Only One to the Seas of the World

PROJECT MEET NEWS

Mitsubishi Marine Energy & Environment Technical Solution-System

08
8th Issue
October 2015

TOPICS

Technology Supporting IMO Tier III NOx Emission Requirements

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Mitsubishi Nagasaki Shipyard & Machinery Works

Interview

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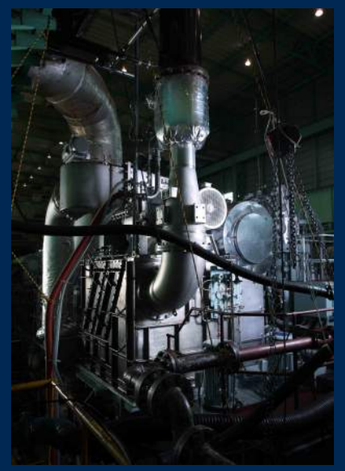
Executive Vice President
Mr. Yasushi Nakamura

The Achievement.

MITSUBISHI HEAVY INDUSTRIES
MARINE MACHINERY & ENGINE CO., LTD.

MHI MITSUBISHI HEAVY INDUSTRIES
/GROUP



Thunder roars, Tranquility sets in.

The almost explosive roar that is accompanied by rumbling when an engine is started up is not unlike the sound of thunder. In April this year, MHI-MME became the first to meet IMO NOx Tier III emission requirements with its low-pressure exhaust gas recirculation (EGR) system installed on a 6UEC 45LSE-Eco-B2 engine in shop testing, something that had been said difficult to achieve through the use of an EGR system alone. Planned numerical values were also achieved in onboard testing on the bulk carrier, Dream Island, in August. This photograph was taken in the deafening quiet of a weekend plant, though there was power hidden within the silence. The low-pressure EGR system will be making its debut, soon, in actual commercial operation.

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C O N T E N T S

MITSUBISHI HEAVY INDUSTRIES MHI GROUP

Message
from the President and CEO

We will aim for an organization with even greater mobility by implementing organizational reform centering on three functions.

MHI-MME was established in October 2013 as a Mitsubishi Heavy Industries Group company specializing in marine machinery and engines. Ever since, the whole company has been working as one, upholding the promotion of Project MEET, globalization and reinforcement of services as our basic managerial strategies. Thanks to these efforts, our visibility has risen among our customers as well as market participants in Japan and abroad. We believe that we are beginning to stand on our own two feet despite the severe market environment.

Meanwhile, with the evaluations and requests of our customers in mind, we implemented organizational reform on October 1, 2015. The aim was to achieve even greater mobility in operating our organization as well as create an organization that can respond to our target priority issues. As compared to the old structure, the reorganization places greater focus on three functions: "planning and administration," "sales and alliances" and "development and design." Although there will be no major changes to the organization and locations of our employees, customers and business partners will be contacted individually by the divisions in charge with further details.

All products and technologies have the following lifecycle: development→design→test production→launch→improvement→maturity→fading out. Within this cycle, achieving a successful launch is the most difficult hurdle that needs to be overcome. MHI-MME's UEC50LSH engine and low pressure EGR system are currently at this stage. They are both off to a good start, and we are looking forward to seeing them become products that achieve long-term growth after going through rigorous evaluations by the market.

The recent inscription of Japanese industrial heritage sites on the World Heritage List has been in the news. One of the sites in the inscription is the giant cantilever crane at MHI's Nagasaki Shipyard & Machinery Works. Built in the UK utilizing what was then state-of-the-art technology, this cantilever crane, which was installed in 1909, is still in use today. In fact, this crane is used to ship MHI-MME products, such as marine boilers, turbines and propellers, from the Works. You could say that it represents interaction between today's cutting-edge technology and state-of-the-art technology from 100 years ago.

President & CEO
Kazuo Soma

10th Anniversary of the UEC-Eco Engine

Ten years have passed since the first UEC-Eco Engine developed by MHI-MME went into service in 2005. To date, 103 engines have been installed in ships. With no major problems being experienced, the UEC-Eco Engine is steadily accumulating a good track record in service performance.

In this feature article, we will look back at the achievements of this engine, which is receiving high customer recognition for its performance and reliability. We will also report on the commissioning of the ship powered by the first state-of-the-art UEC50LSH-Eco engine built.

UEC-Eco Installation Track Record

Over 100 UEC-Eco engines have been installed on ships and are receiving high recognition by customers for their performance and reliability.

The first engine manufactured in the UEC-Eco series – the 8UEC 60LSII-Eco – was installed as the main engine on the Lyra Leader, a large-scale car carrier owned by Nippon Yusen Kabushiki Kaisha (NYK Line). Built by Shin Kurushima Toyohashi Shipbuilding Co., Ltd., the LYRA LEADER is capable of carrying 6,500 cars. Ever since going into service in June 2005, the UEC-ECO engine powering the car carrier has been accumulating a good track record.

UEC-Eco engines have an electronically controlled system that optimally times fuel injection and the opening and shutting of exhaust valves. They are green engines that enable optimal combustion efficiency at any engine load. High fuel-injection pressure can be maintained even at low loads, making continuous operation possible during slow steaming of as low as 20% engine load. The engines reflect market needs and keep fuel consumption low while continually maintaining stable combustion to achieve high performance and reliability.

MHI-MME offers a lineup of UEC-Eco engines with cylinder bores of between 33 and 80 cm. Today we receive inquiries on UEC-Eco engines in the majority of our business talks. MHI-MME will continue to respond to the expectations of our customers toward the UEC-Eco as an engine series that is representative of Japan. We will work towards the further upgrade and expansion as well as the enhanced performance and reliability of UEC-Eco engines.

