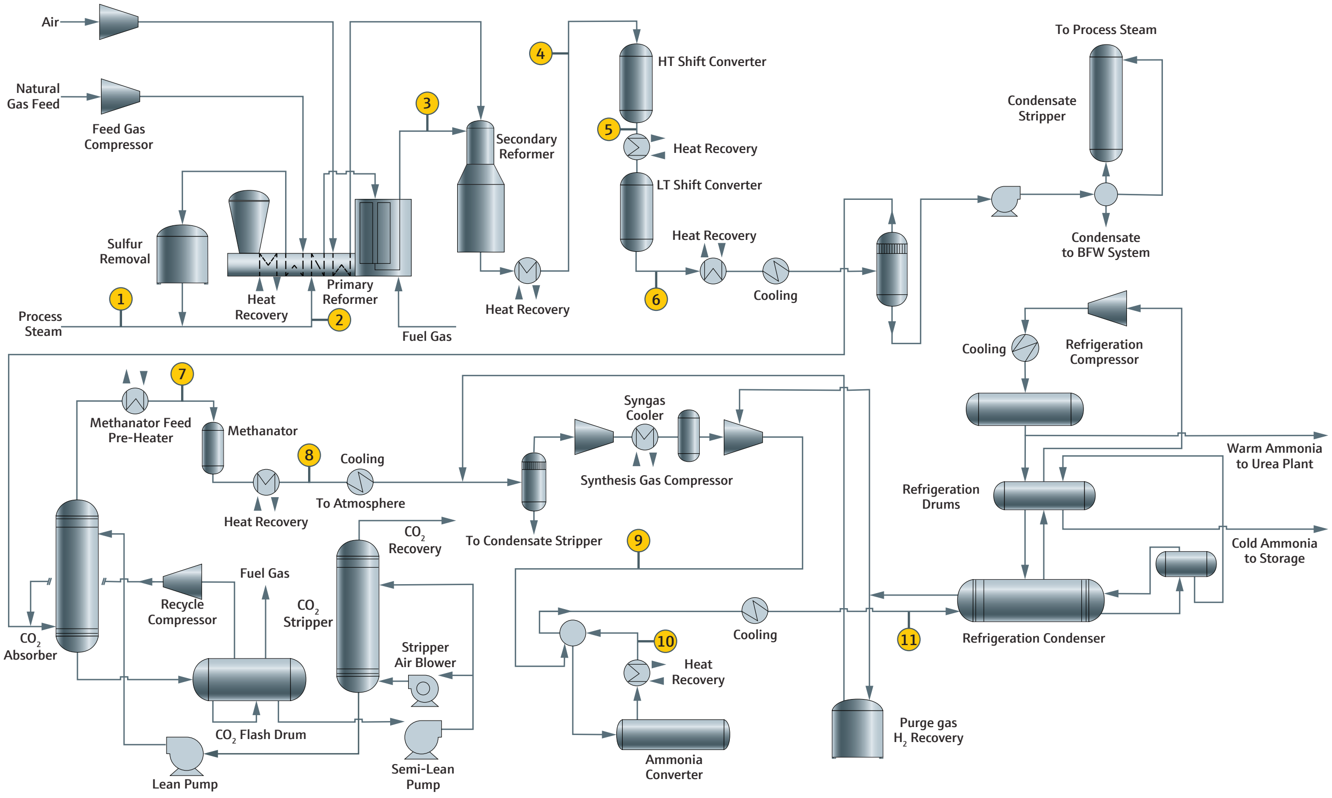
Application Note
Ammonia production analytics overview

Ammonia production and main uses Ammonia is one of the most highly produced inorganic chemicals because of its many uses. There are numerous large-scale ammonia production plants worldwide, producing a total of 146 million tons of ammonia in 2015.[1] China produced 32.1% of the worldwide production, followed by India with 8.9%, Russia with 7.9%, and the United States with 6.3%. Fertilizing agricultural crops consumes over 80% of the ammonia produced. Other uses of ammonia include the production of plastics, fibers, explosives, and nitric acid. Ammonia is also used as an intermediate in the manufacturing of dyes and pharmaceuticals.

