

### **GL** Noble Denton



Has run hundreds of marine warranty projects worldwide

> Helped drill holes in a Gulf of Mexico spar to correct ballasting

> Has assisted the move of an FPSO from the UAE to Brazil

ls up for a black belt in Kung Fu

### Think your assets are safe? Ask Debrin first

**Debrin** is a key member of our Houston offshore engineering team. Her detailed marine warranty experience keeps oil and gas assets safe and compliant, and she specialises in putting our clients' minds at rest.

Debrin double-checks our clients' calculations against ever-changing codes of practice, and ensures the viability of lifting and shipping operations around the world. Thanks to her keen eye for detail, some of the industry's leading operators know that their assets adhere to the highest standards of safety, integrity and performance.

### Debrin is one of the thousands of dedicated experts our clients count on every day

Learn more about her here www.gl-nobledenton.com/Debrin

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GL Noble Denton is the independent technical advisor to the oil and gas industry



Pekka Paasivaara

# **To Our Readers**

**Confidence for continued growth** is an apt description of the prevailing mood in the oil and gas sector this year. Nine out of ten senior industry professionals surveyed for *Seismic Shifts*, GL Noble Denton's third annual research report on the outlook for the oil and gas sector, expect business to grow in 2013 (p. 12). North America – and particularly the US – was identified as the top investment destination for 2013, with the unconventional oil and gas rush viewed by many as a game changer for the world's energy mix. Read how "Shale Gas Rocks the Future", and how GL Noble Denton's Access Manager™ software solution will play a key role in commercialising this burgeoning market (p. 8).

**The prospect of receiving proven capabilities,** including marine operations, technical assurance and project execution expertise as well as software solutions all from a single technical partner recently convinced China National Petroleum Corporation to team up with GL Noble Denton (p. 22). China's largest oil and gas major wants to expand its oil exploration activities from shallow to deep water, and the cooperation agreement shows this operator's trust in our experience and technical expertise.

**To manage safety and risk profiles efficiently**, oil and gas companies are increasingly focusing on working with global technical partners. GL Noble Denton's enhanced global operating model (p. 16) has helped us respond to this development in the market, and enabled us to sign several new enterprise framework agreements with major operators.

**Integrity management from GL Noble Denton** helps Centrica Storage Ltd. operate its large natural gas storage facility off the east coast of the UK. By customising our Galiom<sup>™</sup> solution for this major client, we enabled Centrica to comply with legal requirements for pressure system inspections (p. 26). Our unique certification expertise came into demand when a manufacturer needed its innovative composite pipe repair system to be validated (p. 42). Furthermore, in a great technical and navigational accomplishment our Marine Warranty team successfully moved a huge drilling platform through the Bosporus (p. 28).

**Great opportunities abound:** to better leverage these opportunities, the GL Group has decided to join forces with its Norwegian competitor, DNV, to form one formidable global player. As we move towards our goal of becoming the DNV GL Group, one of the most respected technical assurance and advisory companies in the world, you, our clients, will benefit from an even wider range of services and the combined expertise of both companies.

Yours sincerely,



**Pekka Paasivaara** Member of the Executive Board, GL Group



Unconventional gas changes the energy markets



GLOBAL MODEL Managing safety and risk profiles



GAS STORAGE Written Scheme of Examination required



STUDY Oil and gas industry: confident for growth



PROCESS SAFETY Design verification reveals hazards early



REPAIR SYSTEMS Survival test for pipe bend patches



WATERWAYS Marine warranty: how to ensure safe passage



MAINTENANCE Upgrading gas and water networks



Expanding oil exploration activities to deep water

#### profile

### **GL Noble Denton in Brief**

- □ GL Noble Denton is a TECHNICAL ADVISOR AND TRUSTED PARTNER for the oil and gas industry.
- The Oil & Gas business segment of the GL Group helps to design, build, install and operate onshore, maritime and offshore oil and gas assets to ensure SAFETY, SUSTAINABILITY AND SUPERIOR VALUE.
- □ GL Noble Denton is the MERGER BETWEEN GERMANISCHER LLOYD'S OIL & GAS BUSINESS AND NOBLE DENTON, a premier provider of lifecycle marine and offshore engineering services. Since January 2010, they have been offering their services as GL Noble Denton.

GL Noble Denton is a full-service provider with broad upstream and midstream competence FOR THE COMPLETE ASSET LIFECYCLE.

GL Noble Denton combines excellent engineering and analytical skills with operational experience of offshore, maritime and onshore oil and gas assets. The Oil & Gas business segment of GL employs MORE THAN 3,000 ENGINEERS AND EXPERTS IN 80 COUNTRIES.

We have strong expertise in complex oil and gas assets such as MODUs, FPSOs, pipelines, subsea systems, OSVs – and assurance, asset integrity, safety and risk, marine operations, project management and software services to match. The scope of technical services includes safety, integrity, reliability and performance management.

GL Noble Denton is A TRULY INDEPENDENT ADVISOR without any vested interest in selling a design, installation, fabrication or equipment.

GL Noble Denton services oil and gas clients in onshore production, onshore pipelines, storage, import terminals, LNG, refineries and petrochemicals, distribution networks as well as mobile offshore drilling units, mobile offshore production units, fixed platforms, subsea, risers and flow lines, offshore support vessels, tankers and shipping, and offshore pipelines. We oversee and support the full lifecycle of an asset from project concept to decommissioning. The business segment has A GLOBAL REACH IN THE OIL AND GAS CENTRES of the world.

**GL** Noble Denton www.gl-nobledenton.com



# market

The Americas, Asia-Pacific, the Middle East and Europe: As a world-class technical service provider for the oil and gas industry, GL Noble Denton shows presence on a global scale.

# **Shale Gas Rocks the Future**

Unconventional gas is deemed to be a long-term solution to the world's energy demands. GL Noble Denton provides crucial expertise and software tools

Gas markets across the world are undergoing unprecedented if not revolutionary change. Previously accepted economic models describing how markets would develop have been turned upside down as a growing number of world-class unconventional gas finds across North America, China, Australia and increasingly Western Europe come on stream. This new mar-

ket is dominated by until lately stranded reserves of shale gas, and the US is a prime force. Many countries and regions formlery known for importing huge volumes of gas, particularly as liquefied natural gas (LNG), are today exporting significant volumes, much of it as LNG.

"Accounting for gas volumes as they flow from wellhead to market is becoming increasingly complex. For example, there may be several stakeholders in a well, each with a financial share in the stream of gas flowing through the network, into storage and onto an LNG vessel (carrier)," says Dave Dewett, GL Noble Denton's Global Principal Consultant for Commercial Gas Management Systems. Shale gas dominates the world of unconventional gas. Production data show a rapid rise in output. In 2000, shale gas provided only one per cent of US natural gas production. By 2010, that number had grown to 20 per cent, and some analysts predict it will increase to 46 per cent by 2035. By 2020, it will be a major factor in the country's

energy mix and the US is expected to produce more gas than it needs.

As these global gas patterns evolve, GL Noble Denton's software and engineering expertise play a key role in optimising the route taken by gas molecules emerging from unconventional gas wells through their full lifecycle, whether they flow from shale gas wells or are lig-

energize

uefied at −162 °C (−260 °F) for transportation to storage facilities and onto markets. "GL Noble Denton's Access Manager<sup>™</sup> is key to accounting for these gas flows and combines effectively with the Group's asset management and integrity tools," says Tom Gilmour, GL Noble Denton's Houston, Texas-based Software Product Strategy Director.

#### ABSTRACT

- Shale gas dominates the unconventional gas output and has led to an energy revolution in the USA
- GL Noble Denton's Access Manager<sup>™</sup> will play a key role in the market





### DISTRIBUTION OF GLOBAL SHALE GAS RESOURCES\*

0-100 trillion cubic feet
100-200 trillion cubic feet
200-300 trillion cubic feet

- 300–400 trillion cubic feet
- 400 trillion cubic feet
- no data provided

\*Russia has the largest proven natural gas reserves of nearly 1,570 tcf. However, data on Shale gas reserves is not available. Data on Russia and the Middle East was not provided by EIA, due to reasons such as lack of information availability.

Source: World Shale Gas Resources: An Initial Assessment of 14 Reg Outside the United States/EA 5 April 2011, / Shale Gas – A Global F tive / KPMG GLOBAL ENERGY INSTITUTE

The rapid emergence of economically viable sources of shale gas requires a major shift in strategic thinking about how gas markets function and how companies manage their assets. Shale gas is one of the most exciting developments in the energy market this century and is revolutionising energy and logistics companies' business plans.

Oil and gas industry professionals see unconventional gas as a long-term solution to the world's energy demands, according to a poll conducted by GL Noble Denton at the 20th World Petroleum Congress in Doha in December 2011.

A small majority of participants said that the production of unconventional gas would help fuel the projected longterm growth in global energy consumption, while 43 per cent thought it would not. Commenting at the time, Pekka Paasivaara, Member of the GL Group Executive Board,

#### LNGC.

The demand for LNG carriers has risen sharply. Currently about 80 newbuilds are on order or under construction.

