

Trusted Globally

See why over 3,000 clients a year across industries trust Goltens' global capability to deliver expert, innovative and cost-effective solutions for their most challenging maintenance and repair requirements.

Goltens In-Situ machinist repairing damaged Mitsui MAN B&W 860MC-C crankpin aboard a container vessel in Ambon, Indonesia



Goltens maintains leadership in BWT retrofit market

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Goltens Green Technologies customers share motivation, experiences with retrofits



Offshore drilling grows on efficiency requirements

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Drive for efficiency increases demand – Goltens delivers as promised to the offshore E&P segment



Goltens ties up with Yara for emission control solutions

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Goltens signs global engineering, installation and regional sales agreements for Yara SOx scrubbers

COO's message



Trusted Globally

Signs of economic recovery

There are finally signs of recovery in several sectors of the global economy. As a result, we continue to see positive effects in many of the market segments that Goltens services.

The Maritime, Oil & Gas, Power, Industrial and other commercial sectors all enthusiastically welcome these improvements after nearly a decade of market contraction and consolidation caused by the 2007 global financial crisis and the fall in oil and gas prices in 2014. Generally sluggish economic conditions around the world and in our markets have rendered the past decade difficult at best for most service providers, while others have succumbed and are no longer competing.

Despite the sustained signs of increased activity and resource utilization in our markets, many companies are reluctant to place unconditional confidence in these signs, and we appreciate this sense of cautiousness. Increasing uncertainty and volatility in domestic and international economic policy, expanding trade protectionism and growing geopolitical tensions in many parts of the world are fueling this unease. As such, we continue to witness a cautious approach by many of our customers with regard to capital investment and operational spending.

In the context of these prolonged market conditions, Goltens strongly believes that having dependable business partners who are focused on adding value to operations is a critical component of today's competitive business model. Goltens is committed to these partnerships, and to adding tangible value in the form of cost effective solutions that minimize downtime and increase efficiency for customer operations.

WHAT MAKES GOLTENS DIFFERENT

At Goltens we are driven each day by a corporate mantra of "Presence, Precision, and Response". Our service engineers, support teams and staff are focused on providing the best, most efficient and responsive technical solutions anywhere in the world. We are acutely aware that downtime translates to a loss of productivity and cash flow, and we treat each customer's emergency as our own. Our focus is to restore customer assets and machinery to operation in the quickest, safest and most expert manner possible.

Goltens' service portfolios are focused on minimizing this downtime through efficient performance on routine maintenance, innovative machinery repair solutions, and the development and application of minimally invasive retrofit solutions. With over 1,000

employees in service-focused locations in 14 countries around the world, we are uniquely positioned to respond at any time and deploy the best solution to address and meet our customers' challenges no matter the scope or where in the world these challenges may occur.

VALUE AND PARTNERSHIP

As a specialized service provider, we do not strive to be the lowest cost option in the market. We do strive to provide our customers with the best value solution in the market. We recognize our customers have options in choosing a service provider, and that we must continually earn their business and retain their trust. We seek to maintain long-term partnerships with our customers and embrace the simple notion that a company that delivers as promised and at a fair price will be called on again when needed. This simple notion has driven our performance and success, and our customers' choices, for nearly 80 years.

During this period spanning eight decades, Goltens has continually evolved and expanded its service portfolio and the markets we serve. We continually strive for operating methods and practices to enhance value to customers, while investing in advancing our skills, tooling and processes to meet the ever-changing needs of our expanding customer base.

TRUST, AND OUR EXPANDING FOOTPRINT

In this issue of InService, we share topics that reflect the wide range of challenges we meet each day. Goltens' tested and proven performance has earned the trust and respect of thousands of customers across an increasingly wide range of industries. In an environment where technological advancement is a quarterly reality, our customers demand the highest standards of service, accuracy, responsiveness and quality.

If you are already a Goltens' customer, we hope these stories will enhance your understanding of our capability and inform you of the additional services and innovative solutions you can now rely on Goltens to deliver. If you are not yet a Goltens' customer, we invite you to share these customer experiences, which we trust will give you the confidence to add Goltens to your list of trusted service partners.

Thank you, and we look forward to serving you. ■

Roy S. Strand
Chief Operating Officer
Goltens Worldwide

Drive for efficiency presents Goltens with expanding offshore oil & gas opportunities

Since the dramatic onset of the oil & gas crisis in late 2014, owners and operators of offshore exploration and production assets have been challenged by the need to cut their operating costs while meeting their contractual requirements for operational availability, production and safety of operation. As rates fell and revenues and profits were decimated, rig owners have been forced to look at cutting corporate costs, reducing CAPEX, consolidating operating locations, minimizing manning, implementing wage reductions as well as some seeking the short term protections of bankruptcy to restructure their mounting debt levels. The bottom line is that rig owners have needed to seek efficiencies from every aspect of their business as they have patiently waited for the oil prices around the world to stabilize and for demand, and consequently day rates, to rebound.

Goltens has been a beneficiary of this downturn and the resulting focus on controlling operating costs. Recognizing that deferring maintenance or reducing availability is simply not an option on contracted rigs, owners have proven increasingly open to engaging a global independent like Goltens as they seek a more reasonably priced alter-

native to the engine OEMs that can provide the highest levels of service and support to their fleets globally.

For decades the offshore market has been dominated by engine OEMs and the reluctance of operators to stray beyond the OEM. The recent delivery of a large number of Korean made Mobile Offshore Drilling Units (MODU) powered by HHI engines has changed that dynamic. Many Goltens locations around the world are authorized repair partners with HiMSen and, as such, Goltens has successfully courted many of the owners of these new and highly sophisticated drill ships to perform maintenance and repairs on these engines.

Consequently, due to the value seen by many of these owners due to the responsiveness, efficiency in delivery and quality of results, Goltens has successfully secured opportunities to extend its services beyond the HHI line and into areas more traditionally serviced by the OEM. In the past 12 months, Goltens has supported offshore drillers in Asia, West Africa, Europe and the Americas completing over 35 engine overhauls on Wärtsilä, STX-MAN, MaK and HiMSen engines and a variety of other mechanical services. ■



Five HiMSEN overhauls keep Diamond Offshore MODU operational with zero downtime



Rigging of liner to calibration/overhaul area

THREE HiMSEN 9L32/40 & TWO 18V32/40 ENGINES OVERHAULED IN GULF OF MEXICO

The Diamond Ocean BlackRhino is a Mobile Offshore Drilling Unit (MODU) with large power requirements to meet the demands of its propulsion and drilling plants. To meet these requirements, Ocean BlackRhino is powered by six inline HiMSEN 9L32/40 engines and two 18H32/40V engines. Due to charter requirements the vessel can only have one engine off-line for service at a time and is required to maintain the engines in accordance with the manufacturer's maintenance intervals. Diamond Offshore contracted Goltens Houston to provide complete service maintenance and supervision for two 20,000 hour and three 10,000 hour overhauls on their engines.

To minimize operational impact, Goltens technicians worked around the clock in two, twelve hour shifts in collaboration with the ships' crew. The process was to complete the required maintenance on each engine and finish the test runs before moving on and disabling the next. This allowed the Ocean Blackhawk to continue drilling operations without interruption.

HiMSEN 9L32/40 AND 18V32/40 OVERHAUL RESULTS

Goltens' offshore certified service team was fully compliant with the safety guidelines of Diamond Offshore ensuring the engines were overhauled safely and efficiently according to Permit to Work procedures. Upon completion, operational tests reflected engine performance and operational measurements were within specified ranges and tolerances, allowing the engines to be returned to full service conditions.

I just wanted to let you know how much I appreciate the fantastic job your teams have done here on the vessel. Your lead Service Engineer has really demonstrated his vast knowledge of these HiMSEN engines and gone out of his way to educate the crew how to do things and what to look for during inspections. It has been a great pleasure working with him and the entire Goltens Team.

Chief Engineer, Diamond Offshore



Torque checks of critical fasteners



Removal of cylinder liners from engine

Global Offshore operators require global support



Wartsila 16V32 – 48,000 hour overhaul in West Africa
Installation of Rocker Gear during engine rebuild



Wartsila 12V32 20,000 hour overhaul in US Gulf
Goltens technician tensioning main bearing cap bolts on Wartsila 12V32



STX MAN 16V32/40 – 36,000 hour overhaul in Asia
Goltens diesel technicians rigging vibrations dampener from the engine



STX MAN 14V32/40 – 36,000 overhaul in US Gulf
Goltens technician completing installation of Rocker Arm covers

Diesel Overspeed Protection in Offshore

CRITICAL UPGRADES AND MAINTENANCE

April 20th of this year marked the 8th anniversary of the Macondo Well blowout in the Gulf of Mexico, which many consider to be the worst accidental oil spill in history. The investigation report from the Macondo blowout stated that the explosions occurred almost immediately after the released gas plume came into contact with an ignition source and concluded that the main engines were one of two likely ignition sources. Testimony cited in

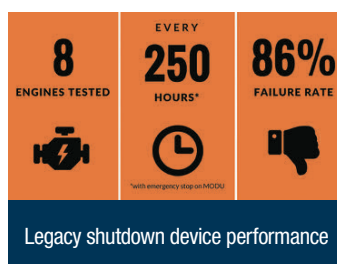
the report, from key technical resources on board during the casualty, would lead to the conclusion that engines #3 and #6, which were online at the time of the explosion, experienced uncontrolled overspeeds. This can occur when combustible gas is drawn into the air intake system, causing the engine to overspeed.

CAUSE FOR ALARM – AN 86% FAILURE RATE

Feedback from engineers who tested their legacy overspeed devices over an extended period provided evidence that upgrades and planned maintenance are critical. Over the course of a 24-month period, one drill ship tested the emergency stop performance of their overspeed device every 250 hours across its 8 diesel engines. The result was a staggering 86% failure rate on older model devices.

WHAT IS A RIGSAVER AND HOW DOES IT WORK?

RIGSAVER is an emergency device manufactured by AMOT, a world leading manufacturer of overspeed valves, installed on the engine's air intake system to cut off air supply to a diesel engine in order to prevent engine overspeed. They are typically found on engines that operate in environments where there is poten-



tial for hydrocarbon vapors to be present in the atmosphere. These devices are designed to be manually or automatically tripped in the event of overspeed condition to starve the engine of fuel and oxygen and ensure that it ceases to operate.

THE SOLUTION – UPGRADES, TESTING AND MAINTENANCE

To address possible issues with older overspeed devices, AMOT developed upgrade kits to improve the valve's performance over the life of the engine and guidelines for properly testing and maintaining RIGSAVER valves. AMOT recommends all valves manufactured

before 2014 be upgraded or replaced should they fail the function test.

In addition to testing the valve regularly, AMOT now has standard maintenance kits for scheduled maintenance at specified intervals. AMOT recommends a full valve replacement every 24,000-hour to ensure that this critical piece of an emergency engine shutdown system is kept in fully tested and operational condition, ready to do its job.

PROACTIVE ACTION

Since engaging with AMOT as a global sales representative for the RIGSAVER product in 2016, Goltens has worked with offshore operators around the globe to educate them on the potential risks associated with the legacy RIGSAVER devices and the benefits of incorporating a replacement and maintenance plan into its standard service intervals for their engines.

