

# **i**NDUSTRIAL PLANTS

May 2015

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OF INDUSTRIAL  
PLANT ENGINEERING

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in the world  
has been accomplished  
without passion"

Georg Hegel

1954-2014

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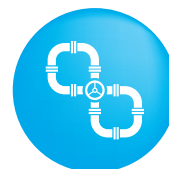
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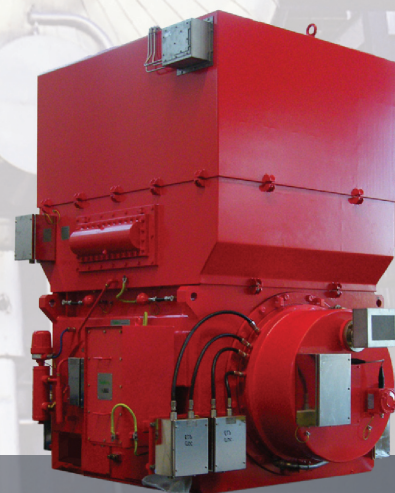
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## An Outlook for the Italian Engineering and Contracting Industry

### After the Growth it is Time for Resilience



**Nello Uccelletti**  
ANIMP President

“*Industrial Plants*”, ANIMP’s yearly publication for our international audiences, highlights selected significant recent achievements of the Italian Engineering and Contracting Industry, currently under execution or recently completed in international or domestic markets, with a special focus on main challenges of today: new markets, new technologies, complex projects, challenging logistics, advanced systems, competitive supplies, need for local content etc.

Over the last decades, these Italian industries have proven their competitiveness, innovation and flexibility in almost every remote corner of the world, from Eastern Russia and Eastern Australia to Western Canada and Latin America. Today, Italian contractors and equipment suppliers are among the global leaders, with high market shares, universal recognitions and growing sales.

Our industry has historically excelled in projects which are more and more complex in terms of size, technology characteristics, extreme logistics and generally very challenging environments. These projects require high technical and management skills in which many of our companies have proven their worth. This know-how and flexibility are excellent sources of competitive advantage vs. newer entrants from emerging markets, often less experienced and not as well organized.

Today’s industrial plant markets are highly transformative and turbulent: in addition to many shifts, rapid changes and evolutions over the last years, the recent fall of the price of oil has somewhat reduced the short term investments in the oil & gas industry and mitigated the medium term growth prospects. Nevertheless, the Italian industrial supply chain, which includes

world-class engineering and construction contracting, onshore and offshore, as well as equipment supply, still looks at the future with a moderate optimism, for a number of good reasons. In complex and rapidly changing global markets, our companies have been forced to be ever more flexible and ever more innovative, by applying successful execution models, mitigating the increasing project risks as well as generally by applying a number of very innovative solutions to new challenges.

The increased sales level in 2014 vs. previous years and consequently the increased backlog of acquired orders at the end of 2014 is firstly a testimonial to the success of the Italian industry in recent years. But it is also demonstration of resilience, allowing the industry in the immediate future to “weather the storm” of reduced short term investments as well as to restructure and become even more competitive for the investment wave expected in the medium term.

In any case, the volume of new investments expected in 2015 and 2016, both in upstream and in downstream markets, still remains substantial, in spite of numerous uncertainties, particularly in some regions.

Generally, therefore, our industry is ready for the next challenges and it looks at the future with optimism, in spite of the expected short-term downturn.

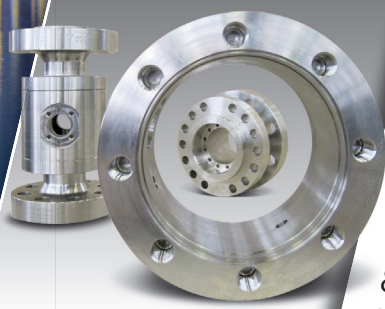
We thank the Italian industry working in the oil & gas sector for their strong and continuing support to ANIMP. We confirm our commitment to provide an ever improving range of services to all our affiliates and to represent the Italian supply-chain of the Engineering and Contracting Industry in all global contexts.

**Nello Uccelletti**



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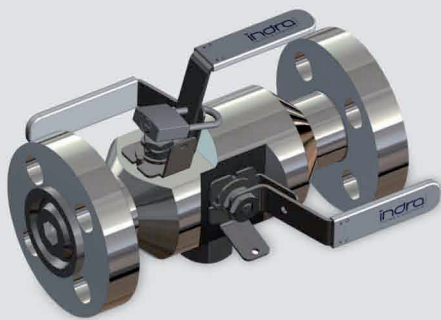
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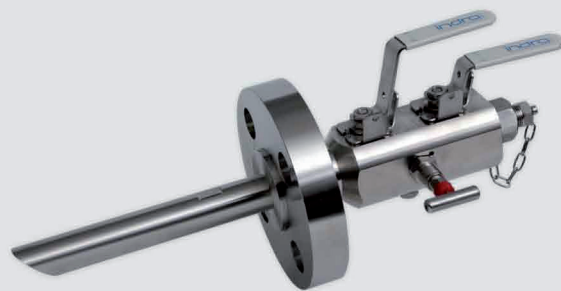
# Iblok Series - Integral type

**Drastic reduction of:** costs • installation and maintenance time • weights • support systems and / or anchorage • leakages

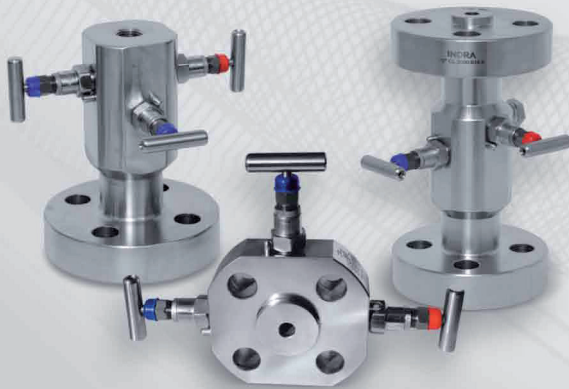
DBB Three Balls



DBB Sampling & Injection type



DBB Needle Type



DBB Ball Type



**Reference standards:**

ANSI / ASME, API 589, Ped, Nace std, etc.

**Standard materials:**

AISI 316, A105, etc.

**Special materials:**

Duplex, Superduplex, Monel, Inconel, Incoloy, Hastelloy-C, etc.

**Options/accessories:**

locking systems, electrical signals, etc.

**Certification:**

Fire Safe Api 607/Iso 10497  
Fugitive Emission/Ta-Luft (Iso 15848-1)  
Nace Standard MR.01.75  
Atex 94/9/CE  
Ped 97/23/CE  
CU-TR (ex Gost)  
CRN

ATEX   
PED   
CU-TR   
TA-LUFT  
CRN  
FIRE SAFE



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# Industrial Plants: the Driving Force for the Dynamic Italian Industry

The growing success of the Italian industrial plant contracting, supply and services industries witnesses our industries competitiveness on world markets

**Pierino Gauna, Gianfranco Tripodo**  
*Centro Studi ANIMP*



increased by 35% over the last 4 years, offsetting the revenues from the Italian market, which plateaued over the same period of time.

Internationalization is the key growth driver. The Italian plant industry has been able to achieve a strong global reach, from Eastern Russia and Australia to Western Canada. Export oriented firms with an increasing turnover reported better results, compared with the ones focused only on the domestic market.

## Global revenues of ANIMP affiliates

The industrial plant sector comprises both manufacturing and service-oriented companies, along with the suppliers of engineering services, plants and components, which provide engineering, procurement and construction.

The Industrial Association ANIMP is a network which gathers together 350-400 companies active in the most important industrial design sectors, such as offshore and onshore oil & gas, petrochemicals, chemicals, iron and steel industry, energy and transportation. The global revenue of ANIMP affiliates is over 35 billion euros, up from 20 billion euros in 2000 and 15 billion euros reported in the 90s. Export

The Industrial Association ANIMP is a network which gathers together 350-400 companies active in the most important industrial design sectors, such as offshore and onshore oil & gas, petrochemicals

revenues account for more than 90% of their overall output. Europe and Africa are the most prominent destinations, both of them with a 20-25% share by volume, while South America accounts for 15% of the overall export revenues (figure 1).

The leading market sector is oil & gas which covers the 2/3 of the global revenues of this industry. Petrochemicals, chemical and power sectors are important as well, given that their global weight is around 30% of the total (figure 2).

During the last years the Italian plant design, equipment supply and construction industry, has played a very prominent role, significantly strengthening its international presence. The ultimate goal of the export-driven Italian plant machinery industry has always been to increase the development of its worldwide presence. So far, the trend is promising: the revenues coming from the foreign markets have

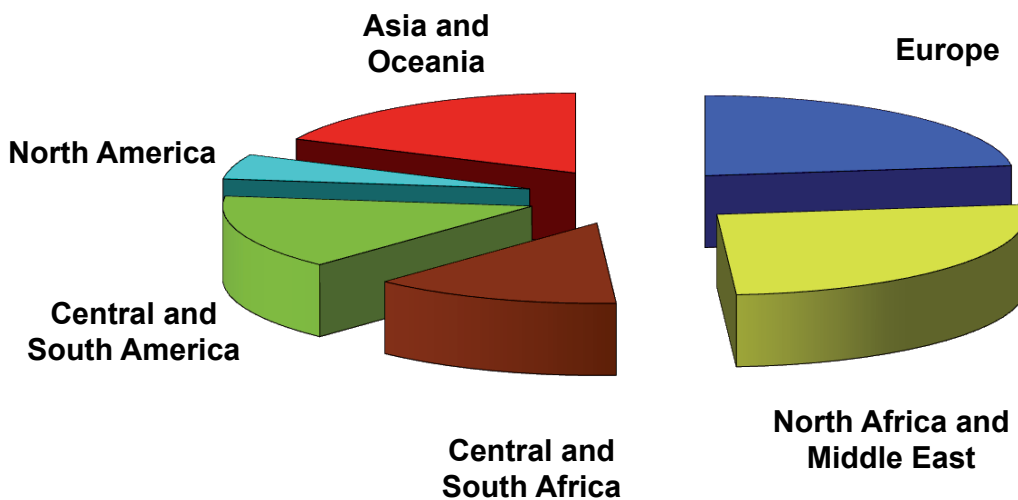


Fig. 1 – Main markets for the Italian Plant Industry (outside of Italy)

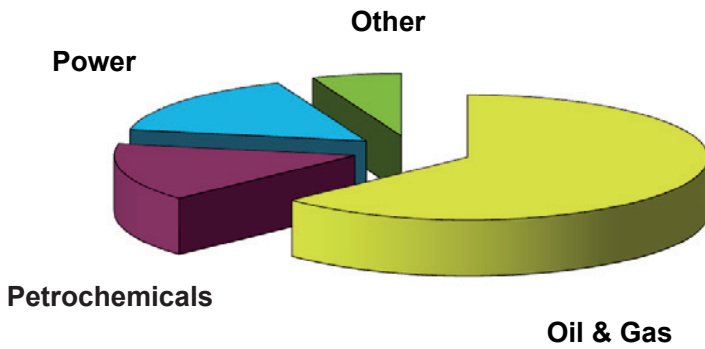


Fig. 2 - Main sectors of activity of Italian Plant Industry

The Industrial Plant engineering is also a significant driver for some associated activities which are pulled in along with a specific project (e.g. the financial and administrative arrangements), and afterwards (e.g. maintenance and assistance).

### Technology and people, core values of the Italian industry

On the global scene, the Italian presence started in the Sixties when the first Italian General Contractors started to build industrial plants and infrastructures in South America, North Africa and Middle East. Gradually, the Italian companies conquered the leading positions in the international rankings, together with American, Japanese and French companies. As an example, in the design and execution of large oil and gas projects in North Africa and Middle East, Italian firms were second only to the Korean ones in 2014 (figure 3). The global income of the main Italian contractors has thus risen from 7 billion dollars of middle 80s to more than 35 billion dollars in 2014. Technology and people are the core values of the

Italian industry. Above all, human capital is the key asset for the sector. The Industrial Plant industry counts a total workforce of about 100,000 people, 2/3 of which are technicians, and 1/3 highly specialized workers.

Thanks to their abilities to succeed on the international markets, our associated companies can count on an order backlog of over 50 billion euros, which implies a full work load over the next year and beyond. This backlog portfolio allows them to operate on a medium term basis, offsetting today's downturn of the oil prices.

### A favorable look to the future

Thanks to the Italian companies' competitiveness and to their strong presence in the emerging markets, we can look favorably to the future, in a general context of gradual economic recovery and overall growth. Investment demand seems to be growing, with good mid-term prospects.

Thanks to their abilities to succeed on the international markets, our associated companies can count on an order backlog of over 50 billion euros, which implies a full work load over the next year and beyond

Above all, the traditional industrial plants markets appear to have very attractive growth prospects. For instance, the North Africa and Middle East areas are growing at a 3%/year pace in 2015 and are expected to highlight a 4% rise in 2016, despite political tensions in the Mediterranean Region.

**Projects** ≥ **0.5 B US \$**  
**Total Awards** ≥ **41 B US \$**

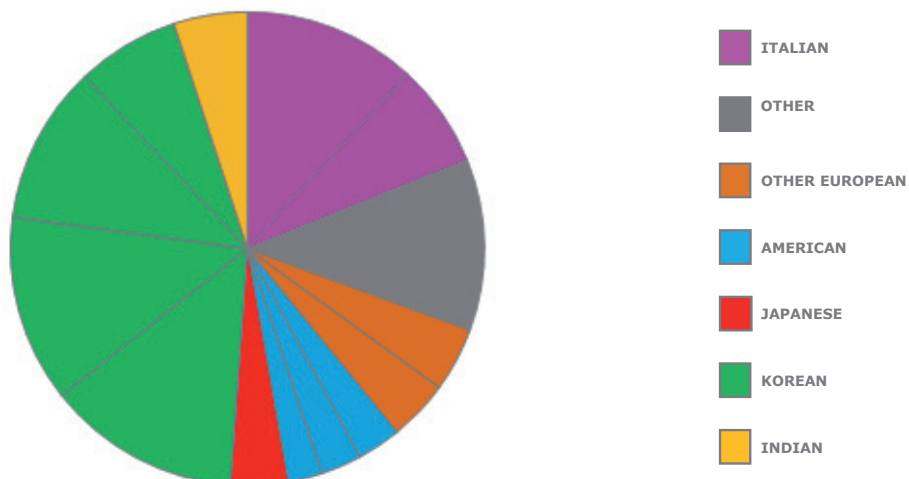


Fig. 3 - Middle East and North Africa large EPC contract awards 2014 (Source: Saipem Data, 2015)

The Sub-Saharan Africa, another market with a strong traditional presence of Italian companies, is growing at a 5% pace.

Although Brazil, Venezuela and Argentina recently faced some financial difficulties, South America is expected to keep growing between 1.5 and 2%/year.

However, China and India, which are growing at a 6%/y

pace, represent a key challenge for the Italian industry. In addition, Italian public institutions such as the Ministry of Economic Development, Ice, Sace, Simest, which support particularly the internationalization of SMEs, are a distinguished partner in advising and often in financing or guaranteeing the companies on how to operate more effectively in the global market arena.



## Pierino Gauna

Pierino Gauna graduated in mechanical engineering, thermal engineering branch, at the Polytechnical of Turin.

He has developed his professional career in the same company, that lived different organizations and properties over the years: Fiatengineering, Fiat Group until 2004, then Maireengineering, Maire Tecnimont Group.

Carrying out his activity he has acquired expertise in the energy plant sector heading for the management of operational units as responsible for underlying entities and covering organizational positions of

greater complexity and responsibility.

Subsequently he has consolidated management experience as a business unit Manager, CEO and President in engineering/contracting companies.

Contract professor for teaching technical facilities at the Polytechnic of Turin – Faculty of Architecture in the years 2003, 2004, 2005, 2006.

He is member of ANIMP's National Council and of the Executive Board.

He serves as Association's treasurer for the biennium 2013-2015.



## Gianfranco Tripodo

Graduated in Economics at the University of Genoa, he joined Italmimpianti in 1976, working in the Technical and economic feasibility studies Dept. of industrial projects.

Then switched to Piaggio, in Marketing Dept. and after prolonged activities in the field of investigations in marketing industry, falls within the world of engineering companies (Innse, Iritecna) thatching, with increasing

responsibilities, roles and tasks related to strategic planning and cost control.

Currently he works as a consultant for private companies and public bodies in the field of planning, organization and control. He also studies market trends of plant-making industry for "Centro Studi ANIMP".



*Borouge 3 plants  
overview*

# Challenges of Megaprojects: Borouge 3 Polyolefins Plant

The joint venture of Tecnimont with Samsung Engineering, key player in realizing one of the largest polyolefins complex in the world

**Marco Crivelli, Valeria Bonetti**

*Maire Tecnimont Group*



**B**orouge, a name, a history made up of experiences, emotions and successes that have enable us to grow and enthuse. After the successful experience of Borouge 1 and Borouge 2 Petrochemical complex started in 1999, we had the honor to be awarded with the subsequent Borouge 3 project, representing the largest Polyolefins project ever built by Tecnimont. This impressive turnkey EPC (Engineering, Procurement and Construction) project is composed by 5 process Units, in particular:

- 2 Polyethylene Units;
- 2 Polypropylene Units;
- 1 Low Density Polyethylene Unit (LDPE) of 350,000 tons/year through an high pressure technology with unique high quality requirement to achieve an extremely clean product.

The package is part of a large portfolio of projects including an upstream ethylene cracker, utilities and offsite facilities, a further refining Cross-Linked Polyethylene Unit (XLPE) and the non process buildings. The project is part of Adnoc (Abu Dhabi National Oil Company) strategic initiative aimed at satisfying the increasing demand for plastics especially in the Middle East and Asian markets. The bidding environment during proposal stage was highly aggressive with all the major contractors in the

game and ready to sign this prestigious contract award. How to win a competition that we just could not lose? Hence the decision to partner one of the most feared

**The project is part of Adnoc (Abu Dhabi National Oil Company) strategic initiative aimed at satisfying the increasing demand for plastics especially in the Middle East and Asian markets**

bidders, Samsung Engineering, and incorporate the so called "TSJ" (Tecnimont Samsung Engineering Joint Venture) with Tecnimont as leader.

## Main stakeholders involved

### Client

Borouge was founded in 1998, when the Austrian Borealis and Adnoc joined their experience and know-how to build what today is one of the largest petrochemical producing companies in the world. The facilities of Borouge, the largest in the Region with 10 main polyolefins process plants, are located in the desert region 250 km West of Abu Dhabi, all concentrated in Ruwais area not far from the Saudi border.

Borouge in Arabic means “tower” such as those 70 m high supporting the loop reactors, the beating heart of the Ruwais Polyolefins Plants, which transform crude oil derivatives into impressive quantities of plastic.

The joint venture is governed by the Project Management Board (PMB), which operated from Tecnimont Home Office in Milan until all the engineering and procurement were completed and then shifted to Ruwais in UAE.

### Licensors

The shareholder Borealis is the licensor for the 4 Polyethylene and Polypropylene Units, while the license of the LDPE Unit is a combination of Basell High Pressure Technology and Borealis know how in the production of high value wire and cable applications.

### Joint venture organization

The joint venture was set up with a “one pocket - one money” concept, where the profits and losses are divided among the joint venture partners, with Tecnimont as leader. The PMB of the joint venture was constituted by a team of Senior Management members from both organizations with a large pool of experience in the petrochemical field and was the guiding body behind all the joint venture operations.

### Project Management Consultant (PMC)

Bechtel UK is the Project Management Consultant appointed by Borouge for the project. Several members from Bechtel were mobilized in Milan immediately after the kick-off meeting and later in Ruwais to ensure that the project is executed as per the specifications.

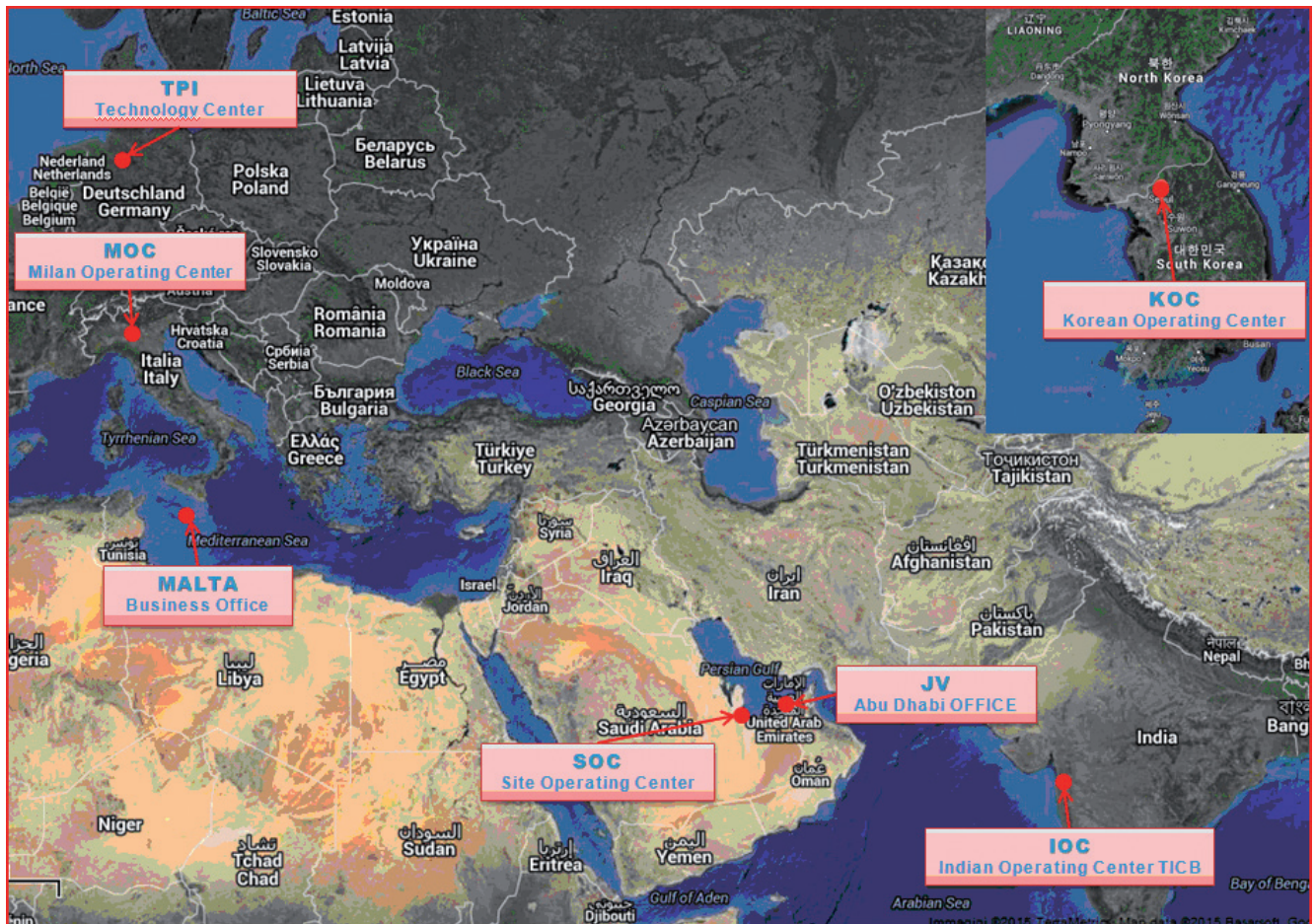
The joint venture PMB was responsible for developing overall project execution strategies, ensuring proper and timely performances by all operational centers, taking care of the interfaces with Borouge and

### EPC Contractor

The EPC Contractor is TSJ are two leading EPC Contractors in the world. TSJ is based in Malta with branch offices in Abu Dhabi, in UAE (United Arab

The joint venture was set up with a “one pocket - one money” concept, where the profits and losses are divided among the joint venture partners, with Tecnimont as leader

Fig. 1 - Project Operating Centers location



monitoring the key project features, like HSE (Health Safety Environment), quality, schedule, cost control and site performances. In addition, two representatives from the top management of both companies constituted the joint venture Steering Committee and acted as sponsors of the project to interact with the top management of the client and to ensure that the project is moving in the right direction and pace.

Considering the know-how and capability of Tecnimont in the petrochemical process and potentiality of the Korean market, the initial split of work between Tecnimont and Samsung Engineering has been done in a "horizontal" way, with both companies involved in all the 5 Units, in particular:

### ***Tecnimont (Maire Tecnimont Group)***

- 100% of engineering works for the 5 Polyolefins Units;
- procurement activities with the exception mainly of the static equipments expected to be awarded to Korean vendors;
- construction and commissioning supervision: key positions with high expertise, including field engineering team to properly support the construction team;
- commissioning execution of LDPE Unit, being a very specialized task where the process knowhow of Tecnimont gained through years of experience was essential;

### ***Samsung Engineering***

- procurement activities of mainly static equipments and some bulk items, where the Korean and Far East markets playing a key role in this respect;
- main construction supervision for all the Units;
- commissioning execution of the 4 Polyolefin Units;

The Operating Centers involved for the execution of the project engineering, procurement and construction phases were distributed all over the world as represented in the **figure 1**.

## **Operating centers**

### ***JV Business office in (Malta)***

The heart of the administration of the joint venture was located in La Valletta, Malta.

### ***Milan Operating Center (Milan)***

Project teams of Tecnimont, few representatives of Samsung Engineering and Borouge / Bechtel teams

were mobilized to Tecnimont Head Quarter, main operating center, in a common task force dedicated exclusively for the project. Having Project Management, Engineering, Procurement and Project control teams located in the same building allowed for a better communication and simple coordination.

### ***Tecnimont ICB (Mumbai)***

The detailed engineering on the basis of basic design developed by Tecnimont Milan team was executed by the fully owned subsidiary of Tecnimont in India, Tecnimont ICB (TICB) with headquarters in Mumbai in Western India. Around 350 engineers were involved in the detailed design engineering phase in TICB and their contribution was an important milestone in the project.

### ***Tecnimont Planung und Industrieanlagenbau TPI (Salzgitter)***

The design and engineering of the High Pressure Process Technology of LDPE Unit were performed by engineers coming from Tecnimont owned subsidiary in Germany, with immense experience and knowledge in this specialized field.

### ***Korean Operating Center (Seoul)***

The key functions performed in this operating center called KOC (Korean Operation Center), where Samsung headquarters are located, were mainly procurement and expediting activities for static equipment and other bulk items, normally purchased by contractors in the Far East highly competitive markets. The knowledge of Samsung Engineering in this specific task proved to be cost effective.

### ***Site Operating Center (Ruwais)***

Construction activities were managed and controlled by a Single Operations Center (SOC) with base at the Ruwais site. All the construction subcontracts were handled and managed by this location. The joint venture PMB, which operated from Milan in the engineering and procurement phase moved to SOC once those activities were substantially completed. Also the personnel of client and PMC moved to site at the same time.

## **Complexity of the project**

Borouge 3 petrochemical complex consists of 5 independent Process Unit converting ethylene derivatives into plastic pellets, packed by product handling facilities either into 25 kg plastic bags or into 40 feet dedicated

containers, in both cases directly loaded on containers ships coming to Ruwais on daily basis.

Massive dimensions in terms of quantities and numbers give an idea of the complexity of the project. In particular, the most significant key parameters can be summarized as follows:

- structural concrete: 205,000 m<sup>3</sup>;
- steel structures: 25,000 tons;
- equipment: 27,000 tons;
- piping isometrics: 50,000 nos;
- piping quantity: 1,600,000 inch dia;
- control buildings and electrical substations: 13 nos;
- instrumentation loop checks: 31,000 nos;
- electrical and instrumentation cables: 4,300 km.

These huge numbers have always been an area of attention to focus on from the very beginning and have indeed motivated all participants in a passionate hard work for the success of this project.

The plant reached the operation stage and started commercial production in 2014 (**figure 2**).

**Fig. 2 – Polyethylene loop and gas phase reactors**



## The challenges

Borouge 3 might have seemed a project to which “the road was paved” since it was about polymer plants, well known technology to Tecnimont. It should have been a copy plant of Borouge 2, however the reality proved to be far different. Brand new challenges were launched:

- implementing a contract with a joint venture Korean partner, whose mindset is of a military imprint and who are extremely proud of belonging to a fast growth country;
- work with operating sites located in different area of the globe Milan, Malta, Seoul, Mumbai, Braunschweig, Abu Dhabi and Ruwais;

- manage in parallel the execution of a megaproject of five process plants, awarded in a highly aggressive arena of competitors, leading to the involvement of new and numerous suppliers on an international scale;
- manage an overheated vendor market in UEA, MENA (Middle East and North Africa) region, as well as in Korea, due to booming of investments in UAE, where a large number of big projects were simultaneously awarded; congested conditions of ABU Dhabi port were also to be faced;
- scarcity in skilled workmen due to the large number of big projects simultaneously awarded in the UAE market;
- constructing in a sandy environment like Ruwais for the first time in the world an LDPE plant peculiar on two counts, for the technical requisite of the cleanliness of the materials, requiring a total absence of impurities (and sand) also invisible to the naked eye, and for the high pressure technology in which the process fluids reach pressure levels over 3,000 atm, demanding the highest standard of quality and safety.