9

#### Energy Mix. The largest shale gas reserves are located in China and the US.

(F

said: "The energy industry's opinion on the future role of unconventional gas has been volatile, as the sector continues to debate profitability and environmental impacts associated with its production."

SHALE.

A sedimentary rock composed of clay minerals and quartz, sometimes carrying trapped natural gas.

#### **New US Terminals**

There are more than 110 LNG facilities operating across the US, performing a range of activities. Some facilities export natural gas, or supply

natural gas to the interstate pipeline system and local distribution companies, while others are used to store natural gas for release during periods of particularly high demand. There are also facilities producing LNG for vehicle fuel and industrial use. US oil and gas companies are planning to set up more than 15 new export terminals, enough to send a full third of current domestic LNG consumption around the world.

There are more than 500,000 gas wells currently pumping in the US, a 50 per cent in-

crease since 2000, according to the government agency, Energy Information Administration (EIA). EIA figures report that the US has 300 trillion cubic feet (tcf) of gas in proven reserves and potentially ten times that amount in unproven reserves, much of which is in shale deposits. By comparison, the US currently consumes about 25 tcf of natural gas annually.

COALBED METHANE



Since its 2005 low, US domestic natural gas production has increased by 28 per cent. Shale gas production has accounted for the bulk of this rise, increasing from 0.39 tcf in 2000 to around 8 tcf in 2012 and is expected to increase significantly in 2013 and beyond.

Asian LNG import prices are averaging around \$15 per thousand cu ft or more, while Eu-

ropean prices are above \$11. With US prices under \$5, US companies are keen to export gas. Domestic users are concerned that their costs will rise as huge volumes are exported, creating shortages in the domestic market. GL Noble Denton's Access Manager™ comprises a

### **Unconventional Gas**

Most unconventional gas production requires the rock to be fractured ("fracked") and stimulated to allow gas to escape from the tight rock and flow through the wellbore to the surface. Complex geology made drilling for unconventional gas uneconomical until recently. These are four of the most significant sources of unconventional gas:

Shale gas – when natural gas is locked in tiny bubble-like pockets within finely grained, layered sedimentary rock. Drilling and production advances and regulatory changes have caused this sector to boom in the USA. Shale gas is encouraged to flow to the surface after a tool called a perforating gun is lowered into a newly drilled well and lined up precisely within the formation where gas is calculated to be. Upon firing, the gun punches small holes into the well casing, cement and rock. Under high pressure, fracturing fluid is then pressed out through the small cracks created in the formation that allow the natural gas to flow from the rock and to the surface.

energize

suite of web-enabled software modules designed to support the hydrocarbon accounting and commercial operations of gas companies involved in the production, transmission, storage and sale of gas. "Gas volumes are batched in so-called nominations, with Access Manager<sup>™</sup> calculating in- and out-flows for multiple companies enabling volumes to be accurately accounted and charged for," says Gilmour.

#### **Counting Molecules**

Keeping track of the gas molecules as they flow from the wellhead to the end-customer is an increasingly complex task. "Access Manager™ follows these molecules from below the surface, to operating and optimising the facilities," says Dewett, "and onto its combustion in a power station, chemical or fertiliser plant."

"GL Noble Denton's SynerGee<sup>™</sup> product suite optimises the design and operations of pipeline gathering, transmission and distribution systems, including compressors, ensuring they meet demand safely and without over engineering. This optimises an operator's capital expenditure on infrastructure



GAS HYDRATE

construction and helps reduce operating costs to deliver gas from the wellhead to the end client including storage and LNG plant," says GL Noble Denton's Gilmour.

When dealing with the financial viability of developing unconventional gas resources, steps must be taken at all stages of the project lifecycle to maximise production

availability along the supply chain from wellhead to consumer. This includes the production facilities, gathering systems, process plants, transportation technologies, logistics, and export routes to market.

"At GL Noble Denton, we aim to design systems and create engineering solutions to meet consumer demand for gas safely, reliably and effectively, " says Gilmour. ם вмм



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Reservoir. Fossil fuels are located in different sediment layers.

- Coalbed methane gas deposits stored within coal formations, either adsorbed in the coal or trapped with the pore spaces within the coal seam.
- Tight gas while shale gas is trapped in rock, tight gas describes natural gas that is dispersed within low-porosity silt or sand areas that create a tight-fitting environment for the gas.
- Biogas a mixture of methane and carbon dioxide produced from the anaerobic digestion of organic waste materials, such as farming waste.
- Natural gas hydrates crystalline solids composed of water and natural gas in the form of a physical compound where individual gas molecules exist "cages" of water molecules.

## **Confident for Growth**

In spite of economic uncertainty, technically challenging operating environments and a lack of skilled personnel, the industry demonstrates optimism and willingness to invest

The oil and gas industry is facing a new reality in 2013. Rising global energy demand and dwindling access to "easy" oil have compelled

the sector to explore new frontiers and technologies to unlock resources once considered inaccessible. New investment is driving innovation and change throughout the industry, but it comes with challenges. In particular, in the wake of the 2010 Macondo oil spill, companies are facing they expected to increase their capital investment this year, with spending on innovation also set to increase. Just 6 per cent of those polled expect to cut spending on research and development (R&D) and, while the highest proportion of companies (44%) expect budgets to remain flat during 2013, nearly four in ten (37%) expect to spend more on innovation.

Yet, despite these positive forecasts, GL Noble Denton's research reveals a number of significant challenges facing

### How confident are you about the oil and gas sector in the coming year?

rigorous regulation and stricter scrutiny from a wide range of stakeholders. Nonetheless, confidence in the industry is rising and *Seismic Shifts: The outlook for the oil and gas industry in 2013*, GL Noble Denton's third annual report on the outlook for the sector, reveals that there is much to be optimistic about.

Around nine in ten (89%) of the 400 senior oil and gas professionals surveyed in the research said they remained upbeat about the industry's prospects in 2013, up from 82 per cent in 2012 and 76 per cent in 2011. In particular, they identified the potential for exceptional growth in pro-

#### ABSTRACT

- Dwindling "easy" oil and gas is a technological challenge
- Investment focuses on the USA, Brazil and Australia

jects across the US, Brazil and Australia. In addition to growing industry confidence, *Seismic Shifts* suggests that investment will remain robust in 2013. Half the respondents surveyed said that "The impact and consequences of the 2010 Macondo oil spill on the industry have now largely faded"

To what extent do you agree?





76%

2011

the industry this year. In particular, increasingly demanding operating environments and a shortage of skilled resources mean that companies will have to deal with tighter margins, greater overheads, higher risks and tougher contract terms in the face of a skills meltdown.

#### **Key Concerns in 2013**

Economic uncertainty tops the list of industry worries in 2013, with forecasts for impeded growth increasingly becoming long-term expectations. This is especially true within Europe, due to concerns about the outlook for the Eurozone, and in Asia-Pacific, where six in ten of those polled flagged economic uncertainty as the principal force likely to impact the oil and gas sector in 2013.

Low natural gas prices were also identified as a cause for concern, even as bullish oil-price forecasts help to propel the industry. But, although the US shale revolution and resulting low wholesale natural gas prices suggest industry unease over a broader global gas "glut", any further worldwide decoupling of oil and gas prices remains unlikely, according to *Seismic Shifts*. Less than half (44%) of the respondents said they believed gas prices would continue to deviate from the oil index, with industry professionals expecting oil prices to remain high in 2013, at around 100 US dollars per barrel.

Which do you expect to be the biggest barriers to growth for your business? (top 5 answers)



Concerns about the industry's shortage of skilled labour were high enough to make skills shortages a top-five issue among those polled for the 2011 research. Worries have risen sharply: 55 per cent cited skills shortages as the num-

82%

2012

ber-one barrier to industry growth in 2013 (see left). Securing and retaining talent from a dwindling pool of resources will be one of the biggest concerns for companies in the coming year.

#### A Changing Global Fuel Picture

2013 could be the year in which we see the beginnings of an east-west divide in energy supply and demand, indicates *Seismic Shifts*. Growth in the production of unconventional oil and gas will increasingly help the US to fuel its own energy needs, leading the country to rely less on the Middle East for imports.

#### NORTH SEA OIL.

Confidence

prevails

After years of decline, higher oil prices have made exploration and production of North Sea oil feasible once again.



How do you expect overall investment by your business in the following energy types to change during 2013 as compared to 2012?

increase stay the same decrease don't know/not applicable 10%

In turn, the Middle East could be able to refocus supply towards growing energy demands in Asia; although, Asia's robust demand may mean it will want to consume more than the Middle East can feasibly supply. Saudi Arabia, OPEC's largest producer, is also set to become a more significant consumer of its own oil, inevitably leaving less available for export. By 2009, Saudi Arabia had already become the world's sixth-largest oil consumer; today, it consumes roughly one third of what it produces.

#### North America: Potential for a Glorious Year

In the US in particular, the effects of the 2010 Macondo oil spill have yet to fully fade: nearly half (46%) of those polled believe that the consequences of this tragic incident are still rippling through the industry. With six in ten North American respondents expecting to increase spending on compliance in 2013 – nearly twice the rate of Europe (32%) – it is clear that concerns surrounding regulatory restrictions are one of the key factors affecting the industry in the US.