Engine Type	
UEC80LSE-Eco	**2** sets
UEC60LSE-Eco	**25** sets
UEC52LSE-Eco	**1** set
UEC50LSE-Eco	**8** sets
UEC50LSH-Eco	**7** sets
UEC45LSE-Eco	**37** sets
UEC35LSE-Eco	**4** sets
UEC60LSII-Eco	**17** sets
UEC33LSII-Eco	**2** sets
Total order	**103** sets

As of August 31, 2015

Still operating smoothly after more than 10 years (TRH about 60,000 hours) in service

NYK Line "LYRA LEADER"


6UEC35LSE-Eco


6UEC50LSH-Eco

1988-1997: Research using test engines (research with NC33)

1988: R&D begins

1999-: Research using prototype engines (retrofitting of Eco parts on the 7UEC33LSII)

2003: Development of the UEC60LSII-Eco (in service since 2005)

1990 1995 2000 2005 2010 2015 year

First Ship Powered by the UEC 50LSH-Eco Engine Begins Service

MHI-MME has been developing the UEC 50LSH-Eco as a state-of-the-art engine that thoroughly incorporates the cutting-edge technology that it has cultivated to date. The engine meets increasingly higher market needs, including reduced fuel consumption, slow steaming and low engine-load capabilities and compliance with emission regulations. Onboard testing of the first 6UEC 50LSH-Eco-C2 engine, delivered to the customer after completing shop tests in March this year, was completed in August. The ship that was installed with this engine went into service without any complications.

In designing the UEC50LSH-Eco engine, MHI-MME began by considering principal particulars on the basis of thorough market research. As a result, the engine power output and speed were adjusted to those suitable for chemical tankers, handymax bulk carriers, supramax bulk carries and medium range tankers.

Following the aforementioned first engine, MHI-MME has been receiving consecutive orders for the engine for service as the main engine of chemical tankers. There are also many inquiries being received. Going forward, we will thoroughly use the information we obtain related to the state of operation of the ship powered by the first engine to further improve the engine.

Table 1. Principal Particulars of the UEC50LSH-Eco Engine

Type		6UEC50LSH-Eco-C2
Cylinder bore	mm	500
Piston stroke	mm	2,300
Stroke / bore	-	4.6
Engine output	kW	10,680
Revolution	min-1	108
Mean effective pressure	MPa	2.19
Fuel consumption rate	g/kWh	164
Weight	Ton	225

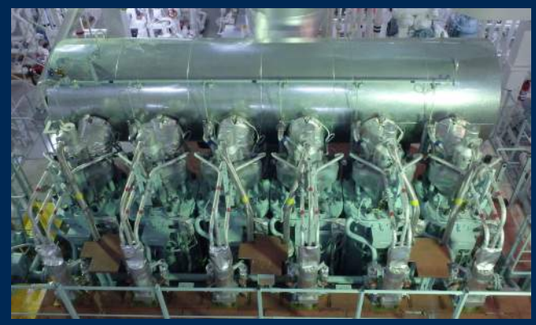
User Evaluation: Nippon Yusen Kabushiki Kaisha

(Mr. Kobune Goto, Corporate Officer and GM of the Marine Group)

In 2005, the NYK Line installed the UEC LSII-Eco engine on one of its car carriers. In addition to its great fuel efficiency, which is one of this engine's selling points, I think that the concept of reducing the generation of black smoke during engine start-up was very innovative at a time when we in the auto carrier units were under pressure to come up with countermeasures for the black smoke generated during berthing and unberthing.

I do recall that because it was the first UEC LSII-Eco engine, we did experience some birth pangs at the time, such as insufficient alignment, minor problems and lack of enough crew members who were proficient in the engine. However, MHI (as engine manufacturer), the NYK Line (as ship owner) and NYK Shipmanagement (as ship manager) worked together and resolved various problems.

It has been 10 years since this carrier went into service. It has steadily accumulated a good track record, which has been recognized. There are an increasing number of our ships powered by this engine. The appreciated prices of ship bunker fuel of recent years make slow steaming necessary for different ship types. The Eco engines, which enable the timing of fuel injection to be adjusted, are engines that can be said to be meeting slow steaming needs. Although the environment surrounding shipping companies is becoming increasingly harsh, we hope to see these engines become an engine that is representative of Japan and increases the competitive edge of Japanese shipping companies.


The engine installed on the ship

Technology Supporting IMO Tier III NOx Emission Requirements

The World's First Low Pressure EGR System
Installed in a Bulk Carrier Built by Hakodate Dock

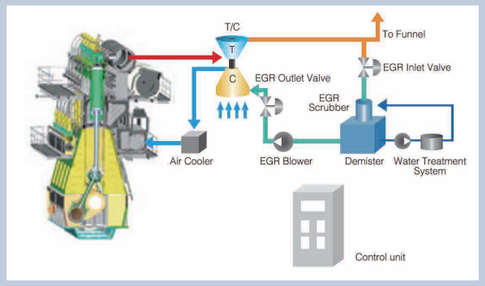
MHI-MME's low pressure exhaust gas recirculation (EGR) system is a technology that will enable compliance with IMO NOx Tier III emission requirements, which will be applied to ships keel laid on or after January 1, 2016. By re-circulating some of the exhaust emitted by an engine, the system suppresses the generation of NOx by changing the combustion conditions within the engine. MHI-MME's EGR system was developed with support from ClassNK's "Joint R&D with Industries and Academic Partners" scheme.

It is a low-pressure EGR system that re-circulates low-pressure exhaust from an engine turbocharger outlet to the turbocharger intake gas. It has a simpler system configuration and is more compact than a high-pressure EGR system, which utilizes high-temperature high-pressure exhaust from a turbocharger inlet. Other advantages are that it keeps both initial and running costs lower.

