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Innovation: strategy and aims

Extracting oil and gas from fields under increasingly complex conditions, developing new drilling techniques, improving the energy efficiency of power plants, and complying with increasingly stringent environmental constraints: these are the main technological challenges that Vallourec has to address to support its customers. By always placing innovation at the heart of its strategy, Vallourec is able to meet customer expectations and remain a supplier of premium solutions.

Innovating in profitable market segments

Vallourec’s innovation strategy is based on a long-term view that considers the growth potential of the energy sector and the increasingly complex conditions of extraction. R&D also focuses on the Group’s other areas of activity such as petrochemicals and industrial applications used by the mechanical engineering and construction sectors.

Anticipating technological challenges

In the oil and gas sector, the technological challenges faced by the Group’s customers (deep sea, ‘high pressure and high temperature’ deposits, deviated wells, salt domes, etc.) require more resistant types of steel and improved threaded connections to be developed.

For offshore line pipes, also exposed to extreme mechanical constraints in these increasingly challenging operating conditions, Vallourec develops coordinated welding and coating (pre-assembly) services. In 2010, the Group acquired Serimax, world leader in line pipe welding for deepwater offshore projects, whose new technologies and solutions enable welding in the most extreme conditions, including offshore.

In the power generation sector, the need for thermal power plants to improve their energy performance and the call for lower CO₂ emissions have led to the development of new alloy steel grades and new heat treatment techniques. The Group also innovates to anticipate future drilling and energy production conditions.

Supporting our customers while maintaining a continuous line of communication

From the creation of the VAM® connection in 1965 to the development of VAM® 21, the latest connection which meets operators’ most stringent requirements, innovation has been behind several advances which have enabled Vallourec’s customers to access previously untapped resources or to improve the performance of their installations. These innovations are attributable to the close working relationship that the Group enjoys with its customers.

Meeting the need for reliability and safety while minimizing our impact on the environment

The appearance of increasingly stringent requirements regarding the reliability and safety of installations and tougher regulations testifies to the importance of innovation. In line with its premium positioning, the Group’s goal is to respond to the far-reaching and rapid changes in the needs of its customers by offering them suitable solutions which are safe, reliable and respectful of the environment. In order to meet this goal, Vallourec has considerably strengthened its R&D capabilities over the past few years.
Extending our lead in processes and innovating in services

Innovation is not limited to developing new premium products. It also involves improving manufacturing processes (particularly full-scale testing capacities and non-destructive trials). Innovation also comprises the creation of new services so that customers can get the most out of our products.

In 2012, the Group filed 16 new patents. Overall, there has been a significant increase in the average number of new patents that have been filed every year over the past six years. Furthermore, 450 studies and projects are currently in progress.
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State-of-the-art tools

- A mini-plant for testing tube rolling processes

Opened in December 2010, 'Vallourec Research Center Technology Riesa' was established to optimize the tube manufacturing processes and increase our expertise of the technologies deployed across the Group’s plants. Vallourec’s Research Center in Riesa is a hot-rolling laboratory with the world’s most modern equipment. This equipment allows Vallourec to accelerate the development of process innovations regarding both methodology and plant equipment by carrying out tests without having to stop a production line or risk any damage to machinery. With this versatile equipment which is at the cutting edge of technology, for rolling as well as forging, Vallourec’s Research Center in Riesa pushes back the technological boundaries of steel and alloy rolling in the Group and accelerates the development of new products for complex applications such as pre-salt (more details on page 19).

- Full-scale testing capacities

Vallourec has three testing facilities around the world to carry out full-scale tests on the behavior of VAM® joints under the wells’ most demanding operating conditions. At these facilities, VAM® connections undergo the harshest full-scale tests: make and break, simulation of combined loads (tension or compression), bending, high temperatures, and fatigue life. Following an increase in demand from its customers, Vallourec recently doubled the testing capacity of the Vallourec Research Center Connections in Houston.