A programme of legislative post-Macondo change has caused a certain degree of frustration amongst some industry professionals, as *Seismic Shifts* quantifies. In North America, 37 per cent believe that many new regulations have been rushed into place. Nonetheless, six in ten of all the respondents contend that they have learnt valuable lessons from the Macondo spill – and changed their operating practices as a result. Safety and environmental concerns are, and should be, of utmost importance.

Despite these concerns, 2013 is set to be a glorious year for the US oil and gas industry. Those polled for *Seismic Shifts* see North America as having the greatest growth opportunities for the coming year with the US named as the industry's number-one investment destination, ahead of Brazil in second place.

#### **Europe: North Sea Revival Gathers Pace**

Seismic Shifts affirms a reignited interest in the North Sea oil and gas industry, with both the UK and Norway listed in the top six destinations most favourable for investment. Technology-led innovation has enabled a number of mature fields in the region to become viable investment options once again. Little wonder then that 44 per cent of European respondents expect capital expenditure on

## Countries that will offer the most favourable overall conditions for investment during 2013, and the riskiest





Top 6 toughest investment destinations



research and development (R&D) to increase this year, a statistic above the global average of 37 per cent.

Gas is also expected to play a growing role in a downstream revival, with 34 per cent of local respondents expecting European governments to prioritise gas investment in 2013. This far outstrips the perceived priority being given to wind (26%) and oil (19%) infrastructure, respectively. The resulting investment in gas projects, such as the North Stream subsea gas pipeline between Russia and Germany, could also lead to cheaper wholesale gas prices by the end of 2013, according to 42 per cent of European respondents.

The resumption of shale gas extraction in the UK will also be an interesting development within the European market, but there are significant safety and perception concerns to be overcome.

#### Asia-Pacific: Strong Boost by Mega-Projects

Seismic Shifts reveals that confidence for business growth remains high in Asia-Pacific's oil and gas industry, but that the weakening global economy is a greater concern for sector leaders there than in any other region. Nearly two thirds (64%) of the respondents said that they feel under pressure to secure greater return from their capital investments.

Although no Asian country appears in the top six investment destinations outlined by the research, Australia was identified by the report as the oil and gas industry's third most attractive investment destination in 2013. The prevalence of the country's high-capital-expenditure mega-projects look set to provide a crucial boost to the wider region, too.

Asia-Pacific could also benefit from the US drive for increased energy security in the long term. Oil and gas leaders interviewed for *Seismic Shifts* believe that an easing of US oil and gas imports will allow more Middle Eastern hydrocarbons to be exported to China and other Asian countries, where demand for energy continues to rise.

The global confidence and increased investment intentions captured by *Seismic Shifts* reflect an industry that continues to enjoy substantial and sustained growth. Macro-economic concerns may still overshadow much of the

industry, but technological advancements and an increase in unconventional hydrocarbon recovery provide much to be positive about. US, Brazilian and Australian growth is likely to drive the oil industry over the coming year, but, as GL Noble Denton's research has highlighted, there are a number of specific issues that still need to be overcome. In particular, skills shortages remain very

much front of mind, and are forecast to be the primary barrier to ongoing growth this year.

The conflicting pressures of talent management, increasingly complex hydrocarbon recovery operations and R&D spending are all likely to drive up overall capital expenditure this year. Companies will have to think smarter to achieve the levels of safety, integrity and performance that will be required to breed success in 2013.

YOU CAN DOWNLOAD A COMPLIMENTARY COPY OF "SEISMIC SHIFTS: THE OUTLOOK FOR THE OIL AND GAS INDUSTRY IN 2013" FROM: WWW.GL-NOBLEDENTON.COM



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#### NORTH STREAM.

The two parallel subsea gas pipelines from Russia to Germany were commissioned in 2011 and 2012, respectively.

# A Global Model for a Global Market

#### GL Noble Denton has further enhanced its global operating model to meet growing operator needs for technical advice to be delivered under global framework agreements

One of the major industry trends that emerged in 2012 was the move by a number of major operators towards a more focused and coordinated approach to the procurement and management of third-party technical services. In an effort to manage the safety and risk profiles of their operations worldwide, many of GL Noble Denton's clients have begun to consolidate and rationalise their suppliers from hundreds of disparate companies to just six or seven global partners, through robust and quality-focused global procurement processes.

Recognising this shift within the industry, GL Noble Denton enhanced its approach to managing global client projects in 2012 by formalising its global operating model. In particular, the company invested in its infrastructure and project management processes, and opened "regional compliance centres" for key services such as technical assurance. Under the global operating model, projects are carried out by local teams of GL Noble Denton engineers across the world, drawing on their in-depth local knowledge and expertise to support their clients' techni-

#### ABSTRACT

- To manage the safety and risk profiles, oil and gas companies focus on global partners
- The global operating model strengthens GL Noble Denton's position as a market-leading inspection services provider

cal challenges. Regional compliance centres support this by coordinating local work under global framework agreements with clients and providing global best practice from GL Noble Denton's international network of nearly 4,000 technical experts. This ensures that work is completed in line with the terms of the clients' framework agreements and always meets the highest standards of service. The global operating model plays a key role in GL Noble Denton's efforts to provide clients with cohesive and consistent levels of service delivery, using common processes, procedures and systems to the benefit of the client and GL Noble Denton itself.

#### A Blueprint for the Industry

The global operating model has already been implemented by GL Noble Denton's Inspection business unit, which won a number of key global contracts in 2012, including a four-year inspection services enterprise framework agreement with oil and gas major Shell. Under this agreement, announced in March, GL Noble Denton's network of highly qualified inspection engineers will provide inspection services for Shell's extensive global portfolio of projects in select



London. Both Shell and BP have signed global inspection agreements with GL Noble Denton.



Network. 4,000 technical experts serve GL Noble Denton's customers around the world.

ating model. This new multi-million-dollar agreement with BP will see GL Noble Denton become one of a small number of preferred inspection vendors across BP's capital and operating expenditure upstream projects. It will also play a central role in BP's procurement process, ensuring that goods supplied to the oil company are compliant with industry best practice.

Pekka Paasivaara, Member of the GL Group Executive Board, said: "BP has taken a major step in refining its selection of inspection partners to ensure it consistently receives a world-class service in vendor assessment. We are delighted that GL Noble Denton has been selected to play a central role in this,

and we look forward to aiding BP's continued drive to operate safe and sustainable assets."

GL Noble Denton's global operating

SUCCESS.

In recent months, GL Noble Denton's Inspection business has won several key global contracts.

locations, both on- and offshore. The company will also supplement Shell's procurement process to ensure that goods acquired by Shell are compliant with the highest industry safety and efficiency requirements across their lifecycle.

#### **Global Presence**

"GL Noble Denton's position as a market-leading technical assurance services provider has been further recognised by this agreement, and we are delighted to have the opportunity to develop a closer relationship with Shell," comments GL Noble Denton's Senior Vice President for Technical Assurance, Paul Shrieve. "With a presence in more than 80 countries across the world, GL Noble Denton is well placed to support oil and gas companies wherever they are operating."

In early 2013, GL Noble Denton was awarded a further international inspection agreement across its global operdesign, dynamic positioning, structural integrity management, risk and safety, gas consulting, software and marine warranty.

"It's not just the inspection and technical assurance sector that can derive benefits from this kind of global model," explains Shrieve. "I expect the whole industry to implement this approach, and we are already seeing many other companies - not just in technical assurance, but also other services – entering global agreements with suppliers like ourselves. It's partly a reflection of the way the industry is becoming more globalised, but also a widespread recognition of the need to be proactive and fully auditable when it comes to risk and safety management."



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Dreamstime.

Sarunyufoto |

Gary718,

Photos:

market maintenance



# Safeguarding Utility Networks

Britain's aging gas and water networks must be maintained in a cost-efficient way. The right kind of challenge for GL Noble Denton's UK Utilities division

Maintenance. The UK's underground water and gas networks are in need of ongoing investment.

Across the United Kingdom, thousands of miles of underground pipelines and buried assets carrying water and gas to customers have lain hidden over many years, perhaps for 60 years or more.

Today, after decades of service, the condition and remaining life of many of these transmission and distribution resources is uncertain. "Many need maintaining, if not replacing, and determining when to intervene cost effectively requires innovative thinking and solutions," says Antony Green, Vice President of UK Utilities for GL Noble Denton.

Created in 2012 by a restructuring of GL Noble Denton's oil and gas business, Green's Utilities team is focused on providing clients in the downstream water and gas sectors with innovative technical solutions to optimally maintain and replace assets in an operational environment that demands improvements in efficiency and safety.

Ian Patheyjohns, Innovation Manager for the Utilities group, says: "Avoiding unnecessary and costly digging of access holes into roads and pavements for gas or water infrastructure maintenance is critical in minimising spend and gaining support from stakeholders, including the general public. Within the utilities business we have a range of expertise to help meet these challenges and have enjoyed particular success in a number of industry award winning developments including the beam drilling system to aid keyhole repair, Burstfinder for leakage location and Effectus for systemwide analysis of risk and consequence of failure. Our developments allow Utilities to identify where essential investment is needed, for maximum effect."

