

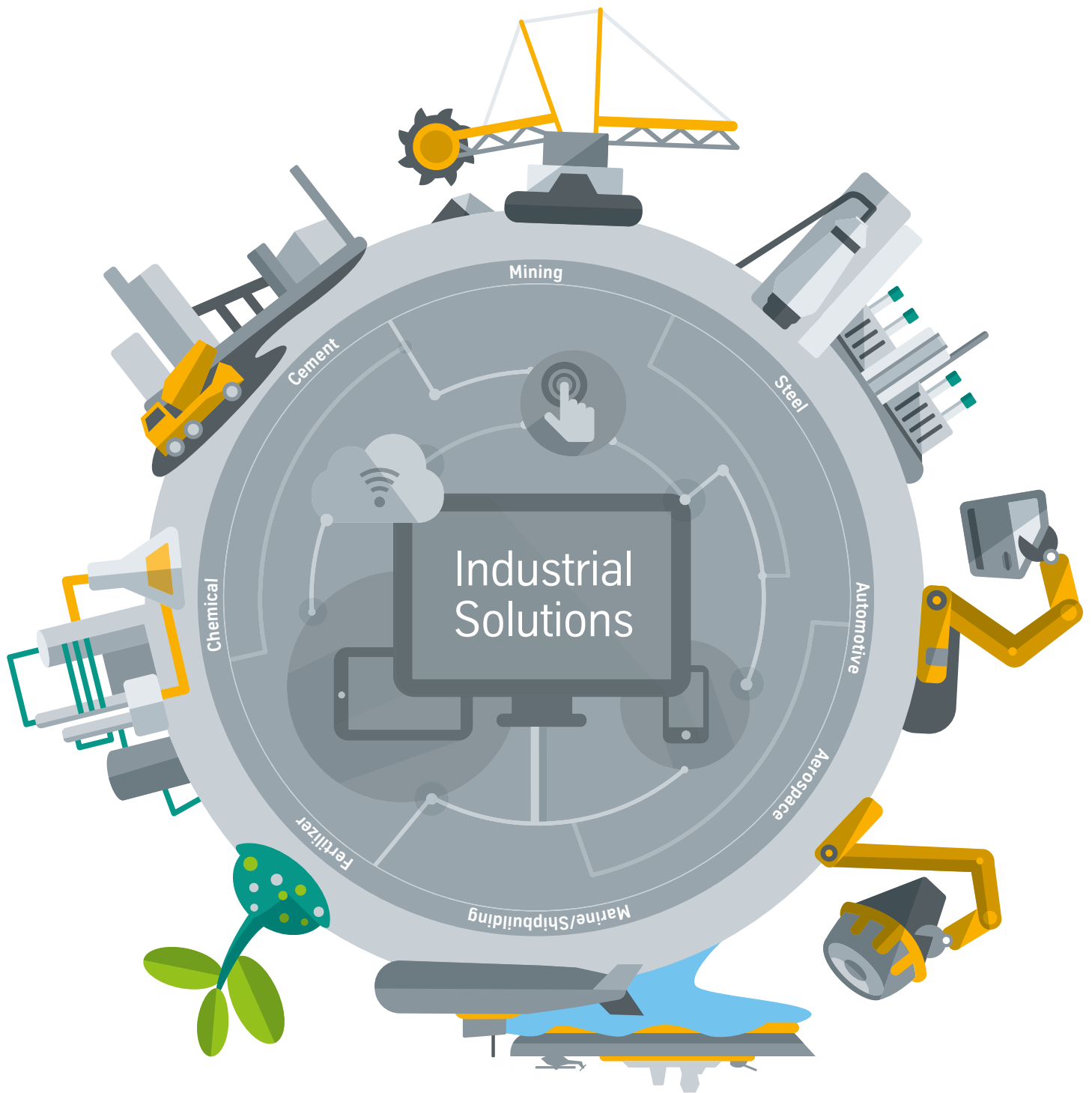
Industrial Solutions

Insights 2016



thyssenkrupp





The Power of True Efficiency

The Business Area Industrial Solutions of thyssenkrupp is a world leader for planning, construction, and service in the field of industrial plants and systems. Together with our customers, we develop solutions at the highest level and deliver efficiency, reliability, and sustainability throughout the entire life cycle. Our global network, with around 19,000 employees at 70 locations, enables us to provide turnkey solutions worldwide which set new benchmarks with their high productivity and, in particular, resource-conserving technologies.

We are at home in many different industries. Along with chemical, fertilizer, coking, refinery, cement, and other industrial plants, our portfolio also includes equipment for open-pit mining, ore processing, and transshipment, as well as associated services. In the naval sector, we are a leading global system supplier for submarines and surface vessels. As an important system partner to our customers in the automotive, aerospace, and battery industries, we optimize the value chain and improve performance.

Insights 2016

Dear Reader,

"We bank on openness, reliability, and transparency to achieve the optimum results together with the customer," says Jens Michael Wegmann, CEO of the Business Area Industrial Solutions of thyssenkrupp, in the interview on page 4 of the new Industrial Solutions magazine Insights. What that means is that whether you need individual products or entire installations, surface vessels or submarines, Industrial Solutions can claim to offer you significant added value with innovative solutions and comprehensive service.

And the same applies to our new magazine, which you are now holding in your hands. With Insights you get interesting and exciting insights into various areas of Industrial Solutions. For example, we take you along to our German research and development team, take a look at over 160 years of successful partnership with Egypt, report on the importance of safety in the workplace, and show you why service is close to our hearts as a global issue.

We hope you enjoy reading about it.

thyssenkrupp Industrial Solutions

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In Discussion with Jens Michael Wegmann

Jens Michael Wegmann, Chief Executive Officer of Industrial Solutions, talks in interview about the realignment of the Business Area, the trends in plant engineering, and the current market situation.

Mr. Wegmann, you have been responsible for Industrial Solutions since the beginning of 2015. What are the distinguishing features of this Business Area?

The Industrial Solutions Business Area has only existed in this form for a little over two years, although we can look back on more than 200 years of engineering excellence. Today, we are a globally integrated engineering network and, together with our customers, we develop solutions which make us a leading partner for planning, construction, and service in all matters relating to industrial installations and systems.

In addition to the major plant construction business, our Business Area is also involved in naval shipbuilding and is a systems partner for all the key components of the body shop and drivetrain process chains in the automotive industry.

Innovative technologies and a high level of engineering competence form the basis of our business. From this and in close cooperation with our customers, our dynamic team develops tailored solutions that cover the entire life cycle of an installation, ship, or submarine.

Plant engineers worldwide are complaining of an increasingly difficult market environment. What is your assessment of the situation?

Growth has slackened temporarily in some of our markets. We have done well so far in this difficult market environment. We continue to see attractive growth opportunities in various business areas, including fertilizers, electrolysis, and cement.

“The customer is the focal point of our activities.”

Jens Michael Wegmann, CEO
thyssenkrupp Industrial Solutions



We also see opportunities for growth in the expansion of the service business. The idea is that together with customers we develop and install the equipment, and remain in contact with them throughout the entire life of the equipment. At the same time we are developing new business models, such as the individual machine business in the cement sector or the standard machine business in the mining sector. So that we can firmly establish ourselves in the growing renewable-energies and electromobility markets, we are investing in research into and development of innovative storage solutions.

Naval shipbuilding and the automotive industry are also important sectors for Industrial Solutions. What does the market look like in those areas?

The key challenges facing naval shipbuilding are to be found in a further intensification of the competition. In the case of submarines the market is concentrated on a few major projects running into the billions, which are increasingly awarded on the basis of political decisions and which are being postponed in some cases as a result of current tight budgets. As a market leader in this segment, however, we still anticipate some very good market opportunities. In the surface-vessel area we definitely intend to win the MKS 180 project, put out to tender by the German Navy in the context of a European competition, and so create a lasting basis for further export successes.

The automotive market is developing positively in a strong competitive environment. We are experiencing a stabilization of growth in the European market and we see

additional potential in Asia and North America. This now puts us in a position to expand our business with globally active customers, and it also helps us to continue developing our cooperation with local OEMs. Both these factors bolster our growth strategy.

Of what significance is digitization for plant engineering?

The issue of digitization is of immense significance for many industries, and yet everyone understands something different by the term. We focus on the explicit benefit for our customers. For that reason, we will concentrate more on the digitization of processes. In the context of our Advanced Automation initiative, we will not only improve our internal production processes; we also optimize the processes between manufacturer, supplier, and customer by means of digital networking. This will make new services possible, such as predictive maintenance, for example.

On that subject, an exciting project in the field of big data analytics: In the mining sector in Australia, the operating data of a crusher were collected over a year. We investigated over 600 million data points for anomalies and identified some relevant parameters that will help to enable predictive maintenance in future. This will reduce downtime for customers and enable the development of new service solutions.

What happens next?

We will continue integrating our offerings and services and expanding our presence in the regions. We also intend to enhance our level of value creation, for example in the fields of automation, the Internet of things, and big data analytics, and implement our interpretation of industry 4.0 as part of the mentioned digitalization. Our enhanced regional presence will enable us to exploit existing synergies even better. We will be banking on openness, reliability, and transparency to achieve the optimum results together with our customers.



Over 17,600

machines and systems in use worldwide

Almost
300

submarines and naval vessels
since 1960

25%

energy savings with
innovative chlorine
production

Almost 70%
of our employees are
engineers and technicians

€6,256
million turnover

Over
2,500
chemical installations
constructed worldwide

Food preservation at

6,000 bar

70

plants in
six regions

19,388

employees
worldwide

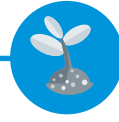
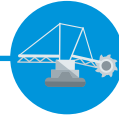
A presence in Egypt for over

160 years

More than

200

years of engineering excellence



Egypt: Our Living Room



1907

One cement plant

1958

Four nitric-acid plants

The first plant was built in Upper Egypt in 1958. The plant is still in use almost 60 years later – inquiries have already been made about the construction of another plant.

