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May 2020

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OF INDUSTRIAL
PLANT ENGINEERING

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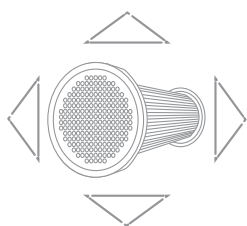
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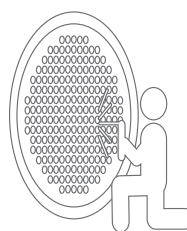
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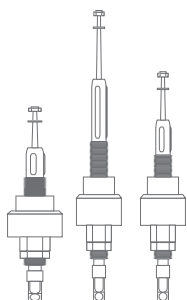
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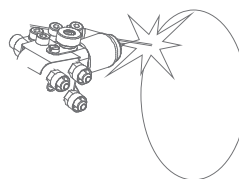
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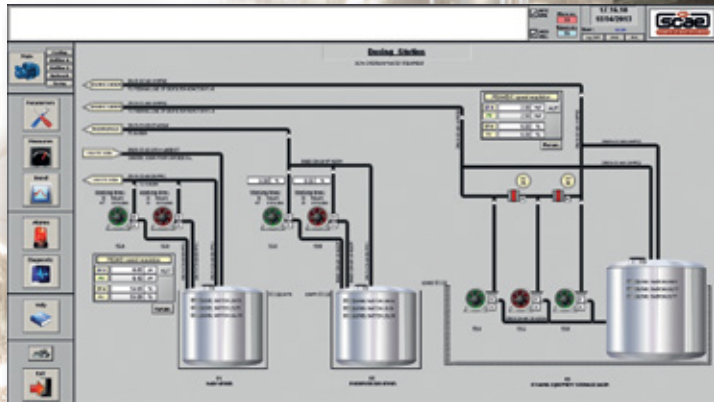


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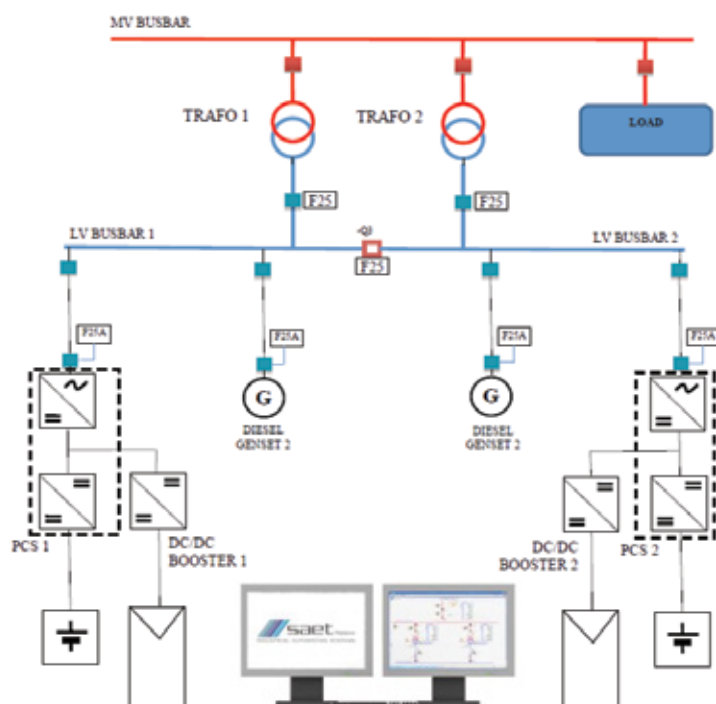
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The future of energy is hybrid



Preparing for the Post-Covid-19 New World



Antonio Careddu
ANIMP President

*Head of Onshore
Business Development,
Commercial and
Tendering
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Also this year, I am pleased to introduce *Industrial Plants*, the yearly publication for international audiences of ANIMP, the Italian Association of Industrial Plant Engineering Companies, which includes engineering firms and general contractors, plant component manufacturers, service suppliers as well as universities, with the main focus on designing and building large industrial plants in every corner of the world. With more than 500 current members, for almost 50 years ANIMP has strived to develop a world-class supply chain, competitive globally in any industrial plant market, and particularly to promote growth, development, innovation and international cooperation. Following our tradition, the current issue shows a selection of our industry's recently completed projects or of those under execution, both in international and domestic markets.

But what a world in which we are living now! Just as our industry had started recovering from the slump in energy prices and consequently in capital investments while seeing the first signs of optimism and prospects for growth in 2019, the world has been hit with this terrible pandemic, whose progress and outcome are still quite uncertain.

From what we have seen so far, we certainly believe that once the overall situation will stabilize one way or another, it will be a 'new normal', very different world from what we have been used to until recently. An

analogy comes frequently to my mind: the assassination of the Austrian-Hungarian heir to the throne Ferdinand in Sarajevo in June 1914 initially looked like an accident of history; but, this seemingly small, local and totally unpredicted event ended up leading to huge consequences: the First World War, shortly thereafter and in part as a consequence, the Second one; a monumental change in the 'world order', with

With the Covid-19 pandemic we are most likely going to witness a revolutionary change, forced upon us by new necessities and situations

the disappearance or obfuscation of large empires and coming to the fore of new, powerful ones, hitherto on the sidelines; the end of the hierarchical social order and lifestyle of the *belle époque* with the emergence of new political ideologies and establishments; the end of most imperial rules and the beginning of widespread decolonization and independence movements; the fast and disruptive development of new technologies, which have completely changed the way in which we live; rapid industrialization and societal transformations, with large-scale population transfer from agriculture-based countryside to newly developing industrial cities; and many more, all in the short time of a few decades.

I believe that with the Covid-19 epidemic we might be

about to witness a similar revolutionary change, rapidly forced upon us by new situations and necessities: although it is still too early to fathom the contours and the details, firstly we see that digitalization, long talked about, has by now made a disruptive entrance into our lifestyles and working habits, with home-based 'smart working' taking a totally new dimension – hence, routine commutes to the 'office' will acquire a different dimension in the future; the same will apply to advanced process control via new digital techniques, etc. Likewise, the process of globalization might take a few steps back: we already see the development of new value and supply chains, where the strategic security will be considered as important as the cost or convenience. We will also see different approaches to manu-

The Italian industry looks at this 'new future' with optimism, since historically we have always excelled in inventiveness, flexibility and capacity to adapt to new and unpredictable circumstances

facturing and delivery to market, with emphasis on appropriately revised new working conditions and retooling. Most likely, the geopolitical world order, to which we have been used one way or another for the last 75

years, will evolve into a new balance-of-power. Individual habits, our ways of spending time, will inevitably evolve. Let us all hope to be able to avoid a large-scale famine and social disruptions and to continue down the path of energy transition into a cleaner and sustainable environment. Inevitably, the industry will change too, with new techniques and business models. Above all, we will need resilience and resolve, but also drive and imagination to reform the product lines and supply chains, to face the new situations, to satisfy new needs and ultimately to be credible.

As members of the Italian industrial establishment we look at this 'new future' with optimism. In spite of the inevitable difficulties, we trust in our skills, capabilities and flexibility. Historically, the Italian industry has always excelled in entrepreneurship, in inventiveness, in its capacity to adapt to new and

unpredictable circumstances, in the speed of adoption and optimization of new breakthrough technologies. In the industrial plants sector, we are one of the world leaders, with more than 5,000 companies, large and small, employing 400,000 people.

ANIMP is the right context in which to continue developing our enterprises in this rapidly evolving new world, by emphasizing cooperation and a network approach:

- By putting together the technical and human resources and experiences among all our players, from the suppliers to universities, in order to satisfy the Clients' future needs;
- By pooling the financial resources, for example, via CDP – *Cassa Depositi e Prestiti*, the national institution which is since 1850 the financier of public investment and supporter of international cooperation, which among others offers a wide range of financial and insurance products and services in support of the Italian businesses;
- To bridge the always too numerous cultural gaps;
- To continue developing and improving technologies and manufacturing techniques, as required by the disruptive forces leading us into totally new situations.

ANIMP is the right context in which to continue developing our enterprises in this rapidly evolving new world, by emphasizing cooperation and a network approach

In spite of obvious current difficulties, we look into the future with optimism and we are ready for new challenges. We also remain always grateful to the Italian and other partner industries for their strong and continuing support.

Antonio Careddu

Antonio Careddu

Antonio Careddu graduated at Politecnico di Milano University and joined Saipem as an electrical engineer.

From 1991 to 1998 he was assigned various roles in Saudi Arabia, Mexico, Malaysia, Republic of South Korea, Oman. In 1999 he came back to Italy to take the responsibility as Department Manager and later as Project Director. In 2010 he became Country Manager and CEO of Saipem Contracting

Algérie and in 2012 Chairman and CEO of Saipem France.

In 2013 he returned to Italy and was appointed Director of the Saipem's Innovation, Systems and Corporate Marketing Unit.

In August 2018 he was appointed Head of Onshore Business Development, Commercial and Tendering.

ANIMP President since mid-2018

Fired heater revamp to reduce emissions

Reducing the CO emission in the flue gas by means of a new catalytic system to be installed in an existing fired heater, while maintaining the CO production unchanged

Mauro Bertolini, Daniele Brambilla,

FW Fired Heaters, Technology and Products, Wood

Wood's FW Fired Heaters division in Milan – which sits within the Technology and Products business group - supported a client with the reduction of CO emissions from an existing fired heater.

The scope consisted of assessing the existing system and proposing the best revamp solution to minimize CO formation. Due to the turnaround duration and plot plan constraints, the removal of the root cause was deemed to be too challenging. The client asked Wood to look at an alternative approach which involved a reduction of the CO emission in the flue gas by using a catalytic system, keeping the CO production unchanged. Wood's Fired Heaters team designed the bespoke catalytic system solution for the client, and following the successful completion of this work, Wood was awarded a contract for the engineering and material supply of the catalytic system package to be installed in the existing fired heater.

Fired Heater Emissions

In a refinery or plant, a fired heater is one of the main pieces of equipment that releases contaminated emissions into the atmosphere.

Being the result of a combustion reaction, CO₂ emissions released into the atmosphere cannot be avoided, and can only be reduced by increasing the efficiency of the fired heater.

For what concerns the other emissions they include NOx, CO, SOx, particulates, and unburnt hydrocarbons

(UHC). Based on the composition of the refinery fuel gas and fuel oil normally used, other compounds emission is rarely expected and most of the times not monitored.

All pollutants contribute to environmental issues: greenhouse effect and global warming, formation of smog and acid rains. These pollutants can also lead to corrosion and integrity issues within the equipment and the unit.

SOx content in the flue gas is stoichiometric to the sulphur compounds in the fuel sent to the burners. To reduce the SOx content in the flue gases it's possible to decrease the sulphur in the fuel by means of sulphur removal systems or fuel blending upstream; as an alternative, by installing a de-SOx system in the downstream equipment.

The same dependence on fuel quality can be found also for fuel-bound NOx and particulates which are normally not an issue when the fired heater is firing only fuel gas, while are taken into consideration when fuel oil is fired.

Therefore, a fired heaters' most critical pollutants are NOx and CO emissions and the clients require guaranteed values for those two parameters.

To minimize NOx contents in the flue gas, many improvements have been made in the last decades. These include:

- Systems to reduce the NOx formation: design and production of low NOx and ultra-Low NOx burners based on many different concepts such as fuel/air staging, flue gas recirculation, cool flame and

others as per burner manufacturers proprietary design;

- Systems to prevent the NO_x release into the atmosphere: de-NO_x systems (SCR, NSCR) are available on the market for any kind of firing system.

The required NO_x guarantee value depends mainly on local laws and regulation or on the refinery emission thresholds. These can be estimated and provided by the burner and heater manufacturer on the basis of the specific service, burner type, fuel and comburent properties.

The CO content in the flue gas depends only on combustion quality with the correct mixing of fuel and comburent.

CO emissions from a fired heater

During combustion reaction, carbon and hydrogen combine with oxygen to produce carbon dioxide and water. When combustion is complete, no carbon monoxide is formed; if the combustion is incomplete, part of the carbon is not fully oxidized, producing primarily carbon monoxide.

The CO emission limit values are stated by API Standard 560 - Fired Heaters for General Refinery Service:

"For floor-fired heaters, the CO content at the bridge wall shall be a maximum of 40 ml/m³ (40 ppm, by volume) for gas-fired heaters, or 80 ml/m³ (80 ppm, by volume) for oil-fired heaters, at maximum design firing conditions."

The CO content in flue gases depends mainly on excess air sent to the burners and on the correct mixing of fuel and air to produce the required combustion reaction.

The carbon monoxide concentration is inversely proportional to the excess air level and increase of CO is linear but slow. At a certain point, called "CO breakthrough", a further drop in excess air will produce a sudden increase of CO.

Burner manufacturers can guarantee very low CO

content over the full rangeability of the burner. However, CO breakthrough can occur when operating outside of the burner capacity range: at overcapacity conditions or below turndown, mainly due to loss of flame stability, incorrect mixing of fuel and air, inaccurate velocity, or improper staging.

In order to reduce the CO content emissions, it is suggested to adjust the operating conditions by controlling the combustion air or properly setting up the combustion variables.

These kind of changes in operations can have an impact on the heaters' performance but solve the emissions challenge.

Process Study

Wood was requested by one major client to perform technical evaluation to improve the performance of many existing fired heaters. A thorough and diversified study was carried out to address and propose various solutions, both in terms of emissions and efficiency.

The analysis covered the refurbishment of many old heaters to improve the efficiency, increase the capacity, change the service, reduce the coke formation and reduce the emissions.

Wood was requested by one major client to perform technical evaluation to improve the performance of many existing fired heaters

To reduce the CO emission of heater B-2, an upgrade of the combustion air control system was proposed.

In addition the thermal rerating of the existing heater was performed with the aim to modify the heater configuration considering the current operating conditions, to improve the combustion conditions and to reduce the CO content in the flue gases as much as possible. CO emissions were too high with respect to the strict local laws.

The heater B-2 was rerated based on the operating data from DCS (Distributed Control System) which was collected during a couple of site visits and the available

Table 1: Heater B-2 rerating results

B-2 heater		DCS data	Calculated values
Radiant duty	MW	N.A.	3.445
Excess air	%	N.A.	55
Oxygen in flue gases	%	8.0 – 10.0	8.0
Flue gas temperature in radiant section	°C	421	432
Burner heat fired	MW	---	0.260
Burner design capacity	MW	0.969	---
Burner turndown	MW	0.232	---

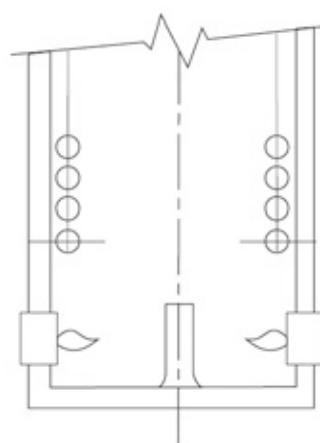


Figure 1: burners at low capacity

documents and drawings.

Rerating results

Heater B-2 was rerated with the following results (**table 1**).

On the basis of the rerating, it was noted that the heater was running at very low capacity, burners were operating close to minimum turndown capacity and the flue gas temperature was very low compared to expected temperature range of 600-700°C.

The flue gas oxygen content was too high, due to excess air of 55%, much higher than API Standard 560 recommended value of 20% for fuel gas, natural draft burners.

As seen in **Figure 1**, it was clear that the burners were operating at a very low capacity with good flame stability.

The technical evaluation indicated that all the conditions for the high CO content were present, as burner operation at low capacity, difficult mixing of air and fuel and possible partial combustion.

New operating conditions

Two different issues were identified which could lead to bad combustion conditions: firstly, the burner was working at very low capacity and secondly, it was operating with a very high amount of air.

In order to make the burners operate at the proper capacity it was suggested to run the current unit load in one half-heater, as the heater is composed by two halves separated by a bridge wall, while shutting down the other half-heater burners and coil passes.

To make the heater operate with proper O₂ content it was suggested to add a common combustion air duct, feeding air to the burners.

A dedicated inlet damper placed at the inlet of the combustion air duct could have allowed more efficient regulation of the excess of air, and a reduction of unwanted air ingress, improving the flame quality and reducing the quantity of O₂ in the flue gas.

The heater was then verified, considering all the process duty and the firing operated in half heater, and based on reduced excess air to 20% (**table 2**).

Operating the full capacity of the heater with only half of the heater, and introducing a combustion air duct to reduce the excess air, would have resulted in the burners working at an acceptable operating point (54% of the design capacity). This would improve the combustion conditions and reduce the CO emissions to a maximum expected value of 40 mg/Nm³ corrected to 3% O₂.

CO oxidation catalyst

The improved configuration which would solve the

B-2		Calculated values	
		Both halves of the heater	Only half heater
Radiant heat flux	W/m ²	6879	13777
Flue gas temp. in radiant section	°C	432	530
Excess air	%	55	20
Oxygen content in flue gases	%	8.0	3.5
Number of burners in operation		18	9
Single burner heat fired	MW	0.260	0.521

Table 2: new operating conditions with only half heater in operation

cause of CO formation, was proposed, however the client decided not to carry on due to the plot plan limitation for the new equipment installation and the shut-down duration, which would be too short to introduce the modifications.

The alternative option was the installation of a CO Oxidation catalytic converter system on the flue gas ducting which was discussed and agreed between the client and Wood to overcome the limitations. This solution was designed and provided as a full package to shorten the installation period during turnaround and therefore minimizing shut-down time

The alternative option was the installation of a CO Oxidation catalytic converter system on the flue gas ducting which was discussed and agreed between the client and Wood to overcome the limitations. This solution was designed and provided as a full package to shorten the installation period during turnaround and

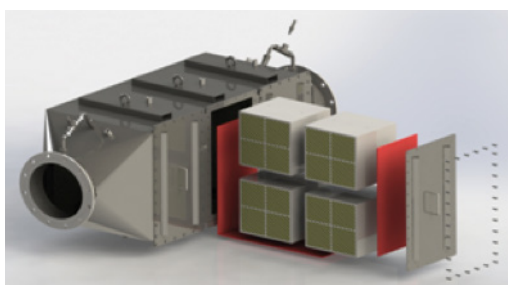


Figure 2: conceptual catalyst system

therefore minimizing shut-down time.

Wood created a process study to cover the analysis and feasibility evaluation for the installation of a CO oxidation catalyst package.

The study was developed according to the client's requests and complying with the following requirements:

- no impact on the footprint,
- minimum shut-down duration,
- catalyst packages on three parallel flue gas ducts, with the possibility to isolate each bed independently for catalyst replacement.

Catalyst vendors as BASF, Johnson Matthey, Emission Partner, UMICORE were contacted.

All of them were not prepared for this type of request, as normally a CO oxidation catalyst is provided for smaller (engines) or bigger (boilers, incinerators) systems, and not for clean and fully controllable combustion.

Nevertheless, all were strongly committed to this challenge. The flue gas was proved dust free and combustion was with fuel gas only. On this basis catalyst system was designed to achieve **(Figure 2)**:

- CO content decrease from 685 mg/Nm³ to 40 mg/Nm³
- guaranteed catalyst life of 2 years, expected catalyst life longer than 3 years depending on the actual operating conditions
- no need of cleaning or maintenance
- minimized flue gas pressure drop

Wood's FW Fired Heaters team engineered the package which include catalyst support, guillotines to allow single catalyst bed isolation, regulation dampers

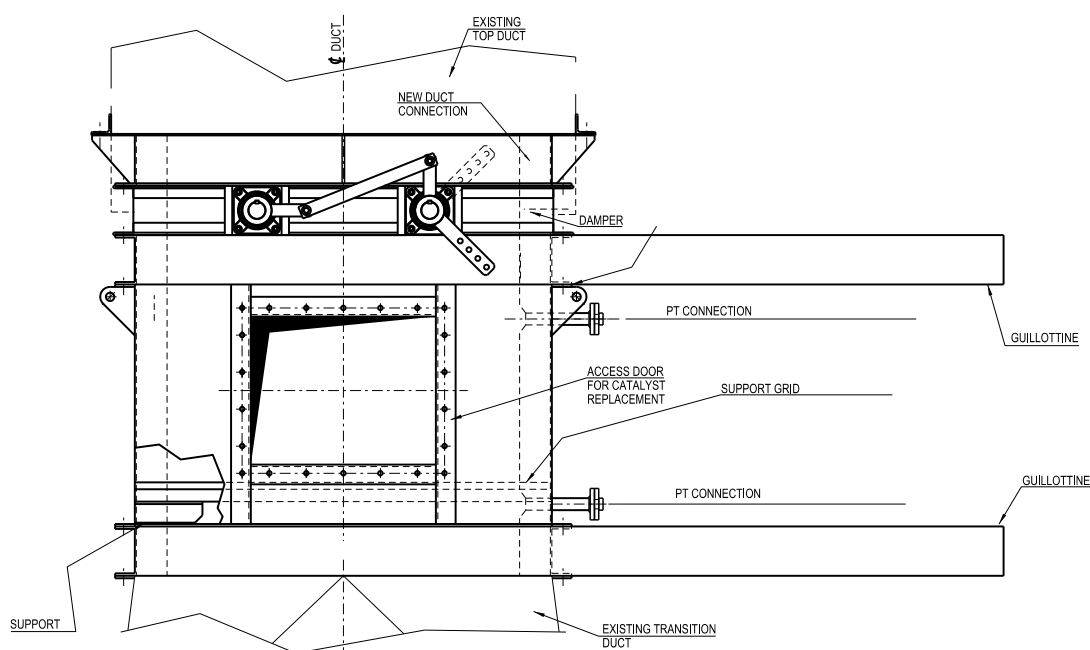


Figure 3: engineered catalyst package

to control flue gas draft and PT connections to measure pressure drop through the catalyst as per **Figure 3**. In the end such an unconventional approach to solve

the CO emission issue, was confirmed by the feasibility of the system and it was overcoming the limits of the plot plan and of time constraints.



Mauro Bertolini

Mauro Bertolini is a graduated Chemical Engineer with over 20 years' experience in the Fired Heaters group of Amec Foster Wheeler Italiana, a Wood Company.

He is the Process and Thermal Design Manager for Fired Heaters Europe & Russia and Key Specialty Leader within Wood Technical Consulting Solutions and Global Technical Expert Network.

His experience includes process and thermal design of technology fired heaters, process follow-up during

engineering execution, proposal preparation and management of all types of fired heaters in oil refining, petrochemical and chemical plants.

He has executed diverse projects worldwide ranging from refineries and chemical projects and his experience includes activities at site for survey, commissioning and start-up, test run of projects executed in Europe, Russia and former CIS countries, America, Asia and Middle East.



Daniele Brambilla

Daniele Brambilla is a graduated Chemical Engineer, with over 14 years' experience in the Fired Heaters group of Amec Foster Wheeler Italiana, a Wood Company.

He is Process and Thermal Design Manager for Fired Heaters Milano within Wood Technical Consulting Solutions.

His experience ranges from process design to detail engineering of all types of fired heaters and waste heat

recovery boilers, in oil refinery and petrochemical sectors.

He has executed diverse projects worldwide ranging from refineries and chemical projects and his experience includes activities at site for survey, commissioning and start-up, test run of projects executed in Europe, Russia and former CIS countries, America, Asia and Middle East.



Saipem's role in Ocean Energy

A key player in the energy and infrastructure sector, single point of contact for clients

Dario Giudice, Renewables & Green Technologies Product Lead, XSIGHT Division, Saipem



Ocean energy can be defined as that sector which produces energy from different sources such as wave energy, tidal or sea current energy, ocean thermal energy conversion (OTEC) and salinity gradient. According to the worldwide organization Ocean Energy Systems (OES), ocean energy development could reach 748GW by 2050 providing benefits both in terms of jobs and investments.

Amongst the renewable energies, offshore wind and ocean energy in particular have a closer DNA to that of Saipem's business

The implementation of ocean energy will significantly reduce GHG emissions, potentially by 5.2 billion tonnes by 2050. Other estimates set the theoretical production of tidal energy at 1,200 TWh/year. Finally, according to carbon trust estimates, between 2010 and 2050 wave and tidal energy markets could amount to 535 billion euros. Thus, it is a growing market where projects are expected to increase in number and where Saipem's added value could make a difference.

Ocean energy development could reach 748GW by 2050

The news of recent an agreement between global players such as Eni, Fincantieri, Terna and Wave for Energy, to mention just one Italian case, underlines the fact that this sector is gaining momentum. More utilities and power generation companies are expected to enter this vast and potentially huge market. While potential is large in various areas of the world, such as the North Atlantic, South America and South Africa, there are also significant possibilities available in the Mediterranean Sea, where optimum wave resource is available along the west coast of Sardinia and Sicily and optimal tidal source has been reported in the Strait of Messina.

During its long offshore experience, Saipem has developed competences that are difficult to match. The company has performed transportation and installation of large and heavy structures as well as small and complex equipment in the seven seas, operating both in harsh environments and in extreme conditions, while at all times maintaining an enviable safety record. Saipem draws upon a state-of-the-art fleet to perform its operations, including vessels equipped with dynamic positioning as well as mooring systems. Saipem can also charter third party vessels to complement the requirements of a project as needed.

Saipem also designs and operates its own Remote Operated Vehicles (ROV), a highly technological fleet that facilitates the execution of delicate operations

Saipem S.p.A. is a global solution provider in the energy and infrastructure industry with more than 60 years of experience in offshore operations. The group is widening its business portfolio by embracing Renewable Energies and Green Technologies with the aim of supporting the energy transition and the decarbonization of our clients' energy assets. Amongst the REN, offshore wind and ocean energy in particular have a closer DNA to that of Saipem's business.

