Long lasting gaskets for ammonium nitrate (AN) (and nitric acid (NA)) applications

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PIPEOTECH

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01 Introduction

An integrated plant for production of mineral fertilizers normally consists of plants for ammonia production, NA production, plants for calcium and/or ammonium nitrate (CAN/AN) production and plants for production of urea. Many such plants also produce phosphorus (P) fertilisers by acidulating phosphate rock (Odda process) and adding potassium chloride (KCl) or potassium sulphate (K_2SO_4) for production of complex NPK-fertilizers.

These plants typically employ various corrosive, hazardous and abrasive fluids, and chemicals. The temperatures may stem from processing and handling of cryogenic liquids (for example at -186°C for auxiliary liquid argon) and at -33°C for liquid ammonia storage to over 1000°C in the reformers. The pressures are as high as 175-350 barg in ammonia converters and 150-250 barg in urea plant reactors.

The industrial production of AN entails the acid-base reaction of ammonia with NA: $HNO_3 + NH_3 \rightarrow NH_4NO_3$. The ammonia required for this process is normally obtained by the Haber process from nitrogen and hydrogen. Ammonia produced by the Haber process can be oxidized to nitric acid by the Ostwald process. Downstream of the ammonia production, the ammonia and carbon dioxide are then reacted at high temperature and pressure to produce molten (liquid) urea which is cooled and manufactured into granules or prills for industrial use and as an agricultural fertilizer (N-fertilizer). The hot melt can also be used to prepare urea solutions. Based on the two main end products, AN and urea, different fertilizer types are manufactured by mixing with ingredients such as phosphorus (P) and potassium (K) to form different types of NPK fertilizers, dolomite to form CAN or by mixing urea and AN to make urea ammonium nitrate (UAN).

The aim of this paper is to describe the challenges placed on gaskets and sealing materials in the different parts of typical fertiliser manufacturing plants, especially for AN and NA plant piping systems, and provides an analysis of the sealing technologies available. It also includes examples of successful sealing solutions.

Selecting the right gasket material can minimise downtime, maintain safety and maximise the efficiency of plant operations as demonstrated by the provided case studies.

02

Best Available Techniques (BAT) for pollution prevention and control in the European fertilizer industry – Production of AN and CAN

In 1995, the European Fertilizer Manufacturers Association (EFMA) prepared eight Booklets on BAT in response to the proposed EU directive on integrated pollution prevention and control (IPPC Directive). These booklets were reviewed and updated in 1999 by EFMA experts drawn from member companies.

Booklet No.2 provides BAT for the production of NA and Booklet No. 6 provides BAT for the production of AN and CAN.

The Booklets give two sets of BAT emission levels:

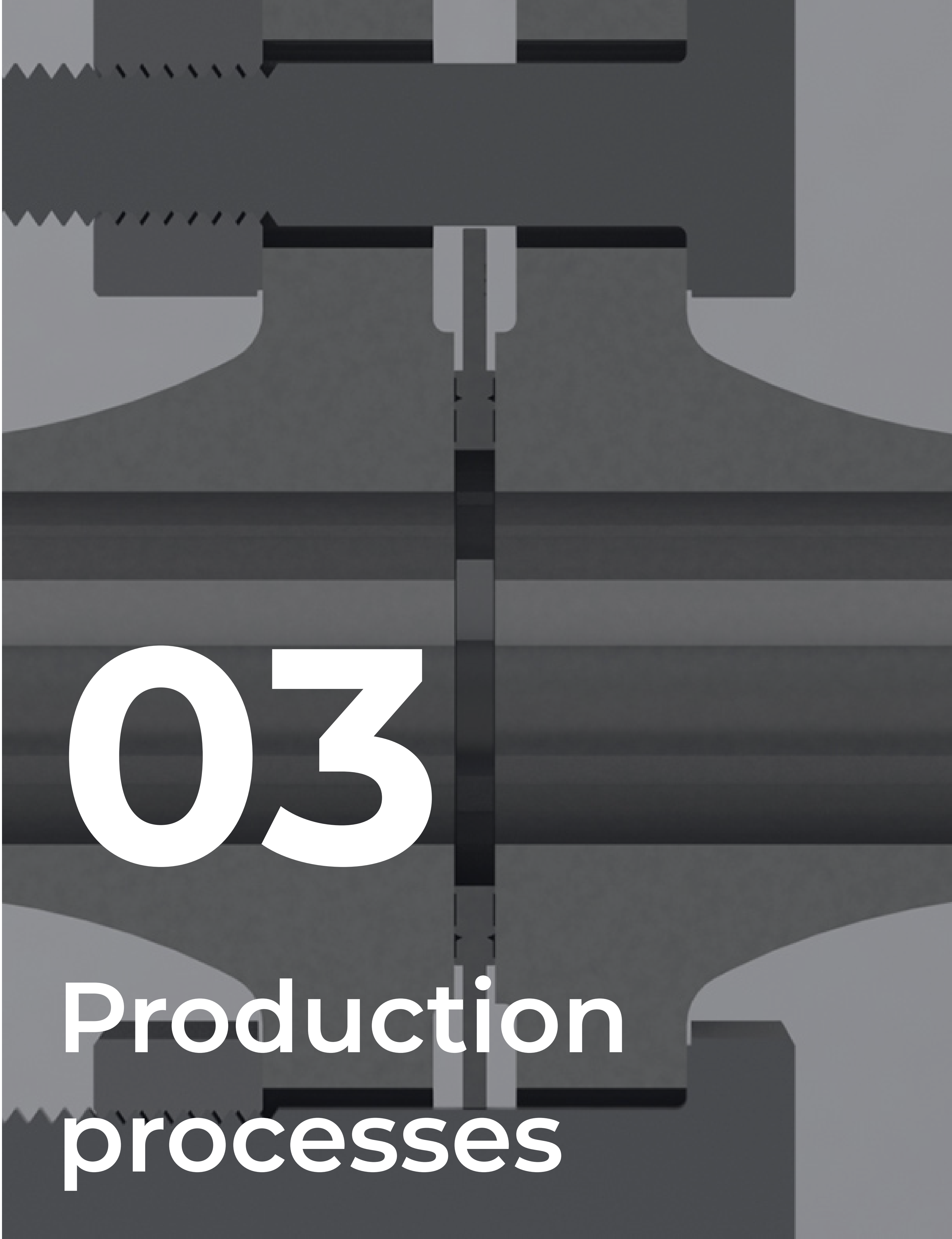
- For existing production units where pollution prevention is usually obtained by revamps or end-of-pipe solutions
- For new plants where pollution prevention is integrated in the process design

