OPERATING **BASE JAPAN**

Network

Service Business Department, MHI-MME Co., Ltd.

The Service Business Department plays a coordinating role in the provision of overall after-sales services for MHI-MME marine machinery products. The department responds to every customer need, dispatching engineers to handle maintenance and machinery-related problems, arranging for parts, exchanging major parts and coordinating retrofitting projects. The Service Business Department also provides solutions for meeting environmental regulations or lowering ship operation costs. After-sales services for equipment manufactured by licensees are also part of the department's tasks.

Although it is based in Japan where the product divisions are located, it also works closely with expatriate employees stationed abroad (London, Singapore, Shanghai, Busan and Los Angeles) as well as with overseas and Japanese service partners. The department endeavors to provide speedy response with an emphasis on seeing matters from a customer's viewpoint. It provides customer support that enables safe sailing and proposes maintenance that matches a product's lifetime.

OPERATING **BASE ABROAD**

Mitsubishi Heavy Industries Europe, Ltd.

Deputy General Manager Aota, London Office

From 2008, I was in charge of the development and design of new models, with a focus on UE Engine moving parts, hydraulic equipment and gears. I was stationed overseas for the first time in July. Going forward, I will work at the frontlines in Europe and serve as a bridge between Europe and Japan to deliver customer opinions learned through negotiations for the production of new engines as well as after-sales services. I will also aim to provide swift customer support.

Mitsubishi Heavy Industries Asia Pacific Pte. Ltd.

Deputy General Manager Jimichi, Singapore Office

My name is Jimichi, and I am stationed in Singapore. I relocated here in July from MHI Europe (London), where I was stationed for two years. I am primarily in charge of two-stroke main diesel engines. I would like to look at things from the customer's perspective and position as I engage in my work. Please feel free to contact me about anything, no matter how small!

Mitsubishi Heavy Industries, (Shanghai) Co. Ltd.

General Manager Du, Shanghai Office

My name is Du, and I am stationed in Shanghai. Before coming here, I handled the proposal sales of off-grid power systems, alliance-related work and marine product sales. I am confident in my ability to build relationships of trust with customers. I have been engaged in sales activities, devising new ways and repeating the process of continual study and improvement of sales techniques, from talking in ways that suit each customer to proposal methods. I am now working in Shanghai, which is the closest to customers than I have ever been. I would like to form even deeper relationships with customers and communicate to customers just how wonderful MHI-MME products are.

MHI Korea, Ltd

Manager Sakamoto, Busan Office

Annyeonghaseyo? My name is Sakamoto from MHI Korea. I have been stationed in Busan, South Korea, since April 2015 and am in charge of marine engines. Before being dispatched here, I was engaged in the design and development of turbochargers. In fact, most of my work here is also focused around turbochargers. I am doing my utmost in dealing with Korean shipyards and engine manufacturers as well as providing licensing support, and in responding to the needs of shipowners.

Mitsubishi Heavy Industries America.Inc.

Group Manager Tsuji, Los Angeles Office

MEET NEWS 10th Issue

NEW-0007E (16-10)

For inquiries, contact:
Mitsubishi Heavy Industries Marine Machinery & Engine Co., Ltd.
16-5 Konan 2-chome, Minato-ku, Tokyo 108-0075
(Mitsubishi Heavy Industries Building)
E-mail: info_meet@mhi-mme.com URL: www.mhi-mme.com

Only One to the Seas of the World

PROJECT MEET NEWS

Mitsubishi Marine Energy & Environment Technical Solution-System

10
10th Issue
October 2016

SPECIAL FEATURES

The History of UE Engines

Looking Back into the History of the UE Engine
—Expected Achievement of the Cumulative Production of 40 Million Horsepower

The genealogy of innovation.

TOPICS

Marine Energy-Saving Turbine Generating System Receives National Commendation for Invention

"Invention Award 2016" Hosted by the Japan Institute of Invention and Innovation

Steady Orders Coming in for the Latest UE Engine Model

UEC33LSE/UEC50LSH-Eco

Presentation of Latest Technologies at CIMAC World Congress

UE Engines/Low Pressure EGR/MET Turbochargers

PRODUCTS

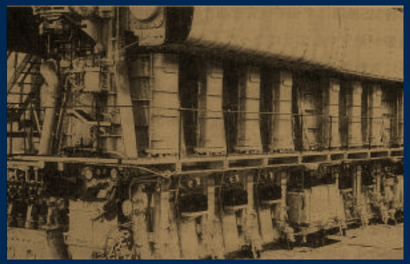
UEC50LSH-Eco Engine

Service results of the First UEC50LSH-Eco Engine after one year operation

Test engine No. 507
(Museum of Maritime Science)

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

MHI GROUP MITSUBISHI HEAVY INDUSTRIES



The genealogy of innovation.

Faster, stronger or greater efficiency—the destiny of technology should be continual change and innovation. Those who command the innovation of technology will also command markets. When Mitsubishi Heavy Industries developed the Mitsubishi MS Engine—the first homegrown large marine diesel engine—in 1932, it shifted the global tide of marine diesel development toward single-acting two-stroke airless injection. Because compression ignition is used, diesel engines have, by definition, a high compression ratio and high efficiency. However, the conventional air injection method of fuel injection consumed between 7% and 10% of engine output for air compression. For its MS Engine, Mitsubishi adopted direct, airless fuel injection, which resulted in the birth of a marine engine that was much more efficient. This was five years after Mitsubishi' s decision in 1927 to carry out its own, unique development. In 1955, the MS Engine was succeeded by the UE Engine, which used an exhaust turbine supercharger (turbocharger) that it had developed on its own. The genealogy of innovation—withstanding time and inherent in MHI-MME to this day.