A full GemStar farm installed in the Strait of Messina could provide as much as 161 GWh of energy per year

underwater where the use of divers would be risky or impossible. Saipem can fabricate large offshore facilities as well as sophisticated subsea components in its own yards located in 5 continents. Finally, Saipem can take on full responsibility for operations by acting as the single point of contact between subcontractors, marine warranty surveyors and clients. Saipem's role as an EPCI (Engineering, Procurement, Construction and Installation) contractor, built on the long-established experience in the offshore Oil&Gas sector, can therefore also be implemented on ocean energy projects. This means that Saipem can fabricate or supervise construction of the facilities, perform the required engineering tasks, oversee and manage project execution, and maintain communications with the technology developer, the marine warranty surveyors and other subcontractors.

Saipem can be the single point of contact for clients interested in developing ocean energy projects

This approach enables the technology developers to focus on their machines while at the same time taking advantage of Saipem's engineering support to optimize several functioning aspects of their devices. Saipem can provide know-how in relation to several topics, like mooring analysis, dynamic analysis, fabrication, structures and cable installation; additional services of interest to small size companies, start-ups and spin-offs include project management, financial advice, risk analysis and more. While Saipem does not yet own ocean energy proprietary technologies, the newly created XSIGHT division, through the dedicated Renewables & Green Technologies product line, is continuously scouting the market for the most promising and advanced energy converters.

Saipem has so far been involved with three technology providers in particular, namely, Sabella, Wello and SeaPower, whose devices can be offered to our energy company clients as a new type of service with the backing of Saipem. Some initiatives are presented here below.

Sabella

Saipem, through its affiliate Sofresid Engineering, has

owned a 13.5% stake in the French company Sabella srl since the latter was founded in 2008 by a consortium of small and medium industrial enterprises. Sabella is one the pioneers of the development of tidal stream device and, indeed, designs production units of electricity from marine currents. In the very year of its foundation, Sabella installed the first tidal turbine in France. The company was awarded several prizes for the D10 1MW power turbine project. The D10 is currently the only turbine so far capable of injecting its produced energy into the French national power grid (Ushant). The turbine has a dry weight of 400 mT, a speed ranging from 5 to 15 rotations per minute and a rated power output of 1MW with a current speed of 4.0 m/s. Further developments will see an increase in the hydroturbine diameter above the 10 meters of the D10, with a corresponding increase in power production. The D12 and D16 are currently being studied and future plans aim to reach a diameter of 20m with the D20.

Some of the key advantages of the technology vis-à-vis their competitors are:

- A simple and robust hydroturbine, with fixed symmetrical blades and no yaw drive
- Reliability, with a direct drive synchronous generator with permanent magnets, avoiding any wearing of parts
- Simple maintenance, with a modular architecture by means of which only upper part of the device (nacelle and rotor) can be retrieved
- Efficient, with an inboard conversion/transformation system that facilitates the mutualisation and transport of the electricity production of several turbines through a single export cable
- Long-standing experience gained through many years of operations

The aim of Sabella is to provide renewable and predictable energy production to remote networks around the world, such as islands or other off-grid locations. Sabella aims to replicate the energetic proven model built for Ushant as a sustainable socio-economic alternative to expensive and polluting diesel groups.

Sabella installed the first tidal turbine connected to the France grid

Saipem has provided Sabella with significant support related to installation of the turbine and the electrical cable, as well as commercial promotion for international clients. In addition, services include engineering aimed at improving the device's foundation, optimization of the grid connection, and much more.

Sabella's Hydroturbines Power [kW]			
Speed	D10	D16	D20
2.5	250	640	1,000
3.0	440	1,120	1,750
3.5	690	1,760	2,750
4.0	1,000	2,560	4,000



Sabella currently has several ongoing initiatives in areas like Southeast Asia (the Philippines and Indonesia in particular), North America (Canadian Bay of Fundy), to mention just a few. Saipem is acting as the technology integrator to ensure that, together with Sabella, it can grasp a significant number of opportunities and deliver them according to the highest safety and quality standards.

Wello Oy

Wello Oy is a Finnish company established in 2008 with whom Saipem signed a collaboration agreement in 2019. Its wave energy converter (WEC) technology, also nicknamed Penguin, is amongst the most developed in the wave energy sector and has been tested in the harsh environment of the Orkney Islands since 2012. Wello has recently launched its second generation of wave energy converter, WEC2, while the third generation (WEC3) is currently under study. The advance in their device has been made possible thanks to the large amount of data collected during the years of operation.

Wello's Penguin is amongst the most developed wave energy converter

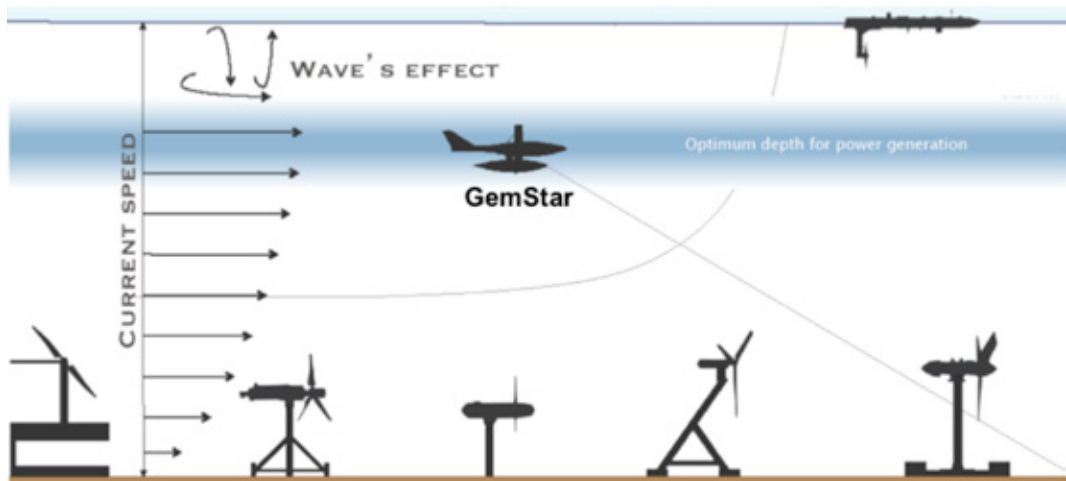
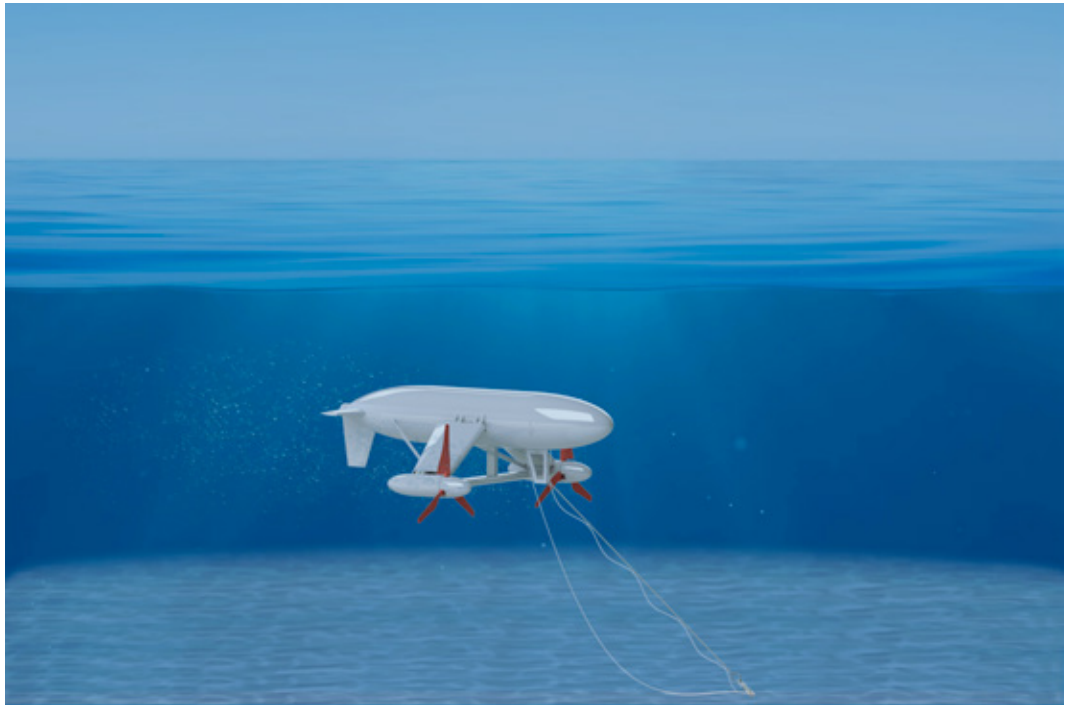
The asymmetrical shape of the Wello Penguin's hull creates a gyrating motion which pushes the rotating mass inside the device with each passing wave. The converter turns it directly into electrical power, immediately transferred to the grid by a sub-sea cable; this direct conversion makes the Penguin a more capable system than those offered by other competitors. The Penguin has no hydraulics or joints,

and no of moving component ever comes into contact with sea water.

The Penguin is only partially visible above water, thus producing no audible disturbance and float outside the wave-breaking zone. It is therefore in perfect harmony with the environment. It is kept in position through a simple mooring system securely fixed to the seabed. Some of the key advantages of the technology over against Wello's competitors are:

1. Off the shelf components
2. Can be manufactured by any shipyard.
3. Towed to site
4. Simple installation on site
5. High efficiency thanks to its direct conversion
6. Easy to operate and service
7. Continuously connected and monitored and hence can be operated remotely.
8. Proven durability having resisted waves as high as 18 meters.

Saipem can further contribute to the optimization of the technology by providing its know-how to improve the mooring system of Wello's Penguin, to simplify fabrication and, finally, to enable better motion response resulting in a more efficient energy production. Saipem's support is of paramount importance to make the technology even more attractive for possible clients who could then purchase and operate the converter. Wello technology can also be applied as an energy source/provider for Oil&Gas platforms with the aim of reducing their energy consumption hence the platform's CO2 emissions. This is a similar concept to what Equinor is doing on the Tampen Hywind project, where offshore floating wind platforms are used instead of wave energy converters. All of this represents an



additional service that Saipem could provide to its usual Oil&Gas clients, allowing the latter to reduce their operating costs by embracing a more sustainable source of energy. Further hybrid applications are envisaged as a source of clean energy to recharge Saipem's Hydrone fleet, our most advanced series of underwater ROVs, the first fully unmanned and autonomous.

Saipem is currently involved with the transportation and installation of a WEC from EMEC site on the Orkney Islands to the BiMEP site in the Basque Country. Saipem will also take care of the installation of the mooring equipment and electrical cable.

There are also further initiatives under discussion with important clients in both Asia and Europe.

Seapower

SeaPower srl is a spin-off of Federico II University of Naples. The company develops both wind turbines as

well as hydroturbines of different types. Their state of the art hydroturbine is the GEMStar. This technology uses two contra-rotating turbines driven by slow-moving water flows, namely river, tidal or water currents, which are mounted on a floating system linked to the seabed by means of a tether. The GEMStar floats around 15m below water surface, where the current speed is generally maximum, unlike that of most of its competitors which rests on the seabed where it encounters the lowest current speed and the high foulage effect from debris. The distance from sea surface allows the device to avoid the effect of waves, unlike the solution of other competitors whose hydroturbine is mounted below the hull of a floating body. The tether allows the device to self-orientate, avoiding expensive submarine foundations; it also enables the hydroturbine to be installed within a wide range of water depths, as the length of the tether can be adjusted according to needs. On releasing the anchorage cable, the system can pop-up for easy maintenance.

A full GemStar farm installed in the Strait of Messina could provide as much as 161 GWh of energy per year

Some of the key advantages of the technology vis-à-vis its competitors are:

1. Relatively cheap
2. Easy to maintain, as it can be brought to the surface without the need for expensive crane vessels
3. Low environmental impact, as it floats underwater and has no foundations
4. No visual impact
5. No interference with navigation lines
6. Installable almost anywhere without significant water depth restrictions
7. Adjustable operating depth in order to reach optimum current conditions

Initial experimental tests were performed at the towing tank at the University of Naples. Subsequently, the first 100kw prototype was deployed in the Venice Lagoon in 2012, where the model tests results were validated by the real operation data collected in situ. Currently Saipem is involved with SeaPower on a project that will see the installation of a 300kw device in the Strait of Messina in 2020. The Strait of Messina is an optimum

Salinity gradient

Seawater is approximately 200 times more saline than fresh river water, derived from rain, snowmelt and groundwater, which is delivered to the coast by major rivers. The relatively high salinity of seawater establishes a chemical pressure potential with fresh river water, which can be used to generate electricity. Salinity gradient power thus has its greatest potential at the mouths of major rivers, where large volumes of fresh water flow out to sea. There are two technologies being developed to convert this energy into electricity: pressure retarded osmosis (PRO) and reverse electrodialysis (RED).

location with strong and predictable currents, relatively deep waters (where competitor solutions would not be applicable) and with highly populated coastlines. The survey campaign to identify the most suitable location has been completed and a more detailed campaign to collect additional data for the selected site is ongoing. Saipem will undertake the transportation and installation of the device while also providing engineering support for optimization of the mooring system. Possible client identification for the final operation of the device is ongoing within Saipem. A full farm installed in the Strait of Messina could provide as much as 161 GWh of energy per year. The clean energy produced could be used both for household needs and for industrial purposes, such as for ports in the area.



Dario Giudice

Dario Giudice has an MA in Naval Architecture and Marine Engineering from the University of Genoa and an MBA in Oil & Gas Management from Robert Gordon University, Aberdeen Business School. He also successively completed the major module in Energy on the MBA course held at the Haute Ecole Commerciale,

Paris. He has been working with Saipem since 2004 performing complex installation analysis of various subsea facilities, in both shallow and deep water. He joined the XSIGHT Renewables & Green Technologies product line at the end of 2017, where he works on ocean energy and offshore wind energy.



Restoring Rhourde Nouss, a key Algerian facility

After a fire, the complexity of the needed repairs kept one of Algeria's biggest natural gas plants partially shut down for six years. Then owner-operator SONATRACH called Arkad SpA (formerly a unit of ABB)

Akli Tarzalt, Business Development Manager for the North Africa Region and Account Manager for Sonatrach,
Domenico Esposito, former Project Manager and Regional Manager,
Arkad SpA



significant concern for the entire country. On the other hand, the opportunity cost of a conventional plant shut down for the duration of a refurbishment made a traditional refurbishment program unworkable.

To work around this dilemma, Sonatrach executives issued a tender in 2016 for proposals to replace the 200 train in 42.5 months while keeping the 100 and 300 trains running, despite frequently extreme and uncertain weather conditions in the spring and autumn.

The request surprised Arkad executives. “Usually when you do such a rehabilitation, the client will try to stop the operation in order to get the contractor to do the job,” recalled Domenico Esposito, past Arkad’s Project Manager of the Rhourde Nouss project and Regional Manager for North Africa.

Despite the unconventional nature of the request, Arkad, then a unit of ABB, submitted a bid, which Sonatrach accepted. The two firms signed the \$100 million contract in January 2016.

Sonatrach, Algeria’s national oil and gas company, had a problem. Following an accidental fire to its central train in 2009, production at one of its most important liquefied petroleum gas (LPG) plants had fallen by more than 30%.

The Rhourde Nouss field held more than 13 trillion cubic feet of proven hydrocarbon reserves. Sonatrach had tapped to produce natural gas, LPG, and condensates, but since the 2009 fire, the second of Sonatrach’s three trains had been knocked out of commission, and LPG production at the Rhourde Nouss plant had fallen to less than 70% of its full operating potential.

This was not only a problem for Sonatrach, but because the company generates over 30% of Algeria’s GDP and 95% of the country’s cash exports, a



Rhourde Nouss by the numbers

- Current production: 1.69 billion cubic feet per day
- Size of gas reserve: 13 trillion cubic feet
- Contract duration: 42.5 months
- Completion: Under 42 months -- 18 days ahead of schedule
- Manhours: +2 million hours of work
- Safety record: 0 work lost hours due to injuries

The company

The decision to hire Arkad was not entirely unexpected. Not only had Arkad been providing EPC services for over 50 years, but it had often worked with Sonatrach before.

Founded in Italy as SOIMI in 1963, acquired by the international group ABB in 1989 and re-launched as a separate company in 2018, two years after winning the Rhourde Nouss contract, Arkad brought a wide range of experience to the table. The independent Milan firm had over a half-century of experience in engineering, procurement, and construction. At the same time, the fact that Arkad is engaged in either designing or building or renovating energy infrastructure in over 30 countries – meant that its engineering and construction methods were absolutely current.

Experienced companies like Sonatrach choose Arkad for turnkey EPC solutions for three key reasons, according to Arkad executives:

- **Reliable approach.** Arkad has developed and rehabilitated a variety of upstream, downstream, midstream assets, Arkad holds the ISO14001 certification for environmental safety, and the 18001OHSAS for worker safety. In the past, the firm had also earned a reputation as an experienced turnkey contractor that could provide everything Sonatrach needed to raise Rhourde Nouss back to its full capability, from basic engineering through facility commissioning.
- **Safety-minded attitude.** The company has had no serious accidents in recent years, and maintained safety statistics that were consistently better than other IOGP competitors. In the past three years alone, Arkad has reported over 10 million construction hours without any lost-time incidents within its two most important markets, North Africa and Middle East. This is by design: Arkad uses a tight system of safety and environmental KPIs that goes beyond the industry standards. Part of the secret, executives say, is





that proactive safety and environmental indicators (i.e. those leading toward continuous improvement of HSE performance) are tracked as a core metric.

- Global and Local orientation.** In addition to its long global track record, Arkad has had significant experience in Algeria. The firm has worked in the country since 1970 and maintained an office in Algiers since the early nineties. Past projects in Algeria included development of the El Merk oil and gas field, a gas flaring elimination project at Haoud Berkaoui, and the delivery of utilities, storage and export facilities for the central processing plant at Menzel Ledjmet East in the Berkine Basin. Many of the 200 people who worked on the Rhourde Nouss project were local employees of SARPI, a construction company jointly owned by both ABB and Sonatrach.

The project

Construction began in November 2016.

Planners had to work around a variety of serious constraints. Located in the remote and almost uninhabited province of Ouargla, 1,200 km from Algiers, the Rhourde Nouss gas fields are served by flights to the capital only twice a week. To make matters still more challenging, in April, May, September, and October, sandstorms can sometimes ground flights and stop outdoor work for 3-5 days.

Most of the equipment and material had to come from Italy, and coordinating its movement presented a number of logistic challenges. One of the biggest:

transporting the two 90-ton separators for the new train all the way from Italy to Algeria to the gas field, which is deep in the Algerian Sahara, 1,200 km from the Mediterranean. Workers had to carefully excavate the ground where the new 200 train would be installed to make room for the new unit and prepare its foundation without disturbing or stopping the operation of the 100 and 300 trains.

Keeping the material arriving at the right time and planning for the arrival of the two 90 ton, 11-meter long separators required extensive planning. "We are not talking about a site where you can reach the facility easily," recalls the Project Manager.

The project's peak workforce reached 200, a number that could have easily overwhelmed the facility without careful scheduling. To limit the chance of bottlenecks, Arkad planners focused on simultaneous operations (SimOps), and securing works permits early.

Arkad's emphasis on health, safety, and environment also helped speed operations. Several Health, Safety, and Environment teams trained workers on a continuous, ongoing basis and monitored the implementation of every HSE-related procedure. Everyone from top management to subcontractors were required to follow Arkad's HSE system and KPIs.

The HSE teams focused particularly on works at height and excavations, which are often particularly thorny from an HSE perspective. Revamping a site like Rhourde Nouss requires delicate maneuvers at height and a lot of excavation work by hand, to minimize the disturbance of systems underground, according to Arkad executives.



Project Scope

- rehabilitation of existing installations
- project management
- HSE studies and activities
- detailed engineering
- procurement and supply of equipment and material
- regulatory authorizations
- transport, logistics and assembly at site
- construction supervision
- assistance during testing and commissioning
- specialized training

Despite the challenges, the renovation was completed in 42 months, 18 days ahead of schedule – something that hardly ever happens in the complex world of EPC, where a wide range of geological, meteorological, and regulatory challenges often throw projects off track.

“Very few projects are finished ahead of schedule,”

says Akli Tarzalt, Arkad's Business Development Manager for the North Africa region and Manager of the Sonatrach account.

Even more importantly, despite challenging conditions, the work was completed without any significant injuries: 2 million hours of work by 200 employees, with no lost hours and no environmental damage.

Summing up

Why did so much go right with the Rhourde Nouss project?

Executives point first to the project's careful management and planning, made possible in part by Arkad's extensive experience in oil and gas projects, as well as history of cooperation with Sonatrach.

Beyond the capabilities of Arkad and Sonatrach, Tarzalt believes that close communication with the client played a key role. “We were very close to the client. When the client made some particular technical requests, we could satisfy them. We were able to work together to achieve an agreement to work jointly,” he says.

Another part of the recipe, is that Arkad's project manager worked to maintain good communication with every level of the Sonatrach organization. “We believe it's crucial to stay close to your client at every level, from the project manager to the line worker,” he explains. “Everybody involved in the project needs to stay on the same page.”



Akli Tarzalt

Akli Tarzalt, an Algerian citizen, works for Arkad SpA as Business Development Manager for the North Africa Region and Account Manager for Sonatrach. He is graduated in civil & structural engineering from Bradford University (UK). Mr. Tarzalt worked for 25 years at Sonatrach group in various roles, he was then appointed

CEO of SARPI the 50-50% JV construction company between ABB and SONATRACH. He worked as General Manager for GE Water and Cobra industries (Spain) for 6 years and returned to O&G sector with Arkad till his current role.



Domenico Esposito

Domenico Esposito, graduated in mechanical engineering from Politecnico in Milan, has worked for Arkad SpA (formerly a unit of ABB) for 15 years, he was

lately Project Manager of the Rhourde Nouss and Regional Manager for North Africa. Domenico has recently left the Arkad Group.

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Picture 1 - View of the bridge after the collapse

Demolition of the ‘Morandi’ bridge in Genova, Italy

Following a tragic collapse in 2018, the Morandi bridge was demolished quickly and efficiently, in order to prepare it for a speedy reconstruction

Rudy Corbetta, Publicity Officer and Marketing Manager, Fagioli SpA



Project Introduction

After the collapse of the bridge, Fagioli was called, together with other expert operators for the removal of Morandi bridge sections. Main temporary joint ventures companies for this project were: F.LLI OMINI S.p.A., which has been appointed as the Head of the group; IPE progetti s.r.l., experts in structural and architectural design ; IREOS s.p.A., specialized in environment services and for over 15 years, in environment reclamation. Fagioli with its high level of engineered equipment was called to cooperate for the lowering operations of the sections which did not breakdown and represented a serious danger for the surroundings. Fagioli put on the table its engineering capacity to handle this huge concrete sections weighing, in some cases, up to 916 ton. Fagioli used tower lift and strand jacking system (with strand capacity up to 600 ton each), SPMTs to mobilize the sections at ground level; Crawler cranes used either for the lifting / lowering of material and as a support for Fagioli equipment; gantry lifting system and modular trailers.

First Operations, February 2019

On the 9th of February 2019, Fagioli managed to execute the first step of the demolition operation of Morandi Bridge in Genoa. After the meeting with Italian Prime Minister Conte and main National authorities, held during the morning of the 8th of February, Fagioli started the operation of lowering the first central bridge section weighing about 916 ton, with a length of about 36 meter and 18 m wide and successfully completed the operation. A delay in the operation was due to bad weather condition, a strong wind which postponed the lowering action.

Fagioli used No. 4 x 600 ton capacity strand jacks (No. 2 strand jacks on the Western side bridge pylon and No. 2 on Eastern side bridge pylon) to lower the central bridge section (**pictures 2-3**).

The jacks used for the lowering operation were positioned onto cantilever beams provided with additional No. 4 strand jacks (180 ton capacity each)

Picture 2



When, on that doomed 14th of August 2018, a 210 meters section of the Morandi bridge collapsed, Genoa was put in knee by one of the saddest tragedy ever occurred to this ancient and glorious city. Since 1963 the bridge was not only part of the modern landscape and architectural representation of the city, but, due to its location, was one of the major links from Italy to France.

After this tragic event, the city of Genoa supported by the Italian government decided to give a boost in accelerating the procedures of demolition of the bridge (including the environment reclamation of the affected area) and to find the most sustainable solution for the construction of a new bridge.

Picture 1 shows a long-distance view of the bridge after the collapse.

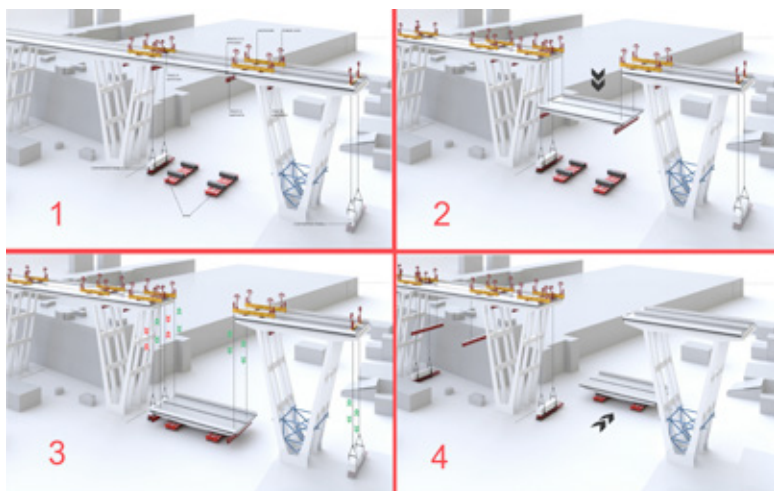


Picture 3

with the task of balance the whole structure. No. 2 support beams were transversally positioned underneath the Western and Eastern bridge pylons in order to anchor all the lifting/lowering structure to the



Picture 4



Picture 5



Picture 6

w/e bridge sections. On the Eastern bridge pylon another structure was positioned at the top end of the bridge with No. 2 additional strand jacks with counterweights with the task of providing a counterbalancing action during the lowering (see details of strand jacking positioning and activity, **pictures 4 , 5, 6**)

Chronicle of the ‘Morandi’ bridge demolition

As described in the previous pages the first operation was the removal of the Berger beam no. 8, comprised between V shape piles No. 7 and No. 8. (please refer to **picture 7**) . The 916 ton bridge deck was lowered by strand jacking system at a speed of 5 m/per hour. Following the same procedure (positioning of the counterweights and strand jacks; removal of decks constraints such as fixed and mobile joints; lifting action of the beam by a few centimeters; cutting operation with diamond wires), Berger beam no. 7 (weighing 850 ton, **pictures 8a and 8b, 8c**), beam no. 6 (916 ton) and beam no. 5 of (916 ton) were lowered by strand jacking system in two months. The section were taken away by Fagioli SPMTs.