- A research center with Petrobras

Petrobras, Brazil’s national oil company, is one of Vallourec’s long-standing partners. The two groups are already working in close cooperation on the development of pre-salt fields off the coast of Brazil: 80% of the products that are currently being delivered to Petrobras to exploit these deposits did not exist in 2009.

The creation of the Vallourec Competence Center in Rio de Janeiro, in the industrial park of the University of Rio de Janeiro, close to CENPES, Petrobras’ research center, represents a new stage in the relationship between the two groups. Inaugurated on July 9, 2013, it will employ 27 people including Master and PhD professionals.
Key themes of the innovation policy

Vallourec’s innovation policy aims to satisfy its customers by offering them products and services which help raise the performance of their operations and installations while minimizing their impact on the environment.

Whether in the area of deepwater exploration or the exploitation of shale gas deposits, safety and protection of the environment are of particular importance in the oil and gas sector. The Macondo disaster in the Gulf of Mexico has led to a tightening of regulations and even more stringent requirements from oil companies regarding the safety and reliability of installations. Vallourec develops solutions that meet these requirements.

Developing products that meet customers' current and future expectations

Oil and gas

In the oil and gas sector, most projects are located either in the North Sea, Brazil (pre-salt fields), the United States (shale hydrocarbons), the Gulf of Mexico, Alaska, West Africa, Malaysia or the Middle East.

The deposits which are currently available are becoming increasingly difficult to exploit. Oil companies are faced with extreme conditions: deepwater offshore, salt domes, shale plays, extended-reach drilling, Arctic environment, etc., all of which represent technological challenges which require increasingly state-of-the-art solutions.

Premium solutions for all applications

To accompany its customers and anticipate their needs, Vallourec develops tubes and connections which meet the specific constraints of operations that take place under extreme conditions: compression, tension, bending, corrosion, acid gases, temperature and pressure, fatigue resistance, etc.
A growing market for premium products:
- Twofold increase in global demand for premium OCTG products between 2005 and 2015
- Rise in the share of premium products in the global market from 22% in 2005 to 30% in 2015.
(Source: Vallourec forecast)

Innovative products to tackle technological challenges

Our research teams work closely with customers to develop tailor-made solutions and adapt the Group's tubes and joints to increasingly complex technological constraints. Vallourec responds to these challenges by developing products that are capable of withstanding corrosive environments, extreme mechanical constraints and high pressure and temperature levels over a long period.

With 'easy oil' drawing to an end, the development of innovative premium products is essential for the Group to meet the needs of its customers in the oil and gas sector.

VAM® 21, the connection as strong as with the tube for the most demanding applications

The next-generation premium threaded connection, VAM® 21, is already on sale and enjoying great success in the growing markets of the North Sea, Brazil, Nigeria and, more recently, the Middle East. This innovative connection, which offers exceptional resistance to compression, is the only one whose performance is similar to that of the parent tube, as required under ISO technical specification, 13679 FDIS-2011 CAL IV, and demanded by oil customers for the most demanding applications, particularly in deepwater offshore.

Cleanwell, the family of grease-free coating products for the difficult conditions of the North Sea

There is strong demand for products that are environmentally-friendly and facilitate the installation of tubes, particularly in the North Sea.

Cleanwell Dry®, the latest edition to the Cleanwell range, is a lubricant ('dry' coating) developed for threaded connections which avoids the use of grease (dope) and effectively protects tubes against jamming and corrosion, including under extreme low temperature conditions.

VAM SG dedicated to the exploitation of shale hydrocarbons

For new shale hydrocarbon deposits, a threaded connection, VAM SG, was designed in record time with customers to meet their very specific performance criteria. The exploitation of shale hydrocarbons requires the use of wells with a long horizontal section (measuring between 1,500 and 3,000 meters) and a very high pressure hydraulic system to fracture the rock, which places great strain on the connection.