PROJECT MEET NEWS
Mitsubishi Marine Energy & Environment Technical Solution-System

VOL. 10
OCTOBER

October 2016 10th Issue
Mitsubishi Heavy Industries Marine Machinery & Engine Co., Ltd.
16-5 Konan 2-chome, Minato-ku, Tokyo
108-0075(Mitsubishi Heavy Industries Building)

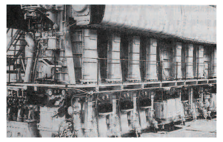
C O N T E N T S

TOP MESSAGE P03

This is a period of change in market structure resulting from a slowdown of the global economy. MHI-MME will not only ensure the provision of satisfying after-sales services but also accelerate developing of products that will enable us to propose strategic solutions to our customers.

SPECIAL FEATURES P04 - 09

The History of UE Engines
Looking Back into the History of the UE Engine
–Expected Achievement of the Cumulative Production of 40 Million Horsepower



TOPICS P10 - 13

Electro-Assist Capabilities Being Retrofitted on Large Turbochargers
Adding Electro-Assist Capabilities to the MET83SE Turbocharger for Large Container Ships

Steady Orders Coming in for the Latest UE Engine Models
UEC33LSE / UEC50LSH-Eco

Exhibits at European Trade Fairs
Posidonia 2016 (Athens) / SMM 2016 (Hamburg)

User Conferences and Technical Seminars Held in Japan and Abroad
User Conference (Tokyo, Hanoi and Ho Chi Minh City) / Technical Seminar (Greece)

Marine Energy-Saving Turbine Generating System Receives National Commendation for Invention
National Commendation for Invention "Invention Award 2016" Hosted by the Japan Institute of Invention and Innovation

Japan Internal Combustion Engine Federation-related Activities
MHI-MME President Kazuo Soma Attended the 28th CIMAC World Conference (Held in Helsinki) as President of JICEF

Presentation of Latest Technologies at CIMAC World Congress
UE Engines / Low Pressure EGR / MET Turbochargers

PRODUCTS P14-15

Retrofitting of Marine ORC Power Generator Completed
Uses the Waste Heat of Engine Jacket Cooling Water

First Dry-dock Overhaul of Hybrid Turbocharger
MET83MAG

UEC50LSH-Eco Engine
Service results of the First UEC50LSH-Eco Engine after one year operation. More than 20 Orders for Chemical Tankers, Medium Range Tankers, Handymax Bulk Carriers, Etc.

Global Network P16

Service Business Department (Nagasaki)
London Office / Singapore Office / Shanghai Office / Busan Office / Los Angeles Office

Message
from the President and CEO

This is a period of change in market structures resulting from a slowdown of the global economy. MHI-MME will not only ensure the provision of satisfying after-sales services but also accelerate developing of products that will enable us to propose strategic solutions to our customers.

The shipbuilding and maritime markets are in a critical phase due to overcapacity and overtonnage that are resulting from economic stagnation. The situation is being further complicated by the decline in freight charges, fall in energy costs, stronger environmental regulations and other factors. These markets as a whole have entered a period of major structural change.

Under such circumstances, MHI-MME is committed more than ever to following the basics, listening to our customers, and engaging unremittingly in the improvement and cultivation of our technical capabilities. We see this as the current path for us to take and are carrying out steady daily efforts. We will continue to propose solutions and provide after-sales services that will satisfy our customers while growing our business for each MHI-MME product.

This newsletter contains many upbeat topics. They include the successive adoption of our CO_2 emission reduction solutions that target conformity with the IMO's Energy Efficiency Design Index (EEDI) standard and our NOx emission reduction solutions that target conformity with IMO Tier III emission standards. We are feeling a very positive response towards these MHI-MME solutions.

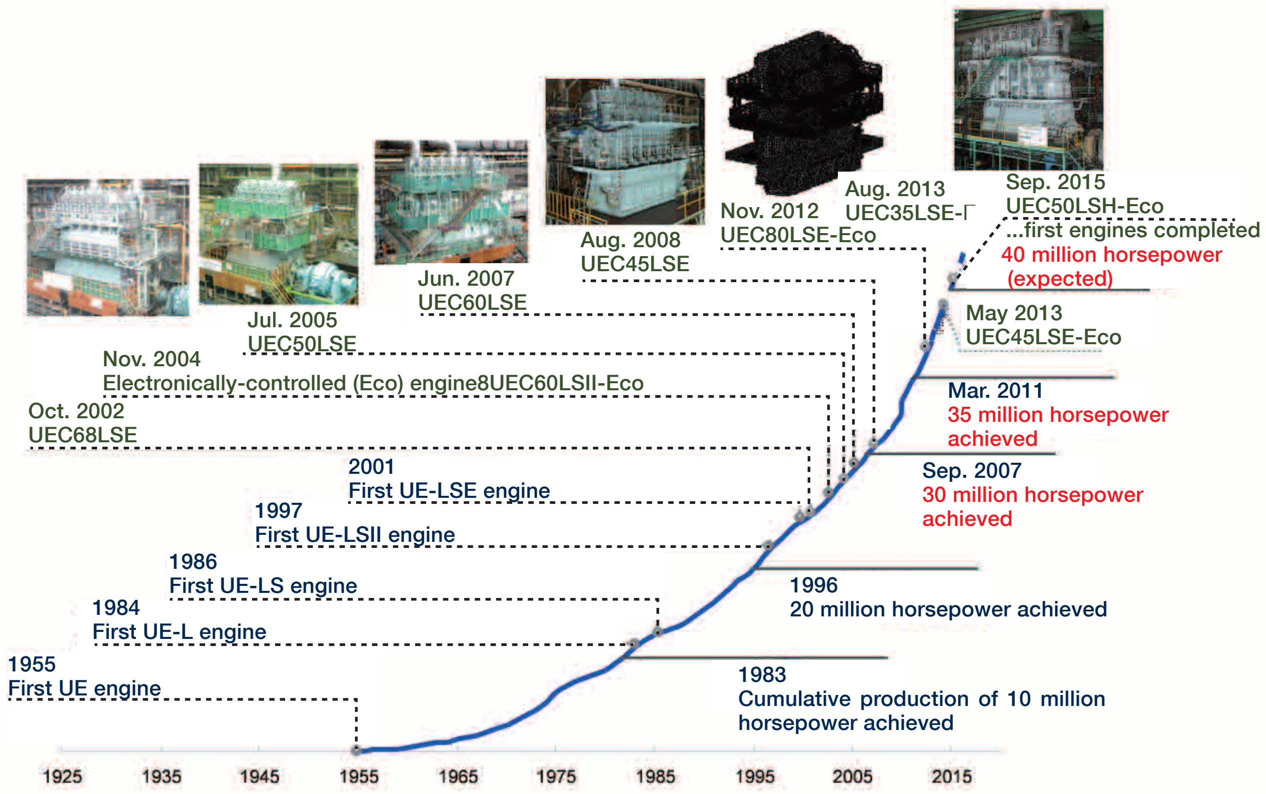
As for individual products, orders are growing steadily in strategically selected markets for our UE Engines—the focus of our Product History special feature—and other products, which we will describe to you in this issue.