In the meantime on March the 18th, No.5 cranes arrived in Genoa, to be used for the dismantling operations of the Western piles. The two main cranes had a capacity of 600 ton. The deck beam number 3, was sectioned into smaller beams and lifted by the 600 ton capacity crane. The presence of asbestos in some of the sections (the bridge was built in 1963), slowed the operations of demolition. By the end of March, deck beam number 4 (**picture 9**) was lowered and touched ground. In order to be able to disassemble this section weighing 920 ton in complete safety and in compliance with the regulations in the presence of asbestos, the cutting operation was subjected to continuous irrigation of water which was then collected and analyzed.

Removal of “V”-shape piles

V Shape pile no. 5 was the first pile to be demolished on the West side of the bridge. The operations started with the removal of the lateral parts, the sidewalks. Subsequently it was necessary to make some holes for the passage of the slings. The deck was sectioned in three parts in the longitudinal direction: the first section weighing 300 ton was lowered on the 16th of April; the second (310 ton) on the 19th of April and, eventually the third one on the 26th of April by Fagioli crawler cranes (**pictures 10-11-12**).

After the three portions of deck beam, the pillars were also sectioned to two thirds (**picture 13**) of their height



Picture 7



Pictures 8a, b, c - beam no. 7



Picture 9



Picture 10

by oblique cuts to allow them a rotation towards the outside and make the lowering by crane easier. In the same way the pile no. 4 (end of May), the pile no. 7 (first half of June), the pile no. 6 (first week of July), the pile no. 3 (end of July) and the pile no. 8 (early days of August), were dismantled and the sections taken away by Fagioli SPMTs (**pictures 14a, b, c**).

After the demolitions of these piles, the Berger beam no. 11 (weighing 750 ton each) was cut and lowered with the strand jacking system by the end of May (**pictures 15, 16, 17**).

The demolition of V shape piles no. 10 and no. 11 pile was executed with an operation of controlled explosion by the end of June, out of Fagioli scope of work (**picture 18**).

Pile no. 8, being 4 meters longer than all the others, required some additional cuts. Pile no. 2, the last one left, was demolished at the same time as the pile 8. The demolition of the bridge ended on the 12th of August 2019 (Fagioli scope of work ended on the 31st of July).



Picture 11



Picture 12



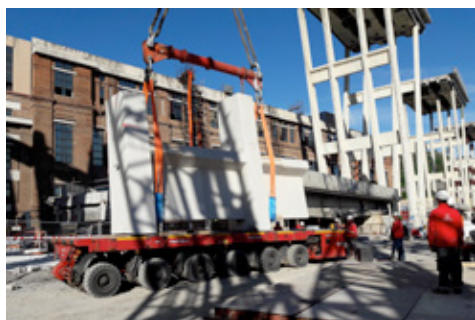
Picture 13



Picture 15



Pictures 14a, b, c



Picture 16



Picture 18



Picture 17

Main criticalities and safety concerns

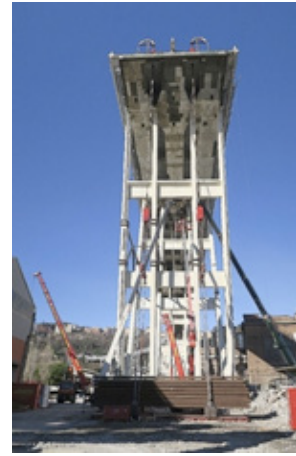
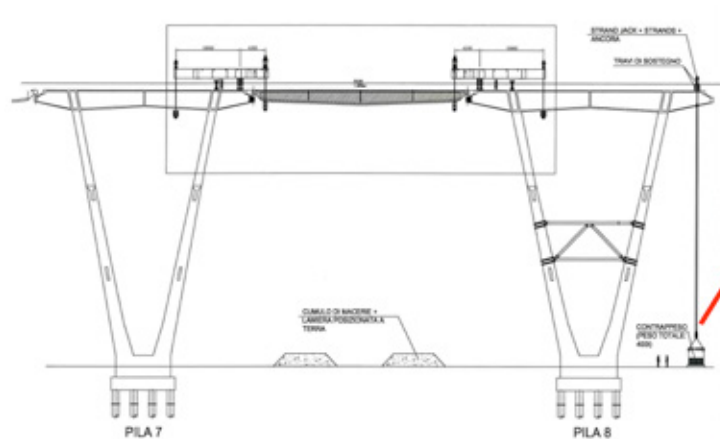
The Polcevera viaduct (Morandi bridge) was one of the highest expressions of the Italian engineering capacity in the field of prestressed concrete structures, designed to withstand high loads, but at the same time extremely fragile. This fragility manifested itself with the partial

collapse of the structure occurred on the 14th of August 2018, determining a situation of anomalous static balance and potentially risky condition, in the remaining structure. The dismantling activities started on the 8th of February 2019 and were completed on the 31st of July 2019. 168 days of uninterrupted works executed by a temporary joint venture companies (ATI) composed by F.lli Omini SPA, Fagioli SPA, IREOS SPA and IPE Progetti srl. The companies have been working in a strict collaboration approach, in a challenging construction site for a unique operation in the world and under a demanding time schedule imposed by the National Authorities.

The procedures adopted for the dismantling of the bridge involved a detailed preparatory phase of securing and functional testing of the remaining structures in order to ensure that the operations would



Pictures 20a, 20b



Pictures 21, 22 - Balance system on Berger beam No. 8

take place in conditions of maximum safety and stability.

Analysis of the structure, tests and engineering solutions

In order to identify the conditions of post-incidental stress and the residual resistant capacities, the entire work was modeled on the finished elements and calculated in all its temporal phases from construction to collapse up to the representation of all the intermediate steps of the planned dismantling operations. Detailed studies were executed, with a comparison with the available data of the original project.

Fagioli proceeded with repeated load tests, carried out by detecting the deformations of the structure at the passage of remote controlled heavy vehicles (SPMT), simulating the future loads to which the structures would have been stressed during the dismantling phases. (Pictures 20a, 20b)

One of the most crucial aspect was the dismantling of the berger beam no. 8 (the first one), due to its unbalanced condition created by the loss of the adjacent beam and pile.

The re-balancing operation was executed by applying external forces at the support of the collapsed pad.

The external vertical load, equal to about 300 tons, was applied by means of two Fagioli Strand Jacks positioned onto the cantilever beam of the pile, contrasted at the base by a counterweight of adequate mass, in order to satisfy the balance verification. The load of each strand jack was distributed in an isostatic way on no. 2 beams by means of a metal carpentry structure (pictures 21 and 22)

Another example of re-balancing load is the one applied to the cantilever bridge sections of the large Eastern piles no. 10 and no. 11. No. 3 pairs of Fagioli lifting towers equipped with strand jacks were erected, two for pile 10 and one for pile 11, each 50 m high, positioned onto concrete foundations. The lifting towers, had the function of temporarily supporting the three cantilever beams of the piles from below, in the event of structural collapse of the stays (See picture 23).

The lifting towers, had the function of temporarily supporting the three cantilever beams of the piles from below, in the event of structural collapse of the stays. The support beams also applied a vertical load upwards of about 600 tons to ensure a re-balancing of the loads. The lattice lifting towers and beams were therefore designed for two load combinations: the first called "service", with loads imposed by the hydraulic system on the concrete structure equal to 600 tons per pair of towers and the second called "extra-heavy" with



Picture 23



loads imposed on the hydraulic system from the concrete structure equal to 2400 tons per tower pair. In order to increase precision and constantly monitor the load transmitted to the reinforced concrete structure a reading system with Fagioli load cells was also adopted, with an accuracy of 0.5%, with readings H24, 7 days a week. The system was mounted at the base of each jack. The securing activity of the piles allowed the lowering and removal operation of Berger beam 11 (760 ton). **Picture 24**

A specific and deep analysis of the eventual deformations of the berger beams during lowering operation was constantly carried out. The berger beams on the Western side, supported by the

Picture 24



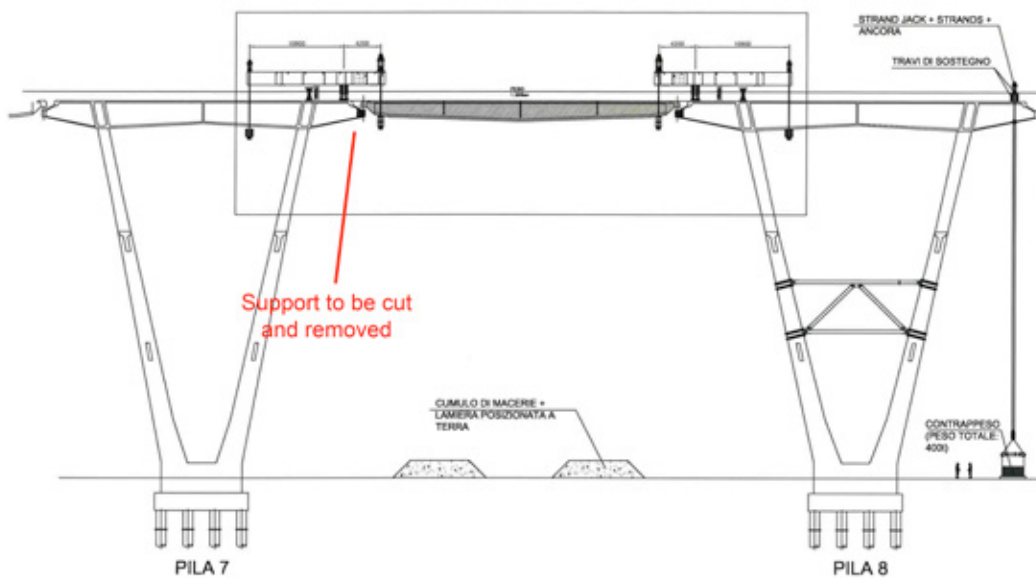
remaining "V" shape piles, were lowered by Fagioli strand jacking system and Fagioli cantilever beam which was designed to distribute the loads onto the pile in an isostatic and uniform manner, able to perfectly transfer the 250 ton load of each of the 2 strand jacks onto the No. 3 beams of the pile. It is worth pointing out that each of the auxiliary metal structural element was designed in such a way that the load transferred to each concrete structure, was applied "by support", that is by contact, and not "by traction". The Berger beam before the lowering operation, was cut and lifted, in order to allow the removal of the structure which supported the road surface (drawing in **picture 25**)

The lifting of the Berger beam was carried out by means of a metal structural beam which supported the floor from below, by contact. (**Picture 26**)

This action increased safety on site

For what concerns the disassembly of the piles, this activity was carried out by making longitudinal cuts in the concrete structure, about 36 m long with thickness up to 3 m. The whole concrete structure was divided into no.3 large blocks with a weight suitable for lifting by means of two Fagioli Demag CC-2800 crawler cranes, in SSL configuration, with 78m boom, Superlift 300 ton at 13m (See **picture 27**)

The rigging system, consisting of two hooks and wire ropes on the hook, was designed in such a way that the concrete structure was supported from below, in strategic positions, so that the bending moment in the



Picture 25



Picture 26



Picture 27

beams was less than the project bending moment of the beam itself which, at the time of lifting, weighed about 350 tons.

Due to the shape of the pile, before it was cut, it was necessary to support it with the cranes, which maintained, for the entire duration of the cut, a weight close to 100% of its weight, so that the surfaces affected by the cut were as discharged and neutral as possible, avoiding the release of uncontrollable and sudden forces when the cut was completed. For the removal of the pile column, the disassembly operation took place using Fagioli CC2800 cranes, which took load and lowered to the ground the pile blocks previously cut with an electric Tyrolit SK B diamond wire, a particularly compact wire suitable for being used on aerial platforms. The sizing of these blocks had been specifically designed to be easily slung, handled and processed once on the ground by means of Fagioli SPMTs. (See **picture 28**)

Picture 28



Final considerations

Just three words to summarize the entire job:

- **URGENCY** - to demolish the old bridge in order to prepare for the new one which is going to be built in the same position with a design specifically provided by the famous architect Renzo Piano. All

the operations were executed under a huge media pressure and with the constant control of National Authorities

- **SAFETY** - was the most demanding aspect, considering the poor conditions of the remaining bridge sections, the presence of asbestos on the bridge and on the buildings around, which were demolished. Every single aspect of the whole operation (168 uninterrupted days), was planned and detailed in order to guarantee the highest level of safety
- **ENGINEERING** - Tower lift system, strand jacking systems, crawler cranes, SPMTs.. just to mention a few, were the technological advanced means used to execute the operation after hundreds of engineering drawings and calculations.

We are extremely proud to have been on board of this challenging project.

Zero accidents!

Special thanks to Loris Giovannini (Fagioli Engineering Director); F.LLI OMINI S.p.A.; IPE progetti s.r.l.; IREOS s.p.A.



Rudy Corbetta

Rudy Corbetta graduated at the faculty of Languages and Foreign Literature of the University of Bergamo. After several years spent as a financial broker, Rudy

Corbetta has been working for Fagioli as Publicity Officer and Marketing Manager since 1999.



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How to succeed in reducing air pollutants and noise emissions in a biomass power plant to extremely low levels less than 1 mg/Nm³ of PM

Giuliamaria Meriggi, Executive Director of International Operations

Matteo Giavazzi, head of technology development and project coordination, Air Pollution Control Division

Luca Monzardo, Senior Project Engineer, AeroTo Division

Boldrocchi Group

Global pollution has increased exponentially through the years, and all the latest environmental studies have clearly shown the devastating effects this pollution can have on both nature and human

health. Environmental organization/groups Worldwide including the populations living in these polluted areas have raised their voices, and governments have implemented increasingly stringent regulations.

Very strict Flue Gas Treatment Regulations have been applied by many of the worlds environmental bodies and countries to both biomass and energy sectors but still companies are preparing for the implementation of even stricter environmental laws soon.

Furthermore, the standards that regulate legally defined noise limits (for each class of intended use) set constraints on noise production to achieve reduced noise pollution in the area surrounding the plant.

Hence, in order to assess the sustainability of a project, it is important to know the impact of these emissions produced by the plant, no matter whether these emissions are related to chemicals generated from combustion and released into the atmosphere, or to sound produced by machinery located inside the plant.

In order to assess the project sustainability, it is important to know the impact of the emissions produced by the plant, both with respect to the chemicals released as well as to the sound produced by the machinery

For the Electric Power Station Lomellina Olevano, southwest of Milan, Boldrocchi devised a technical plan to reduce air pollutants and noise emissions to extremely low levels (less than 1 mg/Nm³ of particulate matter) – among the lowest emissions in biomass power plants in Italy.

The Case

Since its inception in 1909, Boldrocchi has continued to seek better solutions for its customers. In 1914, before most countries had even introduced environmental emission legislation, Boldrocchi started to sell air filtration equipment to reduce fumes in and around plants.

The installation at Olevano di Lomellina is amongst the most impressive results of Boldrocchi as the FGT system measured the following abatement results:

- SO₂ emissions were lowered to 0.00 mg/Nm³
- HCl emissions were reduced to 0.02 mg/Nm³
- NO_x emissions were decreased to 46.04 mg/Nm³, well under the legal limit of 70.00 mg/Nm³.

- Dust particulates were lowered to 0.16 mg/Nm³, including fine particulate matter (PM_{2.5})
- Noise down from 67 dB (A) to 54.1 dB (A), well under the stated objective of under 60 dB (A).

The Olevano Power Plant is designed to deliver 140 GWhe per year of renewable energy, sufficient to meet the needs of about 50,000 families, and consumes approximately 200,000 tons/year of wood chips (coming from Short Rotation Forestry).

The plant has the following characteristics:

- Nominal Heat Output: 64 MWt
- Gross Power: 20 MWe
- Net Power: 18 MWe
- Grate furnace
- Superheated steam Rankine Cycle
- Steam conditions at the inlet of the turbine 525 °C, 92 bar(a)
- Air-cooled condenser

Like any other biomass plant, the combustion generates particulate, nitrogen oxides, volatile organic compounds and a consequential increase of noise pollution.

Boldrocchi was commissioned by the Customer to achieve two groups of objectives:

- Residual emissions of polluting compounds: NO_x < 70 mg/Nm³, SO_x < 10 mg/Nm³, HCl < 5 mg/Nm³, Dust: < 5 mg/Nm³ (dry values, referred to 11% of O₂);
- Average equivalent level of A-weighted sound pressure: at the fence, equal to: ≤ 60 dB(A) – Daytime/ Nighttime; at 1 m from the outlet of the fumes extraction chimney (spherical measurement), equal to: ≤ 67 dB(A) – Daytime/Nighttime

Boldrocchi's highly trained engineering teams devised a



technical plan to reduce air pollutants and noise emissions to extremely low levels – this is now the lowest emitting biomass power plant in Italy.

Boldrocchi was commissioned by the Customer to achieve extremely low levels of air pollutants and noise - this is now the biomass power plant in Italy with the lowest emissions

Boldrocchi APC solutions have been tailored for plants firing

- Waste or virgin wood chips
- Biomass pellets (and other dry biomass)
- Straw
- Bagasse
- Green waste

Reducing air pollution

Boldrocchi experts in FGT designed and manufactured a tailored-made multi-pollutant removal solution for the plant's operation, in compliance with air pollutant reduction targets but keeping a close watch on the budget.

To attain those results, the flue gas line was engineered as following:

- Cyclones to act as particulate pre-separators;
- A Dry Reactor that nearly eliminates acid gases using bicarbonate of micronized sodium injections;
- A pulse-jet fabric filter (baghouse) that completes the acid abatement reaction;
- A DeNOx SCR (Selective Catalytic Reduction) system for dropping NOx using aqueous urea.

The choice to install a dry reactor for SOx/HCl removal was included considering the need for a compact and flexible design approach that would include a fraction of the capital, operational and maintenance costs vs. the installation of a wet system. Furthermore, the resulting by-product could have been used as filler or landfilled – without additional costs for treatment.

A similar CAPEX/OPEX analysis resulted into the decision of a DE NOx SCR system.

A complete De NOx system was supplied using urea as a reagent (which is transformed into ammonia once evaporated). The system includes the urea preparation, gasification, injection, and a dedicated NOx analyzer

for process control at the catalyst reactor.

When a tail-end solution is chosen, particular attention must be paid to the operating temperature to avoid catalyst poisoning and/or obstruction, due to ammonium sulfate formation on the catalyst surface, that would reduce its performance. For this reason, the specialized Boldrocchi team decided to install a main gas burner for flue gas temperature control and catalyst thermal regeneration.

Finally, also the De NOx reactor sizing was conceived to grant a maximum operational flexibility: the casing holds 2 active layers and a spare layer in order to allow greater flexibility on operational parameters and minimize the downtime if maintenance is required.

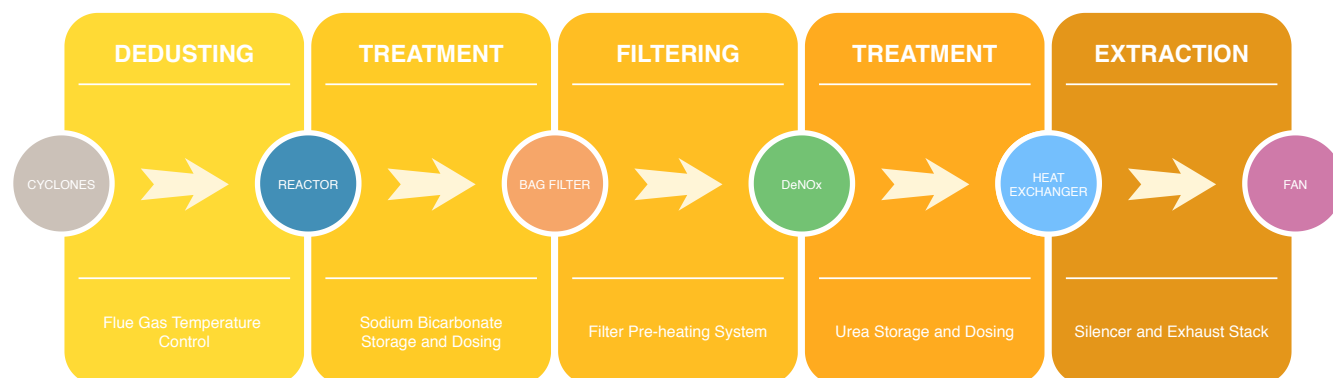
Boldrocchi achieved these objectives with specific choices and technological details based on experience acquired in the sector.

In particular, regarding chemical compound emissions, during the Performance Tests we registered extremely low emissions and – in some cases – (almost) zero emissions (**Table 1**).

Reducing noise pollution

Boldrocchi was also contracted to reduce noise. The specific objective was to reduce the sound pressure to scale A and to under 60 dB (A) from the perimeter fence 7 meters from a pipe linked to the smoke line where the original noise level was 67 dB (A).

Boldrocchi's noise specialists did a precise and



NO	NO ₂	NO _x	NH ₃	HCL	HF	SO ₂	Dust	
mg/Nm ³	mg/Nm ³	mg/Nm ³	mg/Nm ³	mg/Nm ³	mg/Nm ³	mg/Nm ³	mg/Nm ³	UM
29,44	0,99	46,04	0,56	0,02	0,00	0,00	0,16	Average
		70,00	5,00	5,00	2,00	10,00	5,00	Limit

Table 1: Emissions at stack (11% O₂ dry) measured during Performance Test.

detailed analysis of the noise sources, mapping the sound pressure level at the perimeter of the plant (using 40 measuring points and found over 50 sound sources).

During the first analysis, the engineers identified (on project drawings) over 50 sound sources inside the plant and 40 measuring points along the perimeter, positioned at intervals of ~ 5 m, and at a height of 1.5 m from the ground. The first “blocks” of sound sources were selected:

- cyclones for the abatement of large particulate
- bag filter for the abatement of fine particulate
- ash unloading and loading zone Redler
- reactor for the abatement of acidic gases.

For each of these, we carried out a more detailed analysis, on the basis of our experience, the octave and A-weighted sound pressure levels of the known sound sources inside these “blocks”.

One example for all is the bag filter, which was analysed and initially divided into “zones”:

- high zone filter – pulse jet
- central zone filter – filter box
- low zone filter – hopper

to identify (always on the project drawings) the contribution from lesser sound sources, such as the rotary valves positioned under the cyclones. This first essential analysis allowed us to start theorizing the emission limit values measured near receptors. We also identified which soundproofing works needed to be performed, assessing the technical and economic options, before actually assembling the plant and verifying its environmental impact.

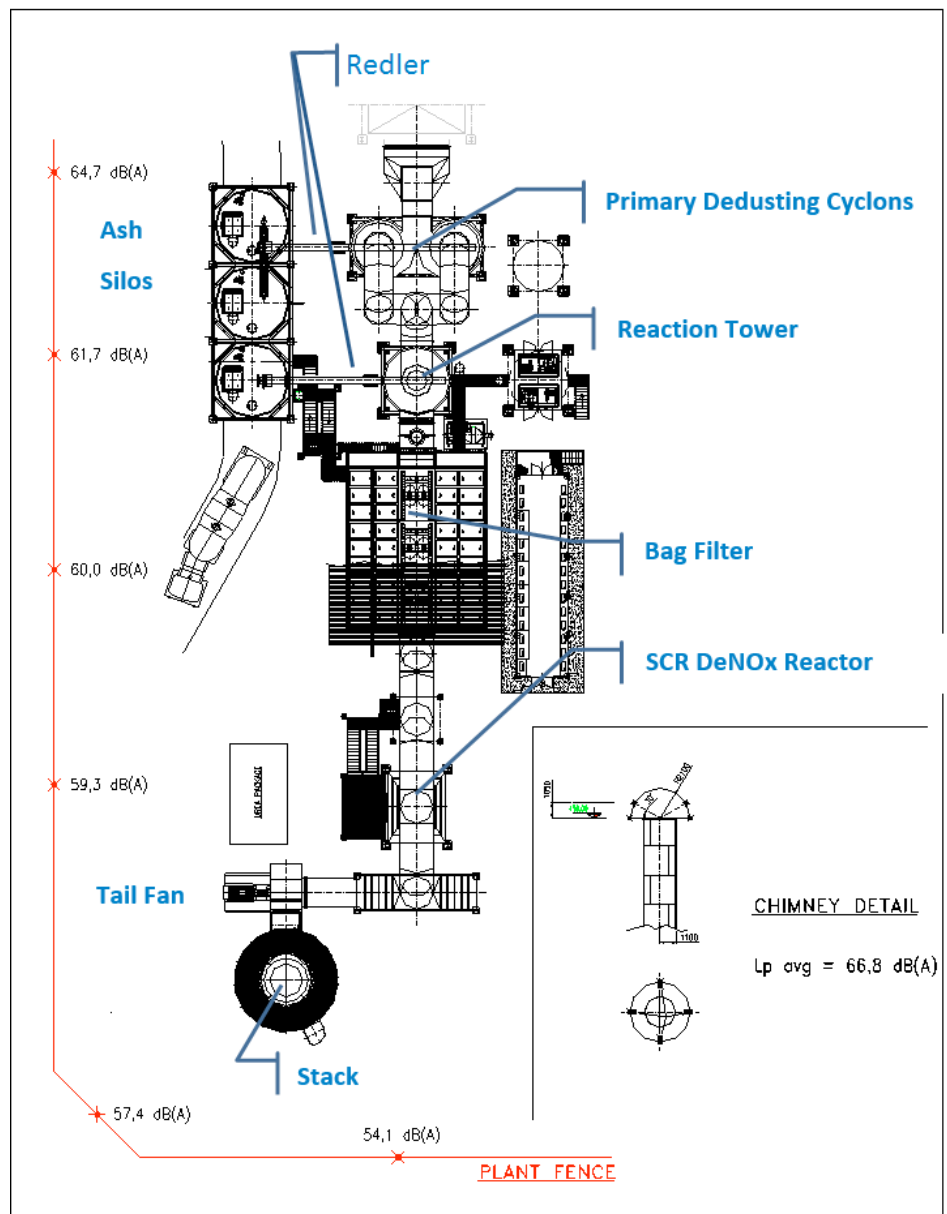
Targeted soundproofing, ranging from acoustic insulation to absorption

silencers and soundproofed booths, ensured that test values in the 40 measuring points identified during the design phase complied with the theoretical assumptions, following installation of the entire plant. The team also extended acoustic insulation to all Redler transport systems, exhaust ducts from the De NO_x extractor fan and other small sound sources to achieve the final objective at the fence.