It had been said that reduction of NOx emissions to Tier III levels would be extremely difficult using only an EGR system. However, it had been confirmed possible using a test engine during the development process. In April this year, the MHI-MME EGR system was installed on a 6UEC 45LSE-Eco-B2 engine at Kobe Diesel Co., Ltd. for shop testing through which confirmation was made that the desired performance could be achieved as planned. This included NOx emission levels and a less than 1% loss of fuel efficiency as compared with the Tier II version. The engine has received a certificate of conformity to Tier III requirements.

In August, test installation of this engine was made on the 34,000 DWT bulk carrier "Dream Island" (ship owner: Shikishima Kisen K.K.) built by The Hakodate Dock Co., Ltd. Confirmation was made that the desired performance could also be achieved as planned in onboard testing.

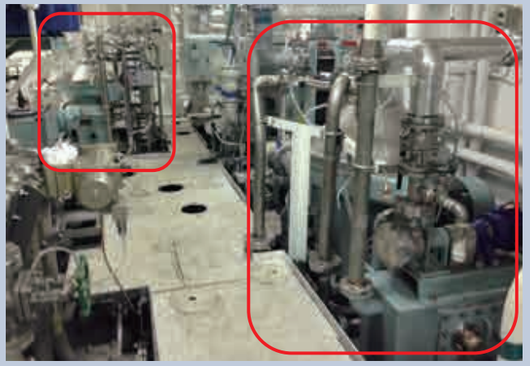
This is the first time worldwide that a Tier III-certified low-pressure EGR system for slow-steaming marine diesel engines was installed on a ship. With the cooperation of Shikishima Kisen K.K., NYK Bulk & Projects Carrier Ltd. (which operates the ship) and Nippon Yusen Kabushiki Kaisha, the system's actual operability, in terms of logistics, operation and other elements, will also be verified during the long-term durability testing that is currently taking place. Overall system optimization will be promoted in preparation of future business talks.



Low pressure EGR system (concept diagram)

Shikishima Kisen K.K. "DREAM ISLAND"

As installed on the bulk carrier



Installed water treatment system

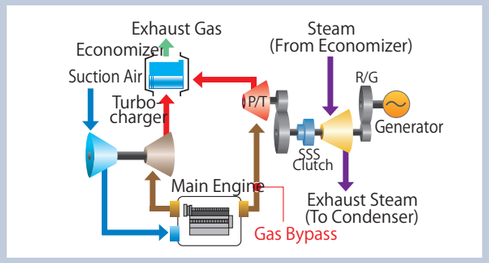
A.P.Moller Maersk

Orders Received for a Waste Heat Recovery System for Large Container Ships

In August 2015, MHI-MME received orders for main engine waste heat recovery systems (WHRS) to be installed in eleven 19,630 TEU container ships to be built by Maersk Line. This system was previously installed in 20 Maersk Line Triple-E class container ships, which boast the highest efficiency in the world and are also among the largest. This is the fourth Maersk Line container ship series on which MHI-MME's WHRS is being installed.

The WHRS is a revolutionary energy-saving, green solution that reuses energy from a main engine's exhaust gas to generate electricity. Orders for installation on87 ships have already been received from around the world. Of them 64 ships are already in service. Stable results are being seen in these 64 ships in operation, and the WHRS is making a large contribution to improving efficiency.

MHI-MME's WHRS, which was developed by mobilizing the expertise amassed by the company over the years, has proved to be an enormous hit and boasts a global market share of over 90%.



WHRS diagram

Organic Rankine Cycle (ORC)

System Development Completed

MHI-MME has completed system development of the Hydrocurrent TM Organic Rankine Cycle (ORC) Module 125EJW, as a low temperature heat recovery system.

With an output of 125 kWe, plant testing of the pilot module has been completed by Calnetix Technologies, which is MHI-MME's partner in the U.S. Approvals from ClassNK and Lloyd's Register were obtained in 2015. Going forward, MHI-MME will evaluate the various data collected through onboard testing to confirm the module's performance and reliability at sea.

The ORC captures the waste heat from the main engine's jacket water (about 85°C) and converts it into electricity. It reduces CO2 emissions by lowering the burden on the ship's diesel generator. Ships utilizing the ORC can expect an improvement in ship power plant efficiency.

(Hydrocurrent is a trademark of Calnetix Technologies.)

ORC module (125EJW)

Based on the registration of over 20% of the world's merchant vessels and their technological cooperation, ClassNK supports the development of various cutting-edge technologies and is committed to the safety of ships and protection of the marine environment as well as the growth of maritime industries.

[Nippon Kaiji Kyokai (ClassNK)]

Executive Vice President

Mr. Yasushi Nakamura

Interviewee: Yasushi Nakamura, *Executive Vice President, ClassNK*

Interviewer: Masahiko Okabe, *Head of Technology Integration & Project MEET Development Department, Mitsubishi Heavy Industries Marine Machinery & Engine Co., Ltd.*

Saori Suzuki, *Strategic Planning Group, Business Development, Mitsubishi Heavy Industries Marine Machinery & Engine Co., Ltd.*

— Thank you very much for accepting this interview. Today, we'd like to ask for your opinion on the present and future of maritime affairs in general from your position of providing support to the overall maritime industry. First, when we think of ClassNK, we tend to think of the enactment, revision or abolition of ClassNK rules and regulations, certification of ships and ship installations and ISO audits. However, I understand that ClassNK is involved in much more.

Mr. Nakamura: Yes, that's right. However, that is something that is not very well known. So, when I was asked to do this interview, I was very happy to accept because I thought that it presented a wonderful opportunity to talk about the full range of ClassNK activities related to the overall maritime industry.

