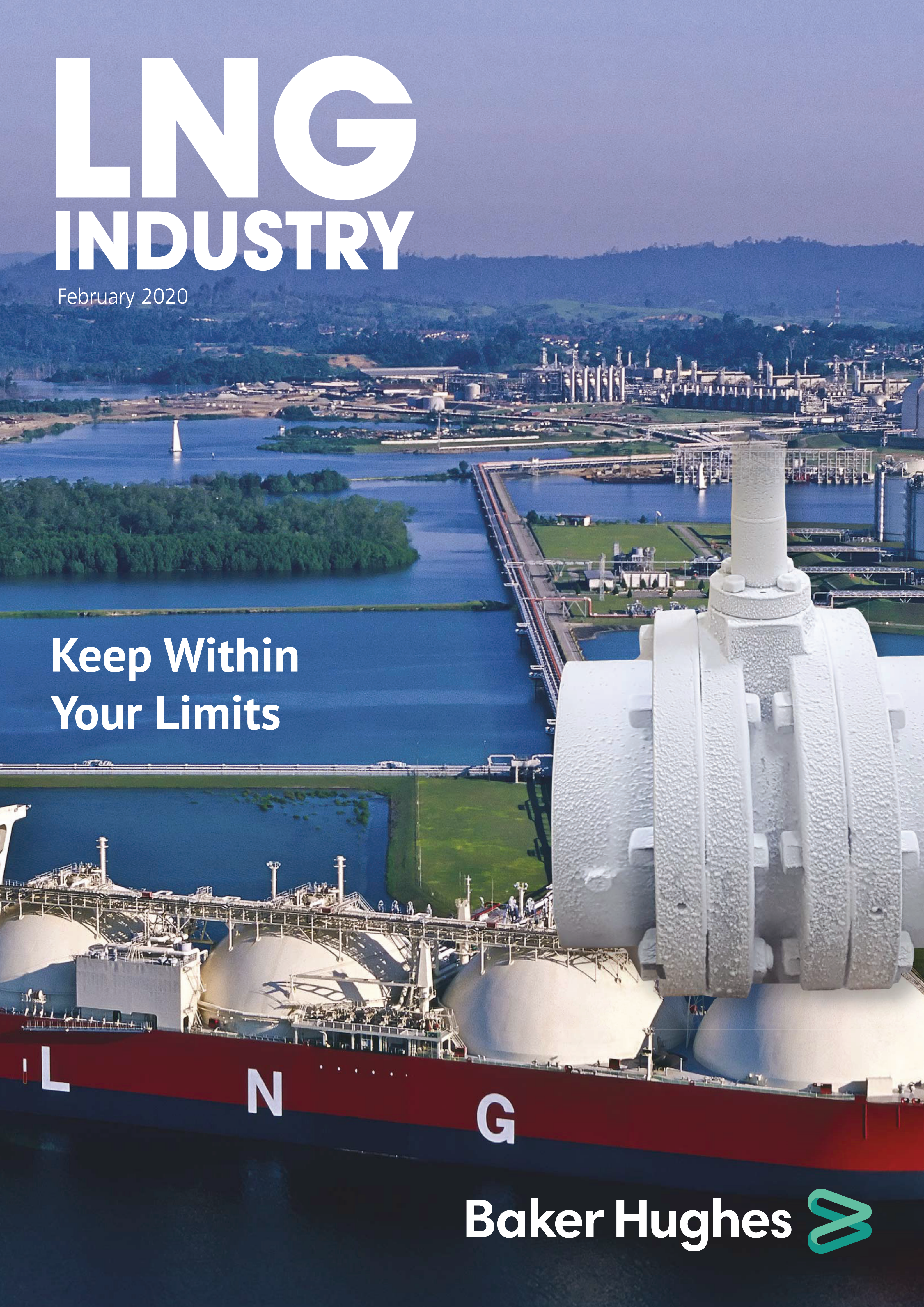
# LNG INDUSTRY

February 2020



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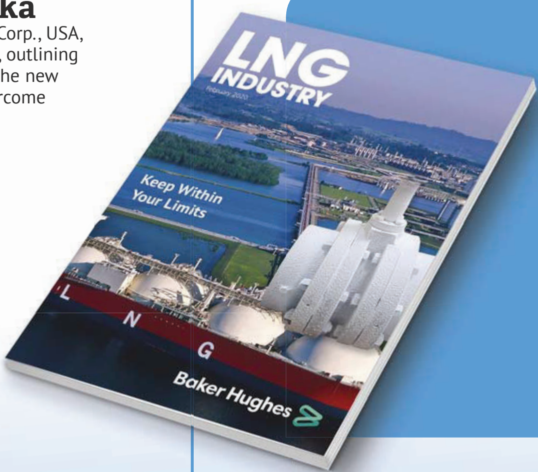