#### **Natural Monopolies**

In the UK, gas and water transportation businesses are natural monopolies, requiring robust regulatory regimes to ensure customers are not disadvantaged. In the gas sector, the Office of Gas and Electricity Markets (Ofgem) oversees the market and protects customers' interests while the Water Services Regulation Authority (Ofwat) fulfils the same function of regulating pricing and revenue in the water industry. "These agencies and regimes are studied across the world as being market leaders in how appropriate regulation can facilitate high quality, value for money services for

#### ABSTRACT

- GL Noble Denton UK Utilities serves clients in the downstream water and gas sectors
- A strong team with solid expertise, UK Utilities now reaches out across the world

customers and encourage innovation in utilities with public and strategic importance," says Green.

In April 2013, Ofgem introduced a new regulatory framework known as RIIO (Revenue = Incentives + Innovation + Outputs) and Ofwat is introUtility works. Massive investments are necessary in the UK energy sector.

ducing its sixth round of industry regulation know as AMP6 (Asset Management Plan) for the period 2015 to 2020. The UK energy sector is now facing a number of challenges in providing safe, reliable and secure energy that will also be sustainable in a low carbon future. RIIO plays a key role in this, ensuring capital investments are made in line with industry needs, which Ofgem estimates to be around £ 32 billion over the period to 2020.

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#### **Growth Opportunities**

GL Noble Denton's UK Utilities team of more than 100 experts is predominantly based in Loughborough, with offices around the country. "We are also reaching out to GL offices across the world and are already working closely with our colleagues on projects in countries as diverse as Qatar, South Africa, Singapore and Australia," says Green. "GL's international network enables us to access some of the fastest growing utility businesses in the world, particularly in the Middle East."

Innovation Manager Ian Patheyjohns adds: "By focussing our efforts on understanding the future challenges faced by utilities and collaborating internally and externally to provide solutions, we will ensure GLND remains at the forefront of innovation."





Expertise. Innovation Manager lan Patheyjohns (top) and Vice President Antony Green.

### Managing Innovation

Ian Patheyjohns was recruited to the newly created post of Innovation Manager in early 2013 by Antony Green, Vice President UK Utilities for GL Noble Denton. Green had previously successfully led GL Noble Denton into the UK's highly competitive water sector, and in 2012 had managed that team's evolution into the Utilities division. Utilities UK has decades of engineering expertise and a rich R&D tradition through its corporate heritage

of British Gas and Advantica.

One of Patheyjohns first roles is to develop the team's response to RIIO and AMP6, ensuring customer needs are identified and met effectively.

As Patheyjohns says: "I joined GL Noble Denton because I believe that the company shares my bold ambition to make innovation a part of everyday life." Constantly looking for ways to improve processes, encouraging everyone to share knowledge, even from apparently unrelated activities, and inspiring new ideas are his core concerns, Patheyjohns adds.

"As Innovation Manager, I strongly believe these principles will enable us to take full advantage of the significant expertise at our disposal, and use it to the benefit of our clients, contractors and other partners."



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# offshore

The demand for engineering services, technical assurance and consulting in the offshore sector is rising. GL Noble Denton supports oil and gas companies with its high-performance spectrum.



# **Towards the Deep Blue**

GL Noble Denton is poised to support China National Petroleum Corporation (CNPC) in expanding its strategic focus from onshore to offshore

A milestone was reached last year in the cooperation partnership between the GL Group and China Petroleum Offshore Engineering (CPOE):

GL Noble Denton signed a strategic cooperation agreement at GL's headquarters in Hamburg with the CPOE, the offshore engineering subsidiary of China National Petroleum Corporation (CNPC).

Zhang Yuntong, Vice President and Safety Director of CPOE pointed out that GL Noble Denton is well known throughout the oil and gas industry in China as an independent provider of verification, technical assurance, offshore engineering consulting and marine operation services. "So we concluded that cooperating with GL Noble Denton would be an ideal way to benefit from their experience, knowledge and technical expertise."

When meeting with the Chinese delegation, Erik van

#### ABSTRACT

- China National Petroleum Corporation wants to expand its oil exploration activities from shallow to deep water
- GL Noble Denton will provide the required consulting, inspection and assurance services

der Noordaa, CEO of the GL Group, added: "With its strong legacy, comprehensive expertise in complex oil and gas assets and extensive global network, GL Noble Denton is well positioned and ready to assist CPOE in reaching its ambitious goals."



Hamburg. CNPC Offshore Engineering signed a cooperation agreement with GL Noble Denton.

According to the agreement, GL Noble Denton will support CPOE's offshore oil and gas development and engineering services in domestic and overseas projects, which involve activities such as master development plans (MDP), front-end engineering and design (FEED), detail design as well as technical communication and training.

#### **From Onshore to Offshore**

CNPC has considerable experience in onshore operations and established the new offshore engineering subsidiary to boost the exploitation of oil in Chinese waters. Currently CPOE offers its offshore engineering services mainly in Bo-



#### CNPC.

China National Petroleum Corporation is China's largest oil and gas corporation as well as one of the world's major oilfield service providers and a globally reputed petroleum engineering and construction contractor.

hai Bay, the innermost section of the Yellow Sea in northeastern China. Offerings include various research and development services, such as Platform Supply Vessels (PSV), anchor-handling tug supply vessels (AHTS) and drilling rigs, as well as construction projects.

Apart from optimising these shallow-water installations, CPOE has formulated a strategy to push its coordinated oil and gas exploration and production activities into deeper waters, both at home and abroad. To accelerate expansion into deeper offshore operations, CPOE is planning to make substantial investments over the coming years. "With shallow water as its traditional battlefield, CPOE is now acquiring the expertise and equipment it needs to pursue its goals in deep-sea operations," Zhang said. Furthermore, CPOE will expedite CNPC's overseas expansion by helping it tap into offshore reserves in foreign countries. "Our main customer is CNPC, but there are many international offshore projects we are interested in, and there will be more clients to serve," Zhang explained.

#### **Sharing Expertise**

With the new facilities in place to prepare for competition in the international arena, a first-class team of technicians and expertise in offshore oil and gas is what the company needs next. During the visit, Tobias Rosenbaum, Head of GL Noble Denton Germany, presented an overview of the proven capabilities of GL Noble Denton, including technical assurance, marine operations, project execution and software solutions.

His presentation was received by the delegation with great interest. Both sides identified a number of potential fields of further cooperation, such as floating production, storage and offloading units (FPSO), design and operation, deepwater installations and technology, as well as potential joint projects, including feasibility studies, verification, technical assurance and engineering consulting, etc. "GL and China Petroleum Offshore Engineering have already established a mutual understanding and friendly cooperation through joint projects in the fields of inspection, design verification and quality assurance," said Wu Yi, Country Manager of GL Noble Denton China, who initiated the signing of the cooperation agreement. "The agreement establishes a solid foundation for expanding our cooperation. I see plenty of potential for the combination of GL Noble Denton's wide-ranging solid capabilities and China Petroleum Offshore Engineering's strong drive for offshore exploration."

Perspectives. "CPOE is shifting business activities from shallow water to deep water," says Zhang Yuntong.



# We're Young and Ambitious

An interview with Zhang Yuntong, Vice President & Safety Director of CPOE

ence and expertise in offshore engineering. This is of utmost importance for a young company like us. We evaluated numerous companies before signing this agreement with GL. The selection process took quite a while. We finally chose GL Noble Denton as an appropriate partner because of the excellent reputation the company enjoys in China and worldwide for its combination of engineering and consulting expertise.

### **ENERGIZE:** What do you expect from the cooperation agreement with GL?

**ZHANG YUNTONG:** CPOE is a fairly young company that focuses exclusively on offshore engineering. Therefore we need a partner to help our engineers accumulate experi-

#### **ENERGIZE: Have you signed other agreements?**

**ZHANG:** It is our strategy to work with one technical advisor. GL Noble Denton has a proven track record in delivering many challenging technical projects and has the competence to help us improve our engineering capabilities.

### CPOE

HEADQUARTERED IN BEIJING, CNPC Petroleum Offshore Engineering has about 4,000 employees. Its business scope covers engineering and research of offshore petroleum drilling and production technologies, integrated offshore oil and gas exploration and production projects, offshore drilling, downhole operations, oil testing/production, fabrication and installation of offshore facilities and equipment, maintenance and related fields. Undoubtedly, China's dynamic economic environment harbours much more business potential for GL Noble Denton as CPOE continues to expand its range of activities. Shortly after the return of the delegation to China, both companies began discussing possible cooperation in the certification of CPOE'S welding workshop in China. "We will follow up with further support and training," Wu said. **D OM/ZL** 



#### GL GROUP EXPERT:

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We are looking forward to learning from GL's engineers. This is the first agreement of this type for us, and we want it to be the only one.

