The Economic Benefits of Retrofitting Oil-Seal-Equipped Centrifugal Compressors with Gas Seal Technology

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Executive Summary

In regard to the Natural Gas Industry, centrifugal compressors equipped with Oil Seal technology are generally acknowledged as the leading source of Methane Emissions offshore and the 4th most significant source in onshore Operations.

This emission source represents a significant economic opportunity for operators, is an area of focus for regulation and included in voluntary programs such as Global Methane Initiative, US Natural Gas Star and UNEP CCAC OGMP.

There are 3 technologies available to reduce methane emissions from existing Oil Seal equipped Centrifugal compressors. **Gas Seal Technology** is proven and available and proposed as the **Best Available Technology** for reducing Methane Emissions from Centrifugal Compressors equipped with Oil Seals.

A number of operators have had success over the past 15 years in upgrading from Oil Seal technology to Gas Seal technology to reduce Methane Emissions.

This presentation also showcases a decision support tool that evaluates the three options from an economic perspective and takes the understanding beyond previous case studies which were necessarily “Typical” using “Static” data.

Background

Globally, the economic, environmental and strategic impact of methane emissions from the natural gas industry continues to garner attention.

From an economic perspective, recent estimates suggest routine losses from current industry infrastructure and practices emit Natural Gas valued at the rate of $30bn annually. From an environmental perspective, Methane, as the principal constituent of Natural Gas, is a potent Greenhouse Gas, which for a comparable volume, has a significantly higher climate forcing impact than Carbon Dioxide. From a strategic perspective, Methane Emissions now have a potential to hamper the role of Natural Gas as the clean bridge fuel between the heavy fossil fuels of the past to the promise of renewables for the future.

Much progress has been made through a number of industry and geo political mechanisms over the past decades. However, this combination of economic, environmental and strategic factors maintain the call to action.

As a result, Governments, NGOs, and the private sector are looking for expertise and proven technology solutions that deliver economic as well as environmental benefit to the Natural Gas value chain.

Why is this paper relevant?

While consistent, comprehensive global data regarding Methane Emissions from the Natural Gas industry is yet to be established, a number of focused studies in particular regions and industry sectors can be extrapolated to provide insight into the likely global landscape.

These studies have guided stakeholders to shape voluntary and involuntary activities over the past two decades. Centrifugal compressors with Oil (Wet) Seal technology have consistently appeared in the top 5 contributors to total methane emissions.

Clearly the specific impact varies upon a number of factors. The specific profile of Natural Gas operations in a given region, (Gas Production, Processing, Transmission or Storage), the balance of onshore and offshore operation, the technology available at the time the equipment was commissioned, operating practices etc.

However the ever-present relevance of this emission source to global efforts is evidenced by

1. Analysis in key independent studies (ICF / EDF)
2. Consistent visibility of mitigation efforts in established NGO forums (GMI, Natural Gas Star)
3. Focus in Industry Coalitions (One of nine sources addressed by UNEP CCAC OGMP)

4. Inclusion in regulation (US EPA NSPS, Canada ECCC draft)

It is unlikely that they are all wrong regarding the relevance of this emission source…

Where are Centrifugal Compressors applied?

Centrifugal compressors are an integral part of the Natural Gas Value chain from extraction to the city gate. This equipment is most intuitively understood as providing the motive force behind the intercontinental transmission of Natural Gas. In addition to Transmission, centrifugal compressors are also deployed in a wide range of Natural Gas applications both onshore and offshore in Upstream and Midstream Natural Gas operations including Gas Processing and Storage.

Shaft sealing technology is an integral sub system of Centrifugal Compressors. Prior to the mid-1980s, a variety of contacting Oil Seal designs were incorporated into centrifugal compressor designs. While representing “state of the art” for many decades, low emissions levels were in most cases not a design objective. Furthermore, in many cases, normal operational wear and tear only further exacerbates emission levels.

Since the introduction of Gas Seal Technology by John Crane in the mid-1980s, the Oil and Gas industry has progressively adopted Gas Seal Technology as the preferred design standard for new equipment realising many economic and environmental benefits. At this time, globally, it is estimated that 99%+ of new centrifugal compressors are delivered with Gas Seal Technology.

Therefore, new installations will likely meet low emission requirements. Stakeholders are in many cases operating an existing fleet of equipment that contains a mix of compressors with Oil Seal and Gas Seal technologies. The ratio essentially depends on the age of the equipment. A portion of the legacy Oil Seal equipped compressors have been upgraded to Gas Seal Technology motivated by economic factors or environmental or both.