Many operators have recognized the potential risks and are taking proactive steps to address the issue in a programmatic manner by purchasing replacement valves and upgrade kits and improving awareness of the criticality of following recommended testing and maintenance among their engineering and maintenance. ■



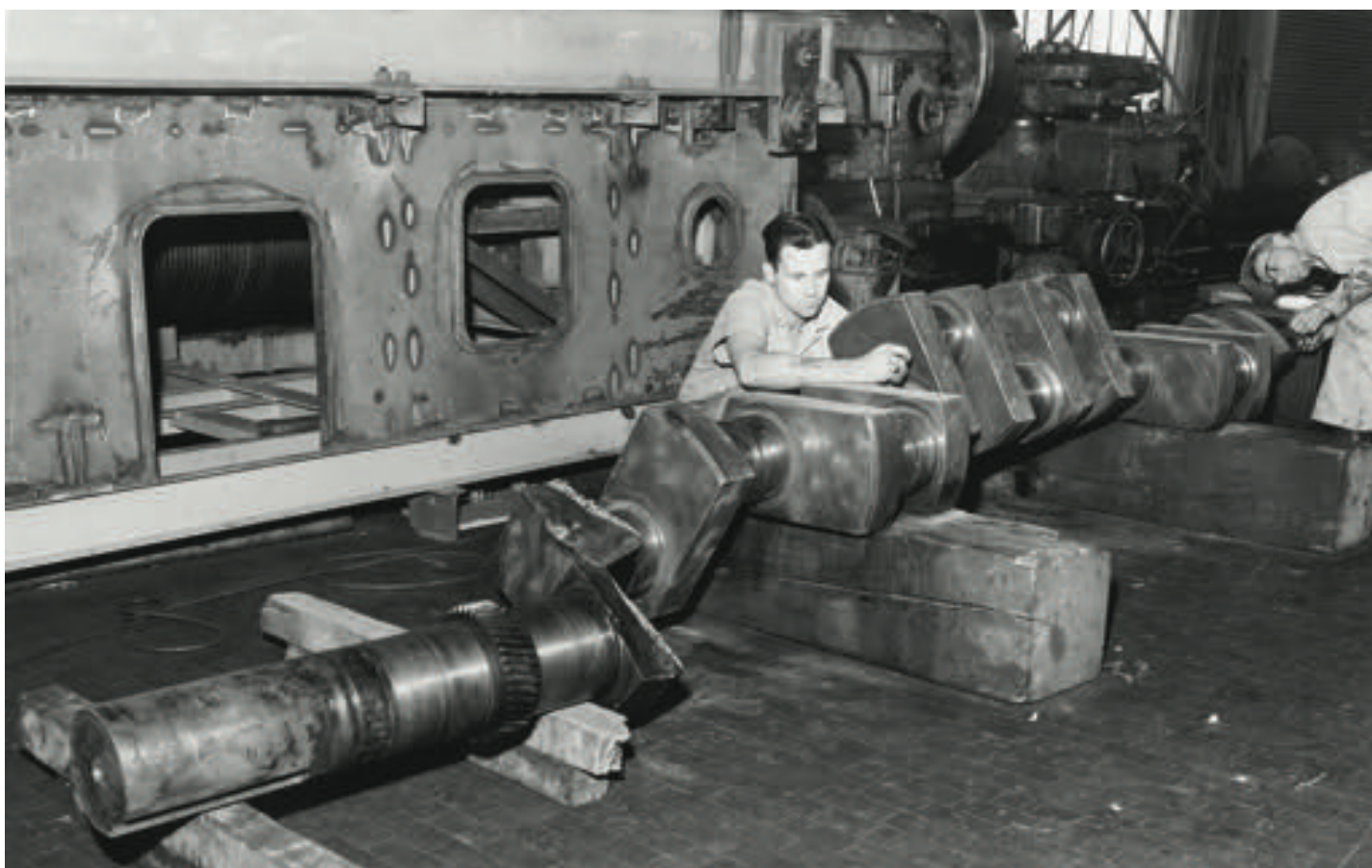
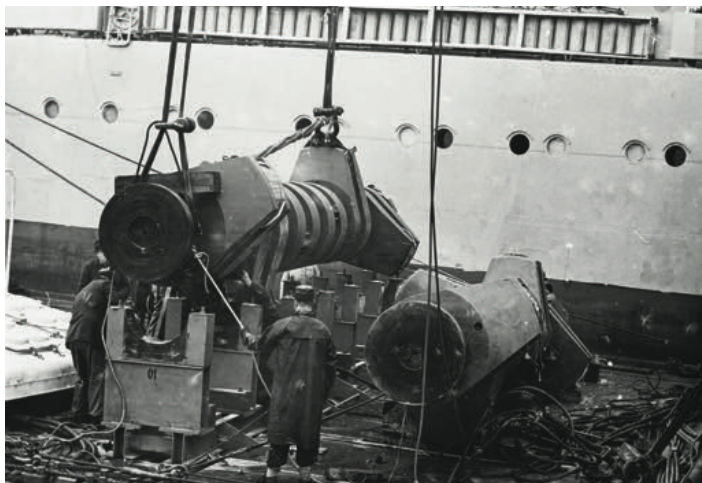
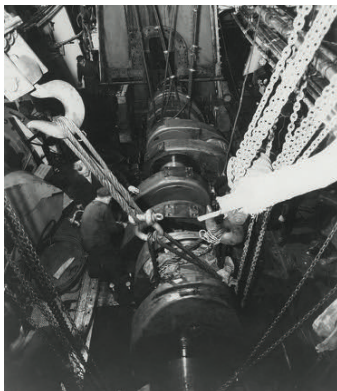
Next Generation Rigsaver 11SGE

A Blast from the past – A Reminder for the future

While winding up the facility in New York in 2014 after almost 75 years, we came across some old pictures of Goltens in its early days doing what we have become globally renowned for.

Too often treasures like these, showing us where we came from, are lost not recognizing at the time how important and appreciated images like these may someday be.

These images are now framed on the wall at Goltens Houston to remind us, each day as we pass them, that our company and its global reputation exist because of the hard work and dedication of eight decades of technical experts that came before us and that we are just the current Goltens generation carrying on a tradition of excellence supporting our customers wherever they are. ■



If you can make it in Nuclear Power, you can make it anywhere



Nuclear plants have arguably the strictest safety and quality standards of any industrial facility. All systems simply must perform as designed, without exception. Meeting the exacting demands of nuclear facilities is the diamond standard for an engineering service provider, and Goltens has become a preferred supplier of Emergence Diesel Backup Generator (EDBG) repair services to the nuclear industry, delivering services to multiple plants around the United States. The following three stories are testimony to Goltens' knowledge, experience, and reliability in diesel engine service and repair.

TACKLING THE BIGGEST JOBS

When one of the Cooper Bessemer KSV-20-T EDBGs at the Palo Verde III Nuclear Generating station in Arizona experienced a casualty on two connecting rods, they immediately called Goltens to inspect the damage and propose a plan for repair. Inspection revealed the engine had suffered the same casualty on the same cylinders 30 years previous. There was significant damage to the block, and repairs would involve extensive metal stitching and machining. Damage to the crankshaft would mean line boring of the engine as well.

The plant had a spare crankshaft on hand, and the decision was made to replace rather than repair the shaft in-situ. Goltens repair teams worked 24/7 through the Christmas holidays to restore the engine, completing all work in 57 days, five days under the defined time limit.

This engine repair was a first for the nuclear industry. No project of the scope and scale of this magnitude had been attempted or approved by the Nuclear Regulatory Commission (NRC) previously. Collaboration and teamwork were critical to the successful execution of the project, a milestone crankshaft replacement delivered by Goltens for the nuclear industry.



Palo Verde III Nuclear Generating Station



Metal stitching large cracks in the underside mating surface



Crankshaft lowered to skid for removal from powerhouse

"HONE" FOR THE HOLIDAYS - GOLTENS STEPS UP ON TURKEY DAY

At a nuclear power plant in the Southeastern United States, personnel had been closely monitoring one of their Nordberg FS-1316-HSC emergency diesel backup generators (EDBG), as they had observed rising aluminum levels in lube oil samples. Consequently, a main journal inspection was performed during a scheduled outage, and the staff noted damaged bearings on two main journal units. The bearings were replaced, and the engine was started once successfully, but showed low lube oil shutdown during the second start.

Goltens got the call on Sunday and engineers were on site the next day to evaluate the condi-

tion of the shaft and identify a repair method for the damage on the EDBG. Goltens undertook an inspection of main journals 7 and 8 and found a breakdown of bearing integrity and signs of improper wear.

In order to address the plant's urgent requirements and help to avoid a shutdown of the reactor, Goltens deployed its in-situ machining tools and technicians to the site on Thanksgiving Day to carry out repairs. Work included machine honing of main journals, straightening of the crankshaft at main journals 7 and 8, and repair of surface irregularities. All repairs were completed within required timelines for restoration and a reactor shutdown was avoided.



Machine honing of the damaged crankpin journal

Emergency Diesel Backup Generators in the Nuclear Power sector

Emergency diesel backup generators (EDBG) are critical to the safety of almost every nuclear power plant globally. During normal operation, a nuclear plant supplies the power required to operate cooling and other critical safety systems and is backed up from power supplied by the grid. When a plant suffers a casualty that precludes supplying these systems itself and there is a LOOP event (loss of outside power) which keeps the plant from using power supplied from the grid, these EDBGs immediately come on line

to ensure the plant has the critical power it requires for a controlled shutdown.

WHY DIESEL?

While many generator options exist in the market for backup power generation, it was determined that none can match the required response time and output power of a diesel generator. To ensure this power is always available for emergency situations, every nuclear reactor has at least two EDBGs for redundancy on standby ready to start up and take the load within 10 seconds.

National regulatory bodies enforce different standards to ensure the reliability and availability of these EDBGs. In the United States, the Nuclear Regulatory Commission (NRC) is the governing body. Under NRC guidelines, the generators must be independent, redundant and testable. In order to meet independence requirements, the EDBGs may not share critical components if the failure of that component could result in the failure of both units to operate. Regarding redundancy, each generator must be capable of

providing the required power to the reactor on its own.

AVAILABILITY TESTING

In addition to extremely rigorous pre-operational testing, each EDBG must be started and loaded at least once every 31 days to ensure its availability and ability to respond to demand and load requirements. In addition, a fast start, load run test is completed once every six months. ■

TEAMING UP ON THE TOUGH TASKS

A nuclear power plant in midwestern USA experienced a bearing failure on one of its four Worthington SWB-VEE-12 backup diesel generators. The 3.5MW engine was revealed to have crankpin journal damage, leading to concern that excessive heat may have introduced high hardness to the shaft. Goltens was requested to inspect and advise, and Goltens in-situ technicians mobilized immediately to conduct an inspection of the 40 year-old engine.

Goltens determined it could repair the crankshaft but discussions with the plant and the engine OEM revealed that employing these standard procedures would be unacceptable, preventing the engine from operating at the plant's required 3.5MW load requirement under strict nuclear standards.