ClassNK's traditional operations include the basic operations of presenting, as ClassNK regulations, the functional and structural requirements of equipment and machinery to be installed on ships, and the registration of ship and ship installations that fulfill the regulations. We also leverage the technical expertise that we have nurtured over the many years of carrying out ship classification surveys to provide a variety of technical assistance services toward ship owners.

In addition to these basic activities, a new, major pillar of our operations in recent years is to provide support for the development of technologies for various sorts of R&D sought by the maritime industry.

As a recent example, we quickly responded to the movement in relation to the Energy Efficiency Design Index (EEDI) regulations, which are aimed at reducing ships' fuel consumption, and established the EEDI Department. We promoted the development of technology for the reduction of fuel consumption and commenced certification and certificate issuance.

At $650/ton, bunker fuel costs were extremely high around the time that the EEDI Department was launched and were straining operating expenses. Ship owners want to reduce operating expenses by any means, and this dovetailed with the direction being taken by the regulation-formulating IMO and others. Bunker fuel prices are lower compared to then. However, based on forecasts, we believe that providing support for the development of EEDI regulation-related technologies is a highly substantive service.

The implementation of EEDI regulations was originally led by the IMO. However, ClassNK was able to provide technological support toward engine manufacturers in the development of super energy-efficient engines, waste heat recovery systems and other technologies that improved the heat efficiency of the whole ship. ClassNK was able to cooperate with activities to reduce EEDI values in the form of providing support toward related R&D.

Furthermore, by presenting such results at regularly scheduled debriefing meetings and so on, we developed the activities into those to announce EEDI-related improvements. These became prime opportunities to talk about EEDI value reduction and ClassNK's activities on a global scale. This is an example of a case that proceeded very well.

Your waste heat recovery system (WHRS) is now installed in many mega containers. ClassNK is currently carrying out activities to promote its adoption by explaining its usefulness.

— Yes, we are aware of it. We appreciate your activities very much.

Speaking of IMO regulations, implementation of NOx Tier III regulations will begin in 2016. This is something that is often covered in ClassNK's technological support programs, isn't it?

Mr. Nakamura: Yes, that is correct. However, whether Tier I, Tier II or Tier III, the objective of the NOx regulations is to reduce the emission of NOx gases, and fuel efficiency is actually worsening. Many ship owners are having a difficult time figuring out how to improve the worsened fuel efficiency.

Furthermore, the upcoming Tier III regulations are very stringent. It makes it difficult to meet the Tier III standards by simply improving the engine itself. An issue for shipyards and manufacturers is the problem of the engine room layout. In addition to NOx reduction technology, the equipment to enable it must be able to fit into the engine room. In other words, the product needs to be compact. This is something that is being required of not only your company but other manufacturers as well.

As far as ClassNK is concerned, in terms of regulations, we will implement revisions, etc., to meet NOx Tier III standards, and also provide cooperation from the aspect of R&D so that technology can be established to fulfill those regulations and incorporated into machinery designs.

— The low-pressure exhaust gas recirculation (EGR) being developed by MHI-MME is also receiving ClassNK's support. We are currently carrying out onboard testing of the system. Going forward, we will be confirming its reliability through the verification of the low-pressure EGR system technology through ships in actual operation. The technology itself is straightforward and has the potential of keeping the worsening of fuel efficiency to a minimum while also improving fuel economy.

Mr. Nakamura: ClassNK is supporting your company's low-pressure EGR technology as part of the Joint R&D

The EEDI Department Established in Response to Movements in Energy Efficiency Design Index (EEDI) Regulations Commenced Certification and Certificate Issuance while Promoting the Development of Technology to Reduce EEDI Values

Cooperation Provided to Manufacturers for NOx Tier III from the Aspect of R&D Support to Be Promoted for the Further Enhancement of Low-pressure EGR Technology

with Industries scheme. As you said, the technology for low-pressure EGR is first shop verified, followed by verification in an actual ship environment. Step-by-step technological development is required. However, ship owners desperately want to lower fuel consumption at the same time. Therefore, we plan to continue the provision of support so that the technology can be enhanced from this aspect of fuel efficiency.

We hope to see the development of technology by your company that will lower both NOx emissions and fuel consumption, which is something that the maritime industry is anxious to see realized, and its commercialization. ClassNK will continue to be proactively involved in the provision of support for the development of technologies that is requested by the maritime industry. Let us promote such development while actively exchanging views.

— Thank you for such very encouraging words. We look forward to continuing to work with ClassNK.

We'd now like to move on to the use of big data in the management of ship operations. ClassNK has been very proactive in this area, from the acquisition of Napa Ltd. to the plan to establish a data center?

Mr. Nakamura: Yes, we have. This is because we believe that the sophistication of ship maintenance itself is necessary to ensure safe and energy-efficient operation of ships. ClassNK has been proposing its

ClassNK CMAXS system for the detection of instrument anomalies and preventive maintenance, so in that sense, systems have been completed for certain equipment. However, we were able to develop a cooperative relationship with Japanese equipment manufacturers and engine manufacturers, so we would now like to develop the system globally as a ClassNK business model.

We would like to carry out talks with many engine manufacturers, including your company, as well as European licensors and involve engineers who are designing engine maintenance programs. We have in sight cooperation with manufacturers around the world so that we can update it into a system that optimizes maintenance of main engines, auxiliary engines and many other equipment installed in ships that are operating around the world.