Thanks to your support, this is the 10th milestone issue of Project MEET News. We will do our utmost in the promotion of our business and hope that you will continue enjoying reading the MHI-MME newsletter.

President & CEO
Kazuo Soma

Looking Back into the History of the UE Engine —Expected Achievement of the Cumulative Production of 40 Million Horsepower

The UE engine, developed in-house by Mitsubishi Heavy Industries, was launched in 1955 to large merchant ships. Since then, production volume has grown steadily with the strong cooperation and support of shipowners, ship management companies and shipyards, as well as the research and efforts of our development teams. In fact, we expect to achieve cumulative production of 40 million horsepower. In response to today's needs for ultra-high-energy-efficiency and compliance with IMO NOx Tier III requirements, new lineups of electronically-controlled engines have been completed. These "eco" engines are available in the LSE series as well as the latest LSH series and are continuing to build up an excellent operational track record.



Cumulative production of UE engines

■ The Dawn of the Development of UE Engines as originally developed Engines for Large Ships

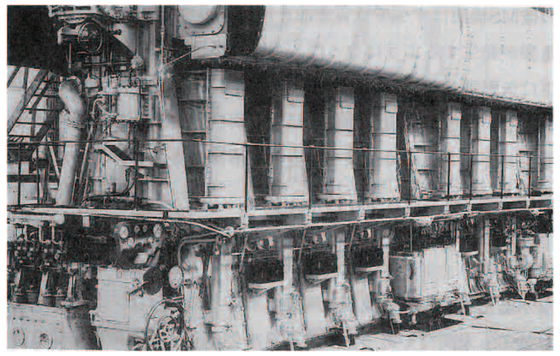
It was in 1893 that Dr. Rudolf Diesel obtained a patent for the diesel engine. Meanwhile, a British patent obtained in 1903 by Desland Dufour is said to have led to the development of the two-stroke diesel engine.

The world's first ocean-going diesel-powered ship—the MS Selandia (4,950 GT; twin 912 kW engines)—set sail in 1912. MHI commenced the investigative study of diesel engines the same year after its engineers took a survey of the Selandia. This became the preface to the birth of the Mitsubishi UE engine.

In 1927, MHI succeeded in the in-house development of a diesel engine (called the MS engine at the time) utilizing an airless fuel injection system. It was Japan's first domestically produced marine diesel engine. Commercial production commenced in 1932. A total of 84 MS engines was manufactured in the 23 years before the name was changed to the UE engine in 1955, after which development of the UE engine began.

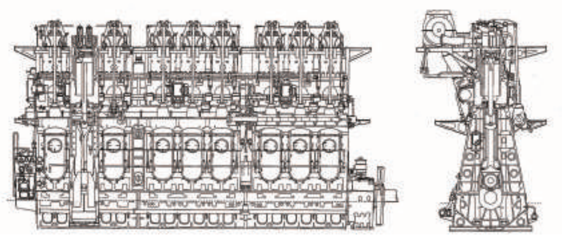
During development of the UE engine, two test engines—No. 503 and No. 507—were produced, with turbocharger matching tests carried out using test engine No. 503. Test engine No. 507 was the full-size prototype model used to carry out various experiments. Testing and research related to technologies such as fuel injection, scavenging, turbochargers and structural strength were carried out at the same time. Today, test engine No. 507 is on display at the Museum of Maritime Science in Tokyo as the 3UEC72/150 engine.

It was after such basic research that the first UE engine (9UEC75/150 engine (8,832 kW)) was completed in 1955. The engine was installed the same year on the NYK Line's M.V. Sanuki Maru (11,040 DWT). It was in this way that the voyage began for the UE engine, Japan's first originally dovelored two storoke marine engine for large vessels.

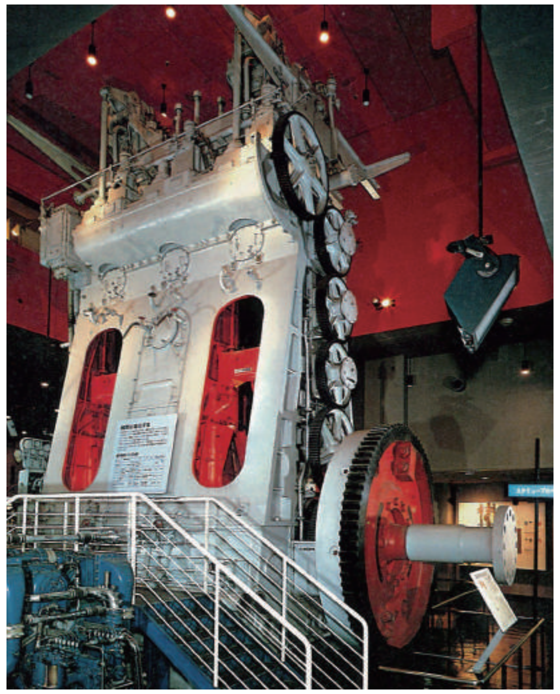


The Mitsubishi MS engine

M.V. Sanuki Maru



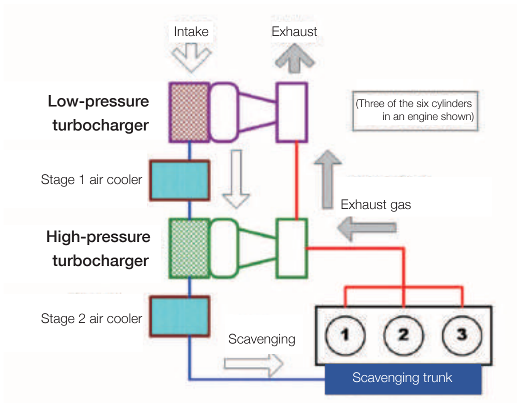
The 9UEC75/150 engine (completed in 1955)