Goltens mobilized two eight-man teams to work day and night on the job, but the work still took

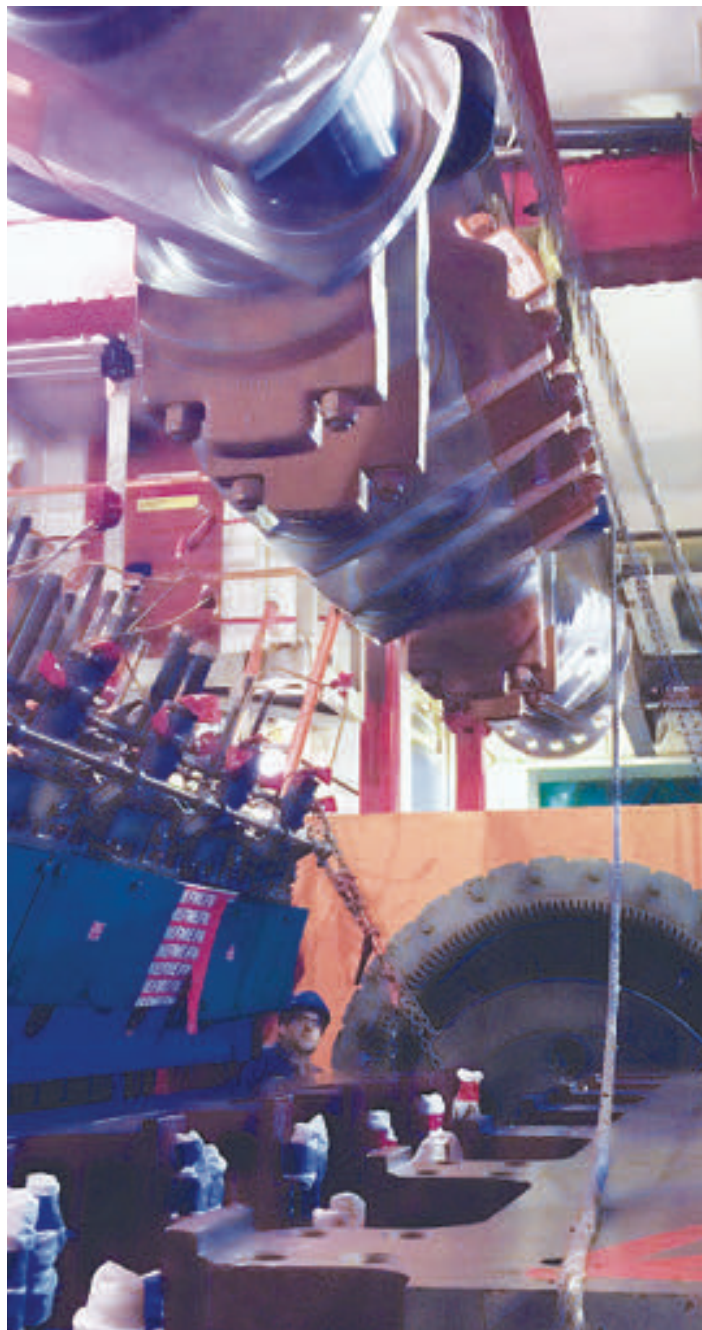
longer than normal, due to the strict regulations and procedures in place. Teaming up with the plant's technical resources, Goltens completed the replacement in 61 days. Upon successful completion of the work, plant management offered this praise:

Thanks to the Goltens personnel and all the people who supported them for bringing their expertise to us ... We have learned much about diesel work from them, and appreciate their engagement.

Plant management ■



Lowering bearing caps into position to complete line bore



Lowering the replacement crankshaft into position

Scrubber retrofit momentum is building

With the IMO 2020 deadline looming, shipowners around the globe are faced with a difficult choice.

The time for hoping the enforcement of emissions regulations will be delayed has passed and owners are now forced to decide on how they will comply. Until January 1, 2020 only those operating in the Emissions Control Areas (ECAs) are challenged by the lower sulphur limits but after that date there are really only two choices: operate using emissions compliant fuels, or ensure that emissions are cleaned using an exhaust gas scrubber.

SCRUBBER RETROFITS START SLOW, BUT MOMENTUM IS BUILDING

Prior to 2018, Goltens Green Technologies had been involved in many emissions control projects evaluating the retrofit of scrubbers, but most of these projects involved cruise and ferry operators and other vessels that spend large amounts of time in the ECAs. For other operators, the retrofit projects involved lower cost piping system modifications and

fuel oil cooler installations to allow vessels to periodically operate on LSGO as required.

Since the beginning of 2018 however, there has been a major increase in interest, and a much broader range of companies actually pushing to retrofit with scrubbers. This has resulted in longer lead times for scrubber delivery and increasing competition for the attention of some of the leading scrubber manufacturers. That said, it does not appear to be the decision most owners are making.

In Skandinaviska Enskilda Banken AB's (SEB) *IMO 2020 Report*, they estimate that fewer than 2,000 vessels will have been fitted with scrubbers by the implementation date, and further project a significant price delta between LSGO and HFO providing the scrubber installed vessels with a significant short-term advantage post 2020.

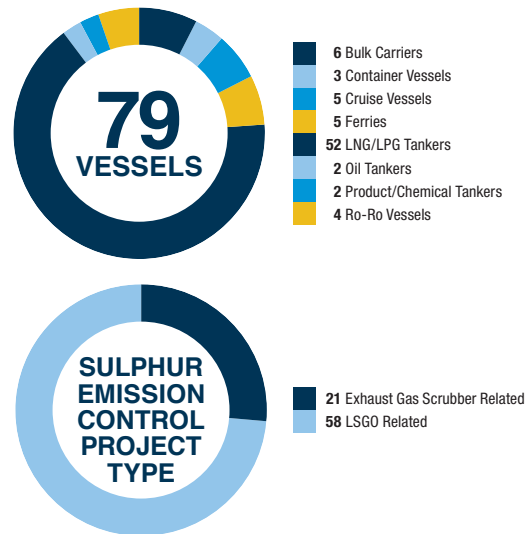
So why aren't more owners rushing to install scrubbers?

THE FUEL-COMPLIANT MAJORITY SETS THE PRICE, BUT THE SCRUBBER-INSTALLED MINORITY WILL BENEFIT

SEB's report highlights that this "wait and see" approach is compounded by the fact that owners pay for scrubbers (CAPEX) and charterers pay for fuel (OPEX), and if most vessels are operating without scrubbers, the market prices will largely be set by those vessels factoring in higher fuel costs without a competitive disadvantage. The analysis further highlights those moving to install scrubbers now will be at a competitive advantage compared to their non-scrubber

counterparts in the first few years after the implementation. These first movers will likely be able to charge significant "freight rate premiums" to account for the savings on fuel associated with operating the vessel. These premiums are projected to allow for a quick payback on the initial investment as others move more gradually to scrubbers.

At that point, SEB contends "it will be too profitable and too tempting not to install a scrubber in 2020". The likely question for the late adopters at that point will be: "How long is the wait?" ■



Sulphur Emission Limits

Outside an ECA established to limit SOx and particulate matter emissions	Inside an ECA established to limit SOx and particulate matter emissions
4.50% m/m Prior to 1 January 2012	1.50% m/m Prior to 1 July 2010
3.50% m/m on and after 1 January 2012	1.00% m/m on and after 1 July 2010
0.50% m/m on and after 1 January 2020	0.10% m/m on and after 1 January 2015

Goltens teams up with Yara Marine on SOx scrubbers

In late 2017, Goltens and Yara Marine Technologies entered into a non-exclusive global engineering and installation pact for Yara's SOx Scrubber System, including sales representation in North America, the Middle East and Singapore.

"Yara Marine is a leader in exhaust gas cleaning systems," says Goltens COO Roy Strand. "The addition of their well proven SOx Scrubber System to our Green Technologies sales and service offerings is a big win for Goltens, and an added advantage for our customers."

Kai Låtun, Chief Sales and Marketing Officer in Yara Marine, is equally happy with the Goltens deal: "The value of a strong sales and service

network cannot be underestimated. Goltens brings proven global environmental retrofit expertise and solid maritime relationships to this agreement."

A bonus for both in the new partnership is the timing. The looming 2020 sulfur cap requirement will lead many shipowners and operators to calculate their return on investment in scrubber technology, compared to spending more on lighter fuels indefinitely.

"The regulatory emissions deadline is no longer in doubt. It is happening," says Strand. "When emissions regulations are applied globally, the investment in exhaust cleaning will make more sense to many operators. There will be more customers who choose to invest in scrubber technologies due to the clear payback."

Those customers will be able to take advantage of Yara's simpler, lighter and more efficient systems: "The Yara in-line system has no internal moving parts, and our magnesium oxide technology is cheaper to operate and maintain, and safer than competing systems that use caustic soda," says Låtun.

Roy Strand has only praise for Goltens' new partner, and their products: "Yara's SOx scrubbers add a new dimension to the Goltens Green Technologies portfolio. Their technology fulfills the strictest IMO requirements, and we are very happy to be able to partner with Yara Marine and offer this line of high quality compliance products to our customers." ■



Yara scrubbers ready for installation on Norwegian Escape



Kai Låtun

Yara Marine scrubber technology – the clear advantages

Yara Marine Technologies is one of the top three exhaust cleaning systems on the market, with more than 200 SOx scrubbers and 1600 SCR systems designed and installed.

The IMO 2020 global 0.5% sulfur cap is now just around the corner, and ECA areas around the world are expected to increase in area and number in the near future. The sulfur cap requirement will lead many shipowners and operators to calculate their return on investment in scrubber technology, compared to spending more on lighter fuels indefinitely.

Each Yara Marine scrubber can handle sulfur content in fuel up to 3.5% and clean it down to the strictest 0.1% ECA requirements, allowing shipowners to futureproof their vessels against both ECA and IMO compliance requirements.

For retrofits on active vessels, Yara Marine Technologies scrubbers can be fitted while in operation, keeping loss of valuable commercial sailing time to a minimum. In addition, Yara scrubbers are fitted with high-grade stainless steel, allowing Yara to offer extended guarantees against corrosion.

Yara Marine Technologies scrubbers can operate in both open and closed loop modes, depending on the specific geographical regulation. With no moving parts or bypass on in-line scrubbers, they are easily installed in the funnel, and the inline system requires approximately the same space as the silencer that it replaces, simplifying installation. ■

Yara Marine Technologies has delivered more than 200 scrubber systems

STX France

SINOTRANS
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SINOTRANS & CSC

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FINCANTIERI

Yara Marine Technologies has more than 2.000.000 running hours on our systems

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REEDEREI
JÜNGERHANS

MSC
CRUISES

Brittany Ferries

Saga

TOLL

Royal Caribbean
INTERNATIONAL

YARA MARINE MGO TECHNOLOGY – HOW IT STANDS OUT FROM THE COMPETITION

- MgO is completely harmless with no health or safety risk onboard
- MgO is available as a powder and is easily obtainable all across the globe
- MgO requires less storage space than NaOH as the MgO consumption is only ¼ of the corresponding NaOH needed
- The Yara in-line system is simpler mechanically, with no moving parts compared to more complex caustic-based systems
- TCO is lower with no internal moving parts and nozzles rated for 40K hours
- Yara's system increases power consumption by max. 1-1.5%
- Consumption of MgO per MW/hr is 25% that of caustic soda per MW/hr
- Caustic soda is 400% more expensive than MgO
- Caustic systems require fresh water as part of the process – MgO uses seawater, lowering costs
- Caustic systems require exhaust fans to compensate for backpressure from the packed bed
- Caustic systems are up to 50% heavier than Yara's in line system
- Designed for 100% dry operation as well

EXPORT CREDIT NORWAY PROVIDES ATTRACTIVE FINANCING OPTIONS FOR OWNERS RETROFITTING YARA SYSTEMS

Export Credit Norway is a governmentally owned financial institution that offers competitive long and short-term loans to finance purchases from Norwegian companies.

- Favorable fixed/variable interest rate
- Borrow up to 85% of the contract value
- Gain access to attractive, stable funding from the Norwegian Government irrespective of market conditions
- Free up credit from your local banks for other financing needs (overdraft facilities etc.)

For ship owners that have several vessels that need to retrofit scrubber systems, Export Credit Norway can offer a credit frame agreement for the entire fleet. The loans for the purchase of the retrofit scrubbers will then be structured as single loans under the credit frame agreement. The single loans will be disbursed upon fulfillment of pre-agreed conditions.

