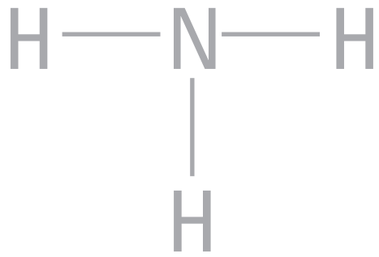
Flexitallic®

THE IMPORTANCE OF SEALING MATERIALS IN SAFE AND EFFICIENT Ammonia Production

CHEMICAL PROCESSING



Introduction

This document describes the challenges placed on gaskets and sealing materials in ammonia plants with a particular focus on syngas production and provides an analysis of the sealing technologies available. Selecting the right gasket material can minimise downtime, maintain safety and maximise the efficiency of plant operations.

The production of ammonia starts with synthesis gas (syngas), a gas mixture commonly produced through steam methane reforming, using a natural gas feedstock to convert to hydrogen (with CO_2 as a by-product). Hydrogen and nitrogen are then synthesized to create ammonia which is used across a range of applications and produced in volumes of over 180 million mtpa globally[1].

Key fact

Approximately 80% of ammonia output is used in the production of fertilisers. Other uses include plastics, nylons and dyes[2].

Balancing the equation

Rising energy prices and environmental regulations pose an ever-increasing challenge for ammonia plant designers and managers to maintain safe and profitable operations. In recent years there have been high levels of development in plant designs to achieve some key objectives:

- Reduce power consumption
- Improve process heat recovery
- Minimise stock losses
- Cut energy consumption for CO_2 removal

The need to balance yield, costs and emissions, while maintaining stringent safety standards, has seen a range of solutions implemented on many plants to optimise their operations. These include increasing the reforming pressure and preheating the process air for the secondary reformer to a higher temperature. Sometimes underestimated within the context of broader improvement plans, gaskets are worthy of consideration, particularly in extreme service environments. These applications require materials resistant to challenging process conditions, making the decision on which gasket technology to choose a crucial component to help improve processes efficiencies.

1. https://www.aiche.org/resources/publications/cep/2016/september/introduction-ammonia-production.
2. https://www.netl.doe.gov/research/Coal/energy-systems/gasification/gasifipedia/fertilizer-commercial-technologies.

The production process

Within ammonia production there are several different processes used to generate syngas. These include gasification (coal), electrolysis (water), partial oxidation (heavy oil) and reforming (natural gas).

Steam reforming of natural gas has been identified as the most reliable and efficient method of ammonia production, accounting for 77% of the world's ammonia capacity[3]. Despite this, it's worth noting that regional energy preferences and infrastructure can significantly impact process used. For example, in China, currently around 80% of ammonia plants utilise coal gasification[4].

Steam methane reforming and alternative processes, including gasification and partial oxidation, present real challenges for gasket materials. For example, the very high temperatures present in the reforming and partial oxidation processes, in some cases in excess of 1200° C (2192° F), places significant demands on sealing materials such as graphite. Such extremes in temperature can often lead to gasket failure or leakage and severely affect plant efficiency.

In addition to the energy required for the steam methane reforming process, ammonia synthesis requires high pressures, placing further strain on the components in this part of the process. The purification of syngas releases large amounts of carbon, placing increasing pressure on plants to efficiently manage emissions. With a growing pressure for all manufacturers to support global environmental directives, including the EU framework that aims to cut greenhouse gas emissions by 40% by 2030[5], there is now an increasing urgency for every plant to respond to these environmental imperatives whilst continuing to balance energy costs and production objectives. Ensuring that you are choosing the best available technology is critical for your plant's efficiency and performance.

Identifying the hotspots

When it comes to choosing the best available gasket technology, how do you know which sealing material is most appropriate for your plant?

Gaskets made from unsuitable sealing materials will degrade prematurely, causing leaks that in many cases require unplanned shutdowns for costly and complex maintenance operations.

The key service conditions you need to consider when thinking about optimising the hydrogen/syngas and ammonia production process are:

1. Temperature
With temperatures approaching 1200ºC (2192°F) in the hottest areas of the plant and other equipment also operating up to 600ºC (1112°F), it's crucial gaskets can deal with extreme heat without compromising on sealing performance.

