World's First Test Operation of Large-bore Low-Speed Ammonia Dual Fuel Engine and Ammonia Fuel Supply SystemCommercial Unit Starts 91

MITSUI-Everllence B&W 7S60ME-C10.5-LGIA-HPSCR

World's First Test Operation of Large-bore Low-Speed Ammonia Dual Fuel Engine and Ammonia Fuel Supply System Commercial Unit Starts 91

MITSUI E&S Co., Ltd. announces that the test operation of MITSUI-Everllence B&W 7S60ME-C10.5-LGIA-HPSCR Large-bore Low-Speed Ammonia dual fuel engine (Maximum continuous output: 17,430 kW (23,700 BHP) x 105 min^{-1} (7 cyl., L1 point)) started at its Tamano Factory. This is the world's first test run with an ammonia fuel on a large-bore, low-speed, two-stroke commercial engine.

In addition, the development of auxiliary equipment other than engine is being carried out with the support of the New Energy and Industrial Technology Development Organization (NEDO) as a part of "Integrated project for development and social implementation of ammonia fueled ships", and during this test run, the verification of the safety and performance of the ammonia fuel supply system and other auxiliary systems developed by MITSUI E&S will also be carried out. The engine and fuel supply system will be delivered to the above project vessel

Ammonia Fuel Supply System (onshore)

World's First Successful Hydrogen Combustion Operation with a Large Marine Engine 92

Hydrogen combustion test on 4S50ME-T

MITSUI E&S Co., Ltd. and licensor Everllence have achieved a world first hydrogen combustion operation of a large marine 2-stroke test engine at its Tamano Factory, aiming for the early launch of hydrogen-related businesses in maritime industry.

One of the four cylinders of the test engine 4S50ME-T (bore size of 50 cm, output 7 MW, rated speed 117min-1, MEP = 2.10 MPa) was converted to a hydrogen operation, based on the LNG dual fuel ME-GI engine design, and high-pressure hydrogen gas was supplied from the hydrogen gas supply facility (liquid hydrogen tank, hydrogen gas compressor, etc.) completed in October, 2024. The coupling operation was successfully conducted with this test engine at 100% load without any problems such as hydrogen leakage.

In this 100% engine load operation using hydrogen fuel, which ignites easily and requires proper combustion control, MITSUI E&S has succeeded in covering the equivalent of 95% of the heat value with hydrogen fuel, and the cylinder pressure curve was equivalent to that of the other three cylinders operated with conventional fuel.

MITSUI E&S also confirmed that the hydrogen gas supply facility is capable of the stable supply of high-pressure hydrogen required from the engine.

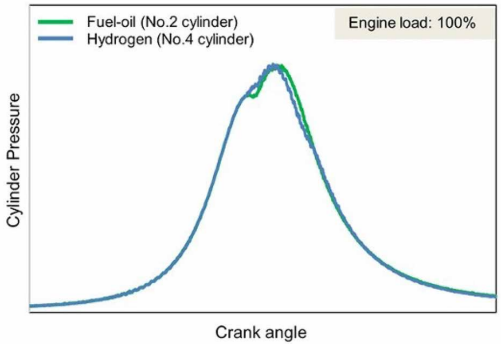


Fig. Cylinder pressure curve on hydrogen and conventional fuel

World's First Engine Equipped with VCR System Completed 93

In 2022, Mitsui E&S DU (MESDU) received an order for two engines equipped with the world's first VCR (Variable Compression Ratio system). VCR adjusts the compression ratio to an optimal level based on engine output and LNG fuel characteristics. Depending on operating conditions such as engine load, it improves fuel consumption by approximately 3% in gas mode and approximately 6% in diesel mode, significantly contributing to reduced fuel costs and CO_2 emissions during vessel operation.

This world-first VCR is integrated into the main engine "6X62DF-2.1" dual fuel engine installed for a coal carrier, with the vessel commencing service in 2025.

VCR technology was jointly developed by WinGD and MESDU, which can be installed on X72DF, X62DF and short-stroke X62DF-S engines, with plans to expand it to other engine types in the future.

Features of VCR

1. Generally, engines achieve better fuel efficiency with higher compression ratios. In conventional engines, the compression ratio is fixed due to structural limitations, resulting in limited potential for fuel efficiency improvements.
2. VCR mechanism incorporates a hydraulic cylinder at the bottom of the piston rod, and by adjusting the volume of the combustion chamber, the compression ratio can be changed to the optimal one according to the engine output, resulting in a significant improvement of fuel consumption.
3. Furthermore, by combining iCER (Intelligent Control by Exhaust Recycling), which significantly reduces methane slip, with VCR, greenhouse gas (GHG) emissions equivalent to those of a high-pressure gas injection DF engine can be achieved.