Yara on board with Norwegian Cruise Line

Norwegian Cruise Line selected Yara Marine Technologies scrubbers for our fleet for several reasons; most importantly, because they have the best scrubber technology available for cruise vessels and provide the best ROI compared to all other existing technologies. Other benefits that are important to us include the installation area needed which does not affect existing guest stateroom or outer deck areas and the ability for the scrubbers to be installed while subject vessel is underway.

Brian W. Swensen, Senior Vice President, Technical Operations & Refurbishment at Norwegian Cruise Line



Yara Marine scrubber at the factory

Goltens expands its footprint in the Turbine Service market

For most of our almost 80 years, the Goltens name has been synonymous with a focus on maintenance and repair of diesel engines around the world. Now that's changing.

Whether the work be reconditioning of components, routine repairs, scheduled maintenance or the recovery from catastrophic failure, the connecting thread has always been our focus on precision and response and a fearless approach to taking on the most challenging of jobs.

Recognizing Goltens' mechanical and in-situ machining skills do not relate solely to reciprocating engines, Goltens has been executing a deliberate cross-market strategy to bring these services to the expansive steam and gas turbine markets around the world. Working directly for end customers and turbine OEMs, Goltens is developing a reputation for tackling and solving difficult repairs for plant operators.

Here is a small cross section of recent projects undertaken by Goltens around the globe. ■



In-place machining of steam turbine rotor shaft in four days – Atlas Enerji, Turkey

Goltens' in-place machining team completed the repair of the 600 MW turbine generator's 500mm diameter journal in just 4 days. Goltens completed the repair 2 full days earlier than the 6 days initially proposed allowing the power plant to keep up with its planned maintenance schedule.



In-place machining of slip rings in the Netherlands

Goltens' In-Situ machinists deployed their single point cutting tools to machine two sets of badly worn slip rings on a 43 year old, BBC, coal fired steam turbine. Goltens completed the repair inside of 5 days minimizing the downtime of the generator for the customer.



Turbine overhaul support

Over 20 Goltens turbine specialists and mechanical personnel supported shutdown maintenance work at two powerplants in the Middle East over a 7-month period. The work involved refurbishment of numerous makes and models of gas turbines, steam turbines and ancillary equipment.



GE frame 9001 DLE troubleshooting

Goltens turbine specialists performed a hot gas path inspection to isolate the damage to a 107MW GE Frame 9001 DLE turbine. Goltens isolated the primary damage on the cross fire tube, combustor liner, and first stage bucket and secondary FOD damage on the turbine stage. Goltens determined the damage was caused by poor HSD fuel quality and provided recommendations for correction. Goltens repaired the damage and rebuilt the turbine.



In-Situ laser cladding & machining for Shanghai Steam Plant

Goltens pre-machined, laser clad and finish machined four HPSV, HPCV, ISV and ICV valve seats to original dimensions for two 900 MW Siemens THDF 125/67 coal-fired supercritical thermal units.



General Electric 7LM6000 gas turbine powerplant repair – Indonesia

Goltens was brought in to troubleshoot problems on a GE 7LM6000 and discovered chipped gear teeth on the 7LM6000 turbine's gear box. To limit expense and downtime, Goltens used selective electroplating to repair the damage to the chipped teeth. Once complete, Goltens specialists reassembled the gear box and laser aligned the gear box to the turbine output shaft.

Full EPC project for chemical plant turbine replacement

LASER SCANNING SPEEDS DESIGN PROCESS

A chemical plant in Jebel Ali, Dubai had a requirement to replace its existing steam turbine generator. Goltens proposed to undertake the EPC project on a turnkey basis to meet the customer's requirements.

After evaluating the technical requirements, Goltens sourced a new 415KW Elliott Model 2DYR3 condensing steam turbine that met the customer's needs perfectly.

3D SCANNING LEVERAGED TO SPEED PROCESS

Given the limited availability and questionable accuracy of the engineering data of the existing plant, the customer was genuinely concerned about the cost and time needed for performing the upgrade design.

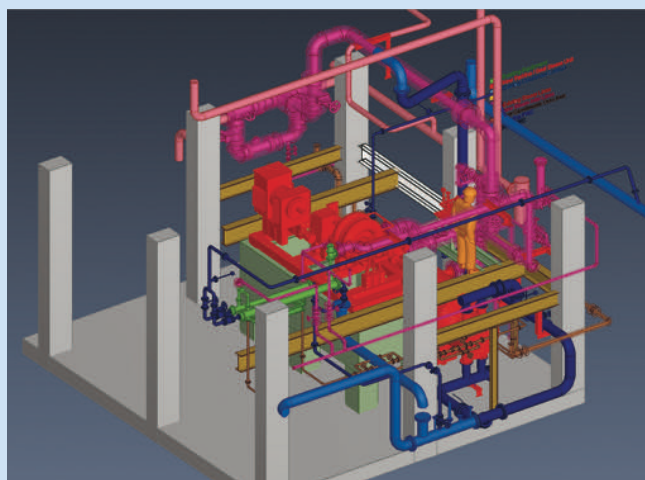
To overcome this challenge Goltens used its 3-D laser scanning equipment to scan the existing plant. Goltens' design engineers then processed the scanned inputs using 3-D modeling tools to deliver a high quality, cost and time effective design solution to the customer.

DESIGN PACKAGE COVERED

1. "As is" model of the existing plant
2. Foundation design including stress & vibration analysis
3. Pumping & piping design including sizing, detailing and routing
4. Structural design including detailed MTOs
5. Electrical design including detailed MTOs
6. Integration of the new turbine with existing switchgear and instrumentation systems
7. Electrical, instrumentation, structural & piping interface (with existing systems) design
8. Plant HAZOP study incorporating the new Turbine

RESULT

The customer was very pleased with Goltens' integrated and innovative approach to the design and sourcing solution. The use of Goltens' well-proven laser scanning and modeling processes dramatically reduced the time involved and the cost to complete the design. ■



New STG Model with complete piping layout



415KW Elliott Model 2DYR3 condensing steam turbine

Nine Days in Arkhangelsk

Bergen crankshaft replacement for Russian powerplant



Steel supports installed under prefabricated braces at the completion of lifting operations prior to removal of crankshaft

When a catastrophic failure occurs on an engine and the crankshaft cannot be repaired, the only option is replacement.

Crankshaft replacements, large and small, are routine for Goltens, and a job we are expert at performing. These complex projects always require careful planning and execution to complete in a safe and professional manner, but not all projects are alike.

Generally speaking, whether onboard a vessel or in large scale powerhouses, sufficient overhead crane capacity is available to support the removal of components and most importantly the lifting of the block. When that is not the case, special tooling and procedures must be implemented to complete the task. Compounding matters is when the engine block weighs 30 tons and you only have nine days to pull it off.

THE CHALLENGE

A powerplant in Arkhangelsk, Russia that supplies power to a local diamond mine



Rigging of condemned crankshaft away from the engine



Replacement crankshaft lifted up into place under the engine block

suffered a casualty on one of its Bergen B32:40V12 engines and the crankshaft required replacement.

Goltens' technical management needed to prepare for the crankshaft exchange without an overhead crane to lift the block. After evaluating the plant layout, Goltens prefabricated tooling and braces for lifting and securing the block safely, allowing the crankshaft to be removed.

LIFTING OPERATIONS

Goltens' diesel team arrived onsite with most of the engine disassembled by the powerhouse team. Goltens team removed some remaining components from the engine, removed the foundation bolts from the engine and fit the 4 specially fabricated frame brackets to the block and began lifting operations with hydraulic jacks.

Goltens lifted the block in stages inserting wooden blocks underneath to support the block during lifting operations. Once the block was lifted to a height of 135cm, prefabricated steel vertical supports were installed to secure the block in place during the crankshaft removal.

CRANKSHAFT REMOVAL

With the block lifted and secured, the counterweights were removed and plant personnel removed the vibration dampener. With chain blocks and lifting slings fitted on the crankshaft, the main bearing caps were removed and the crankshaft was carefully lowered and maneuvered out from under the block.

Bearing caps were then reinstalled and all bearing pockets were calibrated at six points before carrying out a laser alignment check on the main journal bores. All readings were accepted by the client and the OEM.

CRANKSHAFT REPLACEMENT

With the bearing caps removed again, the new crankshaft was inspected and all journals protected for the lifting operation. The crankshaft was then carefully moved by crane to the end of the engine where it was gradually moved underneath the block and lifted into position.

All main bearing caps were then reinstalled with new bearings, side bolts tightened and counterweights reinstalled on the crankshaft.

SAFELY DELIVERED ON TIME

Following the reverse of the lifting procedure, the block was safely lowered back onto the bedplate with a new gasket, and foundation bolts were tightened.

The job was successfully completed inside the nine-day window provided for the work. With the crankshaft successfully exchanged, Goltens' team packed its tools and returned to Rotterdam, leaving the rest of the rebuild to the plant. ■

Daihatsu Diesel (Europe) Ltd. appoints Goltens Rotterdam BV as distributor and agent for spare parts, engines and service work

DAIHATSU

DAIHATSU DIESEL (EUROPE) LIMITED

Daihatsu Diesel Europe recently appointed Goltens Rotterdam as a new official representative of the Daihatsu Diesel (Europe) network.

The impressive engine building history of this renowned manufacturer coupled with the extensive service capabilities and trading history of Goltens Rotterdam BV provide the key ingredients for a long and successful cooperation.

Since Goltens Rotterdam's appointment in August 2017, the company has worked closely with the Daihatsu Diesel (Europe) Ltd. Team in

London, as well as other representatives in the region to provide the highest levels of service to Daihatsu's customers.

Goltens Rotterdam continues to invest in a growing team of trained service engineers as well as an enthusiastic and experienced team for its spare parts and engine sales department. Goltens Rotterdam is able to assist customers with all of their Daihatsu require-

ments and is committed to further develop capabilities and capacity to an optimal level in the near future.

Goltens would like to express its gratitude to Daihatsu Diesel Europe and its Managing Directors, Mr. Miyoshi and Mr. Horiuchi, as well as its Executive Director, Mr. Sengoku, for their confidence in our team. ■

Major overhauls and upgrades provide second life for Wartsila 18V46 plant in Africa

WARTSILA REHABILITATION AND UPGRADE PROJECT – GHANA

- Complete disassembly of the engines
- Renewal of new version air coolers and housings
- Modification of charge air system
- Installation of pulsation damper
- Modification of exhaust system
- Overhauling of engine components
- Installation of new ABB TPL 76 turbochargers
- Renewal of complete camshaft
- Assembly, commissioning and trials

As part of a 370MW power project, Aksa Energy contracted Group Power for the relocation of five aging Wartsila 18V46 engines from Tata Power in Belgium, India to the TEMA Industrial Area in southeastern Ghana.

As part of the relocation project Goltens was awarded a contract to perform complete overhaul of the engines including turbocharger upgrades and major component replacements. The engines had been idle for more than five years and required significant repairs and modification before being returned to service.

The engines had a rated capacity of 15MW per unit (75MW total) and the customer wanted to boost the output of the generators to reach

16.5MW full load capacity, giving the plant a peak output of 82.5MW with increased operational flexibility. To do this, in addition to the overhaul scopes, Goltens would have to remove the legacy ABB VTR 454 turbochargers and replace them with new ABB TPL 76 turbochargers, and replace the old L'Orange PFO-GO13 fuel pumps with new PFO-GO15BH pumps, install new charge air coolers and pulsation dampers, and replace all of the camshafts.

These types of challenging repair and maintenance projects are routine for Goltens diesel experts, but the complexities associated with completing the full scope within the required timelines on five engines added some interesting challenges.

PREDICATABLY EXCELLENT RESULTS

Once the lengthy overhauls and upgrades were completed, all of the generators underwent commissioning checks and full trials. During the load testing phase, each generator reached the required maximum load of 16.5MW. All engine-alternator parameters were observed as normal and within the manufacturer's specifications.