The ClassNK CMAXS system was an early adopter of ANACONDA (IBM Anomaly Analyzer for Correlational Data). Countermeasures were proposed in cooperation with equipment manufacturers that posses various core technology. It is a program that forecasts possible problems in advance and determines the appropriate timing for maintenance. It is already complete as a system, and we believe that ClassNK's role is to make its use widespread in the maritime industry. We would also like to expand the instruments that the system can be applied to.

Besides this system for the detection of instrument anomalies and preventive maintenance, ClassNK has jointly developed ship operation optimization software with Napa, which has already been installed in many ships. This operation optimization software also incorporates weather routing. Minimization of consumed fuel can be made through the input of data regarding the continually changing weather conditions and currents that the ship is navigating so that it can arrive safely at its destination, on time and with no delays.

So, as you can see, ClassNK owns two systems—the system for the detection of instrument anomalies and preventive maintenance, and the operation optimization software. Innovation in ship operation technology will advance, both in terms of operation and maintenance, by using the ClassNK data center to provide to manufacturers data collected by participating shipping companies (for example, engine performance during operation at sea). How is a particular item performing? What are the problems that might arise? That is the kind of data that will be collected and provided to manufacturers. We therefore hope to see manufacturers make effective use, according to product, of the provided data, and carry out further development of technologies.

One thing that I would like to make clear here is that we would not be providing raw data owned by each shipping company freely to manufacturers. Instead, ClassNK would summarize the data regarding the performance of each main engine series to ensure that specific ships cannot be

identified. We would get the ship owner's approval on the relevant data, which would then be passed on to the manufacturer that produced the particular item. We would not be giving any manufacturer unlimited, free access to all data.

— I see. That is grand vision. The use of big data is a challenge that has been difficult for a company to make into a business on its own. Can you tell us the significance of establishing a data center as ClassNK?

Mr. Nakamura: Simply put, ClassNK is not aiming to make the improvements themselves. Instead, we are providing an infrastructure. We want to create a pipeline. As you say, we will be establishing a data center to provide quantitative data, which was not available before, related to the performance of equipment onboard a ship at sea. The data would be provided with the ship owner's permission to the manufacturer of that particular piece of equipment. There will probably be many aspects of development based on such data that will create competition between manufacturers. ClassNK will only provide the stage for such competition, staying outside of the stage itself. In fact, we hope to promote advancement of the maritime industry by offering the stage for competition. This is a plan that we would implement beyond the bounds of global ship classification. We hope to see participation by ships that have received its classification from organizations other than ClassNK as well.

Ships use a diverse range of products including engines, turbochargers, boilers, turbines, incinerators, fin stabilizers, steering gear and pumps. Your company provides many products. As such, we at ClassNK hope that your company will become one of the front runners by making proactive utilization of the useful data that will be provided.

— We'd now like to ask you about the development of human resources who will take charge of the maritime industry in the future. ClassNK reported in its business plan collaboration with Japanese and overseas research organizations, did you not?

Mr. Nakamura: There are different aspects to securing and developing personnel for a ship classification society and doing the same for a company in the general maritime industry. Because the way that new university graduates are recruited as employees differ from company to company, this may not apply to all cases, but as far as ClassNK is concerned, we promote R&D projects in collaboration with universities in Japan and elsewhere as part of its globalization initiative.

In Japan, we carry out joint research with Professor Koji Takasaki of Kyushu University. Overseas, joint research projects are implemented with the Technische Universität München (Technical University of Munich) and the National University of Singapore. We provide support for university research related to maritime affairs in these ways. There is a need to imprint the maritime industry to talented individuals through such activities and make them interested in ships and maritime affairs.

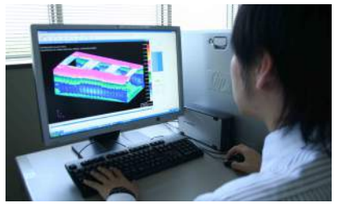
By the way, ClassNK's policy toward the recruitment of new university graduates is that they majored in the sciences and are resilient, creative thinkers.

— Lastly, could you please give us your views on our maritime products?

Mr. Nakamura: Your company leads the pack when it comes to the number of marine machinery and engine products available. Under such circumstances, I think that your Project MEET is very good as a solutions business. I think the fact that you have developed engines, boilers, turbines and other products in-house shows one of the strengths of the Japanese maritime industry. Of course, it also contains the element of risk dispersion.

I hope to see your company continue to engage in the sophistication of your product lines—in other words, keep up your efforts to develop technology that can compete with major overseas manufacturers. ClassNK positions the provision of support for the development of required technology as a request from the industrial circle. It will provide proactive related support to your company, as it does to other Japanese manufacturers of maritime products as well.

— We thank you very much for your very kind compliments and words of encouragement. MHI-MME would also like to do its utmost for the growth of the maritime industry. We look forward to your continued cooperation. Thank you very much for taking time out of your business schedule today.



System Management of Operation and Engine Diagnosis Utilizing Big Data Aims for the Advancement of the Maritime Industry through Establishment of a Data Center

Kobe Diesel Co., Ltd.

Cumulative Total of 2,000 UE Engines Manufactured

神戸発動機株式会社
KOBE DIESEL CO., LTD.

Kobe Diesel Co., Ltd's current Head Office Plant (Futami-cho, Akashi, Hyogo Prefecture) began operations in 2006. With the plant celebrating its 10th anniversary next April, the company took a new step towards the milestone with Mr. Michio Shimizu assuming the post of Representative Director and President in June 2015.

Kobe Diesel is an MHI-MME licensee that has manufactured a total of 2,000 UE engines (17,000,000 PS) ever since concluding a technical tie-in agreement with Mitsubishi Heavy Industries in February 1957.