### **ENERGIZE:** What projects will be realised first under the cooperation agreement?

**ZHANG:** The first projects have already been agreed upon in the contract. We will concentrate on projects that are suitable for joint execution. This approach benefits both parties. While we learn about the working methods of GL engineers, GL can benefit from a much broader exposure to Chinese offshore projects.

I am convinced that a successful start of our cooperation will lead to a long-term, mutually beneficial relationship focused on the emerging offshore markets.

### **ENERGIZE:** How do you perceive the opportunities of the Chinese offshore market?

**ZHANG:** I can clearly see many fascinating projects in Chinese and international waters. China has moved into the offshore market and will be accelerating its pace. Our company was set up in 2004 to focus on offshore engineering challenges, whether they are in shallow or deep waters. Although it will take us a while to get ready for deepwater exploration, we are on the right track to obtain the necessary technical expertise and engineering experience. We are young and ambitious.

#### ENERGIZE: What are the challenges in the short term?

**ZHANG:** While offshore represents a new perspective for China, we at CPOE are shifting our focus from shallow water to deep water, where the requirements are much more complex and reservoirs less accessible. We must put into place appropriate rules and regulations in order to exploit oil and gas reserves in an environmentally friendly way.

In the near future, we have to strengthen our capabilities in line with our business aspirations. Both have to be in agreement in order to make our offshore exploration projects safe, clean and profitable. Beyond shallow waters, we will continue to obtain engineering capabilities and experience in deepwater projects in China and abroad to support the strong ambition of our parent company CNPC.

# **Gas for Britain's Winter Days**

Storing natural gas in depleted subsea fields involves onshore equipment that operates under enormous pressure. GL Noble Denton develops the required inspection regimen

Centrica Storage Limited (CSL) operates a large natural gas storage facility about 18 miles (29 km) off the east coast of Yorkshire to meet seasonal peak demands in the UK. The Rough facility, a partially depleted gas field under the North Sea, is linked to the onshore gas processing terminal at Easington, where CSL has developed a reception facility to accommodate production from the new offshore York field. The easington gas terminal can inject more than 125 million cubic metres per day into the subsea storage facility per day, which represents over 70 per cent of UK's storage capacity and can meet approximately 10 per cent of the nation's peak daily demand.

As part of the development of the Easington facility, all the York onshore assets required Written Schemes of Examination (WSoEs) to be in place prior to first gas to ensure conformity with the applicable statutory requirements, including the Gas Safety (Management) Regulations 1996 and the Pressure Systems Safety Regulations 2000. CSL awarded a project to GL Noble Denton to develop a suite of Written Schemes of Examination for the Easington assets. The project included the following activities:

- Identification of the York assets that required a Written Scheme of Examination
- Obtaining and reviewing the relevant design documents to develop corrosion risk assessments (CRA) for each asset, highlighting the main degradation mechanisms and priority areas for inspection
- Reviewing the outputs from the corrosion risk assessments to produce baseline inspection work

Energy. UK gas storage facilities and receiving terminals operated by CSL.

Caythorpe

Langeled

Easington

scopes and inspection reports to measure the original key integrity data for each asset

- Working with CSL's engineers to develop a methodology for risk-based Inspection (RBI), and a procedure compliant with API 580/581 and CSL's specific requirements
- Completing a detailed RBI study for each of the assets in accordance with the agreed RBI procedure
- Producing Written Schemes of Examination based on the RBI results

#### **Expertise Provided**

Rough

Baird

GL Noble Denton conducted a series of workshops that resulted in the development of a risk-based inspec-

- tion (RBI) procedure in accordance with API 580/581 and CSL's specific requirements. The RBI procedure, which was used to define and agree the Terms of Reference and methodology for the RBI study, in addition to the Written Schemes of Examination, included the following:
- □ Probability of failure calculation methods
- Consequence of failure assessment methods
- Methods for deriving consequence
- Inspection strategy

GL Noble Denton tailored its Galiom<sup>™</sup> RBI/ AIM software package and used the relevant input data to ensure that the RBI study and Written Schemes of Examination were generated in accordance with the agreed RBI Procedure.

#### ABSTRACT

Pressure system inspections must follow a Written Scheme of Examination

Requirements for gas terminals are especially strict

### Integrity Management Software

**GL Noble Denton's Galiom™**, an integrated environment for risk-based asset management of offshore and onshore facilities, supports essential integrity management (IM) processes:

- Risk assessment and IM planning
- Inspection, monitoring and testing
- Integrity assessment
- Mitigation, intervention and repair
- Management of change
- Integrity dashboard

#### Galiom<sup>™</sup> benefits

- Delivers improved visibility of asset criticality, risk and technical integrity
- Identifies the likelihood and consequences of failures to mitigate major accident risks
- Allows operators to benefit from optimised inspection schedules cutting maintenance, downtime and inspection costs
- Demonstrates compliance with management procedures
- Predicts equipment life and inspection dates using corrosion rates and asset criticality
- Improves decision-making on repair, replacement and decommissioning
- Highlights operating integrity issues and can guide a proactive inspection and maintenance methodology

Asset integrity management (AIM) software for operational risk and integrity management.

GALIOM<sup>™</sup>.



Back-up. The Easington terminal processes gas for the Rough storage facility.

#### **Outcome and Benefit**

Through the successful completion of the project, GL Noble Denton has enabled CSL to:

- Commence production from the York field within their specified programme by ensuring that the Written Schemes of Examination were prepared and delivered within the agreed timescales
- Implement an RBI methodology tailored to their requirements, and prepare a suite of Written Schemes of Examination that optimise the frequency and operational costs associated with the York inspection programme
- All the work was completed on schedule to meet CSL's overall strategic requirements for the project. RC



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# Navigating Challenging Waterways

GL Noble Denton's Dubai-based senior marine warranty surveyor, Captain Stephen Craig, speaks about his role in a recent project to oversee the move of a rig through the Bosporus

> Clearance. Moving the structure under two bridges was a precision job.

Narrows. Tight turns, strong currents and heavy traffic make the Bosporus one of the world's most dreaded passages.



It takes meticulous planning and an experienced eye for detail to safely organise the transportation of an offshore drilling platform and accompanying vessels through any waterway. But the risks and requirements are further magnified in challenging waters, such as the Bosporus. This is where GL Noble Denton's team of expert marine warranty surveyors play a crucial role.

Captain Stephen Craig, senior marine warranty surveyor at GL Noble Denton, and the surveyor who recently advised on the transportation by Rigcon AS of the valuable B319 mobile offshore jack-up drilling rig through the Bosporus, says: "Marine warranty surveyors act on behalf of clients and their underwriters to ensure that ma-

#### ABSTRACT

- Moving a rig through the Bosporus is an enormous technical and navigational challenge
- GL Noble Denton's experts know how to ensure safe passage

rine operations are performed to the appropriate industry standards. Those standards and requirements are particularly high in risky waters, such as the Bosporus, which is one of the most hazardous, crowded, difficult and potentially dangerous waterways in the world for marine operations."

The Bosporus is a particularly challenging route because of its narrows, shallow waters and winding shape. The Strait takes several sharp turns and there are around a dozen major changes of course that need to be negotiated along its passage, as well as two low-hanging bridges and power cable structures. As the marine warranty surveyor advising on the tow of the B319 rig through these waters from Kavala, Greece, to the Black Sea, Captain Craig was responsible for verifying and approving the plans, tools, procedures and vessels employed for the move. This included inspecting the heavy-lift vessel and the tugs used for the on- and off-load operations, reviewing documentation, surveying the vessels and equipment, checking the weather and environmental factors. This work must be undertaken to authorise the on- and off-load and the initiation of the tow, and ensure that the parties involved were appropriately briefed.

#### **Experienced Hands**

"For any marine transportation project, the client needs to satisfy their insurance underwriter's standards," explains Captain Craig. "In this case, Rigcon AS had to meet the 'high-risk' standard, as the project involved a busy shipping channel with challenging navigational issues and a highly expensive asset. Due to the high-profile nature of the project, any failure to comply with those standards would also have major commercial and reputation issues."

"My role was to review the initial project plan and the information provided by various sources to ensure that everything was correct and achievable, and to review the data during the implementation of the project and the actual tow to ensure nothing was missed, and to highlight any potential issues," he adds.

Captain Craig has 18 years' experience in the marine industry. He joined GL Noble Denton as a senior marine



Done. The semi-submerged heavy-lift vessel exits the jacket following successful unload.

warranty surveyor in 2011 after a varied career that included starting as a deck cadet with the Royal Fleet Auxiliary in 1995 and qualifying as a Master Mariner (Class 1) in 2005. His previous role included piloting 50-metre to

MARINE WARRANTY. Third-party review and approval of maritime construction or transportation projects on behalf of insurance companies. 300-plus-metre vessels on the Thames Estuary and River Medway in the UK.

Captain Craig says his current role is an exciting and rewarding position, explaining: "Of course, the main role of a marine warranty surveyor is to protect underwriters' interests by ensuring that good industry practice and proper procedures are followed during any critical off-

shore or marine operations. The Marine Warranty team at GL Noble Denton is involved with a lot of rig moves, offshore marine activities and other marine work for our clients so the work is generally very varied from one day to the next."