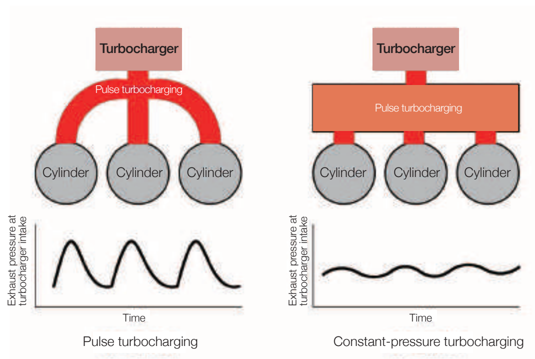
Test engine No. 507 displayed at the Museum of Maritime Science (laterly named the 3UEC72/150 engine)

The times of Two-Stage Turbocharging and into Shift to Constant-Pressure Turbocharging

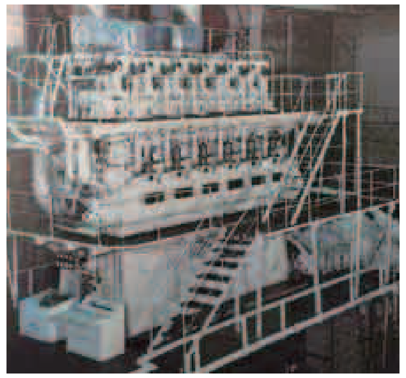
Until the 1973 oil crisis, the focus was on increasing power output. Five UE Engines Series—from the A model to the E model—were developed up to that time. Pulse turbocharging was employed, and adoption of leading-edge turbochargers at the moment was proactively promoted.
To increase power output, more fuel must be burned within the same cylinder volume, and high scavenging pressure is needed to supply a sufficient amount of air to burn fuel. However, the pressure ratio of the turbochargers of that time was only approx 2.5 and was not sufficient for this increased. Power as one way to solve this, MHI launched development of two-stage turbocharging and in 1975 became the first in the world to achieve its practical application. The first such engine—the 8UEC52E—went into service as the main engine of the Atlantic Albatross. A 30% increase in the output and 25% reduction in engine length were achieved by the two-stage turbocharging.
However, the second (1979) oil crisis occurred at the same time of the Iranian Revolution, and the market trends shifted to achieving more higher energy efficiency. Therefore, turbocharging systems were forced to shift to constant-pressure turbocharging.
With constant-pressure turbocharging, the combustion gas in a cylinder will expand more effectively even with a short exhaust blowdown period (the period between the opening of an exhaust valve and opening of the scavenging air port) by the effect of the exhaust pipe capacity is large and pulsation is suppressed. As compared to pulse turbocharging, the timing at which the exhaust valve opens can be delayed by between about 15 and 20 degrees, extending the effective stroke during exhaust gas expansion. At the same time, by degrees the timing at which the exhaust valve closes as well as start of compression, there is less compression work to be carried out by a piston. The overall result was a significant reduction in fuel consumption. This innovative system was later widely used in such UE engines as the H and LS series.

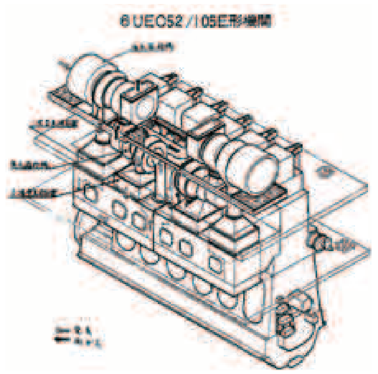


Structure of an engine with a two-stage turbocharging system



Dynamic pressure

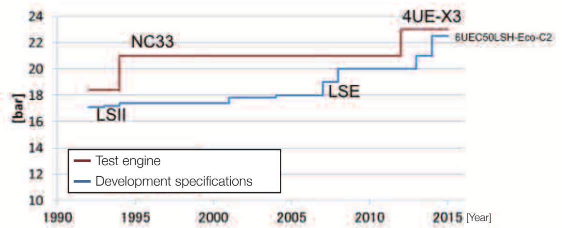




Development of the UEC-LSII and -LSE Series, and the Application of Electronic Control

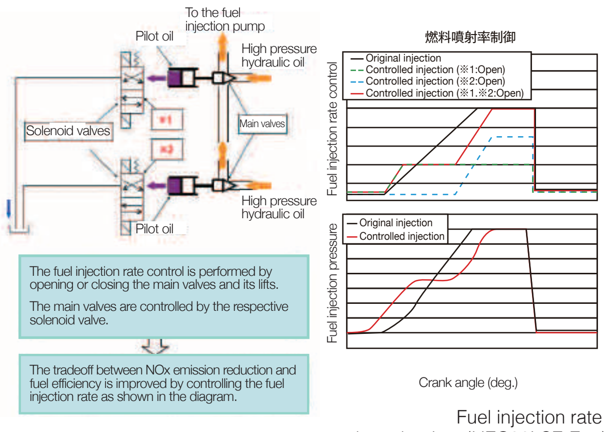
The UEC-LSII series—aimed to fulfill energy-saving needs as well as enable smaller engine sime—was released around 1990. This series unfolded from the UE85LSII to UEC33LSII, to cover wide range of engine output to fullfill various kind of ships.

