THE REVOLUTION OF SHALE HYDROCARBONS

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Foreword

The desire to reduce dependence on oil and gas imports has always been a challenge for the US economy. The US ranks second in the world in terms of energy consumption.

The extraction of oil and natural gas from shale deposits has significantly changed the local energy landscape. This has indirectly helped to boost the US economy by lowering the cost of energy and creating millions of jobs.

In recent years, oil and gas companies, both local and international, have embarked on a mission to conquer this new El Dorado by exploiting massive unconventional basins. This has opened up many opportunities for players in the oil and gas industry, including Vallourec.

In line with its strategy to invest in growth sectors, Vallourec quickly identified the potential of shale hydrocarbons in the US. Already having a strong presence in North America, the Group invested in a new dedicated plant and developed a range designed to support its customers in the exploitation of these hydrocarbons.

To succeed in this project, Vallourec has relied on the experience and expertise of its teams. Every day they demonstrate their ability and determination to provide the Group’s customers with the best performing products. Vallourec also offers oil and gas companies a range of services to support their exploration and production activities.

Whilst the recent fall in prices does not as such call into question the long-term potential of the US deposits, it does now encourage the US industry to streamline its operations in order to optimize development costs and increase the productivity of wells. Vallourec is directly contributing to this shift by offering increasingly tailored tubular solutions and creating value for customers.
The revolution of shale hydrocarbons in the US

ABUNDANT RECOVERABLE RESERVES

With the scale and abundance of shale basins throughout the country, the US has enough unconventional hydrocarbon resources to meet America's energy needs for the next generation and beyond.

The technically-exploitable reserves in the US are estimated, according to the US Energy Information Administration (EIA), at 58 billion barrels for oil and 665 trillion cubic feet of gas. Approximately 5% of these reserves have already been exploited.

- Location of the main basins of shale hydrocarbons in the US
- Exponentially growing production over recent years

The four largest deposits, Marcellus, Haynesville, Barnett and Eagle Ford, now account for two-thirds of US shale gas production. The production of shale oil is also particularly concentrated on the three main basins: Eagle Ford, Bakken and Permian. In six years, the United States has become almost self-sufficient in gas and is about to become an LNG exporter. It has also reduced its oil imports by 20%. However, the influx of gas on the market has had a rapid impact on prices. America’s "Henry Hub" went from 13.30 US dollars/MMBtu in July 2008 to 2.42 dollars in August 2009 before stabilizing in a range of 2 to 5 dollars/MMBtu, a level that has prompted operators to gradually transfer their investments to shale oil deposits. In turn, oil prices fell in the second half of 2014 causing a sharp drop in the number of active wells in early 2015. Beyond these cyclical fluctuations, the longer-term potential of these deposits remains intact.

- Main actors

For historical reasons (see the paragraph on hydraulic fracturing), the majority of the oil companies most involved in the production of shale gas and oil are independent producers. Among the main ones are: BHP Billiton, Chesapeake Energy, Devon Energy, Marathon Oil, EOG and Noble Energy. The North American market for shale hydrocarbons also has many smaller producers, including Continental Resources, Elevation Resources, Goodrich Petroleum Matador and Occidental Petroleum. Major international oil companies are also present, including BP, ExxonMobil, Shell and Chevron.
HYDRAULIC FRACTURING

The shale hydrocarbon basins extend across large areas, in a long and thin formation, with low permeability and low porosity. Their exploitation requires stimulation of the deposit and horizontal drilling.

The use of the hydraulic fracturing technique in horizontal wells began in the late 90s when George Mitchell Energy had the idea of injecting water into horizontal wells at high pressure in order to create permeability and thus stimulate the production of gas in the Barnett shale basin in northern Texas. In this way, by exposing more drill string to the reservoir and taking advantage of the fractures made in the rock, the company was able to develop the commercial production of natural gas from rocky basins long considered too compact to be exploited. Other independent US companies quickly began to learn from these techniques and improve on them.