Set at the dinner of the first team-building session in an eatery at the surrounding of Milan, we looked at each other and counted 11 people sitting at the same table, 11 different nationalities. Rightly we thought that the biggest challenge was certainly going to be communication. Different languages, cultures, behaviors and style of life must live side by side, integrate and achieve one common goal: satisfy the expectations of everyone, from the end user through the 11,000 workers which populated at the peak the Ruwais Construction Site.

## The execution: key factors

### Construction-oriented engineering

The engineering started before the formal signature of the contract and were conducted and completed throughout the project on the early schedule (**figure 3**), also thanks to Tecnimont experience and expertise in polymers units, in PE/PP Borealis and LDPE Basell technologies and in Borouge standards and specifications. This anticipation was a key element to provide sufficient room for the more difficult phases of construction to follow.

In fact, the first P&IDs, as well as material requisitions for critical items were issued as early as the 2<sup>nd</sup> month. The 3D modeling was also done much earlier than normal and by month 18<sup>th</sup>, 90% 3D model was ready. This gave a distinctive advantage to the procurement and construction phases.

This approach resulted to be successful in providing



previously identified long lead items, like plastic extruders, main compressors and process reactors, pneumatic transport, high pressure equipment and others;

- ensuring booking of some raw material in an overheated market quite early in the project;
- large use of vendors already adopted in Borouge 2 project case, as well as vendors adopted by other contractor in projects for other Adnoc Companies, to maximize previous positive experiences, long term reliability equipment and availability of efficient post sales services;
- placing of frame agreements with selected vendors for specific items, as proactive approach to material standardization requirement and better control over sub-vendor performances;
- advance availability of material for steel structures erection and pipe fabrication was available on site as per the feasibility curves shared with erection subcontractors;
- extensive sessions of Factory Acceptance Tests for DCS (Distributed Control System) and related control logics in the vendor premises together with process and automation project leaders, to assure a positive performance of interlocks and functional checks during commissioning stage at site.

### Subcontracting strategy

The construction works were implemented through a pool of specialized subcontractors splitting the overall scope of work by discipline, such as civil, mechanical, electrical and instrumentation. This approach was mainly dictated by the need of finding valuable and enough resources in the market and by the intention to minimize the risk of failure of a general subcontractor to handle wide portion of works under stringent project requirements from several perspectives.

Tecnimont ICB, the totally owned Tecnimont

construction subcontractor, represented a key asset for the joint venture, especially in meeting the highest demand of flexibility imposed by the typology of the works and in the proactive approach put in place to handle interfaces among subcontractors.

Direct manpower injections have been extensively used by the joint venture as countermeasure to boost the progress in specific activities and to sustain subcontractors performance to achieve the challenging targets set up by the project needs. Moreover, the joint venture has also introduced engineers in subcontractors organizations to make sure the correct understanding of contractor deliverables and expectations in specific tasks.

### HSE performance

Safety, environment and the wellbeing of all the individuals building the plant were of paramount importance for the Tecnimont and Samsung Engineering, as well as for all the stake holders, Borouge at first. The contractors and subcontractors complied not only with the HSE (Health Safety Environment) standards of the Adnoc Group, but they took several new initiatives in this respect.

Incident Injury Free program, incentives, safety awards and many similar initiatives assimilated the “safety first” message to all the personnel bringing a culture of safety awareness in the entire project. A permanent training center was established at site by contractor where all the employees, including vendors and labors, have been specifically trained to be able to safely cope with the tasks they were called for. The below recognition of intermediate safety achievement was distributed to all the thousands of people present at site, as sign of appreciation of their attitude versus safety on site.

The project finally reached 65 mil worked manhours without LTI (Lost-Time Injury), a remarkable achievement in this field, with over 11,000 people

Fig. 5 - Medallion for achieving 45 million MHrs without LTI (Lost-Time Injury)



working at site at the peak of construction (figure 5).

### Quality Control

The EPC Contractor along with its construction subcontractors and with the active participation of the PMC and Borouge were successful in breeding a culture of high quality standards, through some essential initiatives, including checking of piping internals with boroscope (figure 6), large use of microscope to detect impurities, stringent audits and zero tolerance policies.

The level of welding defects at site was a clear example of the results achieved: the weld repair rate was significantly lower than the normal industry standards.

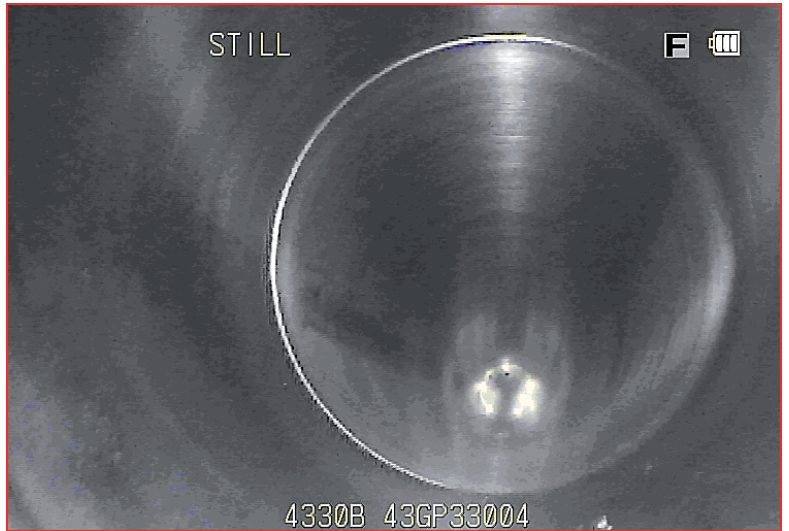


Fig. 6 - Quality checks on equipment internals

### Constructability

Detailed constructability studies were carried out during the beginning phase of the project in the most critical activities, like underground works and heavy lifts (figure 7). The proper implementation of this tool, involving construction knowledge and experience in planning from design to startup stage, resulted to be fundamental to plan the most efficient and effective sequence of erection during the subsequent construction works.

The site activities were also subject of regular "cold eye review" carried out by senior representatives of both joint venture partners organization, with wide experience in construction and commissioning of large packages. The goal of this review was to ensure proper proceeding of the EPC activities, especially in light of their past performances on similar projects, and to minimize the risk of deviating from the right pace of required progress.

### SIMOPS (SIMultaneous OPerationS)

The introduction of hazardous substances like hydrocarbons, in five adjacent process Units at different stages of the project, requires advanced detailed analysis to prevent any possible accident, putting in place all the necessary countermeasures to allow construction, commissioning and start-up activities to be carried out simultaneously in the same area.

The SIMOPS (SIMultaneous OPerationS) assessment was conducted through several dedicated interdisciplinary (commissioning, construction, site HSE) meetings. The mitigation actions identified in the SIMOPS assessment meetings were continuously reviewed, and the implementation progress was monitored by site HSE together with PMC and Borouge representatives, party releasing any Permit to Work in the area affected by hydrocarbon.

All the resulting HSE hazards have been assessed and appropriate control levels have been implemented to

Fig. 7 - Constructability studies for installation of main equipment

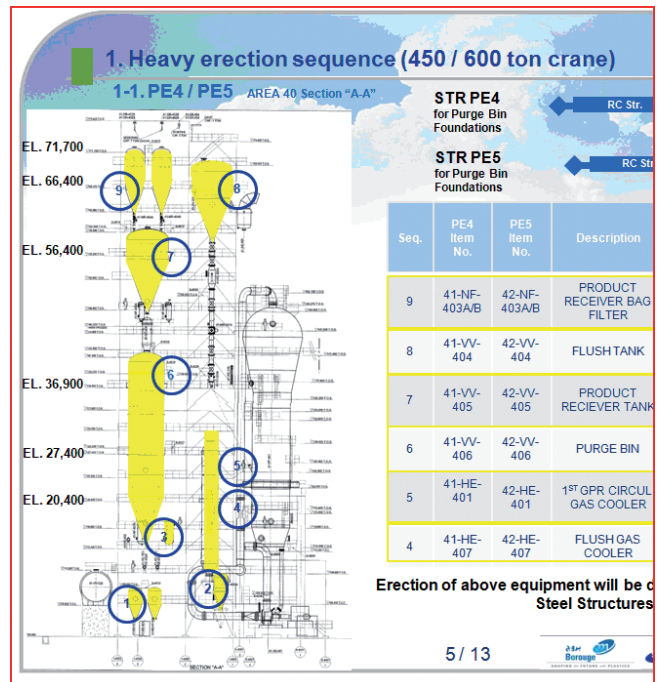
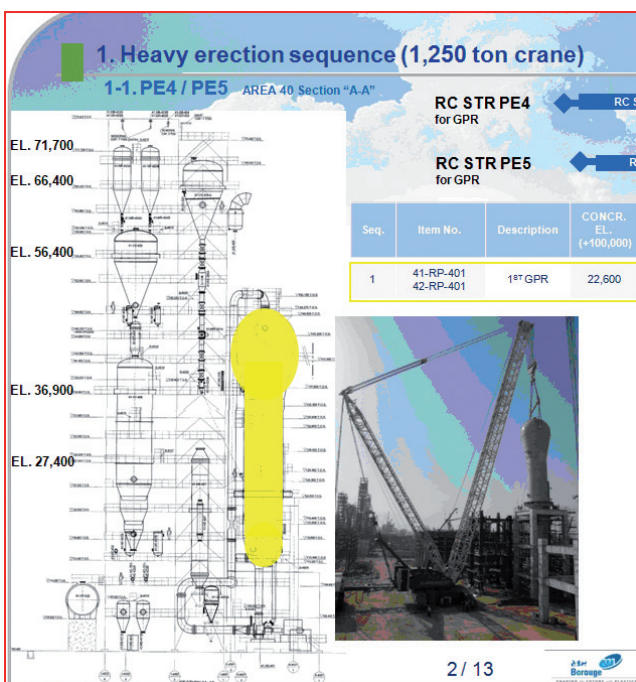


Fig. 8 - Night overview on the polyethylene and polypropylene polymerization areas



reduce the identified HSE risks to a level that is As Low As Reasonably Practicable (ALARP).

## Conclusions

Today Borouge 3 plastics are commercially sold in the world market and we are proud to have been part of the UAE development, thanks to the legacy of resources and competences acquired and consolidated by our

companies, which made it possible to implement a project of such complexity and indubitable prestige (figure 8).

The pillar of all this was the high motivation and dedication of a group made up not only of professionals but, above all, of people who feel part of the project, who share the ongoing desire to learn and the capacity to always rise to the challenge. This is the passion that united us of the Borouge 3 project team.



## Marco Crivelli

Marco graduated in Environmental Engineering at Politecnico of Milan. Seventeen years of experience in engineering, construction and management of LSTK projects. He spent half of his career abroad, mainly in

Middle East area, where he covered different management roles. He was assigned as Project Manager for the Tecnimont-Samsung joint Venture in Borouge 3 Project.



## Valeria Bonetti

Valeria graduated in Chemical Engineering at Politecnico of Milan. She has been working for Tecnimont since 1996, where, in the first 10 years, she worked for process and project engineering departments both in home office and construction site. Afterwards, from 2006, she held the positions of Proposal Manager and

Project Manager, taking part of several international EPC LSTK Petrochemical Projects, either during bidding stage or during execution phase.

On 2010 she was assigned as Project Manager for the Tecnimont-Samsung joint venture in Borouge 3 Project.



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# Full Steam ahead in Nigeria for the Egina Field Mega Project

Saipem's enhanced cooperation with the local industry

**Guido D'Aloisio, Armando Favi**  
Saipem SpA

*Fig. 1 – Egina maiden  
installation campaign;  
long baseline array  
deployment for set of  
positioning grid  
system*

**K**icked off nearly two years ago and fully managed since its onset from Lagos, Nigeria, the Egina UFR (Umbilicals, Flowlines and Risers) deep water field development project is increasingly moving towards its fabrication phase, some of its most emblematic components such as risers, FPSO (Floating Production, Storage and Offloading) foundation piles and pipeline subsea structures being already well underway. Long lead and critical items are well on track, with several key components (such as bulk steel, linepipes etc.) already delivered to the fabrication yards. High pressure subsea ball valves, buoyancy tanks domes and risers flexible joints are next to come. On the installation front, an early offshore campaign executed in October last year enabled UFR package to timely and successfully complete the setup of the subsea positioning grid system, to the satisfaction of the client (figure 1).

## The Egina field development challenges

The Egina field (figure 2) is located offshore Nigeria in a water depth of up to 1,700 m within the OML 130

block, approximately 100 km off the Nigerian coast south of Port Harcourt in the Rivers State.

**Saipem was awarded the \$ 3 billion EPCI contract by Total Upstream Nigeria Ltd in June 2013, the largest offshore contract in the company's history**

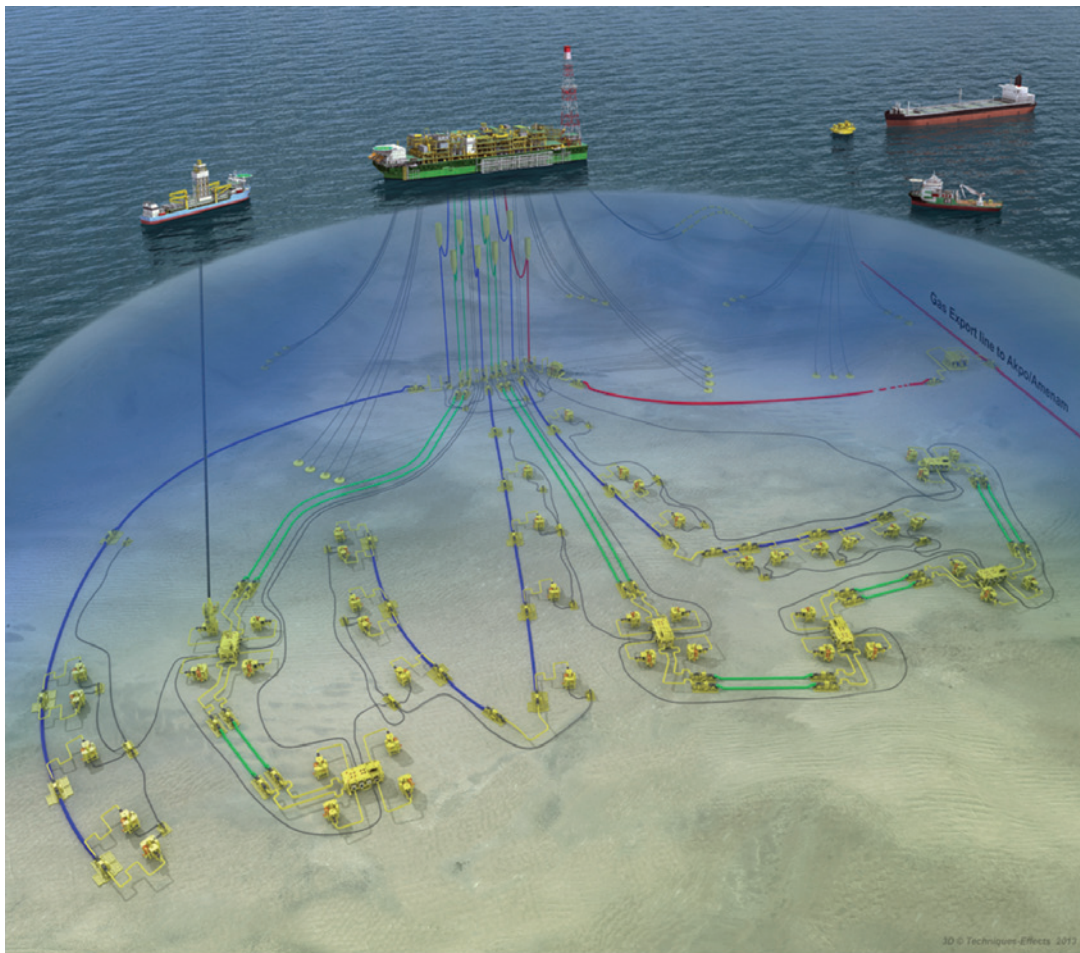
Saipem was awarded the \$ 3 billion EPCI (Engineering Procurement Construction and Installation) contract for the subsea development of the Egina field - the largest offshore contract in the company's history - by Total Upstream Nigeria Ltd in June 2013.

Saipem's UFR scope includes engineering, procurement, fabrication, installation and pre-commissioning of 52 km of oil production and water injection flowlines, 12 flexible jumpers, 2 km of oil export line, 20 km of gas export pipelines, along with installation and commissioning of 80 km of steel tube umbilicals and the mooring of the FPSO and the offshore OLT (Oil Loading Terminal) buoy.

This 4 to 5 year contract is characterized by many astonishing features:

- 10 million manhours will be needed for the entire project execution;
- 200 Nigerian engineers have been fully trained

Fig. 2 – The Egina field (Nigeria)



ABOUT EGINA
The EGINA oil field is located 150 km from Nigerian shore, within the Oil Mining Lease: OML 130, operated by TUPNI, some 200 km South of Port Harcourt.
WELLS
<ul style="list-style-type: none"> <li>◆ 3 main reservoirs: 600 Mboe</li> <li>◆ 21 Oil production wells</li> <li>◆ 23 Water injection wells</li> <li>◆ 2 rigs working in parallel</li> </ul>
SUBSEA PRODUCTION SYSTEM
<ul style="list-style-type: none"> <li>◆ Vertical Xmas trees</li> <li>◆ Optic fibre subsea control system</li> <li>◆ 6 subsea production manifolds up to 6 slots</li> </ul>
FPSO
<ul style="list-style-type: none"> <li>◆ Hull: L330m; W64m; V33.5m</li> <li>◆ Oil Storage: 2.3 Million bbls</li> <li>◆ Oil Processing Capacity: 208,000 bb/d</li> <li>◆ Gas Compression: 10.2 Msm<sup>3</sup>/d</li> </ul>
UMBILICALS FLOWLINES RISERS
<ul style="list-style-type: none"> <li>◆ 78.6 Km Umbilicals</li> <li>◆ 8 single loop tension risers</li> <li>◆ 4 main umbilicals to subsea wells &amp; manifolds</li> </ul>
OLT / BUOY
<ul style="list-style-type: none"> <li>◆ Dual offloading lines</li> <li>◆ Moored 2km from FPSO</li> <li>◆ Buoy Turret Loading System</li> </ul>



Fig. 3 – Saipem FDS2 in action in Nigerian waters



- and are now working on the project;
- 1,200 people will be working in Port Harcourt at peak;
  - 40,000 tons of steel will be fabricated and installed;
  - the hybrid risers will be 1.5 km long;
  - 1,200 people will be working 24/7 during the offshore campaigns to operate a 25 vessel offshore armada.

The Egina UFR presents novel aspects and technical challenges: chief among these is the organization of the riser layout, comprising eight top-tensioned risers including production, gas export and water injection types in a very compact area; and the resolution of the high fatigue loads induced by the slugging effect, in particular to the riser base spools.

### Novel aspects and technical challenges: the main challenge will be the installation of the risers

Turning to the marine operations, the main challenge will be the installation of the risers, which will have to be top-tensioned by huge buoyancy tanks of 6.0 to 7.5 m diameter, and up to 50 m long.

The main marine operations are planned to be carried out from 2016 to 2017 by Saipem's state of the art FDS (Field Development Ship) and FDS2 ultra deep water field development ships (**figure 3**) and by the Saipem 3000 heavy lift DP (Dynamic Positioning) vessel (**figure 4**)

Most of the project activities, including the design engineering and the fabrication, will be performed in Nigeria under the local content rule called "Nigerian Content Act" of 2010.



Fig. 4 - Saipem 3000 heavy lift DP vessel



Fig. 5 – Saipem's Rumuolumeni yard in Port Harcourt

## Egina, a Nigerian project

The Egina UFR project implementation plan confirms Saipem's strong commitment to local content development: the entire project is run from Saipem Contracting Nigeria's premises in Lagos, and most of the engineering is being performed in Nigeria, either in-house by Saipem or by local engineering partners.

### The Egina UFR project confirms Saipem's strong commitment to local content

The vast majority of fabrication works for the Egina project are performed at Saipem's Rumuolumeni yard in Port Harcourt (**figure 5**), established in 1999 and grown over the years to reach today's total area of over 1,000,000 m<sup>2</sup>, of which 70,000 m<sup>2</sup> are covered, offering a total fabrication capacity of 22,000 ton/year.

### Saipem has once again honored his famous pledge "here to stay"

Taking due consideration of its needs for Egina Project, Saipem has once again honored his famous pledge "here to stay", with a 60 million US dollars investment plan in its Port Harcourt fabrication yard turning it into a highly versatile and world-class asset thus maximizing the execution of works in-country.

Second to none in Nigeria, its new-built state of the art Quad and Double Jointing plant (**figure 6**) makes up the lion share of this plan. It was inaugurated on 6 February 2015 by the Executive Secretary / Chief Executive Officer of the Nigerian Content Development Board, Engineer Ernest Nwapa alongside other top executives of Nigerian Content Development and monitoring board and representatives of major oil & gas companies.

In line with its commitment to maximize the use and foster development of Nigeria's indigenous companies'

capabilities, Saipem has also audited and qualified major Nigerian subcontractors, with the view to improving identified competency levels and build up long term relationships.

### Saipem has audited and qualified major Nigerian subcontractors

Among these is Energy Works Technology Ltd. (EWT) in Port Harcourt. Saipem has engaged in a comprehensive mentorship program to bring up



Fig. 6 – The Quad and Double Jointing plant



Fig. 7 – Completed LBL array structures at EWT yard in Port Harcourt



Fig. 8 – Coating at PCNL yard at Port Harcourt Onne area

yard capabilities on par with Egina Project requirements. Next after the completion of LBL structure fabrication (figure 7), this has enabled EWT to qualify for the fabrication of some of the most massive structures of the project - the mooring piles of the Oil Loading Terminal

Buoy, which was recently activated.

Another local designated subcontractor has undergone qualification for insulation coating of the linepipes. The contract is now in place to coat either with 3LPP (anti-corrosion) or 5LPP (insulation) technology over 90 km of linepipes in Onne facility, near Port Harcourt (figure 8).

### Saipem has run an extensive training program for local engineers to develop multidisciplinary expertise

As part of the strategy of building local capacity, growing a proficient and qualified human resource base, and transferring know-how,

## Project in progress

Egina UFR is progressing well with detailed design already being three quarter completed. Next in the EPCI chain, the supply and procurement activity is soon to reach half way while the fabrication activities are gearing up, having already progressed to nearly 20% overall by now.

Four main fabrication sites in Nigeria and abroad are now fully engaged in delivering the 40,000 tons of



Fig. 9 – Risers anchoring piles at Saipem's yard in Port Harcourt



Fig. 11 – Coating of line pipes



Fig. 12 – Coating of line pipes



Fig. 10 – FPSO anchoring piles at Saipem's yard in Port Harcourt

assembled steel required to make up the complex Egina UFR subsea infrastructure.

Some of the heaviest structures such as risers foundations anchors (figure 9) and the first batch of FPSO anchoring piles (figure 10) are already progressed well over halfway which testifies of the pace at which this gigantic project is being executed.

Coating of linepipes in the in-country plant is steaming ahead with over 45km of 12 and 14 inch linepipes already coated to date (figures 11 and 12).

Saipem has also run an extensive training program for local engineers to develop the multidisciplinary expertise required for the development of deep water projects. It covered areas such as cathodic protection, geotechnical, subsea structures, flowlines, risers and installation engineering, and was performed both abroad (Saipem's deepwater competence center in Paris) and in-country.

Last but not least, Saipem has committed - as part of Egina UFR project - to provide 52,000 manhours of training under the National Human Capacity Development program (NHCD) for 20 Nigerian Nationals. Training of the first batch of 9 Nigerian Nationals is now well underway (15,000 manhours achieved to date), covering both theoretical knowledge and the development of competency through project exposure and experience.

## A benchmark for future deep water projects

Egina is proving to be an important milestone for the subsea field development industry, in view of its outstanding scale and by the technical challenges it presents for both engineering and construction works. Saipem is drawing on its experience and technologies developed over the previous deep water projects, so that it can successfully address the challenges at stake and set this project as a new benchmark for future deepwater UFR developments.

Most noticeably, this being the first major oil & gas project run under the Nigerian Content Act 2010, Egina is going to set a first in its kind, turning into reality the growth and valorization of the Nigerian oil & gas industry fostered by the Nigerian authorities.



### Armando Favi

Graduated with honors in Mechanical Engineering at the University of Ancona, Italy, Armando has performed his professional carrier in various companies of the Eni group.

His first assignment was with Norsk Agip in Norway where he spent five years – first at Det Norske Veritas in Bergen and then in Oslo – engaged with technology development projects in the field of deep water production systems and intervention methods and tools.

Back in Italy, he joined Snamprogetti Offshore Division with technical and subsequently commercial assignments.

In Saipem since 2002, Armando has been appointed Group Strategic Business Development Manager and later Vice President, Offshore Business and Technology Development. He is currently Vice President, Business Development, at Saipem Headquarters in San Donato Milanese, Italy.



### Guido D'Aloisio

Guido graduated with Honours in Mechanical Engineering (University of Ancona) and had a Diploma Intercultural Management (University of Cambridge).

He has more than 20 year experience in the oil & gas business (mainly in the offshore / deepwater design and installation activities relevant to risers, pipeline, flowlines, flexibles), participating to main deepwater developments in West Africa, like Kizomba and Akpo).

He is currently Project Director Egina Project, Saipem Contracting Nigeria Ltd.

Previous experiences within Saipem Group: Deputy

General Manager of Saipem Misr, responsible of E&C Business Unit in Egypt; Project Director for large EPCI Projects in Egypt: Burullus Phase IV, Sequoia and Burullus Phase 8B; Proposal Manager for EPCI Contracts in shallow and deep waters; Project Manager/Engineering Manager for EPCI contracts in deep waters; Proposal Manager/Project Engineering Manager for Subsea Processing Projects; Project Manager/Project Engineering Manager for Deepwater Pipeline Repair Systems.



# Advanced Process Control applied to Industrial Powerhouses

ABB software uses state-space models to implement real-time control in industrial process plants with seamless integration with existing automation systems

**Riccardo Martini, Fabio Podestà, Michele Strepparola**

*ABB Italy, Process Automation Division*



**A** macroanalysis of industrial control over the years shows a continuous trend toward greater levels of autonomy. As technology evolves, automation increases its presence and its importance, and automation takes over on tasks once performed manually. This does not apply only to production processes but it is part of a more general pattern seen in many different industries and environments.

A practical example of this trend comes from the world of aviation: a Lockheed Constellation of 1945 required a crew of five members (Pilot, Copilot, Navigator, Flight Engineer and Communications Operator) while today a single pilot can fly an aircraft with very limited manual operations.

The huge progress of automation allowed a drastic reduction of manual operations. A modern Flight Management System, known as FMS, allow pilots to

control and supervise aircraft by means of very few, high-level actions, compared to what necessary decades ago, when the crew had to execute a endless number of low-level actions, and among them, directly interact with positioning of aerodynamic surfaces.

The level of flight automation is such that not only electronics and electrical actuators move aerodynamics surfaces, but automation will safeguard flight by not allowing reaching critical conditions, such as a stall, regardless inputs sent by the pilot.

This feature, known as *flight envelope* protection and introduced in commercial aircraft in the 80s, is crucial in order to safeguard operation of commercial aircraft in all conditions [1].

In most of today flights, pilots directly manage the airplane only in the take-off and landing phases, while the airplane is flown by the autopilot for the remaining part of the flight.

In general, newer technology and more automation allow pilots to concentrate on fewer, higher-level decisions, e.g. deciding flight route, and reduce the need to perform continuous, low-level decision, like e.g. moving the aerodynamic surfaces as needed.

## Why advanced process control?

Moving back to industrial power plant and process industries, we can identify a similar path toward more automation and greater autonomy from manual actions. Advanced Process Control (APC) technology introduction is an important step in this path toward greater autonomy.

The idea behind APC is to move away from implementing multiple single-loop controllers that act independently on a single actuator and introduce a multivariable control system, able to optimize the operation of all these actuator in a coordinated manner. In other words, with the implementation of APC systems, process management moves from controlling a few key process variables separately to controlling an entire process unit in a coordinate manner.

Computational power limits and interface complexity in automation systems limited use of APC in its early days, back in the 70s.

However, improvements in mathematical algorithms and availability of computational capacity have eased significantly implementation of APC, allowing use of process models and configurable algorithms to reduce the need for ad-hoc engineering.

APC technology has therefore become common in the process industries since the early 80s. The first applications were introduced in the refining and petrochemical industry, but, over time, they gradually spread to all process industries, from chemicals end to power generation, from paper to food & beverage and so on.