#### All In a Day's Work

Captain Craig says that a typical day would generally involve surveying and assessing plans and procedures for the approval of towage projects, assessing shipyard facilities, checking safety precautions and arrangements, or ensuring cargo loading and stowage is being carried out safely. "My day-to-day job includes liaising with clients to set up new rig moves, reviewing procedures, issuing Certificates of Approval, and undertaking vessel suitability inspections," he says. An eye for detail is a vital requirement for a marine warranty surveyor, as Captain Craig explains: "Even the smallest detail that has been overlooked in the project plan could result in long delays and additional costs, so you need to be able to spot, predict and fix problems early on in the process.

"When you're working with clients, either new or existing, you're representing GL Noble Denton as a company, so you must be professional in your job at all times. Flexibility and patience are key: offshore project needs can develop quite quickly and clients will often call on you at short notice, so an understanding family is crucial."

Clearly, another key skill is the ability to multitask, as Captain Craig says that at any one time he may have several ongoing projects to manage and monitor at various stages of completion. "The ability to work under pressure is something that we face daily, whether in the office or when working on site," he agrees, "however, it helps immensely to have a strong team to work alongside."

"On the B319 transportation, for example, strong and clear communication with the entire team was crucial to the project's success," Captain Craig adds. "There were a number of things that could have gone wrong, but due to the expertise of the whole team – ranging from Rigcon AS's operational staff to GL Noble Denton engineers in key delivery centres across the world and project managers - the tow was completed safely and efficiently."



#### GL GROUP EXPERT:

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Video. Watch B319's transition through the Bosporus on YouTube.





Photo: Claffed | Prosmetime

GL Noble Denton provides engineering expertise, domain knowledge and many years' experience in upstream, midstream and downstream oil and gas, petrochemicals, and power generation to develop holistic lifecycle-orientated asset integrity management solutions for their clients.

# **Design Check Avoids Costs**

GL Noble Denton is ideally positioned to provide independent process safety design verification to both operators and designers of oil and gas facilities

Given the nature of the risks involved in the oil and gas industry, ensuring the safety and integrity of operating assets is paramount. For most companies, process safety means making sure the facilities are well designed, safely operated, and properly inspected and maintained. The consequences of errors or omissions in the process and safety design for new and existing assets can be potentially disastrous.

#### **Essential Verification**

In the case of new process designs, it is often not possible for the client organisation to verify the work of the designer in sufficient detail to demonstrate that the design is correct and has the required integrity. Equally, it is often difficult for designers to mobilise independent resources to assure

#### ABSTRACT

- Complex asset designs harbour significant risk potential
- Design verification can reveal hidden hazards early, avoiding costly repairs at a later time

themselves that their design is without errors that may lead to process safety issues. In these situations, an independent thirdparty verification of the process and safety aspects of the design is beneficial to provide assurance

that both the overall approach and the detailed calculations performed will result in a safe process plant.

Although for existing operational facilities the possible outcomes from errors or omissions in the process design are similar, the challenges to verify process safety are different. The process plant may be old and key design documents no longer relevant as the facility may have been subject to a number of phases of redevelopment or major modification. In these instances, it is essential that the overall approach to process safety is consistent and the detailed calculations underpinning the design are still relevant.

For maximum return from the independent verification of process safety in design, it would typically be conducted at the following stages of a project or asset lifecycle:

- Towards the end of the FEED and detailed design stages of a new project, to ensure that the design has adequately addressed process safety and is acceptable to take forward.
- After piecemeal or major plant modifications to an existing asset when the original process safety view of the facility may have been compromised by subsequent changes.
- After acquiring new assets when the detailed approach to process safety needs to be verified.

#### **Suitable Facility**

The service provided by GL Noble Denton is aimed specifically at the oil and gas industry, including LNG liq-



Risks. The conseauences of errors can be potentially disastrous.

uefaction and regasification. However within this domain, almost any size of process or modification could benefit from process safety design verification. This can include onshore facilities, offshore platforms and subsea tie-backs. GL Noble Denton's verification track record spans small portable process skids, through to the design verification of a 4 MTpa LNG liquefaction train.

#### **Benefits of Independent Verification**

GL Noble Denton was requested to verify all process safety aspects of the detailed design for a large onshore gas processing facility. Part of this verification included a detailed assessment of the proposed automated staggered blowdown system. On initial inspection, it appeared that the arrangements for blowdown had been designed using appropriate tools and methods. However, the detailed modelling performed during the verification revealed that the proposed timings of the staggered blowdown would result in the design capacity of the flare being exceeded, potentially resulting in damage to the flare system. The use of process safety design verification avoided a potentially hazardous condition and meant that the required changes to the blowdown system could be made at minimum cost before completion of the construction phase of the project.



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### The Verification Process

Verification ensures that the design methods and calculations specified within the standards have been performed correctly. Verification must be conducted by experienced engineers with sufficient domain knowledge to confirm that process hazards have been assessed during the design process. The primary considerations for process safety are:

- Has the design envelope been defined and documented clearly? Do design philosophies and narratives provide sufficient and correct information to guide the subsequent stages of design?
- □ Process hazards. Have appropriate methods been used to identify all process haz-
- **Layers of protection.** Are sufficient layers of protection in place so that the failure of one protective device does

not leave the overall system unprotected? Do they have sufficient integrity to ensure process safety (i.e. SIL analysis)?

**Flare, relief and blowdown.** Is the flare design appropriate to deal with all posblowdown and/or concurrent relief scenarios been considered? Has the flare design been conducted correctly with all scenarios being calculated based on appropriate assumptions?

Photo: Alexkurgano | Dreamstime.com

## Survival Test for Pipe Bend Patches

Composite repairs on straight pipe have been validated by pipe manufacturers in full-scale tests. Additional work is required to qualify the use of this technique on components such as bends. New tests and analyses help operators develop confidence in the technique

The lead time to manufacture and install current methods of repairs, such as epoxy sleeves, to pipeline configurations such as bends and tees is significant. During this time the pipeline will be operating at reduced flow and this may have severe financial and contractual implications. In particular, concerns have been raised as to the suitability of some of the currently approved repair techniques for some emergency situations due to this time delay. Composite repairs may be the answer.

Composite repair systems (e.g. preformed composite sleeves and wet-wrap composite repairs) are currently unapproved for use by UK operators although they have been used offshore by some pipeline operators for a number of years. Additional validation work is required for non-

#### ABSTRACT

- □ Composite temporary repair systems allow pipeline operation to continue for up to two years
- FEA analyses indicate that even repaired pipe bends will survive all required stress tests

straight pipe components in order to ensure compliance with the standards ASME PCC-2[1] and DD-CEN-ISO/ TS 24817:2011[2]. However there is no evidence available to demonstrate this has been performed.

This project was proposed to select, test and approve a composite repair system that could be used on pipeline bends where existing repair methods are judged to be unsuitable. The current intention of the operator is that the composite repairs are to be installed for periods of up to two years before a permanent repair is performed.

Two proprietary wet-lay-up composite repair systems were selected for the full-scale test programme. This type of repair system involves using a liquid resin such as epoxy to encapsulate the fibres or cloth. The result should be a uniform, imperfection-free repair built up of layers of fabric in a matrix of resin[3].

Concerns to address were:

- Qualify the method as a temporary repair on bends to industry standards
- Determine the validity of the method for all diameters or D/T ratios (previous tests were completed only on a single size)



Figure 1. Short-term survival test specimen (I.); defect filled with putty (r.).

Consider the bend/defect geometry to reduce the scope of full-scale tests required

#### **Short-Term Survival Test**

ISO 24817 Annex C describes the test method for qualification of repairs to defects not penetrating the pipe wall entirely. A successful demonstration requires the repaired section to survive the pressure loading to  $P_{f}$ . If successful, the test demonstrates the structural integrity of the repair system up to the yield strength of the original pipe spool for the selected defect. Then the repair system shall be considered qualified for repair defects up to the selected depth of defect used in the test.

The test pressure,  $P_f$ , is defined as existing when the hoop stress in the pipe reaches the yield strength, according to thin-wall shell theory.

#### **Collapse Analysis for Corrosion Defects**

A study based on non-linear finite element analysis (FEA) has been carried out to determine the collapse load of repaired pipe bends under static internal pressure loading for a range of bend geometries. The aim is to advise on the purchase of suitable materials for the full-scale tests to prove the repairs to ISO 24817. In each case, a Riks analysis was undertaken to determine the collapse load of the repaired pipe bend subject to an increasing internal pressure load. The FE analyses were carried out on a selection of pipe geometries and materials with respective design pressures, to provide a full range of available options within the operator's network for investigation.

#### **Scope Limitations**

To fully assess repairs of corrosion patches on bends, a number of variables would need to be investigated, for example, a range of pipe diameters (D) and wall thicknesses, different bend radii and angles and different corrosion patch sizes and locations. Elastic-perfectly plastic properties were conservatively used in all analyses.