At the same time, even higher engine output and higher reliability were also set as development target achieving high energy efficiency. The graph below shows changes in mean effective pressure, which is one of the major parameters associated with UE Engine development. The mean effective pressure was gradually stepped up to achieve the ultra high fuel efficiency that was being required of engines. The graph also shows changes in the mean effective pressure of released engines and the mean effective pressure of the full-size verification-test engine used to verify and validate reliability in advance. Thoroughgoing verification of performance and reliability was always carried out in advance of market-in using a full-size test engine.



Mean effective pressures of commercially released engines and test engines

From around 2006, MHI began releasing the UEC-LSE series, which boasted even higher fuel efficiency and reliability, with the good Sevie reconds of the aforementioned LSII series. The roll-out pace of electronically-controlled engines in the series also increased aggressively in response to needs for greater fuel efficiency and conformity to NOx emission reduction requirements.
The electronic control technology adopted for UE Engines was developed to achieve both NOx emission reduction and improved fuel efficiency under the strict IMO-NOx regulation. In the past, fuel injection pumps, exhaust vents, and other parts were driven by camshaft. However, in the newly-developed electronic-control system, the timing and amount of fuel injection, timing of the exhaust valve and other parameters were automatically controlled to achieve the optimal state. This made it possible to optimize NOx emission and fuel consumption under various operating conditions.
The diagram on the right is a configuration diagram of the fuel injection electronic-control mechanism. The fuel valve actuators are controlled by two main valves, which in turn are controlled by a controlling solenoid valve. An almost ideal injection mode as that shown in the diagram is achieved, contributing to the reduction of fuel consumption by the engine. The ratio of electronically-controlled engines among the UE Engines being manufactured recently is steadily increasing, with more than 100 such "eco"



Fuel injection rate control mechanism (UEC80LSE-Eco)

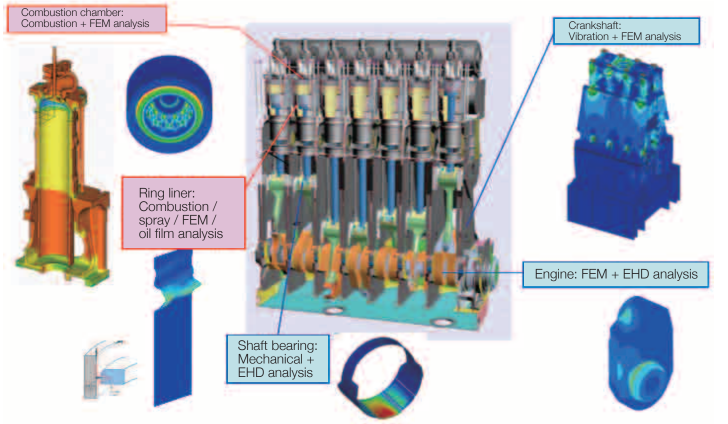
engines already having been manufactured.
In 2015, the latest model, the UEC50LSH-Eco, was finally released. MHI-MME made market reserch to shipyards to assess and select optimum engine power output, rotation speed, and stroke before development of this engine. The power and speed have been adjusted to those suitable for use as the main engine of chemical / medium-range tankers and handymax bulk carriers. The first 6UEC50LSH-Eco-C2 was completed by Kobe Diesel Co., Ltd. in March 2015 and has been operating in very good condition after her delivery. MHI-MME has already received orders for 20 engines (cumulative).


6 UEC50LSH-Eco-C2

Development Technology that Supports Enhancement of Reliability and increased Engine Output

As mentioned, stroke-bore ratio has been maximized (stroke/bore of 4.7 in the latest model) and mean effective pressure increased in engine development up to now. However, verification of reliability is also an extremely important part of the development process.

Particularly in the case of UE Engine development, MHI-MME's developement technology is leveraged along with the utilization of various analysis and verification technology to test important items—such as various bearings, ring liners in hot compoments and fuel injection system—that affect an engine's reliability. Actual performance is also fed back into the development process and a extremely big database accumulated to form a virtuous cycle of utilization in the development of the next engine. The diagram below shows one such example utilizing computer-aided engineering (CAE).



Verification utilizing CAE in UE Engine development

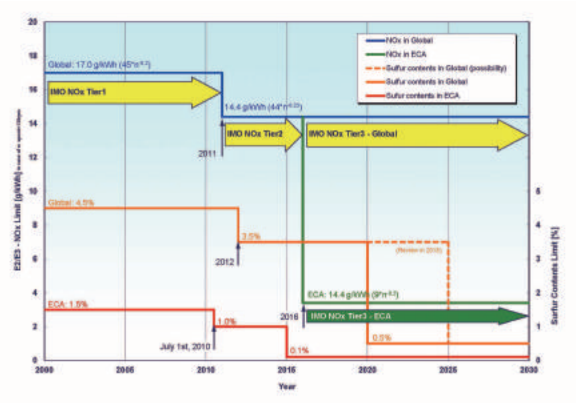
UE Engine Development Responding to NOx-related Environmental Regulations

Stringent environmental requirements went into effect in January 2016 for marine engines. The IMO NOx Tier III regulations require a reduction of NOx emissions by as much as 76% as compared to Tier II requirements.

As technology responding to the new regulations, MHI-MME aims to make low pressure EGR a practical reality for the first time in the world. The Mitsubishi Low Pressure EGR (LP-EGR) system was applied to an actual 6UEC45LSE-Eco-B2 engine. Shop testing was carried out in April 2015, with onboard testing commenced in August the same year. Desired performance values were achieved as planned, including those related to NOx emissions. It became the first domestic system to receive Tier III certificate of conformity from the classification society.

Onboard verification testing is currently taking place. Overall optimization of the system will be carried out after further verification of the actual operability of the system, including its reliability.

(Note: This R&D is being implemented with the support of ClassNK and through joint research with NYK Bulk & Projects Carriers Ltd., Shikishima Kisen K.K. and Mitsubishi Kakoki Kaisha, Ltd.)