It is the remainder of the fleet of existing equipment that require our attention.

What is Gas Seal technology?

It is beyond the scope of this discussion to provide a comprehensive technical review of gas seal technology. The fundamental difference in design is that Oil Seals utilise a contacting seal concept whereas Gas Seals utilise a non-contacting design. The result is a favourable step change in operating costs, reliability, emission levels and carbon footprint with additional important benefits relating to safety.

Since its introduction by John Crane in the mid-1980s Gas Seals have increasingly become the de facto shaft seal standard in Centrifugal Compressors throughout the entire Oil and Gas Industry in Upstream, Midstream and Downstream operations in activities beyond Natural Gas in such markets as Extraction, Production, Reinjection, LNG refrigeration and Refining. It has been adopted by all the major centrifugal compressor manufacturers and by all the Oil and Gas majors operating the equipment.

This technology is globally available, globally supported and globally proven.

The options to reduce Methane Emissions from existing Centrifugal Compressors equipped with Oil Seals

It is generally acknowledged by stakeholders that the technologies available to mitigate uncontrolled methane emissions from existing Centrifugal compressors equipped with Oil Seals fall into three categories.

1. Capture of the uncontrolled methane emission and route the emission to a flare device
2. Capture of the uncontrolled methane emission and route the emission to use for some other productive purpose
3. Upgrade the Oil Seal solution to a Gas Seal solution

Over the years, the Methane Emissions reduction community has documented examples of all three families of solutions being deployed to reduce methane emissions in the Natural Gas Industry. While each approach delivers a comparable methane emission abatement, there are some general considerations.

The use of a flare solution is universally applicable but transforms the Methane Emission into a Carbon Dioxide emission with no opportunity for economic payback and in direct opposition to other parallel efforts in the Oil and Gas industry to reduce Flaring.

The capture of the emission and use for other productive purpose usually takes one of three forms.

A) Reinjection back into the compressor or process
B) Use as a supplementary fuel source for the Gas Turbine powering (driving) the compressor
C) Use as a supplementary fuel source for other equipment in the vicinity of the compressor (Boiler etc.)

In contrast to Flaring, all three of these approaches share the common advantage that the Methane emission is no longer “wasted” and an economic payback can be achieved. The opportunity to deploy a given solution is situation dependant.

In contrast to both of the previous approach categories, the implementation of Gas Seal technology and resulting transition from contacting to non-contacting seal technology eliminates the Methane Emission at source. As mentioned earlier, the implementation of non-contacting technology also uniquely delivers substantial operational cost benefits over and above the economic value of the Methane Emissions reduction. The emission levels are reduced to near zero. The opportunity to deploy a given solution is situation dependant.

The selection process

The selection of an appropriate mitigation approach is situation specific and results from an evaluation of three factors

1. Environmental
2. Technical
3. Economic

This discussion focuses on the economics of the decision.

Assuming a base case of uncontrolled Methane Emissions from a Centrifugal Compressor equipped with Oil Seals, it is relatively straightforward to prepare a qualitative assessment of the economics to implement the three solution families.

	Capture and Flare Solution	Capture and Reuse Solution	Oil Seal to Gas Seal Upgrade
Upfront Investment	Low	Low	High
Methane Savings	No	Yes	Yes
Operational Savings	No	No	Yes

All three solutions deliver comparable reduction in Methane Emissions. While this analysis is not particularly complex, it is insightful. A fundamental understanding of these basic principles allows all stakeholders, (Policy makers, Operators, NGOs) a much more informed assessment of the economics behind these solutions. This understanding can take us well beyond the simple measure of abatement cost. It is clear that in the long term, Gas Seal technology represents the lowest cost solution.

As the discussion moves from qualitative to quantitative, simple generalities are no longer sufficient. Globally, the wide range of Centrifugal Compressor applications results in a wide range of operating characteristics and resulting economics for each mitigation option. Examples include, whether or not the compressor operator owns the Natural Gas being compressed and lost to emissions, whether the compressor is operated in isolation or as part of an installation of multiple compressors, Onshore vs Offshore installation, Percentage of time in operation vs standby, the applicability of carbon tax or credits, the unit value of the gas being emitted, the remaining useful life of the Compressor under analysis and many others heavily influence the analysis.

In turn, these factors influence the economic attractiveness of the available solutions relative to each other.

Historically, interested parties have created case studies and guidance based on specific examples, however these examples necessarily relate to typical scenarios and do not allow easy adaption to specific circumstances. There is no substitute for expertise and advanced economic tools that leverage the expertise.