The final values are reported in **Figure 1**.

Please note that residual values above the guarantee

Figure 1: Sound pressure emission points





value are influenced by sources outside the fume treatment line.

6 years later

The plant has been operating since 2012, and has been subjected to regular maintenance to keep performance levels under legal limits. However, performance has been well above expectations. Residual emissions did not only remain consistently below legal limits, they were also extremely low, similar to or even lower than those found during the performance test.

After six years of operations, the Lomellina Olevano power plant has always operated within the stringent legal limits for emissions. It also demonstrated excellent performance in terms of reliability, since it has required only downtime for ordinary maintenance, guaranteeing an average of 8,350 operation hours per year.

Table 2 illustrates the residual emissions at the chimney after an operating period of about 6 years. In addition to the excellent results in reducing Nitrogen oxides, we also want to highlight the residual emission of dust at only 70 micrograms per cubic metre, which is 70-fold less than the authorised limit value, and almost 150-fold less than the limit established by EU standards!

The plant has also demonstrated excellent performance in terms of reliability, since it has required only downtime for ordinary maintenance, guaranteeing a mean of 8,350 operation hours per year.

Conclusions

Boldrocchi provided complete air pollution control and noise protection solutions for this biomass plant. Analyses shows complete success: air pollutants have

Pollutant in combustion flue gas [mg/Nm³]	Emission limits According to EU Norms	Emission limits According to Local Authorization (daily average)	Emissions after 6 years operation [mg/Nm³]
Dust	10	5	0,07
CO	50	50	14
TOC	10	10	0,4
NOx as NO ₂	200	70	42,3
NH ₃	10	5	1,2
SOx as SO ₂	50	10	0
HCl	10	5	0,2
HF	1	1	0
Sound pressure at plant fence			
Sp dB (A).		60	54,1

Table 2: Emissions measured after 6 years of operation

been removed to well under area limits and noise is nearly completely eradicated.

A particulate matter concentration at the stack less than 1 mg/Nm³ set the plant among the low emissions power plants in Italy (and possibly the world). Once the entire plant was completed, the sound at the fence was reduced to 54.1 dB (A) from the original 67 dB (A), well under the Customer's stated objectives.



Giuliamaria Meriggi

Giuliamaria Meriggi is the Managing Director at Boldrocchi North America and Executive Director of International Operations at Boldrocchi. She splits her time between Atlanta and Milan. She began working in air pollution control shortly after finishing her bachelor's degree in engineering in 2001 and has since amassed

expertise in a wide array of industrial processes with particular dedication to engineering activities and innovative solutions in the air quality field. Over the past 20 years, she has held various engineering, commercial and operational roles.



Matteo Giavazzi

Matteo Giavazzi is responsible for technology development and projects coordination in Air Pollution Control Division of Boldrocchi Group. He started his career in automotive industry with FCA environmental research team; afterwards he focused professional activity in manufacturing industry. Over the last 20 years, he has held varying roles in environmental process engineering for industrial plants. He is a

specialist in air quality, pollution prevention and environmental problems analysis, with particular reference to air pollution from industrial sources. Giavazzi has a Master's degree in Environmental Engineering from the University of Pavia, Italy; he collaborate with Chemical Engineering Department of Naples University "Federico II".



Luca Monzardo

Luca Monzardo graduated in structural aeronautical engineering in 1995 at the Politecnico of Milan, is now senior project engineer in Boldrocchi Group; his activity is oriented to the development of projects related to GT ancillaries (air intake and exhaust systems), as well as to the research and development for Gas Turbine Systems

& Noise Protection division. He is experienced in computational analysis (Acoustics, Fluid-dynamics, Structural) and has contributed to the issue of several courses for the diffusion of basic acoustics inside the company.



Termomeccanica Pompe launches its remote witnessing testing system at a much needed time

A new remote system allowing customers to witness their pump units final performance tests on line and in real time, a very handy innovation in today's times of tight travel restrictions

Massimiliano Borghetti, head of R&D Department, Termomeccanica Pompe

INDUSTRIAL PLANTS - May 2020



performance testing (which allows to check the quality and efficiency of pump sets under real operating conditions) but can also be related to additional testing related to satisfactory operation under certain critical conditions such as insufficient NPSH margin, high energy density or high operating temperature.

Such tests are all highly time- & resource-consuming and therefore entail longer lead-times and higher costs for customers, in total contrast with the current market trends.

**Termomeccanica Pompe
officially and successfully launched
its new remote witnessing system
late March 2020 amidst
the Corona Virus pandemic,
which made the traditional
“in person” witnessed test
impossible for an important
UAE contract**

Therefore, today's global customers, on the lookout for ever-smarter, faster and cheaper solutions, can simply not ignore a remote witnessed testing alternative such as Termomeccanica Pompe's.

First and foremost, it is important to highlight that the new remote testing system TMP has implemented is an integral part of its *Quality Management System* and is therefore in full compliance with the company's testing standards, guaranteeing customers the same level of reliability.

TMP and its customer start by defining all practical details of the remote testing such as the date and the execution methodology. TMP then arranges for a secure dedicated “virtual room” that allows its partner to participate in the performance test in remote mode, i.e. checking the conformity of the test circuit to the test procedure through the display of the system lay-out drawings, interacting “live”

Today, saving time, resources and costs is of the essence to our customers and partners. This is why Termomeccanica Pompe has recently developed a new remote witnessed testing system allowing customers to attend the performance tests of their contract pumping units “virtually” instead of “in person”. Such system has proven quite useful in this time when travel is particularly restricted due to the Corona Virus pandemic.

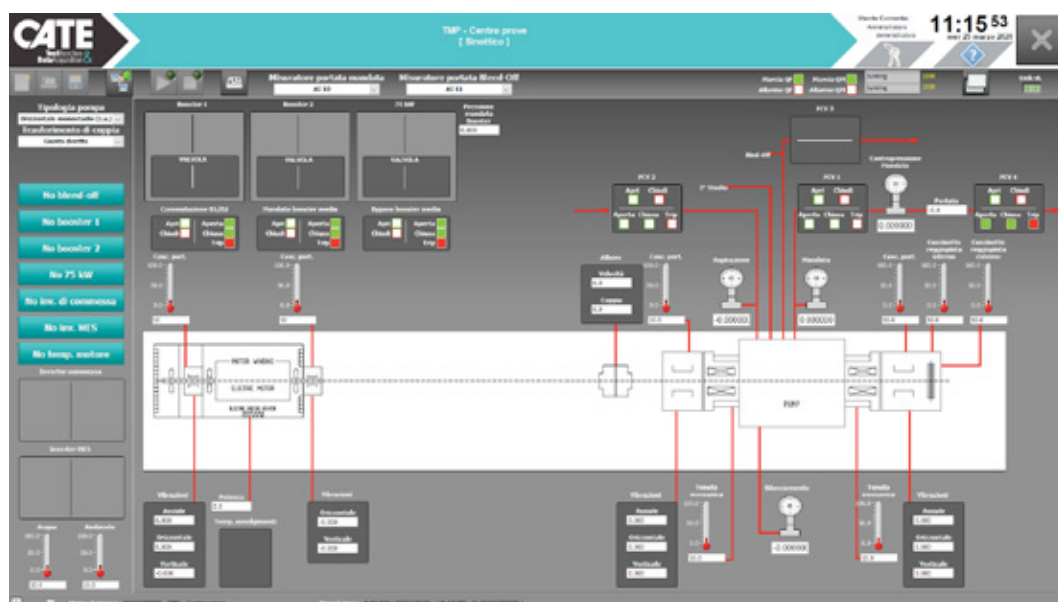
Witnessed testing is a key procedure established by customers to ensure that the equipment purchased from a vendor is in full compliance with contractual specifications. In Termomeccanica Pompe's case, acceptance testing is mostly related to hydraulic



Web camera view of pump being tested



View from Test Center Control Room



Customized data acquisition system view

flow rates, power, RPM, temperatures, vibrations, noise, ...)

- the serial numbers and certificates of the measuring instruments used;
- and all other information agreed upon.

At the end of the remote testing session, Termomeccanica Pompe guarantees the evidence of the results through the issue of certificates (reporting the date and signature of the Test Center Manager) which are transmitted to the customer via e-mail for counter-signing and filing.

Confidentiality is a key concern to Termomeccanica Pompe, whose remote performance testing system guarantees maximum security through password-protected connections carried out with adequate software.

with the Performance Test Manager and viewing all the activities in progress.

More specifically, Termomeccanica Pompe has installed a fixed and mobile web cameras system that allows customers to have a virtual access to the test center to check:

- the contractual performance values (pressures,

Termomeccanica Pompe officially and successfully launched its new remote system late March amidst the Corona Virus pandemic, which made the traditional "in person" witnessed test impossible for an important UAE contract. Both the Customer and End User took part in the remote procedure and confirmed their satisfaction.



Massimiliano Borghetti

Massimiliano Borghetti graduated in Mechanical Engineering from the University of Pisa in 2001. He started his career in 2002 at Termomeccanica Pompe, where he held various positions in both the Centrifugal Pumps Engineering & R&D Departments. In 2010, he moved to GE Oil & Gas where he worked within Advanced Technology Organization, focusing on conceptual and mechanical

design of axial and centrifugal compressors.

Massimiliano rejoined Termomeccanica Pompe in 2018 to run the company's R&D Department.

Over the years, he has gained strong expertise in turbomachinery design (centrifugal pumps, centrifugal compressors, gas turbines) and new product introduction with a multi-disciplinary technology background.



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Technological and energy efficiency for a material handling plant

Focus on E&I supply for industrial production, not only on the CAPEX perspective, but also and above all on the OPEX one, in order to maximize the return of investment and optimize plant maintenance

Alessandra Ranno, Marketing & Sales Manager, Costruzioni Elettrotecniche CEAR s.r.l.

Technological and energy efficiency is an increasingly recurring need for those who must design and maintain a plant, of any nature it may be. The attention of investors is increasingly focusing on high performances in an ever lower time frame, which makes the most of technology, consumption control and related efficiency, so that production results can be optimized to the best.

In consideration of that, attention to efficiency does not only focus on the “CAPEX” perspective, but also, and above all, on the OPEX perspective. In order to maximize the investment and the maintenance of the plants, the entire industrial production supply chain is concentrating in this direction, both regarding the design and the identification of the high performance products, that can be monitored in terms of consumption and performances.

The context and the plant philosophy

Costruzioni Elettrotecniche Cear finds itself in the situation of getting solutions in the electro- technical and instrumental field that meet these specific needs of maximizing plant efficiency.

On the occasion of a “turnkey” supply, complete of the electrical distribution and the automation system of a crushing and handling plant of aggregates and concrete for the construction of a dam, Cear provided a system equipped with components and programming systems for monitoring the energy and the production efficiency of the plant.

In a turnkey contract for the supply of the electrical distribution and automation system of a crushing and handling plant of aggregates and concrete for the construction of a dam, Cear provided a system equipped with components and softwares for monitoring the energy and production efficiency

The supply was studied with the aim of adapting it to the environmental conditions of the site and necessarily to be easily installed. This latter could be described as follows: an “upstream” side consisting of the electrical distribution system composed by electrical and transformation substations, that have the purpose of feeding the “downstream” side, consisting of the automation system for crushing and production of aggregates and concrete.

The yard is located in the horn of Africa, in an area that is hardly accessible to the national electricity grid, that is feed by Low Voltage Generators composing the power plant. The power supply of the yard is done through a step up 20kV Medium Voltage distribution system that is transformed from Medium to Low voltage (400V), to feed motors of Downstream Material Handling plant.

Electrical distribution and automation systems are realized in modular solutions, ready to use, such as containerized substations engineered to guarantee 15 years of operating resistance for all the electrical equipment, installed in an environmental conditions with temperatures between 20 and 55 °, at humidity rates close to 100%.

To guarantee these conditions, the substations are CSC/RINA permanently certified, to have their mechanical structure more robust and make them suitable for multiple maritime transports; moreover, they have been treated with special corrosion-resistant painting cycles, as well as being conditioned with redundant industrial cooling systems.



The “Upstream” system

The electrical distribution system is studied with the aim of having the control and monitoring of consumption and adequate energy efficiency.

This latter is composed by five 20kV Medium Voltage distribution substation that have to feed other seven MV/LV transformer substations, equipped with transformers of 15-20 / 0.4 kV with sizes ranging from 800KVA to 1600KVA.

In order to be able to control all electrical devices and

monitor consumption, a flexible data acquisition system is designed, composed by a remote I/O system, capable of collecting all signals of each substation. All the collected signals are then conveyed to the central Supervision system of the material Handling plant, where the operator has the possibility to have a complete view of the status of the electrical distribution system.

The communication between the data acquisition system and supervision software (SCADA) happens through a Modbus TCP / IP protocol communication with copper converter - Fiber Optic (for long distances), that is configured with the aim of:

- show the status of the circuit breakers and act on them (on the Medium Voltage side);
- show the electrical parameters coming from the network analyzers,
- communicate with the generators;
- report and historicize alarms of protection relay.

The supervision system allows to save the sequence of events recorded on text files or on an excel / database, in order to process and manage them for the purpose of analyzing the energy performance of the system directly on site or through a via web access.

The “Downstream” system

The “Downstream” side, namely the Automation system of the Material Handling plant, is divided in 3 macro area, each of them is able to operate independently:

- Primary Area
- Secondary/ Tertiary/Quaternary Area
- RCC Precooling e Mixing Plant Area



In each area an **Operator control cabin (CT-CR)** and some **Power and Control cabins (CT-PC)** are required.

The three Control Operator cabins represent the “pivot” of the system and they can be considered interchangeable, since in the event one of the three doesn’t functions, the others can intervene on the entire system, thus preventing malfunctions.

These cabins (CT-CR) are designed to host:

- Operator Station (Client PC and printer)
- Server
- Main PLC panels
- UPS
- Electrical Auxiliary panels

The power and control cabins (CT-PC), instead host mainly:

- Power & Control panels complete of PLC remote I/O, inverter and softstarter
- Electrical Auxiliary panels

The automation system of the plant manages around 1700 input and 600 output (digital and analogic) and it’s based on a platform known to the industrial market for its functionality addressed to the world of industry 4.0 and for the possibility of creating multi-users, improving diagnostics (also related to energy management), cloud connectivity and boosting plant productivity.

The system architecture is foreseeing a Client-Server type SCADA supervision, composed by two servers and four Operator Station (OS).

The SCADA system is distributed in three control cabins (CR1, CR2 and CR3), with an Operator Station (OS) for each Operator Control cabin, in order to give the possibility to the operator to have a complete control of its area of competence.

In case of need or unavailability of one of the Operator Stations, the plant could be managed by the other OS in the other Operator Control cabins.

A fourth OS station is placed in offices located in a remote area and allows the personnel to supervise all plant’s areas.

The automation system is based on a platform known to the industrial market for its functionality addressed to the world of ‘industry 4.0’ and for the possibility of creating multi-users, improving diagnostics, cloud connectivity and for boosting plant productivity

The “heart” of the system in which all data is collected



is in the two redundant servers, which guarantee an high system reliability, because of the two machines are able to manage the entire system, so that, in the event of a failure of one of the two servers, the other can continue to guarantee full system functionality; they are the collector of all the information that PLCs obtain with a remote I / O system.

The PLCs are connected to the SCADA system to which they transmit the recorded status and from which they receive commands to be given to the actuators, through a connection to the field systems; the PLC CPUs are able to exchange data with each other to coordinate and / or interlock border areas of the plant.

In this way, a highly performing architecture is outlined both in terms of service continuity and system data collection.

“Intelligent” communications and diagnostics

The Electrical and Instrumental System is designed with the target of having a unique control of the whole plant, where the electrical distribution and automation systems are able to exchange data and dialogue together to allow operators to have the control both locally and remotely from multiple SCADA station.

In order to manage the systems in the best way, an “intelligent” communication network has been used,

making the most of the potential of each electrical and instrumental component.

The communication network between the operator control cabins and the power and control cabins has been made of single-ring fiber optics, to make the most of the signal speed, while inside each substation this connection was made with copper (RJ45) having star connections, exploiting its high level of conductivity.

The Electrical and Instrumental System is designed in order to have a unique control of the whole plant, where the electrical distribution and automation systems exchange data and dialogue together to allow operators to control both locally and remotely from multiple SCADA station

The power and control panels have all been equipped with hardwired remote control system for acquiring the signals from the field and some other signals from the control panel (such as 230 Vac and 24 Vdc circuitbreakers), while Inverters, Softstarters and Measuring instruments have been connected through RJ45, as per above mentioned.

The system and process diagnostics have been designed to ease the so-called “predictive maintenance”: the operator can chose how to act on the system, whether in automatic, semi-automatic or

manual mode, foreseeing appropriate safety tools, in line with current regulations.

The three above mentioned options put in condition to control single users through the system and checking functioning abilitation by means of the key selectors mounted on the local control push-buttons.

Operation in Semiautomatic and Automatic modes always requires that the users of the various zones are organized into groups to allow the implementation of coordinated start and stop sequences.

The tools made available to the operator (groups and time filters) allow the execution of various analyses, which can be performed locally and remotely (also via third party software), among which it is possible to extract:

- the history of the individual weighting scale
- flow data
- production data
- the data relating to KWh, Currents and $\cos\phi$, for each individual user powered by inverter or soft starter
- the alarm history

Conclusions

The management philosophy of this complex plant, although "intelligent", foresees that the operator is the individual who will conduct the operations properly and responsibly.

The automation system and its design conception are the means through which the customer could increase productivity, control and management as per its needs.

This electrical and automation system has benefits that allow the customer to:

- reduce the intervention in field of the operators
- reduce downtime, thanks to a "predictive maintenance" operator interface, that records the hours of operation, maintenance and activities performed
- make all KPIs available in real time for the verification of process and energy efficiency, both locally and remotely with the acquisition of data via web
- improve the security of the exchange of sensitive plant data via web thanks to advanced firewall systems
- increase the reliability of the system thanks to the use of SIL2 safety relays to ensure a safer stop of the machines
- increase the plant's efficiency with the use of the latest generation inverters and softstarters
- reduce cabling and consequently the quantity of interconnecting cables, dimensioning of panels and number of cabins.

Cear has been an advocate of this realization experience, translating the customer's needs into a system designed in its smallest details, both for the hardware and for the software, built with the best products and components offered by the market.

This plant was delivered and completed with a commissioning and an on-site training phase, necessary for operators to take complete control of the work tools and their very high performance potential.



Alessandra Ranno

Alessandra Ranno - Alessandra studied Languages and Communication, then graduated in Marketing and Communication at the University of Milan. She's in Cear Srl since 2010 and as Sales and Marketing Manager

she's in charge of coordinating the marketing activities, the sales team and of implementing international marketing.



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Indra, a 'Made in Italy' experience at the service of the 'Tailor-made' valves production

Emilio Renato Imbriani, Managing Director,
Indra Srl



Established in 1987, Indra Srl is nowadays at the forefront in the designing and manufacturing of ball and needle valves in various configurations and diameters, from integral double block & bleed and split body versions to instrument manifolds, strictly produced in according to the most stringent quality standards of safety and efficiency.

The main characteristics of the company are the 'Made in Italy' production and the 'Tailor made' approach, qualities that represent the trademark.

The quality requirements

To guarantee the high quality standards of Indra

products, the contributing elements are: the use of raw material of prevalent Italian and European origin (Indra does not use the Chinese or Indian supply chain), the product monitoring from engineering to production and the wide range of tests carried out in house, that ensure a tracked product during all its development phases.

The raw material is carefully selected, as it is a fundamental and decisive requirement for the final choice by customers. The excellent quality is deemed a 'must' and the selection becomes then an essential starting point because the good product performance depends on that.

The experience in understanding the 'typical' of the installations, the choices aimed at innovation and the maximum versatility, allow Indra to develop customized solutions, according to customers' specific needs.

The ability to handle the requests, analyzing and implementing even the most complex ones, has made our a Tailor made production, a quality that has allowed the company to be appreciated and recognized over the years within the market.

All the products are machined from the most standard materials, but also from those 'exotic' materials used for critical applications (Duplex, Super Duplex, Monel...).

The areas of application

The combination of these facets has allowed Indra to establish itself over the years in the various sectors of industry: primarily in the Oil & Gas, in the petrochemical sector, to arrive recently in the Power and LNG markets.

The Indra product line is perfected with complementary materials and accessories, something that makes Indra a privileged and reliable partner for those companies that supply 'packages' of various matching goods.

The solutions developed by Indra are mainly used in the oil & gas, petrochemical, off-shore platforms and in the energy sector, used as components of plants and machineries with an high commercial and technological value. Hence the need to guarantee the highest quality.

Today the company has modern machinery for very precise mechanical processing, with testing phases of the single items during the production process.

The certifications

Indra is ISO 9001, 14001 e 18001 certified, proof of a company that works according to growth targets and continuously improving, able to meet specific technical requirements and high performances.

The headquarters is in Magenta, west of Milan, in a 4,000 sqm owned building, 3,000 sqm of which are designated as a production area.

A new machining center was recently purchased to improve the production capacity, an important investment deemed essential to achieve and satisfy a 'high-end' demand.

The certifications play a fundamental role to guarantee the quality of the products, indispensable are those of the product achieved according to the regulations in force in the EEC countries and / or outside the EEC area.

The international role

Indra has always considered its foreign presence important, for this reason the company has built its commercial network over the years in some strategic areas through carefully selected distributors and agents. The participation in exhibitions and in the most important events in the oil & gas sector is another aspect that underlines Indra's will to affirm its role as a protagonist in both the domestic and foreign markets.

The main projects

Indra has recently actively participated in important projects that have covered several sectors.

Among the most relevant we report:

- Arctic LNG
- Yamal LNG
- Kitimat LNG
- Gorgon LNG

for the LNG field and also:

- NASR Full Field Package Phase I & II;
- Ruwais Refinery complex (Takreer);
- Al-Zour Refinery Project;
- Coral South Development Project;
- BAB Integrated Facilities Project;
- Al DABB' iya Surface Facilities for Oil & Gas field.

These are just some of the most important projects that have seen the supply of Indra products.

Indra product overview

- Iblok Line

In the oil industry, safety holds fundamental importance and it is the requisite at the origin of the development of the Iblok valve line. In the DBB version they replace the traditional "Christmas Tree" installation of multiple valves, by combining multiple functions in a single valve body.

Those valves, besides improving efficiency in process installations, offer relevant advantages of reduction of costs, installation and maintenance times.

All valves can be equipped with accessories such as blocking systems, electrical signals, actuators etc., improving their safety and efficiency requirements. Version SB-SBB-DB-DBB; Sizes ½" to 8"-#150/#2500; Floating & Trunnion; Special versions API 10000-15000.

- SIL4 Modular Manifold for HIPPS systems

A recently manufactured product suitable to guarantee a high standard of safety, efficiency and quality in the HIPPS systems is the SIL4 Modular Manifold, designed specifically for instrumental control applications.

The SIL4 Modular Manifold permanently guarantees the continuity of information between the process and the pressure sensors: human error is completely



eliminated and, in the condition of having to replace and / or check electrical or mechanical damage to one or more sensors pressure, one or more sensors always remain active through the various available configurations identified as 1oo2, 2oo3, 1004 and others...

The peculiarities of the SIL4 Modular Manifold consist of:

- compulsory nature of a series of sequential operations, never superimposable;
- reduction of construction costs for a high pressure system;
- protection of the line from overpressure;
- reduction of polluting emissions into the atmosphere due to high pressure lines.

The standard construction of the SIL4 Modular Manifold does not provide for the use of optional protection, however in outdoor installations it is recommended to



use them to protect both the Manifold and the instruments connected to it. For this purpose, a stainless steel and polyester enclosure has been designed and manufactured to safeguard all the components of the system. The enclosure will have different sizes depending on the 1oo2-2oo3-1oo4 configuration selected for the Manifold.

DBB Twin pattern valve

Another product made by Indra is the DBB Twin pattern valve. The valve is realized from a monobloc made of the most common Aisi 316L or of exotic materials. The extremely compact dimensions facilitate assembly in combination with the process variable control instrumentation (pressure transmitters, pressure switches, pressure gauges, etc.) in small spaces. The DBB Twin valve has a single process connection and two totally separate outlet connections, each of which is made in the DBB configuration. The separation of the outgoing lines allows to control the process through one tool, while any other maintenance is being performed. The DBB Twin valve can also be made with separate inlets, so as to have two pressure lines completely independent of each other. The DBB Twin valve is made both in the ball and needle version and in the materials required for the application, including exotic ones.



