

On-line Gas Analysis In Ammonia Plants

APPLICATION

Emerson provides Rosemount Analytical gas analyzer technology for on-line analysis of ammonia plant streams. Strategically placed gas analyzers improve the process efficiency and the purity of the end product.

BACKGROUND

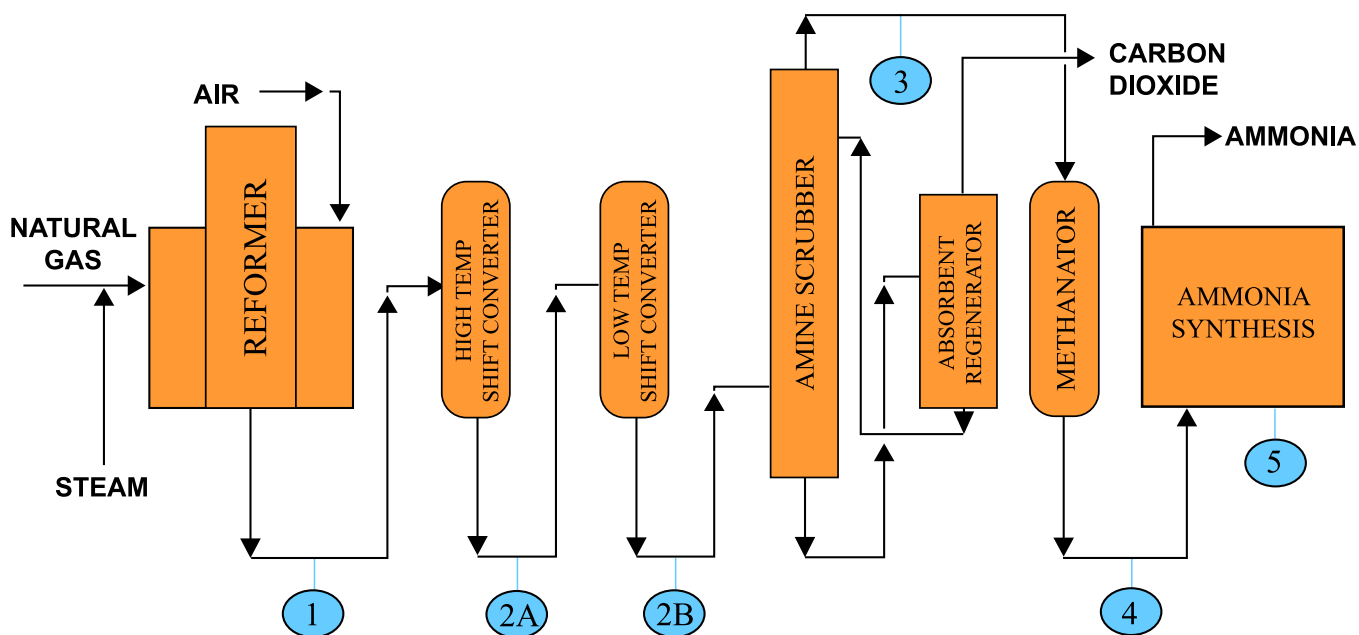
Ammonia is used in the production of a variety of products including fertilizer, nitric acid, nylon, pharmaceuticals, and refrigerant.

Production of ammonia (NH_3) is a two step process. The first step is to produce hydrogen (H_2) by reacting natural gas or methane (CH_4) with steam in a reformer. The second step is to react hydrogen with nitrogen (N_2) in a 3:1 ratio over a high-temperature catalyst in the ammonia synthesis process.

In the process of reforming natural gas or methane to hydrogen, carbon monoxide (CO) and carbon dioxide (CO_2) are formed as by-products. Even at low concentrations, both CO and CO_2 cause irreversible problems in the ammonia synthesis process. When the synthesis gas contains CO, a slow permanent deterioration of the catalyst occurs. The presence of CO_2 in the synthesis gas can result in the formation of ammonium carbamate, a fine white powder, which precipitates out and causes plugging of the ammonia converter. Therefore, to prevent problems in the ammonia synthesis process and to prolong the life of the expensive catalyst, the removal and measurement of CO and CO_2 on a continuous basis is required.

GAS ANALYZER APPLICATIONS

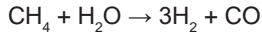
During the production of ammonia, the gases pass through the steam reformer, high- and low-temperature shift converters, amine scrubber and methanator before entering the ammonia synthesis process.



1 = measuring point.

Measuring Point 1: Steam Reformer

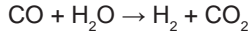
Natural gas and steam react over catalyst to form H₂ and CO:



Also present is CO₂ and unreacted CH₄. Reformer efficiency is monitored by measuring unconverted CH₄. CO is also measured in preparation for the shift converters.

Measuring Points 2A and 2B: High- and Low-Temperature Shift Converters

The shift converters remove CO by reacting with steam to form H₂ and CO₂:



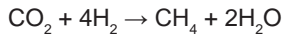
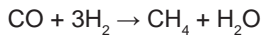
The CO content is measured to determine the efficiency of the shift converters.

Measuring Point 3: Amine Scrubber

CO₂ is absorbed in amine scrubber. The CO₂ is measured to determine scrubber efficiency.