Goltens' team successfully carried out all activities per the customer's requirements and work scope, and achieved the results committed. The newly installed plant was operational at full capacity with increased safety measures & equipment that optimizes efficiency of operation. ■

Senda Shipping Engineering & Service Ltd joined forces with Goltens Singapore

Senda Shipping Engineering & Service Ltd, China have appointed Goltens Singapore as their stock partner for Chinese Genuine Engines Parts in Singapore.

Senda is the authorized official sales agent of CSIC DIESEL ENGINE CO.,LTD (YMD/QMD/DMD) and one of the largest stockists in China for genuine parts made by Chinese maker YMD/QMD/DMD, as well as Shaanxi Diesel Heavy Industry Co., Ltd that supply original engine spares (SXD-PA, SXD-PC, SXD-DK, SXD-MAN and SXD230 series).

With this new collaboration with Senda, Goltens Singapore shall be the stockist for genuine main engines including major components such as cylinder liners, cooling jackets, and pistons to support the local and overseas shipowners and managers with vessels trading in the Asia region.

The optimization of resources and technical expertise from both organizations will definitely create greater synergy between Senda and Goltens which will benefit all shipowners with a higher quality of service and quicker turnaround time at reasonable prices in this competitive market. ■



Overhauling of cylinder heads in powerhouse



Mounting of air cooler housing on engine



Installation of piston assembly during rebuild

Goltens leads the charge to ballast water treatment

Tightening ballast water treatment regulations are driving shipowners down many paths to compliance. One thing they all have in common, though, is the need for efficient and reliable retrofitting of their ballast water treatment systems (BWT).

Goltens is the market leader in BWT retrofits, and in this issue of InService we share the experiences of a wide range of shipowners who have chosen Goltens to keep them BWT compliant while minimizing asset downtime and cost. The reasons for their BWT choices vary, from beating the rush to compliance, to ensuring the necessary flexibility for vessels calling at ports around the world. Regardless of reasoning, compliance must go hand in hand with satisfying a wide range of owner requirements.

Different trades will require different BWT solutions, sometimes even for the same

owner, so broad experience is a critical factor to consider when choosing a retrofit. Goltens has been successful in transferring experience between BWT systems, allowing owners to deal with a single, trusted engineering and retrofit partner, while retaining the option of choosing the optimal system to meet their needs.

Global presence is another must-have for many owners when selecting a BWT service provider. Goltens fits the bill with workshops around the world, and experienced staff ready to roll to where the work is on a moment's notice.

Not only tightening, the regulatory environment is also becoming increasingly complex, with regional, national and international authorities all flexing their muscles, and on their own timelines. Meeting these

shifting demands in the future requires flexibility and knowledge that only experience can provide, and customers consistently confirm the breadth and depth of Goltens' BWT experience.

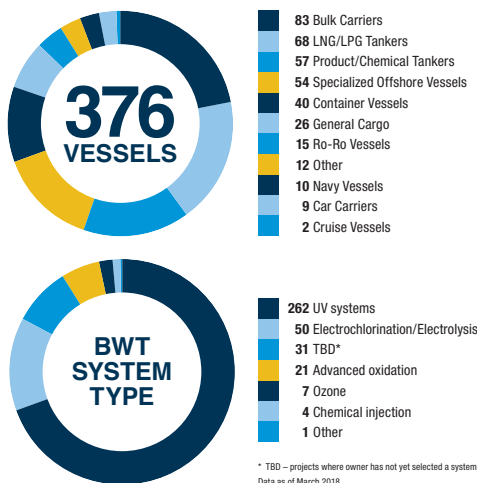
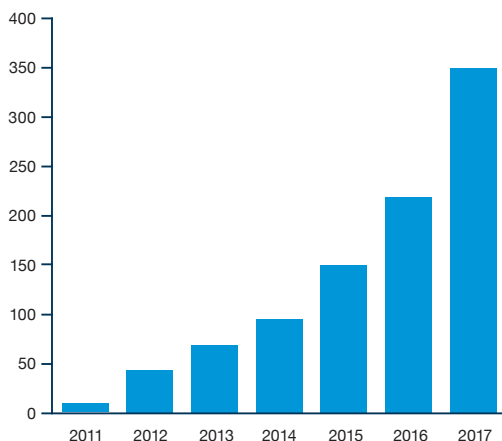
Through it all, good relationships are at the core of any successful retrofit. Goltens takes pride in a high employee retention rate, and our customers appreciate being able to deal with the same experts again and again, building trust and easing communication for both parties. The same applies to communications between Goltens and class representatives on behalf of clients, ensuring the smoothest possible path to compliance.

We are proud to share these stories told by Goltens' valued clients, and we hope you find value for your own business in their experiences. ■

BWT Systems Goltens has undertaken retrofit projects for

Alfa Laval – PureBallast
Auramarine – CrystalBallast
Bio UV – Bio-Sea
Desmi Ocean Guard – Rayclean
Ecochlor
Erma First – FIT
Headway Technology – OceanGuard
Hyde Marine – Hyde Guardian / Gold
Hyundai HI – HiBallast
JFE Engineering – BallastAce
Knutsen Technology – KBAL
MIURA – Miura BWMS
NuTech O3/NK Co – BlueBallast
Optimar – OBS
Panasia – GloEn-Patrol
Samkun Century – ARA
Samsung HI – Purimar
SunRui – BalChlor
TeamTec (Oceansaver) – MkII
Techcross – Electro-Cleen
Trojan – Marinex
Wärtsilä – Aquarius UV

Goltens BWT Retrofit Projects (Cumulative) since 2011



Subsea 7 tackles BWT compliance with Goltens know-how

Offshore service vessels are some of the most complex and costly on the water, and perhaps those most sensitive to time off-hire. Goltens spoke with Cliff Martin, Senior Marine Technical Superintendent at Subsea 7, about the concerns and considerations when installing Ballast Water Treatment systems (BWT) on the first two of its vessels in this highly specialized fleet.

With considerable US operations, Subsea 7 wanted to ensure availability of compliant vessels in order to be able to operate in the region without restrictions. "Our focus is on ensuring full compliance with all applicable international and local environmental legislation," says Martin. "New compliance standards in US waters require existing vessels to have a Ballast Water Treatment system fitted during the first major drydocking after 2013, otherwise restrictions will apply."

Cliff Martin

In order to keep drydock time to a minimum, the BWT retrofits had to be carried out as efficiently as possible, requiring the highest level of supplier technology and experience: "The layout of the ballast system is complex because there is one ballast pump in each of the two engine rooms," Martin relates.

The finalised system required tight routing at the ballast pumps, taking care to avoid clashes with other large-bore pipework, and the water-tight bulkhead between the engine rooms. "The laser scan and subsequent 3D modelling performed by Goltens allowed us to decide on the best layout from two or three alternatives, saving time when installing the system."

Martin adds that highly accurate drawings produced by the Goltens model enabled Subsea 7 to have the pipework produced in advance for the second vessel, giving significant time savings compared to the first installation.

PERFORMANCE UNDER PRESSURE

Offshore operations are notoriously demanding, and operators have to be prepared to meet challenges wherever the work takes them. How did that influence Subsea 7's priorities when choosing Goltens as a supplier? "Our vessels often operate in areas with difficult access and with irregular port calls", says Martin, "so we need to work with reli-

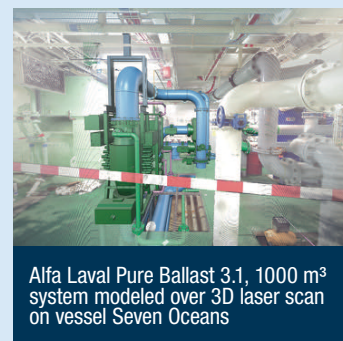
able and flexible suppliers who can adapt to our changing time schedules when supplying personnel and equipment."

And ever-tightening environmental regulations only increase the pressure on already hard-pressed offshore operators. What are Subsea 7's plans for remaining both compliant and competitive in the face of tougher regulations?

"Subsea 7 has a modern fleet of vessels built or upgraded to meet the latest emissions and environmental standard. Our Clean Operations programme continues to drive down emissions

and ensure efficient energy management. The programme started in 2011 with the key objective of raising awareness of energy efficiency and to save fuel without compromising, or being in conflict with safety or the execution of projects."

Meeting USCG requirements for BWT was the most pressing compliance issue facing Subsea 7. With that process well underway, Subsea 7 is looking to stay ahead of the ballast water game internationally as well: "We are making preliminary plans for all remaining vessels to meet the IMO BWT system timetable," Martin concludes. ■



The future is retro for Solvang

Compliance can be demanding enough without inconsistent regulatory demands to contend with. For Solvang ASA out of Stavanger, the key to navigating complex regulatory waters is to stay flexible.

Their average vessel age of seven years places Solvang both at an advantage and a disadvantage. The advantage is clear, with a combination of efficient, competitive ships, and a long horizon for renewing the fleet. The disadvantage is somewhat murkier, shrouded in the uncertainty of looming maritime environmental regulations.

"When the regulative authorities do not cooperate with each other and present clear options, it will affect the users, in this case the shipowners," says Alexander Grødeland, Technical Superintendent at Solvang. "Having to be compliant not just with IMO and USCG regulations, but also with flag state and EU regulations, all with different requirements and timelines, has made the entire compliance process quite turbulent." He notes that this was highlighted when the IMO postponed the BWMC for retrofits.

The question is, how to future-proof your vessels when regulations are certain to change over the lifetime of a ship? The answer according to Solvang is, build flexible ships, and upgrade them wisely.

When they had to select a ballast water treatment system (BWTS) there were a number of factors to consider, leading them to choose two different suppliers: "Our choice was made based on technical and lifecycle cost assessments of relevant BWTS suppliers. There were key technical aspects to consider, but also factors affecting operation, such as filters," Grødeland relates. "We were a little anxious about filters, but in the end, it's about being in compliance with relevant regulations and authorities."

As theirs was the first system approved by the USCG, Optimarin's OBS, which utilizes filters, was Solvang's first choice. Eventually the no-filter Techcross technology was also chosen. "Even though we ended up with two systems, we wanted a single supplier for engineering," Grødeland says. "We had used Goltens quite a lot before, and we knew they were experienced with Optimarin systems. They had less experience with Techcross, but

we trusted that their general knowledge would allow them to handle both system types, and that has proven to be right."

Another factor in Solvang's choice of Goltens was their one-stop shop capability: "They can handle procurement of cables and valves with short delivery time and at reasonable cost, and it is good to be able to get piping from Goltens when we need it fast."

Goltens 3D scanning also helped to keep retrofit costs down and quality up: "For the three projects carried out so far, the feedback from the technical superintendents have been very positive. Pre-fabrication of pipes was done according to engineering package from Goltens and all the installations carried out so far have been completed in time, and at reasonable cost. The key here is proper 3D scanning and accurate engineering."

But one of Grødeland's most important takeaways from the recent retrofit jobs is their working relationship to Goltens. "Communication is important, and it is always easy to communicate with Goltens. Dealing with the same people over time is a big part of this, and Goltens has good

continuity on their staff. Also their ability to deal with class issues is important, to ensure that these processes go as smoothly as possible."

As to the most significant challenges facing Solvang in the near future, aside from market-related concerns, regulations top the list: "Personally I am in favor of strict regulations that will help our industry minimize our emissions and our impact on the environment," says Grødeland. "But there must be a level playing field for everyone, and first movers must not be penalized."