Trends in NOx and SOx environmental regulations

Lessons that Must Not Be Forgotten

MHI-MME has continued to develop the UE Engine series by mobilizing its technological and development capabilities while exercising meticulous care. On the other hand, during the long history of UE Engine development, MHI-MME has never forgotten that there were many instances in which the company caused worries to shipowners in regards to ships in service. Ring-liner issues in a large UE Engine model and bearing damage in a medium bore engine are some examples. Such issues often arose because we relied on conventional design methodology during parts development and did not implement sufficient verifications in relation to changes in engine operation conditions. We believe that applying these important lessons that we learned through such experiences towards the development of more highly reliable engines is what will the true approval from our customers.


7UEC60LSE-Eco-A2 engine


6UEC33LSE-C2 engine


7UEC80LSE-Eco-B1


4UE-X3, the latest UE test engine

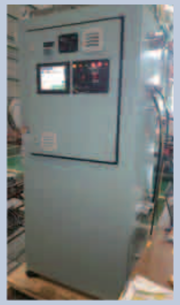
Into the Future

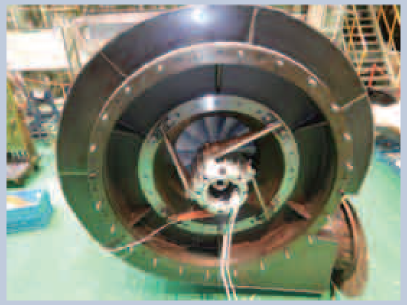
The development of engines with more higher energy efficiency will likely become necessary in the future in order to fulfill the required Energy Efficiency Design Index values in regards to a CO2 emission regulations, in addition to NOx reduction. At the same time, there will be a greater need to develop marine fuel diversification technology (such as the use of LNG) and, going further, to achieve ultra-energy efficiency of the overall plant (including the use of waste heat recovery systems). MHI-MME will continue to mobilize its technological capabilities to develop state-of-the-art marine engines.

SUPERCHARGER **ELECTRO ASSISTED** RETROFIT

Electro-Assist Capabilities Being Retrofitted on Large Turbochargers

Preparations are currently underway to retrofit two sets of MET83SE turbochargers on a large container ship with electro-assist capabilities. Engineers have already boarded the ship several times in preparation of installing wires and terminal box. To add electro-assist capabilities to a turbocharger, an electro-magnetic driving device, which consists of a rotor shaft with permanent magnets and a stator winding that produces torque, must be installed. Before shipping the equipment to the ship, they were mounted for testing on the same type of turbocharger as that on the cargo ship, which confirmed excellent stability and expected accelerating performance of the turbocharger. The electro-magnetic driving devices are shortly scheduled for installation on the ship's turbochargers and are expected to contribute to reducing fuel consumed by the ship.





Rotor with magnets and a stator winding installed on the MET83SE turbocharger

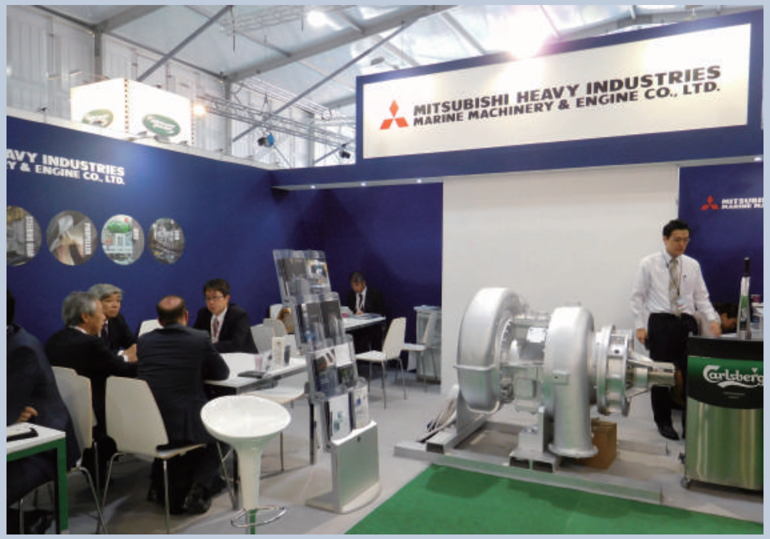
EXHIBITION IN EUROPE

Exhibits at European Trade Fairs

MHI-MME exhibited at Posidonia 2016, held in June in Athens, and at the SMM 2016, held in Hamburg in September.

More than 250 customers, mainly Greek shipowners who use our MET Turbochargers, steering gear and boilers, visited our booth at Posidonia 2016. We briefed customers on the state of operation and maintenance of the equipment owned by them and explained the latest trends in environmental technology. We also asked about their plans, including the building of new ships. A broad range of information was exchanged at the fair.

In our booth at the SMM 2016, we exhibited an actual MET37SRC hybrid turbocharger attracting the attention and interest of many visitors.



SMM2016

Posidonia2016

USER CONFERENCE, TECH SEMINAR HELD AROUND THE GLOBE

User Conferences and Technical Seminars Held in Japan and Abroad

With the objective of carrying out two-way communication with our customers, MHI-MME hosts seminars and user conferences both in Japan and abroad. At the Tokyo User Conference held in May, we introduced the latest information on the operation management, maintenance and inspection of UE Engines, MET Turbochargers, boilers, steering gear and other equipment. We also provided information on the latest trends in technologies conforming to IMO NOx Tier III regulations. Exhaust valves utilizing a new material, which achieved life time extension of parts, as well as information on the state of the cutting-edge UEC50LSH-Eco engine in service attracted the attention of participants. The booths set up to respond individually to technical consultations and a social gathering held after the conference were also packed. The conference proved to be a wonderful opportunity for receiving valuable information from our customers.

In June, we hosted a technical seminar in Greece—Europe's foremost hub for maritime trade. As IMO NOx Tier III compliance technologies, we gave presentations on the state of development of our Low Pressure EGR System and Low Pressure SCR System. We also introduced the state of the latest UE Engine and MET Turbocharger models in service as well as the Organic Rankine Cycle (ORC) waste heat recovery system.