As part of this general trend to use APC in various industries, there is an increased focus in implementing APC to Industrial Powerhouses. Real time operation of an Industrial Powerhouse with traditional technology requires management of many single-loop controllers. How to handle all them to increase efficiency and effectiveness of production is not always easy to understand. A modern APC-based architecture, with direct objectives set in terms of Powerhouse efficiency objectives is capable of optimizing production in all conditions and, at the same time, reduce operator workload.

## APC Technology

As discussed earlier, the purpose of APC technology is to manage the production process in a more structured and efficient way, using multiple actuators in order to pursue a set of coordinated production targets. In practice APC systems do not operate directly on the actuators, but instead they interact with single control loops set point. This allows retaining benefits associated with the use of the control loops on the DCS/PLC, like linearization of actuator, fast response to disturbances etc.

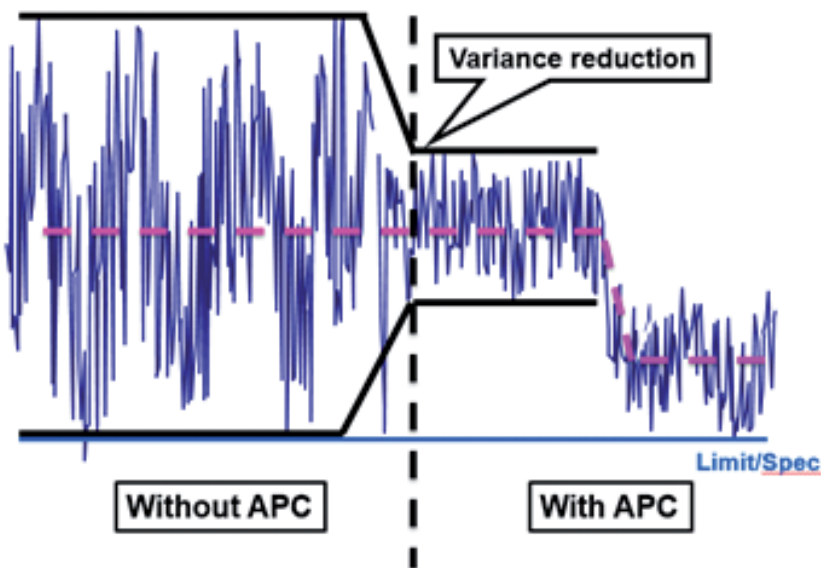


Fig. 1 - How APC improves process control

A modern APC system uses an explicit model of the process to estimate future behavior. Its ability to predict process future values (at least in the *short term*) allows handling of multiple targets and constraints explicitly. As a result, application of this technology brings a reduction in the variability of key process variables compared to a traditional control strategy.

A reduction in process variability has an associated value in itself but, even more interesting, we can use this to increase the profitability of production, for example, by increasing production throughput or reducing production costs.

We can summarize this concept is the **figure 1**: as APC

reduces process variance, plant operation can move operating point to improve production margins while considering all relevant constraints.

The key to this technology is the use of a dynamic model of the process, used in real-time computing, to estimate future trends.

The calculation algorithm considers the process model and a structured set of targets like, as an example, production and physical constraints and is able to determine the optimal moves for the underlying single loop controllers.

Over the years, APC technology has evolved from an approach based on a matrix linking input and outputs dynamics, to a *state space* formulation, using a state vector  $X$  to estimate future values for model outputs through the well-known equations:

$$x(k+1) = Ax(k) + B_u(u(k) + w(k)) + B_d d(k)$$

$$y(k) = Cx(k) + v(k)$$

Where it is:

- $u$  inputs vector
- $y$  outputs vector
- $x$  state vector

ABB multivariable process control software, Optimize<sup>T</sup> Predict & Control, uses state-space models to implement real-time APC control in industrial process plants.

Further details on the APC technology, its evolution and benefits from state-space formulation can be found in articles [2, 3, 4].

## APC applied to Powerhouses

As briefly mentioned, multiple, key technical points favor use of APC technology in Powerhouses and Industrial Power Plants. Among them are:

- multiple process objectives, very often conflicting or partially conflicting;
- configuration with multiple equipment in parallel e.g. boilers, turbines, steam headers, very often with different efficiency;
- presence of multiple degrees of freedom;
- large values/costs at stake;
- different dynamics playing a role – from very fast to slow ones.

APC on Powerhouses is nowadays a mature technology, thanks to hundreds of installations in recent years. Articles [5, 6] provides insight on a few APC implementations on Power plants and Powerhouses. Let us consider the case of an APC application at a Sugar Beet refining plant. The refining process, where

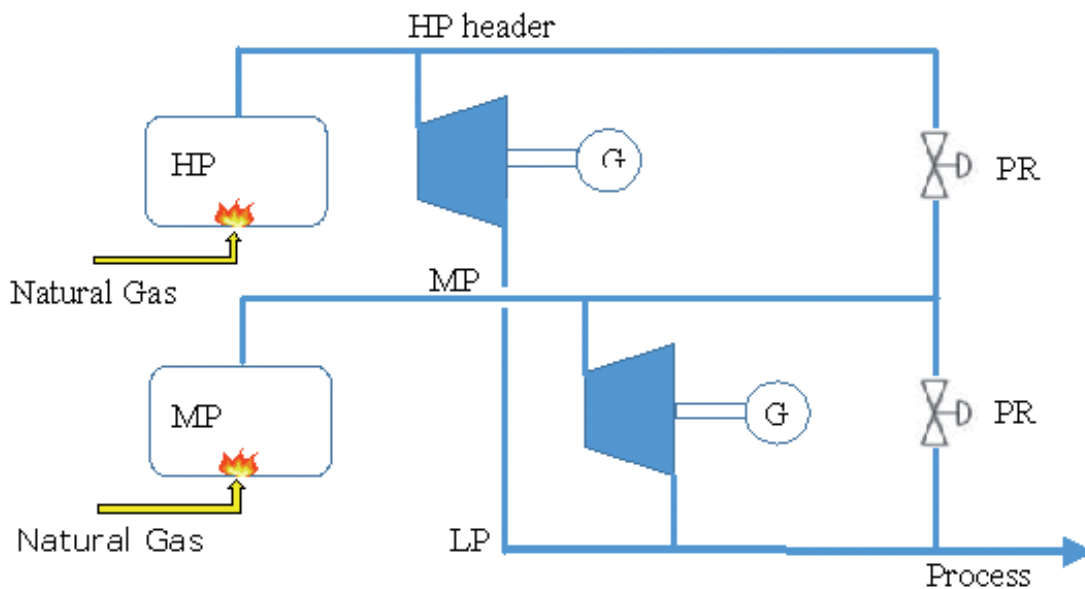


Fig. 2 - Powerhouse simplified configuration

the sugar is extracted from beets and concentrated in various steps until the final stage of crystallization, use large amounts of steam and electrical energy. As a result, each Sugar Beet plant features an integrated Powerhouse to produce all the steam necessary to sustain the main process.

The overall process shows strong, mutual, interactions between multiple areas of the plant, especially between the refining process and the powerhouse, providing an edge to the use of APC technology.

ABB implemented an APC system to a Sugar Beet plant in the Mediterranean region in 2013. The application covers the evaporation section and the Powerhouse, closely interconnected and continuously interacting among them, to maximize energy efficiency for the overall plant.

The APC system directly control production quality (Brix – sugar density) by modulating the main production parameters, like steam usage, in a proper way. In addition, while maintaining production quality and quantity targets, the APC system optimizes Powerhouse, so to minimize its production costs.

This article will focus on the powerhouse section given its widespread use in industrial plants.

## Powerhouse configuration

The plant Powerhouse, despite having some peculiar characteristics, has configuration that is relatively common in industrial environments.

The overall layout is based a backpressure configuration, with two separate boilers, generating steam at two separate pressure levels, 65 and 40 bar, made available on two headers, referred to as HP and MP steam headers in this article.

Each steam header has an interconnected steam turbine, with both turbines outlet connected to a common LP steam header. Attemperators are also available on both the boiler outlets and on the LP steam header and Pressure Reducing Valves (PRVs) are

located between HP and MP steam headers and, also, between MP and LP steam headers.

The **figure 2** shows a simplified diagram of Powerhouse. Steam turbines drive two separate electrical generators, used to provide power supply to the entire plant, for a total generation of up to 25 MW. The internal electrical grid operates as an *electrical island* with no electrical interconnection to the national grid.

As known, when the interconnection to the electrical grid is in place, the grid acts as a prevalent source of energy and hence stabilizes frequency at 50 Hz. However, in an electrical island configuration, the local power production and consumption must be balanced at all times to avoid frequency fluctuations. This implies that turbine control needs to trim steam inlet in the turbines so to balance power production following load changes.

In this configuration, any change in electrical loads causes an action by turbines control to counterbalance the change; this action, in turn, affects steam demand to the boilers, causing a continuous trimming of boilers and steam.

In addition to that, crystallization ovens, a key equipment in a Sugar Beet plant, are an important and large LP steam user. These ovens follow specific production sequences/batches, with steam usage that is highly variable over time. These constant changes in LP steam usage, combined with the need for frequency control performed by turbines, create a strong and continuous disturbance to the powerhouse.

Additional factors contribute powerhouse management complexity in this site. Equipment efficiency is quite different for the two boilers and, especially, for the two turbines. The HP turbine is newer than the MP turbine and its specific production, expressed as power produced divided by the steam flow inlet, is significantly higher.

In normal cases, the grid acts as a prevalent source of energy and hence stabilizing frequency at 50 Hz. In an electrical island configuration, the local power production and consumption must be balanced at all times to avoid frequency changes in the local grid

As a result, the general recommendation for plant operators is, whenever possible, to increase the load of the HP turbine at the expense of the MP turbine so to increase overall efficiency.

Load distribution between turbines, although important for the overall efficiency, must be operated with caution: it is known from practical experience that the turbine of HP loses frequency control ability when its

actuator position is over 92%. Similarly, plant operators should avoid bringing MP turbine to its low limit as this condition may also affect overall ability to control frequency.

In addition to that, there is a general target of reducing the average opening of Pressure Reduction Valves (PRVs) between the headers. Although this objective is obvious from the energy point of view, in practice the demand for process steam is on average higher than steam needed to balance the electric load, so PRVs needs to be partially open in most cases. Therefore, if a complete closure of these valves is

not possible, valve-opening minimization is extremely important and should be pursued at all times.

Combining these practical limitations with the continuous changes in plant loads and in plant steam demand renders powerhouse optimization a demanding task. In practice, Operators tend to optimize powerhouses only to a certain extent, always retaining significant safety margins. With no APC system in place, operators do not update setpoints as process conditions change continuously, thanks to these safety margins, but that happens at the expenses of additional production costs.

Implementing an APC system for supervision and control of powerhouse along with process to streamline utility management looked to be the ideal solution to optimize production. Still, introducing APC in a Powerhouse is not a trivial task due to several reasons e.g. fast dynamics and use of complex equipment.

Equipment efficiency is quite different for the two boilers and, especially, for the two turbines. The HP turbine is quite newer compared to the MP turbine and its specific production, expressed as power produced divided by the steam flow inlet, is significantly higher

In order to control efficiency and hence maximize profits, the APC system should vary HP and MP turbines generation. However, considering that the plant operates as an electrical island, it is not appropriate to move separately HP and MP turbine, as the total generation must continuously equal the total electric consumption in the plant.

It is obvious, therefore, that any decrease in MP turbine generation must counterbalance a similar increase in HP turbine generation, so that the action of APC system is neutral to the frequency control.

However, this specific Powerhouse did not allow direct control of turbine generation due to equipment age. Turbine generation trim was possible only by means of up/down signals, adding further complexity to the APC implemented. The project team implemented a DCS scheme to automatically generate up/down pulses to the two turbines as needed distribute the load in a balanced way and following APC software requests.

A further hurdle to the power management efficiency is that shifting production between the two turbines has an effect on the overall power factor for the generators, which in turn has an impact on the internal grid electrical losses. So, in order to keep the two generators with a balanced power factor and optimize the internal grid efficiency, ABB implemented an automatic trim of generators output voltage to rebalance power factors as the APC system acts on the generators active power output.

The **table 1** shows a list of the main controlled and constrained variables (CVs) and manipulated variables (MVs).

## Project execution

One of the key points in the execution of successful APC projects is the need for a continuous and proactive cooperation between the APC supplier and the customer. In fact, the very nature of this technology requires that the APC implementation team members have a good understanding of the process, including its bottlenecks and basic economics. Although it is

Table 1 APC main variables for Powerhouse

CVs	Process constraints	
	PRVs valve openings	minimize
	HP turbine actuator	keep close to a maximum
	Methane usage	minimize
MVs	HP steam pressure	
	MP steam pressure	
	LP steam pressure	strong link to product quality
	MP boiler output	
	Attemperators HP / MP / LP	
	Turbine load distribution	
FFs	Sugar production load	strong link to product quality

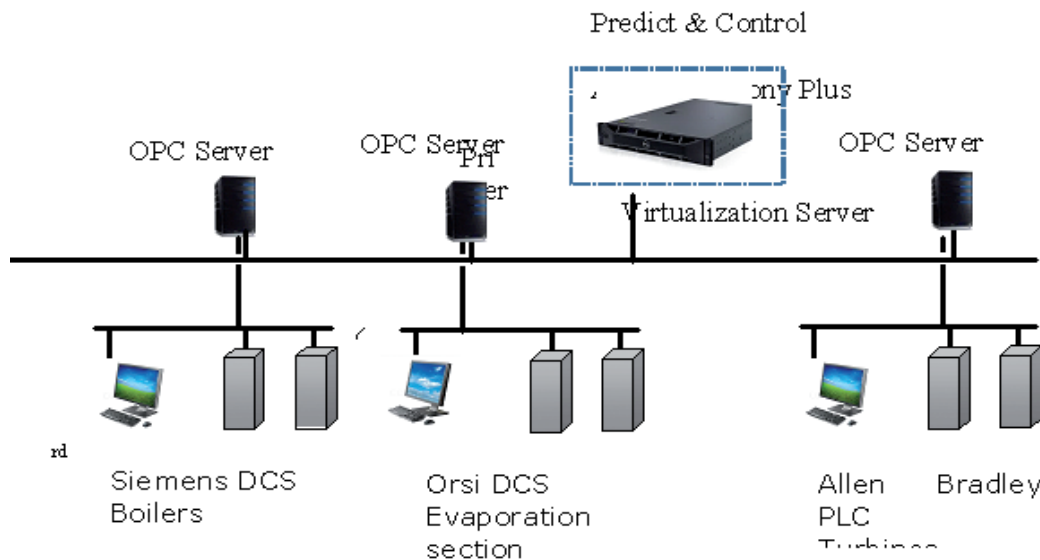


Fig. 3 - Integrated architecture

extremely useful that the supplier has already a significant expertise on the process, even more important is a continuous exchange of information with the customer in order to design and implement the APC application.

In this specific case, ABB and the customer created a very integrated, cohesive and proactive team and with experience in various disciplines: from Process Technology to Energy Management, from Plant Automation and Instrumentation to Plant Production Management.

ABB and the customer have cooperated in all the project phases:

- Initial Design;
- Functional Specification issue and review;
- Base control loop consolidation – instrumentation and actuator review, PID tuning;
- Process Model Identification;
- APC System Configuration;
- APC System Integration with Plant DCS;
- Pre-commissioning and test.

Several factors contributed to create a particularly complex and challenging project. Among them, we can mention:

- Execution schedule - short and challenging;
- Integration challenges – Multiple, separate automation systems covering evaporation, Powerhouse and steam turbines sections.

Regarding the project schedule, it is important to notice the normal production run for this type of plant is some 3-4 months per year. Sugar beet availability is in fact limited over the year and that influences the duration of production campaign.

As known from the general technology background, plant data collected during normal operation while performing some small perturbations, the so-called *step tests*, are necessary build the APC model. As a

result, the process model identification and all other APC related tasks could only be executed in this very short production run.

Based on that, the execution team decided to schedule all the most important activities, from data collection to the identification of the model up to the pre-commissioning over a period of about three months, from August to October 2013.

To further add to complexity, integration with the existing Plant Automation Systems required interaction with three, separate, DCS/PLC systems. The execution team designed and implemented an integrated solution, using the OPC DA technology to consolidate the three separate automation systems into a single integrated environment using ABB Symphony Plus platform and implemented the APC system on top of Symphony Plus platform.

All these steps were executed by using Virtual Machines configured on a customer pre-existing virtualization server. One of the two Virtual Machines is dedicated to offline engineering while a second one operates as real-time control APC. Both Virtual Machines host Optimize<sup>T</sup> Predict & Control software modules.

This integrated architecture, presented in the **figure 3**, allowed the implementation team to reduce lead-time and avoid new hardware supply to a site that has already dozens of servers and workstations to maintain.

## Benefits

The APC system showed tangible benefits in the powerhouse management and, more generally, in the overall process management, during the tests and the pre-commissioning. The main benefits reported can be summarized as:

- 1-2% reduction of powerhouse average specific consumption;
- 58% decrease in steam venting in the evaporation section;

- product quality stabilization (35% reduction in product quality standard deviation).

The following figure shows the increase in the specific productivity brought by APC during the pre-commissioning.

The chart shows that, following APC system turn on and its increase in HP turbine load, the computed steam/methane ratio increases by an average of 2% with a consequent reduction in the natural gas purchase.

The figure shows set point difference between HP and MP turbines, in blue, and the produced steam/natural gas flow ratio, in green. As the APC switches on, moves load from MP turbine toward the HP turbine, finally reaching the maximum allowed opening for the HP turbine actuator, indicated with the dotted red points. Apart from the steam use fluctuations, linked to sugar ovens cycles, the overall trend is an increase in the specific production as load on the turbines is re-balanced by the APC system.

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## Riccardo Martini

Riccardo is Advanced Process Control Operations Manager for ABB Italy, Oil Gas & Petrochemical Business Unit. He graduated in Electrical Engineering at Genoa University in 1994.

Riccardo has over 15 years experience in Advanced Process Control and Process Optimization, covering a different process units and different markets, from

Refining to Petrochem, from Gasification to Gasification to Power Generation. From November 2005 to December 2009 he acted as Product Manager for the ABB Multivariable Process Controller software Optimize IT Predict & Control. He is author or co-author of more than 10 papers published on technical magazines or presented at international conferences.



## Fabio Podestà

Fabio joined ABB in 2001 as software engineer; over the years has worked in the area of Scada software development and operations. Later on he moved to process management, acting as Lead Engineer for Alarm Management & Optimization.

In 2011 he joined the APC & Process Optimization group. Since then he has focused mainly on ABB APC applications and worked, as application specialist, on several complex projects.



## Michele Strepparola

Michele is a Service Sales Manager for ABB Italy, Pulp & Paper, Metal, Chemical and Pharma Business Unit. He graduated in 1997 in Electronic (Optoelectronic) Engineering at Milan Politecnico.

The experience of Michele started in 1999 in service for consumer electronics focusing on customer care and

then moved to industry service for ABB in 2008. Focus of his Activities are Proactive, customer oriented and advanced services. Strong specialization on revamping of old ABB and third party DCS (Distributed Control System) is the challenge of the last years.



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# CO<sub>2</sub> Capture in Steam Methane Reforming Hydrogen Plant

Impact of emissions reduction technologies on plant performance and economics

Guido Collodi, Giuliana Azzaro

Amec Foster Wheeler



concentrations in the earth's atmosphere are driving efforts to reduce emissions of CO<sub>2</sub> by means of integration of carbon capture systems into hydrogen production units.

The paper will highlight the key features of the leading technology used for hydrogen generation at industrial scale, Steam Methane Reforming (SMR), the available options for integrating CO<sub>2</sub> capture system within a SMR based

*160,000 Nm<sup>3</sup>/h hydrogen production plant based on steam methane reforming, designed and supplied by Amec Foster Wheeler*

plant and the relevant economic impact.

**H**ydrogen is one of the key starting materials used in the chemical industry and an indispensable part of refinery operation. It plays a major role in the production of clean fuels

and its demand has increased with the introduction of stricter environmental regulations requiring the use of low sulphur gasoline, diesel and marine fuels.

More than 95% of the hydrogen produced is obtained from steam reforming of fossil fuels (natural gas, refinery off-gases and others).

Hydrogen is used in several oil refining processes including hydrocracking, hydrodesulphurisation and isomerisation. These processes are becoming more prevalent due to the decreasing quality of crude oil and the decreasing demand for heavier products.

Besides hydrogen, significant amount of CO<sub>2</sub> is raised in the process conversion of fossil fuels to hydrogen.

Environmental concerns on increasing CO<sub>2</sub>

## 1. The steam reforming hydrogen plant

Nowadays, steam methane reforming remains the leading technology for production of hydrogen in the oil refining, chemical and petrochemical industries.

The basic process of converting natural gas or other light hydrocarbons into hydrogen in a SMR plant consists of the following steps:

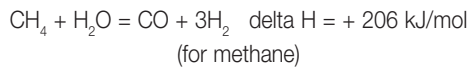
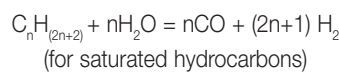
- feedstock treatment, where sulphur and other contaminants are removed;
- steam methane reforming, which converts feedstock and steam to syngas (mainly hydrogen and carbon monoxide) at high temperature and moderate pressure; in case of multiple or heavy feeds and/or for large capacities, an adiabatic, catalytic pre-reforming step is foreseen upstream the SMR;
- syngas heat recovery, which includes CO shift

reactor/s to increase the hydrogen yield and syngas cooling section to recover heat from the produced syngas;

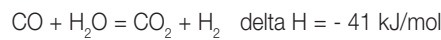
- raw hydrogen purification, which, in modern plants, is accomplished via Pressure Swing Adsorption (PSA) unit and allows to achieve hydrogen product purity above 99.99% mol.

In addition to the core process sections above described, compression is often needed to raise the feedstock and product hydrogen pressures.

The reforming reaction between steam and hydrocarbons is highly endothermic and takes place across specially formulated nickel catalyst contained in vertical tubes situated in the radiant section of the reformer. The simplified chemical reactions are:



In the adiabatic CO shift reactor vessel, the moderately exothermic water gas shift reaction converts carbon monoxide and steam to carbon dioxide and hydrogen:



The PSA purification unit removes from the hydrogen, by adsorption, CO, CO<sub>2</sub> and CH<sub>4</sub> gases.

SMR is a mature technology and is now less likely to yield any large step changes in economic benefit from technological developments. Improvements and optimization opportunities are constantly investigated with reference to plant efficiency and plant profitability.

## 2. The CO<sub>2</sub> balance in the hydrogen plant

In a modern steam reforming hydrogen plant fed by

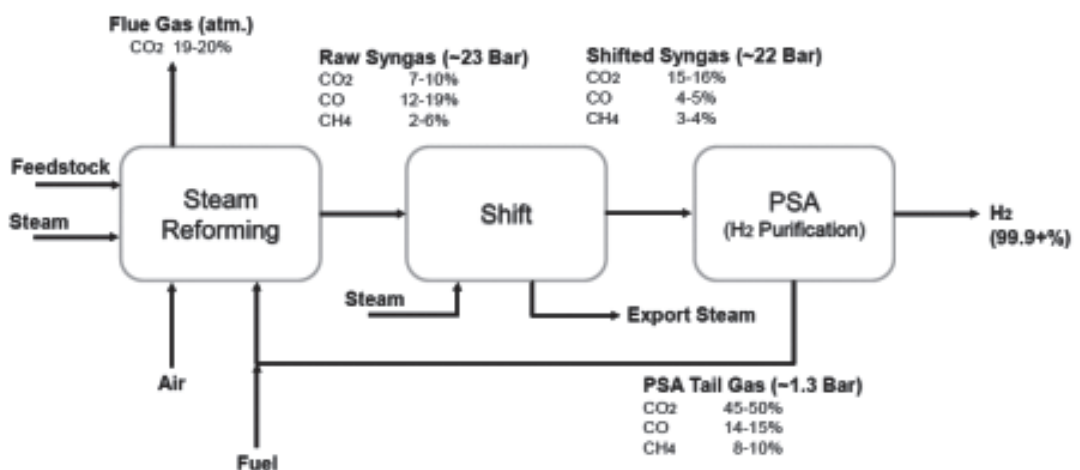


Fig. 1 – Simplified H<sub>2</sub> block flow diagram (pressures are in bar absolute)

natural gas, up to approx. 60% of the total CO<sub>2</sub> produced is contained in the shifted gas (and then in the PSA tail gas), while the remaining 40% is the product of the combustion of the additional fuel gas required by the steam reformer. At last, all the CO<sub>2</sub> ends up in the flue gas of the SR heater (figure 1).

Typical CO<sub>2</sub> flow rates and partial pressures for a 100,000 Nm<sup>3</sup>/h hydrogen plant are reported in table 1. It is clear from this example that one ton of hydrogen produced will also produce about 9 tons of carbon dioxide.

The CO<sub>2</sub> could be captured from any of these three streams (figure 2), with removal efficiency of about 90% (from PSA tails gas and from SR flue gas) and up to more than 99% (from raw H<sub>2</sub> at higher pressure). The total CO<sub>2</sub> potentially removed ( $\eta_{CO_2}$ ) from the three locations, calculated with the formula

$$\eta_{CO_2} (\%) = 100 \times (1 - CO_2 \text{ in flue gas after rem.} / CO_2 \text{ in flue gas without CO}_2 \text{ rem.})$$

is reported in table 2.

It is also possible, in principle, to combine CO<sub>2</sub> removal 1 or 2, with 3 (from flue gas), and obtain an overall  $\eta_{CO_2}$  of about 96% and 94% respectively.

## 3. CO<sub>2</sub> removal technologies

There are several available technologies for CO<sub>2</sub> removal, at different stage of development and commercialisation. The most important de-carbonization technologies that can be employed for capturing CO<sub>2</sub> in SMR hydrogen plants include:

- pre-combustion processes (i.e. from syngas);
- post-combustion processes (i.e. from flue gas).

The next paragraphs will briefly review such technologies and their application. For sake of simplicity, the review is here limited to the CO<sub>2</sub> removal cases 1 and 3, yet recognising the potential carbon capture also from PSA tail gas.

Table 1 – Typical H<sub>2</sub> plant carbon balance

Stream	CO <sub>2</sub> concentration (% mol) wet basis	CO <sub>2</sub> flow rate (kmol/h)	CO <sub>2</sub> partial pressure (bara)	CO concentration (% mol) wet basis	CH <sub>4</sub> concentration (% mol) wet basis
Raw H <sub>2</sub> (PSA inlet)	15.0-16.4	1,000-1,100	3.40-3.7	4.0-5.0	3.0-3.5
PSA tail gas	45.1-50.4	1,000-1,100	0.60-0.67	14.5-15.0	8.5-9.5
SMR flue gas	19.0-19.5	1,850-1,930	0.20	==	==

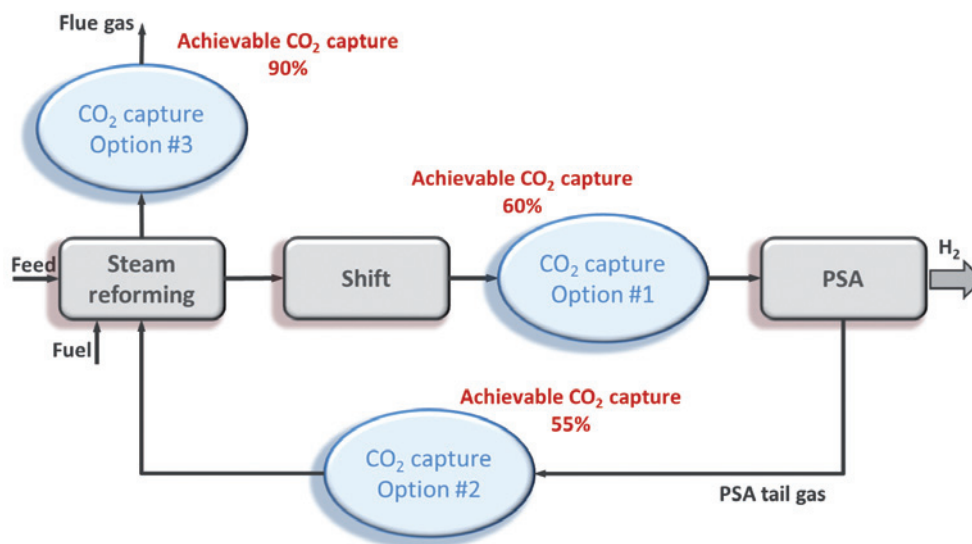


Fig. 2 - CO<sub>2</sub> removal locations

Table 2 – Achievable CO<sub>2</sub> removal

CO <sub>2</sub> removed from:	CO <sub>2</sub> removed from each stream (%)	Overall η <sub>CO<sub>2</sub></sub> (%)
1.Raw H <sub>2</sub> (PSA inlet)	100	60
2.PSA tail gas	90	55
3.SR flue gas	90	90

### 3.1 Pre-combustion processes

According to these processes the CO<sub>2</sub> is removed from the syngas stream exiting the shift section after condensate separation.