The Lifecycle Cost Calculator - A new decision support Tool

Recognizing the opportunity to improve the collective understanding in this critical area, John Crane has leveraged its market leading expertise to develop a quantitative lifecycle cost calculator to provide decision support for all relevant stakeholders.

In summarizing the tool, it is useful to maintain the framework described previously. The tool guides the stakeholder to input the baseline costs of methane emissions and annual operating costs relating to an Oil Seal equipped Centrifugal Compressor with uncontrolled emission, and progresses to input the one-time upgrade costs, cost of resulting methane emissions, and annual operating costs associated with each of the potential solutions. The output consists of comparison of the total lifecycle cost of the baseline sealing solution with each of the three mitigating solutions.

Of interest to those with a technical background, the tool accommodates such factors as offshore and onshore installations, multiple driver types, Standby vs Operating hours, static and dynamic leakages, seal reliability data, pipeline efficiency factors, parasitic losses and different upgrade costs.

Of interest to policymakers, among many outputs, the tool calculates abatement costs and CO2 equivalent emission levels, accommodates different assumptions regarding whether the compressor operator owns the Natural Gas, wholesale Natural Gas Prices and Carbon Tax or other incentives. The economic analysis is supplemented by data relating to the Energy consumption and Carbon footprint of all four scenarios.

In all cases the tool provides default data inputs and assumptions that can be easily overwritten by the user.

The tool has been shared with a number of Government agencies, NGOs and representatives of industry. It has proven to be insightful, comprehensive, customizable and specific.

The conclusions

As discussed earlier, the specifics of a quantitative analysis will result in variations to the economics of a given mitigation technology. This in turn will result in movement in the relative economic attractiveness between the mitigation technologies. The Lifecycle Cost Calculator calculates these costs and for ease of interpretation generates graphical output that easily facilitates interpretation. The Lifecycle Cost Calculator also easily accommodates changes to assumptions to examine the sensitivity of certain outcomes to variations in any parameter. Due to the variety of situations both technical and economic it is not possible to examine all the outcomes in this discussion. However what can be said is that in all cases gas seal technology represents the lowest long term lifecycle cost in all scenarios.

Case studies

The replacement of Oil Seal solutions with Gas Seal Technology in Centrifugal Compressors is well understood in the Oil and Gas and Petrochemical industry in general as well as more specifically in

the Natural Gas Industry to mitigate Methane Emissions. This is undoubtedly supported by the body of industry knowledge emanating from the fact that 99%+ of new Centrifugal Compressors are equipped with Gas Seals.

Industry stakeholders have presented a number of successful case studies in Methane Emission forums over the years, including installations in the Americas, Russia and Asia.

Concluding Remarks

Addressing existing Oil Seal equipped Centrifugal Compressors is clearly relevant in the context of the global efforts of the Natural Gas Industry and other interested Stakeholders to reduce overall Methane Emissions.

Gas Seal technology is a solution that is available now, is well proven and available and supported on a global basis. From a long term perspective, Gas Seal technology provides the maximum environmental benefit, the maximum safety benefit, the maximum reliability and the lowest total lifecycle cost.

The application of this technology to existing equipment has been well documented over the years including the economic case. John Crane has taken this understanding to the next level with the introduction of a lifecycle cost calculator to the benefit of operators and policymakers.

About John Crane

John Crane (www.johncrane.com) is a global leader in rotating equipment solutions, supplying engineered technologies and services to process industries. The company designs and manufactures a variety of products including mechanical seals and systems, couplings, bearings, filtration systems and predictive digital monitoring technologies. John Crane customer service is accessed through a global network of more than 200 sales and service facilities in over 50 countries. Fiscal year 2016 revenue was greater than 1 Billion USD (£830m). John Crane is part of Smiths Group (www.smiths.com), a global leader in applying advanced technologies for markets in threat and contraband detection, energy, medical devices, communications, and engineered components.

John Crane's comprehensive range of dry gas seals are designed to provide you with the correct seal solution suited for your specific application, to ensure optimal reliability, safety and performance. We are committed to providing the latest technologies and designs in order to provide our turbo machinery customers within global energy industries with the solution they need. As technology and industry standards constantly evolve, so do our gas seals. In 1968 John Crane was first awarded the patent for spiral groove technology. Today, our next generation dry gas seals, Aura™, use the latest technology to reduce your operation and transaction costs. With an unrivalled access to localized technical expertise from the largest global service network in the industry, our experienced team will help you find the solution you need to help you plan for tomorrow.