It should be noted that these Booklets only include the more significant types of emissions and not fugitive emissions and emissions due to rainwater.

Of particular importance and relevance for AN production is that fertilizer regulations in the European Union (EU) place specific requirements on the quality of AN which is to be labelled as an EC Fertilizer. The AN product must conform to these specifications if the plant is to qualify for BAT (additions, oil retention, combustible materials, pH, prill/granule size, chlorine content and heavy metals content). It should be noted that several of these contaminations may impact on the chemical/electrochemical compatibility between AN-solutions and containing materials, hereunder piping, flange, gaskets, etc.

In accordance with Booklet No.6, the losses of AN to drain from a large number of sources is a potential problem for all AN plants. A common cause is the losses from pump seals, but losses can be simply leaks from flanges, passing valves etc., or they may be deliberate washings of process equipment because of build-up in solids handling equipment, or the preparation of equipment for maintenance. The problems that will be experienced on a specific plant will be unique to the plant design, but the general points must be considered by all manufacturers.

The purpose of this paper is to demonstrate the beneficial effect on these issues by applying BAT when designing AN plant piping systems, hereunder applying the BAT when selecting gasket technology for bolted flange joints (BFJ).



03

Production processes

3.1 Nitric acid (NA)

Nitric acid is produced by two methods. The first method utilizes oxidation, condensation, and absorption to produce a weak nitric acid. Weak nitric acid can have concentrations ranging from 30% to 70% nitric acid. The second method combines dehydrating, bleaching, condensing, and absorption to produce a high-strength nitric acid from a weak nitric acid. High-strength nitric acid generally contains more than 90% nitric acid. The following text provides more specific details for each of these processes.

3.1.1 Weak NA production

The high-temperature catalytic oxidation of ammonia typically consists of three steps:

1. Catalytic ammonia oxidation at 750°C to 800°C
2. Nitric oxide oxidation
3. Absorption

Each step corresponds to a distinct chemical reaction.

The nitric oxide formed during the ammonia oxidation must be oxidized. The process stream is passed through a cooler/condenser and cooled to 38°C or less at pressures up to 8 bara. The nitric oxide reacts non-catalytically with residual oxygen to form nitrogen dioxide (NO_2) and its liquid dimer, nitrogen tetroxide.

3.1.2 High-strength NA production

High-strength nitric acid (98% to 99% concentration) can be obtained by concentrating the weak nitric acid (30% to 70% concentration) using extractive distillation. The weak nitric acid cannot be concentrated by simple fractional distillation. The distillation must be carried out in the presence of a dehydrating agent. Concentrated sulfuric acid (typically 60% H_2SO_4) is most used for this purpose.

The nitric acid concentration process consists of feeding strong sulfuric acid and 55% to 65% nitric acid to the top of a packed dehydrating column at approximately atmospheric pressure. The acid mixture flows downward, counter current to ascending vapours. Concentrated nitric acid leaves the top of the column as 99 percent vapor, containing a small amount of NO_2 and oxygen (O_2) resulting from dissociation of nitric acid. The concentrated acid vapor leaves the column and goes to a bleacher and a counter current condenser system to affect the condensation of strong nitric acid and the separation of oxygen.

3.2 Ammonium nitrate (AN)

As mentioned, ammonium nitrate may be produced by direct neutralizing nitric acid with ammonia. Most of the ammonium nitrate plants produce an aqueous ammonium nitrate solution through the reaction of ammonia and nitric acid in a neutralizer. The process involves several unit process operations including:

1. Solution formation and concentration
2. Solids formation
3. Finishing
4. Screening and coating
5. Product bagging and/or bulk shipping.

However, many AN plants are based on the nitro-phosphate process (also known as the Odda process) which involves acidifying phosphate rock with nitric acid to produce a mixture of phosphoric acid and calcium nitrate (CN). This CN can then be worked up as CN fertilizer, but often it is converted into AN and calcium carbonate using CO_2 and ammonia (NH_3).

In many cases, solutions are blended for marketing as liquid fertilizers. The number of operating steps employed depends on the specification of the product. For example, plants producing ammonium nitrate solutions alone use only the solution formation, solution blending and bulk shipping operations.

Plants producing a solid ammonium nitrate product may employ all the operations. Approximately 15%–20% (v/v) of the ammonium nitrate prepared in this manner is used for explosives and the balance for fertilizer.

Additives such as magnesium nitrate or magnesium oxide may be introduced into the melt prior to solidification to raise the crystalline transition temperature, act as a desiccant (removing water) or lower the temperature of solidification. Products are sometimes coated with clays or diatomaceous earth to prevent agglomeration during storage and shipment, although additives may eliminate the need for coatings. The final solid products are screened, and sized, and off-size particles are dissolved and recycled through the process.