Peculiarities of the DBB Twin pattern valve:

- compactness of the installations;
- cost reduction in the construction of the plants.



Emilio Renato Imbriani

Emilio Renato Imbriani, the Managing Director of Indra Srl, a company born in 1987 and grown over the years; a company that has been able to build its role as a valve manufacturer, becoming a point of reference for leading companies in the sector in tackling and solving plant engineering and reliability problems of the supplied products, first in the Italian market, and later internationally.

Indra has always been characterized by the desire to overcome the boundaries of its comfort zone, with a competitive approach, essential to respond promptly to the requests of increasingly complex markets. Indra's strategy is to offer high quality products, customized and created specifically to meet the particular needs of the customers.

Natural Gas, protection of tank relief valve vents with extinguishing powder

Ai Group has been awarded the Elengy Fos Cavaou LNG terminal's Fire Safety project located in southern France - a good opportunity to understand and improve the extinguishment laws, since the standards on some aspects of LNG site protection are lacking

Philippe Bichon, R&D Project Manager

Francesco Dartizio, President

Gilles Roure, Technical Director,
Ai Group

Following an intense 10 years of operation, the LNG tanks' safety elements at the Total Fos LNG Terminal had to be rehabilitated. Ai GROUP, a world renowned company with an advocated expertise in high industrial risk's fire protection with a strong focus onto the energy segment encompassing oil& gas and LNG, was appointed to carry out this refurbishment on the basis of Ai group's dexterity and proven experiences in implementing an adequate on-the-ground strategy calling for the combination of fast, efficient results can be used with agents not damaging high value capital. May we take this present opportunity to introduce the topic of Fire Protection at LNG plants.

LNG equipment is subject to strict construction codes. These international standards, such as NFPA, EN and API, allow the gas industry to build production, liquefaction, transfer, loading/unloading and regasification sites according to the rules of the trade. Based upon these similar standards, fire protection of such equipment is preferably done with extinguishing powder and/or extinguishing foam (high expansion foam).

Extinguishing powder for extinguishing LNG fires

Natural gas is, in its gaseous state, flammable. In the case of an LNG leak, in addition to the cryogenic risk, which is of relevant importance, a fire may break out



with potentially dramatic consequences. Thus, fire-fighting facilities are prescribed by international standards (e.g. EN 1473, EN 14620-1, EN 1474, NFPA 59A, CSA Z276-07) either to extinguish the fire, limit its spread and protect both surrounding staff and equipment from mainly thermal radiation. It is for this unique requirement (rapid extinguishing of flames), the use of extinguishing powders is often recommended. It should be noted that water is strongly discouraged for spreading LNG. Indeed, the application of water on

	Recommendations on standards and design
Low-pressure pumps	Fire extinguishing powder nozzles for Local Application
High pressure pumps	Fire extinguishing powder nozzles for Local Application
Charging arm	Fire extinguishing powder monitor for Local Application
Valve vent	Poorly illustrated fire extinguishing powder nozzles for Local Application inside PSV outlet piping

Table 1

cold LNG considerably increases evaporation (through temperature difference in particular) leading to a significant vaporization of natural gas and increasing the fire's intensity (plus the possibility of RPT, Rapid Phase Transitions, in case of water sprinkling on LNG). Nevertheless, water curtains should be provided to reduce the impact of thermal radiation on nearby or adjacent structures.

The use of extinguishing powders is often recommended for rapid extinguishing of flames

The use of High Expansion Foam (and therefore with little water present) can in some cases be considered. Thus, as recommended by EN 1473 (cf. §13.6) norm, water spraying systems, water curtains, foam generators are prescribed on equipment together with a fixed protection system with fire extinguishing powder, which must be installed at possible leakage points, including LNG pumps, transfer areas, ESD

(Emergency Shut Down System) shut-off valves and tank safety valve discharge piping.

Consequently, the Total Fos LNG site's key safety facilities have been refurbished as follows **Table**.

Concerning valve vent protection, the risk is poorly illustrated and documented in international standards; hence, designers/manufacturers have to prove (without international guideline) the effectiveness of their own system.

Designers/manufacturers have to prove - without international guidelines - the effectiveness of their own system for valve vent protection, as the risk is poorly illustrated and documented in international standards

Within this scope, AI Group have carried out a thorough study in order to extend its expertise on the extinguishing of fires with extinguishing powders and

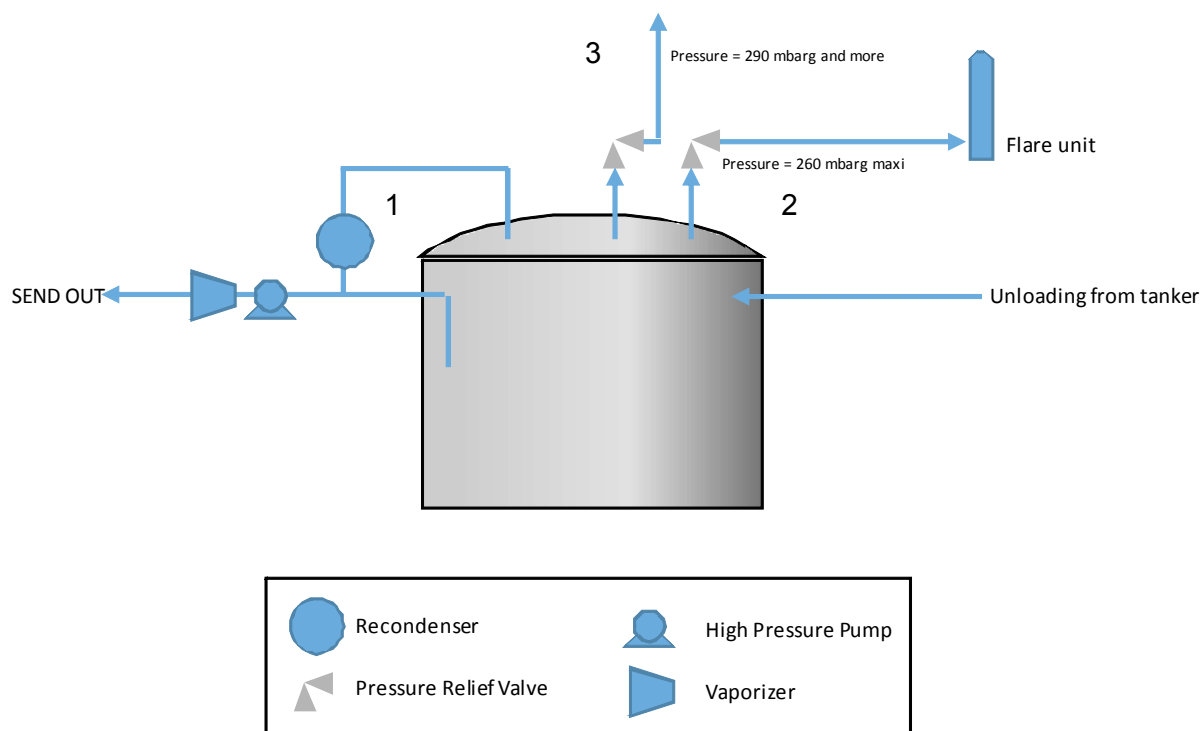


Fig. 1 Scheme of typical BOG system and flare/Pressure Relief Valve pathways (pressures given are mentioned only as examples)

enable Ai Group to propose safe and optimized solutions.

Gas recompression systems and flare/vent network

The LNG is stored in the tanks in its liquefied form at -162°C .

In the tank, a small quantity of LNG evaporates continuously ("Boil Off Gas").

This evaporation is mainly caused by external heat input and/or fluctuations in liquid levels. Thus, this evaporation increases pressure inside the tank.

The gas' evaporation out of the tank is recovered through a compression and treatment system called "BOG system".

In the event of significant evaporation (or from BOG system's failure), the tank's pressure increases and emergency channels are provided to evacuate the overpressure according to the pressure threshold levels reached.

Usually, pressure relief systems can be defined on three levels:

- Regular Run Level - Level 1: collection and treatment of the evaporation gas by the BOG system.
- Alert Level - Level 2: collection of gas from the valves to the flare to be burned (if there is a low-pressure flare on site).
- Critical Level - Level 3: Release of the valves directly to the atmosphere.

The requirements on the network concern the need to collect the gases (from the tank's valves and gas atmosphere) at the flare/venting network, while avoiding continuous flaring (cf. EN 1473).

The position of the discharge points (as well as the relevant dimensioning) is also mentioned in the different standards.

As a last resort (if the event becomes uncontrolled), exceeding of the pressure at the last protection threshold (290 mbarg, see in the nearby **Fig.1**), evaporation gas is released directly into the atmosphere. Thus, as recommended by NFPA 59A (Appendix A §14.8.1.1), if gas must be evacuated intermittently or in an emergency, the evacuation must be done vertically upwards, at high speed, to ensure safe dispersion.

It is preferable the venting of the relief valves be carried out at separate points and not in a common manifold.

It is during these accidental conditions of sudden and extensive discharge (up to one metric ton of methane goes through the Pressure Safety Valve per minute) the ignitions may occur at the vent openings.

Flame of forty-meter-long occurs and can lead to a

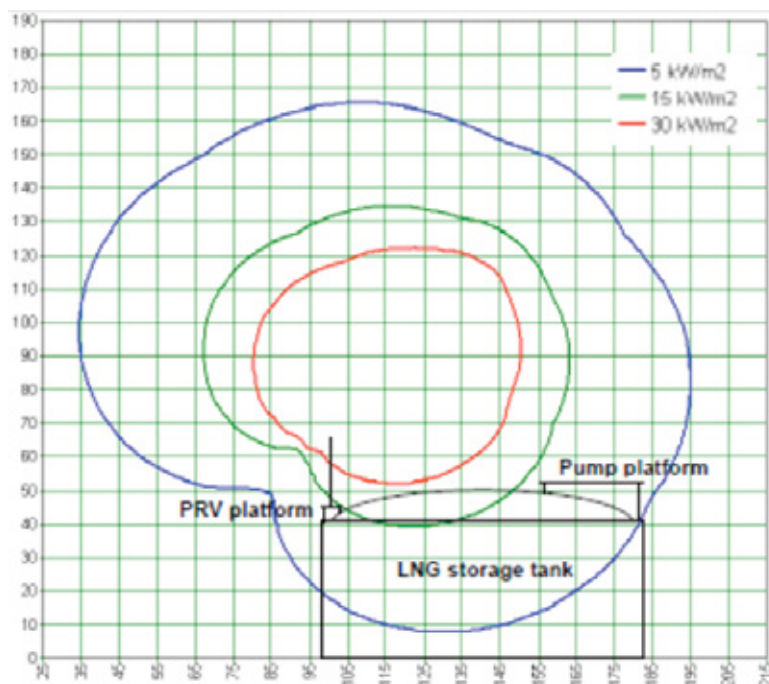


Fig. 2 Impact of the thermal radiation of the flame (with the courtesy of ENTREPOSE)

huge impact on the structure (metal or even concrete), generating dramatic effect (serious damage and lethal effects start at 3 kW/m^2) on staff work nearby.

Thus, the time to extinguish the flame represents safety issues **Fig. 2**.

Notwithstanding these serious implications, existing international standards do not regulate this type of risk nor recommend any solution and design. Thus, commonly, standards do not take into account the specificities relating to valve vents.

In general, their sizing recommendations are based solely on "pool" LNG fires or three-dimensional fires. The case of flaring is never mentioned.

Hence, in the event of ignition at the outlet of the valve, a flame detector triggers the rapid and massive injection (for about 1 minute) of a large quantity of extinguishing agent into the pipe, which quenched the flame.

The Ai Group company, a UL listed manufacturer of BC fire dry chemical for GRANITO™ extinguishing powder, designs and markets a fire extinguishing system by GRANITO™ injection. Although this system has proven its efficiency, the Ai Group is wondering the important parameters in such extinction that explain its operation, and the possibilities of optimization, particularly relating to the quantity of powder. This study will fill the lacks and improve Ai Group's expertise on extinguishing with fire extinguishing powders by proposing the most appropriate safe solutions.

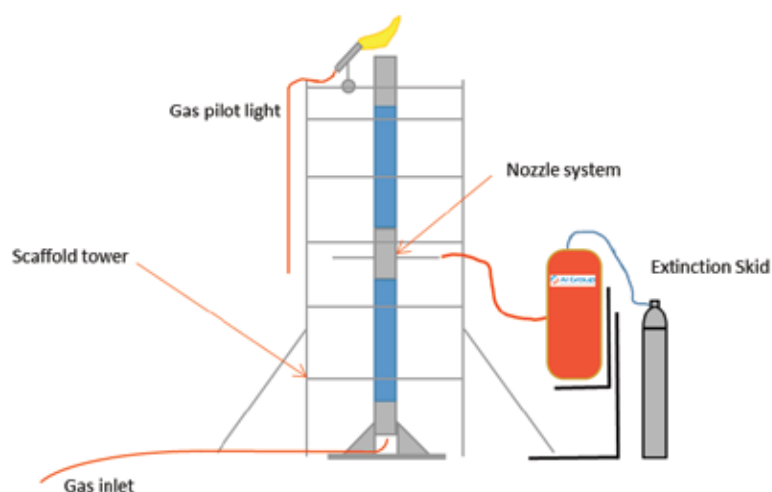


Fig. 3 Scheme of the prototype and picture of the equipment on site (at Verneuil-en-Halatte, France)

Study and results of extinguishing tests on a prototype flare unit

In order to carry out this study, Ai Group have received financial support from partners across the world of oil & gas including from ENTREPOSE, a major player in the design, manufacture and operation of oil and gas infrastructures.

Furthermore, the Ai Group have approached INERIS, a worldwide recognised institute-for the realisation of extinction tests in "realistic" situations.

An extensive bibliography has shown one of the key parameters for extrapolating the results would be to maintain the flow rate of methane into the vent.

Thus, a transparent vertical pipe with a diameter of 200 mm and a length of 4 m is fed with methane from the lower part. The extinguishing system is fitted at the midpoint of the pipe (figure below). The pipe's open end is equipped with a refractory steel tip (where temperature is measured during the tests).

Once the methane is ignited (the flame is about 15 metres high above the end pipe), the flame attachment distance (distance from the end of the pipe to the base of the flame) can be estimated to be about 50-70 cm (distance depending on the methane flow rates).

Once combustion is established, injection of extinguishing powder into the gas stream is initiated, displacing the flame attachment zone. When the powder flow is not sufficient to achieve extinction, flame attachment distances of up to 9 m have been

observed, then going back to the initial distance.

Whenever extinguishing occurred, it occurred within the first few seconds of the extinguishing powder injection (always less than 5 s).

Thanks to this prototype's modularity, many parameters can be explored: e.g. gas flow rate, powder flow rate, powder granulometry, powder formulation, propellant gas composition, injection location etc.

In view of the results, the mechanism of action of the extinguishing powder in the case of torches is quite complex and combines a multitude of parameters.

The injection of powder into the methane stream changes the density of the flow; the air entrainment capacity of the methane stream is altered, resulting in a change in the combustion rate, in a proportion that depends on the size and concentration of the particles making up the fire extinguishing powder.

Thus, the effect of the powder is, on one hand mechanical (variable part according to the nature and granulometry of the particles), by modifying the quantity of movement of the discharge (methane + powder) and on the other hand, thermal via the reduction of the combustion speed.

By introducing these hypotheses, the Ai Group and INERIS were able to develop a model, hence calculating the optimal conditions to obtain the suppression of the flame out of a torch: for a given extinguishing powder granulometry, there is a clear relationship between the gas flow rate and the powder flow rate. Thus, for a gas expansion rate in the vent of the order of 100 m/s, the flow of extinguishing powder (a fine sodium bicarbonate

powder with a diameter of less than 40 μm) to be injected, would be in the order of 1 to 3 kg per kg of methane depending on the diameter of the pipe (from 0.1 to 0.8 m).

"The Ai Group and INERIS were able to develop a model, hence calculating the optimal conditions to obtain the suppression of the flame out of a torch

Conclusions

The safety of the LNG regasification depots is of prime importance and requires a great deal of expertise in fire safety, particularly with regard to periodic ignitions detected at the valves of the LNG regasification depots. Based on this exclusive study, which goes beyond current international standards, the Ai Group can offer a proven and optimised solution for the protection of LNG tank's valve vents; thus, the reasoned use of extinguishing powder limits the impact on the environment after extinction.



Philippe Bichon

Philippe Bichon - After obtaining his PhD in chemistry, Philippe BICHON started his career at Ai Group in 2009 in the R&D department. Philippe collaborates in the

industrialisation of firefighting equipment and in the rationalization of extinguishing agents.



Francesco Dartizio

Francesco Dartizio - Doctor in Mechanical Engineering from the Polytechnic School of Milan, he lead various organizations in different countries in the world as Senior Director within highly demanding corporate

environment. He is the current owner of Ai Group since 2018 and focus in driving the organization to a world leading position.



Gilles Roure

Gilles Roure - Doctor in Mechanical Engineering, Gilles ROURE started his career at Ai Group almost 25 years ago in the engineering department. He successfully

delivered over thousands of projects across his career in the firefighting industry and still focus in delivering on high challenging projects.



Hydrogen firing in industrial steam generators: a look ahead

State-of-the-art industrial applications and boiler designs with various hydrogen fractions in the fuel stream

Marzio Ferrara, Technical Director

Lorenzo Morandi, Burner Department Manager

Alberto Terruzzi, Thermal Department Coordinator

Luca Barbaglia, Construction and Commissioning Department Coordinator

Macchi - a Division of Sofinter S.p.A.

Hydrogen (H_2) is the most abundant element in nature and its use in industrial fired boilers for steam generation can play an important role in the decarbonisation process.

Hydrogen combustion produces only water vapour and hence its use in co-firing with natural gas or standalone firing contributes to reduce carbon dioxide emission.

Hydrogen like fuel is not a new fact; since many years industrial fired boilers, especially for refineries complex, have been operated with fuels containing quantity of hydrogen in the range of 20% - 40% volume. In this paper, state of art of boiler design features with higher quantity of hydrogen is discussed.

Many topics of boiler design are affected by its use and specifically focus on burners, combustion chambers and control are considered hereinafter. Finally, an outlook about the application as standalone firing is evaluated.

Properties of Hydrogen as fuel

The most common gaseous fuel used in industrial boilers is natural gas. The design criteria for boilers using this gas are well consolidated. However, respect to natural gas, hydrogen has different characteristics that impacts boiler design. It has a higher energy content, wide flammability range and high flame speed (ten times higher than natural gas) **Table 1**.

Macchi industrial boiler types

There are two fundamental types of boilers: fire tubes and water tubes. In this paper, only water tube boilers are analysed since generally used in Oil & Gas and petrochemical plants. Steam production range for above industries are within 50 t/h up to 450 t/h with steam pressure variable from 10 barg up to 120 barg and temperature up to 530 °C. Even if there are many type of boilers to respond high degree of customization and flexibility required by End User, the three most common are shown in the **Table 2**.

Properties	Natural gas	Hydrogen (H_2)	Impact on boiler design
Lower heat calorific value MJ /Nmc	35-36	Approx. 10,8	Different fuel flow to boiler, control system, burners
Normal Density kg/Nmc	Approx. 0,72	0,09	Burner design
Theoretical combustion air, kg/Nmc	12,0-13,0	Approx. 3,0	Combustion, furnace and control system
Flammability limit %vol	5-15	4-75	Burner design and furnace
Flame speed cm/s	Approx. 40 cm/s	Approx. 300 cm/s	Burner design
Ignition Energy (mJ)	0.28	0.01	Burner design
Flame temperature K	Approx. 2200	Approx. 2400	Furnace design

Table 1- Properties of natural gas and hydrogen

		
Bi-drum horizontal path boiler with frontal firing. Macchi model TITAN-M Steam production : 10 t/h – 350 t/h Steam temperature up to 525 °C Pressure up to 130 barg Fuels: All gaseous and liquid fuels.	Bi-drum vertical path boiler with frontal firing. Macchi model MVF Steam production: 100 t/h–500 t/h Steam temperature up to 525 °C Pressure up to 130 barg Fuels: All gaseous and liquid fuels.	Single drum vertical path boiler with frontal firing-Macchi Boiler MRD type Steam production: 100 t/h–500 t/h Steam temperature up to 540 °C Pressure up to 150 barg Fuels: All gaseous and liquid fuels.

Table 2

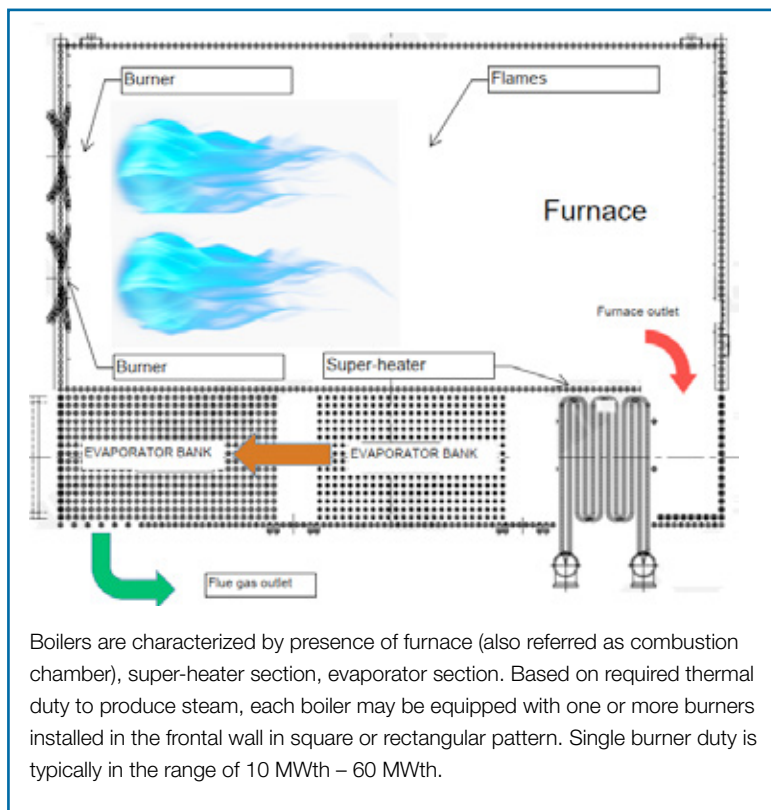


Figure 1- Boiler plan view – conceptual

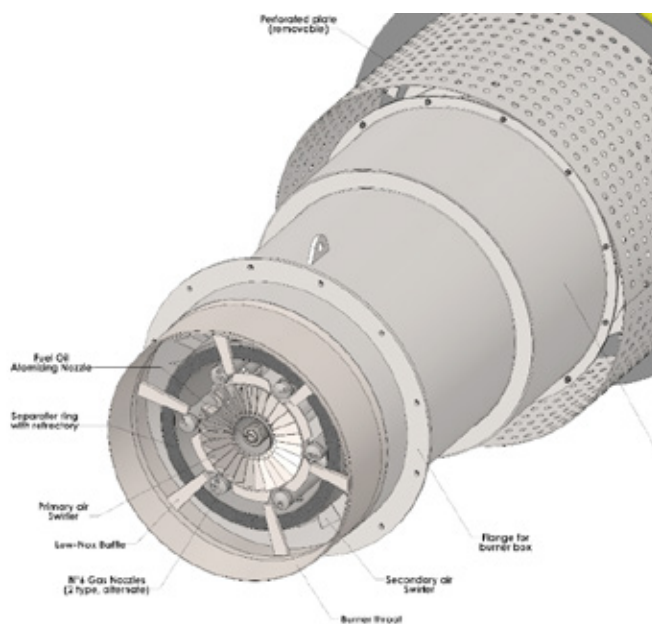


Figure 2- MHM burner front view

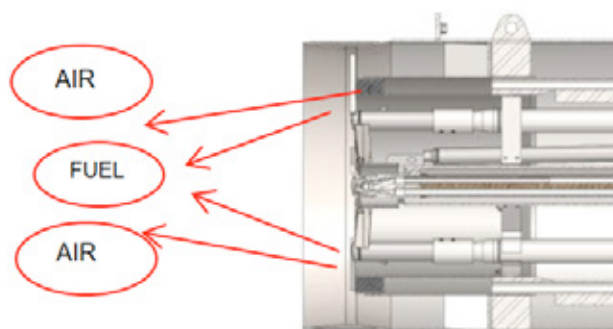


Figure 3 – MHM burner side view- Mixing zone

Macchi burners technology

Burner is a device to feed fuel and combustion air into the boiler furnace with a suitable velocity pattern, turbulence and molar ratio to achieve stable flame and minimizing by-products like NO_x and CO.

Essentially, two type of industrial burner families are available in Macchi production:

- MHM type
- MARS II type

MHM is a conventional burner where fuel injection is located inside the air stream (see **figure 3**). Injection may be designed in different ways (i.e. number and diameter of spuds, size of orifices) but combustion principle is based on mixing between fuel and air. Turbulence plays determinant role.

