to eight applications



Gas Detection with a DFB Laser. Every gas is composed of molecules. Different molecules have various frequencies or wavelengths at which they resonate or vibrate. These are known as the absorption wavelengths because when specific molecules absorb a portion of the light energy, they vibrate at these wavelengths. Because molecules of other gases are different, these gases absorb light at different wavelengths from the target gas. Wavelengths for this principle of gas detection are chosen in regions that the absorption of the target gas does not interfere with the absorption wavelength of any other gases that may be present.

A laser will be chosen which operates at a specific absorption wavelength for the target gas. When the gas molecule is struck by this laser beam, the molecule is induced to vibrate. These vibrations affect the laser beam by changing its superimposed carrier level. The difference in the superimposed signal, together with the intensity of the returning beam, is used by a computer to obtain a measurement of the target gas concentration. This laser operates in the Near Infra-Red spectrum (1300 to 1700 nanometers) and cannot be seen with the human eye. It has a line width of about 0.1 nm and is concentrated

and very intense. For the same power output, it is able to penetrate dust and steam better than any visible laser.

The Boreal Laser Continuous Ammonia Analysers offers the following benefits:

- No consumables, no moving parts - minimal maintenance
- Minimum operation and maintenance needs – saves money AND personnel
- Reliable un-attended performance in all climate conditions
- Gas specific - No False Alarms
- Fast response, no “memory” effects
- Laser light not influenced by water vapor
- No electrical components in the field, no ATEX requirements applicable
- Optical absorption technique - direct measurement of gas, no chemistry kits
- Fast response time, no sample lag time - enables correlation of gas levels with process conditions
- Fibre optic multiplexing, one analyzer can measure up to 8 emission points: lower cost per measurement

Typically one only has connect a BOREAL In-Line Probe to the available 2” nozzle on the stack, which leads to an active measurement path measuring continuously and directly the ammonia concentration of the gas flows in the stack.

The construction details of the BOREAL Laser In-Line Probe are such that the process stream does not come into contact with the optical components of the measurement head. The process can follow unobstructed through the probe without significantly altering pressure or flow characteristics.

The laser light is sent via a fibre optic cable from the analyzer to the In-Line Probe. The active measurement path is formed by the laser passing through the windows of the In-Line Probe (and the process) The laser light is then collected on the photodiode and the signal is carried back to the analyzer via the same fiber optic cable. The concentration is then transferred from the analyzer to DCS.

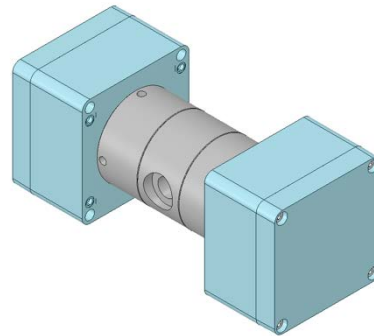


Figure 3: The BOREAL Laser In-Line probe

BOREAL and UreaKnowHow.com offer the Continuous Ammonia Analyzer for the melt and absorber stacks on a **No Cure No Pay Basis**.

Other applications can be ammonia compressor and (high pressure) ammonia pumps, ammonia loading stations and shipments and facility fence line monitoring to protect people living close to the plant.

Another interesting application for the BOREAL laser is the **UreaKnowHow Leak Detection System** for loose liners of high pressure urea equipment items. Several Safety Risks threaten Urea High Pressure Equipment like high pressures, high temperatures, various kind of corrosion phenomena, crystallization risks, large volumes and release of ammonia in case of a leak.

A significant number of serious incidents with Urea High Pressure Equipment still do occur in our industry. And in 50% a failing leak detection system was one of the main causes.

The Risk Register for a 316L Urea Grade Reactor identifies totally 45+ safety hazards of which 75% can be prevented by operating a proper leak detection system. Plus please do realise the typical lifetime of the 316L Urea Grade protective layer of a urea reactor is 20-30 years. While the 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.

The UreaKnowHow Leak Detection System offers the most reliable HP Equipment Leak Detection System available in the market and guaranteed a Pay Back.

The UreaKnowHow Leak Detection System has following features:

- Suitable for all designs of HP equipment, new or existing
- No risks for bulging or damaging of liner (vacuum)
- No risks for stress corrosion cracking of carbon steel (no need to flush with steam or condensate)
- Continuous testing of open leak paths
- No risks for clogging as smallest leak will be detected and leak will be diluted with air
- Best option for existing clogged situations
- No memory effect, no saturation issues with ammonia analyser
- No consumables required for ammonia analyser
- Self (re-)calibrating ammonia analyser
- No maintenance required for ammonia analyser
- Failure safe design
- Gives ammonia leak rate and calculates the leak size reducing required shut down time to find the leak
- Detection of false leaking air versus real liner leak
- Allows introduction of leak tracer to pinpoint a leak
- Most reliable and accurate leak detection system available in the market
- Twin urea lines or urea/ UAN lines can use one system
- Can be combined with a continuous monitoring of ammonia emission points like stack, inert vents, absorber vents, prill tower, granulation stacks leading to a Guaranteed Pay Back.
- Can be easily combined with other ammonia detection applications like ammonia storage tank, ammonia pumps, refrigeration ammonia compressor, etc.
- A Guaranteed Pay Back because of reducing the required shut down to find and repair leak and reduction of the ammonia consumption figures.