The CO<sub>2</sub> removal from syngas is performed at relatively high total pressure (26 - 31 bara) and CO<sub>2</sub> partial pressure (3 - 4 bara). There are several technologies available, most of them being used in ammonia plants CO<sub>2</sub> removal section, or in the “old fashion” hydrogen plant, before the introduction in the market of the PSA technology for hydrogen purification.

Main technologies include:

- amines (MEA, MDEA, aMDEA);
- hot potassium carbonate;
- physical solvents (PEGE, methanol);
- membranes.

The first three categories use liquid solvents in an absorption/regeneration sequence. The “chemical”

solvents in this application are generally less expensive than the “physical” ones and allow an almost complete removal of the CO<sub>2</sub>; depending on plant layout, the CO<sub>2</sub> stream is made available at high purity (say > 98.5% vol.) and at a pressure of 1.5 - 2.5 bara. Membranes performances in terms of removal efficiency and purity are expected to be lower.

When a traditional plant is retrofitted with the addition of such removal unit, the steam reformer burners have to be checked for the new tail gas composition which, being poorer in CO<sub>2</sub>, has a higher tendency to NO<sub>x</sub> formation, with the consequence that low-NO<sub>x</sub> burners and/or space for a future installation of a de-NO<sub>x</sub> catalytic system in the convection section of the heater, could be considered at the design stage. As a consequence of the retrofit the PSA will have some capacity margin due to the reduced inlet flow rate after CO<sub>2</sub> removal.

Licensors active in these technologies include: Basf, Giammarco-Vetrocoke, Linde, Air Liquide, UOP etc.

### 3.2 Post-combustion processes

Post combustion technologies foresee the CO<sub>2</sub> capture downstream the combustion section. In this case, carbon dioxide is contained in the flue gases from the steam reforming furnace together with other products and inerts from combustion.

As indicated in table 1, the CO<sub>2</sub> present in the steam reformer flue gas has a very low partial pressure (about 0.2 bara) and the flue gas actual volumetric flow is 20 times or more the raw syngas volumetric flow (m<sup>3</sup>/h). These two factors and the presence in the flue gas of components like oxygen, sulphur, NO<sub>x</sub>, dust, makes the CO<sub>2</sub> removal from this stream generally more complicated and expensive. Nevertheless its quantity is very high (table 1) and its capture is being considered an environmental and economical challenge.

Main technologies include:

- amines (MEA, MDEA, “hindered” amines);
- chilled ammonia;
- membranes.

The basic principles of CO<sub>2</sub> removal from flue gas are the same as from raw hydrogen, but the experience is so far limited. The environmental concern related to the GHG emissions is determining a growing interest for this application in many industries, for example in the power sector.

In practical terms a CO<sub>2</sub> removal of 85 - 90% is an acceptable target, and the CO<sub>2</sub> is also in this case obtained at high purity and low pressure.

No pre-investment is needed in case of retrofit of a traditional plant, however additional ducting and ID fan addition/replacement shall be considered when the unit is added to the SMR plant.

Licensors active in these technologies are: Axens, Fluor, GTC, MHI, MTR etc.

## 4. Case study

In this section the economic impact of adding a CO<sub>2</sub> removal unit to a SMR based hydrogen plant is analysed.

The conclusions below reported are taken from the preliminary results of the study (under development) prepared by Amec Foster Wheeler Italiana for IEA GHG *Techno-economic Evaluation of H<sub>2</sub> Production with CO<sub>2</sub> capture*.

In the mentioned study, pre-combustion and post-combustion CO<sub>2</sub> removal options are considered. Both technologies are amine based and the results have been gathered using in-house simulations and available technical documentation. Different technical solutions may of course lead to different results, especially considering the different level of maturity of the technologies involved.

The selected hydrogen production is 100,000 Nm<sup>3</sup>/h (from natural gas). For the economic and technical evaluations, the units considered in the study include:

- SMR hydrogen plant;
- CO<sub>2</sub> removal plant (if present);
- cogen plant.

The cogen plant produces the electricity and LP steam required to fulfil the hydrogen unit and CO<sub>2</sub> removal system requirements.

The CO<sub>2</sub> removal efficiency from raw H<sub>2</sub> and from flue gas is considered 100% (rounded off) and 90%, respectively. The pure CO<sub>2</sub> stream is then compressed to 110 bara for sequestration, EOR or other utilisation (out of the scope of the study).

The economics of the alternatives are evaluated through the “abatement cost” concept.

Abatement cost (AC) is defined as the incremental cost of a low-emission technology compared to the reference case, measured as € per ton CO<sub>2</sub> abated emission (ICCA, 2009):

$$AC = \frac{(\text{Full cost of CO}_2 \text{ efficient alternative}) - (\text{Full cost of reference solution})}{(\text{CO}_2 \text{ emissions from reference solution}) - (\text{CO}_2 \text{ emissions from alternative})}$$

The full cost of the alternatives includes investment cost (calculated over 25 years at 8% discount rate), operating costs and possible cost (energy) savings generated by the use of the alternatives. Other economic data:

- natural gas price = 16.8 - 50.4 €/GJ
- electric power price = 70 €/MWh

The results are summarized in **table 3**.

The two AC values per each CO<sub>2</sub> capture case refer respectively to the low and high values assumed for the natural gas.

The “abatement cost” so calculated, compared with the EU-ETS (European Trading System) carbon trading price is an indicator of the profitability of the initiative. This allowance is currently very low (ranging 5-10 €/ton CO<sub>2</sub>) therefore providing the industry with little incentive to invest in low-polluting technologies.

In order to encourage companies in investing in low emissions technologies it is necessary to strengthen the EU-ETS, thus making carbon capture systems integration more attractive options to consider.

## 5. Conclusions

The analyses performed in this study lead to the following conclusions:

- CO<sub>2</sub> emissions from SR hydrogen plants are significant and have the potential to impact the economics of hydrogen production;

Table 3 – CO<sub>2</sub> capture comparison and results

	No CO <sub>2</sub> capture	CO <sub>2</sub> capture 1 (Pre-combustion)	CO <sub>2</sub> capture 3 (Post-combustion)
CO <sub>2</sub> abated emission (t/h)	0	46.6	80.5
NG consumption (Gcal/h)	Base	+11.4	+34.1
Power consumption (MW)	Base	+3.6	+8.3
Investment cost (MM€)	Base	+32	+102
AC (€/t CO <sub>2</sub> abated emission)	<b>0</b>	<b>41 – 50</b>	<b>77 – 101</b>

- CO<sub>2</sub> capture technologies are available and applicable to SR hydrogen plants; experience of removal from syngas is consolidated; fewer references are present in the removal from flue gas, but technology and interest is growing;
- from an economic point of view, with the assumptions indicated in the previous paragraph, the CO<sub>2</sub> abatement cost from flue gas is substantially higher than from raw H<sub>2</sub> and in both cases higher than the current carbon credit;
- investment costs for the two alternatives have an approximation inherent in this kind of studies; however macroeconomic variables like interest

rates, carbon market or socio/political decisions may have a highest impact than the error margins, and may heavily affect the economics of the proposed solution.

## References

Amec Foster Wheeler Italiana for IEA GHG: *Techno-economic Evaluation of H<sub>2</sub> Production with CO<sub>2</sub> capture* (under development)

ICCA, 2009: *Innovations for GHG Reductions, a Life Cycle Quantification of Carbon Abatement Solutions Enabled by the Chemical Industry.*

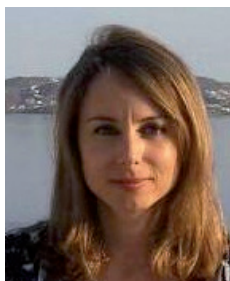


## Guido Collodi

Guido is Process Director, Chemicals, in the Contract Operations of Amec Foster Wheeler in Milan, with responsibilities in fertilisers, syngas derivatives, hydrogen, and SNG technologies. Before joining Amec Foster Wheeler in 2006, Guido spent his career in the process department of Snamprogetti (now Saipem), entrusted with inorganic chemical plants such as

hydrogen, ammonia, methanol and syngas. He then became Technology Leader with process responsibility in major IGCC and gas to liquids projects.

Guido Collodi has published several papers on IGCC, gasification, hydrogen and flue gas treatment and gained his degree in Chemical Engineering from University of Pisa, Italy, in 1979.



## Giuliana Azzaro

Giuliana is a Chemical Engineer with over 10 years' work experience in specialty chemicals, consumer products and oil & gas industries.

She graduated in 2003 at Università degli Studi in Palermo and afterwards she moved to the UK where she spent six years working for multinational companies, covering both manufacturing and process engineering roles.

Her background includes experience in catalyst

business sector with a focus on catalysts/absorbents used in syngas, hydrogen, methanol and ammonia plant applications.

In Amec Foster Wheeler - Contract Operations - since January 2011, Giuliana has taken part in the development of several projects as a Senior Process Engineer and Process Coordinator with a focus on Hydrogen Plants Design and Hydrogen Technology development.



Fig. 1 - Plant panoramic from South Area

# SSBR Rubber- Manufacturing Industry is on its Way Up

APS rises to the challenge of designing and constructing in just two years a new plant for production of solution polymerized butadiene rubber located in Poland

Martina Marmotta, Fabio Paliotta, Ludovico Dorrucchi  
APS



capacity of the plant is 90.000 thousand tons per annum. It will have capability to produce non-oil & oil extended products. APS was in full charge not only of the construction management of the plant, but also of the detail design work, the purchase of all equipment, the supervision and the coordination of civil and electromechanical erection, pre-commissioning, commissioning and start-up activities. In collaboration with the local partner KTI Poland, who has played a substantial role in bringing this initiative to fruition, APS has come close to finishing his mission.

The plant, situated in industrial area in Oswiecim (Poland), needed to be finished in just 24 months because the start of production line is planned in the second half of 2015. The cost of the project was PLN 568 M, of which PLN 147 M co-financed by the EU funds [Source: Press Release of Synthos S.A. on web]. Project investments was part of a sectorial scheme that aimed at implementing the volume and value of exported goods of Synthos Capital Group in the worldwide markets and developing the special economic zone of Oswiecim.

These are of huge importance for the Polish national economy thereby creating numerous jobs and giving a new fillip to growth. A local content rule has been sufficiently implemented and a regional network of suppliers has benefited directly. The services of local providers has been used in order to reduce the product/equipment cost and minimize the delivery time to site. In this context, the involvement and support of KTIP, with its headquarter in Poland, has been essential. The knowledge of the country and the language together with a win-win approach has brought to overall projects benefits by facilitating the exchange of information between the all parties involved. Just as it was expected, the strategic economy has been extremely successful providing the acquisition of KTIP Company that is part of APS Group since 2013.

APS primary objectives of the project were to provide the customer with a plant, which:

- minimizes capital investment;
- ensures a design which is “fit-for-purpose”;
- is “environmentally friendly”
- incorporates the latest technologies in the basic design;
- ensures the resulting facility providing high standards of safety, reliability, operability and maintainability.

The plant is made by a classical process area and by a finishing area and includes four drying lines where polymers are compressed and the exceeding content

The plant, situated in industrial area in Oswiecim (Poland), needed to be finished in just 24 months because the start of production line is planned in the second half of 2015

**O**n March 2013 APS has been awarded for an important EPCM (Engineering, Procurement and Construction Management) project, following a public tender organized by one of the largest manufacturers of emulsion rubber, Synthos Group SA.

APS has managed to gain due to its competitive price, a proposed short time schedule and professional know-how. Based in Rome and operating since 1997, APS enjoys a high reputation in the engineering business world for its capabilities in the oil & gas processing and treatment facilities (including power generation and petrochemical & chemical plants). Today the challenge to execute the new production line for SBR rubber in Poland affirms APS opening to rubber complexes field. Experiences with Versalis in Far East Regions and in North Africa had fully grown the company portfolio and have contributed to this last successful result.

The analyzed project aimed to increase the competitiveness of the plant owner by developing a new innovative SBR (Solution Styrene-Butadiene Rubber) rubber product, based on a license agreement with the Goodyear Tire & Rubber Company. Production

of water is removed. Once the rubber has been separated from remaining, it is conveyed to a press that gives to the product the final shape, which is a rubber bale.

At this point in time, the SSBR project has entered into a final phase, supervising the construction, pre-commissioning and commissioning as the planned start is on next June (figure 1).

## Rubber manufacturing process

Synthetic rubber has its origin in two main raw materials: butadiene and styrene, produced in specific petrochemical production units. When the two are mixed in the presence of soapsuds in a reactor under desired conditions of temperature and pressure, liquid latex results. The downstream elastomer rubber manufacturing generally comprises the following operations (figure 2): raw materials handling, weighing and mixing, milling, extruding and calendaring, component assembly and building, curing or vulcanizing, inspection and finishing, storage and dispatch.

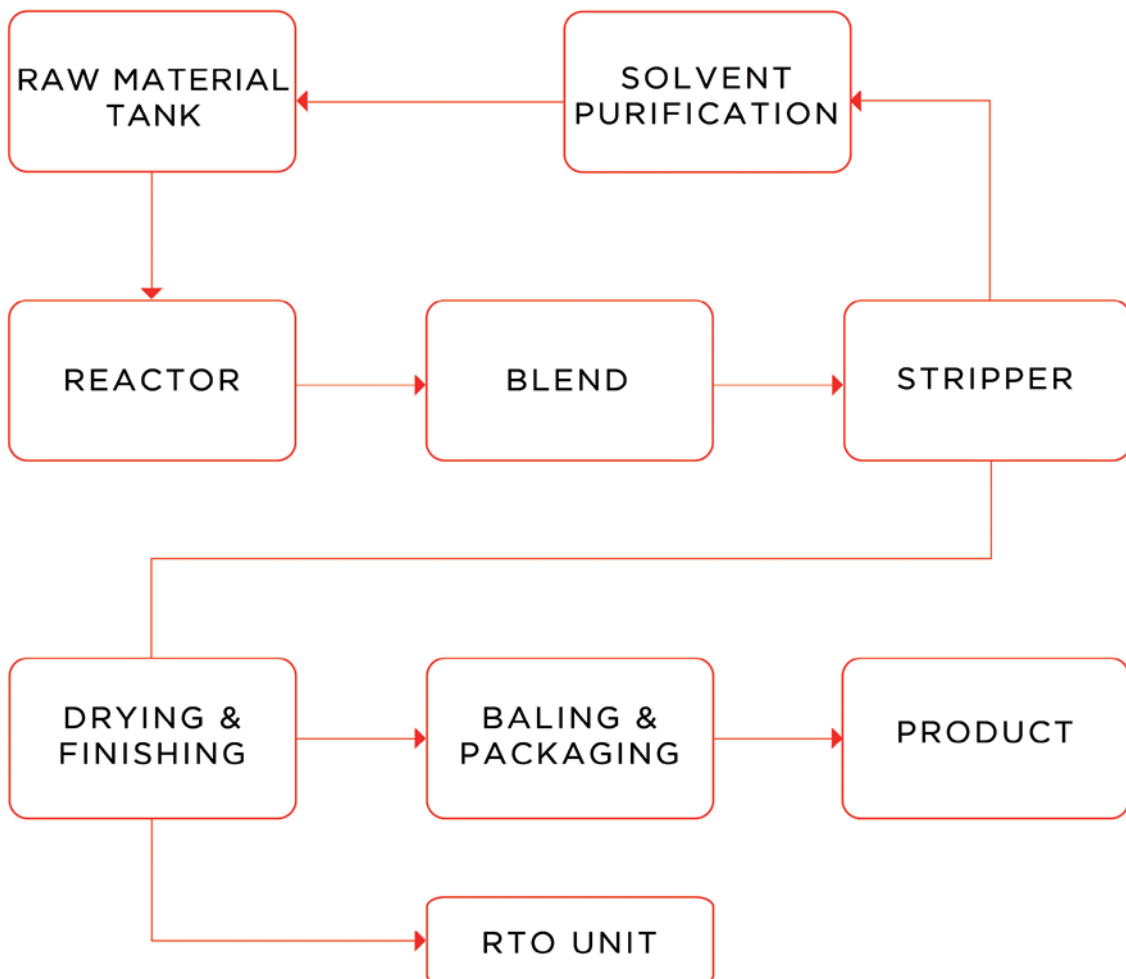
Although the stages described below are applicable to the majority of rubber goods manufactured from solid polymer, a substantial proportion of rubber production

involves the use of latex. The by far most important type of rubber is SBR (Styrene Butadiene Rubber), that have a good abrasion resistance and good aging stability when protected by additives. In 2012, more than 5.4 million tons were processed.

Synthetic rubber has its origin in two main raw materials: butadiene and styrene, produced in specific petrochemical production units. When the two are mixed in the presence of soapsuds in a reactor under desired conditions of temperature and pressure, liquid latex results

This analysis fits perfectly into manufacturing process of SSBR rubber project and above all it fits with the installation made by APS for Synthos Group S.A. that, in addition to be one of the largest manufacturers of chemical raw materials in Poland, is one of the leading manufacturer of emulsion rubbers and polystyrene in Europe. Indeed the project is intended for the manufacture of solution butadiene-styrene rubbers and poly-butadiene in a continuous process based on lithium catalyst (figure 3).

Fig. 2 - Typical process diagram for elastomer plant



## Why tyres market?

Products made from rubber are an important part of everyday living: pneumatic tires, shoe heels and soles, gaskets and even chewing gum, among other things. Within this sub-sector, the automotive area accounts the majority of international production, with its parts and components. The importance rubbers have can be judged from the fact that global revenues will rise to approximately US\$ 56 billion in 2020.

Demanding market analysis in 2012: Asia-Pacific accounted for about half of global rubber consumption and roughly 47% of global output. North America ranked second, closely followed by Western and Eastern Europe [Source: Ceresana Market Study Synthetic Rubber Analysis on web]. The current relatively strong growth of demand for SSBR rubber on the Community market allowed substantial progress for developing projects and research program in this field. Indeed, the tyre industry accounts for 75% of total SBR demand, followed by mechanical rubber goods/ automotive parts, which account for around 20%. Footwear consumes another 5%.

Due to the legislation for labelling of tyres (Regulation No 1222/2009 of the European Parliament and of the council) all tyres produced after June 2012 and on sale in the EU from November 2012 will show grade of rolling resistance, wet grip and noise. This regulation aims at increasing the safety and the economic and environmental efficiency of road transport by promoting safe and fuel-efficient tyres and saving up to 4 million tons of CO<sub>2</sub> per year.

It should be reminder that the efficiency of the tyres is strictly connected to the fuel consumptions of the vehicle. Relative to other commodities SSBR is increasingly favored because it offers improved wet grip and rolling resistance, which translate to greater safety and better fuel economy respectively. That is another reason why the market of advanced SSBR rubber will develop much faster than the other ones.

## Shaping the future: APS next goals

In such period, the future belongs to companies that are able to choose the best strategies and to accept new challenges. The Community industry could benefit fully from the growth of the synthetic rubber demand. With long-standing international and local experiences in processes and technologies development, process licensing and intermediates, polymers and elastomers production, APS should be considered as a reputable engineering firm in the field of SBR.

As a driving force dealing with challenges ahead the CEO and founder Mr. Antonio Quadrato has enabled



Fig. 3 - View from the bottom of the tallest column



Fig. 4 - APS Group team on site

far-reaching innovative projects to be developed. Much of the success in this core business would not be possible without the management's sales ability to offer best proposals in terms of costs, quality and services.

APS has been working diligently towards these targets. Top-level management, talent engineers, successful business people and achievers in all field all set goal shall be aligned with the APS's vision. Supported by an effective shared commitment and enriched by a multidisciplinary approach this company, known as Italian Engineering and Design Global Contractor, is prepared to support these new effective market economies (**figure 4**).

According to Mr. L. Dorrucci, International Sales Manager of APS:

Thanks to the skills acquired in a long lasting experience of collaboration with Eni Group, Versalis and now with Synthos SA for the ESBR, SSBR, HCBR & EPDM synthetic rubber production plants, APS has earned the respect of his customers in the Community and beyond. I may define us one of the biggest designer for rubber production plants in Europe, and hopefully we will become one of the leading players in the international market. This, in itself, would be a very bold objective.

Even Mr. Paliotta, manager of SSBR Project, reports that:

We have worked effectively to meet the needs of the all parts involved. Despite all countless conditions imposed, above all the short timetable of realization, I must say that was a satisfactory performance. An integrated project team with functional experts and experienced engineers have been an essential prerequisite for success. The greatest thing is for APS to experience and learn from this.

This project has given the challenge to APS to prove its efficiency in global business engineering undertaking competitive price, high quality and short schedule; all in full compliance with environmental and quality international standards. At a time when APS is celebrating 18 years of the activities, this important goal has been achieved. Key factors for this success "graduation" were as follows: speed, innovativeness, ability to change and positive motivation of company.



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## Martina Marmotta

Martina is graduated degree in Political Science with expertise concerned International relations and communication strategies. She is registered in the Register of Italian National Journalist with its nearly 10

years' experience of reporting and editing. In APS she has the task of editing promotional literatures and publishing general information about the Company activities.



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## Fabio Paliotta

Fabio is graduated degree in Chemical Engineering. Prior to joining APS, he worked in C. Engineering (CENG) srl and earlier in Sanofi Aventis for inspection, verification and validation of the equipment and systems of pharmaceutical plants. In his large experience in the oil & gas field gained with different engineering

companies, he has covered various positions like Process Engineer, Project Engineer, Proposal Manager and Project Manager. Currently is managing the EPCM project for the construction of the SSBR production plant.



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## Ludovico Dorrucci

Ludovico is responsible of International Sales in APS. His professional knowledge is laying mainly on an open-minded management to improve the Company's profitability and efficiency. At moment, his focus is on the Business Development. In his previous capacity, he

was a Licensors Technology Leader of process discipline. Graduated degree in Chemical Engineering, he enjoys the exceptional decade-plus experience in process coordinating activities in refineries, rubber complexes in several major international projects.



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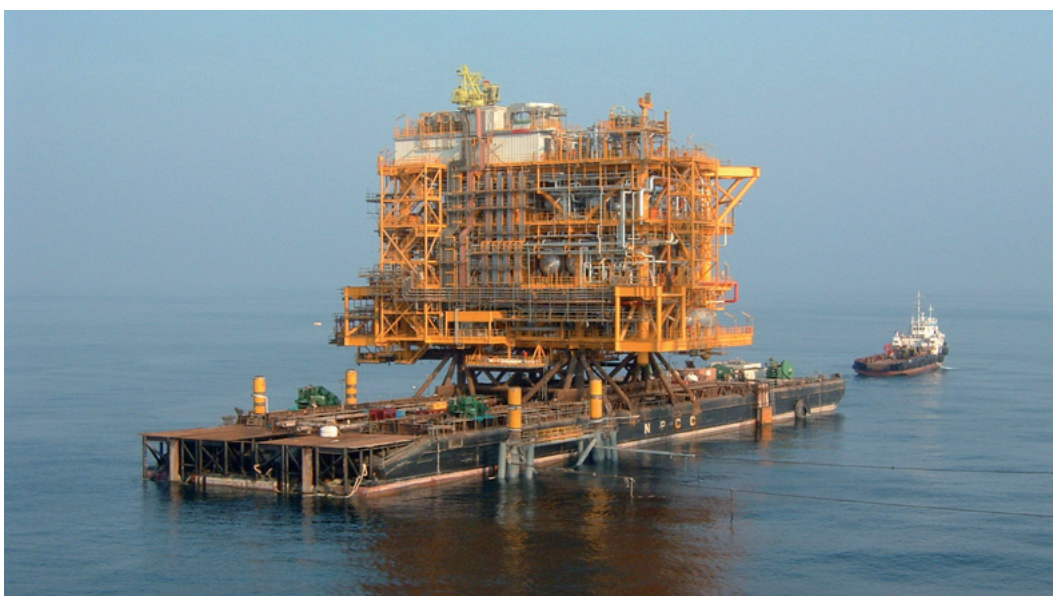
**GEODIS**

# Key Pumps for UAE Offshore Fields

The recent series of orders awarded to Termomeccanica Pompe involves a total of 73 pumps for various offshore installations

**Cesare Nardini**

*Termomeccanica Pompe - TMP*



*Fig. 1 - Umm Lulu offshore platform*

Over recent years, the EPCs and equipment manufacturers willing to maintain their leading position in the complex oil & gas market have had to shift their focus on the market's most challenging projects such as the ones related to the offshore and upstream segments.

This new focus has turned flexibility and innovation into key factors for the success of such players in developing solutions responding to the ever-increasingly demanding clients' requests.

The recent series of orders awarded to Termomeccanica Pompe, involving a total of 73 pumps for various offshore installations in the UAE (United Arab Emirates), exemplifies particularly well how an equipment manufacturer offering customized engineered solutions who counts adaptability and R&D amongst its core values can succeed in re-gaining a leading position in the oil & gas market.

The orders in question, related to the exploitation of the

Abu Dhabi offshore fields of Umm Lulu, Umm Shaif and Satah Al Razboot, cover most of the range of applications of Termomeccanica pumps in the oil & gas market: water injection, sea water lift as well as the typical OH2 and VS4 process pumps solutions for hydrocarbons processing installations.

## Water injection pumps

The first order concerns the supply of four water injection pumps to be installed in the Umm Lulu phase II super-complex (**figure 1**). Such facility, to be commissioned in 2018, has been designed to optimize the exploitation of the field.

The EPC contractor NTC, a joint venture between Technip Abu Dhabi and NPCC, awarded the order to TMP.

The pumps are API 610 BB5 multistage pumps made of super duplex A890 gr.5A.

Each pump will be equipped with a double seal, an

11/62 plan system and an API 614 lubrication system and will be driven by a 3050 kW motor. An API 671 coupling will be fitted onto the skid, which will be installed on a 3-point base plate with gimbal-type ball joints. An API 661 air-oil heat exchanger will also be installed outside the skid.

One of the main features of these pumps, however, is the back-to-back impellers solution. This configuration

TMP carried out relevant team work involving not only the foundry and the pattern maker but also Technip's material engineering experts in order to optimize the design of the barrel and its melting process and reduce material thickness to the minimum

combines the advantage of the balanced hydraulic thrusts derived from the back-to-back impellers with the positively reduced thicknesses of the castings of the BB5 barrel solution in comparison to the "split case" solution. The aspect related to the reduced thicknesses of the castings was particularly critical given that the type of pumped water and its pressure required the use of super duplex stainless steel for the pressure components. In fact, Termomeccanica had to reconcile the mechanical features of the

pressure components, that pushed towards increasing thicknesses, with the metallurgic difficulties of super duplex production that grow in parallel to the increase of the material thicknesses.

In this context, TMP carried out relevant team work involving not only the foundry and the pattern maker but also Technip's material engineering experts in order to optimize the design of the barrel and its melting process and reduce material thickness to the minimum.

As it is usual for such complex projects, the supply includes a complete string test for each pump, test to

be performed at the supplier's facilities, i.e. in Termomeccanica Pompe's case, at its La Spezia headquarters test center. The delivery of the four pumps is planned for July 2015.

## Sea water lift pumps

The second order is for the supply of four API 610 VS1-type vertical sea water lift pumps for the Umm Shaif super-complex (**figure 2**). This order is actually part of the AGFA project (Additional Gas Supply & Flexibility Assurance) wanted by the Abu Dhabi Government to meet Adnoc's (Abu Dhabi National Oil Company) gas need seasonal peaks, optimizing the production of the Umm Shaif complex. In this case too, the order was awarded to TMP by NTC.

The supply consists of two vertical pumps, with 3250 m<sup>3</sup>/h flow rate, 94 m head and 1160 kW and two pumps with 1320 m<sup>3</sup>/h flow rate, 68 m head and 350 kW.

The material used for the 4 pumps is super duplex A890 gr.5A and all pumps shall be fitted with mechanical seals with API 682 13/62 system plan and API 671 flexible coupling.

The main feature of these pumps is their size: 2 pumps will be over 28 m long, motor included, while the other 2 will be 24 m long. The pumps will weigh 36,000 and 19,000 kg respectively.

The development of the project has been characterized by the unusual length of the pumps, which has required a specific involvement of TMP's R&D team in the design of the pump. In fact, particular attention has been given to the accuracy of the modal analysis (so as to guarantee the absence of any vibration) and, consequently, to the modelling of both the pump and the interface between the pumps and the installation deck.

After a first complete assembly, the pumps will be tested in TMP's La Spezia test center at reduced length; they will then be completely re-assembled to finish the various final adjustments before being dismantled and divided into vertical modules for shipment.

Assembly on the platform will take place by inserting the various modules between the decks and by lowering them one at a time into the caisson. The delivery of the four pumps is planned for June 2015.

## Process pumps

A third order concerns forty-eight vertical pumps for the development program of the Satah Al Razboot site (**figure 3**). The order was awarded to TMP by Hyundai Engineering and Construction (HDEC) that won the tender for the EPC activities for package 4 of the Satah Al Razboot Full Field development.