04

Selection of gasket material

When it comes to choosing the best available gasket technology, how do you know which sealing material is most appropriate for your fertilizer 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 that need to be considered when thinking about optimising the fertiliser production processes are described in the following sections.

4.1 Temperature

With temperatures approaching 1200°C in the hottest areas of fertiliser plants and other equipment also operating up to 600°C, it is crucial that gaskets can deal with extreme heat without compromising on sealing performance.

4.2 Pressure

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

4.3 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. This is especially critical when the gasket and the flange are selected in dissimilar materials with different thermal expansion properties.

4.4 Oxidation

Within most of the stated processes, the chemistry 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.

4.4.1 Acids and corrosion

The nitric acid systems represent a key application challenge: achieving reliable sealing with gaskets for strong and highly oxidizing acid service, including also other strong acids like sulphuric acid.

Strong acids, such as sulphuric/nitric acid, are extremely corrosive and, unless the gasket material is chosen wisely, the risk of gasket failure with resulting leakage can be high. This is especially applicable to gaskets containing stainless steels which may lose their passivity and therefore show high corrosion rates due to e.g., unknown acid contaminations. An important factor to consider in any strong acid service application is the concentration of the acid being serviced, as well as the temperature of the media. For example, applications involving sulphuric acid at concentrations of 96% and above can be extremely challenging, and the challenge is exacerbated when hot acid is involved.

Another example is condensing gases in ventilation systems where extremely corrosive conditions have been encountered. There are cases where 304/316 pipework have failed and caused serious leakages of nitrous gases (NO_x) due to pitting corrosion of the pipes/seam-welds leakages in the flanges after less than 4 years. These ambient temperature (20°C-50°C) condensed phases are acidic due to formation of hydrofluoric acid (HF), hydrochloric acid (HCl) and nitric acid (HNO_3) and are also containing chlorides (Cl^-).

Most metallic materials included in metallic and semi-metallic gaskets are sensitive to pollution/contaminations and may lead to dramatic consequences for the longevity of the gaskets if corrosion testing is not conducted prior to investment decision. This is especially true when the feedstock/raw materials have variations of chemical compositions (for example the phosphate rocks used in the nitro-phosphate route for NA/CAN production, see Section 1 and 3.2).

Similarly, it is extremely important to select the flange and gasket material such that the corrosion potential difference between the gasket and the flange is not causing galvanic corrosion of the gasket and thereby causing premature failure and leakage of the joint, refer also to Section 6.2.

05

Review of conventional sealing materials for oxidizing conditions

5.1 Background

In chemistry, strong oxidizers are substances (like chromic acid, NA and AN water solutions) that can cause other substances (like seals and gaskets) to lose electrons. So, an oxidizer is a chemical species that undergoes a reaction that removes one or more electrons from another atom.

This causes a change in mass. Metals will turn into their respective heavier oxides, and the carbon in graphite will oxidize into carbon dioxide—which, although molecularly heavier, is a gas at room temperature.

This happens in pumps, valves, pipelines, or any other equipment that have seals and gaskets carrying a strong oxidizer. It will cause pitting or rust and, depending on your choice of seal material, may require shorter service intervals. Ultimately, you may have to look for a more suitable material that can handle strong oxidizers.

More importantly, an oxidizing agent can cause or contribute to the combustion of another material.

The U.S. Department of Transportation defines oxidizing agents specifically. DOT's Division 5.1(a)1 means that a material may enhance combustion or quickly raise pressure causing a rapid chemical reaction. A fire may start or, even worse, create or facilitate an explosion.

There have been many instances of fires or explosions in mining, chemical process and even fertilizer factories where strong oxidizers were used.

A West Texas fertilizer company storage and distribution facility caught fire on April 17, 2013. As firefighters attempted to extinguish the blaze, the plant exploded with the force of 10 tons of TNT, killing 15 people and injuring 200. It destroyed 60 nearby homes and left a 93-foot-wide crater where the plant once stood. Most recently, the Beirut disaster comes to most peoples' minds regarding handling/storage of AN.

All said, it is important to choose the right sealing material for strong oxidizers. There are multiple sealing products on the market for the chemical processing, oil and gas, mining, and aerospace industries.

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. For example, graphite containing gaskets should not be used for concentrated NA even at room temperature due to the risk of graphite oxidation.

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?

This paper is intending to answer this question by proposing to apply the new and unique fully metallic one-piece DeltaV-Seal™ technology at these and other critical and challenging locations throughout fertiliser manufacturing plants. These proposals are underpinned by several case studies where this new technology has been successfully applied, see below.

5.2 Assessing the impact on gaskets

5.2.1 High temperature applications

In the steam reforming and nitric acid processes, 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 syngas plants using the partial oxidation processes, 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.

5.2.2 Cryogenic applications

Of low temperature applications in the ammonia manufacturing part of fertilizer plants, the recovery of valuable gases from ammonia synthesis purge gas streams also poses challenges to the gaskets due to the cryogenic conditions.

As stated, ammonia synthesis uses syngas generated by steam reforming natural gas (as the feedstock). However, this reaction also produces several other gases that do not contribute to the ammonia reaction. These purge gases need to be continuously removed from the synthesis loop and are generally fed back to the reformer furnaces as fuel gas.

A typical purge gas contains about 60% hydrogen, 20% nitrogen, 5% argon, 10% methane and 4% ammonia in varying concentrations, depending on the process in place at the ammonia plant. Instead of burning purge gases, it makes good financial sense to recover valuable gases such as ammonia, hydrogen, nitrogen, and argon.