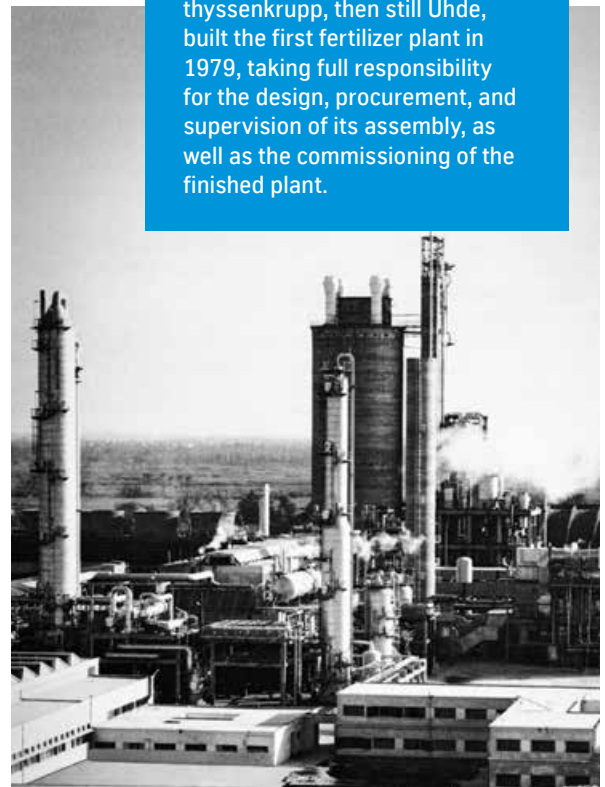
1979

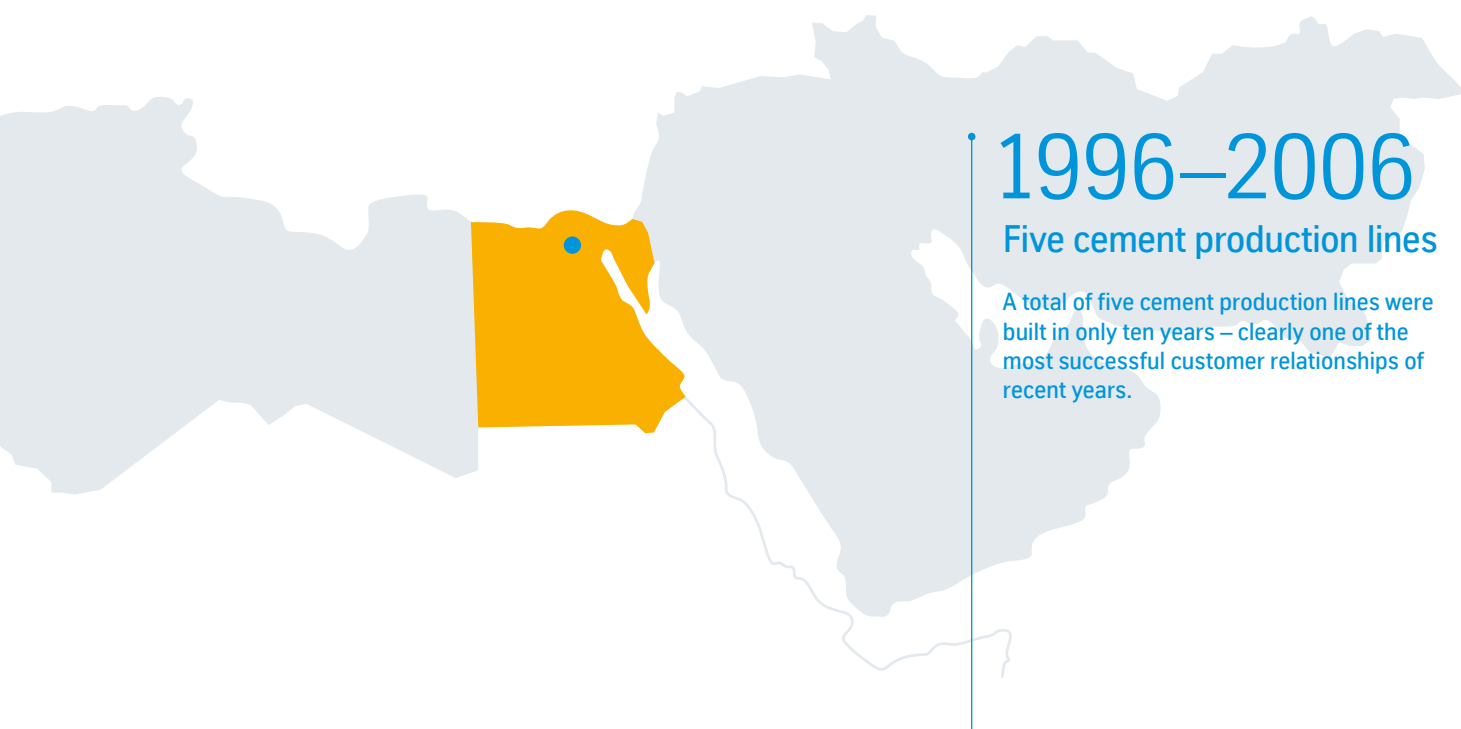
One ammonia and urea plant

thyssenkrupp, then still Uhde, built the first fertilizer plant in 1979, taking full responsibility for the design, procurement, and supervision of its assembly, as well as the commissioning of the finished plant.

It could be said that Egypt is Industrial Solutions' living room. We're at home here. Because the bond between Egypt and thyssenkrupp is based on a particularly successful and lengthy partnership lasting more than 160 years and offering enormous potential for the future.

The success story of thyssenkrupp in Egypt begins as long ago as 1854: at that time Krupp supplied a cast-iron propeller for the yacht of King Said Pascha. 1875 saw the opening of Krupp's first office in Cairo. With the construction of the first nitric-acid plant in Upper Egypt in 1958, thyssenkrupp also made a name for itself in the field of plant engineering – an initial project soon to be followed by many others.





1996–2006

Five cement production lines

A total of five cement production lines were built in only ten years – clearly one of the most successful customer relationships of recent years.

1981/96

Two cement plants

1981/84/96

Three ammonia and urea plants for the same customer in Alexandria

1992/98

One ammonia plant, two urea plants, one nitric-acid plant in Abu Qir

1996

One chlorine/caustic-soda plant

1997/2014

Two chlorine plants

1999

One oxichlorination unit

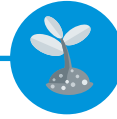
Thore Lohmann in conversation, talking about the opportunities and challenges in Egypt.



As the Country CEO, Thore Lohmann is responsible for the Industrial Solutions business in Egypt. There he heads the local organization in Cairo, with around 200 employees. For Thore Lohmann, the region offers enormous opportunities, but also challenges to be overcome.

Mr. Lohmann, you have been working for thyssenkrupp in and for Egypt since 2005. Do you see special potential in the region for thyssenkrupp products?

I certainly do, and not just for Industrial Solutions! In spite of all the political difficulties, German exports to Egypt increased by 25% last year. Germany and German products enjoy a high level of respect in Egypt. Egypt is a traditionally important country for Industrial Solutions. We built 15 of the 16 nitrogen-fertilizer plants here and we also have a market share of around 30% in the cement sector. However, we cannot rest on our laurels and we must open up new product markets, in particular in petrochemicals. We have a lot to offer in this sector.



You talk about the political difficulties. Where do you still see special challenges in Egypt?

The political changes in 2011 left deep scars in Egypt, but also in some other countries of the MENA region. The region is now also affected by the crash of the oil prices in the last year and the flagging dynamics of the global economy. When I look around the region from inside Egypt, it seems like a haven of stability. That probably sounds strange from the German perspective, but it is a view that is certainly shared in the region.

In your view, what are the obstacles to the economic success of the country and what are the growth drivers?

One of the obstacles at the moment relates to the problems with the Egyptian currency. The Egyptian pound is under great pressure and the Central Bank has imposed various foreign-exchange restrictions, which are also impeding investment in the country. But Egypt, with its 90 million inhabitants, is the biggest domestic market in the MENA region and still heavily dependent on imports. The Egyptian government wants to reduce this dependence on imports and is counting on industrial

growth. Egypt has relatively extensive natural-gas reserves and a strategically good location with access to the Red Sea and the Mediterranean. These factors make Egypt an attractive market for us.

“We built 15 of the 16 nitrogen fertilizer plants in Egypt.”