The pumps shall be installed as part of a series of

Fig. 2 - Umm Shaif site





*Fig. 3 - Sarb 1 & Sarb2 artificial islands*

systems built on 2 artificial islands (Sarb-North and Sarb-South) created specifically for the development of this field, as well as on Zirku Island that has been housing for years the treatment of the hydrocarbons from other fields. The islands lie at about 120 km from the Abu Dhabi coast.

TMP's supply consists of forty-eight VS4-type vertical pumps designed in compliance with the API610 standards. In spite of the type of pump, usually marked by high standardization, this project has been characterized by the high design specificity of the individual pumps. Indeed, the end-user's request to reduce as much as possible the depth of the tanks led to potentially critical use conditions because of the proximity between NPSH A (Net Positive Suction Head) and NPSH R. The development of the pumps had therefore to take into careful consideration these

conditions of use to prevent cavitation and guarantee the necessary machine reliability. The delivery of the forty-eight pumps is planned to be completed by mid-2015.

## Conclusion

Over the latest years, the leading players of the oil & gas market have been driven by the search for projects characterised by higher value-added, i.e. by higher complexity such as offshore and upstream projects in general. Termomeccanica Pompe has followed this market trend, implementing a specific investment program (involving engineering, R&D, manufacturing and testing facilities) geared towards serving the high value added oil & gas market segment. Such strategy has borne fruit and allowed the company to confirm its prominent role in this demanding market.



## Cesare Nardini

After attending the University of Wollongong in Australia and Universitat Politècnica de Catalunya of Barcellona (Spain), Cesare completed his studies in 2000 at Politecnico di Milano obtaining a graduate degree in Management Engineering.

He started his work experience the same year at Alstom T&D in Montpellier (France), where he worked for two years on the development and installation of digital control system for electrical networks and substation, starting with product engineering development and then moving on to site- and project-management.

In 2002, he changed to the automotive industry and went to work as a project manager for Saira SpA, a

company of Gruppo Industriale Tosoni, which focuses on the railway market. He was first in charge of all projects related to foreign markets but later moved on to the domestic market, being also the project manager for the engineering and supply of the components for the ETR 600 / New Pendolino project, developed in co-design with Alstom Transport and Giugiaro Design. He finally joined Termomeccanica Pompe's Project Manager team in 2008 with whom he has followed to date more than 30 projects in the power generation market (including the nuclear sector) and oil & gas market (including both the onshore and offshore sectors).



# Air Cooled Condenser for Combined Cycle Power Plant

Spig Group was awarded a contract from Ansaldo Energia for the design, supply and construction of an air cooled steam condenser

**Simone Lucchesi**, Spig, Operation Director  
**Gabriele Miccichè**, Spig, Project Engineer  
**Marianna Caputo**, Spig, Marketing Manager

*Fig. 1 – Yeni Elektrik  
850 MW CCGT power  
plant project, Turkey  
(photo credit: Ansaldo  
Energia)*

In 2011, the Spig Group was awarded a contract from Ansaldo Energia for the design, supply and construction of an air cooled steam condenser for a 850 MW combined-cycle gas turbine power plant in Gebze, Turkey. The 42-cell, air cooled condenser was designed by Spig to meet stringent contractual performance for thermal duty, noise limits, plant layout restrictions, vibrations, wind and earthquake impacts.

The 1 billion USD Combined Cycle Project (figure 1) owned 60% by Unit and 40% by Ansaldo Energia, went online in 2013, connected to the national grid, to provide power to the neighbouring industrial district as well as to cope with the electricity demand of 15 million households in Istanbul, complying with Turkey's emission requirements. The environmentally friendly plant in 2+1 configuration uses the largest units

condenser mounted on a hot dip galvanized steel support structure, was designed by Spig's thermal and mechanical engineering team to meet stringent contractual performances for noise limits, wind & earthquake impacts, thermal duty, plant layout restrictions and vibrations control. In addition, the requirement was to complete the construction phase within a strict schedule.

Being the plant nearby the city, the ACC could not exceed the prescribed noise values. In fact, it was developed in order to satisfy the overall noise emission limits. To minimize the level of noise, the ACC was equipped with wind cross solution for noise optimization, underneath the platform level (figure 3).

The external perimeter of the condenser has been equipped with windwall, to minimize air recirculation.

Turkey is a highly seismic active area and during the

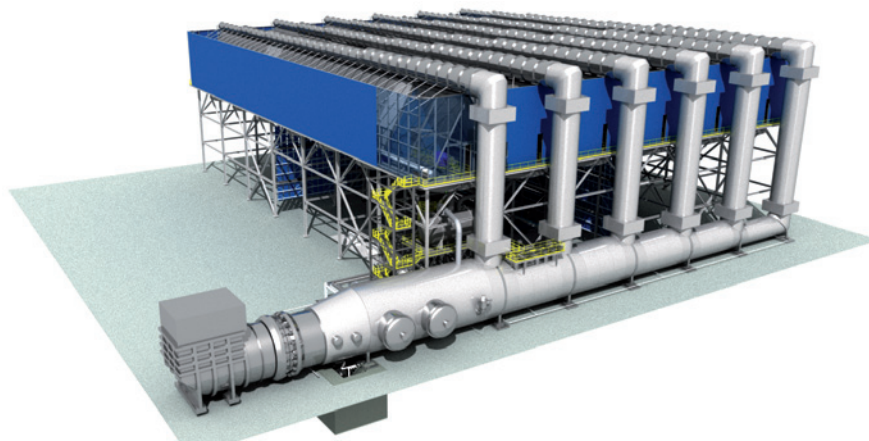


Fig. 2 – General arrangement ACC view

produced by Ansaldo Energia. This mainly Merchant Plant, considered one of the cleanest of its kind in Turkey, is designed for heavy cycling with net efficiency Lower Heating Value, being one of the highest rates of its category.

In July 2011 the Spig Group was awarded a contract from Italy's leading builder of thermal power plants, Ansaldo Energia for the engineering, procurement and construction of an air cooled condenser (ACC) for the 850 MW CCGT (Combined Cycle Gas Turbine) power plant, in Gebze, Turkey (figure 2). The EPC Contractor was a consortium of Ansaldo Energia & Yeni AEN İnşaat A.Ş and the owner's engineering, a consortium of Tractebel Engineering & Coyne et Bellier.

In June 2013, the engineering, procurement, delivery and construction were achieved, guaranteeing the mechanical completion of the plant, in full compliance with contractual milestones. In September 2013 Spig carried out the commissioning and between December 2013 and February 2014 the performance test.

## Technical features

The 42 cell, forced draught single row air cooled

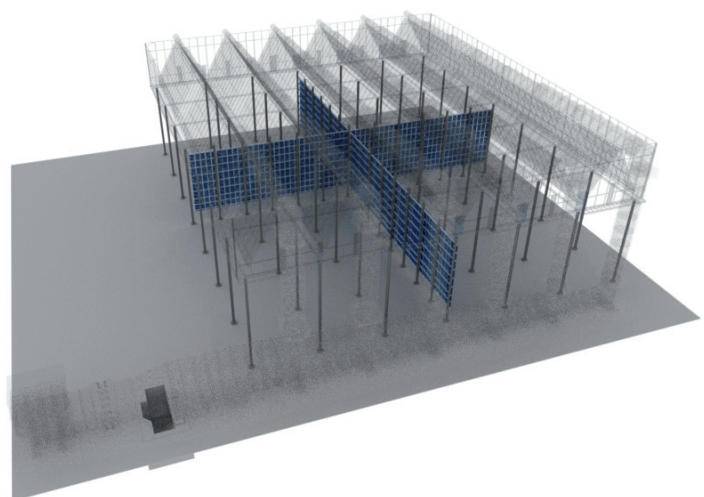


Fig. 3 – Wind cross solution

design phase the seismic prescriptions were observed and implemented by Spig engineers, who had to consider both American Asce 7 and Turkish Tec 2007 standards.

According to the project specific criteria, this flexible ACC has been designed for heavy cycling duty, for daily start-stop (200 starts per year), daily variation from minimum to maximum technical load, fast start up, fast load variation .



Fig. 4 - Spig environmentally friendly air cooled condenser



Fig. 5 - ACC testing

The design of the environmentally friendly Spig ACC consists of six parallel roofs, each one completed by seven cells using the state-of-the-art single row aluminium flat steel tubes with brazed aluminium corrugated fins, built on an overall 94 × 79 (m × m) footprint (figure 4). This technology offers better thermal performance, lower power consumption, higher reliability and a smaller plot area when compared to the commonly used multi row technology. Spig supplied the cooling system complete with single row tube bundles, steam ducts, piping, structural steel, vacuum systems and all integral components of the entire system. The condenser has been supplied with a semi-automatic tube bundles cleaning system, consisting of high pressure spray water suitable to clean up the tube bundles outside surface. This system is aimed to keep them free of any deposit and maintaining the overall heat

transfer coefficient unchanged during the lifetime of the plant.

## ACC testing

The ACC was subjected to thermal performance, noise testing criteria and electrical consumption validation and was totally successful in meeting the strict technical contractual requirements (figure 5). The official performance test was carried out with Unico, Spig Online monitoring System, in remote mode.

After the final commissioning completed in September 2013, with the aim to demonstrate the full compliance to the contractual guarantees, Spig and Ansaldo Energia arranged an intensive ACC performance test plan between December 2013 and February 2014. The tests were executed according to VGB-R 131 international standard. All the critical parameters of the ACC were monitored through the Unico System, the new generation wireless data logging developed by Spig's laboratories specifically for dry and wet cooling applications.

The ACC was tested under several operating conditions, different steam loads, turbine by-pass and

Spig supplied the cooling system complete with single row tube bundles, steam ducts, piping, structural steel, vacuum systems and all integral components of the entire system

shut-downs. The ACC was indeed able to successfully keep the expected turbine back-pressure and deliver a reliable performance in a wide range of ambient conditions.

During the same period an extended investigation on the ACC noise emissions was also carried out by Spig and Ansaldo Energia technical specialists. Both mechanical equipment and main steam duct noise emissions were checked by means of electronic noise analyzers.

The challenging contractual ACC noise limitations were successfully matched at the design operating conditions. Finally, the ACC was certified by the power plant end user as ready for commercial operations.

## A unique online monitoring system

Unico Spig continuous online monitoring system has been designed to improve plant efficiency by processing

## About Spig Group

Spig, established in 1936, is a global turn-key Cooling Systems designer and supplier. Since its early establishment, the Company has been providing customers with an increasingly extensive range of energy efficient and highly performing Cooling Towers, Air Cooled Condenser, Air Fin Coolers and related Services. The

world Headquarters is Spig SpA which is located in Arona, on the Lago Maggiore, Italy. Operating globally through nine subsidiaries, the Group's offices are strategically located in USA, Brasil, Germany, Russian Federation, Turkey, UAE, India, China and Korea.

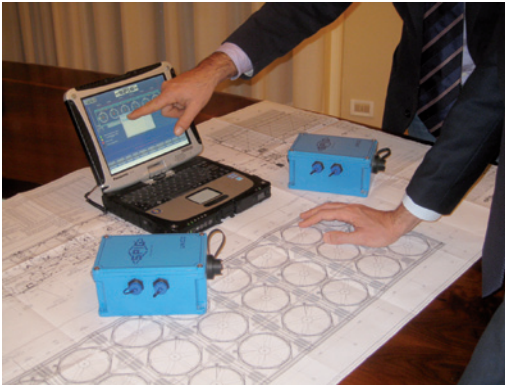


Fig. 6 - Unico Spig continuous online monitoring system

parameters and mechanical equipment conditions (figure 6).

Unico is aimed at assuring the global performance of cooling towers & air cooled condensers and improving plant management.

A network of localized smart sensors collects data that are converted into digital form and sent to a supervision system using wireless technologies.

The supervision system validates and integrates the data in a single data base, processes the information to check process parameters variability and equipment reliability, detects potential problems, generates alarms and determines responses.

All information is published on a web page, where graphs display performance trends and tables show performance parameters, anomalies diagnosed faults, alarm messages and mailing actions.

By presenting data on a web page, Unico provides global remote control capabilities. Furthermore, over the years Unico allows design review to guarantee reliable efficiency of the ACC and enhancing the customer revenue, minimizing lost time production, through Spig in house software able to provide a predictive long term analysis on ACC performance detrimental.

Moreover, thanks to the analysis provided by Unico, Spig is able to find an excellent compromise between the efficiency of the ACC and the cleaning activity carried out in order to minimize the water consumption where this commodity is considered a scarce resource. With an installed cleaning system Spig is able to guarantee an overall performance of the plant.

## Stringent time frame, flexibility & safety

With a challenging Preliminary Acceptance Certificate, Spig is one of the few large components suppliers of the CCGT who achieved 95% erection completion in just 20 months. Thanks to its flexibility, the Company was able to manage the preliminary and detailed engineering in order to meet the stringent time and the complexity as per the project specific.

The engineering team was able to cope with the initial material requisition to new more severe conditions without any high impact on the original concept.

The delivery and construction were performed without any interference with the schedule of the project (figure 7). In fact, the ACC was commissioned two months in advance respect the completion date.

Fig. 7 - Construction phase of the ACC



Thanks to an effective HSE (Health Safety Environment) policy and training the equipment erection and maintenance for Gebze project were accomplished in 45,000 man hours, without LTI (Lost Time Injuries).



## Delivering Excellence globally

The Spig engineering, project management and site teams demonstrate their commitment to achieve

Ansaldo Energia and Yeni AEN İnşaat objectives to deliver the ACC into operation successfully.

This order confirms Spig's reliability in dry cooling technology and leadership in the global Power market. Through the direct support of the local Spig Soğutma Sistemleri Tic Ltd Şti located in Izmir – a wholly owned subsidiary of Spig SpA - the strict construction phase has been reached as per customer's requirement.

Spig has been giving particular attention and confidence in the Turkish promising power generation market since 2004, when the local operation started up allowing the completion of about 100 flagship projects.

The Gebze plant is subsequent to a positive series of ACC provided by Spig and represents a further consolidation of the company on this market.



## Simone Lucchesi

Simone graduated in Mechanical Engineering at Politecnico di Torino. He joined Spig in 2003 and developed a wide experience as Project Manager for 10 years, managing successfully several outstanding projects such as 42-cell Air Cooled Condenser at 850 MW CCGT power plant in Gebze, 48-cell 5 Cooling Towers at Rabigh Refining and Petrochemical Company,

16-cell 2 Cooling Towers at 850 MW Combined Cycle Edison power plant in Simeri Crichi ,30-cell 3 wet/dry cooling towers for 1300 MW EDF CCGT power plant in West Burton. He is actually in charge as Operation Director at Spig, developing and implementing strategic plans to increase efficiency and effectiveness within the organization.



## Gabriele Micciché

Gabriele graduated in 2007 in Aerospace Engineering at Palermo University, Italy. After three years of experience in the thermal engineering division of an international group providing cooling systems, as Sales Engineer first

and then in the R&D department, he joined Spig as Sales Engineer, where is now covering the position of Revamping Manager in the Dry Cooling Department.



## Marianna Caputo

Marianna graduated in Political Sciences at the University of Pavia and then obtained a Marketing and Sales Management B2B master diploma at SDA Bocconi, in Milano.

She has been working with Spig since 2001 as marketing assistant supporting executives on projects directed at maximizing the company profits and

developing sales strategies and marketing campaigns. As Marketing Manager she is actually responsible for performing many duties such as Brand Development, Competitive & Market Intelligence and Public Relation, aimed at developing and implementing the long- and short-term marketing strategies and enhancing the Spig Group awareness and positioning on the global market.



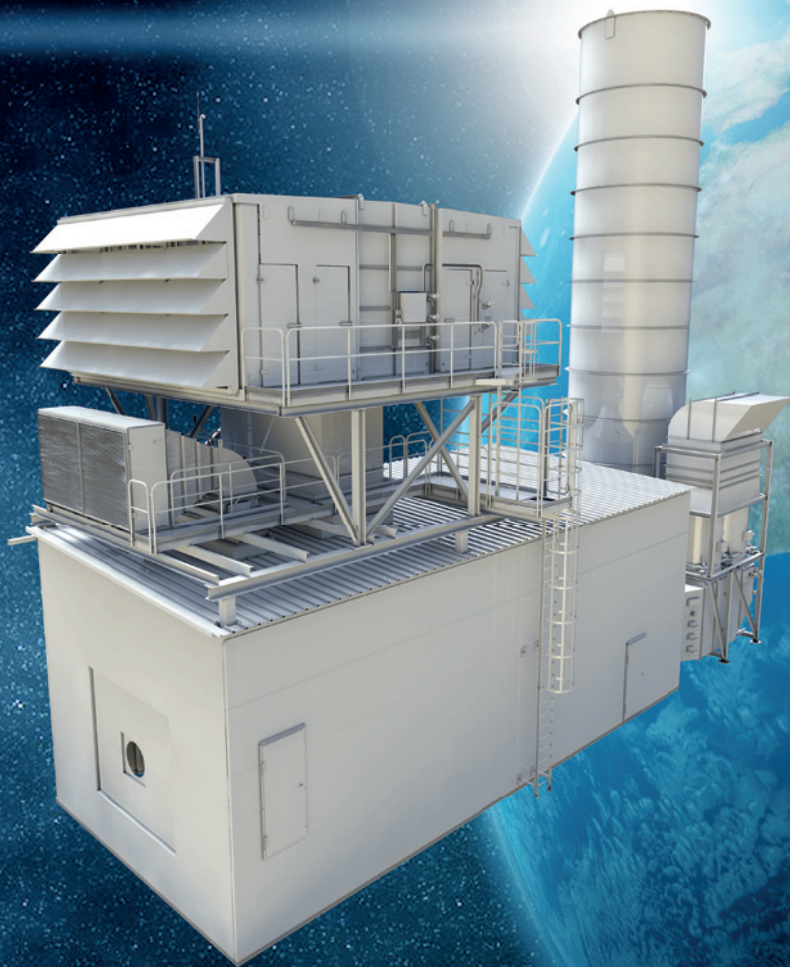
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## CLEAN AIR POWERS THE WORLD

Clean air is an important factor to consider when operating gas turbines. Camfil Power Systems provide air filtration solutions that are not only robust enough to ensure the day-to-day reliability in hostile environments, but are also cost-efficient and have minimal environmental impact over the entire life cycle. Camfil have executed thousands of Gas Turbine auxiliary equipment projects to all of the major OEMs for machines from 3 to 300 MW. Read more at [camfil.com/ps](http://camfil.com/ps)

Learn more  
about air filtration



# Gas Turbine Air Filtration System Optimization

Camfil Air Inlet Systems reduce environmental impact and increase power output

Jan-Peter Nilsson

Camfil



In a gas fired power plant where electricity is generated by a gas turbine the fuel cost represents a majority of the total costs. As an average the fuel cost represents about 60% of the electricity selling price. One of the most important factors influencing the fuel consumption is the design of the gas turbine air intake system.

Gas turbines burn fuel with enormous volumes of air pulled from the atmosphere and to prevent damage to the turbine interior the air needs to be cleaned from pollutants. The quantity of contaminants like dust and water varies dramatically depending on ambient

conditions. Air pollutant characteristics vary with place, time and local conditions such as climate, the surrounding environment and human activity such as industry and traffic. Therefore choosing air filtration system to clean the air is complex involving a number of considerations and experience.

## Why air filtration?

Air filtration systems for gas turbines have evolved from simple coarse solid particulate removal systems to complex ones that remove solid, as well as liquid particles. As the demand for gas turbine thermal efficiency escalate; with firing temperatures increasing and machine tolerance decreasing, gas turbines become more sensitive to particles in the combustion air, thus requiring more efficient and reliable air filtration equipment (**figure 1**).

With proper function of the gas turbine being so critical, reliability is of utmost importance. With increase of gas prices, a tougher financial situation and environmental issues it's not only important to keep the gas turbines running, it's also important to do it as efficient and with as little environmental impact as possible.

Gas turbines are exposed to pollutants through two possible sources. Combustion air and fuel. The latter is normally defined and content is most cases known when the installation is selected. Inlet combustion air quality however varies from site to site and many inlet filtration systems fail to protect the gas turbine due to incorrect selection and/or sizing.



Fig. 1 - Air Inlet System for a Siemens SGT800 gas turbine (courtesy Camfil Power Systems)

The gas turbine Inlet filtration system therefore has two main missions:

- reliable operation;
- engine efficiency.

The costs of fouling far exceed the cost of eliminating it but since capital costs tend to be weighed heavy in equipment purchase decisions many gas turbines are equipped with inadequate inlet air filtration and the operator ends up paying many times more in extra operating costs.

Reliability means that the inlet filtration system be able must protect the gas turbine from penetration of particles that could over time be a danger to the gas turbine. These typically are particles that could cause wear, or fine particles that could plug the holes in vanes and blades for cooling air and consequently cause

damages due to overheating. In addition the inlet system has to prevent the entrance of humidity and salt which could cause corrosion and in combination with sulphur in the fuel and high temperature, hot gas corrosion in the power turbine.

Engine efficiency assurance means that the Inlet filtration system efficiently must remove the entrance of small particles in order to avoid compressor fouling resulting in degradation of the gas turbine performance. A gas turbines sensitiveness to fouling is normally increasing with its efficiency. Axial compressor fouling is primarily caused by airborne particles below one micron in size (figure 2). Fouling changes the shape of both rotating and stationary vanes and results in a reduction of both mass flow and pressure ratio generated by the compressor. The net result of fouling is a reduction of power output and an increase in heat rate for a given combustor outlet temperature – conversely if an engine is not running at its temperature limit a fouled engine has to run hotter to produce a given output.

A secondary effect of fouling is an increase in airfoil temperatures in the high pressure turbine as fouling in the internal vane and blade cooling passages reduces heat transfer effectiveness and ultimately reduces the life of the hot section. The costs of fouling far exceed the cost of eliminating it but since capital costs tend to be weighed heavy in equipment purchase decisions many gas turbines are equipped with inadequate inlet air filtration and the operator ends up paying many times more in extra operating costs.

The major cost consists of the actual and potential loss of revenue. The filter maintenance costs, often looked upon as high, is in reality marginal compared to mayor ones such as:

- poor efficiency gives rapid engines degradation resulting in loss of production and/or higher fuel

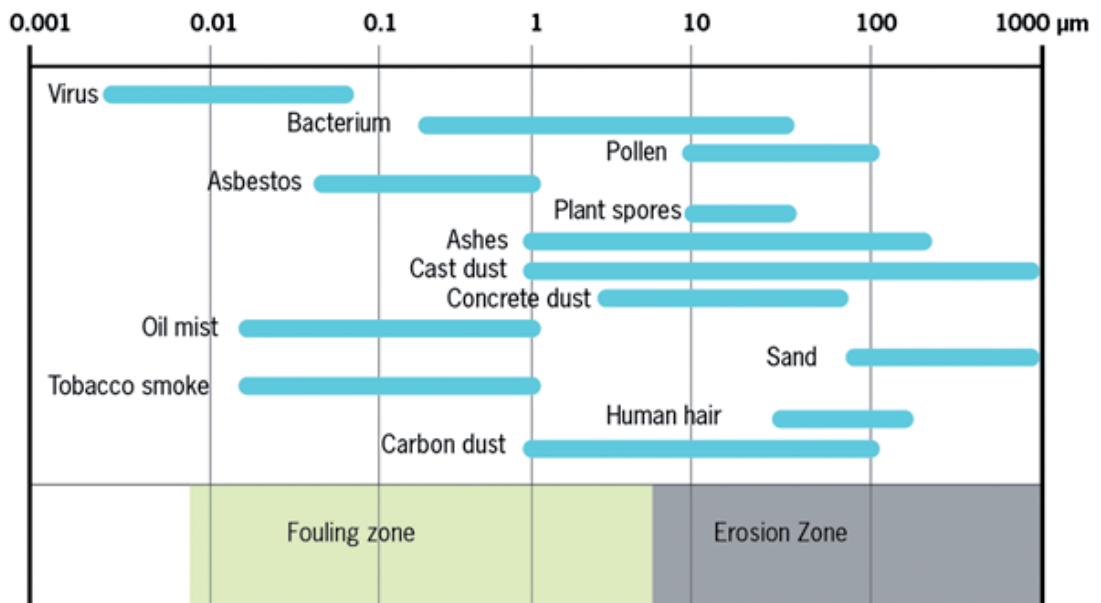


Fig. 2 - Particle size and engine degradation intervals

- and environmental costs;
- stopping a gas turbine for offline compressor washing and/or filter change out means in many cases stop of production / revenue;
- fouling and erosion of turbine blades may also cause imbalance and vibrations, resulting in higher stress on components and consequently destruction of vital parts. Starting and stopping the turbine for cleaning lead to thermal stress of components that may shorten the life of the engine and lead to unnecessary maintenance stops;
- gas turbines exposed to fine dust, humidity and/or salt and are faced with high risks of serious breakdowns caused by hot gas corrosion, cooling hole plugging etc.; again potentially very high costs for loss of production and equipment.

## How to evaluate the filtration system

Most operators know there is more to filtration than the actual filter cost. Shipping, installation and lost production during filter replacement are obvious and easily accounted for. But when it comes to the indirect costs associated with fouling, such as lower MW output and downtime for water washing or the cost of higher pressure drop, making a full evaluation is not as straight forward.

When selecting a filtration system, one must decide the level of protection the system should achieve. This includes the particle filtration efficiency, the particle size to be filtered, the filter replacement cycles, what rate of degradation is acceptable for the gas turbine, the required availability of the gas turbine, what type of washing scheme will be used (online, offline, or a combination of both), and initial cost of the filtration system. The cost impact of each of the items mentioned is quantified to compare different filtration system options. The main parameters for evaluating the inlet system are:

- *Purchase Price / Initial Cost*: initial investment for the complete Air Inlet System;
- *Maintenance Cost*: cost of replacement filters and labor cost for filter replacement and disposal;
- *Availability / Reliability of Gas Turbine*: downtime for complete offline water washes and downtime during filter replacement;
- *Turbine degradation and compressor washing*: gas turbine degradation, performance loss (% per kPa, heat rate, heat rate increase % per kPa);
- *Pressure Loss*: costs related to pressure drop across other components as a sum of power output loss and fuel cost increase;

- *Failure / Event Cost*: unplanned stops and repair due to parts wear out and/or accidents.

### **Purchase Price / Initial Cost**

The purchase price occurs in the first year of the LCC analysis. It is the cost to purchase and install the inlet filtration system. Once these costs are established, they are brought back to the net present value.

### **Maintenance Cost**

The maintenance cost includes the cost of filter replacement and disposal. It is a recurring cost that should be included in each year that the cost is acquired. This cost is calculated based on estimated filter change out frequencies, cost of filters, labor cost for maintenance per hour.

### **Availability / Reliability of Gas Turbine**

The availability/reliability of a gas turbine impacts the cost due to the lost production and revenue due to shutdown of the engine. The loss of revenues is based on average value of output (electricity, oil, gas or other unit for revenue), the service cycles and the estimated life time of the filter (filter change-out can either be based on the final pressure drop or scheduled operating hours).

If the engine is not used 100% of the time, for example, because it is a standby or peaking unit, the cost of lost revenues must be adjusted accordingly.

### **Gas turbine degradation and compressor washing**

Gas turbine degradation is perhaps the most important cost in the analysis. This is often the cost which drives the analysis to favor one filtration system option over another. The cost a fouled

**Gas turbine degradation is perhaps the most important cost in the analysis. This is often the cost which drives the analysis to favor one filtration system option over another**

engine is calculated based on the reduced power output and increased heat rate due to the lost engine efficiency. The change in fuel cost is calculated based on the fuel consumption in relation to the change of efficiency and the price of fuel. Compressor cleaning is often performed in a gas

turbine in order to minimize the effects fouling on the performance of the gas turbine. However, the most effective type of cleaning is on-crank washing, which requires that the engine is shut down. This results in a lower availability of the engine, and, associated with this, may cause the cost of lost production.

### Pressure Loss

The pressure loss across the inlet filtration system also have a significant effect on the cost of operation. An increase in the pressure loss across the filtration system leads to reduced power output from the gas turbine and an increased heat rate. The cost of these effects is included in the LCC analysis as 1. a pressure drop value per stage and filter in operation and 2. Pressure drop for the housing itself including cooling/heating and silencers.

### Failure / Event Cost

Not included in the LCC software analysis is the cost associated with a failure or event that occurs due to the inlet filtration system or inlet air quality. This could be a failure of a gas turbine blade or other interior parts which occurred due to corrosion from poor inlet air quality. These costs are often included based on past experience with the gas turbine or other filtration systems and should favorably be added to the total cost of operation.

## How to optimize the filtration system

In line with tougher environmental as well as operational requirements there is a clear trend that operators are requesting higher grades of filtration efficiency in order to achieve better protection of their gas turbines and longer operational cycles. It's

more and more frequent that operators are asking for 1 up to even 3 years long cycles between shutdowns. This means that gas turbine air intakes need to enter the HEPA (High Efficiency Particulate Air filter) world, a world previously normally seen in surgery theatres, sensitive labs, nuclear power plants etc. This puts high requirement not only on the filter system design but also on the construction and the air tightness of the system. Even a small leak will move the system back to the F-world.