The technique was subsequently refined, in particular by drilling multiple horizontal wells from a single drill pipe.

Hydraulic fracturing increases the permeability of the source rock. A network of fractures is caused by injecting pressurized water. It is enriched with sand or ceramic micro-beads to prevent the fractures from closing and facilitates the circulation of the hydrocarbons to be extracted.

The wells can reach a depth of 4000 meters, with a horizontal section in the range of 1,000 to 2,000 m. The latest technological advances enable the length of horizontal sections to be increased up to 3,000 meters (approx. 10,000 feet), thus limiting the number of wells and optimizing operating conditions.

The improvement of operating conditions from an economic perspective explains the development of shale drilling. On average, the proportion of horizontal drilling rigs (mainly involving shale drilling) has increased in North America from 25% of all active wells in 2008 to approximately 60% in 2014.
THE SPECIFICS OF OIL & UNCONVENTIONAL GAS DRILLING RESULT IN THE USE OF SMALL-DIAMETER TUBES AND SPECIFIC REQUIREMENTS

Horizontal drilling and the hydraulic fracturing technique require tubular products and services with specific characteristics:

- The increase in the number of horizontal drilling wells generates growing use of small-diameter tubes.
- The tubular products used must meet specifications such as: alloys resistant to significant pressures and high torque connections.
- The industrialization of the production needed to make it economically viable requires a high level of service. This includes optimized logistics, the supply of tubes and reliable connections, close to wells.
- Finally, many shale hydrocarbon wells have a rapid depletion rate: the vast majority of production is completed in the first year, which means that new wells must constantly be drilled to maintain the level of production.

FROM SHALE GAS TO OIL

Starting in 2011-2012, due to the fall in gas prices, the North American market has moved from the exploitation of shale gas to that of shale oil. This evolution has led operators to make more suitable technical choices, exploitation of shale oil requiring fewer premium connections and more standard or semi-premium connections.

THE EXPLOITATION OF SHALE HYDROCARBONS HAS GENERATED A PROFOUND TRANSFORMATION OF THE US ENERGY SECTOR

Thanks to the emergence of shale hydrocarbons, the US has not only reduced its energy dependence but has also been able to benefit from gas resources at a price three times lower than those in Europe and five times lower than those in Asia, with improved industrial competitiveness as a direct consequence. This advantage benefits, in particular, the petrochemical sector and sectors deemed energy-intensive (cement, glass and steel) which are back on the path towards growth.

Furthermore, the American oil and gas industry, consisting of numerous independent producers, has benefited from the development of shale hydrocarbons. The producing regions, of which many were affected by the economic downturn, have benefited from the creation of millions of jobs and the activity generated by the sector.
The Youngstown plant, a strategic investment to support the exploitation of shale hydrocarbons in the US

VALLOUREC IN NORTH AMERICA: THE LEADING LOCAL PRODUCER OF PREMIUM TUBULAR SOLUTIONS

A major player in seamless tubes since the acquisition of Vallourec Star in 2002, Vallourec employs approximately 2,700 people in North America, spread over 22 industrial and commercial sites in the US, Canada and Mexico.

From these locations, the Group mainly serves the local needs of the oil and gas market. Vallourec production facilities are located close to unconventional basins. Its integrated facility (steel and pipe mills), one of the most competitive in North America, is located in Ohio, in the heart of the Marcellus and Utica basins.

In the US, Vallourec also has heat treatment and threading units located in strategic areas, complemented by services for threading and assembling accessories. Lastly, skilled technicians and engineers working on site and Vallourec’s network of licensees can assist customers of the Group in the most remote regions.

Map of Vallourec locations in the US
The main products marketed by Vallourec in North America are OCTG (Oil Country Tubular Goods) and the VAM® range of premium threaded connections for oil or gas wells, line pipes and (drill pipes). Most other market segments (excluding oil and gas) are served by Vallourec entities in Europe or Brazil.