2000/06

Two ammonia and urea plants

2006

One ammonia and urea plant

2007

Two fine-grinding plants/cement mills

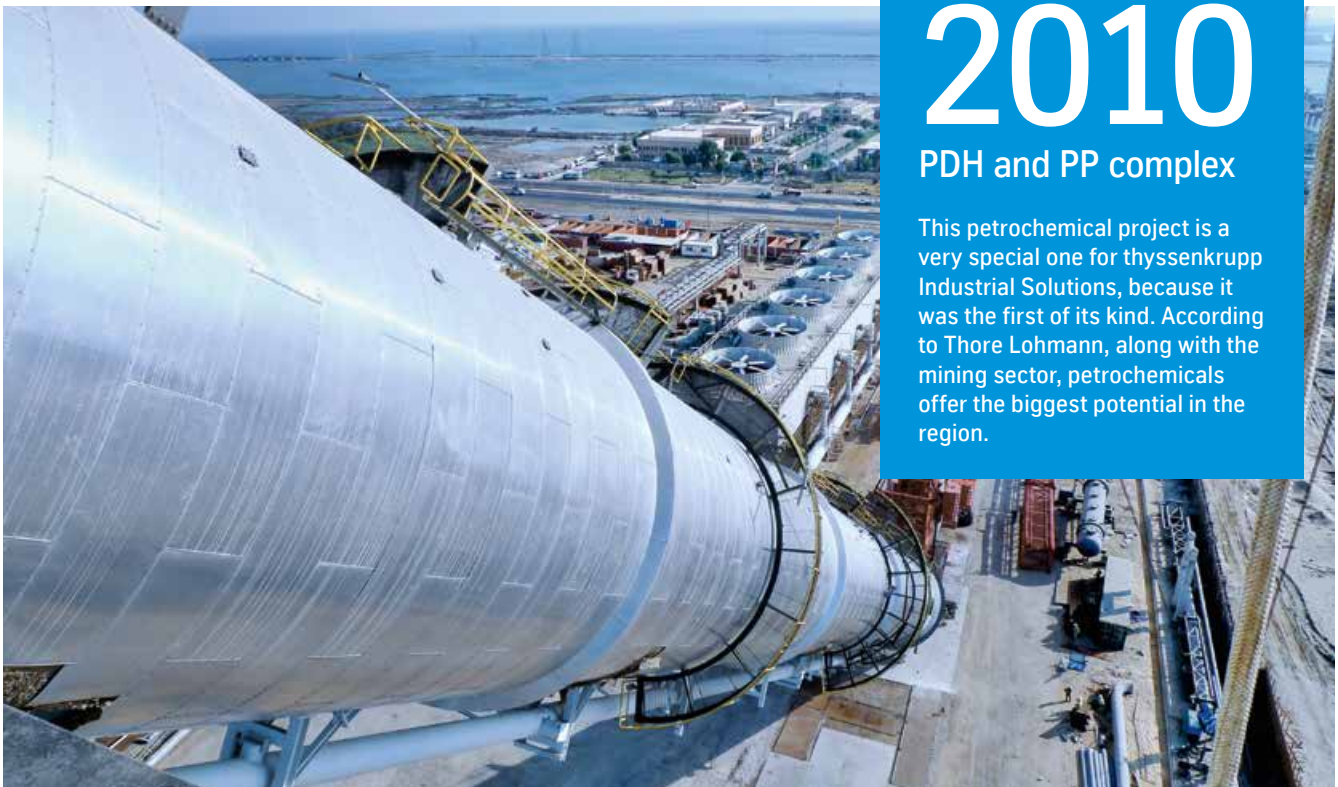
2008

One ammonia and urea plant

2010

PDH and PP complex

This petrochemical project is a very special one for thyssenkrupp Industrial Solutions, because it was the first of its kind. According to Thore Lohmann, along with the mining sector, petrochemicals offer the biggest potential in the region.





2016

Two ammonia and urea plants in Damietta

This fertilizer complex is the biggest that Industrial Solutions has built so far in Egypt. The plants will be commissioned this year.

2013

One ammonium-sulfate plant

2014

One low-density ammonium-nitrate (LDAN) plant

Modernization of a chlorine/caustic-soda plant

2015

CO₂-removal plant

One current project involves the construction of a CO₂-removal plant using a basic engineering solution from a licensor – the first EPC project of the local organization, and at the same time the personal favorite project of Thore Lohmann.

Alexandria. This is the local organization's first EPC project. We managed to beat Italian competitors with our bid. Now, we are working on the implementation of the project and we are in the process of putting together a dynamic organization from the well-established departments of the company, to complete the EPC order.

And are there any special events that link you very personally to Egypt?

Yes, two events in particular: firstly, I met my wife in Cairo in 2006, and secondly our second daughter was born in Cairo.

If you risk taking a look into the future, what are the long-term objectives of thyssenkrupp Industrial Solutions in Egypt?

The aim is to continue strengthening our local organization and to find our way back to our old dominance in our overall business with new products. We made great progress in establishing our local organization in recent years. We currently have an order book that is fuller than ever before. Now the task is to complete the orders successfully too.

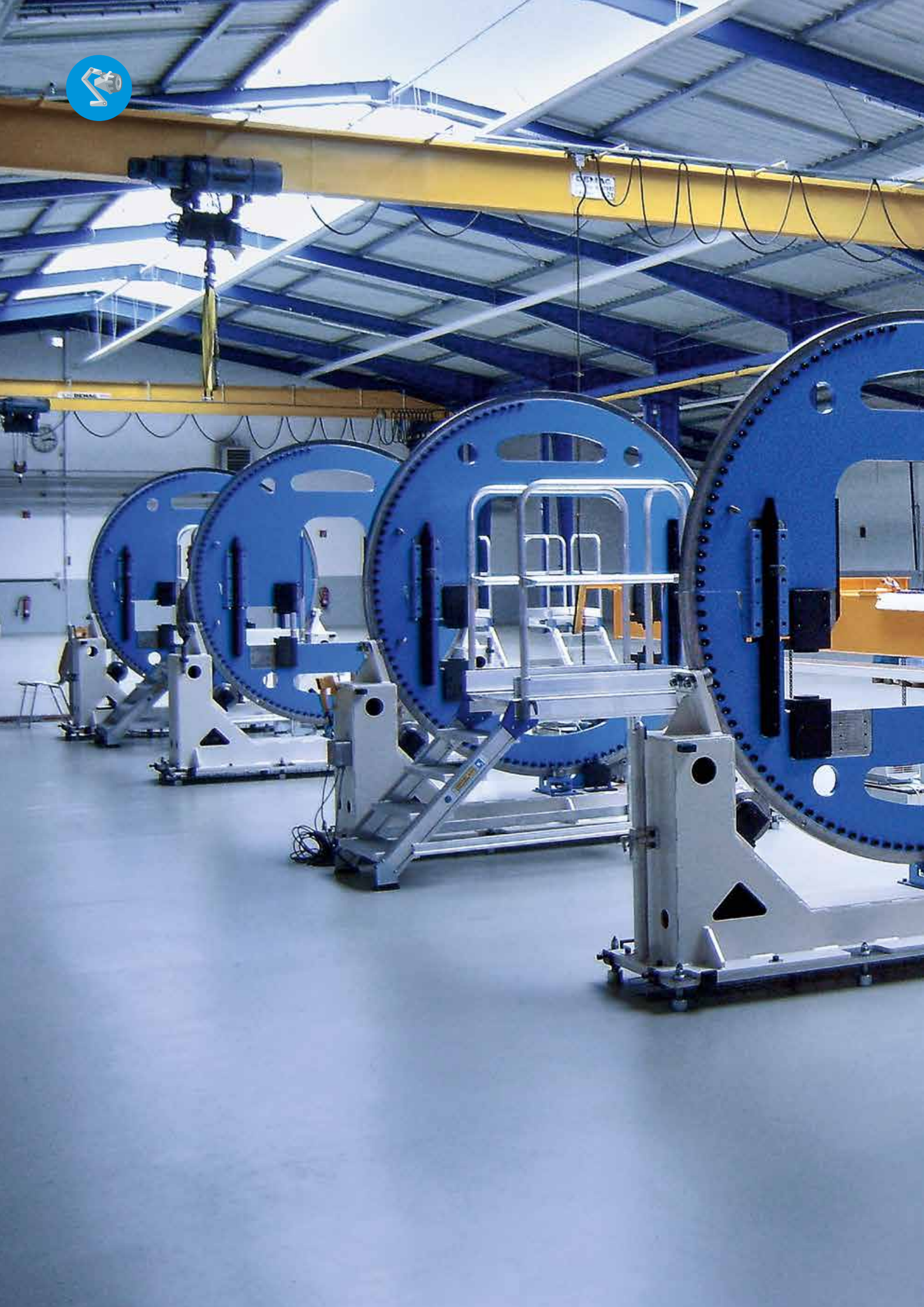
Another outstanding issue is to establish our local service competence. We have an awful lot of catching up to do in that area – and not just in Egypt.

You have been out and about in Egypt for a long time now. Do you have a personal favorite project?

My personal favorite is a current project. We are building a CO₂-removal plant using a basic engineering solution under license for the state-owned CO₂ specialist in

Thank you Mr. Lohmann.







Aircraft-Component Handling in the Production Process

The fully automated turntable takes the preformed, carbon-fiber-reinforced aircraft components (wing spars) of the new Russian Irkut MS-21 passenger plane from an 18-meter-long steel mold and places them in an equally long mold for curing in an autoclave. The component is then consolidated and cured under pressure and heat in the autoclave, i.e. it gets its final shape and strength.



Excellent Business Facilitator

When Arno Höfner describes his work with long-standing customer Volvo Cars, he almost goes into raptures. As a Business Development Manager at thyssenkrupp System Engineering, he has been looking after the customer Volvo for three years and he is closely linked with them through numerous projects.

For half of his working hours, Arno Höfner is to be found at the plants in Lockweiler, Heilbronn, and Bremen. The rest of the time he is away in Sweden and China – always really close to the customer. In 2015, Volvo Cars awarded thyssenkrupp the title of VQE supplier once again: VQE stands for Volvo Cars Quality

Excellence – great recognition of successful project work for an entire team.

Mr. Höfner, System Engineering has been supplying Volvo for over ten years. Which definite projects are currently on the order books?

We are currently supplying Volvo with the production lines for the bodyshell, in conjunction with the weld technology for new generations of vehicles. Some of the projects are at the final acceptance stage; some new projects are in the design phase. In the engine-assembly section, the assembly lines for modern four-cylinder engines came from our company in the last ten years. We have been supplying weld technology to Sweden since 2003, and more recently also to China. We are a Preferred Supplier for doors and closures. At the end of 2015, we were also commissioned as a supplier of press tools for the first time, with a project running into the tens of millions.



“We develop solutions for our customer Volvo in Sweden and China.”

Gothenburg: Headquarters of the Volvo Car Corporation.

Olofström: Volvo production plant.

Bremen: The plant's portfolio in the automotive sector includes powertrain production lines, testing systems, and electric motor assembly.

Heilbronn: 710 employees work here at the System Engineering plant.

Lockweiler: This is where Arno Höfner has his desk. The focus of the plant includes the body shop.

With confirmation of its Volvo Cars Quality Excellence status (VQE), thyssenkrupp established its position as a selected partner at Volvo Cars once again in 2015, following on from 2012 and 2014. What does this award mean?