In MARS II burners, fuel injection is located outside the air stream (see **figure 5**) flow except a minimum quantity used as stabilizer. The separation of fuel-air injection is achieved through installation of shaped metal ejector, which overhangs of approximately 500-



Figure 4 – MARS II front view

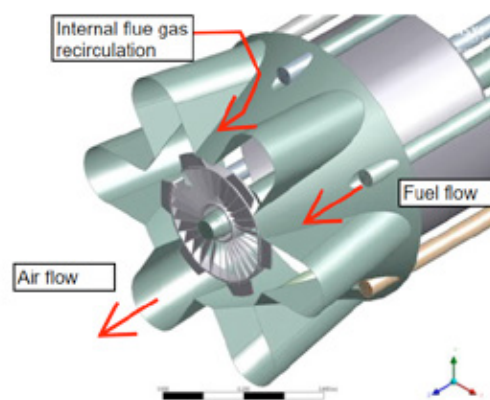


Figure 5- Mars II front/lateral view



Figure 6 - Mars II – Natural gas flame – Thermal Duty : 35 MWth

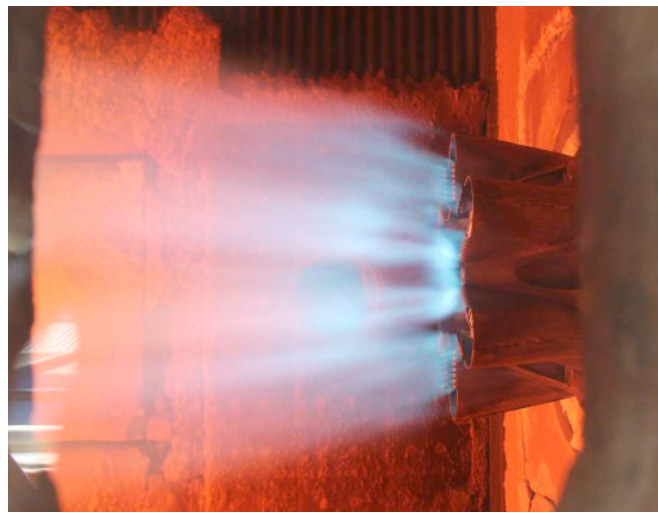


Figure 7- Mars II – Natural gas+ H₂ (80% volume) flame – Thermal Duty : 35 MWth

800 mm in the furnace. The air velocity coming out from inner part of burner generates localized low-pressure conditions close to fuel injectors, which promote the flue gas recirculation inside furnace. Recirculated flue gas will “mix” with fuel creating a lean fuel mixture. This principle is a driver to reduce NO_x emission of burner.

Respect to MHM, MARS II burner has demonstrated to reduce NO_x emission of approximately 50% without any external flue gas recirculation or steam injection.

The principle of internal flue gas recirculation is a key aspect of hydrogen firing. The formation of lean mixture mitigate high reactivity, promoting sufficient delay of combustion far from burner. Conversely, without this mechanism the injection of high amount of hydrogen inside air path (see **figure 3**) improves combustion rate leading to localized high temperatures not tolerable by burner materials. Flash back is also another potential issue present in this type of burner. The use of burner technology where fuel and air are de-mixed provides best solution to handle high level of concentration of hydrogen ruling out overheating and flash back issues. In the following pictures, flames with natural gas and natural gas **figure 6 and 7** hydrogen are reported.

The principle of internal flue gas recirculation is a key aspect of hydrogen firing. The formation of lean mixture mitigate high reactivity, promoting sufficient delay of combustion far from burner

Despite of high quantity of hydrogen (80% volume H₂) flame is well developed downstream ejector (from figure 07) and there aren't signs of over-heating. As expected, natural gas flame is located further the

burner ejector since less reactive. Natural gas flame result of dark blue colour with some yellows parts whilst NG/H₂ flame is of pale blue and more transparent (low flame emissivity). In the next pages, NO_x emission will be discussed.

Boiler furnace design

A considerable quantity of energy is exchanged, mainly by radiation, from flames to boiler inside furnace. In natural gas units, this value is around 30-40% of total heat input. Using co-firing natural gas – hydrogen, furnace temperature is higher with lower heat exchanged in combustion chamber.

For the scope of this simplified analysis, the following equation and assumptions have been applied:

$$Q = \sigma * \epsilon * S * (T_f^4 - T_w^4) * fb \quad (\text{heat transfer duty to furnace})$$

$$\epsilon = f(C/H) \quad (\text{flame emissivity})$$

Q: exchanged duty

S: Furnace projected surface

σ : Stephan Boltzmann constant

T_f : Furnace outlet temperature (FEGT)

ϵ : flame emissivity – as function of ratio C/H

T_w : tube wall temperature

(C,H: Carbon, Hydrogen content in fuel mixture)

fb : flames-furnace interaction factor

Evaluation has been carried out on a bi-drum boiler with following characteristics:

Steam production kg/h	145000	Natural gas emissivity	0,37
Pressure, barg	47	Hydrogen gas emissivity	0,15
Steam temperature, °C	400	Flame-furnace interaction factor	1.0
Furnace volume m ³	336	Air excess %	10
Furnace surface m ²	261	Ambient temperature °C	25
Number of burners	3	Air humidity %	60

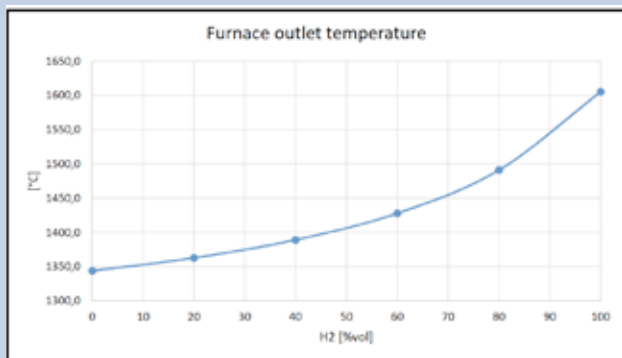


Figure 8- Effect of Hydrogen on furnace outlet temperature

Keeping same furnace size, furnace flue gas outlet temperature increases considerably especially for H_2 content greater than 70%. Higher flue gas temperature requires careful evaluation of superheater thermal performance and re-evaluation of metallurgy of tubes. The use of hydrogen, generally, requires more combustion chamber surface to keep temperatures within typical industrial limit (around 1400 °C-1450 °C). Nevertheless, in case of high concentration, the furnace size increasing may lead to expensive design of boiler and external flue gas recirculation (EFG) shall be an unavoidable option. Principles and effects of EFG will be discussed in the next pages.

Combustion control

If hydrogen concentration in the fuel blend is constant, combustion control system does not require any particular precaution. Very often, its content in fuel stream is variable and hence fuel mixture properties at boiler entrance change with the time. For this reason, combustion control logics shall consider more complex algorithms to evaluate the correct air-flow demand based on flowrate and characteristics of fuel.

Final scope is to maintain overall air/fuel ratio within burner limits avoiding sub-stoichiometric conditions.

Following diagrams show fuel mixture parameter as function of hydrogen concentration.

The **Figure 12** suggests the principle of combustion control for hydrogen firing boiler.

In conclusion on-line densimeter may provide evaluation

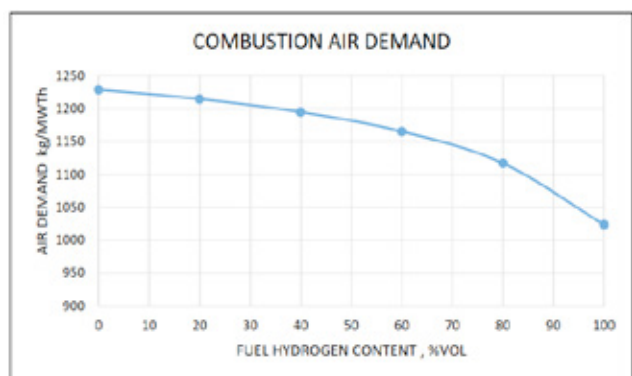


Figure 9- Combustion air demand for fuel mixture

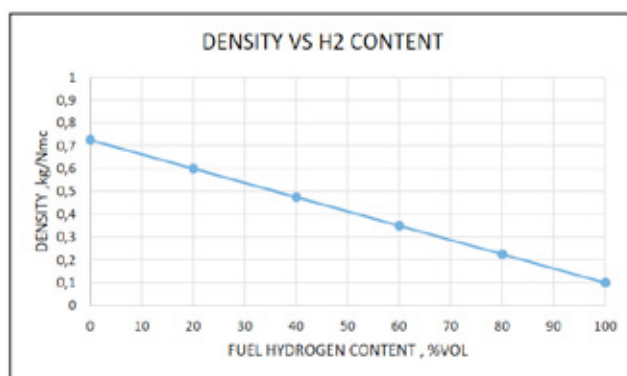


Figure 10- Fuel gas mixture density

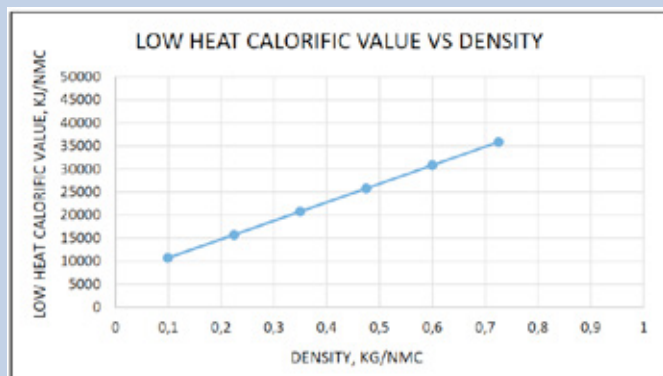
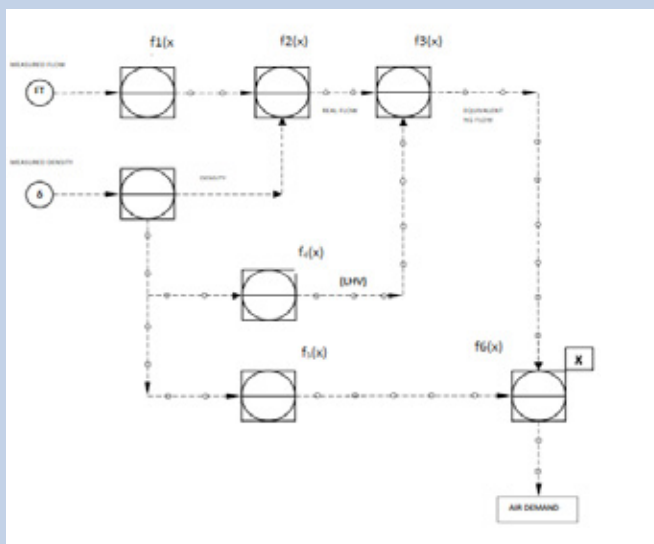


Figure 11- Low heat calorific value of fuel gas mixture vs density

In a fuel blend, specific air demand (required air for unit of energy of fuel input) is not constant. Therefore, if hydrogen content changes during boiler operation, air demand needs to be corrected with a factor depending on H_2 content. Since normal density of fuel mixture is linear with hydrogen content and low calorific value, density value, obtained through on-line densimeter, may provide signal to combustion logic to perform required correction.



Blocks description:

- f1: Pressure, Temperature flow compensation
- f2: Density compensation to obtain real fuel flow.
- f3: Correction with low calorific value. Output of block represent the "thermal energy equivalent" natural gas flow
- f4: Density – Low heat calorific value curve
- f5: Air demand curve based on density
- f6: Air demand correction

Figure 12- Typical DCS block diagram for hydrogen

of all correction factors to estimate the correct air demand to combustion control also in case of natural gas/hydrogen blend variation.

Environmental Aspect

As anticipated, one of the most important reason to use hydrogen in boilers is the reduction of CO₂ release to atmosphere. Following diagrams show CO₂ reduction as a function of H₂ concentration.

It can be noted that consistent reduction of CO₂ may be obtained for hydrogen content exceeding 50% volume due to non-linearity of curve. Moreover, huge CO₂ reduction can be achieved passing from 80% to 100% (approximately 40% of total).

From NO_x point of view, there are significant impacts on emission. The effect on NO_x formation is briefly described in the following diagram. Effect of external flue gas recirculation and steam injection are analysed.

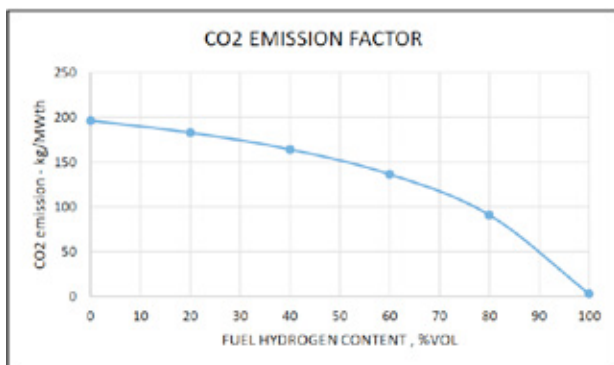


Figure 13- CO₂ emission for unit of energy

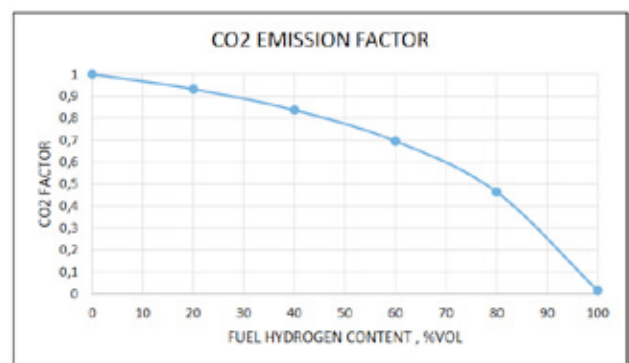


Figure 14- Normalized CO₂ emission

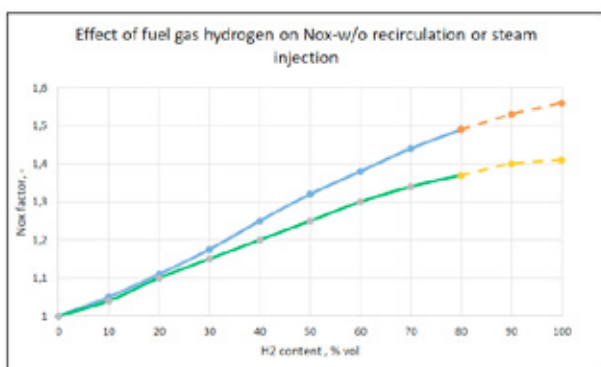
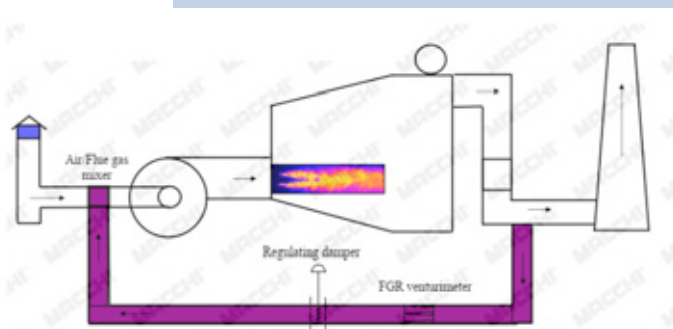


Figure 15- Effect of gas hydrogen on NO_x formation

Curves are a fitting of field data of Macchi burner.

Dotted lines represents extrapolation of NO_x prediction, by CFD calculation, for cases where industrial field data on large scale are not available.



External Flue gas recirculation (EFGR) is a technique where the combustion products are drawn back into the burner. Typically, EFGR flow is branched off from exhaust duct upstream stack, where temperatures are lower, and are routed back to fan suction. Effect of flue gas recirculation is primarily to reduce peak flame temperature.

Figure 16- Principle of external flue gas recirculation

Common NOx reduction technology can be used to compensate increase of NOx due to hydrogen

FGR effectiveness depends on many factors including furnace dimension and flame interaction between burners.

Figure 17 shows EFGR trends and effect on NOx. As example, 10% of FGR may reduce NOx of 50%.

Another way to reduce NOx emission is the steam injection. It is a technique where steam is introduced in the burner to reduce flame peak temperature; it is essentially expressed as quantity of steam for unit of fuel (kg steam/ kg fuel).

Effect of steam injection is complex and shall be evaluated case by case but NOx reduction could be in the range of 5%-10% for each 0,1 kg of steam/kg of fuel.

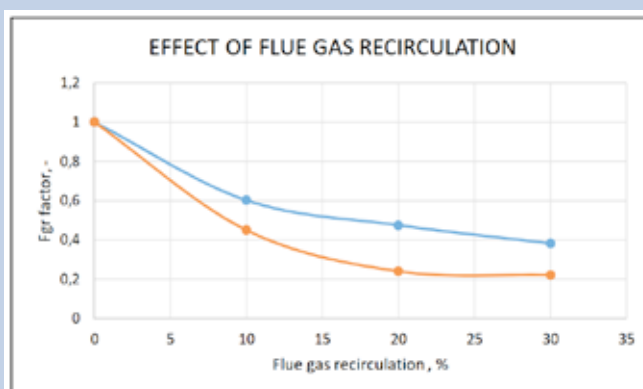


Figure 17- NOx reduction effect of flue gas recirculation

Hydrogen disadvantage on NOx formation may be solved with well know NOx abatement techniques like flue gas recirculation or steam injection or combination of both.

As an example, considering a flue gas mixture containing 80% H₂ volume, the use of approximately 10% of recirculation or 0,5 kg/kg steam injection could bring back the NOx emission to same level of natural gas.

The use of EFGR may significantly contribute to the reduction of flue gas temperature at furnace outlet. As rule of thumb, 10% of flue gas recirculation could reduce furnace temperature of approximately 100 °C. In some cases, this could avoid furnace size increase.

Other aspects

Use of hydrogen shall deal with safety aspect.

Hydrogen has difficult confining since it is the smallest element in universe, it is odourless and colourless.

Therefore, for example, fuel gas piping components (like shut off valves) shall be carefully designed. Also hazardous area classification and material selection shall be duly evaluated during design of boiler components.

Case history

Macchi has been designing boiler firing hydrogen since many years.

Boilers for petrochemical plants burning refinery gases are the most common applications.

Refinery gas has typical concentration of H₂ of approximately 20-40 % volume. In the following diagram, hydrogen experience in industrial boiler is reported.

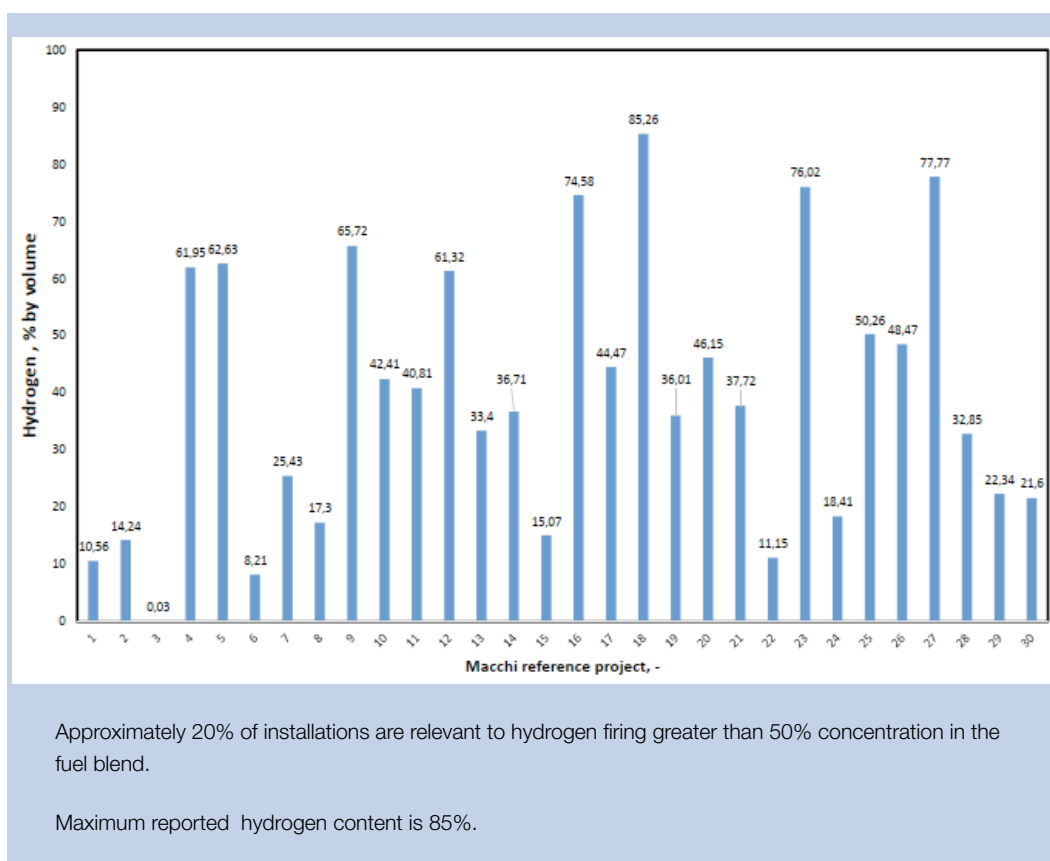


Figure 18 – Macchi Industrial Hydrogen experience

What's the future?

Many analysts predict a growth of hydrogen use in the next future. Similarly to other industrial application (like gas turbine), efforts are continuously made to maximize the hydrogen content in fuel stream and adapt boiler design accordingly.

Experiences up to 80% hydrogen content are available but research and firing at maximum capacity is still an on-going activity.

Even though the gap seems small, fuel blend properties substantially change passing from 80% to 100%. In this respect, Macchi is making research and studies on MILD - flameless combustion where a prototype burner has been tested and already patented. The adoption of this combustion technology permits the achievement of very low NO_x emission levels without use of external flue gas recirculation or steam injection. We believe that MILD will play important role in achieving 100% H₂ combustion.

Experiences of burning hydrogen concentrations of up to 80% are available but research and development to reach full firing at maximum capacity is still on-going

Conclusion

Environment needs urgent solution to reduce carbon dioxide to atmosphere. From boiler manufacturer's point of view, the combustion of hydrogen in steam generators may give tangible contribution to decarbonisation. Technology and experience, to achieve co-firing with high fraction of hydrogen, is

Macchi is researching and studying MILD - flameless combustion where a prototype burner has been tested and patented. The adoption of this combustion technology permits the achievement of very low NO_x emission levels without use of external flue gas recirculation or steam injection

available and supported by applications in large scale. Burners may not be of conventional type and special fuel injection shall be considered; furnaces shall be enlarged progressively as hydrogen content increase but use of flue gas recirculation shall be evaluated to avoid excessive combustion chamber dimensions and costly design.

NO_x can be easily controlled with Ultra-Low NO_x burner and adopting external flue gas recirculation

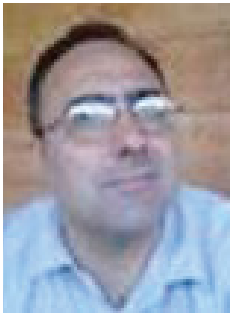
and steam injection. Combustion control needs more complex algorithm and use of on-line densitometer may provide all correction factors to maintain air/fuel ration inside safe limit.

In conclusion, high hydrogen firing in steam generators is technically feasible and commercially proven; boiler units firing hydrogen, like standalone

fuel, are not very far to be available in the nearest future.

Reference:

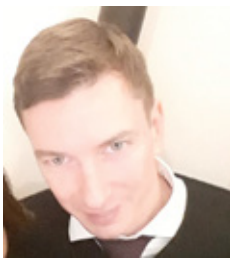
API 538 – Industrial fired boiler for general Refinery and Petrochemical Service – October 2015.



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Industrial hose reels for Kuwait (285 pieces)

SANCO and the extreme global weather challenge

Being a simple supplier is different from working in complex turnkey construction contracts, while challenging the local climate and geography

Nico Zorzetto, Export & Marketing Director, SANCO S.p.A.

Dealing with International EPC-Projects is hard. It is even harder when weather conditions need exceptional requirements on equipment and logistics.

Consequently, you need to:

- have extensive professional and practical experience with large-scale and complex infrastructure projects
- make huge financial and resource efforts due to contractual commitments
- invest in your team by training also commissioning supervisors (sometimes speaking local language) and
- work hard together for reaching goals and on relationship with your clients for accomplishing the specified objectives.

Moreover, at project execution, deviations from desired performance in terms of time, cost and quality easily take place.

At the end, your team's and your client's success is shared with you, and you'll want to empower everyone to succeed and reach their goals so you can reach yours.

High integration and effective synergistic management of projects ensure project quality as long as the results are in compliance with the functional specifications and they achieve the performance guarantees.

During the last decades, thanks also to its R&D department, SANCO has been working for guaranteeing and enhancing the quality level of its products, thus further strengthening the company's position in the fire

suppression systems market.

With its full in-house capability and its human resources - including project engineers, an engineering department (made up of more than 35 highly specialized technicians), which use three teleconference rooms available in SANCO quite often during project development - SANCO has worked by taking in consideration more than a few aspects for planning projects in a very accurate way, in particular the ones located in areas where weather conditions are really harsh.

SANCO has applied accurately state-of-the-art fire-fighting technologies in very difficult environments, in harsh weather conditions and in remote and almost inaccessible areas

Various plants on which we have worked are located in remote areas, in some cases inaccessible for most of the year, where the supply of materials and resources to the sites is also a major logistical achievement: sometimes main logistic routes are only rail roads.

These projects have been demanding to reach the following goals:

- meeting the specifications of both EPCs and end users thanks to structured progress reporting and review meetings
- following local authorities in charge for specific local certifications
- considering specific weather conditions, in some



Deluge valves for Kuwait



Special convoy (19 trucks) and trailers



Internal view of one deluge valve container for Russia



CO₂ systems for Russia (more than 1400 cylinders)



Deluge valves on skid for Russia

cases with very extreme temperatures (-52°C +65°C)

- improving the performances of the fire-fighting systems and equipment accordingly
- granting the agreed delivery schedules and warranties, tailored to meet client's construction needs.

As a result, SANCO has been working and challenging for:

- accurate selection among the end user's

approved vendors of the suppliers of instruments that had to be installed with packages

- identification and choice of special construction materials and alloys that can withstand extreme cold or extreme warm environments, suitable for enclosures/containers (cooling systems for hot environment and heating systems for very low temperatures)
- special welding processes done by qualified welders and with special tests such as penetrant liquids, X-rays, even in presence of external inspectors also during construction process
- assembling with internal final acceptance tests even before visit of EPC's inspectors
- finishing and painting with several cycles, specific painting processes and special thickness
- shipment with suitable logistic means, also special cargo because almost packages reached 30 tons weight each.
- meeting delivery times at site

SANCO has managed voluminous and complex projects but some have turned out to be more remarkable than others.