World's First iSCR-Equipped Engine Completed 94

Mitsui E&S DU (MESDU) has delivered a new 5X52-S2.0 engine, equipped with the world's first iSCR (integrated Selective Catalytic Reduction) system, to a domestic shipyard.
This engine has been installed on a 40,000-deadweight-ton bulk carrier scheduled to enter service in 2025.
This iSCR system, newly released by licensor WinGD to comply with the International Maritime Organization (IMO) NOx emission regulations, effectively minimizes engine room space by installing SCR unit in the unused space under the exhaust manifold. Furthermore, the space-saving effect is expected to enable faster and more efficient outfitting work at shipyards, leading to shorter shipbuilding cycles and reduced outfitting costs.

Features of iSCR

1. iSCR is completely integrated on engine and is launched to address the growing demand for a compact solution while still capable of fulfilling Tier III emission regulations as required in designated Emission Control Area (ECA) zones.
2. Promoting higher operation temperatures (favoured by the SCR reactions) while achieving a very compact overall system design with limited external piping.
3. iSCR is applicable for WinGD engines X52, X52-S, X62 and X62-S at moment.
4. It is also compatible with the methanol dual fuel engine “X-DF-M” and the ammonia dual fuel engine “X-DF-A”.

The Latest Next-Generation Engine Equipped with VCR. 95

Mitsui E&S DU (MESDU) has received an order for the world's first LNG dual fuel next-generation engine, “7X62DF-S2.0.” X62DF-S2.0 series to be installed this time is lighter and more compact than the conventional X62DF series, while improving gas mode fuel consumption efficiency.
Furthermore, this engine incorporates a VCR (Variable Compression Ratio system) that achieves excellent fuel consumption. VCR adjusts the compression ratio to an optimal level based on engine output and LNG fuel characteristics.
This significantly contributes to reducing fuel costs and CO_2 emissions during vessel operations.
This engine will be installed on a large pure car carrier scheduled to enter service in 2026.

Features of X62DF-S2.0

1. The selected stroke-to-bore ratio results in a compact engine with low manufacturing and assembly costs. Service-friendly design will reduce downtime and cut operating costs.
2. WinGD's well proven electronically-controlled common-rail technology results in lower fuel consumption across the entire operating range, especially at low and part loads.
3. X-DF engine allows iCER to be integrated as an on-engine type.
4. The short-stroke concept engine is also applied to the X52DF-S.

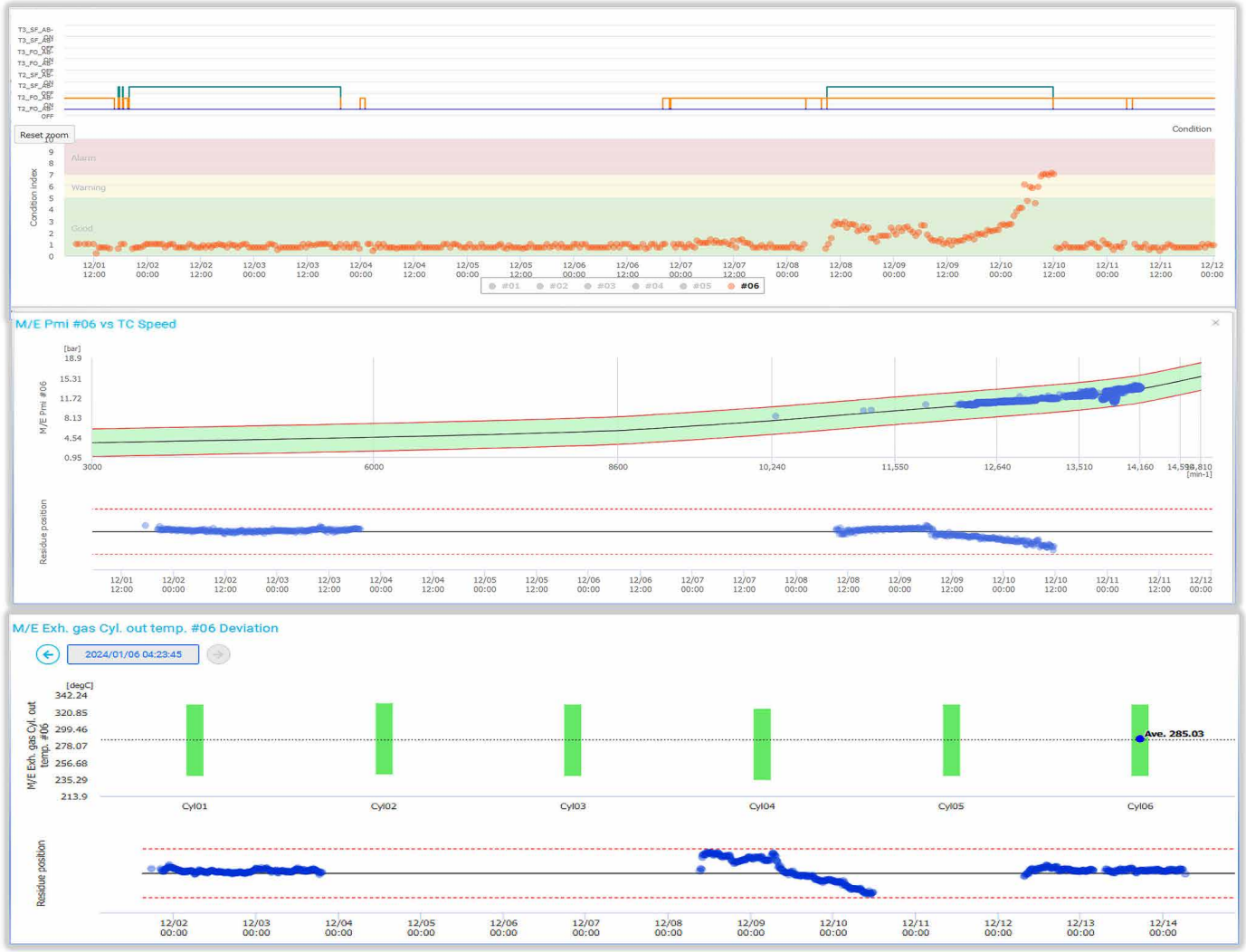
ClassNK IE P&S Certification for Marine Engine Monitoring System CMAXS LC-A 96