Investigation showed that the number of required geometries to be assessed could be reduced by  $\triangleright$ 



Figure 2. Repaired bend.

selecting variables that predicted the most conservative stress:

- Smallest bend radius: 1.5 D selected
- **Tightest angle:** 90° selected
- **Corrosion patch** to be located on the bend intrados

Furthermore the following simplified assumptions were made:

- Internal corrosion was not considered a credible threat as the network transports sweet, dry natural gas, therefore only external defects were considered.
- The corrosion patch was limited to the minimum size specified for the short-term survival spool test in ISO 24817 Annex C (0.5D × 0.25D), using a maximum defect depth equal to 80 per cent of the wall thickness.
- The composite material was modelled as a single layer with anisotropic properties, perfectly bonded to the bend.
- A pressure load was applied to all internal surfaces of the model and pressure end loads were applied to represent the pipe being "capped off". Additional loading was not considered in the current scope due to the temporary nature of the repair.
- The material properties were based on manufacturer specifications. The local coordinate axes in FEA were defined to represent the bidirectional fabric orientations (0° and 90° to the roll direction of the fabric, i.e. bend circumferential and axial directions).

Note that it is an inherent assumption that the fabric is applied so that the directional assumptions are correct. Composite fibre strength can be seriously compromised if loaded in a direction other than that for which it is designed. However, it is noted that both manufacturers employ trained personnel to perform the repairs, rather than selling the repair technology to third parties. This provides confidence in the repair method and helps to justify the assumptions made above.

#### **Repair Thickness**

ISO 24817-2011 Annex C specifies an equation for the minimum required repair thickness for the short-term spool survival test. This applies to straight pipe. Section 6.5.10.3





Figure 4. Example of failure predicted for unrepaired bend (150 NB model illustrated, at 95.8 bars applied pressure).

provides a factor to increase repair thickness when applied to a bend, however this is not included in the FEA for conservatism.

The repair method in ISO 24817 then states that the actual repair thickness shall be determined by dividing this calculated thickness by the individual layer or wrap thickness. The required number of wraps of the repair shall be this number rounded up to the next integer. The actual repair thickness shall be the number of wraps times the individual wrap thickness. For conservatism, the FEA uses the minimum calculated repair thickness.



Figure 5. Predicted failure pressures for Unrepaired Bends with Corrosion Defects of Size D/2 x D/4 x 0.8T.

#### FEA

An example of the FE mesh generated for the assessment is shown in Figure 3. The elastic-plastic stress analysis method, as per Section 5.2.4 ASME VIII Division 2 2010[4], provides an approach to predicting the maximum load carrying capacity of a structure. At this maximum load, called the plastic collapse load, the structure deforms without bound.

For each geometry and repair type assessed, the Riks algorithm, which is available within the general purpose FE code ABAQUS, was used to evaluate the collapse load. In a Riks analysis, the loads applied are increased incrementally until the collapse criterion is met. Collapse is deemed to occur when very small increments in load induce large displacements at a pre-specified location.

The predicted failure pressures were then compared against the required short-term survival test pressure,  $P_{\rm f}$ . Next, the results were reviewed in order to provide guidance on which sizes to use in the full-scale tests.

#### **Unrepaired Corroded Bends**

In each case, failure was predicted to occur in the thinned ligament at the centre of the corrosion patch, as illustrated in Figure 4. The predicted failure pressure in each case (illustrated in Figure 5) is noted to be below that of the required spool test survival pressure. This is expected since the bend has a corrosion patch of 80% depth.

#### **Repaired Bends**

The assessment shows that the repair strengthens the bend and failure is predicted in the pipe instead of the corroded section of the bend, as illustrated in Figure 6. The load displacement curves are shown in Figure 7. The assessments were performed using both the composite repair material properties, one material having a transverse strength that is half the other, though the longitudinal (bend circumferential) strength is similar. The load displacement behaviour and failure pressure predicted in each case are almost identical for both repair ABAQUS. Software

suite for finite element analysis and computer-aided engineering, originally released in 1972.



Figure 6. Example of failure predicted for a repaired bend (900 NB bend first predicts failure at bend/pipe transition).









methods, suggesting that the circumferential yield strength of the repair material is the property dominating the behaviour. Therefore the different materials are not distinguished in the results presented below.

#### Discussion

The truncation of the LPF plots in Figure 7 was determined to be a result of the conservative assumption that the material model used was elastic-perfectly plastic.

For each geometry, the failure pressure for the repaired bend is predicted to be higher than the calculated pressure required for the short-term spool survival test to be classed as successful. This is illustrated in Figure 8, which shows the predicted failure pressure for each model against the factor (D/TSy), compared with the ISO 24817 test pressure P<sub>f</sub>.

This was considered further, and two major factors contribute to the difference between the predicted LPF and the short-term survival test pressure redefining  $P_{f}$ :

- P<sub>f</sub> is based on thin-wall shell theory. This assumption is not valid for use on all the D/T ratios in the FEA.
- P<sub>f</sub> is based on the hoop stress reaching yield strength, whereas the von Mises yield criterion is used in the Riks analysis to determine the LPF.

The pipe will be capped at both ends during the test and therefore will be subject to an axial stress due to internal pressure, in addition to the hoop stress. Calculation of the failure pressure based on von Mises stresses will therefore be more representative.

If both of these factors are taken into account, then the failure pressure (Pmin) is calculated based on the von Mises equivalent stress reaching the SMYS and using thickwall theory for the principal stress components. This compares well with the failure pressures predicted by the FEA. According to a comparison with the FE results for undamaged specimens, the repaired bends are predicted to be as strong as the undamaged components, as required by the spool test survival criteria (see also in Figure 8).

The acceptance criterion under the requirements of the ISO 24817 short-term spool survival test is that the repaired section survives a test pressure equal to  $P_f$ . It is not intended to be a test to failure and it is therefore expected that  $P_f$  be less than the actual failure pressure. However, the intention of the repair is stated as being to "restore the pipe spool to pressure  $P_f$ ", the implication being that the repaired section should be at least as strong as the undamaged section. It may therefore be more representative to use a test pressure that is calculated based on von Mises stresses multiplied by a design factor.

#### **Conclusions and Recommendations**

The main conclusions from the work undertaken to evaluate the applicability of the two composite repair methods for use as temporary repairs are:

- 90° bends with a 1.5 D radius and a corrosion patch located on the bend intrados were selected for the FEA as this geometry is shown to be the most conservative.
- II. The unrepaired bends are all predicted to fail in the

centre of the corrosion patch at a pressure considerably below that required to pass the short-term survival test.

- III. For both repair materials assessed, the pipe away from the repaired section is predicted to fail before the repaired bend. Furthermore, the predicted failure pressure exceeds the pressure required to satisfy the requirements of the short-term survival test for all geometries assessed.
- IV. Full-scale tests can be conducted using any of the geometries and materials assessed in this report. The decision should be made on availability of pipe material and geometry. Approval will ensure that the operator is in a position to react more quickly when pipeline damage is detected, thus minimising the risk of loss of supply.

To verify the applicability of the repair method for longterm repairs on bends, additional work is recommended to cover different loading scenarios, pressure/temperature cycling, debonding, etc. **D** JC



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- [4] ASME/BPVC Section VIII Division 2, "Alternative Rules Rules for Construction of Pressure Vessels", American Society of Mechanical Engineers, July 2010

LPF. Load proportionality factor for the risks analysis.



## **Making Pipes Last Longer**

Composite pipe repair systems are the outpatient approach to asset integrity when a full system renewal is not an option. GL certified Henkel's solution for pressure equipment

Oil and gas assets are subject to corrosion or other types of material erosion that compromise asset integrity, especially in the offshore environment. However, until an entire system is ready for rebuilding or scrapping, its damaged components need to be restored temporarily to ensure safe operation.

Rehabilitation of critical piping systems carrying hazardous substances requires a highly reliable repair system applied by trained professionals. The ISO/TS 24817 standard defines design, installation, testing and inspection criteria for composite repair systems for oil, gas and petrochemical pipework. Based on this standard, German manufacturer Henkel and its cooperation partner, Spanish Grupo NAVEC developed a composite pipe repair system that uses a bandage made of high-strength fibres and epoxy resin to rein-

#### ABSTRACT

- Composite pipe repair systems extend asset lifetime by allowing external spot-repairs
- Henkel had its comprehensive repair system certified by GL to ISO/TS 24817

force weakened pipe sections. The system is designed for high-pressure piping in outdoor environments and has proven to be highly resilient.

Henkel approached GL requesting certification of its composite repair system to ISO/TS 24817. This was essential to ensure that assets repaired using the system would continue to comply with the standards to which they had been certified. The ISO standard also covers training of personnel performing the repairs. Furthermore, Henkel had developed a calculation tool helping asset operators determine the precise composition of the repair system for specific applications as required under ISO/TS 24817. Henkel wanted to have this tool certified as well.