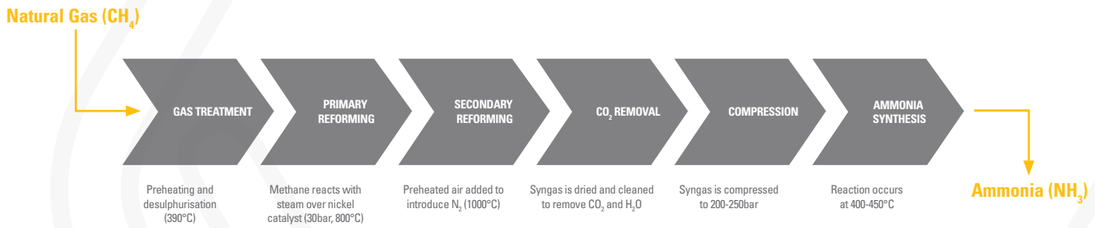
2. Pressure
Combined with high temperature, significant pressure across the production process, up to 200 bar (2,900 psi) during ammonia synthesis, places additional requirements on piping components and sealing materials.

3. Thermal cycling
Typically caused by routine maintenance, unplanned shutdowns or activities such as de-coking for the gasification processes, thermal cycling can adversely affect gasketed joints as components struggle to cope with repeated contraction and expansion. Mitigating avoidable sealing failures across the plant is crucially important to avoid further unplanned shutdowns or maintenance.

4. Oxidation
Within the steam methane reforming process, the chemistry of the process is highly oxidising, providing an additional challenge for sealing materials, and for graphite, a service environment where failure is ultimately inevitable.

Consideration of the most suitable sealing materials from each of these perspectives can help to drive further improvements by improving safety, increasing time between failures, improved reliability and reduced operations costs.

Ammonia process overview



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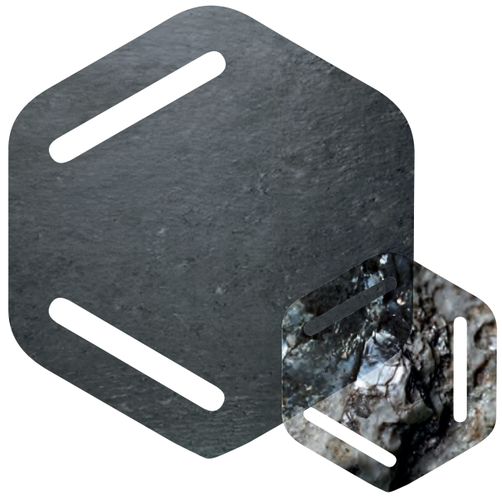

Reviewing conventional sealing materials

Graphite is widely used in industrial sealing applications due to its acceptable sealing properties and ability to cope with moderate temperatures. However, its performance reduces significantly in high temperature applications and particularly in oxidising environments where material degradation can be severe and rapid, leading to gasket failure and leakage.

Within the steam reforming process, both conditions are present, creating a serious problem for operators who need to ensure gaskets provide leakproof performance with a minimum impact on operations.

Graphite's short operational life in these more challenging environments is a known problem in the industry but often tolerated without considering better alternatives. But what other options are there?

Assessing the impact on gaskets

In the steam reforming process, the combination of high temperatures and oxidising conditions make for a demanding environment which directly impact on gasket life and performance.

In addition, thermal cycling exposes gasket and flange materials to different degrees of thermal expansion and contraction. Often occurring due to plant maintenance shutdowns or process upsets, thermal cycling frequently results in a critical drop in bolt stress, leading to a loss of gasket compression with a detrimental impact on sealing performance.

For those plants using the partial oxidation process, the higher temperature and more severely oxidising environment present, in comparison to the steam reforming process, will also play a significant role in a faster and more severe degradation of sealing materials such as graphite.