**In line with tougher environmental as well as operational requirements there is a clear trend that operators are requesting higher grades of filtration efficiency in order to achieve better protection of their gas turbines and longer operational cycles.**

With standard filters, E12/H13 needs a 3-stage system to provide long enough filter life. With new deep type filters the same grade of filtration can be achieved in a 2-stage filtration system. Remember, with an efficiency of 99.5% of MPPS (Most Penetrating Particle Size), an E12 "takes it all". With a system in EPA- or HEPA-class it's possible to achieve intervals between shutdowns of 1 year and above.

An typical offshore CamGT Inlet filtration system (figure 3) consists of:

- Stage 1: (optional) weather hoods as first stage arrest snow and large water droplets;
- Stage 2: vertical droplet separator with a vane profile design for keeping pressure loss and noise levels to a minimum;
- Stage 3: prefilter / coalescer. Normally a bagfilter with large surface for long life and low pressure drop. The prefiltration stage captures coarse

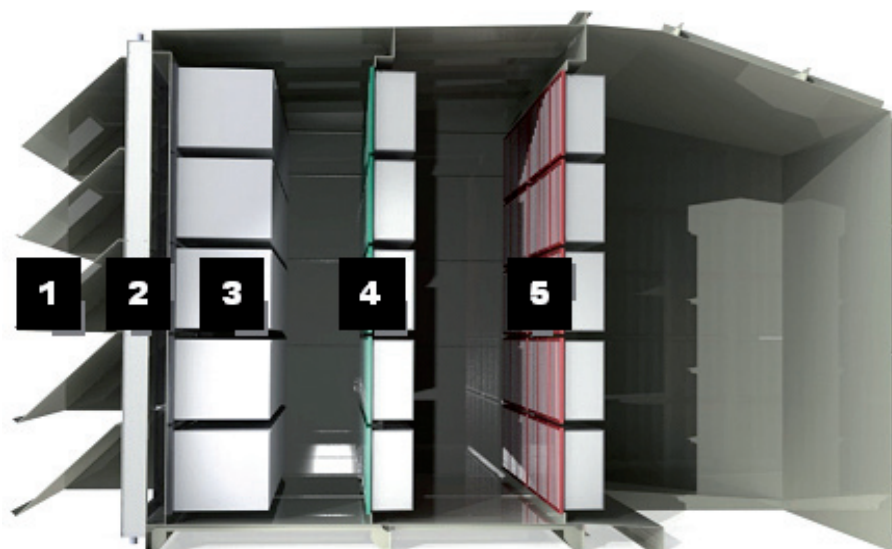


Fig. 3 - Three stage Air Inlet System

Table 1 - Results of case study 1

	Original system setup	Upgraded system
Air flow	4400 m³/h, filter	4400 m³/h, filter
Pre-filter stage	bag filter F7	Cam-Flo XMGT, F9
Final filter stage	E10	CamGT 3V-600; E12
Initial pressure drop over system	250 Pa	200 Pa
Final stage efficiency MPPS (*)	85%	99.5%
Reduction in air resistance		20%

(\*) Most Penetrating Particle Size according to EN1822\_2009

- particles, moist salt and small water droplets media area: 6-8 m²
- face velocity: 2.3 - 2.9 m/s
- media velocity: 0.29 - 0.48 m/s
- Stage 4: compact filter F9-E10 (optional E11-E12, H13) high efficiency filter. The fine filter stage collect small, dry salt particles, sticky hydrocarbons and sub-micron dust particles
- media area: 18 - 26 m²
- media velocity: 0.09 - 0.16 m/s
- Stage 5: (optional) to protect the turbine from harmful fouling the final stage is a EPA or HEPA class filter with filtration efficiencies from 85% MPPS (Most Penetrating Particle Size)
- media area: 29 - 30 m²
- media velocity: 0.076 - 0.1 m/s

The above system is proven after 10 years of operation on hundreds of installation world-wide. Even if dimensions are larger compared to the high velocity type it offers a number advantages in terms of reliability and efficiency:

*reliability assurance → less stops*

- clean engine due to minimized penetration of sub micron particulate
- long operational cycles gives maintenance during planned shutdowns
- flexibility, the individual filter elements can be replaced if site conditions shows to be different than expected

*efficiency assurance → more production:*

- higher power due to less engine degradation
- higher power due to lower pressure drop
- less shutdowns due to higher dust holding capacity and less fouling

We can conclude that it's extremely important to keep

the gas turbine clean to assure good economy and reliably. Secondly, a clean gas turbine operates efficiently and with less environmental impact and finally, the cost of clean air is not the cost of replacement filters – it is how much energy the filters use during their working life at the desired efficiency.

## Case study 1

### Filtration system upgrade solves salt ingestion problem for land based power generation turbine

A 33 MW land based gas turbine installed near a salt mine, where potash and magnesium crude salts are extracted, suffered from peaks in air resistance and frequent exchanges of final filters after some time in operation. The air inlet system was equipped with a standard filter setup consisting of a F7 bag filter and an E10 final filter.

An on-site air analysis revealed that levels of sodium chloride – salt – were higher than expected, due to the production and transport of potash in the surrounding area

An on-site air analysis revealed that levels of sodium chloride – salt – were higher than expected, due to the production and transport of potash in the surrounding area. Salt, in combination with seasonal humidity, creates a challenging environment for gas turbines. Dry salt was being captured in the pre-

filter media, and when humidity rose, liquid salt slowly penetrated the pre-filter and was carried over to the final filter, causing a rapid increase in pressure drop. To deal with this amount of contaminant, the system was upgraded with deep filters CamGT 3V-600 (figure 4), a

Fig. 4 - CamGT 3V-600 gas turbine filter (courtesy Camfil Power Systems)



Table 2 - Results of case study 2

	High velocity system	2 stage medium velocity system
Air flow	7200 m <sup>3</sup> /h, filter	4100 m <sup>3</sup> /h, filter
Pre-filter stage	bag filter G4	Cam-Flo XMGT, F7
Final filter stage	bag filter M6	CamGT 4V-300; E12
Initial pressure drop over system	996 Pa	478 Pa
Reduction in air resistance		-52%

cartridge solution that has three times the amount of media, compared to the original setup, for a significantly higher dust holding capacity. The new deep filters did not only replace the existing cartridge filter, but also the F7 bag filter used in the pre-filter stage. To avoid turbine fouling and engine degradation effects, the filtration grade has been raised from F7 to F9 (EN779:2012) in the pre-filter stage, and from E10 to E12 (EN1822:2009) in the final filter stage.

The CamGT E12 offers >99.5% MPPS efficiency – meaning that it collects at least 99.5% of the particles most difficult to filter (approx. 0.1 - 0.2 µm in size). Particles of all sizes, both bigger and smaller, are filtered more efficiently.

## Results of case study 1

Not only is the turbine significantly better protected with the CamGT 3V-600 E12, the initial dP has also been reduced to 200 Pa at 4400 m<sup>3</sup>/h, compared to the 250 Pa with the original filter setup. After six months of operation, pressure drop has remained low and stable even during humid conditions and the engine performance has been improved significantly (**table 1**).

## Case Study 2

### High velocity system replaced by medium velocity deep filter solution

One of the world's leading oil & gas companies had severe problems with the operation of their gas turbines offshore, with frequent filter replacement intervals and engine degradation. Many of the turbines also suffered from corrosion damages due to poor filtration efficiency.

The fleet of gas turbines for mechanical drive, 16 - 30 MW, were all equipped with high velocity systems. A high velocity system is normally a one stage filtration system with a droplet separator before and after the filtration stage. High velocity systems have the advantage of reduced size, weight and lower initial cost. A disadvantage is that there are performance

losses due to high pressure loss through the inlet system. Also, filtration efficiency for small particles are significantly lower than those of a low- to medium velocity system. In this case the operator was facing filter replacement every six months and the filtration efficiency did not reach over 70% on 4µm particles which would equal M6 filter class according to EN779:2012.

High velocity systems have the advantage of reduced size, weight and lower initial cost. A disadvantage is that there are performance losses due to high pressure loss through the inlet system. Also, filtration efficiency for small particles are significantly lower than those of a low- to medium velocity system.

A new air intake system was installed on one of two neighboring compressor packages (16 MW aero derivative gas turbines). Past experience from filtration offshore pointed towards a multiple stage filtration system but the weight and space restrictions limited the options to a 2 stage system. The harsh environment offshore called for a solution with high resistance to humidity and salt. If salt is ingested in the turbine the operator face the risk of irreversible damage to the turbine and extremely costly downtime for engine overhaul. The filtration efficiency must, according to experience be above 99%, so the filtration grade was set to E12 (EN779:2012).

The new air intake system had a first pre filtration stage, a bag filter for applications in high humidity filtration class F7. The final stage was equipped with a CamGT 3V-600 deep filter with more than 50 m<sup>2</sup> effective filtration media.

This situation with two air intakes in identical environments provided an excellent opportunity to demonstrate the benefits of employing a high efficiency deep filter solution (**table 2**).

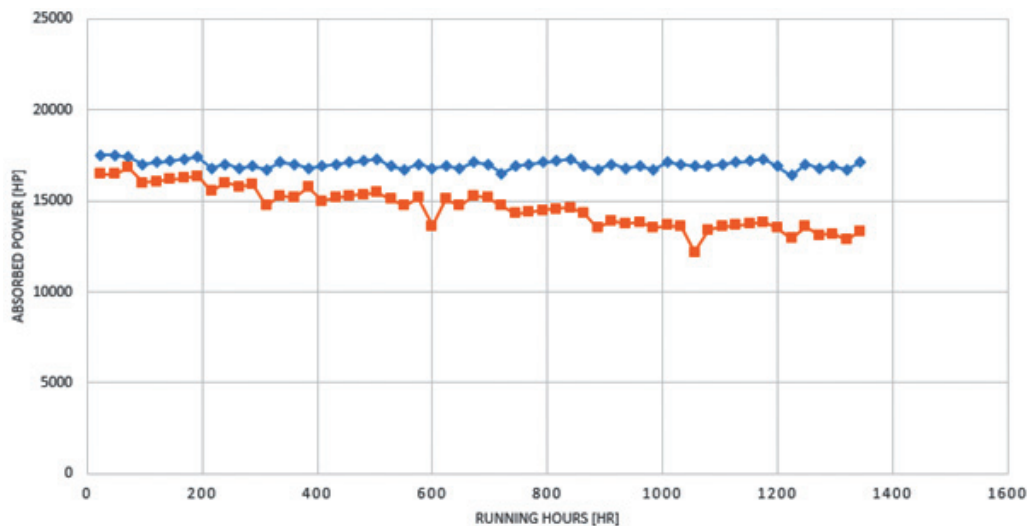


Fig. 5 - Engine performance in HP on two neighboring inlet systems

## Result of case study 2

Initial pressure drop was reduced by more than 50% applying the new filtration system, from 996 Pa down to 478 Pa. From the day of installation the upgraded engine gained around 1000 HP more than the one with the existing high velocity system. This represents an increase in power output of ~6%.

After three months in operation the replaced intake

system showed no increase in pressure drop and no sign of turbine performance degradation. The turbine with the existing high velocity system suffered from a degradation of ~15% during the same period, which lowered the output even more, compared with the improved and better performing installation (**figure 5**).



## Jan-Peter Nilsson

Jan-Peter is Senior Engineer at Camfil Power Systems with more than 30 years of experience of gas turbine enhancement systems and air filtration for turbo machinery. Jan-Peter is active member of ETN

(European Turbine Network) and has been part of air inlet advisory board at GMRC (Gas Machinery Research Council) as well as the co-author to numerous industry publications and white papers.



*Fig. 1 –Sanco's headquarters in Galliate, Italy*

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# Italian Fire Extinguishing Technologies Around the World

Sanco SpA has been sharpening its focus on delivering consistent and high quality products and services by giving priority to proper project management

**Nico Zorzetto**  
Sanco SpA



**E**xtinguishing a fire is not only a simple intervention but it also requires a lot of skill. For this reason, project management for the supply of fire detection and fire suppression systems has to be the result of numerous decisions made by every single person of the organization day by day. In order to align decisions, employees and directors need a shared vision: a customer experience strategy even in case of users that are poles apart.

Sanco SpA, an Italian company, successfully operates not only in design and construction of fire suppression systems and equipment but, above all, in the research and development of new technologies for a highly specialised sector in which the human factor still has a very important value, where the capability and experience of the people are fundamental factors to face new global challenges everyday **figure 1**).

Sanco has been sharpening its focus on delivering consistent and high quality products and services by giving priority to proper project management. This has been made by planning in appropriate way projects, by meeting objectives on time and on budget. The goal is defining in an accurate way requirements and objectives by thinking about the user needs and environment, by preparing functional

specifications and providing training and implementation.

To meet customer experience ease-of-use and time-to-delivery objectives, resources with experience in user-focused design and rapid development methodologies are especially important.

Sanco has been recently turning out to be the largest

Italian company in the fire fighting field both for its dimensions (28,000 m<sup>2</sup> of which half is covered) and its annual turnover, reaching about 50 millions euros and this could be done thanks to its experience all around the world, at different latitudes, touching Norway down to South Africa, crossing over the Middle East till the Empire of the Rising Sun.

Its two different production lines, namely the electronic one for fire & gas detection control panels and relevant accessories and the other one relevant to mechanical fire

suppression systems, equipment and fire trucks, have been growing thanks also to recent projects. For these reasons Sanco's continuous growth has led the company to increase its production range; among the traditional fire fighting systems included in its program, it provides to its clients the following:

- fire & gas detection systems;
- deluge and water mist systems;
- foam systems (low, medium and high expansion);
- twin agent systems;
- dry chemical powder systems;

**Sanco SpA, an Italian company, successfully operates not only in design and construction of fire suppression systems and equipment but, above all, in the research and development of new technologies for a highly specialised sector**

- remote controlled monitor systems;
- gas fire fighting systems: CO<sub>2</sub> (high and low pressure), argon, IG541 (Inergen), IG 55, HFC227ea (FM-200);
- mobile equipment;
- fire fighting vehicles (water, water/foam/powder, twin agent, multi-purpose etc.);
- special equipment/systems.



Fig. 2 - Deluge valves on skid



Fig. 3 - Deluge valve units for low temperatures

In particular, there are four countries that have to be mentioned in relation to recent projects: Japan, Iraq, Uzbekistan and Algeria.

## The first case: Japan

Japan might never enjoy the oil and gas production that Middle East has, but it is reforming its energy markets. In few years, Japan's energy markets will have a whole new look. Thanks to the remarkable design work in the Research & Development Department of Sanco, new models have been planned and constructed in particular for this technologically advanced and competitive market, such as:

- trailer-mounted monitor, Red Typhoon, capable of discharging 30,000 l/min at 12 bar with a throw of up to 150 m, particularly indicated to fight massive fires that cannot be met with traditional means;
- container-type trailer-mounted units (40') holding the Red Hurricane pumping station, capable of discharging 30,000 l/min at 12 bar, a special mobile unit mainly made up of a system complete with generator, motor-pump and other equipment;
- other mobile and vehicle means.

Sanco got this job thanks to the experience that has been demonstrated to a most demanding customer, who would usually make numerous obstructions and restraints to non Japanese suppliers, favouring local constructors. Nevertheless, the contract was awarded to Sanco by recognizing the special quality of its products and services: Sanco's staff demonstrated its professionalism by following both the specifications and, above all, keeping to the contractual delivery date.

The entire Red Hurricane unit was, in fact, built and tested in less than 3 months and then the 27,000 kg unit was loaded onto the Antonov 129 airplane for delivery.

## The second case: Iraq

Sanco has recently been involved to the engineering and construction of fire fighting packages including also many water-foam deluge units for an oil field development project located in Iraq. The project has been carried on in full compliance with the client's specifications and high quality materials have been used, such as nickelbronze valves special stainless steel alloys, thus granting high performances, low maintenance and a long life.

One of the dozens of deluge units is represented in **figure 2**.



*Fig. 4 - Fire fighting trucks*

The skids have been transported with special trailers since its dimensions were really out larger than overall road size. Anyway, the biggest project that have been carried on was the one for Baiji power plant, for which our engineers have been consulted for the design, manufacture and installation of all systems and equipment for a total amount of over 12,5 million euros.

Even if this project has involved significant financial and human resources, Sanco met all the contractual terms within the schedule times and within the scheduled budget.

### The third case: Uzbekistan

Uzbekistan possesses significant oil and gas energy resources and recent investment by other countries in its gas and oil industry offers economic diversification and growth prospects for the country. Development of these energy resources will generate viable export opportunities and help reduce Uzbekistan's reliance on importation of hydrocarbon products.

Sanco has been supplying its systems and equipment in order to contribute to the broader development goals of the Republic of Uzbekistan through the expansion of the area to extract natural gas and subsequent gas processing for a total amount of about 3 millions USD. All the fire & gas detection systems and fire suppression systems and equipment into the buildings and on site have been selected in order to be supplied by Sanco that has been developing the whole package in order to be used at really low temperatures down till -32 °C.

All outdoor systems have been manufactured by

taking into account of wet and cold climate conditions in Uzbekistan. Really low temperatures demanded to

All the fire & gas detection systems and fire suppression systems and equipment into the buildings and on site have been selected in order to be supplied by Sanco that has been developing the whole package in order to be used at really low temperatures down till -32 °C.

use suitable special material, in order to grant the integrity of the systems, their good performance, a low maintenance and a long life (figure 3). The supply has been certified according to the local Authorities procedures (GOST-U).

Algeria's power consumption has been increasing by about 10% annually in recent years, and large-scale investment program have been carried on in order to almost double electricity generation within the next years. For these reasons the presence of Sanco in this country has been

consolidated by recent projects for several power plants located in different sites such as Boufarik, Naama, Terga, Djasser, Labreg, Hassi Berkine etc.

All systems and equipment that have been supplied, including all fire & gas detection control panels, related accessories, fire suppression systems as well as special fire trucks and ambulances have been planned to be used into particular plant environmental conditions (figure 4).

Presently Sanco can certainly be considered, in its field, a referenced company both in Italy and overseas, by directly and indirectly supplying in more than 70 countries.

Thanks to targeted actions, in the last 3-4 years Sanco has gained attention from important customers and organisations, who involved the company in the study of some subjects and problems that have been solved together with them.

Sanco objectives do not end with the increase of customers; quality, safety, reliability of the service, continuous improvement, confronting the market,

technological innovation, cost reduction, personnel growth through update courses, represent the pillars of Sanco's activity. For these reasons Sanco has recently got Lloyd's Register Quality Award: it was the only fire fighting company to win this prize, among 1500 selected Italian industrial manufacturers that were participating to this event.

Sanco is today at the top in the protection against fires and can satisfy any request on the International

market. Merit not only to its range of products, but also to the organisation which is cared for in detail.

The evolution of Sanco is also fruit of a meticulous and detailed commercial organisation present in dozens of countries with representatives and its own managers. Priority is the study of customer needs. The Sanco team operates to the "customer satisfaction principle".



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## Nico Zorzetto

Nico Zorzetto, Export & Marketing Director as well as shareholder of Sanco SpA, has been working in the fire fighting field for the last 40 years. Even if he graduated in Economics, he has always been dedicating its interest to technological innovation for "reliable products".

He has been participating to the realization of several new products and systems; in particular he is co-creator

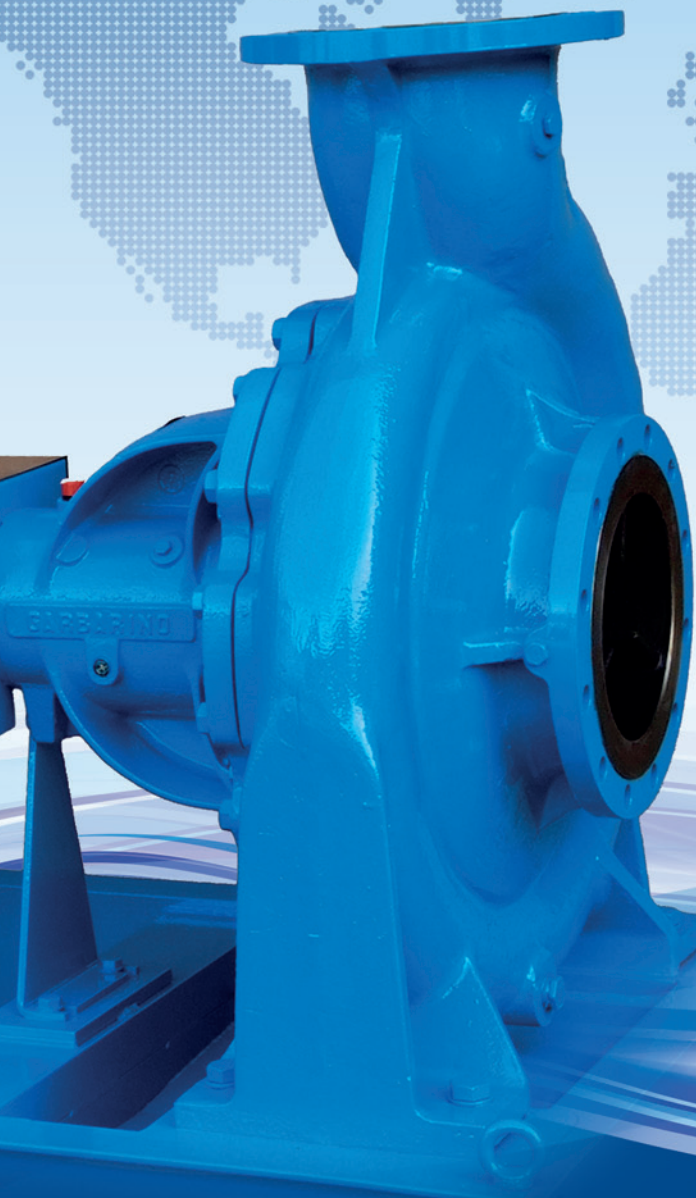
of airmobile fire fighting systems (fixed type and rotating wing) for the fire fighting of bushfires. He has been publishing several articles – national and International - relevant to fire fighting subjects.

He operates also with national and International organizations for the Civil Protection Organizations, as well as with security matters, with jobs also with NATO.

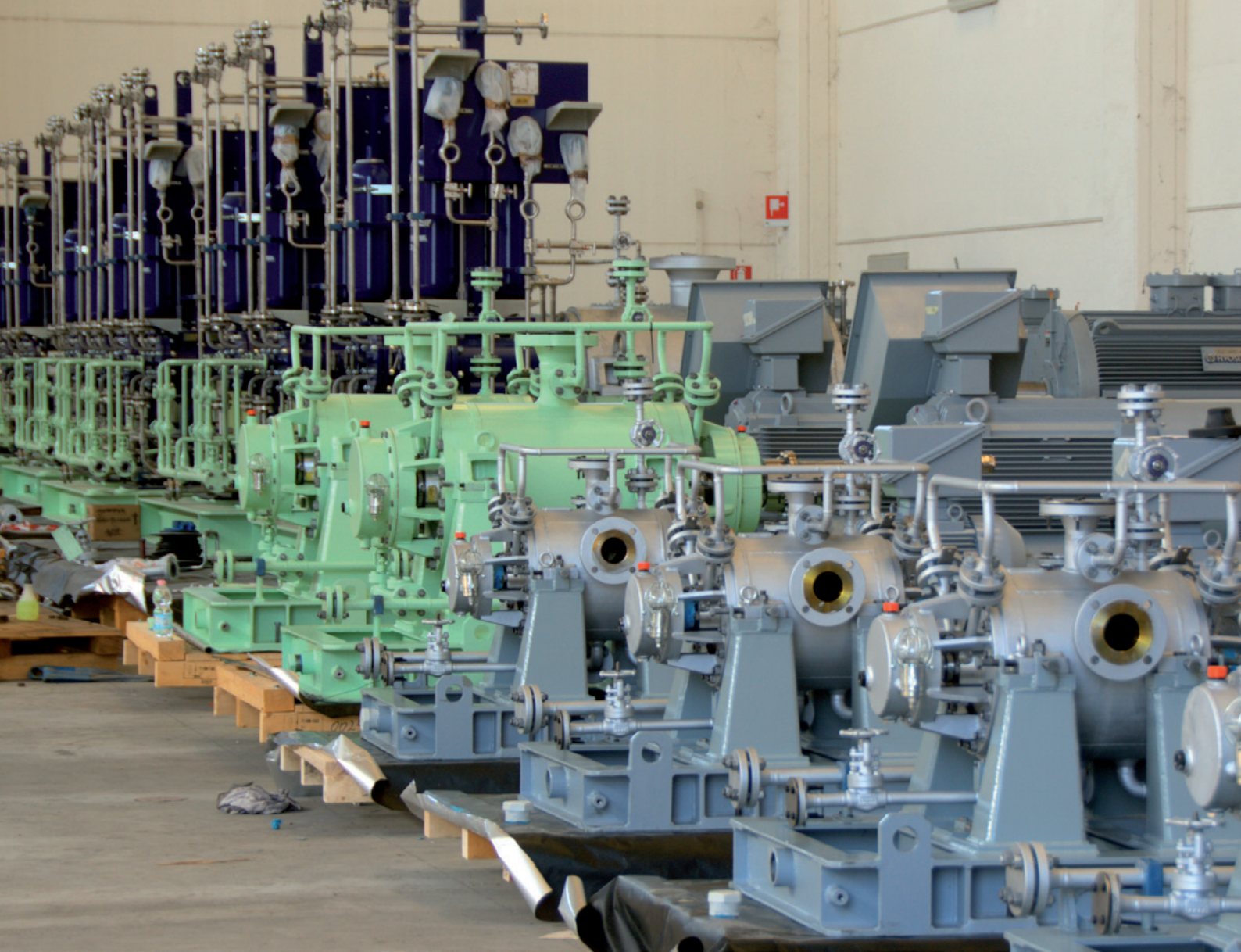


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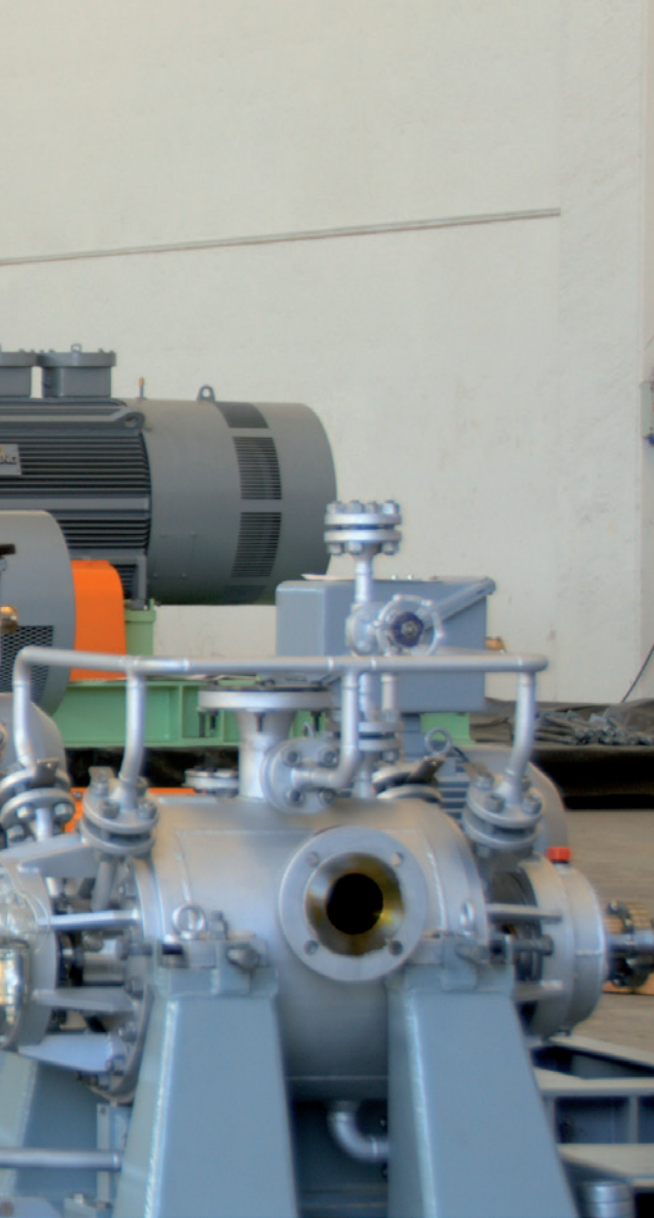
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# Pumps for Large Thermal Power Plants in Saudi Arabia

Finder Pompe has been awarded quite big orders for the Jeddah South and the Shuqaiq 2640 MW Thermal power Plants

**Susanna Bollini**

*Finder Pompe SpA Corporate Marketing Director*



pumps to be used for these applications, but then HHI revised the process and decided that a mix of centrifugal and screw-pump technologies would be required. This decision had been extremely beneficial for Finder since there was just one other company that was bidding on the project that could supply both centrifugal and screw-pump technology.