5.2.3 Typical challenging locations for gaskets in ammonia manufacturing plants

In ammonia production plants including support systems there is a range of known locations where gaskets are facing challenging conditions:

- 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
- Purge gas recovery

06

DeltaV-Seal™ technology

6.1 Introduction

Pipeotch is developing a wide portfolio of gasket products specifically designed for the complex environments present in current and future fertiliser production. Core to the range are three products:

- DeltaV-Seal™ S235 (mild steel)
- DeltaV-Seal™ 316L (stainless steel)
- DeltaV-Seal™ 800HT (nickel-chromium-iron alloy)

All DeltaV-Seal™ gaskets are of a simple construction, one-piece, fully metallic, and precision machined under tight tolerances.

The gaskets provide very high tightness to bolted flange joints (BFJ) under both static and dynamic conditions through an innovative gasket design whereby the pressure (internal or external) is contained by interaction between the gasket and the flange surface at discrete and carefully selected sealing points on the flange surface. The number of sealing points are determined by the specific design conditions for the BFJ (pressure, temperature, required tightness class, environmental conditions, pipe/flange material selection, etc.).

All Pipeotech's products have undergone extensive qualification testing programs which have been documented in certified test reports, data sheets and white papers, all available on request or at www.pipetech.com.

6.2 Corrosion and integrity management of BFJ gasketed with DeltaV-Seal™

6.2.1 Corrosion processes in sealing connections

Corrosion processes in static and dynamic sealing connections in piping systems, pumps, armatures, and containers can cause significant costs and endanger the operational safety and service life of machinery and equipment.

Corrosion in sealing connections can be significantly reduced with the selection of suitable sealing materials and construction measures.

Firstly, adequate, and evenly distributed surface pressure must be observed during assembly of seals and gaskets. Secondly, great care must be taken in the selection of adequate auxiliary materials, such as e.g., adhesives, release agents or lubricants, so that no corrosion-promoting side reactions do occur under operating conditions.

Although the appearance of various corrosion cases may often look similar at first glance, different corrosion mechanisms, which are triggered by different causes, must be distinguished.

The most common long-term threats to BFJ integrity are the following time dependant interactions between the gasket and the flange surface:

- Contact corrosion
- Crevice corrosion
- Electrochemical corrosion (galvanic corrosion)

Since in practise these mechanisms hardly ever occur in isolation, it is often difficult to carry out a definite damage analysis as exemplified by the case described below on a failed spiral-wound gasket.

<u>Contact corrosion</u> is the type of corrosion occurring when polymeric materials are releasing foreign/unknown ionic materials at the contact surfaces between the gasket and the flange surface. This is due to the sealing material containing components that trigger a chemical reaction upon contact with a metallic sealing surface. Common ions are chlorides and sulphides from many types of polymers used in semi-metallic gaskets and these ions are often causing corrosion attack on flange surfaces made of stainless steels and thereby causing leakage of the BFJ.

Probably the most common case of damage – both on armature spindles and flanges – occurs with flat gaskets or stuffing box packings, which cause pitting corrosion on Cr/Ni-stainless steels due to high halogen (chloride, fluoride, bromide, iodide) content. Another typical example is in the case of PTFE (Teflon) gaskets where highly corrosive fluorine compounds are released. This decomposition process already starts at temperatures around 300°C. Even though the short-term resistance of PTFE lies at approx. 400°C, the temperature of permanent operation for gasket materials containing PTFE should not exceed 300°C.

<u>Crevice corrosion</u> requires very tight clearances where stagnant conditions can exist in electrolytic media. It is not uncommon for some gaskets to wick and allow favourable conditions for crevice corrosion to initiate. Even with highly pure, electrochemically inactive materials of high chemical and thermal stability, such as e.g., PTFE, strong corrosion effects can be observed under adverse installation conditions.

The corrosion mechanism is attributed to concentration differences (e.g., oxygen) in narrow crevices, as they can be commonly observed in sealing gaps, and thus resulting electrochemical potential differences. These potential differences permit electrochemical corrosion currents, with metal atoms being dissolved in form of ions due to redox processes. Through the enrichment of corrosion products, a self-intensification effect sets in, which can finally result in the dissolution of substantial amounts of metal and thereby causing the BFJ to start to leak.

In one case, where spiral-wound gaskets were applied, there where deposits accumulated between the retaining ring and flange surface. The failure investigations showed clear signs of oxides and when the deposits were removed, the flange face was still in good condition. Crevice corrosion is not preferential in where it attacks, yet there was a clear demarcation line between the attacked region (under the spiral windings) and the retaining ring that did not meet the flange surface as was evidenced by the accumulation of deposits.

In the case of flat gaskets, crevice corrosion processes are to be expected if there is an insufficient adaption of the gasket surface to the flange sealing surface. In the event of flange sheet bending or uneven flanges, particularly with relatively hard fibre gaskets, there is a chance that parts of the sealing surfaces (particularly at the inner diameter) suffer from insufficient pressure, allowing the formation of a sealing gap. These effects become even more critical if an improved behaviour of the gasket is attempted by a reduction of the gasket thickness (reduction of relaxation). In this situation, a high halogen content in the gasket material can have an intensifying effect.

The electrochemical corrosion (galvanic corrosion) form of corrosion is characterized by the occurrence of electrochemical processes in an ion-conductive phase (electrolyte). Characteristic for this type of corrosion is the dependency of the corrosion strong corrosion effects can be observed under adverse installation conditions.

The formation of galvanic cells, i.e., the certain arrangement of non-precious with precious elements, in particular metals, in the copresence of an electrolyte (electrically conductive aqueous solution by dissolved ions), causes dissolution of the non-precious element through a redox process (electron donation by the non-precious element, resp. electron acceptance by the more precious element).

In sealing connections, galvanic cells are often formed through the interaction of various materials and metals, resp. alloys. In any case, an electrolyte must be present such that both transport processes and the corresponding electrochemical reactions can take place. In mere steam systems, however, the danger of this type of corrosion is generally considered low due to the absence of electrically active ions.