The confirmation of VQE status is an acknowledgment of our work: we delivered above-average performance in order to achieve the project targets – both in terms of quality and in adherence to deadlines and cost targets. The tolerances are particularly close on the body parts which are visible to the end customer. The achievement of product quality is always to be seen as a process which requires continuous adjustment. We did in fact achieve the required quality very quickly in this case. That makes us one of the best suppliers in the eyes of our customer. In addition, however, this status also provides us with the opportunity to expand our collaboration with Volvo Cars. Some very recent new orders from Volvo China confirm the quality of our work.



Hangzhou: Headquarters of Chinese automotive group Geely, which took over Volvo Cars from Ford in 2010.

Shanghai: Production plant of Zhejiang Geely Holding Group Co., Ltd.



What is your impression of working with the customer Volvo cars?

Volvo Cars is a strongly technology-driven company, and that is also our major strength: we continuously extend our expertise and grow with product and customer requirements. For that reason, the customer relationship is in the nature of a partnership: the customer not only permits this, but actually requires it. In the last three years, we have strengthened this relationship and we are now for the first time partners for the entire process chain offered by thyssenkrupp.

What does partnership actually mean in this context?

Volvo is very open to innovation. We get the opportunity to develop along with the customer, and in that way grow to meet their requirements. And on top of that, the Swedish company Volvo Cars has a great family feel, which I experience when I am there in Gothenburg or Olofström. Volvo has set itself the target of being able to produce a new car from development through to start of production within 24 months by 2020. This sort of target is only possible with a reliable partner like thyssenkrupp.

What is your function in the projects that thyssenkrupp System Engineering implements for Volvo Cars?

As Business Development Managers, we are very close to our customers. Like my colleagues who are responsible for other customers, I first looked after Ford and now Volvo Cars. We are already involved in the customers' projects two or three years before they are market-ready. Following acquisition, I support a project over and beyond signing the contract, through to handover of the equipment. At the moment, I am increasingly focused on Volvo China, with regular visits there. Since 2010, Volvo has belonged to the Chinese company Geely Holding – that is my personal challenge: to use our successful collaboration with Volvo to establish ourselves as a supplier to Chinese vehicle manufacturer Geely. The collaboration with my Chinese colleagues is very important in this respect.

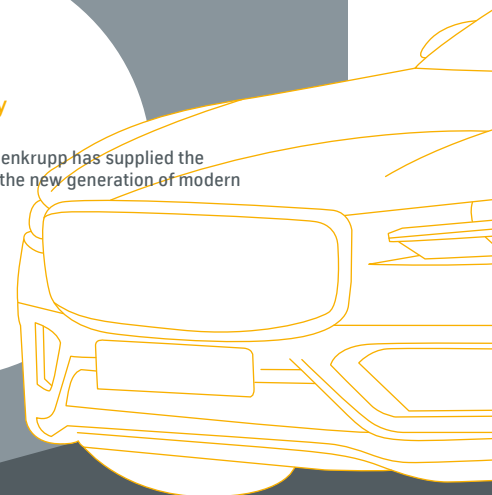
How did you get into Business Development?

My background is in mechanical engineering, and I started over 20 years ago in what was then Nothelfer Planung, in project-bid planning for the body shop. In 2002, I switched to sales. As the company grew increasingly larger and our product portfolio was considerably expanded, Business Development Management was introduced seven years ago. In this function, my customers include Volvo, Geely, and Ford.

For the first time, we implemented the entire process chain, simultaneous engineering – press tools – bodyshell lines – weld technology, for our customer Volvo.

Power-train assembly

In the last ten years, thyssenkrupp has supplied the engine assembly lines for the new generation of modern four-cylinder engines.



“Our strength lies in our expertise and the will to grow with product and market requirements.”

What does an award like the VQE mean for you personally?

With confirmation of VQE status, the performance of an entire team is acknowledged. But an award like this makes me feel proud, of course. We get an indication that we made the right decisions – we selected good employees, outstanding technical solutions, and the right subcontractors. Then we were in Gothenburg for the official award ceremony at the start of January. Håkan Samuelsson, CEO of Volvo Car Corporation, had a few personal words for invited partners. Of a total of 1,500 partners, around 80 were awarded VQE status along with us. It was a nice slap on the back.

One last question: what car do you drive?

I am delighted to say that I got the first Volvo XC60 as my company car in the spring. My own car is an open-top model, and unfortunately the Volvo fleet does not include one of those at the moment (he laughs).

Body in white and laser technology

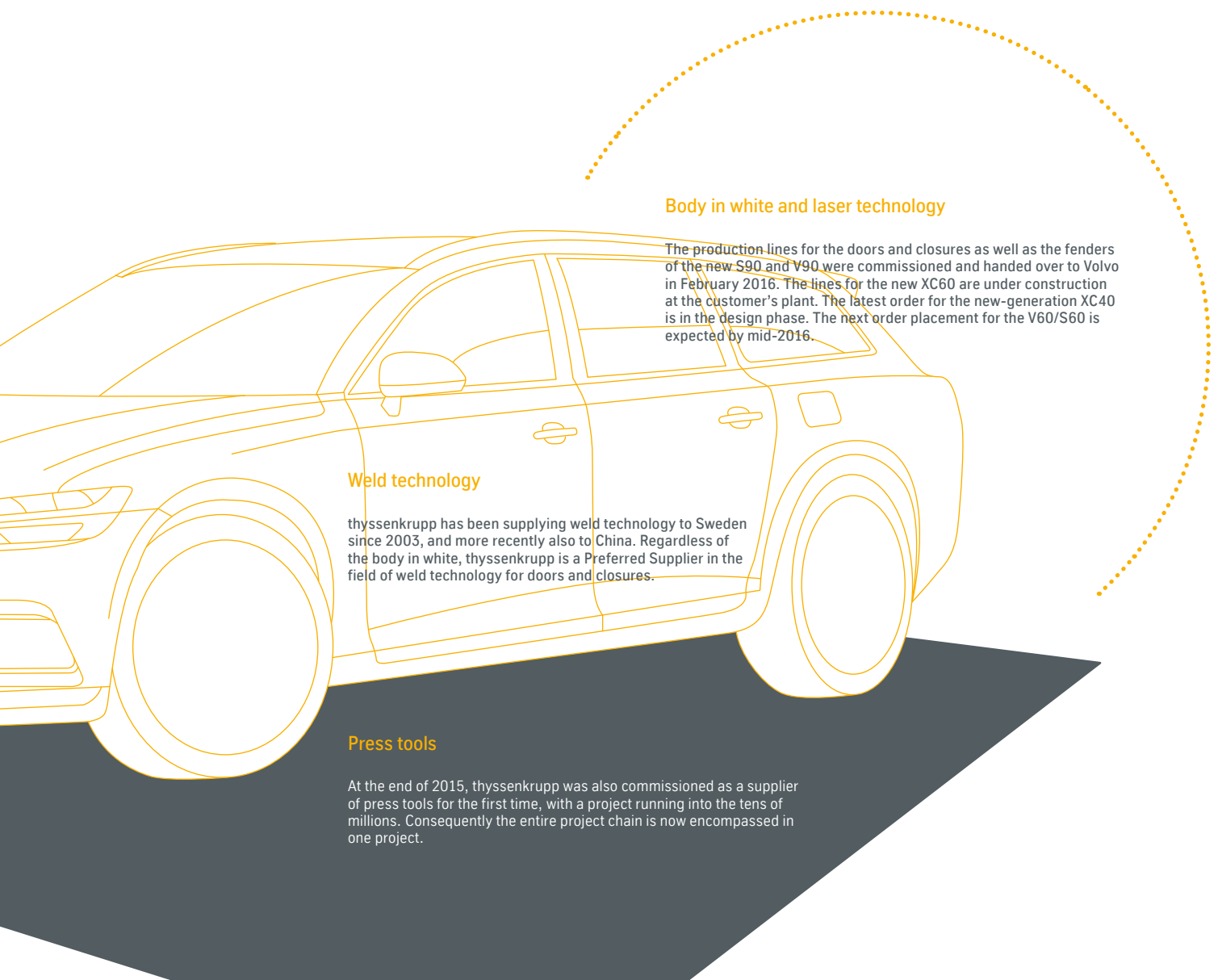
The production lines for the doors and closures as well as the fenders of the new S90 and V90 were commissioned and handed over to Volvo in February 2016. The lines for the new XC60 are under construction at the customer's plant. The latest order for the new-generation XC40 is in the design phase. The next order placement for the V60/S60 is expected by mid-2016.

Weld technology

thyssenkrupp has been supplying weld technology to Sweden since 2003, and more recently also to China. Regardless of the body in white, thyssenkrupp is a Preferred Supplier in the field of weld technology for doors and closures.

Press tools

At the end of 2015, thyssenkrupp was also commissioned as a supplier of press tools for the first time, with a project running into the tens of millions. Consequently the entire project chain is now encompassed in one project.