Measuring Point 4: Methanator

The methanator removes the remaining traces of CO and CO₂ by converting them to methane:

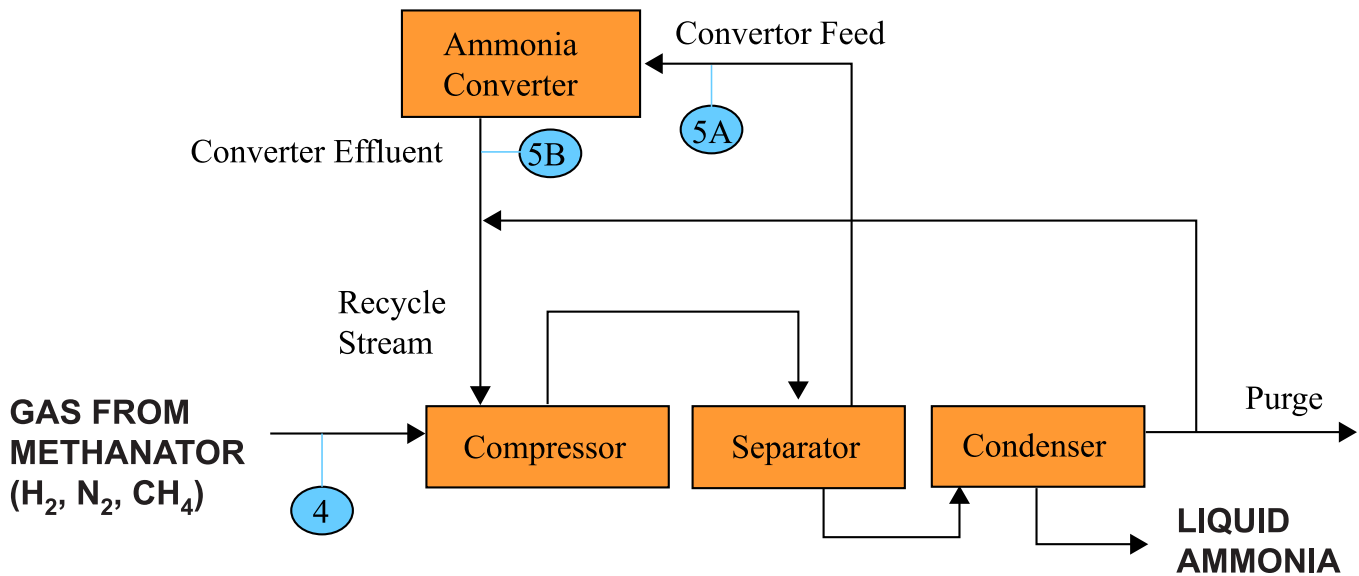


Trace CO and CO₂ are measured because they must be removed before the ammonia synthesis process or the CO will poison the ammonia converter catalyst and the CO₂ will react with ammonia and cause plugging of the ammonia converter. H₂ and CH₄ are also measured to control the feed for ammonia synthesis (described in next section).

The X-STREAM analyzer is extremely well-suited to make the CH₄, CO and CO₂ measurements described above using NDIR (non-dispersive infrared) photometric detectors. Typical analysis ranges after the Methanator are 0 to 10 ppm CO and 0 to 5 ppm CO₂. Abnormally high concentration levels should be alarmed.

AMMONIA SYNTHESIS PROCESS

Hydrogen - nitrogen rich gas from the Methanator goes into the conversion - separation loop where it is mixed with recycle gas from the Ammonia Converter. In the Ammonia Converter hydrogen reacts with nitrogen over catalyst to make ammonia.



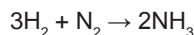
Measuring Point 4: Methanator

In addition to measuring trace CO and CO₂ at measuring point 4, H₂ and CH₄ are also measured to control the feed for ammonia synthesis. The ammonia yield from the combination of H₂ and N₂ depends on how closely the 3:1 ratio of H₂ to N₂ is maintained. The point in the process where this ratio is usually measured is at the inlet of the compressor which feeds the synthesis gas to the ammonia converter. At this point the stream composition is approximately 25% N₂, 73% H₂, and 1% CH₄ plus 0.5% Argon (Ar) and 0.5% water (H₂O). Air added to the secondary reformer provides the N₂ for the ammonia reaction. The CH₄, Ar and H₂O are carried over from the previous process steps and do not enter into the ammonia-forming reaction.

Since the background gases (CH₄, H₂O and Ar) have low concentrations, the sample may be considered essentially a binary mixture of H₂ and N₂ which enables the H₂ concentration to be measured using a thermal conductivity detector in an X-STREAM analyzer.

Measuring Points 5A and 5B: Ammonia Synthesis Converter

At this point, hydrogen reacts with nitrogen over catalyst to make ammonia:



Ammonia is measured before and after the converter to determine converter efficiency. The ammonia synthesis process is then optimized by "trimming" the hydrogen - nitrogen ratio entering the reformer.

Ammonia concentration can be measured using an NDIR photometric detector in an X-STREAM analyzer.

Summary

Emerson can supply either Rosemount Analytical X-STREAM Flameproof analyzers or X-STREAM Field Housings with purge/pressurization systems for these applications. The analyzers are used to insure more efficient production, longer catalyst life and higher quality product.

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