In 2014, Vallourec's sales in North America amounted to € 1.7 billion, or 31% of the Group's consolidated revenue.

NEW YOUNGSTOWN PLANT

- A small-diameter plant specifically for shale hydrocarbons

In order to provide customers with the products they need in the best economic conditions, Vallourec opened a second high-end pipe mill on the Vallourec Star site in Youngstown in 2012.

With an initial capacity of 350,000 tons of seamless tubes per year, the new plant is specialized in the manufacturing of small-diameter tubes. It also has heat treatment lines and ultra-fast API threading lines.

The new pipe mill has enhanced the range of existing products and improved the capacity of its Vallourec Star subsidiary, which already included in Youngstown a steel mill with an annual capacity of approximately 700,000 tons of steel and a pipe mill with an annual capacity of around 400,000 tons of tubes.

A new premium threading plant was established in 2015 in Youngstown which complements the supply of the Vallourec Star plant nearby. Production started in May. The site produces VAM® premium connections for oil & gas applications.
- Choosing the Youngstown region

There were many justified reasons for choosing to set up this new plant in Youngstown, including:

- its location near an existing plant enabling cost synergies and efficiency gains
- a skilled and experienced workforce
- the proximity of the Marcellus and Utica shale basins and thus of end customers
- the cooperation of local authorities, the State of Ohio and federal authorities

THE HISTORY OF VALLOUREC IN THE YOUNGSTOWN REGION

The Vallourec Star unit is located on the former Youngstown Sheet & Tube Briar Hill Works site dating back to the early 1900s. Hunt Steel acquired the site in 1980 and installed a steel production plant there as well as an experimental rolling unit. Cargill (North Star Steel) purchased the site in 1985 and installed modern equipment to manufacture tubes. It also bought Universal Tubular Services in Houston (Texas) to install modern heat treatment units. During the years that followed, North Star Steel made many improvements to the equipment and has built an excellent reputation for the quality of its products and customer service.

In July 2002, Vallourec acquired North Star Steel's tubes operations, including the Youngstown and Houston facilities. Under the control of Vallourec, Vallourec Star increased its capacity and improved its performance in terms of safety and continuous improvement. Vallourec Star continues its proud history of respect for the environment, production quality and customer service excellence.

- Revitalization of the labor market

It was important for Vallourec to contribute to the economic recovery of an industrial area where the oil and gas sector offers genuine prospects.

The new pipe mill played a significant role in revitalizing Youngstown's urban area. According to the city's Chamber of Commerce, Vallourec's investment in the new seamless tubes plant in Youngstown had an economic impact on the region of more than a billion dollars and created more than 1,800 temporary full-time jobs during its construction.
A FULLY INTEGRATED PRODUCTION FACILITY

- One of the largest investments made by the Group

The new high-end plant for seamless steel tubes in Youngstown (Ohio) is one of the largest investments the Group has ever made ($1.05 billion). It is also one of the most significant investments in the energy sector in the US in recent years.

- The new plant in detail

The size of the new plant is considerable: one kilometer long, 402 meters wide and 34 meters tall, or the equivalent of a 10-story building. The complete structure is 93,000 m², a surface area of almost 9 hectares.

With the steel mill and Vallourec Star’s other pipe mill specifically for producing larger-diameter seamless tubes, altogether it is the first fully-integrated site in the US combining:

- steel manufacturing,
- tube rolling,
- heat treatment,
- threading,
- inspection,
- storage,
- logistics
- and value-added services.
The combined capacity of the two adjacent rolling mills enables Vallourec to locally produce seamless tubes of 2 and 3/8 inches with a 10 and 3/4 inch diameter, given that each of the two units can produce tubes from 5 to 7 inches. With regard to the most popular size range on the North American market, this symbiosis affords greater flexibility to be able to respond to customer needs.
**PRESS KIT**
**SHALE HYDROCARBONS**
**JUNE 2015**

Vallourec, a full range of tubular products and services specific to shale oil

**THE VAM® TEST CENTER IN HOUSTON**

Created in collaboration with the Japanese groups, Sumitomo Corporation and NSSMC (Nippon Steel & Sumitomo Metal Corporation, ex-Sumitomo Metal Industries), this center focuses an important part of the Group’s research efforts in the area of metal-to-metal threading and sealing, which stands at the heart of VAM® joint technology.