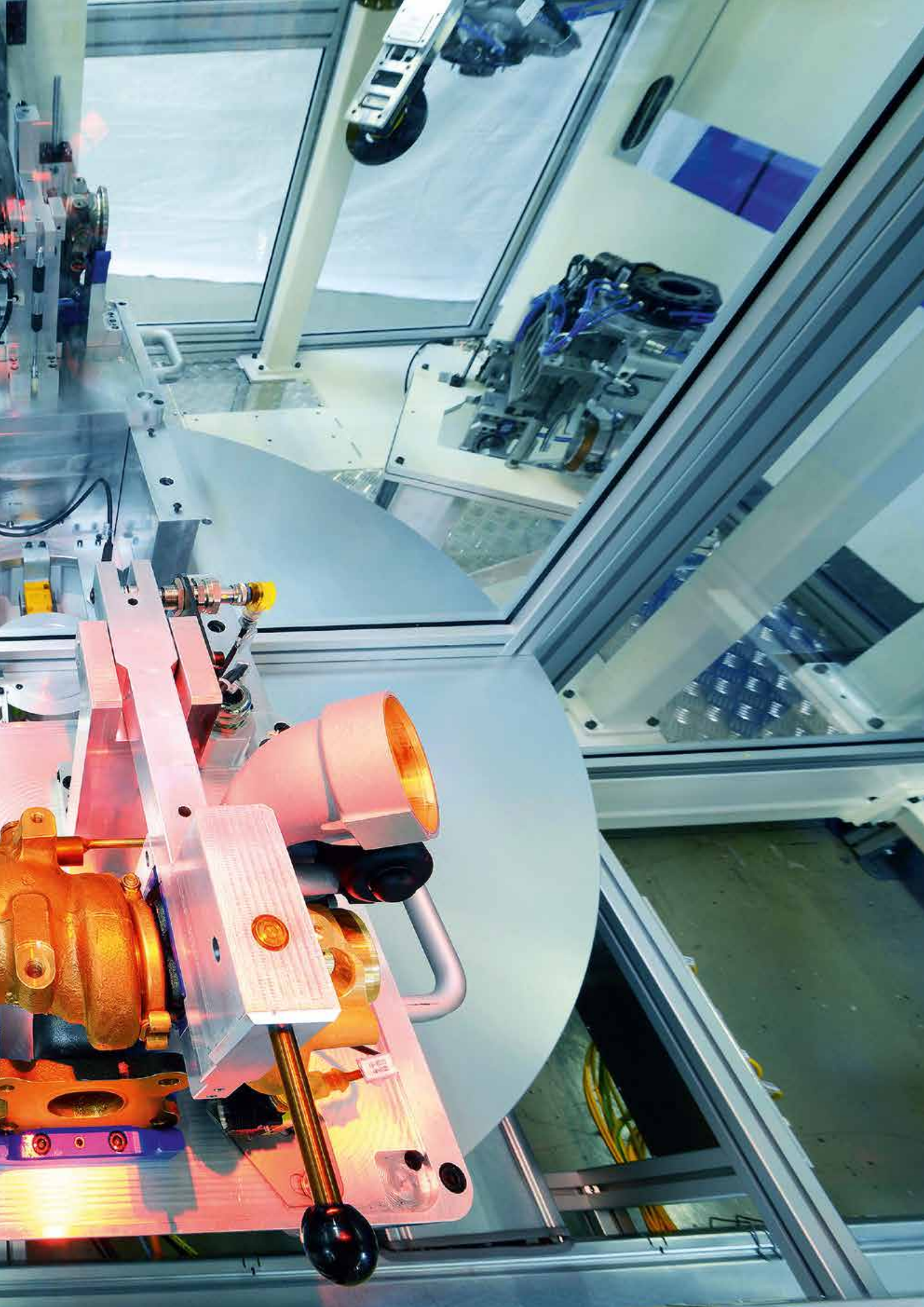


Fostering Automation to Improve Plant Performance

Digitization and advanced automation will significantly change the production processes in the future.

At Industrial Solutions, more than 950 employees work on the development of electrical systems, controls, and automation solutions.

Through continuous model-based analytics, thyssenkrupp will allow pre-warnings of abnormal machine or plant behavior, thus allowing plant operators to reduce downtime and reach new levels of plant performance.





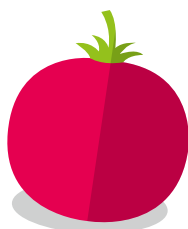
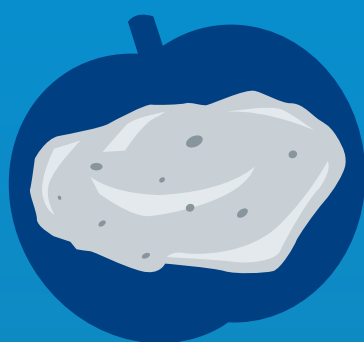
High-Pressure Preservation

Fast, safe, pure: the high-pressure preserving process from thyssenkrupp Industrial Solutions. A real innovation for the food industry, because many foodstuffs have their shelf life extended with the systems from thyssenkrupp – and entirely without chemicals.

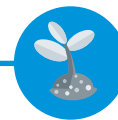


Fresh for Longer at 6,000 Bar

With the force of a column of water 60 kilometers high, the innovative high-pressure technology from thyssenkrupp extends the shelf life of food – entirely naturally, without any chemicals.



In this process, tomatoes, cherries, or strawberries are placed under such high pressure that bacteria and germs are destroyed. Because the pressure is even at all points, the food remains intact – which means that it looks just as delicious after the pressure treatment as before. And, of course, all the vitamins and nutrients are retained. Bon appétit with high-pressure technology from thyssenkrupp.



Satisfied Customers Come Back Again and Again



Industrial Solutions builds third fertilizer plant for Nitrogénművek in Hungary.

Last year, thyssenkrupp Industrial Solutions received the order to build a plant for Hungarian fertilizer manufacturer Nitrogénművek Zrt. for the production of 1,150 tons of nitric acid per day at the Pétfürdő site. This is already the third order within two years. Susanne Rieck, Senior Sales Manager, and Dr. Andreas Krake, Senior Project Manager, are significantly involved in this project. In her role as Sales Manager, Susanne Rieck has been in close contact with the customer for many years and has now also successfully acquired this project for thyssenkrupp.

As Project Manager, Andreas Krake heads the implementation of the project. In an interview, these two provided some interesting insights into the project.

Ms. Rieck, the project in Pétfürdő is the third follow-up order from Nitrogénművek and is therefore a good example of an effectively functioning customer relationship. How did it come about?

As part of a major capital investment scheme in 2007, a plant was built using our technology for the manufacture of liquid ammonium nitrate, an intermediate product in the manufacture of fertilizers.

The excellent performance of the plant and our team's collaborative approach impressed the customer. As we feature a wide range

of products in our portfolio, we were also able to support Nitrogénművek in subsequent years in the gradual expansion of production capacity, starting with another plant for the manufacture of liquid ammonium nitrate (2013), followed by a plant for the granulation of ammonium nitrate and calcium ammonium nitrate (2014), and the construction of a turnkey nitric-acid plant (2015). Acquiring this last contract is of particular significance for us, as we won through against some very fierce competition. It was not always easy, but we did it. In the course of all these projects we have established a very trusting relationship with the customer, which is the optimum precondition for successful cooperation.

Pétfürdő site

Nitrogénművek Zrt. is already operating two plants supplied by thyssenkrupp for the manufacture of ammonium nitrate at the Pétfürdő site. In the case of the new nitric-acid plant, thyssenkrupp is responsible for the turnkey delivery of the process plant, as well as for the construction, assembly, and commissioning.

“Mutual trust and reliability are key requirements for success.”



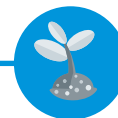
Susanne Rieck works as Senior Sales Manager at thyssenkrupp Industrial Solutions in the hydrogen and nitrates division and has been with thyssenkrupp for almost 15 years. She was involved in the Nitrogénművek projects on the sales side, from tendering through to the contract coming into effect.

The customer knows that they can rely on us and we are 100% there for them until the project is completed.

In the meantime, we signed another contract in the first quarter of this year with Nitrogénművek for the supply of engineering and equipment for an ammonium-nitrate plant. A project with some very challenging delivery deadlines, both on our part and that of the customer. The work is already well underway and we are certain that once again we will not disappoint the customer. It demonstrates that in addition to excellent technology, mutual trust and reliability are also key requirements for success. I was involved in these projects on the sales side from the start, right through to signing the contract – which was also a major success for me personally.

What goods and services is Industrial Solutions providing for this order?

We are building the nitric-acid plant as a turnkey solution, i.e. we are responsible for the design and the engineering of the plant, the supply of all the necessary machinery, equipment, pipes, measurement and control technology, and electrics, as well as for the construction and assembly of the plant in Pétfürdő, through to the successful test run.



Dr. Krake, you are responsible for the implementation of the project. The plant is due to start operating in the autumn of 2016. How is the project progressing at the moment?

We have already achieved a lot since the start of the project in January 2015 and we are still heading in the right direction.

For example, after the first twelve months of the project up to the turn of the year, we already completed the concrete work and the erection of a large part of the steel structure. Then we started the installation of process machinery and connecting pipes. This phase is reaching its peak now that the engineering and procurement team have managed to get the biggest items of equipment onto the site ahead of schedule. At the beginning of April, we accomplished one of the biggest road shipments in Hungary, including machinery up to six meters in diameter. Among other things, it involved briefly interrupting the rail connection between Budapest and Vienna.

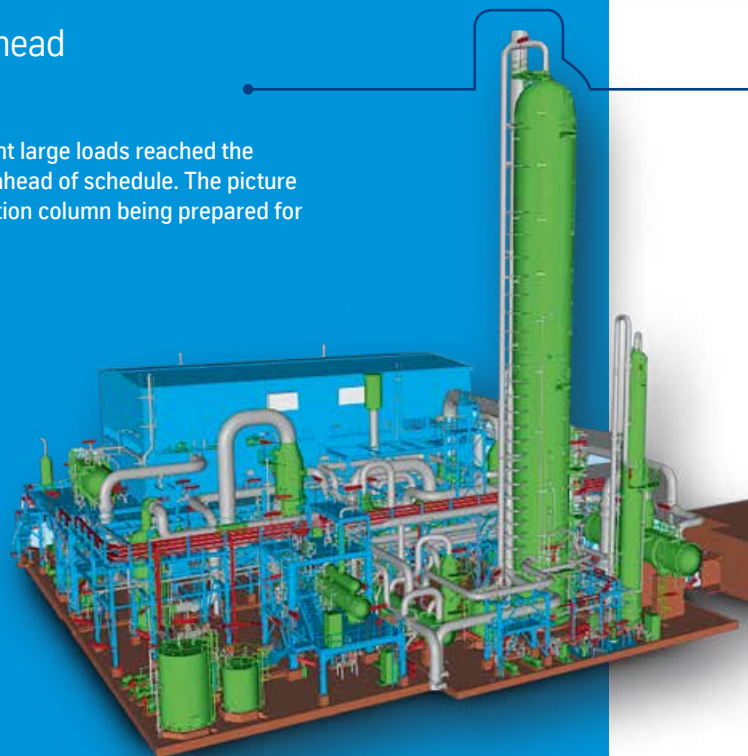
We can now therefore enable work on the building site across a broad front. While this work is continuing at full speed, we are now focused on the commissioning of the plant. The commissioning team is just being put together, procedures are being developed, and timetables are being refined. The customer is impressed by our rapid progress and is noticeably keen on keeping pace with its neighboring operations, which it is achieving very well. So, from the current perspective, everything indicates that we will commission the plant in the autumn of 2016 and hand it over to the customer before the end of the year – half a year before the contractual deadline.