At the end of the day, Alexander Grødeland believes that a more complex regulatory climate, with more parties involved and more demands being made, might not be all bad. "The best and strongest players will emerge as survivors, and leaders," he predicts. "Foreseeing the future is like of standing on an exponential curve: when you look backward, it looks flat, and when you look forward, it looks steep. But taking steps every day to become better is the only way to meet the future. We have found a way to do that together with Goltens, and their experience will be more important to us than ever going forward." ■



Solvang ASA's LPG carrier Clipper Sun



Techcross 1600 m³/hr system modeled over 3D scan data onboard Solvang's Clipper Sun

Jacob Shipping beats the rush to BWT with Goltens

Goltens has installed ballast water treatment systems (BWT) on four Jacob Shipping tankers, ahead of the rush anticipated when IMO regulations kick in for retrofits.

Mr. Gert Koehler, Fleet Manager for Jacob Shipping Group, tells that while the choice to install BWT ahead of compliance was strategic, the choice of Goltens was more practical. "We had worked with Goltens on various repairs jobs, and we knew they had installed a similar BWT system. When we did decide to involve external expertise, they were the preferred choice for us."

Tankers need to fill and discharge huge amounts of water during discharging and loading of cargo. Jacob chose the NK-O3 ozone treatment system due to technical advantages over alternative installations. "Other systems require too much energy, and nearly all systems have filters subject to clogging and malfunction," Koehler says. "The

ozone system works with moderate energy consumption and without need for filtration."

Did Goltens' previous experience with NK systems pay off for Jacob?

"Goltens Singapore had done the previous installation, but the experience was transferred to Goltens Green in Europe and they worked closely with our project engineer to get up to speed quickly," Koehler says. "We had a very tight schedule, nine months from signing the contract to the first delivery, and Goltens had to do some one-off engineering due to inconsistencies in between the ships, but they handled the challenges very well."

What were your most important takeaways from the retrofit jobs?

"We used Goltens for 98 per cent of the work, but decided to install one small control valve ourselves. This complicated the commissioning more than justifiable, because respon-

sibility became too pulverized," Koehler relates. "Next time, we will do everything top-to-bottom with one engineering company. The cost may be slightly higher, but the overall outcome is still reasonable, and much more practical."

How important is the Goltens global network for Jacob Shipping?

"As a ship manager we have limited technical manpower, but Goltens can draw on their global network. On the BWT work, they had project managers from the Netherlands, Singapore, Dubai, and Vietnam. They can bring in expertise from everywhere."

How does Jacob plan to grow your fleet and yet stay both compliant and competitive in the face of expanding and tougher regulations?

"Jacob was one of the few installing BWT systems as a retrofit when we started. We had to do so in order to pick up cargo in the US. Now

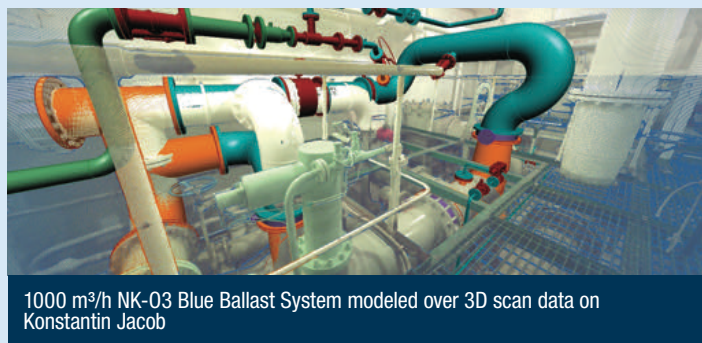
we feel we have a competitive advantage. The yards will be overloaded in the future and the BWT makers will become unable to commission the coming number of installations, but we are ready now. For that reason alone I would say that our strategy has been successful." ■

FAST FACTS

- Four Jacob Shipping tankers were outfitted with 1000 m³/h NK03 (Ozone) ballast water treatment systems from end 2015 to second half 2017
- Goltens Green Technologies performed 3D laser scanning, detailed engineering of piping, foundation and electrical layout
- Goltens stations (Green NL, Singapore and Vietnam) teamed up to deliver piping and materials and performed the complete installations at the MMHE yard in Malaysia



Jacob Shipping's product tanker Konstantin Jacob in drydock in Malaysia



1000 m³/h NK-O3 Blue Ballast System modeled over 3D scan data on Konstantin Jacob

Royal Netherlands Navy continues green collaboration with Goltens

A series of ballast water treatment systems (BWT) installations for the Royal Netherlands Navy has kept Goltens busy for more than two years serving one of the worlds greenest naval fleets.

The partnership started on 25 May 2016, with the signing of a contract between Goltens Green Technologies and Defence Materiel Organisation in the Ministry of Defence for engineering and turnkey installation of 16 Optimarin Ballast Systems on ten naval vessels.

Now systems have been installed on eight vessels, with the ninth job underway and the final installation pending. "Goltens has kept to the schedule all along," says Project manager Roy van Kruisbergen of Defence Materiel Organisation. "Of course there were some ups and downs, but Goltens has come through. They don't let problems stop them."

Goltens' comprehensive retrofit work included high level design and 3D scanning of engine rooms including photography, producing drawings and prefabrication of piping, concluding with installation and commissioning.

"Six of the ships are naval working vessels, and four are warships," reports van Kruisbergen. While ballasting might be essential for stabilizing a warship in combat, treating ballast water is not. "Naval vessels are basically exempt from BWT requirements," van Kruisbergen relates, "but the Dutch government wanted to set an example, as they are among the ratifying countries of the IMO treaty."

In fact, the Dutch Ministry of Defense has an environmental and energy policy outlining 26 measures to protect the environment, and ballast water management is one of them. An added advantage of installing BWT systems was flexibility: "The navy also wanted to be able to call anywhere in the world."

Installation on warships met with different requirements than the merchant fleet, such as shock requirements and providing extra protective measures. "This should make the experience Goltens gained on these jobs interesting for other navies," van Kruisbergen concludes. ■



Roy van Kruisbergen



Optimarin OBS system modeled over 3D scan data on the frigate Zr.Ms. Evertsen



Optimarin OBS installed onboard frigate Zr.Ms. Evertsen



Zr.Ms. Johan de Witt - Optimarin 500 m³/h and 1500 m³/h systems installed



Goltens expanding Woodward network in Middle East and Africa

Woodward controls cover much more than just engine speed governors.

Their products range from the traditional hydraulic speed control to complex electronic power management synchronization and controls components. Goltens Dubai's distribution area covers the Middle East and Africa, and the portfolio covers everything from small engines to large power plants. Goltens has been busy reviewing the ability of the service network to respond to and serve the customers' requirements.

With Goltens businesses acting as long-term Woodward service facilities in Dubai,

Saudi Arabia and Bahrain and channel partners acting as authorized service centers in Nigeria and Durban and Cape Town in South Africa, many key Woodward customer densities within the region are already covered. Goltens now intends to expand this coverage to get closer to key customer bases. Plans are currently underway to establish new authorized service centers in Namibia, Cameroon, Kenya and Oman, with additional countries being considered in the future. These authorized service centers will be equipped with all the necessary tools and equipment to provide certified factory service on conventional Woodward products and will have units available on an exchange basis. ■

Power management controls and upgrades

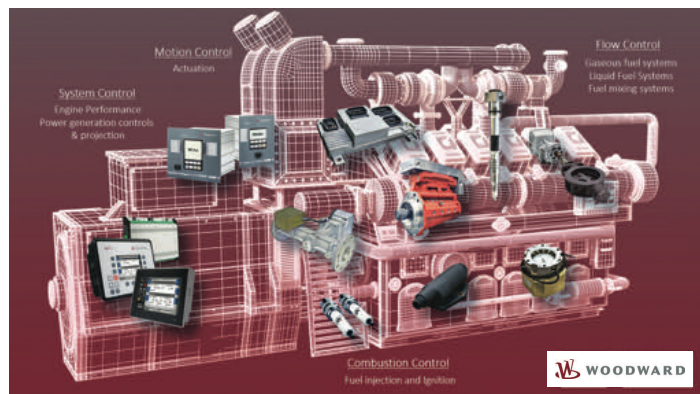
Within the extended Woodward portfolio now available to Goltens, one of the busiest areas has been related to Power Management and Control.

Throughout the Middle East, there are many captive power plants, factories and other facilities with older versions of Woodward Generator Controls installed. Over time, the availability of the electronic components and limitations on processor performance within

these units become issues, and customers are recommended to upgrade to the latest control systems. Goltens has been able to work with customers to undertake these upgrades in the shortest possible time, minimizing the cost by using existing panels and changing the controller, and adjusting the internal wiring to suit. Depending on the complexity of the controls, this typically takes three to four days per generator. ■



Goltens governor technicians performing upgrade of four Woodward AMG2 controls to easYgen 3500XT-P2 Genset Controls at Al Watana Gypsum Company in Inbu, Saudi Arabia. The original controls on the 15 year-old 1400KVA MTU generators were obsolesced and two of the four units had failed, requiring replacement to restore the plant to full operation. The total project was completed in 14 days.



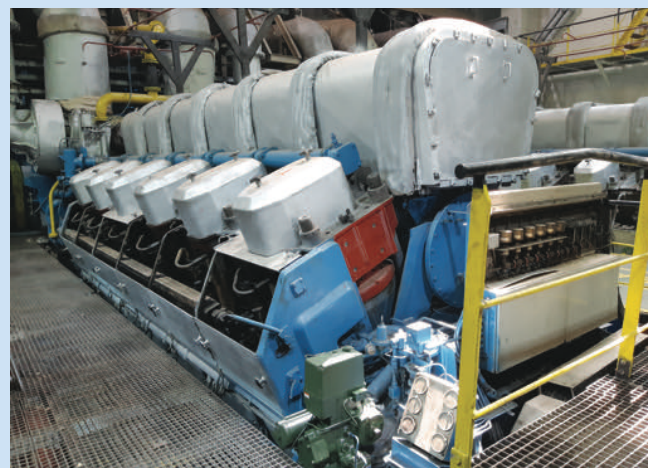
The Woodward portfolio of engine products extends far beyond the governor

Woodward governor and controls upgrade in Sierra Leone

As the Recognized Engine Retrofitter (RER) for Woodward in the Middle East and Africa, Goltens is not only responsible for supporting customers and channel partners in the repair and overhaul of existing governors, but also for supporting more complex requirements for the upgrade of obsolesced or aging governors and controls.

Goltens was contacted by a customer looking to upgrade their aging Woodward PGG governors and 721 controls on six Wartsila 12V46 engines with new PG-EG200 Actuator with 723Plus controls. While the initial requirement was only to supply the governors and electronic controls, the need for external expertise to complete the upgrade became apparent. After installing the units on the engines, the customer requested Goltens provide configuration and commissioning assistance. Based on the information provided by the client, Goltens developed and delivered a configuration file to upload into the units and then mobilized a governor specialist to Africa to complete the commissioning.

The final configuration and commissioning of all six engines, including full load testing, was completed within six days onsite. ■



PG-EG actuator (bottom center) installed on the newly overhauled Wartsila 12V46 in Sierra Leone



Goltens governor specialist configuring the controls onsite in Africa

FSRU repair and maintenance

Expanding natural gas market presents new opportunities for Goltens

As global demand for natural gas expands around the world, most notably in developing economies, Floating Storage and Regasification Units (FSRU) are playing an ever increasing and critical role in the natural gas supply chain. FSRUs provide critical infrastructure in remote areas that are often underdeveloped or cannot sustain the large shore based

infrastructure required for a traditional LNG terminal.

These highly sophisticated vessels may be deployed temporarily to fulfill supply needs while shore based terminals are being constructed, or permanently where building a terminal is impractical. Presently 24 FSRUs are operating around the globe, but the size

of the global fleet is expected to continue to grow as developing economies expand their energy consumption and their needs for cleaner burning fuels.