Founded in 1910, Kobe Diesel gradually expanded its operations after the company's superior technological capabilities were recognized through its success in the development and manufacture of Japan's first Borinder-type petrol engine. Beginning with the start of the manufacture of a four-stroke diesel engine in 1938, the company specialized in the development and manufacture of marine engines. Later, under the UE engine lineup license agreement, Kobe Diesel has consistently focused its strengths on the development and improvement of UE engines. It includes development of the C-series, which is a further improved version of conventional UE engines, production of the world's first two-stroke, two-stage turbocharging engine and manufacture of a NOx emission regulation compliant engine. Kobe Diesel has been serving a pioneering role as a marine engine manufacturer.

Especially since 2009, the company has delivered more than 150 UEC 45LSE series engines, with a backlog of more than 10 units. In recent years, Kobe Diesel manufactured the first UEC 35LSE-Eco and UEC 50LSH-Eco engines, carrying out verification testing with MHI-MME, and it manufactured the UEC 45LSE-Eco installed with a low-pressure EGR system as IMO Tier III capable technology. The company's relationship with MHI-MME goes beyond that of licensee and licensor. Kobe Diesel is becoming the "mother" plant for first engines in the UE engine lineup and the verification of new technology.

MHI-MME will continue to maintain and develop its close collaborative relationship—including technological collaboration and joint development and manufacturing—with Kobe Diesel Co., Ltd., which is a partner that responds immediately to customer needs and speedily provides high value-added products. With Kobe Diesel as a partner, MHI-MME will continue to engage in efforts towards further energy-efficiency, environmental-friendliness and high reliability of UE engines.


Michio Shimizu, President

Bird view of Futami-cho Head Office Plant


Inside the Plant

High-performance Auxiliary Boiler MAC-HB Series

MHI-MME utilized the characteristics of the two-drum water-tube boiler and developed the MAC-HB auxiliary boiler, which follows the design of a highly-reliable standard model while significantly improving boiler efficiency. The MAC-HB received high evaluations from its launch and has already been adopted for use in four ships. Firm orders have been received for a further 12 units this year, and there are many still under negotiation. The MAC-HB auxiliary boiler series has six evaporation capacities ranging from 35 to 60 tons per hour. As with the standard model, the MAC-HB has a problem-free, durable structure that requires almost no maintenance. It is a new type of boiler that can achieve a significant reduction in the amount of fuel consumed.

Boiler Performance Table

Boiler model no.	No. of ships	Ship type	Production status
MAC-H60B	4	Oil tanker	Delivered
MAC-H35B	6	-	Order received
MAC-H40B	6	-	Order received
MAC-H45B	6	-	Order received


MAC-H60B

Characteristics

- Improves boiler efficiency by up to 6%.
- Enables a reduction of up to 8,000 dollars(about 960,000 yen) in fuel costs in a single unloading of cargo at port.
- Retains the superior durability of a two-drum water-tube boiler while ensuring low maintenance costs after service at sea.

Structure

- The heat-transfer coefficient has been improved by 5% and heat-transfer area expanded by 30% through a change in the configuration of the boiler's heat-transfer tubes.
- A sturdy furnace with water-cooled walls allows the use of any kind of fuel.
- The heat-transfer tube array has no increase in soot adhesion because the diameter of the bare tube was reduced while keeping the grid arrangement.
- The heat-transfer tubes are supported in the middle and are unaffected by roll and pitch or vibration of a ship.

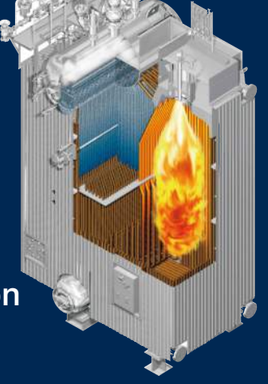


Diagram-1 MAC-HB Auxiliary Boiler

Benefits during construction and operation

- The external dimensions of the boiler are nearly the same as that of the standard boiler (Diagram-1).
- Reduced auxiliary particulars and decreased power consumption as compared with the standard boiler.
- Reduced boiler operation costs during outfittingand test operation.
- Fuel cost reduction increases in accordance with the number of annual cargo unloading operations and fuel prices. (Diagram-2 shows cost reductions as compared with the standard boiler)
- Standard low sulfur diesel oil (LSDO) capability-a requirement in designated SOx emission control areas.
- Standard adoption of highly functional, easy-to-operate, highest-level control devices.

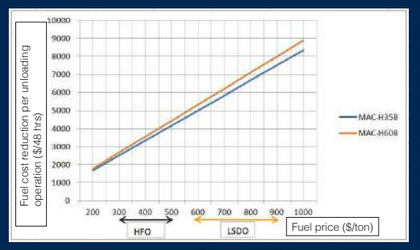


Diagram-2 Fuel cost reductions

Additional benefits

- Can be changed to a gas-fired boiler.

Sites of Japan's Meiji Industrial Revolution:
Iron and Steel, Shipbuilding and Coal Mining Inscribed on the World Heritage List

Mitsubishi Nagasaki Shipyard & Machinery Works

Tradition and the Spirit of Innovation Being Passed Down to the Future

Photo courtesy: Mitsubishi Heavy Industries, Ltd.

The Mitsubishi Nagasaki Shipyard & Machinery Works began as the Nagasaki Yotetsusho Foundry, which was built in 1857 during the Edo period at the request of the Tokugawa Shogunate. It underwent several name changes (Kan'ei Nagasaki Seitetsusho (National Nagasaki Ironworks; 1868) and Kobusho Nagasaki Zosenkyoku (Ministry of Industry Nagasaki Shipbuilding Bureau; 1883)) under the Meiji government before the business was succeeded by Yubin Kisen Mitsubishi Kaisha (Mitsubishi Mail Steamship Company) in 1884. Since then, a history of more than 130 years has been accumulated at the shipyard.