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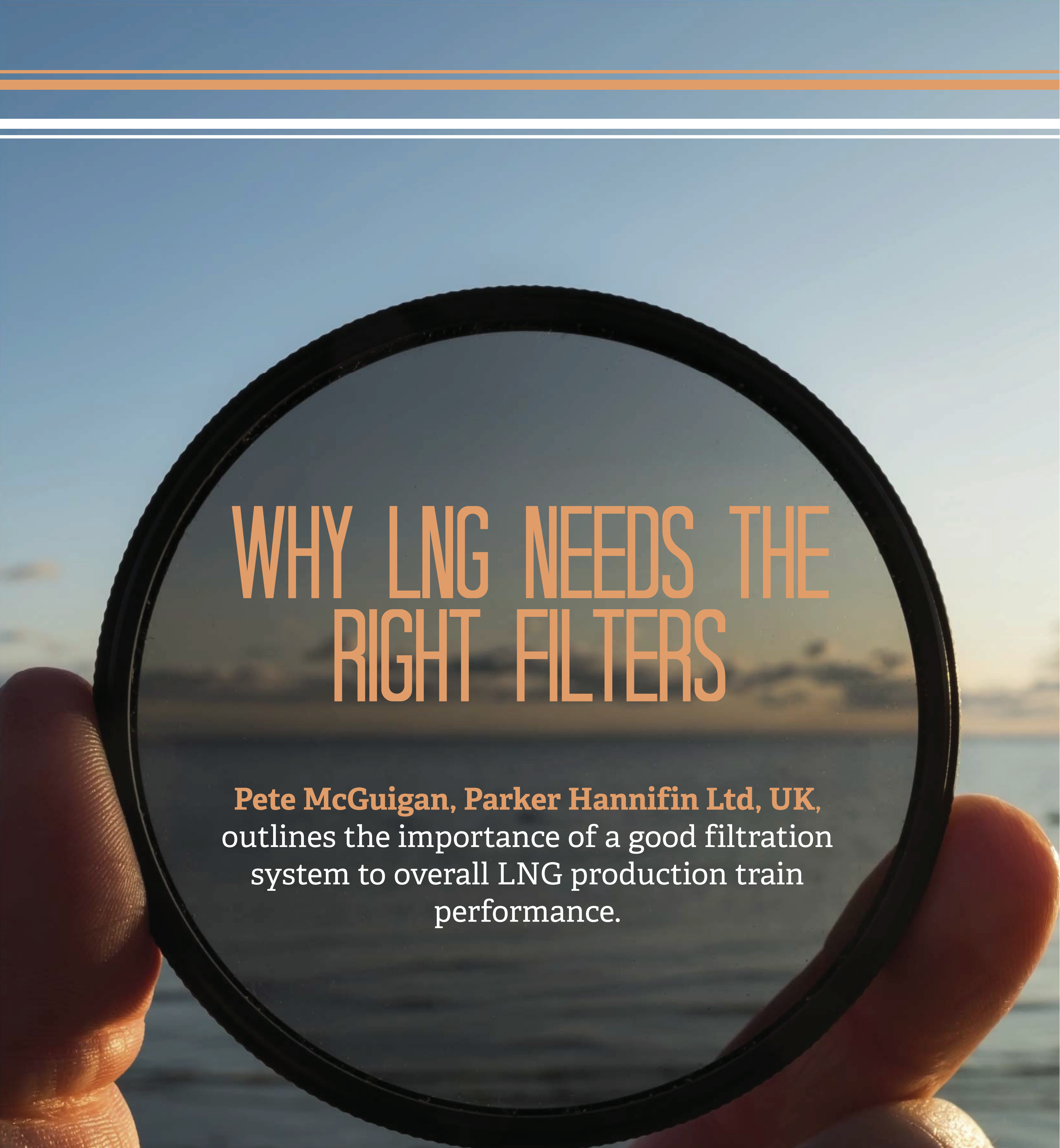

# WHY LNG NEEDS THE RIGHT FILTERS

**Pete McGuigan, Parker Hannifin Ltd, UK,** outlines the importance of a good filtration system to overall LNG production train performance.