Finder could also leverage the successful past history with HHI. In particular, Finder had supplied large numbers of pumps for a series of floating production, storage and offloading (FPSO) units for use in oil exploration that were being constructed by HHI's Offshore & Engineering Division, including:

- 48 pumps for Eni Norge / Statoil's Goliat FPSO in Norway in 2010;
- 17 pumps for Total's Ofon FPSO in Nigeria in 2010;
- 24 pumps for PTT Exploration and Production's Bongkot FPSO in Thailand in 2009;
- 27 pumps for Total's Usan FPSO in Nigeria in 2009.

## Jeddah South and Shuqaiq Thermal Power Plants

Because of this past history and Finder's ability to meet all technical requirements, along with HHI's need of flexibility regarding pump supply, cost and delivery, in June 2013 it announced that Finder had secured the contract to supply a total of 99 pumps with value of 11 million euros for the Jeddah South Thermal Power Plant. This made it the largest pump order that Finder had ever received.

HHI then won, in August 2013, a contract worth 3.4 billion US dollars again from SEC to build Shuqaiq Thermal Power Plant in Saudi Arabia.

The Shuqaiq Thermal Power Plant, that will be generating 2640 MW, is a heavy oil-fired supercritical pressure power project based on the SEC's medium- and long-term plan to expand power generation facilities. The plant, located on the Red Sea, about 135 km north of Jizan City, in the southwest corner of Saudi Arabia, is scheduled to be built by 2017.

Also in this case, Finder has been awarded a quite big order consisting of 76 API 610 and ISO centrifugal pumps. Unfortunately, in this case part of the process has been changed compared to Jeddah project and it allowed the use of triple screw pumps, that are not included in Finder's portfolio. The pumps will be delivered in the second half of 2015.

In the last quarter of 2012, Saudi Electricity Company (SEC) announced that it had contracted with Hyundai Heavy Industries (HHI) to build the Jeddah South Thermal Power Plant near the town of Jeddah on the country's Red Sea coast. The project, worth 2.4 billion euros, will be completed in early 2017 and will be the Saudi Arabia's largest thermal power plant, with four 660 MW steam turbines, therefore producing 2640 MW of electricity. The plant will feature a highly efficient, fuel-saving supercritical pressure boiler, which will be the first of its kind to be used in Saudi Arabia.

Finder Pompe has been bidding for this project since the budgetary phase, back in January 2013. One of the requirements for pumps was the capability to convey several different types of medium, including heavy fuel and crude oil, distillate fuel oil, boiler water, seawater, oil, oily water, rainwater and chemical water.

The original project specs called only for centrifugal

Finder could also leverage the successful past history with HHI. In particular, Finder had supplied large numbers of pumps for a series of floating production, storage and offloading (FPSO) units in oil exploration

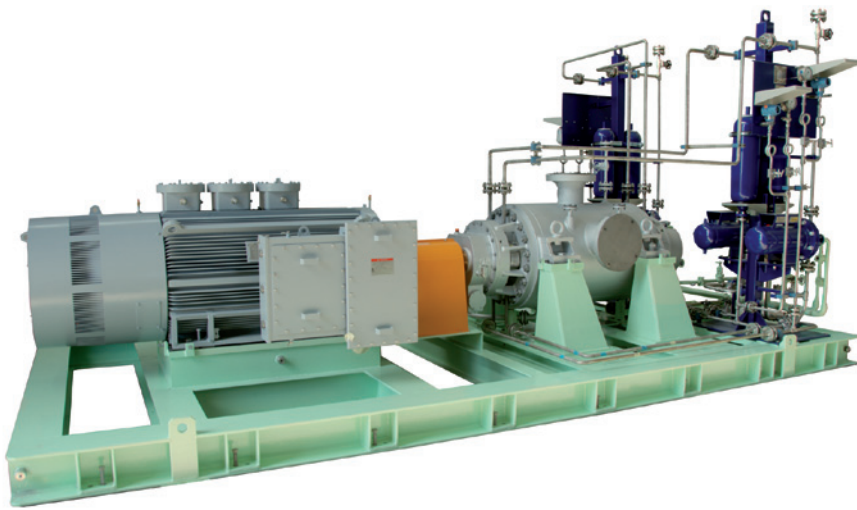


Fig. 1 – Screw pump

## Jeddah

- 39 RRLO Series API 676 twin screw pumps (figure 1 and figure 2)

The pumps are designed and built in accordance with API 676 norms. They are self-priming and can convey fluids containing small amount of gases. The wear-resistant inner casing can be cast in a wide range of materials, with optional wear-resistant surface treatments also available. The screw shafts are machined from forged mono block pieces or bars and hardened steel gears are fitted directly on the rotors while over-dimensioned roller bearings ensure smooth and reliable operation.

All RRLO pumps include relief valves that can meet the particular requirements of the plant. Optional steam or hot-fluid heating chambers are also available.

- 14 HPV Series VS4 API 610 vertical sump pumps  
These pumps are designed according to the norms of API 610, 11th edition, and are suitable for heavy-duty applications in many industries. Each HPV



Fig. 2 – Screw pumps

## About FINDER Pompe SpA

FINDER Pompe SpA is a leader in the design and manufacture of API-engineered pumps and systems for the global energy market, primarily oil & gas. FINDER has operations in Merate and Querceta, Italy, as well as a network of representation in more than 75 countries worldwide.

FINDER can boast an over 60 years' experience in the design and manufacturing of engineered pumps for critical applications in the power-generation, oil & gas, and general industrial process industries. Since November 2013 FINDER has become a member of Dover Corporation, Downers Grove, Illinois, USA, a Fortune 500 company, with

revenues of 8 billion US dollars.

Dover is a diversified global manufacturer with annual revenues of 8 billion US dollars. It delivers innovative equipment and components, specialty systems and support services through four major operating segments: energy, engineered systems, fluids, and refrigeration & food equipment. It combines global scale with operational agility to lead the markets it serves. Recognized for its entrepreneurial approach for 60 years, Dover team of over 27,000 employees takes an ownership mindset, collaborating with customers to redefine what's possible.



Fig. 3 – Low flow-high head vertical sump pump (PEP pump)

pump is engineered to suit customer's specifications, application and needs. Any pump length from 0.5 to 6.5 m below the mounting plate can be achieved. Standard construction features a single piece shaft guided by sleeve type line bearings, where needed. The span between line bearings, which are available in different materials depending on pumped fluid and operating conditions, is studied for each application in order to assure reliable and smooth operation, paying special attention to lateral critical speed issues.

Lubrication of the line bearings is normally obtained by means of the same pumped fluid or from an external lubricating source (clear liquid or grease) in abrasive services available in different materials depending on pumped fluid and operating conditions. The mounting plate, which is integral part of the pump, can be designed in either square or round shape, to match sump or tank plates or flanges.

### Shuqaiq

- 4 V-PEP VS4 API 610 low flow-high head vertical sump pumps (figure 3)

The PEP pump range has been specifically designed to meet low flow, high head, low NPSHa API 610 requirements without requiring increased speed solutions. Hydraulic working principles are the same described in the literature for "Partial Emission" or "Barske type" pumps, i.e. open impeller with full radial vanes and 90° exit angle, concentric volute, the energy being transferred to the liquid in a forced vortex regime

**The peculiarity of PEP range is that the required output velocity is obtained by increased impeller diameter instead of increased rotating speed. Low rotating speed grants low NPSHr values all over the operating range: in all PEP pumps, NPSHr remains less than 1 m at 3000 rpm without the use of inducers.**

and converted into pressure in a diverging diffuser.

The peculiarity of PEP range is that the required output velocity is obtained by increased impeller diameter instead of increased rotating speed. Low rotating speed grants low NPSHr values all over the operating range: in all PEP pumps, NPSHr remains less than 1 m at 3000 rpm without the use of inducers.



Fig. 4 – Heavy duty process pump

The result is a robust, maintenance-friendly pump for extreme service conditions: from less than 1 to 25 m<sup>3</sup>/h, up to 300 m head, with casing pressures of 50 bar and over, at temperatures up to 400 °C and with any type of hazardous and flammable fluids. Open impeller design and generous clearances allow moderate solid contents in the process fluid and surface coating if required.

- 16 C2PO BB1 API 610 axially split pumps (figure 4)

C2PO heavy duty process pumps are horizontal, between bearings, axially split casing, double suction, one stage impeller (BB1 configuration), in full compliance with API 610 std., latest edition (ISO 13709). The specific pump construction allows to achieve very high efficiency with low NPSHr values. Robust casing, stiff shaft design and different bearing arrangements to meet specific applications make the C2PO a fully reliable pump, granting long life in service and reduced maintenance costs. Thanks to its specific construction, inner parts are easily accessible, without disconnecting the casing from the piping and the electric motor.

The pumps have been delivered to the Jeddah South plant site in 2014 and are expected to be installed sometime in 2016 and go into operation when the



Fig. 5 – Vertical turbine pump



Fig. 6 – Horizontal OH1 pump

## Shuqaiq

- 32 HCV Series ISO 5199 vertical sump pumps
- 14 CKVN ISO 5199 vertical turbine pumps
- 10 HC Series ISO 5199 horizontal OH1 pumps (figure 6)

These centrifugal pumps are designed and manufactured according to ISO 5199 – ISO 2858 norms, making them suitable for process applications in the chemical industry, as well as heavy-duty general services in all industrial fields. They are designed to operate at both 50 and 60 Hz at temperatures ranging from -40 °C to 350 °C and up to 3600 rpm. The casing is radially split end-suction and top-discharge nozzles, while the hydraulic axial thrust is balanced by means of back wear rings and balancing holes at the impeller's eye. A deep stuffing box allows the use of either conventional or cartridge-style mechanical seals in single or double configurations.

The pumps can be manufactured in any material combination depending on service conditions. A semi-open impeller design is also available for fluid-transfer operations that feature charged liquids or suspended solids.

plant begins producing electricity in the first quarter of 2017.

## Jeddah

- 28 HCV Series ISO 5199 vertical sump pumps
- 18 CKVN ISO 5199 vertical turbine pumps (figure 5)

Finder was able to secure the order for the Jeddah South project and the Shuqaiq project, not just because it had the best pumps, but also because it parlayed prompt and comprehensive communication and support during the budget and bidding phases, and competitiveness in price and delivery capabilities. All this, combined with the successful supplies of the past, granted Finder to get the largest pump order in the company's history.



## Susanna Bollini

Susanna is the Marketing Manager for FINDER Pompe SpA, Merate, Italy. She has been working with FINDER since 1989; at that time she was the International Sales

Director for the FINDER Group. In 1999 she left the Sales and became the Marketing Manager.



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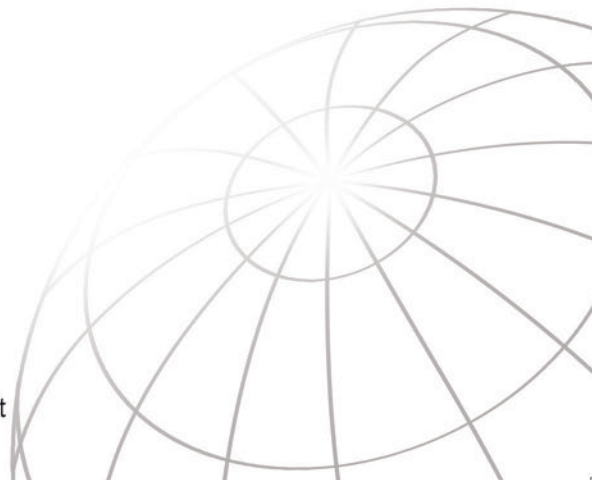
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# Guaranteeing System Safety With Maximum Performance

Cear, with Premabergo Italiana, was involved in the construction of two automation systems for two electrochlorination packages on a platform in India, operated by the company Oil & Natural Gas Corporation

**Alessandra Ranno**

Marketing Manager, Costruzioni Elettrotecniche Cear Srl



Fig. 1 - The platform in India

Oil platforms are very impressive facilities built or assembled near oil wells and, for this reason, in addition to being exposed to explosion risks, they must also perform the task of providing multipurpose facilities and structures to accommodate the workers and equipment needed for production. For these reasons, platforms are a hostile environment in which to operate, where it becomes essential to maintain and ensure high levels of safety and reliability both for systems and installed equipment.

Over the course of many years, Costruzioni Elettrotecniche Cear has been operating in the oil &

gas sector both in off-shore and on-shore environments, and has already dealt with the typical needs required for electrical installations and automation in systems at risk of explosion. Based on this specific know-how, the company has been able to develop projects and solutions that meet customer needs.

The main requirement of our customer was to have the power and control system installed on each electrochlorination skid. This requirement involved the need to think of an Ex p pressurized PLC panel therefore able to operate in the hazardous zone

Cear, in collaboration with its customer Premabergo Italiana, was involved from the early stages of the tender and in the feasibility study for the construction of two automation systems for the management of two electrochlorination packages, on a

platform in India operated by the company Oil & Natural Gas Corporation Ltd (figure 1).

The supply was not limited to the manufacturing of

the special control panels, but involved Cear engineers from the early stages of the project in the electro-instrumental engineering, selection of components and materials most suited to the application, construction and programming of the PLC (Programmable Logic Controller) and HMI (Human Machine Interface) software, and the commissioning and start-up activities in the platform, completed in 2013.

## A necessary choice: overpressure execution

The main requirement of our customer was to have the power and control system installed on each electrochlorination skid. This requirement involved the need to think of an Ex p pressurized PLC panel therefore able to operate in the hazardous zone.

The Ex p plc panel was designed to allow the control units and switchgear, as well as complete automation systems suitable for the safe area, to be mounted into the pressurized cabinet.

The overpressure (Ex p) ensures that the pressure inside an enclosure is sufficient to prevent the entrance of flammable gas, vapour, dust or fibres and prevent possible ignition. Another process maintains a constant flow of air (or an inert gas) to take away any potentially explosive atmosphere. Thanks to this type of protection, even non-explosion-proof devices could be operated in potentially explosive areas, as the underlying idea is to prevent an explosive atmosphere from entering a sealed protective enclosure by generating a permanent overpressure against the surrounding atmosphere.

To obtain this condition, the cabinet is equipped with an additional external panel, in Ex d execution,

containing the components necessary to activate the overpressure process, which is achieved with the release of a protective gas (normally consisting of instrument air) within the closed control panel.

The release of this gas is preceded by a “washing phase”, during which the protective gas entering the casing to be protected flows under the control of an exhaust valve that changes the air; then the “maintenance phase” of pressurization, which allows the control panel to operate safely, thus allowing the full commissioning of the equipment.

In case of failure or malfunction, the control panel is also equipped with signal alarms to put the equipment out of service until the necessary pressurization is restored.

In the specific case, we made two power and control panels marked Ex pz (ia) zone 2 3G IIB T5 that, according to the Atex/94/9/EC Directive, adopt a system of protection for overpressure joined to the intrinsic safety equipment which makes them suitable for use in zone 2, guaranteeing a maximum surface temperature of less than or equal to 100 °C. The cabinets were made of stainless steel Aisi 316, with an enclosure rating IP 66, to resist environmental corrosion and meet the requirements of the standards, while the internal electrical components, thanks to the Ex pz execution, permitted the installation of components for safe area.

Being automation panels, they are also provided with an external HMI touchscreen operator panel, suitable for operation in zone 2.

## Double system to optimize production

A particular feature of the two electrochlorination packages is that, being placed near to each other, they would have to work, alternately or together depending on the production needs of the plant. In this way, we could achieve the goal of optimizing production while also ensuring the continuity of operations (**figure 2**). Obviously, this operation must always take into account the presence of an environment at risk of explosion, and therefore, during the design of the automation system, we considered various precautions so as not to compromise operational security.

So that the two panels could operate safely, in a precautionary way, and in line with the intrinsic safety requirement for this application, Cear engineers developed an analysis of Ex i loop safety parameters to verify that the energy that passes through the loops to the field does not cause sparks in the event of a short-circuit.

In addition, we did not overlook the element of

*Fig. 2 - The electrochlorination package working on platform*



control flexibility of the system through an intelligent system that combines the activity of two systems according to the production needs, and following some predefined and functional modules in the process continuity.

The automation system developed by Cear was then arranged so that the two PLC panels (**figure 3**) dialogue with each other via serial communication to coordinate the operation of the two systems.

The two control panels could dialogue only if both were in overpressure; the system was designed to interrupt both the power supply and the communication signal between the two panels in case of the loss of overpressure of one of them.

The external case Ex-d, as well as containing the start-up system of the overpressure system, also contained the components for handling the communication between the two panels. From an electrical point of view, a circuit breaker would interrupt the electrical power supply in case of loss of overpressure of a panel, and the hermetic relays (*vacuum*) would interrupt the signal between the two PLCs.

## Customized automation system

The special feature of the automation system was the programming of the PLCs and the customized user interface; the request from our customer was that the two panels (therefore, the two associated skids) should be interconnected, thus creating one master skid and another automatically being the slave, with the possibility of interchanging the scenario.

The two master and slave scenarios obviously had different functions; the master PLC would make the system run relative to production and the injection of chlorine continuously, whereas the slave would make the system run relative to production and the injection of chlorine in shock mode, with integration of the various control and safety loops for both.

The above-mentioned injections of chlorine (continuous or shock) were also adapted automatically using algorithms specifically designed to optimize the various system requirements of the



Fig. 3 - Ex p power & control panel

customer, which reached the PLC as inputs from the DCS (Distributed Control System).

Lastly, always thanks to the specially designed algorithms, the program allowed the constant monitoring of the state of cleanliness of the electrolyzers (**figure 4**).

## Conclusion

Electrical applications in a hazardous area are a “critical” element that cannot be overlooked by any plant engineer who has to create a system in a platform. The possibility of having a reliable partner in the field of electricals and automation can be a clear advantage.

From the design stage until the construction and installation, Cear remained at the side of its customer. This was particularly the case when it came to maintenance of the platform by trained personnel (Bosiet certified), who collaborated in the completion of the commissioning, start-up and training of personnel who were to be directly involved in the use of the system.

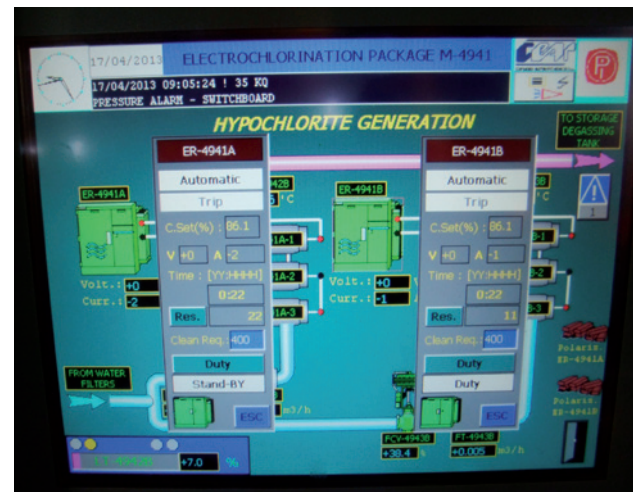


Fig. 4 - A detail of Scada system



## Alessandra Ranno

Alessandra has studied Languages and Communication, then graduated in Marketing & Communication at the University of Milan. She's in Cear since 2010 and she's in charge as Marketing

Manager for coordinating marketing activities, implement international markets and support sales team.



# High Energy Pumps for Water Injection Service

In 2014 Weir Gabbioneta supplied three of these pumps to Kuwait Oil Company for their North Kuwait field operations

**Ilario Sacchi**

Weir Gabbioneta Srl

*Weir Gabbioneta Srl  
historical headquarters in  
Sesto San Giovanni, Milano,  
Italy*

*Weir Gabbioneta Poland Sp.  
z o.o. plant in Myszków,  
operating since 2012*

*Weir Gabbioneta Srl future  
facility, as it will be in 2016,  
in Nova Milanese, Monza  
Brianza, Italy*



Established in 1897, Weir Gabbioneta (formerly Pompe Gabbioneta) has become over the years a leading manufacturer of process centrifugal pumps with focus on the oil & gas market, significantly extending its range of products and successfully facing the most challenging duties and applications in this demanding market. Among the products shipped in 2014 from the historical factory in Sesto San Giovanni, Milano, Italy a note of mention is to be given to three Water Injection Pump (WIP) units supplied through a local contractor to the Kuwait Oil Company (KOC) for their North Kuwait field operations.

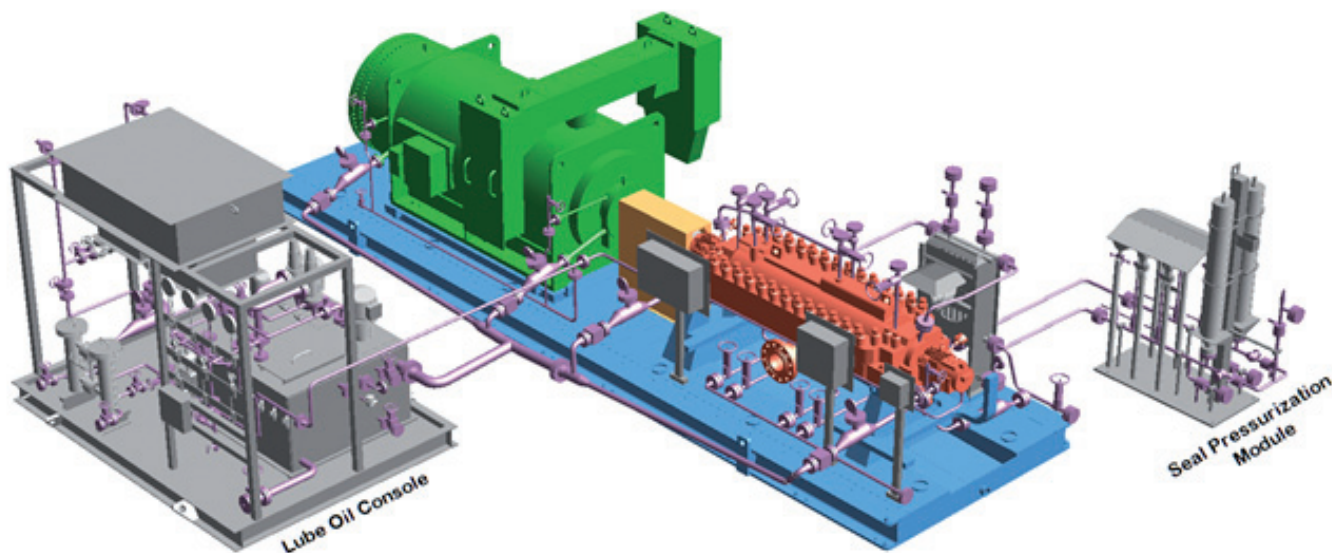
With their 5,6 MW installed each pump, these are in fact the largest - in terms of power - pumps ever manufactured by Weir Gabbioneta. Built in BB5 configuration (radially split double casing multistage) according to API 610 11<sup>th</sup> edition and made with all

wetted parts in duplex stainless steel, these products belong to the Gabbioneta AHPB series, well known for its proven reliability and having, among other features, back to back impellers arrangement to grant full axial thrust balance in all operating conditions and cartridge type construction for easy field maintenance.

The three above mentioned WIP units are complemented by two effluent water pumps built in BB3 configuration (axially split multistage) and belonging to the Gabbioneta AHP series.

In spite of their different construction these two product series share a number of components: although each pump item manufactured in Weir Gabbioneta is practically unique in all its details, product standardization is a normal concern to our engineering department. All product lines are taking benefit from this approach offering, among other advantages, the possibility for the clients to optimize their spare parts inventory (**figure 1**). Back to the subject, each unit supplied for this job is

*Fig. 1 - Water Effluent Pump: 3D modeling of the installation*



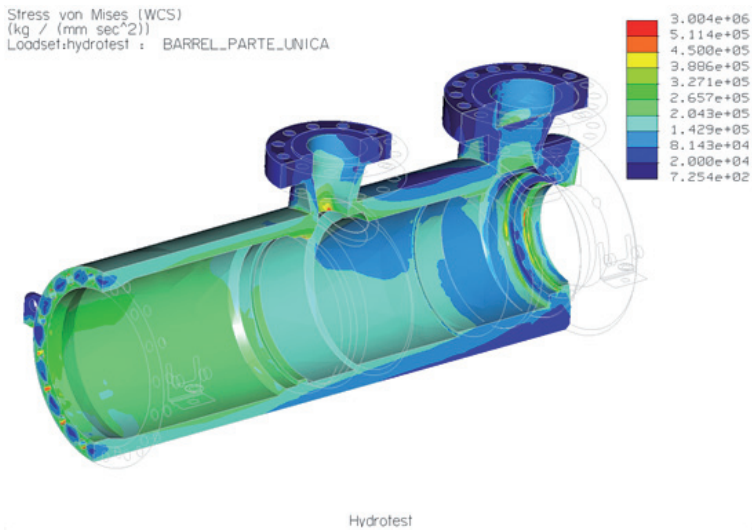


Fig. 2 - Stress analysis: pump casing

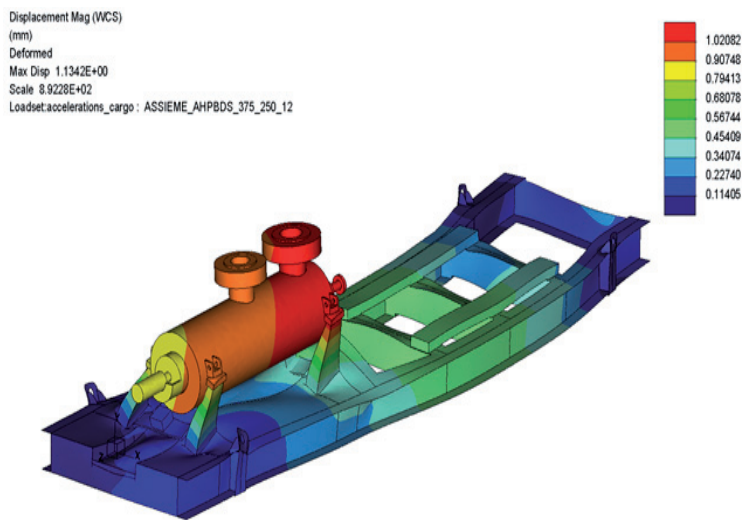


Fig. 3 - Stress analysis: pump and baseplate

installed on a common skid with a high voltage electric motor and served by an air cooled type lube oil console designed in accordance with API 614 standard, strictly meeting the applicable project specifications. Mechanical seals are double pressurized type, also equipped with air cooled buffer fluid systems. Each water injection pump skid, not including the lube oil console, is 10.14 m in length, 5.4 m wide and 4.2 m high at the motor, with a total weight of 42,830 kg.

As standard practice for this class of pumps an extensive calculation process including pump rotor lateral and torsional analysis was carried out from the design stage.

Pump casing and baseplate design have been verified and validated through FEM (Finite Elements Method) analysis for structural rigidity. Modal analysis of the main baseplates was also performed to prevent any resonant frequency issue at operating speed

Furthermore, in view of the project requirement, for the pumps to withstand nozzle loads up to 4 times the API 610 standard values, pump casing and baseplate design have been verified and validated through FEM (Finite Elements Method) analysis for structural rigidity. Modal analysis of the main baseplates was also performed to prevent any resonant frequency issue at operating speed. All these activities are normally done internally by means of advanced engineering software tools (figure 2 and figure 3).

As a matter of fact, while the design and the manufacturing of these pumps did not represent a particular problem to Weir Gabbioneta engineers, the CUT (Complete Unit Test) of the main water injection pumps in particular has stretched the limits of the existing testing facilities due to the size and weight of the skids on one side and to the required electric power and heat dissipation capacity on the other (figure 4).

Built in the 1990s as state-of-the-art fully automated installation to fit - with a remarkable engineering work - the existing facility, the current test room arrangement has been showing in the recent years some limits against the increased size, required power and overall complexity of the manufactured products.

From the early 2000s it was already necessary - mainly for space reasons - to open an auxiliary site in the neighborhood of the main manufacturing plant (Cinisello Balsamo) and more recently in 2012 a new production facility was started in Myszkow (Poland). This latter has become the COE and main manufacturing unit for the Gabbioneta and Begemann API 610 pumps type OH2, OH3, OH5, VS4 as well as "low energy" VS1, whilst the Italian operations remain focused on larger and more complex BB and high energy vertical pumps.

## A new suitable location

The need for a more modern production plant in order to give adequate response to the increasing requirements in terms of products size, lean manufacturing process and - last but not least - HSE (Health Environment Safety) standards became more and more evident to the Weir Gabbioneta management over the recent years.

As a consequence, after having considered different options the decision was eventually taken to build a new state-of-the-art production plant bringing under the same roof the activities currently done in Sesto San Giovanni and Cinisello Balsamo sites, upgrading at the

same time the manufacturing and testing capabilities to support products growth..

A suitable location was identified in the industrial area of Nova Milanese, just 5 km far from the two existing sites. An investment of nearly 25 million euro has been approved by the Weir Group Plc – that is entirely owing and controlling Weir Gabbioneta - to fabricate from grass root a new property building and related facilities. The erection works of the new plant that will cover a surface of 32,000 m<sup>2</sup> already started at the end of 2014 and are currently proceeding ahead of plan.