VAM® HTF for deviated extended-reach wells

For the most difficult situations, and for deviated wells with long horizontal sections in particular, a high performance connection, VAM® HTF (High Torque Flush), has been successfully developed and launched on to the market. This extremely compact premium threaded connection combines a metal-to-metal seal and self-locking variable threading, enabling it to withstand very high torque forces.
Steel grades especially designed for corrosive environments and HP/HT applications

The development of steel grades which withstand H₂S (hydrogen sulphide) corrosion is also vital for the oil and gas industry. Especially intended for the corrosive environment of deepwater offshore applications, the range of Sour Service grades has been extended with VM125SS, a grade specifically created for 'high pressure and high temperature' (HP/HT) applications. In 2011, Vallourec teams delivered tailor-made tubes, developed using these innovations, for the exploration of deposits in the North Sea and Asia Pacific.

VAM® RISER for deepwater applications

Vallourec is a leader on the market for threaded connections used for riser applications. As the threaded tubes that link floating platforms to the seabed have to withstand exceptional levels of fatigue, cutting-edge technology and specific approval tests were developed. Several projects are currently taking place in Brazil, Australia, the Gulf of Mexico and Indonesia.

Several drill pipe innovations

Since it was created, VAM Drilling, Vallourec's subsidiary that specializes in drill pipes, has become in the space of five years a technological leader by developing, in particular:

- high-torque and high-performance drill pipe connections (VAM® Express, VAM® EIS and VAM® CDS) which offer excellent operational reliability and boast a very low repair rate (as these connections are reusable);
- unprecedented high-grade steel (165 ksi) for highly deviated drilling and a wide range of steels for all applications, including wells in highly corrosive environments;
- a new generation of drill pipes under the HydroClean® brand which accelerate the removal of drill cuttings and thereby improve drilling performance.

New solutions for umbilicals

Umbilicals are lines made up of tubes, cables, and optic fibers which serve to connect installations on the seabed to their control station on the sea's surface for the transport of liquids and energy.

A newcomer to this market, Vallourec has developed an innovative premium stainless steel welded tube manufacturing system. The know-how acquired by the Group through its subsidiary, Valtimet, in the production of long welded tubes has enabled the Group to reduce the number of orbital welding points for these components.

Following completion of several crucial steps at the end of 2012 in certifying its product range and plant in Venarey-Les Laumes, France, the new products are now ready to be manufactured.

The umbilicals assembled with Vallourec tubes are both lighter in weight and provide greater resistance to fatigue, which is substantial at sea.
Power generation

In the power generation sector, research is now focusing on the next generation of coal-fired power plants known as 'advanced supercritical' plants, whose energy efficiency exceeds 50%. To achieve such an efficiency rating, these plants require stainless steel tubes that are able to withstand corrosion as well as very high temperature (up to 700°C) and pressure (350 bars) levels. Work on the performance of different types of stainless steel is carried out with Vallourec’s Spanish partner Tubacex. Vallourec's ‘Boiler & Line Pipe Competence Center’ in Düsseldorf, a specialized research center, is also working on new challenges such as the tubes' resistance to thermal cycles of power plants that operate to support renewable energy sources.

Solutions for future power plants

For the construction of thermal and nuclear power plants, Vallourec is a world leader for tubes with different diameters and alloy steel grades used by the power generation sector. New-generation power plants, which pollute less, require tubes that can withstand very high pressure and temperature levels for very long periods.
12% chromium steel

The Group works on the development of stainless steel tubes in partnership with the Spanish Tubacex and thereby completes its offer for the world’s most efficient power plants. Vallourec’s patented VM12-SHC, 12% chromium steel, was designed to be used at high temperature levels and now forms part of the new generation of power plants. In 2011, Siemens chose the Group’s new VM12-SHC steel tubes for its combined cycle gas power plant in Irsching, Germany, the first to achieve an energy efficiency rating of 62%. Vallourec’s VM12-SHC steel tubes were selected in 2012 for the new Lausward combined gas cycle power plant being built by Siemens in Düsseldorf. With a capacity approaching 600-megawatt and a yield of 61%, the new unit is expected to set a new world efficiency record when it is delivered in 2016.