The McKinsey 'Global Gas and LNG Outlook to 2035' report, issued in September 2019, predicts that the demand for LNG will increase annually by an average of 3.6%, significantly outpacing overall gas demand in this timeframe.[1]

The very large contraction in volume that the liquefaction process introduces to the product makes it significantly more economical to store and transport over long distances. The strength of the LNG market is ultimately defined by this ability to economically transport the denser liquefied fuel long distances from source, allowing new customers to be established and supporting economies where domestic supply is struggling to meet rising demands. A bonus for storage and transport is that LNG is not at all explosive or flammable in its liquid state.

## The gas

Raw natural gas (the feed gas) extracted from the reservoir in its 'wet' state (but after removal of water, $CO_2$, $H_2S$ and Hg) typically contains 85 – 95% methane. It also contains heavier hydrocarbons, such as ethane, propane and butane. The allowable ranges of non-methane content within the LNG varies with prospective buyer and/or end-user specifications. Conditioning of the natural gas to remove

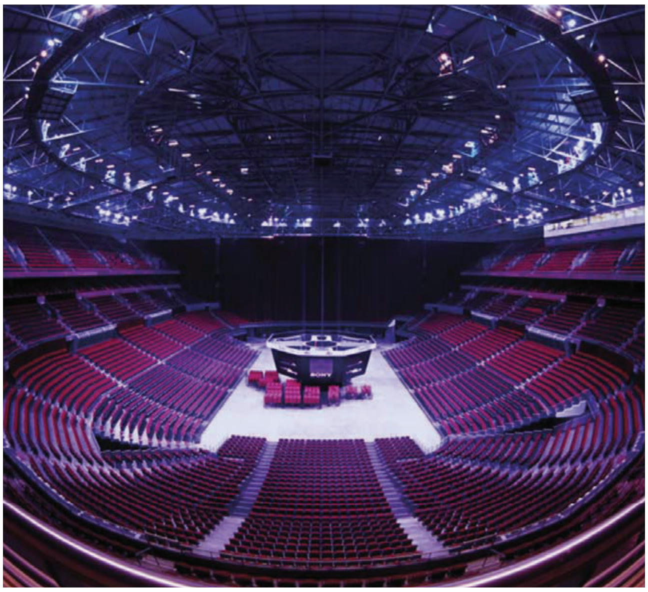

**Figure 1.** A Frame 7E gas turbine would consume all the air within the Sydney Superdome each and every 24 minutes.

**Figure 2.** Extreme dust events require specialised filtration systems.

some/all of the non-methane components is then a common requirement of LNG production. These components are then often sold separately as natural gas liquids (NGLs) or natural gas condensate. Methane needs to be cooled to -162°C to liquefy it, a temperature considered as cryogenic. Storage and transport of the LNG then needs to ensure this cryogenic state remains.

## Getting cold

Gas compressors are widely used in the gas industry for the production, transmission, liquefaction, storage and distribution of gases. For LNG production, compressors are used to compress refrigerants (methane, ethane and propane) as part of a process to cool them. These cooled liquefied refrigerants are then employed as the cooling medium in the main LNG heat exchangers, transferring heat away from the natural gas until the hydrocarbon components previously discussed (including methane) reach a liquid state. It is worth thinking this through a few times to understand it better – the key message being that these compressors are used to compress refrigerants, not to compress the actual unprocessed natural gas. These cooled, liquid refrigerants are then subsequently used as the cooling medium within heat exchangers, which cool the natural gas and convert it into LNG.

In theory, compressors used as part of the process to produce LNG can be reciprocal, screw, axial or centrifugal in design. In practice, however, the centrifugal compressor has almost exclusively been adopted for this application in LNG plants with individual train production capacity greater than 1.5 million tpy, commonly considered as 'large'. There are two reasons for this: firstly, the other compressor designs, which use pistons, screws or multiple rotating airfoils, have multiple mechanical moving parts. This increases the risk of failure and poses a risk to reliability and so typically requires more frequent maintenance and planned shutdowns. For LNG production, the loss of a compressor that may ultimately lead to an operational shutdown (planned or otherwise) could cost millions of dollars per day in lost production, so reliability of operations for extended intervals is essential. The second reason for the selection of centrifugal compressor technology is their proven ability to deal with very high volumes of fluid at very low temperatures.