In particular, it is worth to mention three totally different projects located respectively in Russia, Kazakhstan and Kuwait.

SANCO has managed sizeable and complex projects in very diverse environments, e.g. in Russia, Kazakhstan and Kuwait

The projects have been carried out throughout two years by three different project task forces.

In **Russia**, with compact fog clouds over the steppes at the end of the earth, weather is severe cold and polar, with icy winds. Temperatures fall as low as -40°C or even -50°C .

For this specific job, SANCO has been requested to design the equipment and select EAC certified special instrumentation for -52°C as well.

The scope of SANCO has been the engineering, procurement and construction of modular self-contained fire suppression systems (deluge valves, CO₂ gas systems and HFC227ea systems) for a total value of more than 9 million Euros throughout two years.

Low temperature materials have been used for piping and structures to withstand in the cold climate. Since water may freeze, heat traces have been installed at piping and machineries have been placed into special containers with air conditioning systems to prevent possible freezing.

The packages, together with two power generators for granting temperatures not down 5°C in order to avoid any sudden change of temperature during transportation to the site, have been loaded and shipped on board of special oversized cargos in convoys escorted by police.

150 deluge valves have been enclosed into the above mentioned 19 containers.

Additionally, other containers have been delivered enclosing more than 1400 high pressurized CO₂ cylinders of 67 liters capacity / each.

Every container had a weight of about 20-30 tons and, thanks to the rail crane owned by SANCO (able to lift



up to 40 tons), all of them have been easily loaded.

Deluge valves on skid for Kazakhstan

In **Kazakhstan**, a significant project has been accomplished by supplying similar systems for a total value of more than 17 million Euros.

The project included:

- 90 skid mounted units with HFC227ea gas systems into insulated and warmed enclosures
- 38 skid mounted units with about 194 deluge valves of different sizes contained into insulated and warmed enclosures
- a big foam pumping station installed inside a large size insulated and warmed prefabricated house
- 2 big storage insulated tanks, each one of 54000 liters capacity
- more than 100 tons of AFFF 3% foam concentrate and 20 tons AR/AFFF 3%. Both the foam concentrates were freeze protected type, suitable for very low temperatures.



Foam deluge skids for Kazakhstan

Foam concentrate storage tank for Kazakhstan (54000 liters)



SANCO was selected for another noteworthy project by two significant Kuwaiti local oil Companies, namely KOC and KNPC, for a total value of more than 14 million of Euros throughout the last 3 years.

Kuwait is a Country where dust and sand storms are common extreme weather events and it suffers from several environmental challenges, including higher temperatures rates, lack of seasonal rains, limited water resources and increased desertification.

Beside the weather conditions, SANCO had to deal with local approvals by the local fire brigade (KFSD).

The Company has supplied more than 80 deluge valves skid mounted in insulated and cooled enclosures suitable for temperatures up to +65°C. Other systems and equipment such as CO2 systems, IG541 systems, hundreds of hydrants, hundreds of monitors, industrial hose reels and many tons of foam concentrate and associated products (nozzles, foam branchpipes, hoses,

breathing apparatuses, windsocks, foam chambers, risers, safety showers, engine suctions and other safety equipment)

The projects have been actually processed on time, with certified approval of inspectors, thanks to the organizational structure and facilities in SANCO. The performances of every single equipment and package have been tested at SANCO's own testing ground by inspectors.

SANCO has managed the projects in an effective way, also while dealing with International transport logistics which needed even more efficient solutions.

Having followed the customer 'satisfaction policy, SANCO has been awarded two good reference letters by its clients for its good job, but it is still ready for new challenges all around the world.



Nico Zorzetto

Nico Zorzetto, Export & Marketing Director as well as shareholder of Sanco S.p.A., has been working in the fire-fighting field for the last 45 years. Even as a graduate in Economics, he has always been keenly interested in technological innovation for "reliable products".

He has participated in the execution 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 published several articles – national and international - relevant to fire-fighting topics.

He also cooperates with national and international organizations and Civil Protection Organizations, as well as with matters of security, e.g. projects with NATO.

For further information n.zorzetto@sanco-spa.it

**NEW BARRIER
VERSION**



To be sure to be safe.

FOCUSED ON YOUR SAFETY



Wide service temperature range:
-60°C+130°C



IP68 protection rating: tested at 30 m
depth for 12h



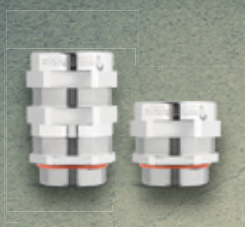
'Ex db', 'Ex eb', 'Ex tb' and 'Ex nR' methods of Protection



Suitable for different types of cables including lead sheathed,
flat, instrumentation and fiber optic cables

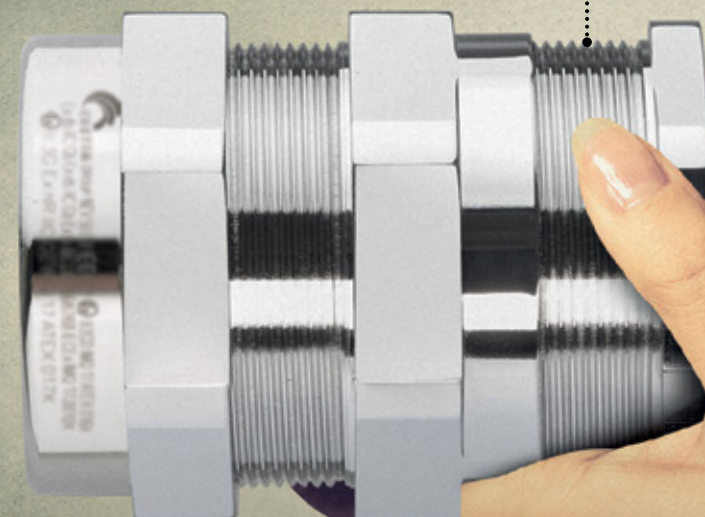
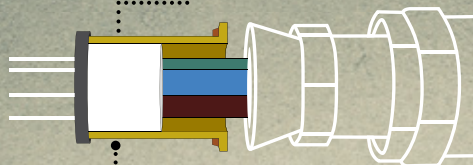


Barrier model supplied with the resin sealing kit



NEVB

NAVB



Cortem Group expands the cable glands family and presents the **new barrier version for armoured cables NEVB series and for non-armoured cables NAVB series**. The barrier is shaped around the conductors thanks to the particular mixture that flows through them in the special bushing ensuring a complete seal. The liquid resin used prevents the formation of air pockets or voids between the conductors and the bushing.



cortemgroup.com

Cortem Group Lighting fixtures with LED technology for areas at risk of explosion: innovative and enhanced EVL series

The continuous innovation processes and technological updates for the EVL lighting fixtures series makes them a safer and more performing product

Francesca Merola, Communications & Marketing Specialist,
Cortem Group

In a rapidly evolving scenario such as the LED technology, the process of developing new products and the innovation and updating of the existing ones for continuous performance improvement are a crucial element for the Cortem Group.

The EVL series of LED lighting fixtures, launched by Cortem Group in 2015 and available in four sizes, has been innovated and enhanced to offer an even safer and more performing product.

The explosion protection method has been improved with the 'Ex op is' certification, the so-called optical safety governed by the IEC 60079-28 Ed. 2 standard

which concerns the Ex world only (such as, for example, the certifications ATEX / IECEx).

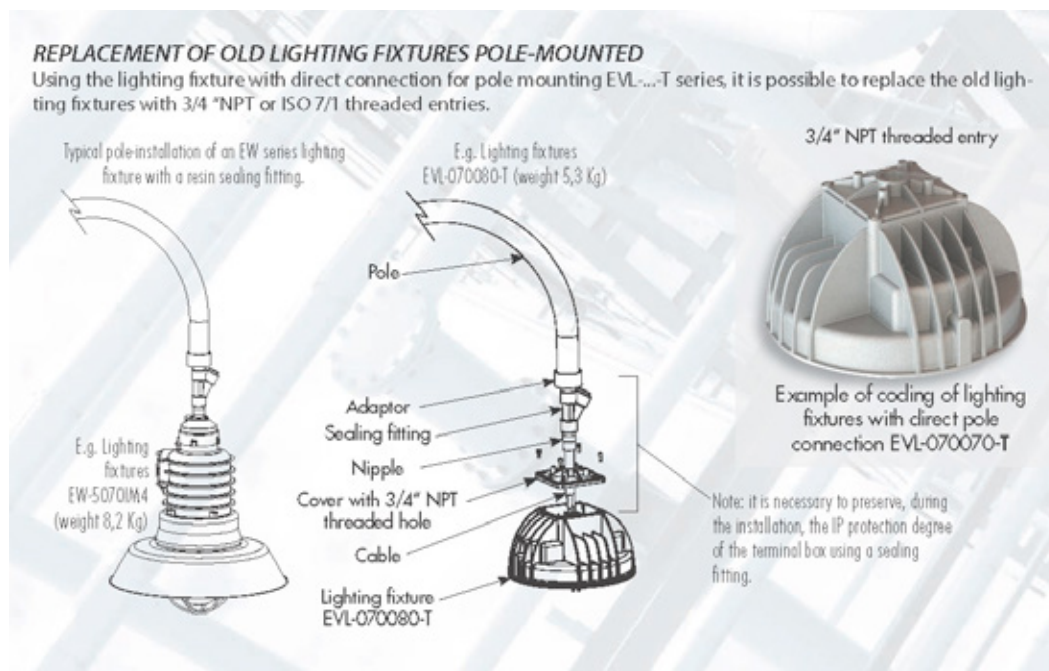
The new multiled board plates offer better control of heat dissipation, excellent mechanical strength and a wider light emission area which allows greater illumination and reduced glare

EVL lighting fixture



Specifically, the standard identifies two parameters that measure the hazard of a light emission: optical power (mW) and optical irradiation (mW/mm²). In the case of classified areas, an optical source can represent a trigger when it exceeds certain values of power and collimation of the beam. The "op is" protection is applied when the radiation is not confined in a closed space, but exits the device (as in the case of the light beam coming out of the lighting equipment) and has the purpose of ensuring that, even in fault conditions, the optical power emission or the optical irradiation emission does not exceed the expected levels.

"This result has been achieved - explains Cortem Group R&D Manager Cristiano Decorte - thanks to the use of specific multiled board plates and the implementation of particular electronic and mechanical safety measures. The new multiled board plates offer better control of heat dissipation, excellent mechanical strength and a wider light



emission area which allows greater illumination and reduced glare”.

All models were also subjected to new explosion tests which allowed to extend the range of the ambient temperature to $-40^{\circ}\text{C} + 60^{\circ}\text{C}$ and to reach, with gas group IIB+H₂ and IIC, temperature classes colder (T5) for some models.

As regards the electrical and photometric characteristics, the choice of supply voltages and powers has been expanded to meet all possible application requests: the supply voltages range go from 12 to 277 V for each of the 4 sizes, while the powers available start from 20W up to 220W, with steps of 10W and 20W. All this is reflected proportionally into different lumen outputs ranging from a minimum of 1,700lm to a maximum of 21,000lm.

In the technological world, the state of continuous improvement is called permanent beta mindset, that is, a state of permanent beta in which the improvement of the product is constantly pursued in order to increasingly satisfy customer requests and increase the value offered to the market. The EVL series innovation project also included the development of a transportable version with an electronic driver, to be used mainly in inspection and maintenance activities on industrial plants and tanks, and a model specifically designed for a rapid and a timely replacement of the old generation discharge lighting fixtures installed directly on a pole.

From a mechanical point of view, the EVL series is characterized by a patented design: the body, made of aluminium alloy, is equipped with fins that act as a heat sink allowing a fast and effective dispersion of heat generated by the normal operation of the LED, as can be seen from the thermal imaging.

Following a very brief initial period, the lighting fixture reaches thermal stability. This image shows the

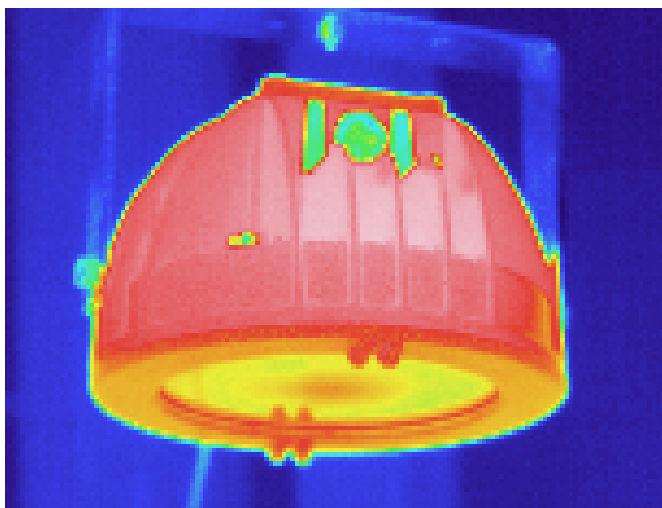
detected heat. With the ambient temperature at 18°C (as shown by the blue background) the LED lamp barely touches 42° at the hottest point. This thermal performance is tangible proof of the high efficiency of LED lamps as a source of light.

The EVL series innovation project also included the development of a transportable version with electronic driver

The geometric conformation of the cooling fins was also designed with the objective of minimizing the deposit of combustible dust, allowing the self-cleaning of the lighting fixture by air or water present in the environment. Furthermore, thanks to the absence of UV emission, there is no ionization of the air particles around the lighting fixture, an intrinsic characteristic of LED technology which limits the attraction of dust and insects.

The design of the lamp body, in addition to being functional to the duration of the system, gives the equipment very high light efficiency in relation to the maximum surface temperature (T), a very important factor for the installation of lighting fixtures in places with explosion hazard, containing gas or dust at low ignition temperature.

A further saving is obtained thanks to the fact that, while discharge lamps require a preheating time for their complete ignition and, for this reason, often remain on 24 hours a day, the EVL series lighting fixtures, featuring an immediate ignition (Instant Restrike), can be effectively connected to automatic ignition systems in case of low light, allowing the use only in the periods of time really necessary and, consequently, further savings in energy costs.



Thermal imaging



Terminal board enclosure



Cable Entry

The electrical connection is easier thanks to a 'Ex e' terminal housing which allows the entry with a 'Ex e' cable gland (no barrier). In addition, an opposed plugged hole permits the through wiring connection. EVL series LED light source allows a better identification of colors of the objects than traditional sodium vapor lamps which have a low color rendering index (CRI = 25). The EVL CRI typical value is CRI = 80. The standard color temperature is cold white, other color temperatures can be supplied on request.

The EVL series represents the LED alternative for all those areas where low and medium power discharge and incandescent lighting fixtures up to 400W were used. For example, the EVL-70 series, which has a consumption of 55 W, is able to replace a 100 W metal and sodium halide lighting fixture, a 200 W mercury vapor lighting fixture and a 500 W incandescent one. Finally, the EVL series has a 115° light beam aperture, falling within the limits dictated by the most recent light pollution standards.



Francesca Merola

Francesca Merola is the Communications & Marketing Specialist of the Cortem Group. She has been working there since 2008. She has an in-depth knowledge of

Cortem products and, along with the R&D department, works to communicate their pluses in the best way.

Monsud at the service of the execution of major Oil & Gas plants

Engineering, supply, inspection, testing, packaging and transportation of steel structures (Pipe rack, Process structures, Shelter, Walkways and secondary structures), including surface protection and fireproofing, as Saipem's subcontractor for the Cornegliano Laudense Natural Gas project

Domenico Pierni, President and General Manager,

Carmine Pierni, lawyer and CEO

Monsud S.p.A

In a scenario where the storage of any energy source appears as a winning solution to several supply issues, a valuable contribution was given by the gas storage plant of Cornegliano Laudense, owned by Italgas Storage and achieved through the "Cornegliano Laudense Natural Gas" project by Saipem S.p.A., who has entrusted to Monsud S.p.A. the supply of metal carpentry of Pipe Racks, Process Structures, Shelters and accessories, including surface protection treatments and fire protection treatment of structures (fireproofing).

The project "Cornegliano Laudense Natural Gas" provided of the construction of a gas collection, storage and purification plant, as well as the construction of a process water purification plant and associated warehouses

The Italgas Storage plant was an old natural gas field with an extension of about 6 Km² and located at an average depth of 1.4 Km in the subsoil of the municipality of Cornegliano Laudense, discovered by ENI (then AGIP) in 1951. Following the exhaustion of natural gas, having the related cavity a geological structure with petrophysical characteristics suitable for the gas storage, it has been converted into an infrastructure capable of storing gas purchased during the summer months, where the price is significantly lower, then extract it and put it back into the distribution network in the



winter months, thus giving rise to a sequence of cyclical operation.

The project "Cornegliano Laudense Natural Gas" consisted of the construction of a gas collection, storage and purification plant, as well as the construction of a process water purification plant and warehouses servicing of the plant.

In the period between 2017 and 2018 the company Monsud S.p.A has carried out the activities of engineering, supply, inspection, testing, packaging and transport of steel structures, for a total of about 1800 tons (**Figures 1 and 2**), including the various surface treatments, through the company Saipem

Figura 1 - Metal structures supplied by Monsud S.p.A to the Construction site

Figure 2 -
Construction site of
the gas storage plant
"Corneghino Laudense
Natural Gas"



- Supply of sandwich panels, corrugated sheets, eaves, flashing lights, rainfields, doors and gates;
- Supply of settling tanks, clarification, rain water, process water treatment plant and accessories.

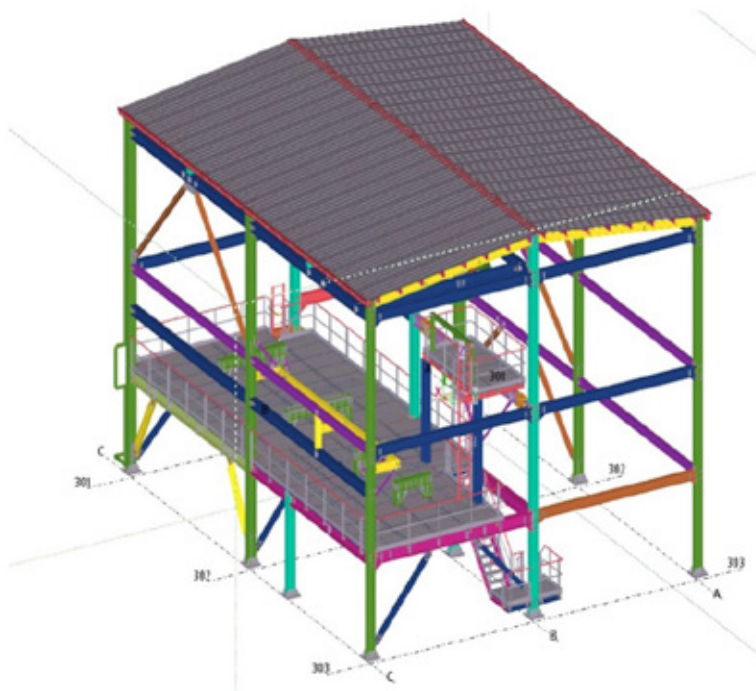
Between 2017 and 2018 Monsud S.p.A has carried out the engineering, supply, inspection, testing, packaging and transport of steel structures, including the various surface treatments, as a subcontractor to Saipem S.p.A. , the EPC general contractor responsible for the entire plant's project, from design and engineering to supply, construction and commissioning

S.p.A. (EPC), which has taken care of the management of the entire plant's project, from design and engineering to supply, construction and commissioning of the plants.

Here following a detailed list of activities carried out by Monsud S.p.A. in relation to the project "Corneghino Laudense Natural Gas":

- Detailed executive design, i.e., structural design of pipe-racks, piping and mechanical components, workshop and assembly drawings;
- Supply of metal carpentry for Pipe Racks, Process structures, Shelters, Gangways;
- Provision of stairs, parapets;

Figure 3 - Structures
modeled with Tekla
Structures software



Monsud S.p.A. has made use of an internal team of structural technicians and mechanical designers of proven experience to carry out the complementary engineering and executive design activities. Sophisticated and dedicated softwares were used. The software Tekla Structures version RELEASE 21 was used for the development of complex structures, allowing the modeling of steel structures and the creation of shop drawings starting from the 3D MODEL (**Figure 3**).

The works supplied by Monsud S.p.A. mainly concerned the following structures:

- Pipe racks: about 998 tonnes;
- Process structures: about 200 tonnes;
- Shelters (sheds): about 550 tonnes;
- Gangways and secondary structures: about 100 tonnes.

The structures were built according to the EXC3 execution class, in accordance with EN 1090, and the steel used is quality S275JR, according to EN 10025. All the structures were prefabricated at the Monsud factory in Tufo (AV).

The sequence of working of steel structures was as follows:

- sandblasting of beams, profiles, sheets and pipes carried out with OMSC blasting machine with 8 turbines, Turbotecnica 16 turbines;
- cutting, drilling and marking operations carried out with GEMINI/FICEP automatic lines with numerical control for L-beams and profiles;
- cutting, drilling and pre-processing of the plates and handkerchiefs for the composition of the knots performed with automatic thermal cut (plasma /oxy-cut) ESAB table 3000 x 1600 with numerical control assisted by

Columbus software;

- assembly of beams and columns according to workshop drawings;
- final welding of the brands assembled according to the welding planes;
- CND checks on welds;
- sandblasting shots;
- application of protective coatings with booth-furnace painting plant, as well as temperature and humidity detection plant and air emissions filtration plant.

For the shelters and secondary structures that did not require fireproofing treatment, a painting cycle was applied directly at the Monsud plant in Tufo, which is equipped with sandblasting machine and painting cabin.

The steel structures, according to ISO 12944-3, were constructed in such a way as to facilitate their preparation for the various surface treatments.

The surfaces were washed with pressurized water to remove any residues and impurities, and then cleaned with a specific solvent before sanding. After sandblasting with angular metal grit, an epoxy primer was first applied, then an intermediate and then a polyurethane finish.

The pipe racks and process structures, beams and columns were treated with a fireproofing cycle Fireproofing Jet Fire of 60 and 90 minutes.

The fire protection from JET FIRE has been realized with intumescent treatment and certified in accordance with ISO 22899 regulation.

The project criteria were:

- Fire: Powered by hydrocarbons
- Reference test: LLOYDS
- Fire protection criteria: jet fire 60/90 CCT 400°C

The fireproofing treatment of the structures - "Fireproofing" - was carried out in the factory of Monsud S.p.A. located in Avellino (**Figure 4**). The fireproofing process covered about 15.000 square meters of profiles, using the product CHARTEK 7, biocomponent based on flexible intumescent epoxy resins, fire retardant suitable for the protection of steel structures and mainly used in the oil & gas and petrochemical industry.

The entire phase of product application was carried out in environments where the conditions for treatment were restored and constantly kept under control and recorded, such as:

- Air temperature $\geq 10^{\circ}\text{C}$
- Relative humidity $\leq 85\%$
- Surface temperature of steel $\geq 3^{\circ}\text{C}$ higher than the dew point of ambient air.

The application of Chartek 7 took place according to the following cycle:

- Dusting of surfaces;
- Masking of all surfaces not affected by Fireproofing and bolting;
- Hand application of Chartek 7 layers until design thicknesses are reached;
- Application of reinforcement mesh to about half the thickness;
- Rolling and smoothing of surfaces;
- Application of a polyurethane paint;

The Chartek 7 has been sprayed on the surfaces with biphasic Covercat pumps by means of flexible hoses for successive coats, until the final thickness is reached. Each coat was applied when the previous one was not yet completely dry. Measuring devices were used to ensure that the different covering layers were of constant thickness.

The Shelter SHL300/301 were designed to isolate the high noise emitted by the gas compression system.

Sheds with acoustic insulation through sandwich-panels sound type have been realized.

Sandwich acoustic panels with PWD-F and TW5-F rock wool insulation, with sound-absorbing and sound-insulating properties have been used both for the roof of the sheds and for the walls, made with external support in galvanized steel sheet and with micro-perforated internal support and insulating windows also made with the same type of acoustic panels. The minimum acoustic performance required was not less than $R_w = 30 \text{ dB}$.

As part of the same project Monsud S.p.A. has

*Figure 4 -
Fireproofing treatment
application at the
Monsud S.p.A. plant in
Avellino*



Monsud S.p.A

Founded in 1979 by the idea of the engineer Mr. Domenico Pierni, born initially as a company of assembly and production of metal carpentry. As the years passed, with the acquisition of know-how and increasingly innovative machinery, Monsud S.p.A. becomes a leading company in several and different sectors. Monsud S.p.A. owns three production plants located respectively in Avellino, Tufo and Montemiletto, and operates as Main Contractor for the construction of civil, industrial, road, networks and transport, complex industrial facilities and infrastructure, power plants producing electricity, plants for the exploitation of alternative energies (wind, photovoltaic, geothermal and incineration of RSU), special constructions and engineering services, plants for the glass and petrochemical industry. Monsud S.p.A. holds many certifications, such as EN ISO 9001, EN ISO 14001, EN 1090, EN ISO 50001, OHSAS 18001, SA 8000, SOA, ASME VIII Part.I.

- a 300 collection tank (VASCA B-725) where meteoric water convey for disposal to the purifier through a tank;
- a rolling tank (B-720) equipped with a flow regulator that allows the passage of the established flow.

The entire work has been developed in accordance with EN UNI 9001 and in compliance with the provisions on safety by the D.L. 494/96, D.L. 528,99 and D.L. 81/08.

At the end of this description it appeared clearly that "Cornegliano Laudense Natural Gas" was a very innovative project, mirroring the idea that "*storage is the future of the energy system*", as stated by Mr. Bitetto, President of Ital Gas Storage.

also built secondary structures to serve the water purification system of the storage plant, consisting of separate systems for the collection of stratum water, meteoric water, oil drainage and industrial waste water.