Petrochemicals: welded stainless steel and titanium tubes for gas liquefaction and desalination

In petrochemicals, the Group focuses particularly on the development of welded stainless steel and titanium tube technology that can withstand the low temperature levels that characterize the gas liquefaction process. Welded titanium tubes are also made for the seawater desalination market.

Mechanicals and construction

In the mechanical engineering and construction markets, the search for performance requires new ranges of fine grain steel that further increase the strength of tubes which are subject to high levels of tension to be developed. High-strength hollow-section tubes developed by the Group also allow a substantial reduction in weight while guaranteeing high levels of resistance.

Tubular solutions for metal structures

The deployment of light solutions for metal structures is a major area of development. Pioneering tubular solutions have been developed for industrial and commercial buildings, especially in Germany and Brazil. The Group’s patented tubular roof frame system (Preon®), which considerably increases the span of a roof, is now being used in several other applications: bridges, stadiums, airports, etc.
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Vallourec contributes to the renovation and construction of Brazil’s main football stadiums for the 2014 FIFA World Cup™

Vallourec is providing structural seamless tubes for the renovation and construction of Brazilian stadiums, prior to the FIFA Confederations Cup Brazil 2013 and the 2014 FIFA World Cup™. A total of 10,500 tons of tubes were supplied by Vallourec’s Brazilian mill in Belo Horizonte to equip nine stadiums. Thanks to their high performance which allows the construction of unsupported wide-span structures, Vallourec tubes are used to build stadium roofs and related equipment.

Span and pre-assembly calculation software

Vallourec applies the same approach to the construction sector. The Group offers, for example, software programs which optimize the use of structural tubes. These tools facilitate the pre-dimensioning of structures and speed up the design and construction stages by allowing building structures to be pre-assembled. The duration of the building works can thereby be cut by a third.

Fine grain steel for lifting equipment

In the industry and mechanical engineering markets, the new ranges of fine grain steel developed by the Group further increase the strength of tubes which are subject to high levels of tension. These new heat-treated low-carbon steel grades improve the resistance and elasticity of structures while making them lighter. This dual advantage in terms of resistance and weight meets the requirements of many industrial applications and is particularly suited to the specific constraints of the hydraulic systems of large lifting equipment such as gigantic cranes that are capable of carrying loads of several thousand metric tons.

Perfecting manufacturing processes

The Group constantly strives to improve its manufacturing processes at each step in the production chain, launching initiatives concerning charcoal-making for the cast iron process in Brazil, the optimization of steel mill capacities, hot forming processes, heat treatments, threading solutions and non-destructive examinations.
**Hot-rolling processes**

Hot-process steel tube-making is a form of technology that is vital for the Group and constantly improved through innovation. For example, Premium Forged Pipes (PFP®) is a new process that was developed for the manufacture of thick wall, large-diameter tubes intended specifically for the mechanical engineering and power generation sectors (see Focus below).

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**Premium Forged Pipes (PFP): a unique process**

Aulnoye pipe mill (France) implemented in 2011 a manufacturing process not found anywhere else in the world: the combination of a forge and hot piercing technology, which makes Vallourec's seamless tubes unique. This new process enables the plant to produce tubes in a wider range of sizes, both in diameter and thickness, and work with steel with a higher alloy content, all of which means that the Aulnoye plant is destined to produce premium tubes. The process, which makes it easier to change the machinery in use, is also very flexible, which favors the provision of tailor-made products in small production runs.

Thanks to this technology and its extended deployment in 2011, Aulnoye pipe mill has refocused its business on small production runs with high added value for the mechanical engineering, power generation, and petrochemical markets.

Following the successful implementation of this new technology at the Aulnoye pipe mill, a new forge was commissioned at Vallourec’s Changzhou plant in China in 2012. This forge expands the six-year-old plant’s capacities to include locally produced large diameter seamless tubes, specially designed to meet the needs of new generation supercritical and ultra-supercritical power plants.