The Group has doubled its capacity there to test connections in the US in order to respond to the growing demand of customers to certify existing product ranges for new standards related to the most extreme well conditions.

At these facilities, VAM® connections undergo the harshest full-scale tests: make and break, simulation of combined loads (tension and compression), bending, high temperatures, and resistance to fatigue.

Vallourec has also developed a testing protocol with its customers specifically adapted to shale gas application which makes it possible to reproduce on test benches what connections will live specifically in the wells during the different phases: installation of the column (fatigue induced by rotation), fracturing (fatigue induced by fracturing cycles) and production (maintaining the integrity of the connection). The adaptation of this test protocol ensures the integrity of wells.
DRILL ACCESSORIES AND PIPES

The Group has a portfolio of innovative products designed for drilling horizontal wells:

- high-torque connections for drill pipes, including VAM® Express, with excellent operational reliability and a very low repair rate

- an ultra-resistant steel grade (up to 165 ksi) for highly deviated drilling and a wide range of steel grades and tube thicknesses to cope with the specific constraints encountered during drilling operations in shale deposits

- a new generation of 4''4'' shale drill pipes to optimize drilling performance, including accelerating the penetration rate of the tool and improving the guidance of the pipe. In addition, as it is resistant to buckling, it can drill vertically and horizontally, whereas before this would require different pipes. Finally, this drill pipe can reduce costs and extend the lifetime of the operation tubes

- the HydroClean® product range for the optimal cleaning of wells.

In addition to the product portfolio, Vallourec Drilling develops tube inspection and maintenance services to its North American customers in order to increase the lifetime of the tubes.
STEEL GRADES AND CONNECTIONS: A SIGNIFICANT INNOVATION EFFORT TO ADAPT TO MARKET NEEDS

Vallourec has developed two specifically tailored steel grades for the US market: the P110EC grade (Enhanced Collapse) for requirements in terms of traction and pressure, and the P110MS grade (Mild Sour) for requirements in terms of H2S corrosion resistance. The P110EC grade was met with great success, becoming by far the most widely sold grade in the US by Vallourec.

The threaded and coupled connections, flush and semi-flush, are the market benchmarks. Discussions amongst the Vallourec teams and operators since 2010 revealed an immediate need for premium connections for wells with medium-length (2,000 to 5,000 feet) lateral sections and anticipated a future requirement: a connection adapted to longer lateral sections (up to 10,000 feet), thereby maximizing production per well.

These grades and connections perfectly meet the needs of customers, enabling them to optimize their investments without compromising performance or quality.

_VAM® SG_

*Advanced semi-flush shale gas*

VAM® SG, a connection with high tensile strength and high torque, was developed in a very short time to meet immediate needs.

_VAM® EDGE SF_

*Extreme semi-flush shale gas cylinders*

VAM® EDGE SF was launched and certified in 2013. This new high-end connection has technical features such as higher tensile strength and high torque, and a gas tightness which is compliant with even the most stringent ISO standards. It’s very first order was recorded in late 2013 in the US.
Other connections specifically for shale hydrocarbons:

- **VAM**™ **21 HT™**
  Advanced premium T&C high torque

- **VAM**™ **TOP HT™**
  High torque standard

- **DWC/C™**
  Semi premium reference

- **VAM**™ **SFC™**
  Standard premium shale gas

Overview of the entire range
SEAMLESS STEEL TUBES

Thanks to its two additional pipe mills, Vallourec offers a wide range of products, with seamless tubes of 2 and 3/8 inches with a 10 and 3/4 inch diameter, given that each of the two units can produce tubes from 5 to 7 inches. With regard to the most popular size range on the North American market, this symbiosis affords greater flexibility to be able to respond to customer needs.