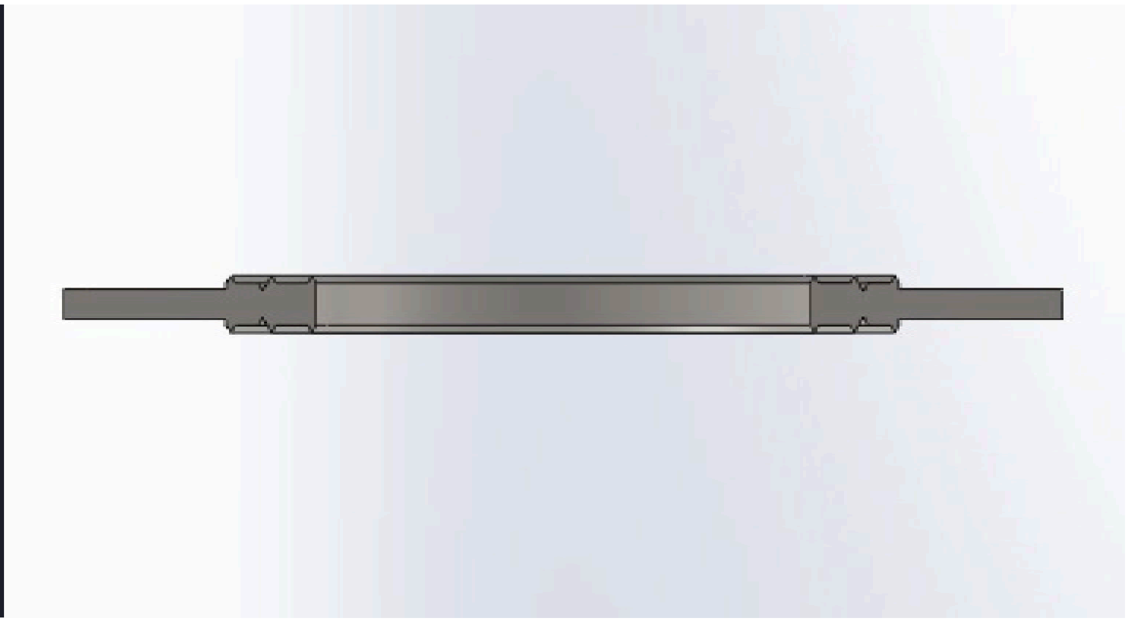
6.2.2 Corrosion and integrity management by applying DeltaV-Seal™ gaskets

BFJ's gasketed with DeltaV-Seal™ are tighter over time than BFJ's gasketed with other types of gaskets. The main reason for this is the way the main threats to the long-term integrity, as described in the previous section, of BFJ's are managed.

The risk of crevice corrosion is eliminated by applying DeltaV-Seal™ gaskets since these gaskets only seal on discrete points and not on surfaces, also refer to Figure 1 and 2.

Figure 1

DeltaV-Seal™ gasket with sealing points



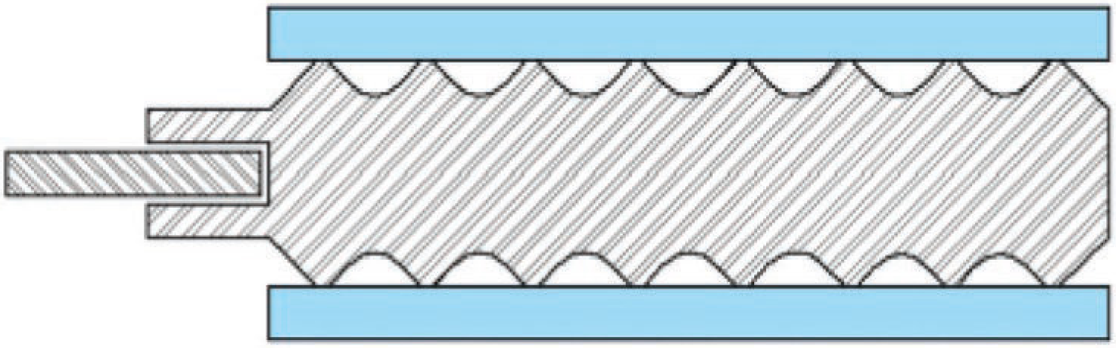


Figure 2

Semi-metallic gasket with seaing surfaces

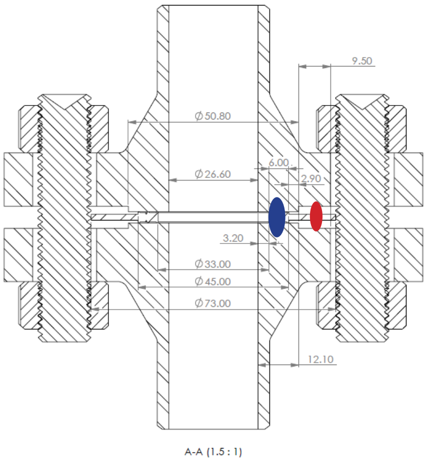
The risk of contact corrosion is eliminated by applying DeltaV-Seal™ gaskets since these gaskets are single metal gaskets.

The main issue with fully metallic gaskets is always the risk of electrochemical/galvanic corrosion between the flange surface and the gasket. It is of paramount importance that the gasket is nobler (more precious) than the adjoining flange surface, note that the potential difference will never be zero. In the opposite situation, the large cathode/small anode surface ratio would appear which would quickly set up a dangerous galvanic cell whereby the gasket will be the anode with a high corrosion rate and would quickly loose its sealing ability.

In principle, there are two galvanic cells to be managed circled in blue (internal cell) and red (external cell, not covered in the following text) in Figure 3.