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**The strategic importance of finishing processes**

The Group has also allocated resources to the development of threading and heat treatment capacities which have enabled it to extend its range of premium products in the world's main regions and operate as closely as possible to its customers' installations.

At the beginning of 2013, Vallourec announced the full qualification of a new finishing plant in Saudi Arabia dedicated to the heat treatment and threading for the full range of VAM® premium connections, with an annual capacity of 100,000 tons. It will mainly supply Saudi Aramco, the Kingdom's national oil company, along with other regional operators.
In-depth developments are applied to the Group’s non-destructive examinations to ensure its products remain highly reliable. Innovations in this area play an important role in helping the Group stand out from its competitors.

The charcoal process in Brazil

Demand for steel and sustainable development requirements have boosted interest in the cast iron and charcoal process in Brazil, which Vallourec has been continuously improving and which combines respect for the environment and competitiveness. The scientific selection of trees, the improvement of forest nutrition programs and the industrialization of the continuous charcoal-making process constitute the key elements of this process.

- **Making the forest more productive**
  In Brazil, Vallourec manages eucalyptus plantations to produce charcoal for the blast furnaces of the country's steel mills. A pioneer in the management of this type of plantation, the Group has an R&D team with over 40 employees dedicated specifically to this activity. Research work, which chiefly focuses on improving soil fertility, the trees' genetic stock and disease and pest treatments, has increased the productivity of the plantations by a factor of seven in 30 years.

- **Carboval: a new way forward**
  The Group is developing new processes to lower the greenhouse gas emissions of its charcoal-making furnaces in Brazil. Carboval is an innovative state-of-the-art carbonization process which improves efficiency and produces extremely pure charcoal with a particularly high heating value. Furthermore, the process captures the energy of the gases emitted during carbonization and channels this energy back into the process, thereby making it self-sufficient in terms of electricity and avoiding the release of harmful emissions into the environment.

**Alloy steel production**

Used for the most demanding applications, 9% and 13% chromium steels are a basis for the Group's high-tech solutions. A great deal of research has gone into the development and continuous casting of these steels, providing the Group with high capacity and high-tech steel mills, which, in turn, strengthen the independence of the Group with regards to the supply of premium steel.
Also innovating in services

**Oil and gas: doubling of full-scale testing capacity**

In April 2011, VAM USA opened the doors of its new integrated R&D center in Houston, Texas. The outcome of a cooperation agreement with Sumitomo Corporation and NSSMC (Nippon Steel & Sumitomo Metal Corporation, ex-Sumitomo Metal Industries), this center contains a large share 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. Later the Group doubled the testing capacity of this center to respond to customers’ increased demand to qualify existing product lines to the new standards for extreme well conditions. At these facilities, VAM® connections undergo the harshest full-scale tests: make and break, simulation of combined loads (tension or compression), bending, high temperatures, and fatigue life. In total, Vallourec has three testing facilities around the world to carry out full-scale tests on the behavior of VAM® connections under the wells' most demanding operating conditions.

**Oil and gas: VAM Global Solutions**

The Group has stepped up its commitment to offering customers a portfolio of solutions which encompasses all of the Group's various areas of expertise. The VAM Global Solutions premium offer, whose roll-out was accelerated over the past few months, illustrates this commitment.

Developed for the oil and gas sector, it combines a set of products and services which provide a tailor-made answer which is specific to all of the oil companies' needs, throughout the value chain, from the manufacture of the tubes and connections in the plant to their installation at the well head.
The most recent services that form part of this offer include assistance with well designs, which involves helping the customer ascertain the dimensions of its casing and tubing products and select the appropriate steel grades and the connections which are best suited to the drilling rig's constraints. It is also worth noting that the Group's Field Service has been broadened with teams now tasked with monitoring the connection of tubes on site.

This global solutions process for the oil and gas sector is gradually being extended to other Group activities.