## Choosing a driver

A compressor is a rotating piece of machinery and requires something to mechanically drive (rotate) it. There are four basic options for this: a reciprocating engine, a steam turbine, a gas turbine or an electric motor. Of these, the reciprocating (piston) engine has lots of moving parts, again making it more prone to failure, and the steam turbine requires a boiler plant making it more expensive to implement. It should be noted that a recent floating LNG (FLNG) installation, deployed northwest of Australia, employed steam turbines as compressor mechanical drives and also that some older LNG plants still employ this technology. This leaves the gas turbine and the electric motor as the most common options in use today. Sometimes a combination of both are used with an electric motor as a 'helper' to counterbalance the effects of performance loss of a gas turbine with increases in ambient air temperature. This periodic performance drop may also be significantly recovered by introducing power augmentation/air cooling systems within the gas turbine air intake system design.

With acute focus on the environmental aspects of oil and gas production, the electric motor has been gaining traction as an alternative to the hydrocarbon-fuelled gas turbine. Let us be honest here though, electricity must be produced somewhere and does not just come from a plug. The chances are that the electricity used to power any driver motor has been generated using hydrocarbons at some stage, probably gas, possibly even coal, which slightly negates the environmental argument. The other challenge with this technology for LNG application is that, to ensure continuity of supply is met, LNG plants typically employ their own power generation infrastructure on site, rather than relying on any external grid (if present). This means that the CAPEX for the plant increases significantly. The upside of electric motor drivers, however, is that they are extremely reliable. They are unaffected by the temperature of ambient air (and more specifically the density of ambient air), which provides

**Figure 3.** Inadequate gas turbine air intake filtration – sodium sulfate ($Na_2SO_4$) buildup on power turbine blades and vanes.

significant operational benefits, stability of production and a reduced need to flare to avoid excessive pressures or flows in the system. Not flaring is beneficial both operationally and environmentally.

The proven LNG-applied performance, cost and wide range of available sizes of gas turbine, however, means today it remains by far the most popular choice for LNG refrigerant compressor drivers.

## Liquefaction cycles

There are two dominant options in today's marketplace for the refrigeration cycle process for 'large' capacity LNG trains: Air Products' propane precooled mixed refrigerant process, AP-C3MR™, and the ConocoPhillips Optimized Cascade® process. It should also be noted that a number of variations on these two processes have been developed and implemented in recent years. When a process has been selected, this then helps define the number of refrigerant compressors required and the number of mechanical drivers needed.

Typical gas turbines used may be heavy duty frame engines (currently the frame 7E is a popular choice) that generate approximately 90 MW (equivalent), or a higher number of smaller aeroderivative units, which tend to generate approximately 30 – 35 MW (equivalent), such as the LM2500+. Whichever architecture is selected, keeping the plant running for extended periods is always the top priority. Frame engines have bigger output, are heavier and more robust. Economy of scale also provides for a lower dollar per kW ratio with frame engines.

Aeroderivative engines are smaller but with higher efficiency and easier maintenance/changeouts of components. They are less robust and typically require more frequent maintenance. They do, however, offer significant operational flexibility by allowing some gas turbines to be taken offline for periods of time (with reduced LNG output), without having to take the entire liquefaction train down and flare all gas being processed. Frame engine driven refrigerant compressor trains do not typically have this capability – when the gas turbine goes down, the entire train goes down. The size and weight of the aeroderivative engine also makes it more suited for FLNG applications.

## Filters may seem less important than compressors and turbines, but they are vital to system performance

As discussed, in an LNG train, a single turbine shutdown could result in the process being taken offline with lengthy shutdown and startup procedures leading to huge losses. To maximise the uptime and ensure continued, consistent performance of the gas turbines requires a carefully designed air intake filtration system. Typically, gas turbine compressor issues relating to the ingestion of ambient air particulate, salts and hydrocarbons account for 60 – 80% of overall gas turbine losses,[2] so if you can control this aspect correctly, you are well on your way to having reliable plant operations and maximising LNG output.