The World Heritage Committee inscribed the Sites of Japan's Meiji Industrial Revolution as a UNESCO World Cultural Heritage in July this year. Among the 23 component sites located in three regions of Japan, MHI's Nagasaki Shipyard & Machinery Works, along with Yawata Works (Nippon Steel & Sumikin Stainless Steel Corporation), is a site that continues to be in operation today. In this special feature, we will take a look at five assets related to the Nagasaki Shipyard & Machinery Works that formed a foundation for the current Mitsubishi Heavy Industries Group, and trace the source of the tradition and spirit of innovation that we should pass on to future generations.

First completed in 1905, various shipbuilding-related facilities, which were cutting-edge at the time, were completed in quick succession at the Nagasaki Shipyard & Machinery Works. It included the No.3 Dry Dock, which is still in use today; Japan's first ship model testing tank; the No.1 power-generating turbine unit with an output of 500 kW; gantry cranes on building berths; and the giant cantilever crane. The shipyard is a witness to the history that supported Japan's technological innovations and rapid industrialization during the Meiji period. At the same time, it is an operational asset that represents the spirit of innovation that has been passed down through the ages at the Mitsubishi Heavy Industries Group.

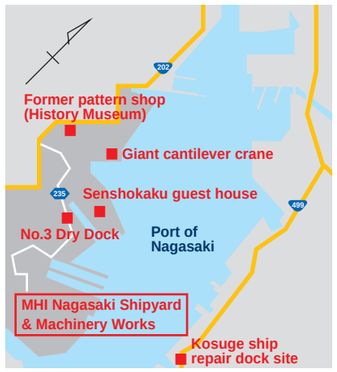
Of the five MHI-related assets of the Sites of Japan's Meiji Industrial Revolution inscribed on the World Heritage List, four are located within the Nagasaki Shipyard & Machinery Works' Main Plant, which was Japan's first full-fledged Western-style factory. The fifth is located on property owned by Nagasaki Shipyard & Machinery Works. If you climb to a bluff overlooking the Port of Nagasaki and look at the bay, you will see those assets dotting the area alongside the beautiful blue of the sea and greenery of the peninsula. The achievements of our predecessors display the forefathers' enterprising quality, attitude of continually pursuing challenges, and spirit of innovation. They are also heritages of a spirit that is shared by the Mitsubishi Heavy Industries Group, which has its origins here at the Nagasaki Shipyard & Machinery Works.

■ Kosuge Ship Repair Dock Site (And Winch House

※Winch House Interior Closed to the Public)

The Kosuge ship repair dock was built in 1869 by the Satsuma Clan and Scottish merchant Thomas Blake Glover. It is Japan's first Western-style slip dock equipped with steam-powered winches. After acquisition by the Meiji government, ownership was later transferred to Mitsubishi Heavy Industries in 1887. Since it was first built, the Kosuge ship repair dock was used for more than 80 years until it was finally closed in 1953 due to the growth of ship sizes. It was designated a historical site by the Japanese government in 1953. The dock's ship cradle (no longer in existence) was shaped like an abacus. For this reason, the Kosuge was commonly called the Abacus Dock.

The winch house that contains the winches is the oldest, full-scale brick building still in existence in Japan. It is made of what is known as Hardes bricks, which are thinner than today's bricks. The method of baking these bricks was taught to the Japanese by Hendrik Hardes, a Dutch naval engineering officer. The winch house interior still contains the gear device and boiler.



■ Giant Cantilever Crane (Closed to the Public)

Japan's first electric crane of its kind, this giant cantilever crane was assembled and erected in 1909. It was imported from Scotland, which boasted state-of-the-art technological capabilities at the time. Although it is the world's oldest existing crane of the same model, it is still in use today. Along with the No.3 Dry Dock, the giant cantilever crane was included among Japan's first operational assets inscribed on the World Heritage List.

The crane is 61.7 meters high, soaring high above the Port of Nagasaki. It boasts a lifting capacity of 150 tons. Since it first went into operation, the crane contributed to the Japanese shipbuilding industry in its use primarily for loading or unloading heavy marine machinery. Today, it continues to be used actively for loading the steam turbines and propellers for large ships that have been manufactured at the Mitsubishi Hitachi Power Systems, Ltd. Nagasaki Plant.

One of the differences with modern cranes is the positioning of the crane cockpit. The crane cabin, which contains the cockpit, is at a height of 56 meters. To get there, the operator must climb a stairwell with 223 steps. Furthermore, because the motor that swivels the crane is the original direct-current motor, there is a possibility of a short out if not operated correctly. Both stamina and technical skills are required of the crane operator.

■ Former Pattern Shop (History Museum)

Constructed in 1898 as a wooden pattern shop on foundry premises, this brick building is the oldest plant structure within the Nagasaki Shipyard & Machinery Works. In 1985, it was converted into the History Museum introducing the history of Nagasaki Shipyard & Machinery Works. Today, it is the sole building within the premises that is open to the general public. On exhibit are historical materials from the days when the shipyard was government-owned, photographs of ships built, marine machinery and engines, power generation plants and other materials totaling about 900 items.

One of the first things that catch a visitor's eye is a 4.5 ton diving bell, an apparatus for underwater work. It was used for the construction of the Nagasaki Yotetsu Foundry, a predecessor of the Nagasaki Shipyard & Machinery Works. Also on site is Japan's oldest machine tool known as a slotter (registered as an important cultural property) and Japan's first onshore steam turbine (registered as a mechanical engineering heritage). It is a valuable historical museum that shows the origins of Mitsubishi's manufacturing. Also on display are materials related to Yataro Iwasaki, the founder of Mitsubishi. Reservations for visits to the museum as well as phone inquiries have increased sharply since inscription on the World Heritage List. Since July 1, 2015, the museum is now open seven days a week and on holidays, accepting a great number of visitors from the general public.