**Line pipe: welding and coating solutions**

Vallourec now has a comprehensive range of solutions for the offshore construction market, in which project management is key to a company's success. For example, coordinated coating and welding (pre-assembly) services are now available alongside the supply of tubes for offshore line pipe projects, thanks to the expertise and know-how of Serimax (see Focus below).

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**Serimax, world leader in welding solutions**

A specialist in line pipe welding solutions, especially for deepwater offshore projects, Serimax was acquired by Vallourec in 2010. This company develops new technologies and solutions that enable the Group to improve its range of services for customers. Saturnax 09 is the latest welding device developed by Serimax. As a polyvalent system, it can handle all kinds of welding processes.

Another key feature of this new automatic welding system is its flexibility in terms of welding shape and position. It can weld any type of edge and attach two elements in any welding position, which generates time savings.
Organization of R&D and innovation culture

In order to quickly design tailor-made high-tech solutions which are completely reliable, Vallourec has significantly strengthened its technical and human resources. The Group has put in place an organizational structure that also favors the development of an innovation culture, an essential component of the achievements made over the past few years.

A single department: TRDI

Vallourec decided to bring all of its research capacities into a single department: the Technology, R&D, and Innovation (TRDI) department. In addition to coordinating Vallourec’s R&D centers, this department facilitates the sharing of best practice and knowledge within the Group.

Its role

- Coordination of R&D and Technology to foster the emergence of innovative solutions and technologies
- Development and promotion of best practice and of the best technologies available
- Implementation of an innovation culture through an internal Knowledge Management system

Its resources

- 500 engineers and technicians
  
  TRDI has 500 engineers and technicians spread throughout the world on production sites and in the Group’s six research centers.

- Ever-increasing funding
  
  Spending on R&D stood at €93 million in 2012, a rise of 19% on 2011. Over a period of six years, the Group has invested €448 million in research and development.
A strong innovation culture

To favor and instill an innovation culture within the Group, TRDI is working on strengthening the sharing of knowledge, project team operations, and networks of expertise.

Process communities

Introduced several years ago, process communities are multidisciplinary teams which bring together the Group’s main areas of expertise, including: steel production, hot rolling, heat treatment, threading and non-destructive examinations. By sharing best practice thanks to internal and external benchmarks, they create common indicators for all of the plants and analyze the overall performance of equipment.

The ‘Expert Career’ program

To support careers in innovation and R&D, Vallourec has established an 'Expert Career' program in order to offer new career opportunities to Group engineers working in Technology and R&D. Now, these engineers can choose, at each stage of their career, between management responsibilities and responsibilities for technical expertise equivalent status and pay. To facilitate this, parallels between the two career paths have been introduced by the Group's Human Resources Department.

Excellence Awards

To encourage initiatives within the Group, two Innovation Excellence Awards (process and product) are presented each year (see Focus below).

**FOCUS**

The latest Vallourec Innovation Excellence Awards presented to American and French teams:

- For the Process category, the award was presented by Philippe Crouzet, Chairman of the Management Board in December 2012 to Valti in recognition of the creation of the Group’s first quench and tempering line by induction, which allows for a greater flexibility of heat treatment operations and offers shorter delivery times.

- For the Product category, the award was presented by Flavio Azevedo, Group Innovation Manager in November 2012 to Vallourec Oil & Gas France, Vallourec Research Center France and Vallourec Research Center Connections (Aulnoye) and VAM USA (Houston) in recognition of the development of VAM® BOLT. One year following its introduction on the market, this premium connection totally flush with the pipe body especially designed for deep water wells has demonstrated commercial success in 2012 including in Egypt, Mauritania, Azerbaidjan and Iraq.
A worldwide network of research centers

With the opening of a center in Rio de Janeiro, Brazil, Vallourec has six main research centers equipped with high-performance research and modeling resources and which contribute their expertise to Vallourec’s core subject areas: metallurgy, thermics, non-destructive examinations, corrosion, surface treatment, product and process simulations, etc.