In relation to the purification system, Monsud S.p.A. has provided:

The fact that Monsud S.p.A. operates in such a growing industry as the oil & gas field, taking actively part in projects of this scope, is a clear sign of an innovative and dynamic company, very reliable and gifted with strong personality and advanced technologies, with a constant look into the future.



Domenico Pierni

Domenico Pierni is a Mechanical Engineer, graduated from the Università Federico II di Napoli. He founded the Monsud company in 1979, of which he is President and General Manager, consisting of about 90 employees. With his company he has worked for important customers

such as Saipem S.p.A., Dow Chemical S.p.A., Eni S.p.A., Foster Wheeler, Sogin S.p.A., Enel S.p.A., Trenitalia S.p.A., CCR ISPRA, Telecom Italia, Vodafone, Jacobs, Fincantieri, Iter, Aeroporti di Puglia, Aeroporti di Milano, making the company grow in numerous and important sectors.



Carmine Pierni

Carmine Pierni, lawyer and CEO of Monsud S.p.A., has been managing various jobs for 15 years in various European countries: in France with construction of a reinforced concrete building called TAPS (Tokamak Assembly preparation building) complete with mechanical and electrical systems, for ITER; in Italy with Design and construction in a

waste-to-energy plant on the Macomer site (NU), Executive planning and Erection works of Material Treatment Facility in SOGIN Nuclear Power Plant in Latina; in Romania with supply of steel structures for the Closed Blow Down System and POLYFUEL Project in Ploiesti for Foster Wheeler

Eurotecnica, technology provider, designer and implementer of melamine production plants

The company is active also in the Oil & Gas sector, as well as in some pioneering areas such as the one of thermal energy storage applied at concentrated solar power station

Established in 1962, Eurotecnica is known for its leading position as a technology provider, designer and implementer of melamine production plants. Besides, Eurotecnica is the most reputed independent technology provider and contractor for carbon black production plants. Also, the company is active in the Oil & Gas sector, as well as in some pioneering areas such as the one of thermal energy storage applied at concentrated solar power station.

Eurotecnica is part of the Proman family of companies, a global leader in natural gas derived products and services, with assets in Trinidad & Tobago, USA, Mexico, Germany, Italy, Switzerland, Portugal and Oman.



Eurotecnica head office in Milan, Italy

Technologies - Melamine

Melamine is a 2 million ton/year market, it expands and covers a wide spectrum of growing applications.

Melamine is a constant presence in everyday life.

Dinnerware, laminates, flooring, and medium density fibreboards owe their hardness, flame-resistance, mar-resistance and waterproofing to melamine.

Capable of forming strong and stable bonds with

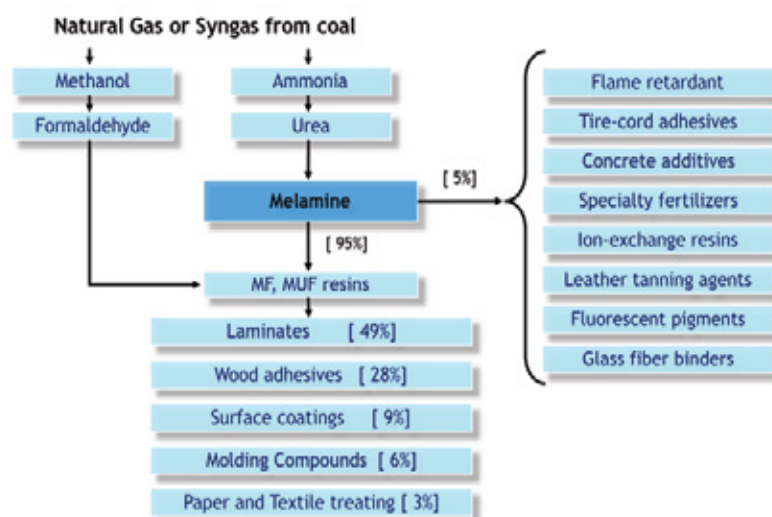
formaldehyde, melamine confers MF and MUF resins. These unique features are thanks to the high nitrogen content (66% wt) of the molecule, which is essential for the flame retardant and fire-resistant properties in the finished goods.

If exposed to intense heat they give off nitrogen without producing toxic gases, diluting oxygen and inhibiting the combustion.

New aircrafts interiors, for instance, make use of melamine-based flame-retardants in order to comply with the most stringent safety requirements.



Side view of XLX Euromel® Melamine Plant, Xinjiang, China – World's largest single-train HP melamine plant, 60,000 ton/year



Euromel® Melamine

Euromel® is the melamine exclusively produced at plants licensed, designed and implemented by Eurotecnica.

Cumulatively, several million tonnes of Euromel®



QAFCO Melamine Plant – Mesaieed, Qatar - view of Euromel® Plant, the largest melamine plant in the Middle-East

melamine have been produced to-date – a sign of its superior quality.

Originally introduced in the 1960s, this high-pressure non-catalytic technology was ahead of its time and considered truly innovative because it was the first high-pressure melamine technology ever implemented in a commercial-scale plant.

Across the years, the Euromel® melamine process has enjoyed some remarkable improvements that make it a unique technology, thanks to a skilful R&D department and cooperation with all licensees.

Environmental compliance, low energy consumption and absence of add-on chemicals for purification (that typically generate safety and environmental concerns) contribute to the lowest OPEX throughout its considerably extended time span.

The latest generation of the Euromel® Melamine Process (G4) has witnessed a phenomenal reduction in energy consumption that has no equal in the industry. Eurotecnica's vast experience in the design and implementation of melamine plants has been key in finding ways to further reduce energy consumption.

The G4 Euromel® Melamine Process has been completely re-engineered and revised in order to reduce the number of critical components, simplify

others and, in general, reduce the investment cost extensively without compromising the quality of the equipment and materials used.

This has led Euromel® Melamine plants to become particularly cost-effective.

The trend for building ever-larger urea plants involves the demand for larger and more OPEX-efficient melamine plants as well.

To cope with this trend, Eurotecnica has developed and implemented the 60,000 ton/year single-reactor single-train unit.

As many as twenty-two Melamine plants worldwide are based on the Euromel® Melamine Process.

Technologies - Carbon Black

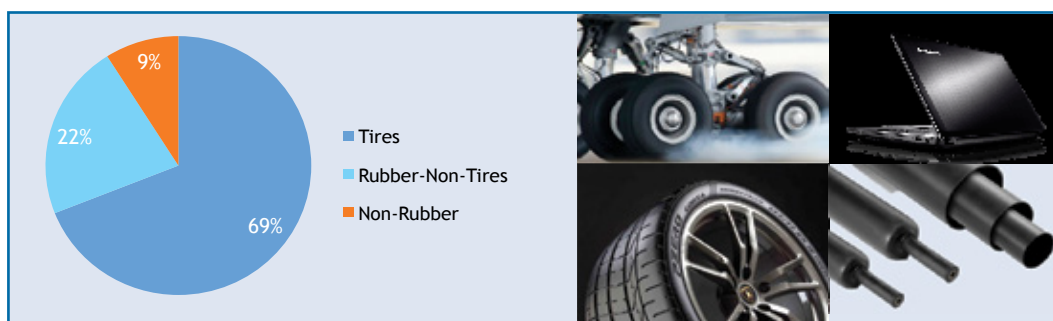
Carbon black is a 12 million ton/year market, it's expanding and covers a wide spectrum of growing applications.

Carbon black is primarily used in the manufacturing of rubber-based goods, such as tires, where it plays a vital role in increasing tire's tread wear and rolling resistance. Regardless how the new vehicles are powered, either by engines or electric motors, they will always need tires.

Carbon black is a 12 million ton/year market, it's expanding and covers a wide spectrum of growing applications.

Tires are by far the largest single market for carbon black, consuming 69% of total demand, which is growing around 3.8% per year. About 70%-75% of the carbon black used in tire manufacturing consists of tread (or reinforcing) grades, while the remaining 25%-30% consists of carcass (or semireinforcing) grades. World demand for carbon black used in the production of non-tire rubber products is 22% and it is growing at 5.2% per year.

Major applications include automotive products as well as all general rubber components for industrial applications. Specific items include belts and hoses (such as conveyor belts, hydraulic hose, fuel hose, etc.) and mechanical and industrial rubber goods (seals, gaskets, membranes, wheels, etc.). In terms of grade



mix, the rubber non-tire segment uses 75% of soft grades and only 25% consisting of hard grades. Global demand for special blacks, which encompasses all carbon black used in non-rubber applications, totals about 9% of the carbon black industry's volumes but 20% of its value, because of much higher prices. The largest single market for carbon black outside the rubber industry is in plastics compounding, which accounts for 52% of volume demand of special blacks. Printing inks, paints and coatings together account for another 20% of specialty blacks demand. Carbon black feedstock oils, such as FCC Slurry Oil, Hydro-treated RFCC Slurry Oil, Ethylene Tar Oil, Heavy oil from Coal Tar Oil form the raw material for the production of carbon black. Their aromatic contents can easily be assessed from API gravity which is directly related to the yield.

Eurotecnica Furnace Black - ET Black™

The most important development in carbon black has been the introduction of furnace blacks which have replaced almost all other carbon blacks. Today the furnace black process accounts for more than 95% of carbon black production worldwide. ET Black™ Carbon Process is a high-yield furnace black process. The production of carbon black in the ET Black™ furnace black reactor is accomplished by the partial combustion and thermal decomposition of highly aromatic residual oils (such as FCC Slurry Oil, Hydro-treated RFCC Slurry Oil, Ethylene Tar Oil, Heavy oil from Coal Tar Oil) at high temperature, from 1400°C to 2000°C depending on the type of carbon black produced, whether *soft black* or *hard black* grades. across specific reaction times for each grade.

The feedstock can be burnt in the furnace with the amount of air enough to keep the flame alive so that it gives maximum soot and does not convert carbon atoms to carbon monoxide or dioxide.

Across the process, the feedstock oil molecules break apart releasing their carbon atoms. These atoms reform first into tiny particles of carbon and then into clusters called aggregates.

The size of the particles and the aggregates can be controlled by adjusting various reactor conditions, thus determining the grade of carbon black.

The reactor is actually the most important and critical item as it is the heart of the process, where the conversion oil feedstock is ultimately transformed in carbon black of defined characteristics.

An ET Black™ plant produces a certain amount of



QAFCO Melamine Plant – Mesaieed, Qatar - view of Euromel® Plant, the largest melamine plant in the Middle-East

energy surplus, which is conveniently recovered and converted in steam and/or electricity. A 50,000 ton/year ET Black™ carbon black plant is able to generate 10 MWe.

ET Black™ Carbon Plant at ADNOC Refinery U.A.E. Within the frame of U.A.E. Abu Dhabi strategy to reduce its reliance on the crude oil market by developing a number of downstream sectors, ADNOC Refinery decided to implement a carbon black delayed coker (CBDC) at the Ruwais Industrial Complex.

The purpose of this new plant was to produce higher value-added products, such carbon black, from the crude oil refining and heavy residual oil recycling.

Eurotecnica's ET Black™ Process was selected, with the aim to design a Carbon Black unit able to produce Hard Black grades, in particular the N115 semiconductive and N220 UV Grade.

Both high value-added grades are used for production of plastic pipes for water supply and wire/cable products. Both require very low grit residue and no-taste/no-smell feature.

The Carbon Black unit is also able to run on some desulphurized feedstocks (main and secondary) with particularly low BMCI, 91 and 95 respectively.

The feedstock in fact comes out of a Slurry Oil Hydro-Desulphurization Unit that treats the Resid Fluid Catalytic Cracker (RFCC). The ADNOC ET Black™ plant is capable of producing more than 40,000 ton/year of carbon black, making of them one of the largest carbon black producers in the Middle East.

Technologies - Oil & Gas

Oil & Gas, Refinery, Petrochemical are sectors where Eurotecnica has been active since the company's foundation.

Recently Eurotecnica's technologies have contributed



to the implementation of a GPU (gas processing unit) at DeNovo Energy Ltd. facility in Trinidad and Tobago. GPU is a complex industrial technique, used to separate components from raw natural gas for different downstream processes. The composition of the natural gas extracted from the wells depends on the type, depth, and location of the reservoir, and the geology of the area. As natural gas can be used as feedstock for different processes, including liquefaction or fuel, its treatment is required in order to remove impurities and water.

DeNovo Energy Ltd., a company incorporated in Trinidad and Tobago, was created with the vision of an independent upstream company for monetising stranded natural gas reserves for the benefit of the country.

Technologies - Thermal Energy Storage (TES)

The Concentrating Solar Power (CSP) plants are innovative utilities that produce electricity from green and renewable resources. CSPs make use of parabolic troughs, which concentrate the sunlight in tubular devices where a transfer fluid (thermal oil) is heated up to about 400° C. In a standard configuration, 100% of thermal oil flows into boilers where the steam is produced and used to drive the steam turbine, and finally operate the power block.

However, the electricity pays better in the evening, when it is in demand, rather than during the day. For this reason the Electric Companies seek ways to accumulate the solar energy, at least part of it, for later use, so to be able to improve the dispatchability of green electricity and increase the overall economics.

ET Sun Energy™



ET Sun Energy™ Thermal Energy Storage for Andasol III Solar Power Plant _ Spain

Thanks to the massive experience gained in the design and implementation of molten salts and thermal oils systems used in the chemical and petrochemical complexes, Eurotecnica has been involved in the development of Thermal Energy Storage (TES) systems, following the concept of transferring by means of a heat exchanger part of the heat of the thermal oil to the molten salts, that finally accumulate into large storage tanks.

At evening hours, the flow is reversed. The molten salts, passing through the heat exchanger, release the heat to the same thermal oil that flows into the steam boilers, so to keep the steam turbine and the power block at full capacity.

The extraordinary performance of Andasol-3 TES system, based on Eurotecnica's proprietary ET Sun Energy™ technology and recently implemented in the Spanish region of Andalusia, has set a new standard for safety, reliability and profitability within a promising industry.

M2E Projects 2019, the year of internationalizations

M2E Projects has just concluded 2 new branch openings: the first one, located in Azerbaijan, in order to cooperate in the Oil&Gas industry, and the second one in Germany born for Chemical and Pharmaceutical industries.

The above-mentioned investments reflect the management philosophy and approach always oriented to the innovation and diversification.

The first investment takes advantage of special cooperation between Italy and Azerbaijan, active since more than 20 years.

The Azerbaijan, The Land of Fire, has still several opportunities in the Oil&Gas industry both in Onshore and Offshore fields.

M2E is actually involved in the Project Management Consultancy (PMC) services for the Modernization and Reconstruction Project of Heydar Aliyev Oil Refinery located in Baku.

Furthermore, Azerbaijan has just started a tight reforms program in order to decrease the Oil&Gas dependence and, on the other hand, the national government has declared to develop sectors such as: power, infrastructure, transportation,

M2E Projects is expanding worldwide



M2E's HeadQuarter
Via Olmetto 10
20123 - Milan - Italy

M2E's German Branch
Amalienstraße 62
80799 - München - Deutschland

M2E's Azerbaijan Branch
Hasan Aliyev Str., Falez Plaza
AZ1078, Baku city,
Nasimi district 4/189 Azerbaijan

agribusiness and food transformation.

There are several possibilities to increase the business in strategic sectors related to the industrial plants engineering.

On the other side, the German branch, as said before, is essentially oriented to the pharmaceutical industry: the German market is basically the major in Europe and the third one in all over the world just after United States and Japan.

The market value is approximately 53 billion euros, 2019 value, and it was 38 in 2009: 4.9% annual growth.

In 2021 the overall market value should be 68 billion euros (forecast before COVID-19).

Therefore, taking in consideration the COVID-19 issue, there are significant global efforts underway to diagnose, treat and prevent infections from the virus. Pharmaceutical companies are working globally to combat COVID-19.

Pharmaceutical companies have deep scientific knowledge gained from decades of experience with similar viruses. Companies are researching vaccine candidates and undertaking inventories of research portfolio libraries to identify additional potential treatments for R&D.

Due to above, it reasonable to expect a remarkable increase of business in Pharma market, in Germany and generally worldwide.

Since 2019 M2E is involved in the industrial area of Ulm, inside the TEVA production complex Ulm lies in the federal German state of Baden-Württemberg.

The other important sector where M2E is involved is the Chemicals: is the largest chemicals industry in Europe and the fourth largest in the world.

At the moment M2E is involved in PISA Projects (new polyamide 12 production complex, to be built at the Marl Chemical Park, Marl, Germany) providing staffing services for Construction Management phase.

At last, in order to provide the recruitment and staffing services, M2E Projects in 2019 has achieved the AÜG license (Arbeitnehmerüberlassungsgesetz).

Both of our new branches could generate several opportunities such as:

- to develop new countries and markets;
- to acquire new clients;
- to develop agreement with local suppliers;
- to improve local recruitment according to the EPC contractual local content.

The technological heart of Ravenna's Green Port is “Made in Italy”

Italy's first liquefied natural gas (LNG) coastal deposit, built by Depositi Italiani GNL S.p.A. (a joint venture between Gruppo P.I.R. and EDISON), will become operational in 2021.

Located in the Port of Ravenna, in the Porto Corsini area, the deposit represents an outstanding opportunity for Italy, a new source of supply of LNG (Liquefied Natural Gas), essential to reach the greenhouse gas emission reduction targets, especially in the heavy-duty and maritime transport sectors.

The facility will have a capacity of 20,000 cubic meters of LNG and an annual handling capacity of more than 1 million cubic meters of LNG, which will be used as alternative sustainable fuel in the heavy-duty and maritime transport sectors: the facility's capacity will enable it to handle enough LNG to supply at least 12,000 trucks and approximately 50 ferries every year.

It is estimated that during the life cycle of this

project which is expected to start operating in the second half of 2021, it will prevent the production of 6 million tons of CO₂.

Because of its location, the deposit will have a tangible impact on ship bunkering activities in the entire Northern Adriatic area and will also be an excellent endorsement for extending the Green Port project to Ravenna's entire port area.

SIAD Macchine Impianti (SIAD MI) was chosen to design and install a SMART LNG system to re-liquefy evaporated gas (Boil-Off-Gas – BOG) from the tanks of the coastal deposit. Once reconverted into a liquid state through a nitrogen recycling refrigeration system, the retrieved gas will be re-introduced into the deposit's tanks, with zero emissions in the atmosphere, through a closed circuit that has no impact on the environment.

SIAD MI is also involved in the provision of cryogenic compressor packages - BOG



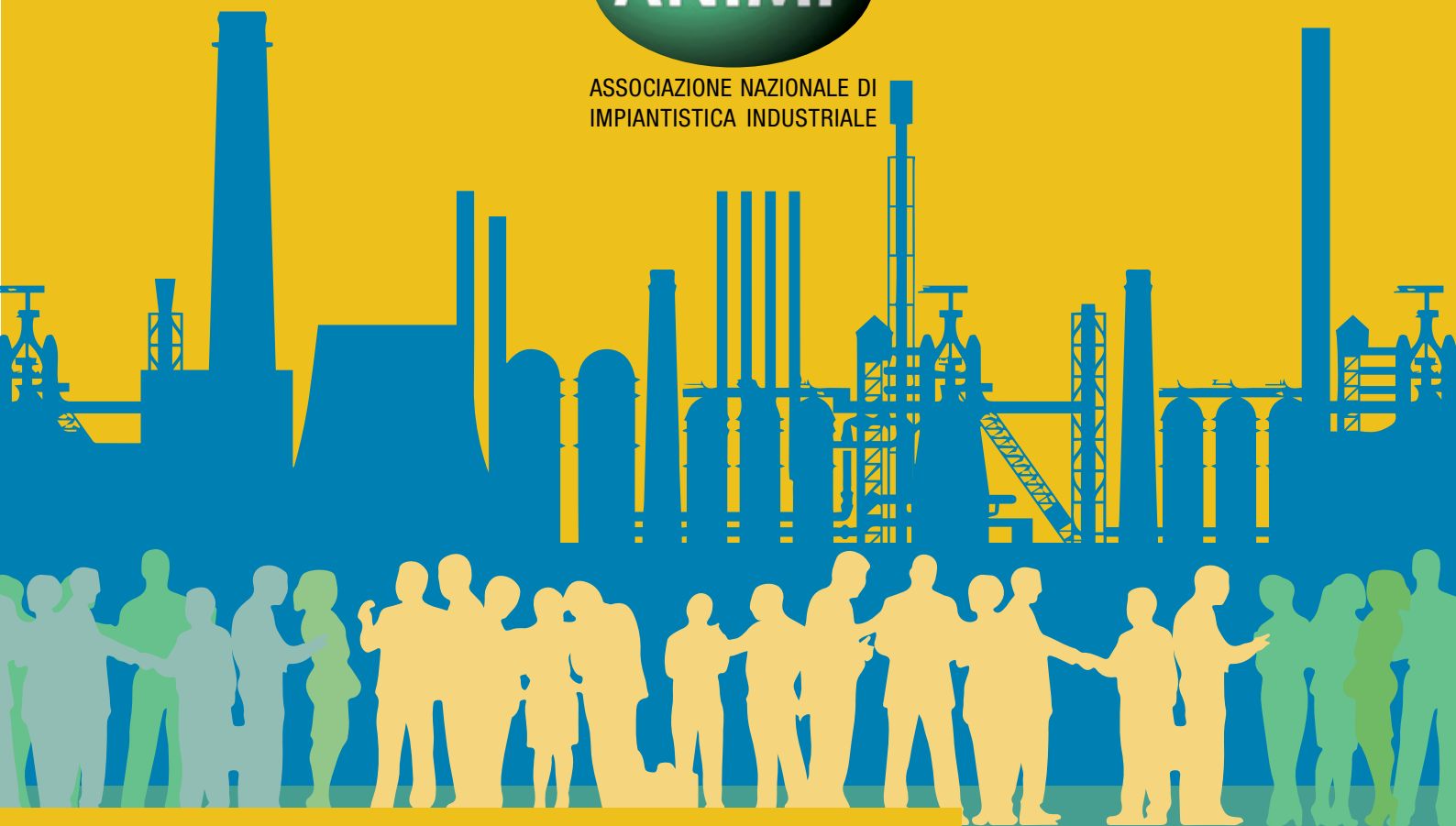


compressors - to be installed to manage the Boil-Off-Gas during the unloading stages of LNG cargo ships, when LNG is transferred from the ships' storage tanks to the deposit's tanks. SIAD MI was not just selected by chance to supply this type of system : the Bergamo-based company boasts extensive and consolidated experience in the LNG systems sector, thanks to the significant expertise acquired as a result of being part of the SIAD Group (formed by companies which operate in the Industrial Gas, Engineering, Healthcare, LPG and Natural Gas sectors). This factor, combined with a substantial engineering knowledge in component selection,

ensures that the systems built by SIAD MI are the epitome of reliability and efficiency, which is why the company has been assigned important projects in Europe and throughout the world. In Italy, as in the rest of Europe, the market for LNG as an alternative fuel is still relatively new but since 2014 it has been developing quickly, especially in the heavy-duty road and maritime transport sectors: the construction of infrastructures of this capability will undoubtedly help the rapid expansion of this type of fuel in Italy, significantly contributing to building an eco-sustainable future both on land and at sea.



ASSOCIAZIONE NAZIONALE DI
IMPIANTISTICA INDUSTRIALE



Chi è ANIMP, che cosa fa e chi sono i suoi Associati

L'Associazione è luogo d'incontro tra aziende del mondo dell'impiantistica e università e costituisce il punto di riferimento per la filiera.

Da oltre 40 anni ANIMP fa della passione per la ricerca e il progresso nell'ambito dell'ingegneria industriale, il motore di crescita del settore organizzando eventi sempre su temi attuali che riguardano tutta la filiera

Tra gli associati figurano Società di Engineering&Contracting, PMI fornitrici di materiali e servizi, installazioni e montaggi, end-user, docenti universitari, professionisti e studiosi, tutti accomunati dal mestiere di progettare e costruire sistemi industriali, grandi opere e infrastrutture.

Mission di ANIMP è quella di costruire una rete capace di connettere persone, competenze, realtà imprenditoriali e di studio nel campo dell'ingegneria industriale per elaborare una visione strategica di sviluppo del settore.

Il sito dell'Associazione è aggiornato quotidianamente www.animp.it

Associarsi è facile:

Compilare la scheda di iscrizione pubblicata al link:
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€ 100,00	Socio Individuale (escluso Società)
€ 900,00	Socio Collettivo fino a 50 dipendenti
€ 1100,00	Socio Collettivo da 51 a 200 dipendenti
€ 1400,00	Socio Collettivo da 201 a 400 dipendenti
€ 2000,00	Socio Collettivo oltre i 400 dipendenti
€ 4000,00	Socio General Contractor fino a 400 dipendenti
€ 8000,00	Socio General Contractor oltre a 400 dipendenti
€ 4000,00	Socio Sostenitore

Il versamento della quota dovrà essere effettuato a mezzo bonifico bancario:

- intestazione ANIMP ASSOCIAZIONE
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Cortesemente indicare la tipologia di Socio nella causale (Socio Individuale, Socio Collettivo, Socio General Contractor Socio Sostenitore)

Le Società Associate potranno indicare, per una o più Sezioni, nominativi di collaboratori in qualità di Aderenti che potranno candidarsi e votare per l'elezione del Comitato Direttivo della Sezione di appartenenza.

Tutti gli iscritti riceveranno la rivista "Impiantistica Italiana".

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The first step to fight competition in the chemical industry is digitising your capital projects and manufacturing plant. An effective digital transformation strategy allows you to establish a circular economy, introduce new raw materials, promote energy recovery, capture data to lower costs, and reduce downtime, increasing collaboration for better productivity. The strategy must include people, processes, and technology to deliver improved performance, agility, and reliability.



Maximise the Asset



Digitise the Plant



Optimise the Process



Improve Supply Chain Agility



Enable the People



Drive More Efficient Capital Projects

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