What is particularly important to tackle a project like this successfully?

The successful implementation of a project is always a team effort. Thanks to our committed construction site team, we have already achieved many milestones on schedule. This would not have been possible without a speedy engineering phase with very sound results. The fast-track approach chosen in engineering, making use of intelligent assumptions, required a high degree of detailed knowledge, flexibility, responsibility, and interdisciplinary vision from everyone

Assembly ahead of schedule

All the heavyweight large loads reached the construction site ahead of schedule. The picture shows the absorption column being prepared for final assembly.



involved. Because we worked in a single task force, all pulling as a team in the same direction, the project got off to an extremely positive start. For example, we managed to reduce the planned weight of the steelwork by a third by means of optimizations, as a direct result of which the costs of concrete foundations and construction work were considerably reduced.

Thanks to intensive and open communication in every project phase, potential problems were detected early and effective countermeasures were taken. We are still actively pursuing this approach at the moment, by involving the commissioning team at an early stage. I am sure that the commitment shown to date will continue, and enable us to conclude the project successfully.



Dr. Andreas Krake has worked for thyssenkrupp since 2006 and last year he took over project implementation in Hungary as Project Manager EPC.





Fertilizer from the Coke Plant: Useful Exploitation of Industrial Emissions

Cleaning industrial emissions protects the environment, but it also creates costs. A newly developed technology from thyssenkrupp helps out. It uses process gases which are created in the production of coke and protects the environment by converting them into recyclable materials: from fertilizers and propellants for the chemical industry, through to baking powder. And the CO₂ emissions are reduced.

The world's first trial plant of this type was recently put into operation at the Schwelgern coke plant in Duisburg, Germany. The gas from the coke oven is washed in a complex process. Ammonium bicarbonate, also known as salt of hartshorn, is produced by adding carbon dioxide. The resulting end products can be used in a wide variety of ways: as nitrogen fertilizer, as propellants and foaming agents for plastics or porous ceramics and finally also in the food industry.

One positive side effect is the reduction in CO₂ emissions. With an annual production of 45,000 tons of ammonium carbonate, it would be possible to save around 25,000 tons of CO₂. If the project continues successfully it will mean a genuine breakthrough for coke-plant operators in terms of productivity and resource efficiency. This concept and type of plant could be used worldwide in future.







Ambassadors on the World's Oceans



The submarines and naval surface vessels from Marine Systems have been deployed worldwide for over 50 years – and the German Navy, our NATO partners, and other friendly naval forces value the effectiveness of our technologies.

thyssenkrupp Marine Systems has concluded almost 300 contracts for highly complex submarines and naval surface vessels since 1960, making it one of the world's leading naval system providers. 163 units sold also make thyssenkrupp the world market leader in the field of non-nuclear submarines – a genuine success story, which is only possible as a result of the satisfaction of our customers. Our collaboration with the German Navy, our “parent navy,” plays a particularly significant role in this respect. The German Navy has long backed the technological excellence, reliability and long service life of the boats and ships designed and built by thyssenkrupp, acting as an ambassador on the world's oceans to demonstrate their effectiveness.

Your requirements, our challenge

Today the boats and ships of the German Navy and of many partner countries have to be ready for action worldwide, which means they must have a long range. The requirements in terms of mobility, endurance, and mission flexibility have increased. This change in the deployment spectrum is reflected in the continuous advances and new developments in our product portfolio. These also include the Blohm+Voss Class 125 frigates. They were designed for long-term global assignments in coastal waters, to oversee and stabilize crisis regions.



23,000_{devices}
600 rooms

500

kilometers of cables
control the transfer of
data in the frigate

200

specialists construct the
Class 125 frigate

The latest generation of frigates from Marine Systems

With a length of 149 meters and measuring 19 meters in width, the Class 125 frigate is the largest surface vessel in the German Navy. Its equipment also makes it the most modern ship. It carries a regular crew of 120, two helicopters, and four speedboats. And not only the military equipment is ultra-modern: the Class 125 frigate is the first naval vessel to have a CODLAG propulsion system fitted. The combination of a diesel generator and a gas turbine means that it can reach a top speed of 26 knots – which is equivalent to 47 kilometers per hour. The Class 125 frigate is designed for intensive use and can be deployed for up to two years: the crew can be changed while the ship remains in the operational area.





Eco-Friendly Transport of Raw Materials

Carrying 700 tons per hour over 12 kilometers, straight through the middle of a forest. This is exactly the type of technological challenge that is solved by thyssenkrupp using belt conveyor systems. In this particular case with a single conveyor belt, through seven curves with a minimum radius of 1,000 meters and over seven bridge structures with a total length of over 1.7 kilometers – it has never been done before.

Practically nothing else apart from a conveyor belt makes it possible to achieve lower CO₂ emissions than a truck or a rail locomotive, while overcoming the local challenges such as those here in Estonia with the same levels of flexibility and cost-effectiveness. Covered with shiny silver-colored hoods – to minimize noise emissions – the belt snakes through the forest and past the nearby housing development.

Finding the best and most economical engineering solutions to meet the requirements of the mining and minerals industry – this is the challenge and pledge met by the portfolio of Industrial Solutions. It ranges from innovative machines through to turnkey solutions for the mining, processing, storage, and transportation of raw materials.



Exemplary Safety

“The health of our employees and safety in the workplace take top priority.”

The fact that Occupational Safety & Health is embedded in the mission statement of thyssenkrupp reflects not only the company’s corporate responsibility – its safety performance is also crucial for customers, from both sustainable and commercial perspectives.

Dag Peiffer is Head of Occupational Safety & Health (OSH) at thyssenkrupp Industrial Solutions, which means he bears a major responsibility – not only for the health and safety of our own employees, but also for employees of external companies who work on the building sites. And each accident is far more than a figure in the accident statistics: the fate of a human being lies behind each of those figures.

The fatal accidents cause particular distress. They are rare, but unfortunately they still happen – a warning sign reminding us that safety at work has to be the focus at all times. Since 2013, the OSH activities within the Business Area Industrial Solutions have been combined under the leadership of Dag Peiffer. Dag Peiffer and his team not only set the parameters in the area of OSH: in its governance function, the OSH team provides advice at all levels on the issue of safety in the workplace. One particular strategic objective is to effectively bolster the exemplary function of the managers. So one of the indicators of safety in a project is the extent to which managers are committed to safety: Do they look around on the building site? Do they report any faults and defects to the colleagues at OSH?

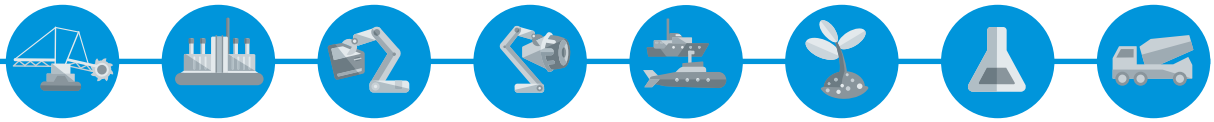
“We need more good examples, not more regulations.”

The second function illustrates the operational activity of OSH: “They are the colleagues who monitor safety compliance on site as project or site OSH managers,” says Dag Peiffer, describing the project function of the OSH.



Dag Peiffer
Head of Occupational Safety & Health

Dag Peiffer was born in 1965. He studied Mechanical Engineering, specializing in environmental technology. Right from the start of his career in the chemical industry, he was addressing the issue of occupational safety. In 2004, he moved to thyssenkrupp and was immediately tasked with running Occupational Safety & Health (OSH). Dag Peiffer has headed all the activities associated with the issue of OSH since 2013.



Discussion with colleagues worldwide, the involvement of the regions, and personal contact with the coordinators are all essential in this context. OSH is organized within a tight network for that reason. The OSH requirements vary from country to country, but also from industry to industry. "Safety at the workplace is relatively well harmonized around the world. The relevant legal provisions on the subject of occupational safety do not differ greatly. However, that only applies on paper," explains Dag Peiffer. So, on some building sites, OSH finds itself doing proper development work.

"There are some workers who come onto the site barefoot. Some of them have never owned any sturdy footwear. Many of the workers on the building site cannot read or write, so the safety rules are communicated in various ways, including in the form of pictures or in comic style," explains Dag Peiffer. The issue of OSH is subject to a uniform standard throughout the Group – irrespective of local legal provisions and regional conditions. This area of conflict between their own standards and local conditions is a challenge for the OSH team. For that reason, the theme of occupational safety plays a key role right from the bidding phase of a project.


"Occupational safety plays a key role in every phase of a project – starting from the bidding phase."

Last but not least, a safe building site is also commercially successful, because safety defects or accidents lead to lost production and timetable delays. "If safety provisions are not met, work is stopped, and if necessary a complete building site is closed down," says Dag Peiffer. The protection of life and the environment is also of utmost importance for every customer. In the spirit of sustainability, every company makes an effort to meet the requirements of everyone involved. Customers from the chemical industry in particular –

but also customers from other industries – are under the public gaze. With good safety performance, thyssenkrupp lays the foundation stone to ensure that the customer can also meet all the expectations in terms of sustainability that are placed upon them.

"If the safety provisions are not satisfied, work is stopped."