Meanwhile, in April, we held the first MET Turbocharger user conference in Hanoi and Ho Chi Minh City, Vietnam. We are striving to expand our service networks in various parts of the world.

BRAND NEW **UE ORDER BRISK**

Steady Orders Coming in for the Latest UE Engine Model

Orders are coming in steadily for the two latest UE Engine models, which we have been introducing to you here in Topics and elsewhere in Project MEET News—the UEC33LSE (5th Issue) and UEC50LSH-Eco (8th Issue).

Thirteen orders have come in so far for the UEC33LSE, which is optimized for vessels under 30,000DWT, including bulk carriers, chemical tankers, cement carriers and coastal ferries. Three of the engines are already in service.

Meanwhile, we have received 20 orders for the UEC50LSH-Eco that is optimized for Handymax / Supramax bulk carriers, medium range tankers and similar vessels. One engine is already in service.

Boosted by a good in-service track record, we continue to receive many inquiries from customers.

Primarily, the UEC33LSE engine is manufactured by Akasaka Diesels Limited, while Kobe Diesel Co., Ltd. is manufacturing the UEC50LSH. Aggressive sales activities are being carried out for ongoing expansion of orders, while collaborating with our licensees.

The "UE Family," the group of companies that are involved in the design, manufacture and sales of UE Engines, will continue to make utmost efforts, working as one to ensure the development and supply of highly reliable engines.

UEC33LSE Principal Particulars

Engine format		6UEC33LSE-C2
Cylinder bore	mm	330
Piston stroke	mm	1,550
Stroke-to-bore ratio	-	4.7
Output	kW	4,980
Revolutions	min^{-1}	167
Mean effective pressure	MPa	22.5
Fuel consumption rate	g/kWh	174
Weight	ton	79

UEC50LSH-Eco Principal Particulars

Engine format		5UEC50LSH -Eco-C2	6UEC50LSH -Eco-C2
Cylinder bore	mm	500	
Piston stroke	mm	2,300	
Stroke-to-bore ratio	-	4.6	
Output	kW	8,900	10,680
Revolutions	min^{-1}	108	
Mean effective pressure	MPa	2.19	
Fuel consumption rate	g/kWh	164	
Weight	ton	194	225

Marine Energy-Saving Turbine Generating System Receives National Commendation for Invention

Wins “Invention Award 2016” Hosted by the Japan Institute of Invention and Innovation

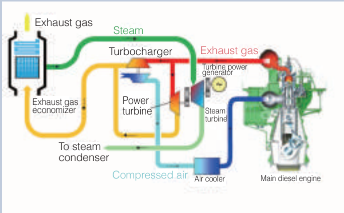
The “Marine energy-saving turbine generating system for container ships, etc.,” invented and developed by MHI-MME, received the Japan Institute of Invention and Innovation’s National Commendation for Invention “Invention Award 2016.”

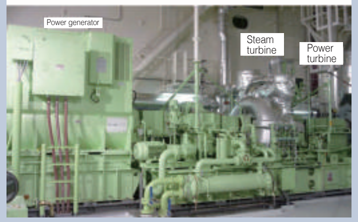
The National Commendation for Invention is a distinguished award that was established in 1919 for the purpose of contributing to the progress and development of science and technology in Japan under the Imperial Household’s fosterage of inventions. MHI-MME’s invention, which contributed to environmental protection by improving the energy-efficiency of marine engines and reducing CO2 emissions, received the prestigious Invention Award for this fiscal year after careful consideration.

In addition to generating electric power onboard with a steam turbine power generator that uses a conventional main diesel engine waste heat recovery system, this invention uses, through a power turbine, high thermal-energy extraction gas from the main engine for increasing power generation. The invention is Japan’s first compound marine system for energy recovery.

The mechanism of the reuse of exhaust gas by this system is as follows. It extracts a portion of the exhaust gas upstream of the turbocharger and sends it to a power (gas) turbine. It drives a power generator together with a steam turbine to which it is coupled using an SSS clutch (automatic disengagement clutch). When the onboard power demand falls below the maximum possible power output of the waste heat recovery system, the system prioritizes use of the steam turbine that utilizes, as its heat source, waste heat that is normally released outside the ship. This increases power output by about two to three times as compared with conventional waste heat recovery systems. At the same time, it greatly improves marine engine plant efficiency (by a relative value of between 8% and 10%). The system has been installed on 74 container ships that mainly require large amounts of power. As a high-efficiency energy recovery system used in combination with a main diesel engine, it is making a big contribution to boosting the energy-efficiency of marine engines as well as in protecting the global environment.

Invention Award 2016
Japan Institute of Invention and Innovation





System diagram and onboard photo

Japan Internal Combustion Engine Federation-related Activities

In July 2015, Kazuo Soma, President of MHI-MME, succeeded Mitsui Engineering & Shipbuilding Director Mr. Shinsuke Minoda as President of the Japan Internal Combustion Engine Federation (JICEF). An organization of long standing established in 1954, JICEF represents Japan as a National Member Association of CIMAC, the International Council on Combustion Engines that was founded in 1951 in France. The primary activities of JICEF are engaging in CIMAC-related work, promoting internal combustion engine-related standardizations, fostering young engineers and communicating international information. It aims for the sound growth and development of the industry through the advancement of technologies related to internal combustion engines.

This year, Kazuo Soma attended the 28th CIMAC World Congress held in Helsinki in June as President of JICEF and served as Chair of the 62nd General Assembly of JICEF in July.

As the only Japanese licensor of 2-stroke marine diesel engines, MHI-MME will work to develop technologies that meet customers’ needs for energy-efficiency and environmental friendliness, while contributing, through such external organizations, to the sound development of the industry as well as enhancement of the technological capabilities of the industry in Japan.

JICEF General Assembly

Kazuo Soma, President, MHI-MME

MHI GROUP MITSUBISHI HEAVY INDUSTRIES

Presentation of Latest Technologies at CIMAC World Congress

The CIMAC World Congress was held between June 6 (Mon.) and June 9 (Thu.), 2016, in Helsinki, Finland. MHI-MME presented its latest technologies under following three themes.