TYPICAL CHALLENGING LOCATIONS FOR GASKETS

- **Hydrocarbon (gas) feedlines and pre-heater exchangers**
- **The pre, primary and secondary reformers**
- **Pigtails and syngas piping**
- **Shell & tube heat exchangers**
- **Downstream syngas cooling**
- **Waste heat recovery and steam generation**
- **Superheated steam lines**

Case study 1

A global producer of ammonium nitrate experienced several unplanned outages a year on their US plant. This led to the natural gas preheater exchanger experiencing leaks due to the thermal cycling caused by the restarts.

Solution: Thermiculite® Change™.

The previous solution was only operational for 1 year before needing to be replaced. Change™ has provided more than 3 years leak free performance.

Case study 2

A large petrochemical facility on the US Gulf Coast was seeing oxidation in less than two years on hundreds of graphite filled spiral wound gaskets on their reformer pigtail flanges.

Solution: Thermiculite 845.

Switching to Thermiculite® eliminated oxidation and has improved reformer reliability.

Thermiculite® and Change™ gaskets

Flexitallic has developed a wide portfolio of gasket products specifically for the complex environment present in ammonia production. Core to the range are two products: Thermiculite® and Change™.

Fig 1: Material comparison table:

MATERIAL	SEALABILITY	RESISTANCE TO PRESSURE	RESISTANCE TO TEMPERATURE	RESISTANCE TO OXIDATION
Thermiculite®	▯	HIGH ▯	HIGH ▯	HIGH ▯
Thermiculite® + Change™	▯	HIGH ▯	HIGH ▯	HIGH ▯

▯ HIGH suitability to all potential environments in ammonia production

Thermiculite®

Our tested and proven gasket material is made from chemically and thermally exfoliated vermiculite, which has a structure similar to exfoliated graphite. However, **Thermiculite®** offers one clear advantage - it can endure a wide range of temperatures without compromising integrity.

All **Thermiculite®** products are developed for use in high temperature processes in services up to 1000°C (1832°F) working in highly oxidised environments. **Thermiculite®** is intrinsically resistant to oxidation. Conventional graphite gaskets cannot withstand higher temperatures and are susceptible to oxidation, which leads to sealing failure and leakage.

Key features

- **Total freedom from oxidation**
- **Wide chemical compatibility**
- **Can be used in temperatures up to 1000°C (1832°F)**
- **TA Luft compliant**
- **Fire safe**
- **Proven track record**
- **Wide range of formats to suit all applications**

Change™ gasket

Manufactured with proprietary equipment and a unique laser welding process, **Change™** is able to perform longer than any other heat exchanger gasket, CGI spiral wound, double jacketed, CMG or kammoprofile.

For applications where leaks are caused by thermal cycling such as heat exchangers, **Change™** with **Thermiculite®** offers the ideal solution.

Thermiculite® is available as a sheet product, spiral wound gasket, kammprofile, Change™ gasket and valve stem packing.

Additionally, Flexitallic manufactures solid metal ring type joints and Lens rings that are often found in the high pressure ammonia synthesis vessels.

For more information on specific products, please download our **Products and Services** brochure or visit our website.

Conclusion

The need to optimise plant operations, driven by a range of external and internal influences, means plant operators must be confident that all equipment is both reliable and high-performing. High-temperatures in a difficult environment where oxidation is likely can lead to a variety of complications. Ensuring the best possible sealing materials are specified can help to prevent leaks, in turn increasing efficiencies across the board – with a significant reduction in unplanned shutdowns.

Flexitallic has designed its range with operators' needs in mind, never compromising on performance in even the most challenging environments present in syngas and ammonia plants.

To find out more about how **Thermiculite®** gasket materials and **Change™** gaskets can help you to maximise safety and efficiency in ammonia production, visit our website or contact your nearest Flexitallic office.

CHEMICAL PROCESSING

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About The Flexitallic Group

The Flexitallic Group is a global leader in specialised sealing solutions and products serving the oil and gas, power generation, chemical and petrochemical industries in emerging and developed markets. Focused on the upstream, downstream and power generation sectors, it has operations in France, the United States, Canada, Mexico, the United Kingdom, Germany, United Arab Emirates, Kazakhstan and China plus a network of worldwide licensing partners and distributors.

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