These R&D centers are spread over four countries:

- France:
  - Vallourec Research Center France (Aulnoye)
- Germany:
  - Vallourec Research Center Germany (Düsseldorf)
  - Vallourec Research Center Technology (Riesa)
- United States:
  - Vallourec Research Center Connections (Houston)
- Brazil:
  - Vallourec Research Center Brazil (Belo Horizonte)
  - Vallourec Competence Center Rio (Rio de Janeiro)

1. In France:

   ➢ Vallourec Research Center France (Aulnoye)

Vallourec Research Center France (Aulnoye), the Group’s long-established research center, focuses on alloys and new steel grades which improve the resistance and weight of tubes destined for either the oil industry or mechanical engineering applications. Its role: development of alloys and steel grades, non-destructive examinations, corrosion resistance, surface treatments, product and process simulations.

There are also three VAM centers in Aulnoye which specialize in threaded connection design, proprietary grades and threading line industrialization.

2. In Germany:

   ➢ Vallourec Research Center Germany (Düsseldorf)

Vallourec Research Center Germany located in Düsseldorf comprises two units:

- The Boiler & Line Pipe Competence Center (BLCC) in Düsseldorf, installed close to large German boiler and steam generator manufacturers, particularly focuses on the development and design of tubes and steel used in conventional and nuclear power plants, as well as oil and gas line pipes.
- The Rolling Competence Center is working in tube hot-rolling research, specialized in rolling processes of the Group. It is engaged in improving the performance and quality of new implemented process aggregates as well as operational changes on existing devices of the rolling mills of the Group together with the mill people. This long-established center (2001), which is responsible for innovations involving Vallourec’s core processes, is now supported by a new rolling laboratory.

- Vallourec Research Center Technology (Riesa)

Inaugurated in December 2010, this research center houses the latest technology to test and optimize production methods. Unparalleled, it operates like a miniature plant and brings together all of the Group's key areas of know-how: piercing technology, which turns a billet into a shell, rolling on a mandrel, and since May 2012, forging. It is the only research center in the world to combine a piercing mill, a mandrel mill and a forge. This industrial equipment allows tests to be performed without having to stop a production line or risk any damage to machinery.

This center allows tests under real-life conditions to be carried out for all of the Group's units and innovative production methods to be developed; it thereby contributes to improving Vallourec’s competitive advantage. It is at the Vallourec Research Center in Riesa that the technologies which will enable the Group's plants to improve in quality and speed in the future are tested.

The center has a number of state-of-the-art measuring instruments and a data processing and transmission system. Cameras, placed at twelve control points, film the process that is being tested and directly send data to the Group’s other sites around the world. The Group's production and R&D teams thereby have access to all of the test results in real time. The tests carried out at the center also allow new steel grades and even industrial automatisms to be tested before they are applied to the production process. The Riesa center also hosts a number of technical courses for mill people and newcomers.
3. In the United States:

- Vallourec Research Center Connections (Houston)

This VAM threaded connection design and test center focuses on the developments required by the US market and benefits from the combined experience of VAM and Atlas Bradford teams. In 2012, the Group doubled the testing capacity of this center to respond to customers' increased demand to qualify existing product lines to the new standards for extreme well conditions.

The outcome of a long-standing cooperation agreement between Vallourec, Sumitomo Corporation and NSSMC (Nippon Steel & Sumitomo Metal Corporation, ex-Sumitomo Metal Industries), this center contains a large share of the Group’s expertise and research efforts in the area of metal-to-metal threading and sealing, which stand at the heart of VAM® joint technology.

Its purpose is to respond to the increased demand for testing following the tightening of regulations, which took place after the Macondo accident, as well as to local inquiries from oil companies. At these facilities, VAM® connections undergo the harshest full-scale tests: make and break, simulation of combined loads (tension or compression), bending, high temperatures, and fatigue life. The Houston center also helps develop and approve new VAM® premium connections.