■ Senshokaku Guest House (Closed to the Public)

Senshokaku is a two-story English-style wooden structure built in 1904 as the company-owned home of Heigoro Shota, who was the second Director of the Nagasaki Shipyards. It is situated on the north side of a hill overlooking the No.3 Dry Dock. The building was designed by Tatsuzo Sone, who studied Western-style architecture from British architect Josiah Conder. The total floor area of the structure is about 185 square meters. It contains a dining room, reception and study on the first floor, with bedrooms and a hall on the second floor. The kitchen is on the basement floor. Furnishings were high-end items of the time that were imported from England. The name "Senshokaku" was given by Marshal-Admiral Prince Higashifushimi Yorihito when he stayed at the house in 1905. It means that it occupies a place of great scenic beauty. Artwork presented to Sone from the Prince is also on display within.

It has been used over the years as a guesthouse for entertaining distinguished visitors from Japan and abroad, playing a role in supporting the modernization of Japan. Among them was Sun Yat-sen, the founding father of the Republic of China. A framed piece of calligraphy of the word "Senshoka-ku," which was written by Sun Yat-sen upon his visit to Nagasaki in 1913, adorns the structure's entrance hall. It is still used today as a guest house for the Mitsubishi Heavy Industries Group and is the venue for tours and lunches by business-related VIPs as well as for gala banquets for ship christening and delivery ceremonies.

■ No.3 Dry Dock (Closed to the Public)

Completed in 1905, the large-scale dock is still in use after the passage of 110 years. As the largest dock in the East at the time, it was originally constructed for building and repairing large ships. As the sizes of the ships being constructed became larger, the dock has undergone expansion work three times since. However, the stones laid at the center of the dock floor are the original, retaining the extremely sturdy form of the dry dock.

The British-made 4,000 ton drain pumps (three units), which were installed when the dry dock first opened, are still in use today. They are an essential facility and are in full operation for in-dock work on naval vessels and commercial ships.

A characteristic of the No.3 Dry Dock not found in other docks at the shipyard is that the bottom of the dock has the same camber curvature as that on ship decks to drive water to the sides. As for the large-scale drain pumps, they are extremely durable with very few breakdowns having occurred in the past 40 years or so, according to confirmable records.

The dry dock has, without doubt, lived up to its reputation in being inscribed on the World Heritage List as Japan's first operational asset.

News from MHI-MME Offices Abroad

Mitsubishi Heavy Industries Asia Pacific Pte.Ltd.

Marine Machinery & Engine Business Unit

Shinichiro EGASHIRA, Manager

The MHI-MME Singapore Office has been launched in April 2011 as the Southeast Asian after-sales service base for the large marine diesel engines manufactured by Mitsubishi. In April 2014, the office was reinforced with the addition of a marine machinery service engineer. Today, we handle all MHI-MME products (UE engines, main engine turbines and main boilers, power-generation turbines, auxiliary boilers, turbochargers, propellers, steering gears, fin stabilizers, offshore turbines and boilers) between the two of us.

My primary duties are handling new manufacturing projects and handling after-sales service orders. In regards to new manufacturing, I introduce our various engines and machinery with a focus on new products and solutions centered on environmental-friendliness and energy efficiency. As for after-sales services, because we are in Singapore, one of the world's leading port cities, we see many highly urgent requests for servicing arise. Depending on the situation, I will visit the ship with a local authorized repair agent. From confirmations of the state of engines and machinery to the implementation of maintenance, we do our best to ensure that we can provide detailed services.

We will continue to do our utmost each day to respond to the diverse needs of our customers. We look forward to serving you, so please feel free to contact us if you have any questions.

MHI-AP exterior

From left: Shinichiro Egashira (Manager) and Katsuhiko Tatsumi (General Manager)

NEW ORGANIZATIONAL STRUCTURE

New Organizational Structure Launched

Up to now, we have had the Marine Machinery Division and the Marine Engine Division at the center, along with corporate departments and Business Development, which handled planning and sales administration. This has been reorganized with "planning and administration," "sales and alliances" and "development and design" functions at the center, with the aim of achieving even better function-oriented organizational operation as a company, going beyond products and office locations. The new structure is effective October 1. Please note that there will be no major changes to the locations of the contact points or individuals in charge of customers and business partners.

<New Organizational Structure>

- President & CEO (Shinagawa)
  - Quality Management Department (Nagasaki)
  - Corporate Planning Department (Shinagawa)
  - Sales Strategy Headquarters (Shinagawa)
    - Marine Sales (Shinagawa / Nagasaki)
    - Services Planning Department (Nagasaki)
  - General Business Headquarters (Nagasaki)
    - Technology Integration and Project MEET Development Department (Kobe)
    - Marine Machinery Division (Nagasaki)
    - Marine Engine Division (Kobe)

Primary locations are shown in parenthesis

<Organizational Structure before Change>

- President & CEO (Shinagawa)
  - Quality Management Department (Nagasaki)
  - Administrative Management Department (Nagasaki)
  - Technology Integration and Project MEET Development Department (Shinagawa)
  - Business Development (Shinagawa)
  - Business Operation and Alliance Department (Shinagawa)
  - Marine Machinery Division (Nagasaki)
    - Business Management Department (Nagasaki)
    - Engineering Department (Nagasaki)
  - Marine Engine Division (Kobe)
    - Business and SCM Development Department (Kobe)
    - Designing and Service Engineering Department (Kobe)

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