Marine Engines

■ Presentation on Latest UE Engine Technologies

①UEC50LSH engine design concept

Overwhelmingly low fuel consumption, wide rating power curve, electronically controlled system with camshaft, measures taken against low-temperature corrosion, and etc.

②Status of the first engine, which went into service in September 2015

Reduced oil consumption of cylinder lubrication. Extremely low wear of the piston ring and cylinder liner, and future improvements

■ Presentation on Latest Low Pressure EGR Technology

①Outline of the highly superior Mitsubishi unique low pressure EGR (Exhaust Gas Recirculation) system, with low initial investment and operation costs compared with other systems, as a countermeasure towards IMO NOx Tier III regulations

②Results of shop test and sea trial of the onboard verification test implemented as part of ClassNK’s “Joint R&D for Industry Program” scheme, obtaining of certification, and etc.

Turbochargers

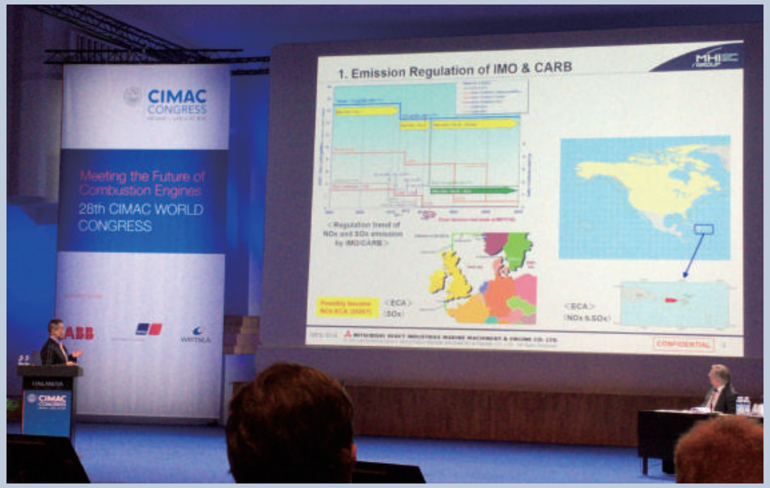
■ Presentation of Latest Development Trends in MET Turbochargers

①VTI (Variable Turbocharger Inlet – a technology unique to MHI-MME) turbocharger

②Turbocharger with integrated EGB (Exhaust Gas Bypass)

③Improvement of turbocharger efficiency through a higher lubricating oil temperature and noise-reduction technology, such as acoustic filters

Many questions were arisen by the audience at all the presentations, evidencing the great amount of interest in MHI-MME technologies. MHI-MME will continue to disseminate information on its latest technologies through opportunities like this.



*CIMAC: International Council on Combustion Engines (Conseil International des Machines a Combustion), a globally authoritative organization related to internal combustion engines, which was established in 1951

Retrofitting of Marine ORC Power Generator Completed

- Uses the Waste Heat of Engine Jacket Cooling Water -

Organic Rankine Cycle (ORC) is a thermodynamic cycle that uses an organic working fluid with a boiling point of around 15°C. Because relatively low-temperature heat can be converted into power, it is already used in power generation utilizing waste heat from incineration plants and hot springs. MHI-MME newly developed a marine ORC generator with an output of 125kW that operates using low temperature heat sources so as to enable the utilization of main engine cooling water as the heat source (85°C). It was fitted to a large container ship owned by Danish shipowner Maersk Line and began onboard operation.

Installation work was carried out several times while the ship was berthed, causing no disruption to the ship's sailing schedule. Work was completed in early April this year. It has been operating smoothly to date and is contributing to the reduction of fuel consumed for power generation.

First Dry-dock Overhaul of Hybrid Turbocharger

-MET83MAG-

The world's first large bulk carrier fitted with a hybrid turbocharger for diesel main engines, which generates electricity in addition to boosting charging air pressure, set sail in May 2011. The bulk carrier underwent its first dry-dock overhaul in May this year after five years of operation. Careful inspection and maintenance was carried out. Due to slow steaming and other factors, the hybrid turbocharger was used to generate power for only about 60% of the time that the carrier was at sea. Nevertheless, about 1,400 tons of fuel oil for power generation was saved.

The hybrid turbocharger itself has been operating without any problems, and this was its first overhaul. When the internal state was inspected, no abnormalities were found in the turbocharger, generator shaft bearing, rotor or other parts, corroborating the high reliability of this system.

Generator shaft bearing

UEC50LSH-Eco Engine

Service results of the First Engine after one year operation

The vessel fitted with the first 6UEC50LSH-Eco in the state-of-the-art LSH Series of the UE Engine, went into service in September 2015. About one year has passed since then, and the ship continues to operate smoothly after logging more than 6,000 operating hours.
Careful measurement and testing of this first engine's performance, reliability, vibration and other items were carried out in shop test. Further verification was implemented in sea trial before going into service, and the engine went into service after confirming that it exhibited performance in line with the development concept.
Even after the ship went into service, MHI-MME engineers have been visiting the ship periodically and inspecting in accordance with a testing plan that had been formulated in advance for the first engine. The long-term reliability of the combustion chamber, various shaft bearings and other parts with its leading-edge design specifications are checked on a continuing basis. Verification of the state of achieving anticipated maintenance intervals is also carried out. Everything is maintaining a favorable state. Furthermore, in regards to low fuel efficiency—one of this engine's characteristics—it is exhibiting performance as originally planned, and the engine is being well-received by our customer.
Boosted by the favorable operational state of the first engine, there have already been more than 20 orders for the UEC50LSH-Eco engine for installation in chemical tankers, medium range tankers and Handymax bulk carriers. Going forward, MHI-MME will ensure that the track record and improvements of this first engine are reflected in the production of new units so that they will be completed as engines with even higher reliability and performance.

First 6UEC50LSH-Eco engine

Upper part of the running surface of the cylinder liner

Piston rings

Plateau honing of the cylinder liner