#### **Rare Certification Expertise**

"We searched the market thoroughly for a classification society or certification body with relevant experience in this complex technical field," says Bernd Hammer, Market Development Manager with Henkel. "Due to its good reputation for past certification projects and the professional working style our choice for GL as a partner was clear." Henkel's composite repair system consists of products from Henkel's Loctite range. "GL's role in the certification process included observing and monitoring the procedures and tests as required by the ISO standard," reports Guido Michalek, Deputy Head of Department Materials & Welding with GL. "In addition, GL undertook the pressure and material tests



Pipe Doctors. The Henkel composite repair system features high elongation at break and high impact resistance, and is comparatively easy to apply.



specified by the standard, and verified adherence to the requirements for application training."

ISO/TS 24817 calls for complex calculations to determine the exact composition of the repair laminate for a given application. To be able to offer a standardised repair system, Henkel developed a software tool that simplifies the calculation process for specific applications and eliminates potential errors. GL examined this tool thoroughly for compliance with the ISO standard and was able to recommend enhancements to improve accuracy.

Pressure tests are necessary to determine the maximal permissible pressure for the repaired pipeline. "These short- and long-term tests, which GL organised and supervised, were quite dangerous," explains GL's Michalek. "But they are crucial to demonstrate that repaired pipes will physically survive the pressures calculated in theory." GL also oversaw the material tests carried out to determine the characteristic values

#### Restored. The Henkel composite repair system for pipes.



needed for the calculation tool, as well as the temperature exposure limits and resistance to chemicals. "The ISO standard is very detailed in every respect, which meant our repair system had to stand up to rigorous testing," says Hammer.

#### PARTNERS.

Henkel is global leader in sealing, bonding and surface treatment products. Industrial service company Groupo NAVEC is specialised in maintenance of composite repair in the oil and gas industry.

#### **Training Programme Tops It off**

The ISO standard does not stop there. To make sure composite repair systems are applied properly, ISO/TS 24817 requires companies and technicians carrying out this work to be trained appropriately by the manufacturer of the system. "Henkel has developed a special in-house training programme for repair personnel. GL scrutinised and certified this programme as well," reports Hammer.

Henkel's certified composite repair system relieves operators from having to engineer pro-

prietary repair systems specifically for their assets on a trial-and-error basis. It gives operators peace of mind while ensuring asset integrity and compliance. "Beyond oil, gas and petrochemical pipelines, the Henkel repair system is also suitable for pipes carrying water or other substances," Michalek points out. **GM** 



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# <sup>2</sup>hotos: Henkel AG & Co. KGaA, 2013

# projects in brief

#### PGN SynerGee<sup>™</sup> Gas to Target Network Expansion

Jakarta GL Noble Denton has signed a new agreement to provide its SynerGee<sup>™</sup> Gas network modelling software to Indonesia's largest natural gas transportation and distribution company, Perusahaan Gas Negara (PGN). The contract will see PGN's simulation engineers use SynerGee<sup>™</sup> Gas to simulate and optimise the company's 6,000-kilometre gas pipeline network, which serves millions of customers in Indonesia's domestic, industrial and power plant sectors.

SynerGee<sup>™</sup> Gas uses a powerful transmission and distribution modelling engine that will help PGN develop a more efficient and cost-effective gas pipeline network and plan the long-term supply of natural gas to Indonesia's burgeoning economy. The software offers a state-of-the-art mapping facility, which will allow the company to download pipeline layouts from its geographic information systems (GIS), and simulate potential new gas networks alongside its current infrastructure.



Distribution. SynerGee<sup>™</sup> helps to control PGN's gas pipeline network.

Colin Weir, GL Noble Denton's Senior Vice President for Software Solutions, said: "Indonesia is emerging as one of the fastest growing economies in Asia, resulting in a rapid surge in demand for natural gas across the country. I'm delighted that PGN has chosen GL Noble Denton's SynerGee<sup>™</sup> Gas software to plan for the long-term growth of its network and deliver the highest levels of safety, integrity and performance from its assets."



#### GL Noble Denton New Base for MCI Operations

seattle GL Noble Denton has expanded its Marine Casualty Investigation (MCI) practice in North America by launching operations in Seattle, a primary hub for marine insurance. The new base will allow the company's team of experienced surveyors to meet the growing demand for marine casualty investigations off the west coast of the US and Canada.

GL Noble Denton's MCI practice works with vessel owners, insurers and protection and indemnity (P&I) clubs to determine the cause and extent of machinery damage, fires, collisions, groundings, salvage operations and other marine incidents around the world. The Seattle base is the latest addition to the company's growing network of MCI units, which operate from many key locations including New York, London, Dubai and Singapore.

John Walker, Vice President for GL Noble Denton's North American MCI practice, said: "As Alaskan offshore activity continues to prosper and a burgeoning fishing industry relies on local ports to make repairs, our West Coast clients will benefit from faster incident response times and greater local marine surveying expertise."

hoto:

#### TADC GL Noble Denton Expert recognised for Contribution to ISO Standards

london The International Association of Drilling Contractors (IADC) has presented its Exemplary Service Award to GL Noble Denton's Mike Hoyle for his contribution to new ISO standards for the site-specific assessment of mo- Expert. Mike Hoyle bile offshore units. has been awarded. Mr Hoyle was the



leader of a dedicated International Standards Organization work group, which developed the ISO 19905-1 and ISO 19905-2 standards for assessing the safe operation of mobile offshore units.

The group spent more than 15 years researching and developing ISO 19905-1, which was published in 2012, and ISO 19905-2, which will be published this year, setting an important benchmark for oil and gas industry professionals to follow when undertaking mobile offshore unit site assessments.



#### **XAFE Boost for Safety and Risk Services in Norway**

stavanger GL Noble Denton has expanded its safety and risk services to the Norwegian oil and gas market through a new strategic partnership with the Stavanger-based consultancy XAFE. Under the agreement, experienced local GL Noble Denton and XAFE engineers will deliver leading-edge safety engineering solutions and consultancy to a wide range of clients, supported by GL Noble Denton's worldwide team of senior safety experts.

Both partners will expand their presence in Norway through a broader range of complementary services. GL Noble Denton will bring increased analytical modelling capabilities to the partnership, while XAFE will provide enhanced operational knowledge to GL Noble Denton's North Sea business.

GL Noble Denton's Managing Director for Norway, Tore Lea, said: "Norway's oil and gas industry is entering a period of considerable growth. The partnership with XAFE will allow both companies to respond to the industry's risk mitigation and safetyrelated requirements rapidly, accurately and with the level of service they expect from a world-class technical advisor."

XAFE's Managing Director, Ørjan Stien, added: "Both companies have a clear vision to build upon our presences in Norway, and this new combined approach will provide a peerless solution to the challenges facing North Sea operators by increasing the range of services and the speed at which we are able respond to our clients' needs."

#### GLRC Updated Guideline for the Certification of Offshore Wind Turbines

hamburg GL Renewables Certification (GL RC) has published its new "Guideline for the Certification of Offshore Wind Turbines". This guideline was compiled by GL RC in cooperation with its Wind and Marine Energy Committee. The new guideline provides a fully integrated design and analysis concept for offshore wind turbines. Every aspect of development from blade tip to foundation and power export cable is considered, while also allowing for offshore type and project certification.

"The updated guideline reflects the main developments in the offshore wind industry," explains Andreas Schröter, Managing Director of GL RC. "For example, it considers the increased size of turbines and

mitigation of loads using advanced, intelligent control systems. As a consequence, the examination and testing of control systems are now part of the guideline."

Order your copy at www.gl-group.com/ glrenewables



# dates

### **Conferences & Fairs**

#### MAY

#### 07.05.2013

**IGEM/EUA Gas Industry** 

**Awards Lunch** 

London, UK

#### JUNE

#### 04.06.2013

ALARP – learning from the experience of others London, UK

#### 05.06.2013

Subsea Asia Conference 2013 Kuala Lumpur, Malaysia

#### 11. - 13.06.2013

Floating LNG 2013 London, UK

#### 17. – 19.06.2013

FPSO Training Series London, UK

#### 20. – 21.06.2013

European Dynamic Positioning Conference London, UK

SEPTEMBER

#### 03. - 06.09.2013

Offshore Europe 2013 Aberdeen, UK



Seminar. Discussing upstream operations.

FLNG. Rising to the key

technical challenges.

Lecture. DP: Which

direction?



London Hilton. The event

attracts 600 gas professionals.

Platform. Fields of the future – latest developments.



Field installation. Training course for FPSO professionals.



Topic. Offshore Europe – the next 50 years.



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> Operates a wide range of vessel stability and marine engineering software packages

Applies his skills both at his desk and out on the high seas

Rides a Kawasaki KLR650 trail bike around the Newfoundland wilderness

### Complex marine engineering's a breeze when John is on the case

**John** brings 15 years of naval architectural engineering experience to GL Noble Denton's team of expert technical advisors in St John's, Canada. As one of our Principal Engineers, he's trusted to provide guidance on a multitude of industry challenges from highvalue marine warranties to asset structural design and analysis.

Our clients rely on John when time's tight and there's a window in the weather to get an asset moved and secured. One particular project team knew they had the right man for the job when a semi-submersible that John had meticulously moored emerged unscathed from an encounter with Hurricane Bill.

# John is one of the thousands of dedicated experts our clients count on every day

Learn more about him here www.gl-nobledenton.com/John





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