It is worth highlighting that gas turbines consume enormous amounts of air, so even if the concentration of ambient air contaminants to start with (which will vary daily and seasonally) a considered 'low', the sustained cumulative effect is what the filtration systems employed need to be assessed against and designed for.

Gas turbines are subjected to a wide variety of contaminants, which will cause corrosion, erosion and fouling, leading to reduced performance, or even complete and catastrophic failure of internal components, if not dealt with. A filtration system, therefore, should be designed based on specific installation and environmental conditions on site, as well as the operational needs of the end-user. For LNG compressor drivers, this typically means extended uptime with very high efficiency (EPA+ levels of filtration), minimising compressor fouling. By their very nature, LNG plants will be situated in coastal (salt laden) environments, so wet and dry salt mitigation and the use of hydrophobic filtration are also key requirements.

A filtration system will always need to protect the critical asset (the gas turbine) from multiple contaminants present in the air, contaminants that will vary significantly day-to-day and season-to season. For example, in a dusty coastal location, there will be high levels of both dust and salt. If an area is prone to high humidity or fog events, moisture will periodically also be a crucial factor. To handle different challenges, multiple stages of filtration are required.

In high dust areas, as levels of captured contaminant build up, the differential pressure across the filter will increase sharply. In these areas, self-cleaning filters, which use reverse pulses of compressed air to periodically remove layers of captured dust, are often selected. To handle moisture, coalescing filters are often added upstream of the main filters to agglomerate droplets and help stop the captured dust becoming sticky/muddy (with a resultant pressure drop increase). If there are very high levels of dust, however, there is also a risk that the coalescer itself becomes blocked and is either forced out of place, or the large pressure spike causes the unit to alarm and shut down. The TS1000 is a technology from Parker which uses a mesh designed to deliberately allow dust and sand to pass through while coalescing free moisture. This leaves the final filters to deal with the relatively dry dust and sand; something they are perfectly well designed to handle. Treated Microfibre glass is the preferred choice of filtration media for very high efficiency final stage filters, providing high-level dry particulate removal and hydrophobic (wet salt removal) performance. Microglass is approximately 10 times thicker than some other high efficiency medias on the market. This ultimately means it is more resistant to blockages, and any pressure increases occur slowly and predictably over long periods of time, avoiding the infamous ‘hockey stick’ effect, when pressure drop (Delta P) increases rapidly with very little warning.

Having multiple filtration stages for LNG intakes also provides the ability to change filters without the need to shut down the turbine, commonly a key requirement. This requires careful design to ensure the stages offer the right incremental levels of filtration to avoid frequent blockage, and to ensure contaminants do not affect turbine performance. As changeout of the prefilter stages, which are designed to capture larger particulate and coalesce moisture, can occur without shutting down the turbine, the air intake system designer needs to consider and design for ease of online changeout from the outset.

For the very high efficiency final filtration stages, filters should be selected that offer extended service life. Using an extended 24 in. deep filter, rather than a traditional 12 – 17 in. filter, is one option which increases the surface area for particulate collection and, therefore, requires less frequent changeout. In general, prefilters should require changing no more than around once per year; second stage filters once every two years; and third or fourth stage filters (if present) approximately once every four years. If a filtration system requires more regular maintenance than this, a review of its design is recommended.

## Summary

The demand for LNG is set to continue to rise and the reliability of the systems used to liquefy the gas is critical. Any unscheduled shutdown can lead to significant costs and a huge revenue hit from lost production. Although the gas turbine filtration system may appear a small concern for the overall LNG train performance, having the right filters in place will have an enormous impact on the short and long-term performance of the plant. On paper, the efficiency of the filter system may not be how it performs in the real world, due to the presence of moisture or multiple other contaminants. To protect the integrity of the system, therefore, a filtration system should be specifically designed to handle the real-world challenges it will face; challenges that are particular to the turbine installation environment. When it comes to filters, one size does not fit all – the right gas turbine air intake solution, protecting these operationally critical assets, requires very careful assessment and product selection. **LNG**

## References


1. McKinsey & Co., ‘Global Gas and LNG Outlook to 2035’, (September 2019), https://www.mckinsey.com/industries/oil-and-gas/our-insights/global-gas-and-lng-outlook-to-2035
2. GEA18414 – offline water wash optimisation for F-class gas turbine pulsed wash systems.