Along with the vision of zero accidents and a reduction in the incident rate, Dag Peiffer describes the impending tasks for OSH in concrete terms: "We have to get away from reactive consideration of the accident figures. Analysis is important, but we do above all have to think in preventative terms." Unfortunately, accidents can never be entirely avoided, primarily because a large number of accidents can be attributed to misconduct on the part of employees. For that reason information and education are the most important tools for OSH work. The focus is on the area of occupational safety, but it is also important to keep in mind the occupational health of the employees. For that reason, Dag Peiffer stresses: "We will in future consider the H (health) in OSH as a whole, so that we can also keep in mind the illness rates. Health is of the utmost importance."



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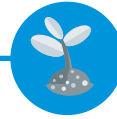
accidents – that is the
vision of thyssenkrupp.





Energy-Saving Chlorine Production

An ideal customer relationship: together with Covestro, both a customer and a development partner, thyssenkrupp has developed an innovative electrolytic process. Thanks to the oxygen-depolarized cathode (ODC), the production of generally undesirable hydrogen is prevented in the process. As a result, up to 25% of the energy can be saved in comparison to the conventional membrane process, and CO₂ emissions in production are also reduced. ODC technology has the potential to reduce CO₂ emissions by up to 20 million tons worldwide.



The Linchpin for New Developments in Plant Engineering

Falk Silbermann (left) and Karl Lampe (right) head the technology unit of the R&D Center.

Research is in their blood. When you talk to Dr. Karl Lampe and Dr. Falk Silbermann from the Research and Development Center in Ennigerloh, you quickly notice that you are in the presence of men with a passion for research.

The Research and Development Center, at the heart of the Münsterland region, has existed since 1968. In the meantime the Center, now part of Technology, Innovation & Sustainability, has grown to cover 50,000 square meters and house 100 employees, forming “the linchpin for research in plant engineering,” according to Falk Silbermann. It is true that Ennigerloh is not the only site where research is carried out, but it is the location of the biggest Technical Center of Industrial Solutions. There are currently over 20 projects underway here at the same time.

Karl Lampe has been working at thyssenkrupp Industrial Solutions since 1995 and was initially responsible for technical calculation in the R&D department. In 2009 he switched to the Technical Sales department of Mineral Processing. Falk Silbermann chose the opposite route. He joined thyssenkrupp in 2003 and started his career in sales, before taking the leap into R&D eleven years later – “a useful move,” as he says, because it gave him the opportunity to contribute his sales perspective in the field of R&D when developing marketable products and technologies with his colleagues.

But it is not only the marketability of products that plays a major role here. Feasibility is also a crucial factor. Various technical departments collaborate closely with R&D to examine these factors and to trigger new initiatives. The POLTORR project, an advanced multi-hearth furnace, which is used to produce biocoal from biomass, is a perfect example of this. Karl Lampe started the development of this product with an interdisciplinary team made up of employees from the technical departments and from the Research and Development Division.



The Technical Center in Ennigerloh, Germany, is always prepared for new series of experiments.

Research and Development Center, Ennigerloh, Germany

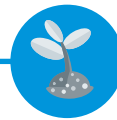
Established: 1968
Usable area: 50,000 m²
No. of employees: 100



“We continue to develop market-relevant products together with our customers.”

He looks back fondly on that time. “As our team came from a variety of areas we were able to benefit from each others’ knowledge and experience.” Currently the team is engaged in the installation of a first pilot plant in France. At the same time in Construction they are already working on the scale-up for further applications.

But how are the ideas for new products and processes generated and who triggers new developments of this type? “That varies greatly,” say the two men. In most cases current issues and customer requests are taken to R&D by the specialist department in question. These requests come from all around the world. Existing technologies are also optimized to remain competitive. “We always have one ear for the market and one ear for our customers,” says Karl Lampe, summing up the situation.



Innovation POLTORR – the Future of Energy Security

The industrial use of biomass gains an entirely different significance against the backdrop of a sustainable energy policy. Industrial Solutions recognized this trend at an early stage and launched the development of a new, second-generation technology for the production of biocoal from biomass, at the R&D Center.

Second-generation biomass materials include not only wood chips, straw and plant residues (rice husks and coconut shells) which cannot be used as foodstuffs, but also industrial biogenic waste materials.

Why torrefied biomass?

Untreated biomass is virtually unusable for industrial applications. It is difficult and expensive to shred and, in addition to a high moisture content, it also has a low calorific value. So to make fresh, moist biomass easily usable for thermal process technology, it first has to be heat-treated in the torrefaction process, leading to a thermo-chemical splitting of the volatile components. In the process, the fibrous structure of the biomass loses stability and so it becomes easier to grind. At the same time, the calorific value is increased. In this way, a product which is of consistent quality and has the same properties as charcoal is produced on an industrial scale.

What is torrefaction?

Employing a similar method to the one used in the production of coffee, in torrefaction the biomass is roasted at temperatures between 220°C and 320°C in the absence of air. The roasting process is generally preceded by intensive drying to achieve a residual moisture level of 2 to 3%.

POLTORR multiple-hearth furnace

The specially optimized POLTORR multiple-hearth furnace is the linchpin of the torrefaction process. The POLTORR technology is notable for its compact design and small footprint. The consistently high quality of the biocoal produced, along with high yield and maximum efficiency, is a crucial advantage in this context. An exhaust gas recirculation system with heat recovery, as well as the low thermal energy requirements resulting from internal post-combustion, contribute to the energy efficiency of the process.

A wide range of possible applications is opened up for POLTORR. POLTORR can be used in the fields of biorefinery, cement and lime production, ore processing, and power generation.

Biomass procurement

Preparation

- Shredding
- Transport/storage



Drying (residual moisture < 3%)



Torrefaction

- Roasting at 220°C – 320°C
- Cooling, possibly briquetting, storage/transport



The future of biocoal

There is great and worldwide customer interest in processes for the production of biocoal. No wonder, because not only POLTORR but also the use of biocoal offer considerable advantages for customers and the environment.

Fossil fuels are replaced by the use of biocoal. Biogenic waste is also prepared and processed and made usable for thermal pro-

cesses in industry. In this way the carbon footprint can be reduced by virtually 100%. Biocoal is far more than a substitute. With innovations such as POLTORR, biocoal is becoming the sustainable fuel of the future.

**Special Innovation Prize**

Last year the research and development team of the groundbreaking POLTORR project was awarded the special "Energy and Environment" innovation prize. The jury was particularly impressed by the demonstrable reduction of the carbon footprint resulting from the efficient use of biogenic waste.

100

percent reduction of the carbon footprint



Well Supplied from the Ground up: Services in the MENA Region

It's eight o'clock on a Monday morning in April. The sun is burning down from the sky, the thermometer is already showing temperatures over 30°C – not a regular occurrence, but by no means an exception. Especially not for North African circumstances. To be more precise, we find ourselves on Africa's Atlantic coast, one hour's drive south of Casablanca, in an industrial zone in Morocco. The heat is bearable here, although the area is quite well protected from the wind. This is an advantage, because there are no storms whirling in from the nearby Sahara, carrying the sands of the desert into the town. Which also means the conditions are good for fertilizer production.

Mineral fertilizer, an important commodity in agriculture

In Morocco, that means predominantly phosphate fertilizers: thousands of tons of phosphate, but also nitrogen and potassium-based fertilizers are manufactured here from phosphate ore and other raw materials every day. Plants need these basic nutrients. However, their natural occurrence on the world's cultivable land is now nowhere near enough to feed more than seven billion people.

Industrial Solutions: a reliable service partner

thyssenkrupp has entered into a long and lasting strategic partnership with a state phosphate company, undertaking the proactive maintenance of various production facilities in a large industrial area, as well as parts of the port's transshipment zone.

The majority of the thyssenkrupp team are local nationals, with some specialists from Germany and France backing them up and helping out when required. The magic words are "asset management."

The customer benefits from the wide-ranging expertise of a leading global provider of fertilizer production plants. thyssenkrupp provides plants for all the key types of fertilizer and their intermediate products, as a planning service with the supply of special equipment or as turnkey solutions for a fixed price. The complete range of products and services offered by thyssenkrupp includes equipment for the recovery of raw materials, plants for the manufacture of urea, nitrate fertilizer, mono and diammonium phosphate fertilizer, and the representation of the associated process chains from phosphate processing and natural gas cleaning to the production of ammonia, sulfuric acid, nitric acid, and phosphoric acid, as well as granulated, prilled, crystallized, or liquid fertilizer. thyssenkrupp also offers facilities for the storage and loading of the produced fertilizer. In addition, the specialists from Industrial Solutions are also ideally qualified for the conversion of existing plants to achieve more capacity, for the purpose of better raw-material exploitation, for greater reliability, or, last but not least, to reduce the emissions from old plants and improve their environmental compatibility.



75% of the world's phosphate reserves are to be found in the MENA region.



Our Services:

- Full integration of process plants
- Full competence in the fields of technology, engineering, procurement, construction, commissioning, operation, and maintenance
- New plants, revamps, and services in existing installations for single units and for complete plants
- Better risk structure for customers
- Most cost-efficient solution for the whole project



Revamps & Relocation

Over the course of time, the demands placed on production plants often change. In order to meet these changed demands, we offer you our services in the field of:

- Revamps/retrofit
- Debottlenecking/capacity increase
- Emission reduction
- Efficiency enhancement
- Converter revamp



Asset Management

As partners, we take joint responsibility for production, including the risks. thyssenkrupp optimizes plant availability and minimizes maintenance costs. In this context, thyssenkrupp can fall back on many years of experience in the field of plant engineering.



Service Center & Field Services

We can offer you assistance everywhere when it comes to overhauling strategic spare and wear parts, or when it comes to maintenance and servicing.



Engineering, Training & Consulting

For us, a good partnership also means ensuring that you can operate your plants in the best possible way and thus better achieve your corporate objectives. We contribute to the achievement of this aim by offering a comprehensive range of consultation and training services.