The Nova Milanese plant has been designed to host over 500 employees and workers and will comprise a 15,000 m<sup>2</sup> manufacturing area as well as 5,000 m<sup>2</sup> of offices for a total covered area of 17,000 m<sup>2</sup>.

The new plant, due to enter in operation within 2016, will also host a newly conceived testing room basically doubling the existing one thanks to an installed power of approximately 8 MW with VFD (Variable Frequency Drivers), a capacity of over 10,000 m<sup>3</sup>/h and a pressure of more than 400 barg, let alone the improvements planned in available space and equipment handling.

It will probably be sad for many Weir Gabbioneta employees to leave the historical red bricks factory that has seen the successful growth of the Company over more than one century, becoming an icon in the



Fig. 4 - Testing the 5,6 MW Water Injection Pump Unit in Sesto San Giovanni facility

world of pump manufacturers and more lately a last industrial stronghold right in the heart of Sesto San Giovanni. On the other hand the renewed commitment of an international investor in our country in a period of persisting uncertainty for our economy is seen as a proof that quality and commitment still pay back, giving to all of us new enthusiasm for the challenges to come.

## Weir Oil & Gas Division

The Weir Group Plc, publicly traded at the London stock exchange (Weir: LSE), employs around 15,000 people worldwide across three divisions - Minerals, Power & Industrial and the youngest Oil & Gas formed in late 2008 – each focused on a key market sector and with independently successful companies with leading brand name products.

Thanks to a fast-paced organic growth, the Weir Oil & Gas Division can deliver innovative end-to-end solutions for customers worldwide in upstream, midstream and downstream markets - both onshore and offshore.

Weir Oil & Gas comprehensive portfolio includes: pressure pumping well service & stimulation pumps, flow control products, pressure control surface equipment, drilling mud-gas separation equipment, API 610 centrifugal pumps.

This is supported by an extensive global network of local Service Centres, that can locally deliver mechanical and rotating equipment repairs and spare parts, asset management and field engineering services to ensure the highest levels of continuity and productivity.



## Ilario Sacchi

Ilario has over 30 years experience in rotating equipment acquired throughout his professional career in the oil & gas market. He worked at most major pump and seal manufacturers with different responsibilities covering

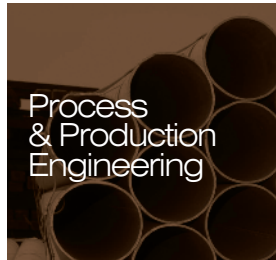
first service and then sales as well.

In 2011 Ilario joined Weir Gabbioneta Srl, where he has been in charge of the Sales & Marketing Department as Sales Director since then.

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# 570 tons of tanks from the Czech Republic to Austria

Bertling Logistics Italy handled with success this difficult project, that required detailed pre-planning, the consideration of all possible obstacles and excellent connections to sub-contractors and suppliers

The task for Bertling Logistics Italy was to offer studies and a transport solution for the shipment of six tanks from Decin (Czech Republic) to Braunau (Austria). Each tank measured 30,450 × 475 × 480 cm and weighed 95 tons. The distance between Decin and Braunau is approximately 400 km.

The dimensions of the tanks made the transportation by road impossible. Hence Bertling had to find another solution. After careful evaluation of all possibilities and given the fact that the manufacturer's factory was located close to the river Elbe, Bertling proposed a solution by using waterways; even though this plan increased the total voyage length to 1.910 km and 30 days transit time.

Three barges, loaded with two tanks each, were used to transport the equipment from Decin to Aschach (Austria), where the tanks were temporarily stored, and then moved for the remaining distance by road. The reason for choosing Aschach rather than Passau as discharging port was a damaged bridge crossing the railway, which was blocked since the flooding in 2014. Moreover, this bridge was downgraded, so that it could not support the total weight of the convoy.

An additional survey executed by Bertling proofed the possibility to load out the tanks in Aschach by using the berth on the river Danube which offered enough space for the crane operations and also the capacity to store the tanks on special trailers before their 200 km on-carriage to the final jobsite. Six days after the tanks

were moved to the river quay, the three barges left Decin on time for their 30 day journey. While the barges were on their way, Bertling was informed that the river ways were obstructed by repair works on the locks in the Main Donau Canal during the period of the transit of the convoy. As this would have had a negative impact on delivery schedule, Bertling decided

and agreed with the client to carry out an alternative plan: All six tanks were transshipped from the three barges on a river-going vessel in Duisburg (Germany). Thus the tanks reached the river port on time, as the ship had much more speed.

Another variation to original planned route was the port of arrival. Instead of Aschach, Bertling decided to receive the ship in Linz (Austria). With all the necessary equipment (cranes, self-propelled modular transporter (SPMT), stools, storage area) already in place, all mobilization / demobilization operations could be avoided.

The ship arrived to Linz on time, where all tanks were offloaded, put on SPMTs and moved to the storage area.

The last and final step of the whole operation took place three days later, when the tanks were transferred by three convoys of two special "Schnabelbrücke" trailers on a round trip basis to their final destination, absolutely on time, as per the original schedule and to the client's full satisfaction.



Fig. 1 - Transportation from the workshop to the River Port of Decin (Czech Republic)



Fig. 2 - Transshipment in Duisburg (Germany)



Fig. 3 - River-going ship sailing from Duisburg

# Oil & Gas Exploration is Evolving on a Global Scale

From the end of 2014 M2E Projects is developing, in a completely unexplored and high-potential geological basin located in Mozambique, offshore and onshore activities

**W**ith traditional locations like the North Sea, Russia and West Africa still firmly on the radar, countries such as South America, Congo and Mozambique are now catching the attention of the major oil companies especially regarding the nearshore and offshore activities.

The recent big injection into the extraction and processing of shale and LNG (Liquified Natural Gas) has put on the scene other main actors such as Asia, the Middle East and of course, the US. Also considering that ultra-deep water, tar sands and FPSOs (Floating Production Storage and Offloading), as the future energy frontiers, are currently driving the industry into these innovative new territories.

years, creating a relevant skills gap with an accelerated loss of experience that could deeply affect the market. We believe that in order to meet the challenges, is important to bring local knowledge with a global perspective, working within the political, geographical, social and cultural reality, not against it. Our consultants are experts in their sector and our global hubs ensure we have access to the world's best talent across the oil & gas industry.

## Focus on Mozambique

Due to the significant natural gas discoveries in 2013, Mozambique has become the focus of attention for numerous international oil companies and the Mozambican legislative regime is changing accordingly. Mozambique has the potential to be the world's fourth largest source of natural gas and, as a result, the sector has experienced a flurry of activity in recent years.

From the end of 2014 M2E Projects is working closely to mayor Oil and Gas companies in performing deepwater, nearshore, onshore investigation and pre-FEED activities for:

- deepwater subsea structures;
- floating production facilities (FLNG);
- deepwater pipelines to the coast of Mozambique;
- onshore LNG plant.

## Challenges and opportunities

Considering that oil & gas exploration is evolving on a global scale, the need for specialist talents is becoming more and more a priority. This complicated market is evolving fast and the need of energy is increasing, as a result there is a strong need of a workforce able to play such a demanding game. Many high-level specialists will leave the industry in the next ten

Such a demanding and complicated project, also considering the challenging environmental and geological conditions encountered, definitely requires significant preparation and sophisticated equipment, but also trained and skilled personnel able to coordinate activities with a wide range of stakeholders, to oversee the different aspects of the work and to high HSQE standards. Despite the geopolitical and geological criticality, Mozambique will be the one of the future oil & gas global challenge.

Marco Ungari

Managing Director, M2E Projects



Fig. 1 - Shore approach in Cabo Delgado, North of Mozambique



Fig. 2 - Near shore Geotechnical site investigation - Jack up rig performing Boreholes and Piezocone Penetration Tests (PCPT)



Fig. 3 - Mozambique areas of activities

# ANTI SURGE

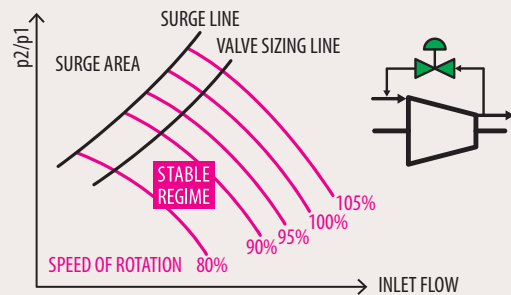
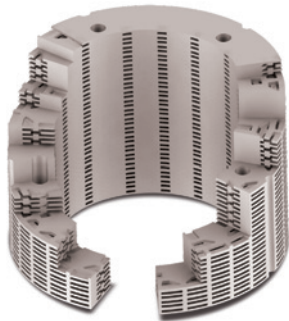
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Smart protection & control systems



# E-House Modules for the Deep Offshore Kaombo FPSO Project in Angola

Schneider Electric has been awarded by Saipem a contract to design, fabricate and pre-commission two fully-integrated technical buildings

Schneider Electric, a global specialist in energy management, has been awarded by Saipem a contract to design, fabricate and pre-commission two fully-integrated technical buildings (also called "E-House modules") to support the deep offshore Kaombo FPSO project in Angola, operated by Total E&P Angola with a 30% share on Block 32.

Located 260 km offshore Luanda in water depths ranging from 1400 to 1950 m, the Kaombo project will develop oil fields with estimated reserves of 650 million barrels covering an area of 800 km<sup>2</sup>.

The Kaombo development scheme includes two FPSO (Floating, Production, Storage and Offloading) vessels, each with a production capacity of 115,000 barrels per day, capable of producing 50 MW electrical energy through gas turbines. Associated gas will be exported to the onshore Angola LNG plant. The Kaombo project includes 59 subsea wells, connected through around 300 km of subsea lines.

Saipem France is the contractor in charge of the engineering, procurement, supply, construction, and commissioning for the FPSOs.

These two FPSOs will be the first turret moored production plants based on converted Very Large Crude Carriers (VLCCs) for Total. The final investment decision to develop the project was made in April 2014, concluding an intensive optimization exercise that reduced capital expenditure from 20 billion to 16 billion dollars, with start-up expected in 2017. Through this contract Schneider Electric confirms its role as a global partner for oil & gas offshore companies in providing integrated, cost-effective and packaged solutions.

\*\*\*

Schneider Electric's E-House solution meets all the challenging technical specifications and standards defined by the customer in Kaombo project. Each of the two E-House modules will be 30 m long by 20 m high on 2 stories, and weighs approximately 1300 tons.

Design Engineering and Project Management will be performed from Schneider Electric's Asia-Pacific E-House Engineering Center in Brisbane, Australia. The construction, equipment integration and testing will be carried out onto an offsite yard in Batam, Indonesia. Final integration of the FPSO will take place in Singapore before a final transfer up to Angolan's coasts.

Patrick Albos, Oil & Gas President at Schneider Electric, says: "In a fast-track, cost-effective and high-profile project like Kaombo FPSO, our customers are seeking a strong E-House project partner. The E-House module package is very complex to build and sits on the project's critical path. Schneider Electric brings the required multiple competencies, like: structural, electrical, HVAC, Fire & Gas, We understand the strategic importance of these modules to power Kaombo project, and how strategic the project is for Total and its partners. Our teams are committed to deliver on-time with full satisfaction and displaying our Schneider Electric values: we are passionate, open, straightforward and effective".

The delivery of the first technical building for Kaombo project will be early 2016 for a first oil expected in 2017.

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As a global specialist in energy management with operations in more than 100 countries, Schneider Electric offers integrated solutions across multiple market segments, including leadership positions in Utilities & Infrastructure, Industries & Machines Manufacturers, Non-residential Buildings, Data Centres & Networks and in Residential. Focused on making energy safe, reliable, efficient, productive and green, the Group's 170,000 plus employees achieved sales of 25 billion euros in 2014, through an active commitment to help individuals and organizations make the most of their energy.



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# The Next 50 Years

How Adma-Opco, a major producer of offshore oil & gas in the Emirate of Abu Dhabi, is using AVEVA software to future-proof its assets

**A**bu Dhabi Marine Operating Company (Adma-Opco) is a major producer of offshore oil & gas in the Emirate of Abu Dhabi. The company prides itself on being a pioneering petroleum organisation in this part of the world, having completed over 45 years of oil and gas production. But with assets now around fifty years old, Adma's challenge is to ensure safe and productive operation for the next fifty years.



Zakum West (Photograph courtesy of Adma-Opco)



Das Island (Photograph courtesy of Adma-Opco)

Central to the challenge of modernisation is the development and maintenance of a digital asset to support and inform long-term life cycle management of the physical asset. As a result, Adma-Opco has begun its As-Built Campaign to provide Adma with a digital asset and develop a digital hub of up-to-date, validated information that accurately describes the current condition of its super-complexes, rather than how they were designed some fifty years ago. Adma's Engineering Services Team Leader, Mohammed Al-Amry, explained their life extension strategy: "We would not extend the life of a particular platform simply for the sake of doing so. Safety remains paramount in all operational and maintenance decisions. The challenges are really all centred on the age of our facilities. One issue was the fact that we could not be sure that our documentation was up to date; the information existed but it was scattered, making it difficult to integrate and access. The key objective of the implementation of our Engineering Information

Management System (EIMS; namely, AVEVA NETTM) is to compile everything in one place, while the As-Built Campaign will ensure that this accessible information is also accurate".

## The information problem

Basem Elnaggar, Adma-Opco's As-Built Campaign Team Leader, highlighted the severity of the problem: "Imagine that you are working in operations and you need some drawings that contain information that will affect the safety or the progress of a project. You start searching but cannot find these documents. So you approach head office and the engineering services team, who may then approach individual engineers or the asset management team. This process can take anything from one day to a month – and in the meantime the issue that you were trying to resolve has seen no progress and your ability to keep to the production plan and meet deadlines is compromised. These kinds of situations, where the required information is not available when it is needed, could result in project delays, loss of production, or even safety issues. 'Engineers must be able to trust that all the information they have is up to date, accurate and complete,' continued Basem. 'Both original and current drawings must be categorised and accessible so that an engineer is not working with outdated information that could lead to misinformed and potentially dangerous decisions. Our As-Built Campaign is a concerted effort to make engineering decisions and actions faster and safer". The As-Built Campaign also aims to provide contractors with all the required information from the outset. This sharing of high-quality information would avoid common situations in which a contractor who does not have that necessary information simply charges the company to go on site and survey a particular area, or where the late discovery of an unexpected problem leads to costly contract variations and delays.



Zakum Central (Photograph courtesy of Adma-Opco)



Zakum Central (Photograph courtesy of Adma-Opco)

## The AVEVA solution

Adma began its AVEVA partnership in 2004, when it deployed AVEVA Pdmstm. In 2012 it went on to choose AVEVA NET to support the As-Built Campaign project. Adma's selection of AVEVA NET was based in part on its integration with their design systems. This made the design processes much easier and eliminated time wasted in having to replicate information across multiple systems; an important facilitator of the As-Built Campaign project. With information coming in from a vast array of equipment, Adma considered that establishing an Eims was vital for handling the sheer size of

the data stream. All of this information needs to be collated, managed and maintained alongside the physical maintenance of the super-complexes

themselves. The As-Built Campaign project will provide the company with most of the 3D models for its assets.

## Taking the lead

Mohammed explained: "Adma needs to meet the challenges of maintaining the engineering information, and of keeping its facilities safe and productive, in order to drive the company forward through the next fifty years of operations. The timeline for the As-Built Campaign is three years and we are firmly on track to build a system that will accommodate information streams from both our brownfield and our greenfield projects. It will provide a system that accommodates all the deliverables and will impose consistent standards throughout. We asked ourselves: do we want to be leaders or followers? This is a decision that every company must make. We see AVEVA technology as one of the key elements that support our leadership."

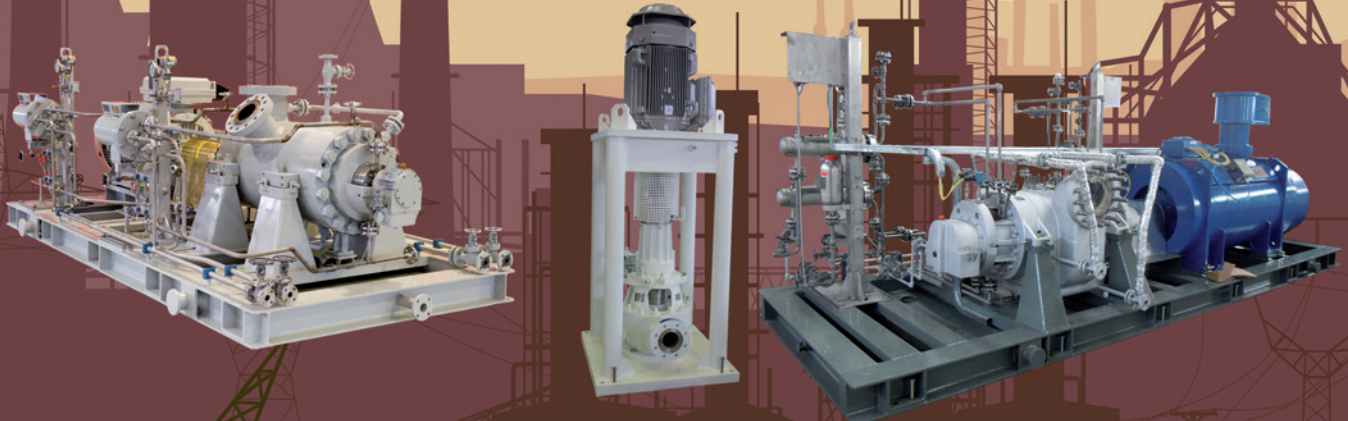
*Audrey Sequier*

Marketing Manager Middle East & Africa, AVEVA

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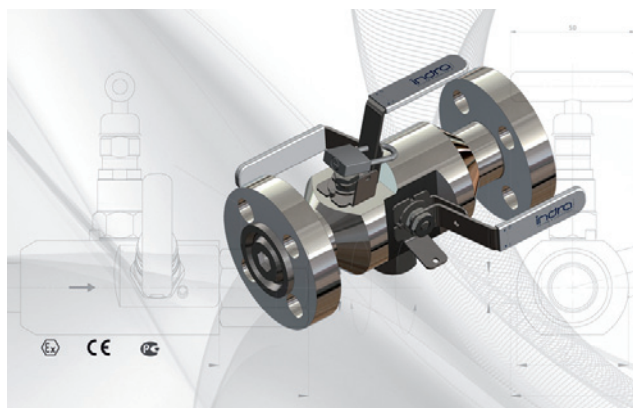
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# From engineering to manufacturing

Indra is a skilful partner in the design and manufacturing of a broad range of valves and manifolds, with solutions intended for various industrial sectors

**E**stablished more than 25 years ago, Indra located in Magenta has accomplished a course of specialization in the design of valves for the oil & gas sector. Activity that over the time, thanks to the attention paid to the more and more specific requirements expressed by the market, has allowed it to be in the forefront in the development and manufacturing of valves & manifolds for instruments, needle and ball type SBB & DBB valves, implemented according to high quality and safety standards. The company is mainly characterized by the realization of 100% made in Italy products: from engineering to manufacturing, using raw materials of prevalent Italian origin.

“Today – underlines Renato Imbriani, Managing Director – the attentive selection of the base material for the product implementation has become a fundamental and determinant requisite for our customers’ final choice. Especially in critical fields like the oil & gas industry where we operate. Besides, due to the globalization and the presence on the markets of manufacturers coming from rising Countries, also the excellent quality of raw materials is deemed a “must”; the selection becomes then for us an essential starting point, because the good product performance depends on that”.



*The 3-ball DBB valve designed and developed by Indra*

Further guarantee of the high quality of the materials selected by Indra is the use of an instrument that analyses their peculiarities: Pmi (Positive Material Identification), a non-destructive method of analysis of the chemical composition of incoming raw materials, analysis sometimes requested by the customer but always and anyway performed by the company's quality control department. Experience and innovation, then, always tuned with the target of satisfying the most different needs, with customized solutions, too.



*The Sampling DBB valve in integral version*

## From the product to the complete “package”

The line of designed and developed products is then perfected also with completion materials and accessories, making the company the privileged and reliable partner of numerous realities for the supply of complete “packages” of various products, mutually complementary.

“The solutions that we develop – adds Renato Imbriani – are mainly used in the chemical, petrochemical, oil & gas, off-shore platforms and energy industry, as well as in shipbuilding and highly reliable components in plants and machines featuring very high value and technological content”. Certified Iso 9001, the company can then satisfy demanding technical and performance requisites, relying on a well organized structure at its Magenta (headquarters) headquarters, where it operates on a



property surface of about 3000 square metres. A unit provided with modern machinery for very precise and accurate machining, with testing phases of single products in the various production stages. They have recently bought also a new machining centre to enhance the productive capacity.

"It is a very huge investment – states Renato Imbriani – deemed essential to manufacture a high-end product". The certification factor plays then a fundamental role for the certified quality of products. The certifications attained according to the regulations in force in Countries of EEC and/or outside EEC area are provided as enclosures to Indra products (certificates Fugitive emission, Ped, Atex, Fire Safe, Api 598 etc.)

## A bent for the constant development

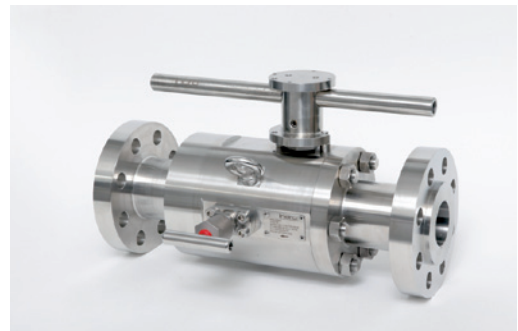
*Indra products are integrated into plants and machines of high value and technological content. Hence the need of paying particular attention to quality in all development phases.*

"To be producers – points out Renato Imbriani, Managing Director of the company – allows selecting everything at best or, at least, in conformity with customers' requirements: to manage delivery times, prices and quality of products". Among the distinguishing qualities of the company, it is then worth mentioning also the great operational flexibility and versatility, necessary in those fields (like oil & gas) that require a continuous adaptation both in structural and material study terms. "It is then clear – further adds Renato Imbriani – that our production is not standard but on the contrary, very often, thanks to a consolidated bent for supplying the most suitable solutions for the various plant problems, oriented to manufacture valves

according to the specific demands". Concerning this, the discussion between user and manufacturer is essential to permit the continuous development and adaptation to the reference sector, in compliance with new or in force regulations.

## A single integral compact body

In the oil industry, safety holds fundamental importance and it is the requisite at the origin of the development of the Iblok valve line. We are speaking of a needle and ball-type valve line implemented to replace traditional "Christmas Tree" installation of multiple valves, combining in a single integral body intercepting (single "SB&B" or double "DB&B") and vent/drain functions. Flexible and reliable, those valves, besides improving efficiency in process installations, offer relevant advantages of reduction of costs, installation and maintenance times, weighs, support and anchorage systems, leakage points and other problems connected with the presence of possible vibrations.



*A detail of the full bore valve*

Available in various versions (with flanged, welded, flanged/threaded, flanged/flanged and single-flange extremities) and in various materials (from the more recurrent Aisi 316, A105 steels to special ones like Duplex, Superduplex, Monel, Inconel, Incoloy, Hastelloy-C, Titanium etc.), the valves belonging to this series can also be equipped with accessories like lockout systems, electrical signals and so on, enhancing safety and efficiency requisites.

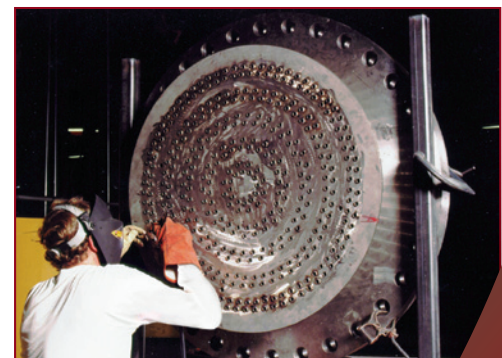
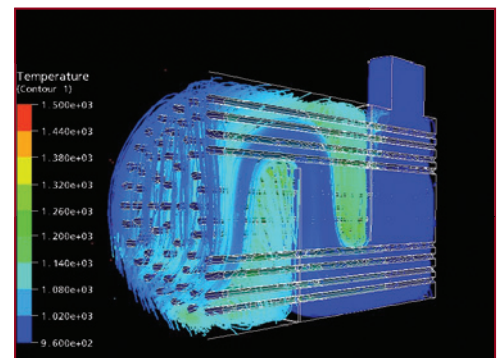
Moreover, it is worth highlighting for Iblok valves the full compliance with the various reference regulations (Ansi /Asme, Api 598, Api 607, Ped, Nace std etc.), with specific product certifications (CU-TR for the Russian market, CRN for the Canadian market), in addition to the above mentioned ones. The mentioned range includes also injection and sampling DB&B valves and is completed by a series of components and accessories for a correct installation.

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# Pumps for Marine & Offshore, Navy and Industry

*The most important projects got by Pompe Garbarino in 2014*



*MU-L: vertical in line pump*



*VS: vertically suspended line-shaft pump*

Since 1932 Pompe Garbarino SpA has been manufacturing centrifugal and positive displacement pumps for marine & offshore, navy and industry. The most important projects got in 2014 are the following.

#### Offshore:

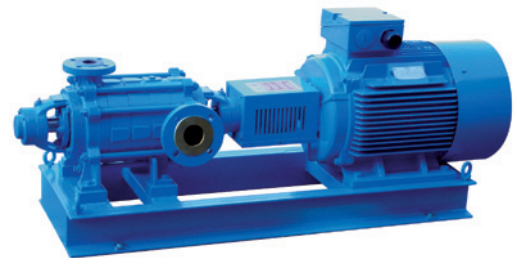
- in the UAE with the shipyard Lamprell 2 jack-up drilling rigs for the owner Ensco;
- in China with Shanghai Waiqaoqiao Shipbuilding 6 self-elevating drilling rigs (4 for the owner Blue Ocean Drilling Limited and 2 for the owner ESSM Pte Ltd) and with the shipyard Shanghai Zhenhua Heavy Industry 2 jack-up barges for the owner National Petroleum Construction Company;
- in Singapore with PPL Shipyard 9 jack-up rigs for several owners and with the shipyard Keppel Singmarine 1 subsea construction vessel for the owner BP Exploration.



*CN: chemical pump according to ISO 2858-5199*



*MU: horizontal pump according to EN 733*



*G: multistage high pressure pump*

#### Industry:

- in Pakistan several power stations (through Metito Overseas located in the UAE);
- in Kuwait several power stations (through Alghanim International located in Kuwait);
- in Qatar and in the UAE several power stations (through Technip);
- in Kuwait a water treatment plant (through Veolia Water Systems).



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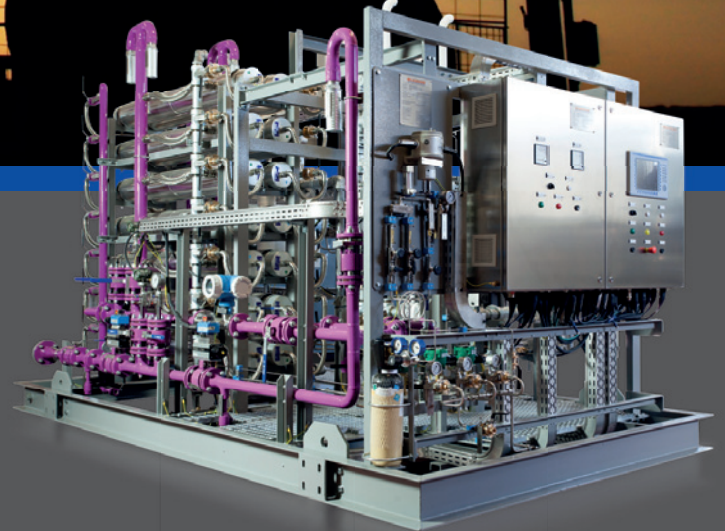
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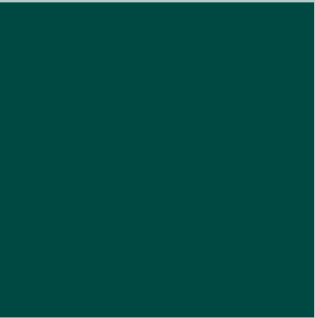
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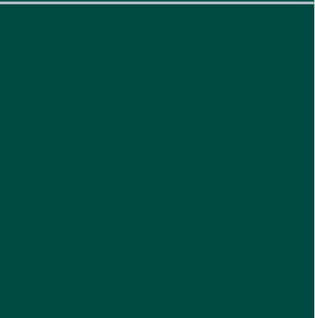
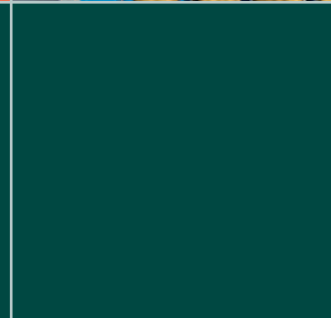
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