4. In Brazil:

- Vallourec Research Center Brasil (Belo Horizonte)

Within Vallourec Research Center Brasil, which is made up of teams of experts and test laboratories, Vallourec adapts the Group’s solutions to the needs of its Brazilian customers.

- Vallourec Competence Center Rio (Rio de Janeiro)

Vallourec decided to step up its cooperation in the area of research with Petrobras, Brazil’s state-owned oil company and the Group’s main customer in the country. Vallourec Competence Center Rio which will be inaugurated on July 9, 2013, is located close to CENPES, the Petrobras research center.

The new center will cover all of the Group’s activities in the pre-salt sector including drill pipes, umbilical products, and accessories. It will put Vallourec directly in touch with the needs and expectations of the Brazilian oil group, which exploits deposits characterized by extreme pressure, temperature, and corrosion conditions. The Rio de Janeiro competence center will benefit from synergies with the Federal University of Rio de Janeiro in areas such as the environment, robotics, and energy use. Integrated within TRDI, it will share its competencies with the Group's five other research centers.
Leading partners

Long-term partnerships which have allowed Vallourec to extend its leadership

The Group carries out its research in partnership with other industrial groups, particularly companies that are at the forefront of their field, such as Sumitomo for the development of VAM connections and Tubacex for the development of different types of stainless steel, as well as the Salzgitter Mannesmann Forschungsinstitut in Duisbourg, a long-standing partner for research into improving the Group’s manufacturing processes.

Nippon Steel & Sumitomo Metal Corporation

Vallourec has worked with Sumitomo since 1976 on special joints for the oil and gas market. Both groups signed an R&D partnership agreement in 1984 concerning VAM® products in order to share their experiments and R&D resources and accelerate the development of this line of products. All developments in the VAM® range, which is now a world leader in premium connections, can be traced back to this partnership. The recent developments to the VAM® 21 premium threaded connection and the dry coating, Cleanwell Dry®, are a direct consequence of this partnership. Furthermore, Sumitomo Metals, Sumitomo Corp. and Vallourec have entered into VAM® threading joint ventures, particularly in the United States, Brazil and China.

Tubacex

The cooperation agreement signed in February 2009 with Tubacex (Spain), the world’s leading manufacturer of high added value stainless steel tubes, has allowed Vallourec to broaden its range of products and services. This agreement concerns the development of seamless stainless steel and nickel alloy tubes for the oil and gas and power generation markets. It particularly focuses on the most demanding applications in terms of corrosion and resistance to high temperature levels.

Salzgitter Mannesmann Forschungsinstitut

Vallourec also relies on a long-standing research partner, Salzgitter Mannesmann Forschungsinstitut, located in Duisbourg (Germany), to support its program of testing and manufacturing process studies.

Operational partnerships with customers

As R&D is a process of continuous communication with customers, the Group works closely with some customers to develop solutions that meet their own operational needs.

The Group’s main partnerships with customers include:
- Petrobras: innovative tubular solutions for the exploration and exploitation of the most difficult oil and gas reserves (very deepwater, salt, corrosion, CO₂, etc.) and pre-salt fields off the coast of Brazil in particular;

- Total: premium joints that allow the company to extract under unparalleled conditions on difficult wells;

- Weatherford: development and industrialization of a specific premium connection for innovative applications;

- BP: development of high-performance drill pipes for horizontal drilling (ERD) and development of tubes and connections for risers;

- Hitachi Power Europe, Alstom, Doosan: development of high-performance steel for ultra-supercritical power plants.

**Essential research with international university laboratories**

Finally, Vallourec participates in essential research with several university laboratories around the world.

The Group’s main university partners include:

- Mines ParisTech (France)
- RWTH Aachen University (Germany)
- Carnegie Mellon (United States)
- UFMG (University of Minas Gerais, Brazil)
- Unicamp (São Paulo, Brazil)
- UFRJ (University Rio de Janeiro, Brazil)