Spare Parts Supply & Management

We are there to help when it comes to optimizing your spare-parts management and are happy to advise you as to the correct time to replace components and as to which spare parts are suitable.

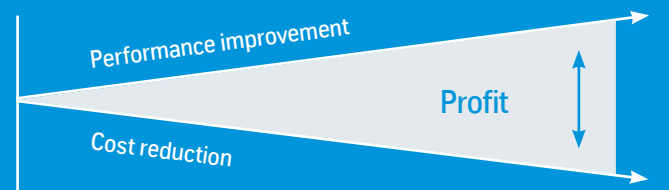
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Integrated Service Concept

With Asset Management (AM), thyssenkrupp Industrial Solutions offers an integrated service approach to reduce our customers' total cost of ownership (TCO) while improving the profitability and performance of their plants.

We know that by improving reliability and performance, hidden costs can be reduced and profitability can be increased. By simultaneously minimizing complexity inside their companies, our customers can achieve a win-win situation.

We meet this expectation by offering a comprehensive service concept. This takes into account the entire life cycle of a plant and, in addition to outstanding expertise, it includes ultramodern technologies, tools, and skilled technicians, as well as tried-and-true asset management processes. In this way, we support the continuous improvement of existing processes and plant performance.





At Your Service

Three questions for Marcelo Mata

Mr. Mata, how would you describe your day-to-day work?

A typical day is comprised of different activities that need to be done. It is focused on the search for new, innovative, and reliable business opportunities – opportunities that move us forward. Besides the preparation of proposals, I work together with my colleagues analyzing the documents and drawings that come together with the RFQs.

I take part in internal technical discussions, calculate the number of hours which are necessary to perform a job, and also check the feasibility of possible investments – all this always in close cooperation with the customers.

What excites you about your work?

The willingness to understand how things work led me to engineering, and understanding the value of personal relationships led me to work in sales. So, what excites me the most is that my job allows me to combine these two passions, and that really satisfies me. Besides, I appreciate the wide range of businesses of thyssenkrupp, which gives me the chance to learn and face different challenges every day.

What is important for you in the service business?

In my opinion the most important consideration is that we generate value for the customer through our service – from submitting a proposal to the delivery of a service. Also, it is important that everyone who is part of the service acts professionally, always looks for the best possible solution, supports the involved parties, and delivers to the customer the expected results.

One of our regional Service Centers is located in Brazil.

The growth of the economy together with the shortage of water and the lack of clear politics from the Federal Government led to a critical situation in the energy sector. In the last five years, wind generators have become an increasingly important source of energy, supplying most of the installed base of machines in the country. Taking a ride on this wave, this year the Service Center got the first order for the machining of parts for wind turbines from an important Brazilian company. In addition we are involved in the tendering for the machining of parts for another important global player. Marcelo Mata, Technical Sales Manager at the Service Center in Brazil, focuses on identifying new business opportunities, as he explained in interview.

Brazil

Marcelo Mata,
Technical Sales
Manager at the
Service Center
in Brazil.



South Africa

thyssenkrupp Industrial Solutions is known as an all-embracing service partner for the primary sector.

That is why the company established excellently equipped Service Centers in all key mining regions of the world. This also includes the sub-Saharan region in Africa, enabling us to be close to our customers – not only geographically, but also through our profound understanding of their specific requirements. Located in Chloorkop, east of Johannesburg, the gateway of the African mining industry, our 10,000 m² Service Center facility contains 1,700 m² of technologically advanced workshops and warehouses. They have been designed and equipped with state-of-the-art equipment to meet the high standards set by ourselves and expected by our customers. Our highly qualified and motivated staff work according to international quality and safety standards – including John Stapelberg, Sales Manager at the Service Center in South Africa. The extractive metallurgist answered our three questions about his daily work.



John Stapelberg,
Sales Manager at
the Service Center
in South Africa.

Three questions for John Stapelberg

Mr. Stapelberg, how would you describe your day-to-day work?

As a Sales Manager at the Service Center in South Africa, my day-to-day work includes the expansion and strengthening of our capabilities and customer support in the mining and cement industries across the African continent. I manage our sales team and we guarantee our customers the best and most comprehensive services to achieve the highest level of quality. I have been in my profession for more than 25 years now and I hope to share my experiences the best I can.

What excites you about your work?

What excites me about my work is that we have to face new challenges every day. Currently, our challenge is to be more cost-effective whilst offering the best solution for the customer and still maintaining quality throughout the supply chain – no easy task, but with our technical capabilities, professionally trained technicians, and state-of-the-art equipment and tools, we are able to maintain that aim.

What is important for you in the service business?

Our aim is to build long-term customer relationships with a full service offering. In December 2015, for example, we once again showed that we walk the talk. Our Service Center was fully operational right through the month to meet the customers' requirements during their shutdown period. In addition, we placed service teams on customers' sites where 24/7 service was required. At present, we are planning to expand our regional network by establishing service offices in Zambia and Ghana in an effort to get even closer to our customers.

Our Portfolio

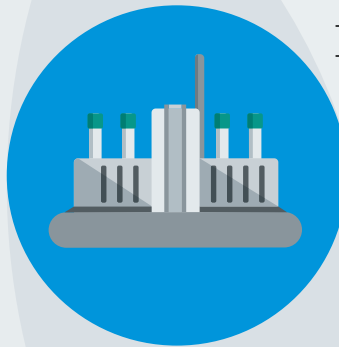
Fertilizer

- Ammonia
- Urea
- Nitrates
- Phosphates



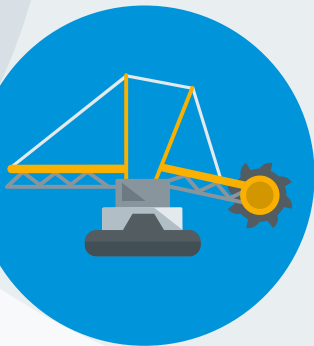
Steel

- Coke Plant Technologies
- Metallurgical Injection Systems



Chemical

- Hydrogen
- Electrolysis
- Gas Technologies
- Organic Chemicals
- Biotechnologies
- Polymers
- High-Pressure Technologies
- Oil and Gas (Upstream and Downstream)
- Oleochemicals



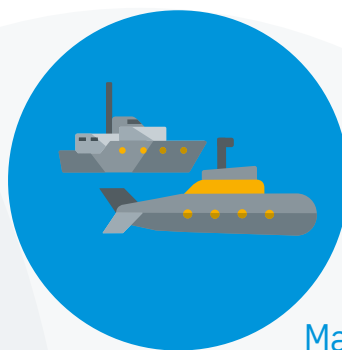
Mining

- Open-Pit-Mining Technology and Systems
- Mineral Processing
- Bulk-Materials Handling Technology and Systems



Aerospace

- Automation and Assembly



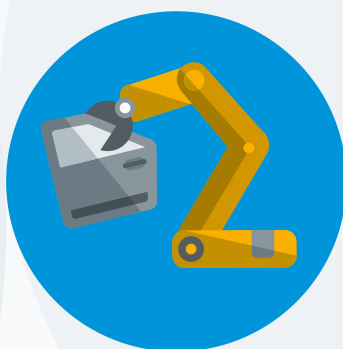
Marine

- Submarines
- Naval Surface Vessels



Cement

- Raw-Material Processing
- Clinker and Cement Production
- Factory Automation



Automotive

- Assembly Systems
- Car-Body Technologies
- Lightweight Solutions
- Forming Dies
- Battery and Testing Solutions



Services

- Asset Management
- Spare Parts Supply & Management
- Engineering, Training & Consulting
- Service Center & Field Services
- Revamps & Relocation



At Home the World Over

Along with its lengthy experience in the field of plant engineering, thyssenkrupp Industrial Solutions is primarily known for one thing: its international competence.

At over 70 locations in six regions, Industrial Solutions offers its customers a wide range of engineering skills for numerous processes and competent all-round service. In future, Industrial Solutions will enhance its presence still further in the regions.

The Americas

Argentina: Buenos Aires
Brazil: Belo Horizonte, Diadema, São Paulo
Chile: Antofagasta, Santiago de Chile
Canada: Calgary
Mexico: Colonia Lomas de Chapultepec, Querétaro
Peru: Arequipa, Matarani
USA: Atlanta, Auburn Hills, Bridgeville, Denver, Greenwood Village, Janesville, Milwaukee

Asia-Pacific

Australia: Melbourne, Perth – Henderson, Perth – Stirling
China: Chongqing, Peking, Shanghai
Indonesia: Jakarta
Japan: Tokyo, Yokohama
Kazakhstan: Almaty
Malaysia: Petaling Jaya
Pakistan: Islamabad
Philippines: Makati City
Singapore
Thailand: Bangkok
Vietnam: Hanoi



• Location of Industrial Solutions

• Headquarters, Essen, Germany

Europe – CIS

Germany: Bad Soden, Beckum, Berlin, Bremen, Burghaun, Cologne, Dortmund, Emden, Essen, Hagen, Haltern am See, Hamburg, Heilbronn, Hohenstein-Ernstthal, Kiel, Langenhagen, Leuna, Lübeck, St. Ingbert-Rohrbach, Wadern-Lockweiler

France: Aix-en-Provence, Ensisheim, Sarreguemines

Great Britain: Ascot, Coleshill, Coventry, London, Port Talbot, West Sussex

Italy: Milan, Turin

Netherlands: Roermond

Russia: Dzerzhinsk, Kaluga, Moscow, Nischni Nowgorod

Switzerland: Domat (Ems), Schwerzenbach, Zurich

Spain: Barcelona, Madrid, Rubi

Czech Republic: Brno

India

India: Maharashtra, Mumbai, Pune

MENA

Egypt: Cairo

Qatar: Doha

Morocco: Casablanca

Saudi Arabia: al-Khobar, Riyadh

United Arab Emirates: Dubai

Sub-Saharan Africa

Ghana: Accra

Mozambique: Maputo

South Africa: Sunninghill

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