The overall ammonia process In a typical ammonia producing plant using natural gas feedstock, a Steam Methane Reformer (SMR) is used to convert the natural gas to syngas, which is a mixture of mostly H_2 and CO. The CO is then converted into additional H_2 and CO_2 using Water-Shift (WS) reactors. Subsequent syngas processing purifies the syngas by removing the CO_2 via a CO_2 absorber followed by the methanation of any remaining CO_2 (which is a poison for the catalyst used to synthesize NH_3). The N_2 from an air separation unit is combined with the H_2 and reacted via the Haber-Bosch process in an ammonia conversion reactor. Because the $H_2 + N_2 \leftrightarrow NH_3$ process is reversible, the equilibrium is driven towards the NH_3 product side by continuously liquefying and removing some of the NH_3. This continuous synthesis loop results in the build-up of the original impurities in the purified syngas used as feed to the ammonia reactor, and needs to be purged on a regular basis.



A Simplified Process Diagram showing the Main Process Units in a Modern Ammonia Plant using Natural Gas as the Primary Feedstock

1. U.S. Geological Survey, 2016, Mineral Commodity Summaries 2016: U.S. Geological Survey, pp 118-119.

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Process analytical challenges There are several streams that are typically analyzed during the ammonia manufacturing process, and the analysis results form the basis for controlling and optimizing the main process units. Although most of the streams are relatively easy to analyze using traditional on-line analyzer techniques, such as GC, MS, and photometry, in several cases steam content and the process conditions are severe enough to require special sample conditioning techniques. The use of the Optograf Analyzer, combined with the OptoDRS Sampling Interface, is a unique and robust solution for these challenging streams.

The solution: Optograf™ Analyzer and OptoAST™ or OptoDRS™ Sampling Interfaces The Optograf Analyzer provides the unique spectroscopic ability to analyze the mononuclear diatomic gases H_2 and N_2, which allows measurement of all the streams shown in the typical "Stream Services" list below. Speciation is achieved without any columns, valves, stream switching or the need for carrier gas. In addition, the OptoAST and OptoDRS interfaces are based on the pipe-centric concept of performing the process sampling, sample conditioning, and measurement in a single, integrated module that can be installed at the sample tap. Below is a list of typical process conditions and the process sampling interfaces recommended by Kaiser Optical Systems, Inc., for each of the streams analyzed on-line. The OptoDRS sampling module is capable of dealing with the preconditioning of hot, dirty (particulates) and moisture-saturated samples, whereas the OptoAST module can interface to relatively dry and clean process samples at line temperature and pressure (up to 150°C/1000 psig). As such, only minimal sample conditioning is required, while avoiding any need for sample transport to the analyzer in a shelter, because the optical probe sensor transmits spectral information via an optical fiber to the analyzer.

	Stream Service	Key Measurement Parameter	Pressure* (barg)	Temp* (°C)	Recommended Sampling Interface
❶	Natural Gas Feed to Primary Reformer	Carbon Number	26	25	OptoAST
❷	Fuel Gas to Reformer Furnaces	BTU	6	40	OptoAST
❸	Raw Syngas – Primary Reformer Outlet	Composition/CH_4	36	800	OptoDRS
❹	Raw Syngas – Secondary Reformer Outlet	Composition/CO	35	370	OptoDRS
❺	High Temperature Shift Converter Outlet	Composition/CO	34	445	OptoDRS
❻	Low Temperature Shift Converter Outlet	Composition/CO_2	32	220	OptoDRS
❼	CO_2 Absorber Outlet – Methanator Inlet	Composition/CO_2	31	25	OptoAST
❽	Methanator Outlet – Purified Syngas	Composition/ H_2/N_2	30	330	OptoAST
❾	Ammonia Converter Feed Stream	H_2/N_2 Ratio	57	400	OptoAST
❿	Ammonia Converter Exit Stream	Composition/ Impurities	220	440	OptoAST
⓫	Synthesis Loop Purge Gas	CH_4 Impurities	150	25	OptoAST

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