These special purpose vessels are operated with the highest level of safety and maintenance standards as the transfer of LNG and the heating of the gas in liquid form

back to gas form is inherently dangerous and the ramifications of accidents potentially disastrous on many levels. Over the past few years, Goltens has been playing an ever-increasing role in the maintenance of these highly sophisticated, special purpose vessels providing an increasing range of services to key operators in this expanding market. ■

Alternative pump repair solution minimizes downtime on two FSRU vessels

FSRUs rely on heavy seawater lift pumps to operate their regasification trains.

Without fully operational pumps, FSRUs cannot deliver their full re-gas rate during peak demand periods. In two separate instances on two FSRUs in Kuwait and Egypt, Goltens was engaged to provide a solution to return these 6,000 M³/hour pumps to service in the shortest possible time.

Goltens evaluated the condition and location of the pumps and determined that the location of the pumps several decks below

the main deck made rigging the casings out and sending them to a workshop too time consuming. Also, given the condition of the pumps, it was estimated the repairs using traditional methods could take as much as a month on the large pumps. An alternative solution was clearly required.

In both instances, the pumps were heavily worn. Clearances were well beyond tolerance, specifically on the wear rings grooves, which were nearly gone. Unable to build up with weld and machine in place, Goltens was able to put decades of pump experience to use.

As an alternative, Goltens carefully coated the internal delivery side of the pump casing with Belzona® and utilized the same compound to build up the wear ring grooves. Building up the grooves eliminated the excess clearance and allowed the pump to build pressure again while coating the internal casing ensured the longevity of the pump.

COST EFFECTIVE LIFECYCLE EXTENSION WITH MINIMAL DOWNTIME
Using Goltens' repair methods, repairs took less than a week at a fraction of the cost of an offsite repair, and brought the pumps back to

near original delivered conditions, essentially resetting the lifecycle of the pumps.

On one of the FSRUs, the pumps were opened for inspection after 6 months and found to be in better condition than others without the repair Goltens undertook.

Since these first pump repairs, Goltens has been engaged multiple times to repeat the process on other damaged pumps with similar results each time. ■



Heavily worn pump casing prior to repair



Goltens technician applying Belzona to pump casing



Pump assembly after casing refurbishment

3D scanning, design engineering for FSRU regassification train pipe replacement

When natural gas demand is high, FSRUs operate at peak capacities with no tolerance for downtime.

As maintenance windows are very narrow and ability to perform hot work very limited, careful planning and preparation is required to limit the impact of maintenance on natural gas production.

An FSRU operating off the coast of Egypt identified heavy corrosion in the seawater intake and outfall piping associated with the four trains on their regasification units. With the annual one-week maintenance window approaching, the equipment OEM approached Goltens for a solution. With gas production values of roughly \$200,000 per day for each of the four trains, any delays beyond the maintenance period would be extremely costly. As such, the essential part of this project was to ensure the correct fit of the pipes spool without test installation.

FABRICATION AND REPAIR PROCESS

To solve the problem, Goltens proposed leveraging its laser scanning and design capabilities to create highly accurate piping designs that could be prefabricated and delivered in time for the maintenance period.

The Goltens team moved ahead and made the initial inspection onboard in Egypt. The survey helped us to understand the site condition and project requirements for 3D laser scanning and any onboard installation challenges. The result was a detailed execution plan for 3D laser scanning, staging requirements and a detailed safety assessment for the client's review. Goltens' team then produced a detailed execution plan of 3D laser scanning staging requirements, and a detailed safety assessment for the job was produced for the client.

A week later Goltens mobilized the explosion-proof 3D laser scanner and a squad of scanning and scaffolding technicians onboard in Ain Sukhna port in Egypt.

ON TIME AND AS PLANNED

The 3D laser scanning data was used in engineering design software for the production of 3D models and detailed fabrication drawings, material take off and installation plan. Based on this design, Goltens prefabricated all required piping and mobilized technicians for a successful installation completed within the maintenance window.

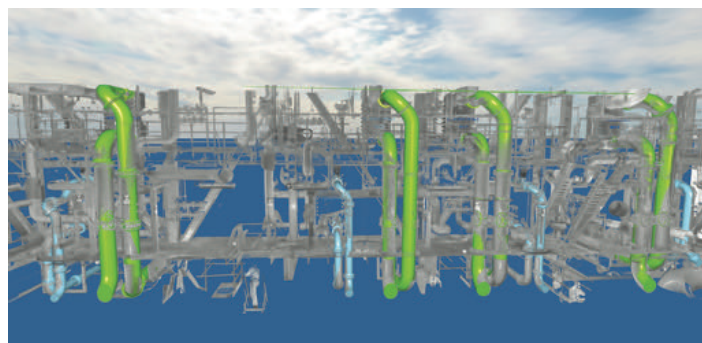
The scan data and 3D model further helped the client to make improvements in existing design and fittings. ■



3D laser scanning in progress onboard FSRU



Regassification train piping



3D modeled piping overlaid on 3D scan data



Goltens technician working onboard FSRU during installation

Crankshaft Annealing – 256 repairs in 50 countries

Saving operators millions on repairs and limiting asset downtime around the world

The process is proven and the benefits are clear.

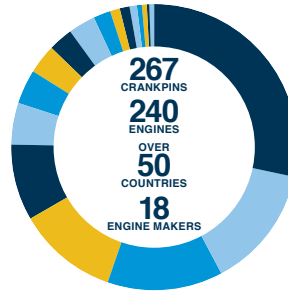
Six years after receiving its first marine class approval from Germanischer Lloyd (now DNV GL) for its crankshaft annealing repair process, Goltens has now successfully salvaged 240 crankshafts in over 50 countries across industries.

Crankshaft casualties often result in extremely high hardness levels in the crankpin, and that hardness has to be removed or the shaft will have to be condemned and replaced. Historically the only option was to try and machine below the hardness, which very often resulted in a condemned shaft if the hardness extended below the rated diameter. Even if the machining was successful, a large amount

of material generally needed to be removed from the shaft, limiting expected lifespan.

With annealing, the amount of material machined off the crankshaft is generally much less substantial, leaving significantly more material on the journal, which extends the life expectancy of the shaft. With the annealing repair process so well-proven, pursuing a pure machining repair is akin to throwing away money.

At the end of the day, it's really about two separate but related costs; the cost of the repair path chosen, and the cost of avoidable downtime for the engine. Annealing minimizes both, limiting out-of-pocket repair expense, and restoring the engine in a matter of weeks as opposed to what can often turn out to be months. ■



76 Man B&W	8 SWD/Wartsila
37 Mak	5 Mirreles Blackstone
35 Wartsila	3 Daihatsu
30 Bergen	3 Niigata
23 Sulzer	2 Colt Pielstick
13 Mitsubishi	2 Mitsubishi Man
10 Pielstick	1 GMT
9 Ruston	1 IHI Pielstick
8 Deutz	1 SKL

Main journal annealing and line boring in Colombia

After a main bearing failure on a 18-cylinder Niigata 18PC2.6-2 engine, Goltens was called to Colombia to evaluate the extent of the damage and recommend a repair protocol.

The bearing failure resulted in excessive hardness on the main journal, and as annealing on main journals cannot be done inside the engine due to space constraints, and the bore alignment needed to be checked as well, the crankshaft had to be removed.

Once the crankshaft was removed, Goltens' annealing and machining process was executed on the damaged main journal and polishing was completed on several other crankpin and main journals. In parallel, the alignment was checked with lasers and it was determined the engine required full line boring. Goltens deployed its purpose-built engine line boring equipment and completed the boring to restore the line.

With that complete, the engine could be rebuilt and brought back into service. ■



Goltens In-Situ specialists completing line boring on Niigata 18PC2.6-2 in Colombia



Goltens technician applying ceramic annealing tiles to the damaged main journal for heat treatment

A tale of three Journals – two mains and a crankpin

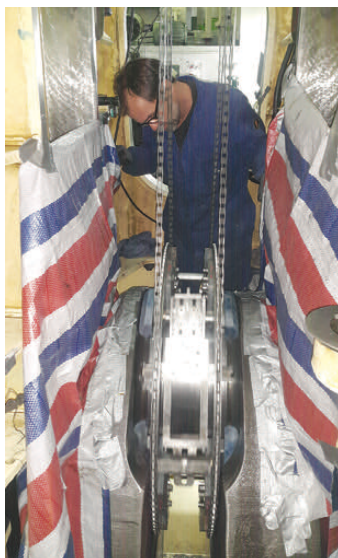
ANNEALING ISN'T ALWAYS THE ANSWER

A busy containership suffered a major failure on its B&W 7S50MC main engine. Inspection on the main journals revealed two adjacent journals had suffered complete bearing failures and had significant heat damage, with hardness as high as 460HB. Additionally, one of the crankpin journals was discovered to have deep dent marks on the surface.

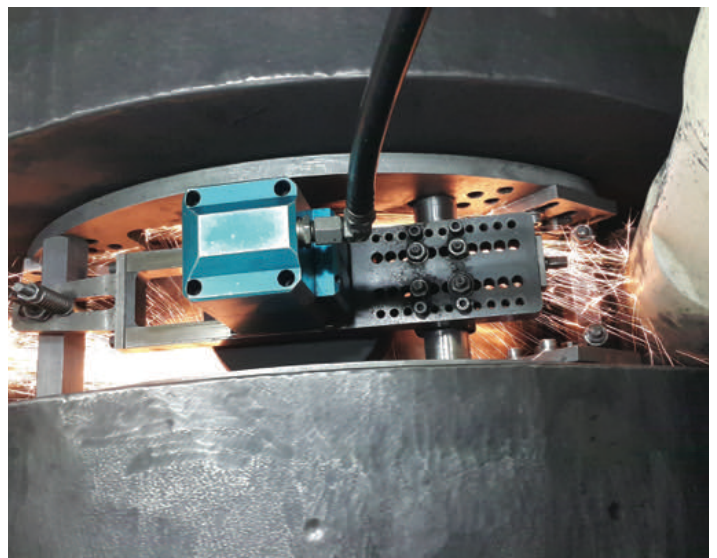
Although annealing would reduce the main journal hardness, in the case of main journals, it would require the crankshaft to be removed from the engine. Pursuing annealing would add a significant and unacceptable amount of downtime and cost to the project. Based on the inspection and the depth of the cracks, Goltens suggested salvaging the crankshaft with in-situ machining to remove the hardness.

ANOTHER SUCCESSFUL REPAIR

Goltens' machined 7.69mm and 5.70mm from the two 560mm main journals to remove the surface cracks caused by the bearing failures. As a result, the hardness on both main journals was returned to acceptable limits. The main journals were then honed and polished before moving on to the damaged crankpin. Goltens machined 4.5mm of material to remove the dents and restore the surface. All were inspected and accepted by vessel's class and the ship returned to service. ■



Machining of damaged/dented crankpin journal



Grinding of main journal after machining

Annealing repair for Wartsila dual fuel engine leads to expanded service relationship



Machining new fillet radii after annealing completed

Goltens saves another Wartsila 18V50DF crankshaft for a Trinidad powerplant.

Ahead of a scheduled 36,000-hour overhaul, one of Trinidad and Tobago Electricity Commission's (T&TEC) Wartsila 18V50DF dual fuel generators experienced a crankpin casualty. The maker was brought in to inspect the damage and provided a report that resulted in the generation of a public tender for the completion of the crankshaft repairs and the 36,000-hour overhaul.