Figure 3

Galvanic cells



For these reasons, Pipeotech performs electrochemical corrosion testing, hereunder running polarisation experiments where the corrosion potentials of the gaskets and the flange materials are determined, refer to Figure 4 and 5.

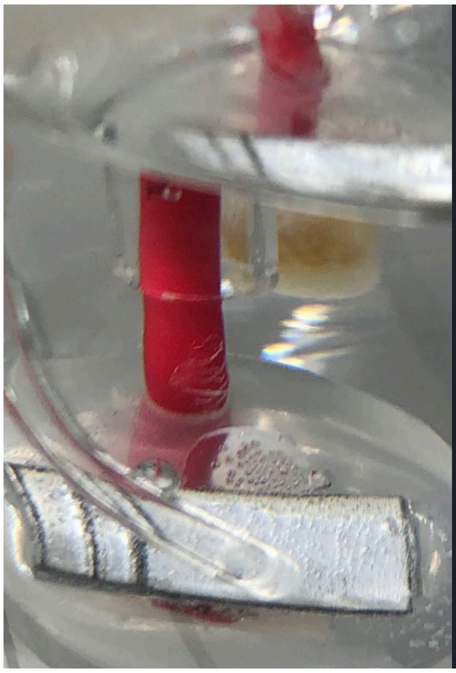
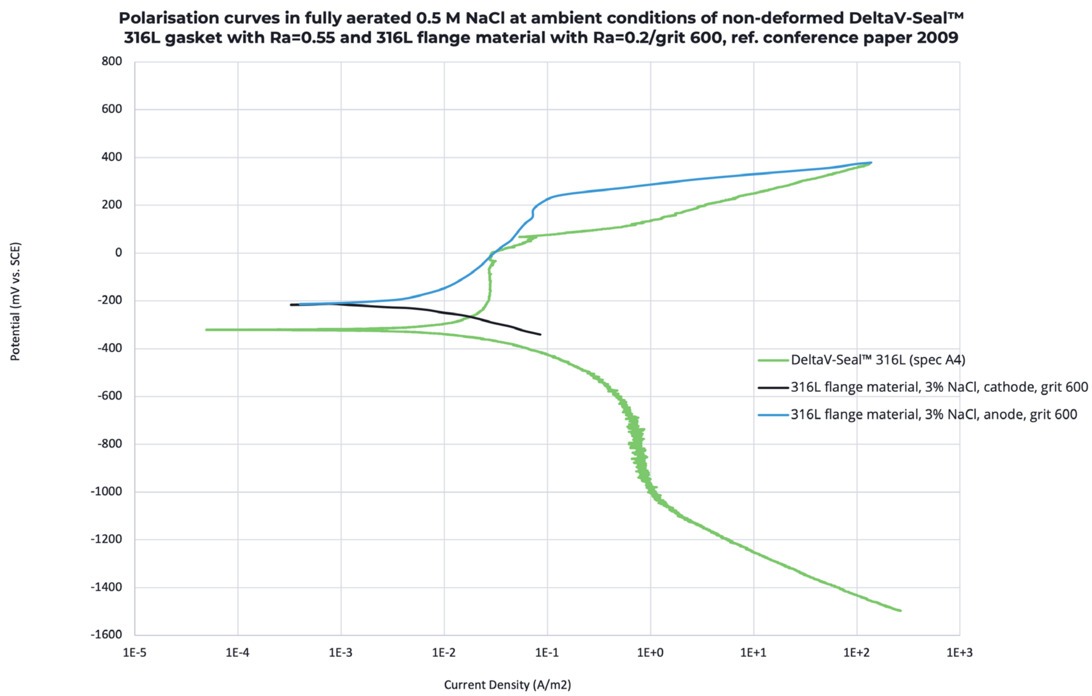


Figure 4

Polarisation cell with cut-out Delta V-Seal™ gasket segment

Figure 5

Polarisation curves of DeltaV-Seal™ and adjoining flange material (example)



Polarisation testing is done following the ASTM G5-14 standard; Standard Reference Test Method for Making Potentiodynamic Anodic Polarization Measurements. By means of this testing, Pipeotech are managing and documenting any risk of galvanic corrosion between DeltaV-Seal™ gaskets and adjoining flange surfaces under any general or customized conditions, i.e., gasket surface state, environment, flange material grade, etc.

The polarization curves are implemented in numerical corrosion models using FEA-based software whereby any risk of galvanic corrosion can be predicted via electrolyte potential distribution predictions. An example is shown in Figure 6 below which shows the electrolyte potential and current density distribution inside a DN40 PN40 flange joint made of austenitic stainless-steel 1.4404 and a DeltaV-Seal™ 316L gasket carrying 0.5 M NaCl at ambient temperature.