AN EXCELLENT LEVEL OF SERVICE

Vallourec also offers oil companies a range of services to support their exploration and production activities.

The aim is to ensure the proper implementation of Vallourec products, essential for ensuring well integrity. This offer includes checking the make-up of VAM® connections on site, inspecting connections at the customer’s yard and preparing equipment on land prior to delivering it to work sites. These services use around forty site engineers in the US within the VAM USA Field Service subsidiary.
FIVE ASSISTANCE OFFICES ON SITE

In 2013, Vallourec expanded its US service network with the opening of a fifth on-site assistance office, located in Pittsburgh, Pennsylvania. It provides services specifically for the preparation of platforms, including assistance to operators in using the VAM® connections and tubes in northeastern United States.

PARTNERSHIPS WITH DISTRIBUTORS

Vallourec is uniquely qualified to support oil and gas companies in shale drilling operations in North America.

In particular, Vallourec has developed a long-term partnership strategy with the major distributors in North America.

This strategy has enabled Vallourec to gain the trust of the main exploration and production companies in North America which have chosen to entrust the Group and its distributors with managing their supply of OCTG products and accessories, as well as the delivery of services.
Exportable expertise

NEW DISCOVERIES IN THE WORLD

The reserves of shale hydrocarbons are worldwide. China comes first in terms of gas reserves with 1115 trillion cubic feet, or two to three times more than the United States. After Argentina and Algeria, with 802 and 707 trillion cubic meters of recoverable gas reserves respectively, are the US and Canada in fourth and fifth position.

With regard to oil shale reserves, in the lead is Russia with 75 billion barrels, followed by the US and China with 58 and 32 billion barrels respectively.

PANORAMA OF OTHER REGIONS CONCERNED

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1 Source: US Energy Information Administration (EIA)
VALLOUREC PREPARED TO SUPPORT MARKET PLAYERS IN OTHER REGIONS OF THE WORLD

Today, only four countries outside the US exploit and market shale hydrocarbons: China, Canada, Argentina, and to a lesser extent Poland. With unconventional hydrocarbons constituting a major potential source for renewing energy resources, other countries are planning to exploit shale hydrocarbons in the short term on their territory, including Algeria, South Africa, Australia and the United Kingdom.

With the expertise it applied in the US in the field of shale hydrocarbons, Vallourec is ready to assist oil companies in other parts of the world by implementing innovative solutions close to operations.

The global solutions developed by Vallourec optimize the profitability of unconventional hydrocarbons development projects, while ensuring well integrity, operational safety and the environment.
Valourec at a glance

The world leader in premium tubular solutions primarily serving the energy markets (oil and gas, power generation); Valourec also provides its expertise to the industry sector.

With more than 23,000 employees, sales of €5.7 billion in 2014, 81% outside Europe, integrated manufacturing facilities, advanced R&D and present in more than 20 countries, Valourec offers innovative global solutions to meet the energy challenges of the 21st century.

Specialized in the most complex applications, Valourec relies on its six research and development centers in the world and more than 500 engineers and technicians to maintain its technological leadership and meet its customers’ new demands. Control over the entire production chain, from the production of the steel to the finishing, guarantees the excellence of our products.

For the oil and gas market, the Group designs and develops a complete line of products, including seamless tubes and premium connections, designed for drilling operations, line pipes and well equipment in the most extreme conditions: high pressure, high temperature, corrosive environments for deviated wells or wells deep offshore, for example.

On the power generation market, Valourec offers a range of premium tubes resistant to temperatures and higher pressures that allow electricity operators to meet the challenges of energy efficiency and controlling the CO₂ emissions of power plants.