Goltens traveled to the plant to complete an inspection of the engine, which had been completely disassembled by plant personnel at the maker's recommendation. Goltens determined that the 450mm diameter journal had surface cracks and excessive hardness (as high as 568HB) from the bearing failure, and proposed an in-situ machining and annealing repair in addition to the overhaul.

IN-SITU MACHINING AND ANNEALING

After the tender was awarded, Goltens in-place machinists first machined the crankpin to -4.5mm to remove all surface cracks leaving a hard spot 250mm x 120mm. Goltens then performed the annealing process and reduced the crankshaft hardness from 568HB to a maximum of 300HB. A new radius was then cut for the final undersize of -6.0mm and final machining and polishing was completed with a surface finish of 0.4Ra.

MAJOR SCHEDULED MAINTENANCE

While the annealing was being completed, Goltens deployed diesel teams to begin the overhaul of components in parallel. The 36,000-hour scope was comprehensive and included:

- Calibration/overhaul of pistons and connecting rods
- Honing of cylinder liners
- Replacement of all crankpin and main bearings
- Overhaul of cylinder heads
- Remove and replace all cam bushings & Polish Camshafts
- Overhaul Vibration Damper
- Overhaul Turbochargers & Fuel Equipment
- Complete rebuild of the engine
- Commissioning and Testing on Diesel and Gas

SUCCESS RESULTS IN EXPANSION OF SERVICE AND PARTS SUPPLY

Based on the successful result of the in-situ repairs and the successful overhaul, Goltens has expanded its role with the customer, supplying the parts for and completing two additional 36,000-hour overhauls, as well as working with the customer to evaluate and determine a repair process for another engine that had experienced multiple piston seizures. ■



Final calibration checks on repaired crankpin after annealing and machining completed



Removal of vibration dampener for overhaul



Lowering connecting rod to reconnect to piston

Metal stitching revives Wartsila 18V32LN

When reciprocating engine parts seize or break free at high speed, the results are never positive.

If luck is on your side, emergency shutdown procedures can sometimes limit the damage, but when parts come loose from the engine the result is most often catastrophic.

Such was the case for a leading cement producer in the Dominican Republic. During routine operation, one of its Wartsila 18V32LN engines suffered a connecting rod failure resulting in major damage to the engine block and the crankshaft. Collisions with the connecting rod knocked large pieces of the block free between the inspection doors

and smaller pieces inside the crankcase. The casualty also resulted in significant damage to the lower liner landing surface and the engine's crankshaft.

Goltens inspected the damage and performed crack testing on other areas to ensure all damage was identified, assuring the customer that the block was not condemned and could be repaired in place with a combination of metal stitching and in-situ machining.

LASER SCANNING RESULTS IN PRECISION INSERT CASTING

Goltens performed laser scanning on the damaged areas to facilitate the casting of

precise inserts for the block. The damaged interior and exterior sections of the engine were cropped to ensure clean mating surfaces, and the areas for the fabrication of cast inserts to be stitched into the block were then measured. The inserts were carefully positioned and metal stitched into place. With metal stitching complete, Goltens machined the stitched surfaces and performed thorough crack testing to ensure the repairs were successful.

To repair the damage to the liner landing surface, Goltens line bored the damaged bore and installed a sleeve insert and machined it to standard diameter.

ANOTHER BADLY DAMAGED ENGINE BLOCK SAVED BY GOLTENS

What appeared to be a potentially condemned engine block was restored to service by what has become a routine, albeit high precision and challenging, repair for Goltens' in-situ machining experts. The block repairs were thoroughly checked and cleared before Goltens moved on to repair the damage to the engine's crankshaft and restore it to full operation. ■



Goltens In-Situ Machinists inspecting the exterior block damage



Damaged section of block cropped for cast insert



Stitching pin insertion on center wall insert



Laser Tracker in place on job site during scanning operations

3D Dimensional laser

LARGE-SCALE LASER MEASUREMENT

When evacuation is required onboard a submarine, personnel are transferred to a Deep-Submergence Rescue Vehicle (DSRV) and into de-compression chambers in order to restore them to atmospheric pressure. Six such double duplex stainless steel chambers were to be mounted on a skid with extremely tight tolerances, and the owner needed to determine if there would be any structural deformation after undergoing a hydro test for leakage.

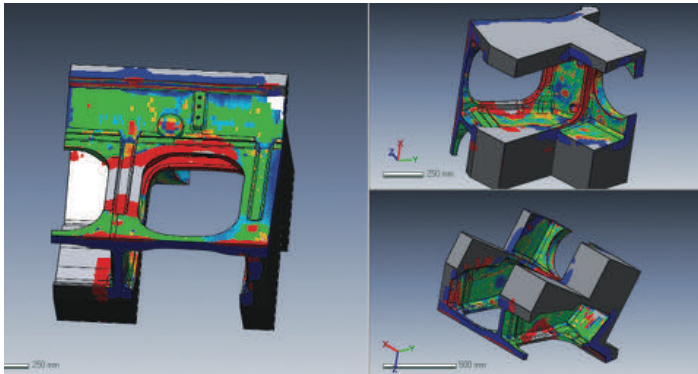
Goltens undertook 3D laser measurement and structural analysis on these duplex triple lock chambers using a Leica AT402 Laser Tracker with an accuracy of 0.015mm. The tracker determines the positions of optical targets used, in this case the SMR (Spherical mounted retro reflector). A laser beam was sent to the SMR, which is held against the object to be measured. Light reflected off the target retraces its path and re-enters the tracker,

giving the user a set of readings. Due to the size of the chambers, Goltens determined the chambers needed to be scanned from three separate locations.

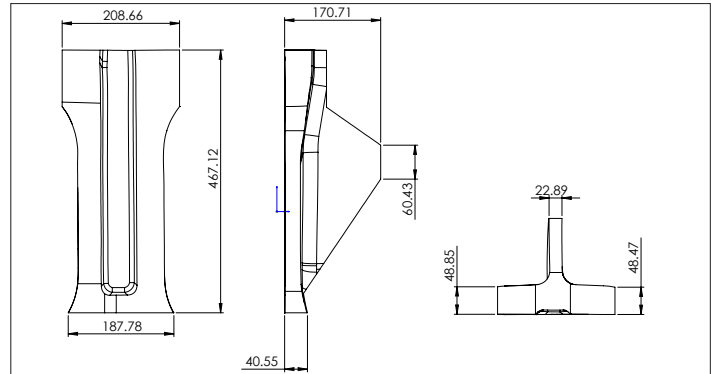
Results obtained were analyzed using SpatialAnalyzer, a high-precision metrology software built especially for large-scale applications, allowing users to integrate data from the Laser Tracker and other sources. Goltens imported the CAD file in .IGES format to use as an overlay for the measured points, enabling deviation checks to be performed.

THE RESULT

The 3D dimensional check and detailed report provided a clear and concise picture of the as-built condition of the chambers, allowing the customer to verify whether deviations were within tolerances, also providing the customer with the cause of deformation to determine the surface machining process required. ■



3D Laser scan of block damaged section of the block



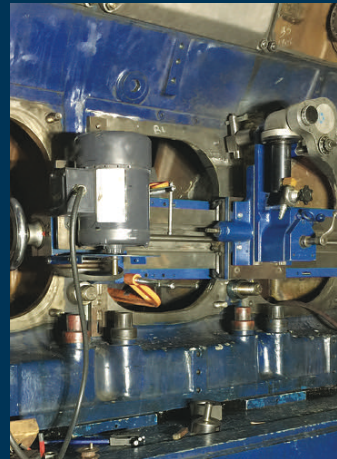
Design for center wall cast insert from laser scan data



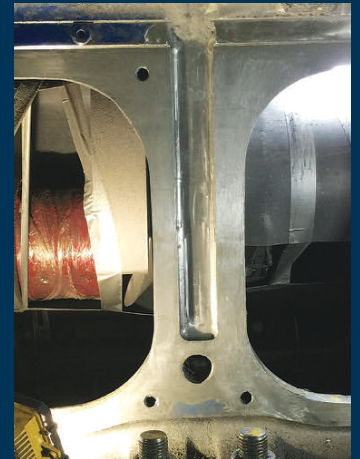
Center wall cast insert metal stitched in place



Metal stitching in progress for inspection door header insert

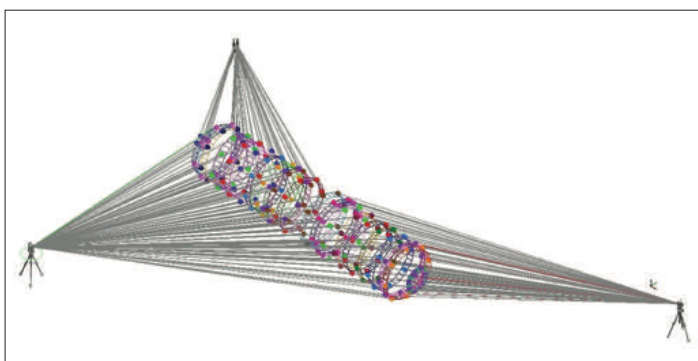


Finish machining of block exterior after metal stitching

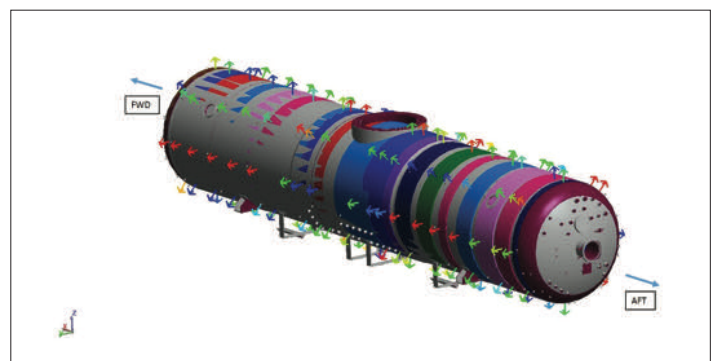


Fully restored block after finish machining of block

check of decompression chambers



Laser Tracker in place on job site during scanning operations



Measurement of total chamber length (26 sections)

A work of art

Blast Doors for the Louvre Abu Dhabi

The Louvre Abu Dhabi opened in November 2017 as the result of a partnership between France and Abu Dhabi to develop a new kind of cultural institution. Made up of 55 unique buildings, it is the largest art museum on the Arabian Peninsula.

A joint venture consortium, ASO Louvre, led by construction giant Arabtec with Constructora San Jose SA and Oger Abu Dhabi LLC, secured the contract for building the museum.

Based on the recommendation of the engineering designer, Goltens Dubai was contacted by ASO Louvre for the fabrication and installation of custom built steel blast proof doors to protect the loading bay.

The large blast door, weighing 51 tons along with the doorframe, measures 5 meters high x 4.4 meters wide and 1.1 meters thick and was built to provide truck access to the loading bay. The smaller blast door weighs a more modest 12 tons and was designed for emergency exit.

FABRICATION AND INSTALLATION – NO EASY FEAT

After procuring the materials and cutting the material to required size using CNC, fabrication of the doors and the frames was completed at the Goltens facility in Dubai Maritime City. The large door and frame, secured with a custom built hydraulic jack with 10 hydraulic locking cylinders, was assembled in the workshop to ensure proper fit, but due to the size the frame had to be cut into four sections for transport before being reassembled on site. The smaller

door and frame, complete with hydraulic opening and closing mechanisms designed by Goltens, were fabricated in sections and assembled on site due to limited access space on site.

The assembly was made all the more complex by the absence of lifting points on the building. Goltens had to use a specially fabricated jacking system to erect the main door. Once erected, all systems were tested and accepted and the long job declared complete. ■



Large blast door installed on-site at the Louvre Abu Dhabi



Fabrication of blast door in progress at Goltens Dubai