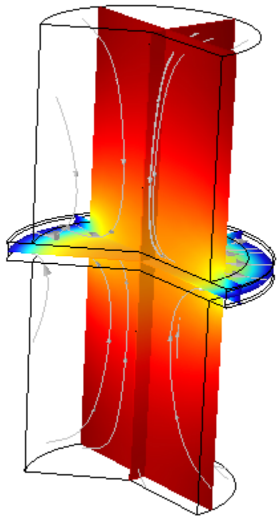


Figure 6

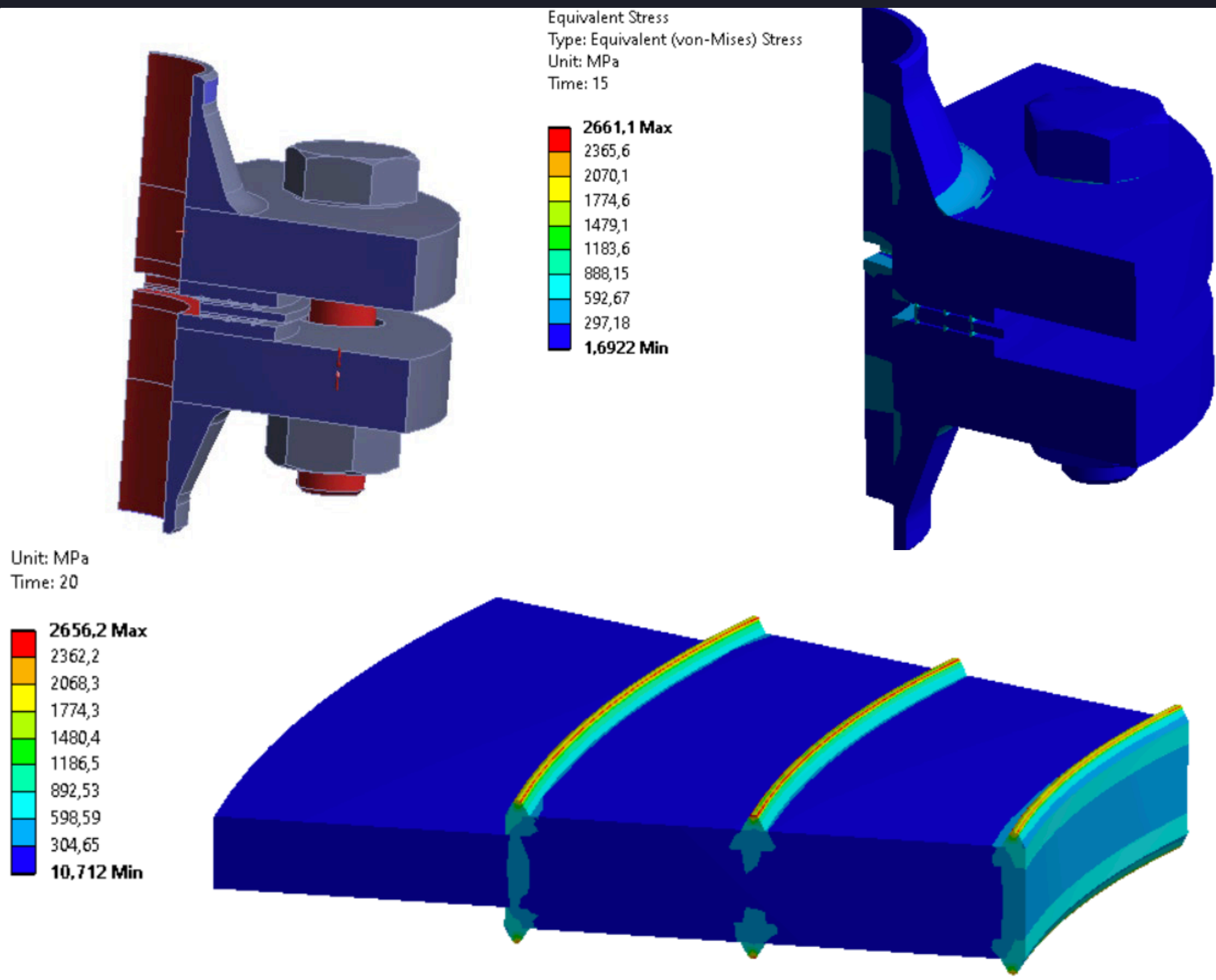
Electrolyte potential distribution and direction of electrolyte current density from anode (flange) to cathode (DeltaV-Seal™)

In addition to galvanic corrosion processes, other time-depending processes affecting gasket integrity such as creep, relaxation and leakage are included in the modelling. The development of response functions for the local contact stress/strain distribution are the fundamental basis for these time depending models. The contact stress/strain distribution is obtained from validated BFJ FEA models whereby the predicted gasket deformation is validated against experimental data from EN 13555 gasket testing with boundary conditions for the FEA modelling obtained from EN 1591-1 predictions of assembly force.

An example of an FEA model with DeltaV-Seal™ contact stress/distribution is shown in Figure 7.

Figure 7

Example of DeltaV-Seal™ contact stress/strain distribution in a DN40 PN40 BFJ as predicted by a validated FEA model



In summary, Pipeotech takes corrosion and integrity management aspects of BFJ's gasketed with DeltaV-Seal very seriously and are therefore issuing specific and robust installation instructions for each DeltaV-Seal gasket to be installed.

07

Case Studies with DeltaV-Seal™ Gaskets

The performance of DeltaV-Seal™ technology as a problem-solver under different in-service conditions typical of fertilizer manufacturing plants is demonstrated by the following case study examples:

Case study 1 (AN)

A global fertilizer producer experienced several unplanned outages every year on insulated AN 304L pipework. The pipework flanges operating at 16 barg and 160C were gasketed with Gylon microcellular PTFE sheet gaskets and constantly leaking causing expensive shutdowns and serious HSE implications.

Working with the customer for a long-term solution, Pipeotech proposed the 316L DeltaV-Seal™. The austenitic stainless steel material match ensures corrosion resistance and galvanic compatibility, and the extensive product testing and certification creates confidence that a long lasting and non-leaking seal can be achieved.

> **“We are very pleased with both the service from Pipeotech but also the DeltaV sealing of course.**
> **- (Client rep.)**

Before gasket replacement

(Large leakages of AN water solution and crystallization)

“DeltaV-Seal™ was selected due to historic performance issues with previous incumbent gasket technologies, leakage, retorquing, shutdowns, CUI (especially within the ammonium nitrate piping trains) and meeting our company’s overall operational excellence and corporate responsibility for zero leaks and zero fugitive emissions.”- (Client rep.)