Valourec also offers a wide range of tubes for petrochemical installations (refineries), as well as tubular products for mechanical engineering applications, the automotive industry, construction (stadiums, other complex buildings and structures) as well as various other sectors.

To support the growth in energy markets, Valourec is pursuing an ambitious local development strategy with new locations in Brazil, the US, the Middle East and China, in order to bring solutions closer to its customers and improve its competitiveness.
The construction stages of the Youngstown plant

CONSTRUCTION IN RECORD TIME

The decision was made to invest in the construction of a new pipe mill in February 2010. Tenders were launched and suppliers were selected immediately.

Work officially started in the summer of 2010

Following various ceremonies and celebrations, the excavation operations and site preparation began. For the foundations of the building, over 9,000 steel columns were driven into the ground, which constitutes 13,000 tons of steel or the equivalent of two Eiffel Towers.

A HIGHLIGHT: A VISIT FROM PRESIDENT OBAMA

In May 2010, Vallourec's teams had the honor of receiving a visit from President Barack Obama, a mark of recognition of the Group's ambition to become a major player in the oil and gas industry in the US. During this visit, President Obama confirmed his commitment to this region and the importance he placed on the Vallourec project, one of the largest investment programs in the US.

Presented by the US President as an example ("Vallourec is a venture for both US manufacturing and of the region"), the new plant in Youngstown is not only a cornerstone of Vallourec's long-term growth strategy, but also strengthens the Group's position among the leading producers of seamless tubes in the US.

More than 111,000 m³ of earth was extracted. The columns were then prepared to receive stringers; reinforcing bars were first installed, the forms were put in place and the stringers cast. During this process, more than 17,500 m³ of concrete was poured, and the underground infrastructures were installed.
While the site preparation progressed, the 50,000 pieces making up the rolling mill arrived almost daily from the Italian company, Danieli, and were stored in a nearby warehouse before being installed in the future plant.

The skeleton of the new pipe mill was made using Vallourec’s Preon® system, consisting of joists and other structural components produced by Vallourec in Germany. This Preon® structure is the first of its kind to be used in the US.

To complete the project, the raw elements of the Preon® structure were transported by boat to the US port of Houston, then by rail to the Ambridge manufacturing plant in Pennsylvania. Once production was complete, the components were delivered and assembled on the Youngstown site.

Despite the scale of the project, the building structure was completed in autumn 2011. The drilling of the first steel billet took place in June 2012 and continuous production was first achieved in October 2012. The pipe mill gradually ramped up in 2013.

**CHOOSING THE MOST ENVIRONMENTALLY-FRIENDLY TECHNOLOGIES FROM THE START**

For the construction of this new high-end pipe mill, Vallourec wanted to implement the most eco-environmental technologies used in the sector. From the beginning, special attention was paid to selecting the most energy-efficient and environmentally-friendly equipment (burners, closed-circuit air coolers, air compressors, etc.). It should also be noted that the plant is built on a renovated former industrial site and enjoys a huge green belt.

**2014 AWARD FOR ENVIRONMENTAL MANAGEMENT AND RECYCLING FROM THE STEEL MANUFACTURERS ASSOCIATION**

Vallourec Star was awarded the environmental management and recycling award by the Steel Manufacturers Association in 2014. The company was recognized for the good results of its new ultramodern water treatment facility, which implements all of the best practices recommended by the SMA.

Vallourec Star’s treatment station produces high quality water adapted to the needs of production and the finishing of tubes. The treatment facilities are fully automated; they recover and recirculate more than 99% of the water of a consistent quality, comparable to drinking water. Furthermore, 97% of the waste from production is recycled by the site’s waste treatment plant.
In addition to responsible behavior in the area of sustainable development, safety is a priority for Vallourec. As part of Vallourec's CAPTEN+SAFE program, safety audits are regularly carried out and the construction of Youngstown's new seamless tube plant was recognized "best in class" for its practices related to safety conditions.