[Click here for more information.](#)



Figure 4: UreaKnowHow Leak Detection System

Providing information to the operators will automatically focus their attention to ammonia emissions, which will reduce the emission and consumption figures and lead to better performance figures.

But how to minimise ammonia consumption figures ?

Once one monitors automatically the ammonia emissions and even with optimizing the process parameters one cannot further reduce the ammonia losses, it is time to develop revamp schemes to reduce the ammonia losses.

The most effective way to catch ammonia from large inert gas streams like the prilling tower or granulation is by means of a wet scrubber with an acid. Typically one should think about sulphuric acid or nitric acid. In an acid scrubbing step the ammonia will react with these acids and form either an ammonium-sulphate or ammonium-nitrate solution.

The ammonium-sulphate solution can be re-processed in an evaporation step and mixed with the urea melt to produce a sulphur enriched urea fertilizer either by means of granulation or rotoformer technology. UAS is a popular fertilizer in many places in the world as many areas suffer from sulphur deficiencies. [CASALE](#), [GGT](#), [IPCO](#), [NIIK](#), [STAMICARBON](#) can provide solutions to produce UAS granules.

The ammonium-nitrate solution can be mixed with urea solution and form a UAN liquid fertilizer, which is a very popular fertilizer in Europe, North America and also getting more and more popular in other areas. [CASALE](#), [CEAMAG](#), [NIIK](#), [STAMICARBON](#) can provide solutions to produce UAN.

In more concentrated ammonia gas streams, absorbers, coolers and condensers using cooling and/or chilled water can reduce the ammonia emissions effectively. [CASALE](#), [NIIK](#), [SAIPEM](#) and [STAMICARBON](#) can support you in providing these solutions.

To reduce the ammonia emissions from leaking safety valves via the stack, [BADOTHERM](#) has developed an innovative and effective solution: Like many chemical processes, also in urea plants pressure safety valves safeguard against too high pressures. Urea plants are however unique because the very corrosive and easy crystallizing ammonium-carbamate poses challenges to assure a safe and reliable operation of these safety valves. Passing safety valves can cause clogging of the outlet line and is a serious threat for safeguarding your equipment against too high pressures.



Figure 5: Clogged outlet line of a ammonium carbamate safety valve

Also losing valuable ammonia and risking a negative environmental impact are related consequences. The synthesis section of a urea plant is safeguarded against too high pressures by synthesis safety valves. Operators prefer to operate the synthesis at a maximum operating pressure to realize a maximum conversion of ammonium carbamate into urea. But at the same time they need to be careful not to pop up the safety valves causing a major environmental impact and an unplanned expensive shut-down. The innovative BADOTHERM solution realises a reliable and accurate measurement of the synthesis pressure and a detection method for passing safety valves. This solution can also be applied in other sections of a urea plant such as the recirculation section and hydrolyser/desorber section.



Figure 6: BADOTHERM Synthesis Pressure measurement

Find the complete information at: [BADOTHERM Pressure Measurement Solutions improve safety and reliability, improve performance figures, avoid unnotedly ammonia losses and reduce environmental impact of your urea plant.](#)

The above BADOTHERM solution can be perfectly combines with the LESER Flush Safety Valves For ammonium-carbamate service. The German company [LESER](#) has developed state of the art safety valves with a special LESER Flush system, which leads to a higher safety and reliability standard. These safety valves are available in 316L Urea Grade, 25-22-2, duplex and Safurex® material and avoid that one needs to shut down the plant to service the safety valve after a pop-up / blow-off situation. Further with the LESER Support Loaded System (SLS) one is able to operate close to the set pressure of the safety valves and reduce the ammonia emissions to a minimum extend. A pre-condition for such a SLS system is that one needs to measure the pressure close to the safety valve. BADOTHERM has a proven and innovative solution available for this service.

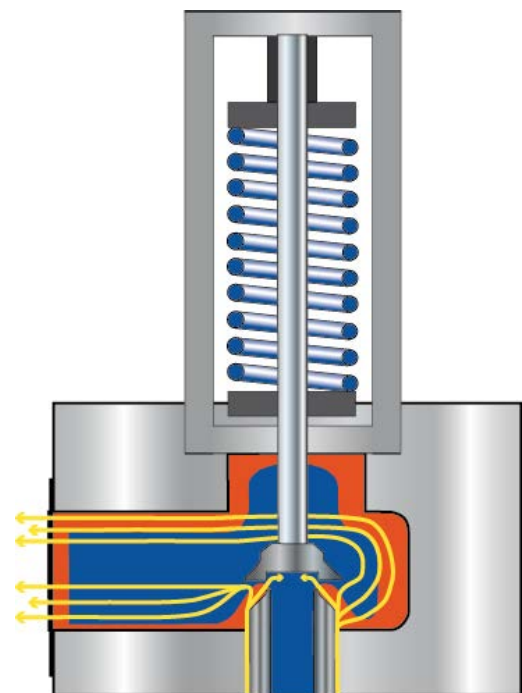


Figure 7: LESER Flush safety valve

Conclusions

Measuring continuously and paying attention to ammonia emissions pays easily back. The technical solutions are available and well proven allowing any urea plant to minimize the ammonia emissions and at the same time the ammonia consumption figures.

As an independent expert company, UreaKnowHow.com can support you to evaluate the proposals offered by the various solution providers. Contact us via mark.brouwer@ureaknowhow.com