After gasket replacement

(No leakage)

Case study 2 (steam)

In the gas processing systems typical of the methane steam reforming steps, high pressure steam, various chemical components and severe temperature fluctuations put continuous strain on the flanges and gasket seals of condensed steam lines, causing leakage and costly maintenance.

The customer plays a key role in processing and transporting gas and condensate/light oil from major sites on the Norwegian continental shelf. In the insulated 316L steam carrying pipework operating at 150°C and 20 barg pressure, traditional seals were causing leakage, resulting in costly downtimes for maintenance and repair.

Pipeotech suggested that the inherent fit, durability and all-metal design of the DeltaV-Seal™ 316L gasket would ensure a snug connection, one that can withstand temperature fluctuations, and would resolve the leakage issues.

The customer reported that there has been no leakage since switching to the DeltaV-Seal™ 316L during 2016. As the seal retains its fit without any intervention, no re-torquing or periodical replacement needed, the cost of maintenance is dramatically reduced. Not only is the solution cost effective but ensuring pipeline and process integrity also lends to a safer and more efficient work environment.

Case study 3 (cryogenic)

Following a highly successful test period, the client has announced that the DeltaV-Seal™ 316L has been named as their exclusive seal of choice for all current and future liquefied natural gas (LNG) operations. As a provider of services such as: LNG & LPG facility construction, control systems, and operation monitoring, the client understands the tremendous importance of utilizing the DeltaV-Seal™ unique sealing strengths. Its reliance on components capable of tolerating temperatures fluctuating from ambient, down to -160°C is integral in their operations.

Case study 4 (NA)

A global manufacturer of agricultural fertilizer products with several large facilities in Europe and North America was experiencing constant flange leakage on their 60%/80°C/14 bar nitric acid pipework due to the use of traditional spiral-wound gaskets, leading to regular expensive shutdowns and HSE implications. The customer wanted to eliminate nitrous oxide emissions from the lines to increase safety and reduce environmental effects.

All valves and fittings in the nitric acid pipework were stainless steel 316L with the associated piping in 304L. Pipeotech put forward the DeltaV-Seal™ 316L as a long-term sealing solution. The material match ensures corrosion resistance and galvanic compatibility, and the extensive product testing and certification provides the customer confidence that a long lasting and tight seal can be achieved.

DeltaV-Seal™ 316L was installed and monitored with no leakage reported since the initial bolt-up. Installation of DeltaV-Seal™ provides a tight and maintenance-free sealing solution. In this example, gasket selection has played an important role in creating a safer, more profitable, and environmentally sustainable facility.

> **“Since metals contract and expand with changes in temperature, producing the gasket out of the same metal enables the seal and piping to expand or contract in unison, this way we obtain solid pipe connections without leaks.”**
> **- (Client rep.)**

> **“A service call to a location such as the Hammerfest facility would take us between two or three days. These kinds of operations can easily cost 100kNOK (approx. 12kUSD), so 316L DeltaV-Seal™ gives us big savings. Previously, we used other sealing solutions that did not follow the movements of the piping in the same way. We began testing DeltaV-Seal™ 316L a little over two years ago and we now have switched to using this solution exclusively at all LNG plants.” - (Client rep.)**

When developing new gasket products, Pipeotech adopts a suite of advanced techniques, methods, and software. These include finite element analysis (FEA) and bolted flange joint (BFJ) and piping/pipeline system mechanical strength calculations to ASME/EN pressure vessel design codes. Full galvanic compatibility between the fully metallic DeltaV-Seal product and the surrounding flange materials is ensured by corrosion modelling based on electrochemical polarization curves.

Proof of DeltaV-Seal™ gasketed BFJ mechanical integrity is also ensured through extensive international collaborative laboratory testing programs which include testing under simulated BFJ mechanical conditions as well as testing of actual gasketed BFJ at e.g., -196°C.

The DeltaV-Seal™ performance under cyclic conditions is ensured by vibration testing, pressure pulsation testing and temperature cycling testing.

The foundation for DeltaV-Seal™ product development for specific in-service conditions is the inherent and uniquely low leakage rates (<1e-8 mg/m/s) obtained during standardized gasket testing in accordance with e.g., EN 13555. The obtained gasket data are implemented in certified EN 1591-1 software for verification and documentation of stability and leak tightness of all Pipeotech’s DeltaV-Seal™ products.

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Conclusions

The need to optimise fertilizer plant operations, driven by a range of external and internal influences, means that plant operators must be confident that all equipment is both reliable and high performing. High temperatures in a difficult environment where oxidation, corrosion and non-static process conditions occur are likely, can lead to a variety of sealing complications. Ensuring that 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.

This will be even more important in the future for the fertilizer producers as they are seeking to cash in on the green energy transition by e.g., decarbonisation and reconfiguring their ammonia plants to produce clean energy to power ships. The consumption of oil for transportation is one of the top contributors to global greenhouse gas emissions that cause climate change, and fertilizer producers are currently joining a growing list of companies adjusting their business models to profit from a future lower-carbon economy.

Fundamental to addressing these challenges is to have the best sealing/gasket technology available and implemented.

Pipeotech is in the right spot to support these reduced emissions initiatives with the DeltaV-Seal™ technology to assure that piping/pipeline systems and equipment do not leak. The industry's traditional project development approach to seals and emissions needs to change to be much more front-end heavy (FEED) on these aspects. Successful outcome is depending on an early implementation of best available seal technology in project specifications and design.

This paper demonstrates how Pipeotech's range of products are designed for problem solving with these operators' current and future needs in mind, never compromising on performance in even the most challenging environments present in current and future fertilizer manufacturing plants.

Contact Pipeotech for further information and adoption of DeltaV-Seal™ technology and gasket parameters to your current and future fertilizer manufacturing facilities.

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