Marine engine monitoring system CMAXS LC-A

MITSUI E&S Co., Ltd. has obtained Innovation Endorsement for Products & Solutions (IE P&S) certification from Nippon Kaiji Kyokai (ClassNK), for its next-generation marine engine monitoring system, CMAXS LC-A , provided by MITSUI E&S Group. In January 2025, the first vessel equipped with MITSUI E&S marine engines and featuring CMAXS LC-A system entered in service.

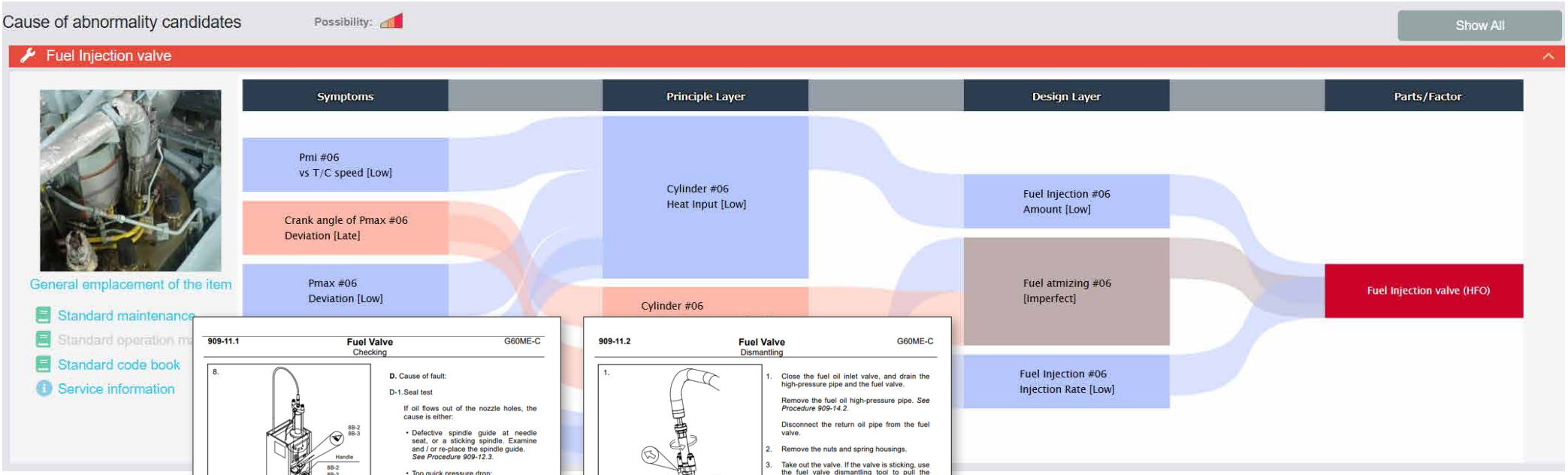
Predictive Maintenance Technology outline

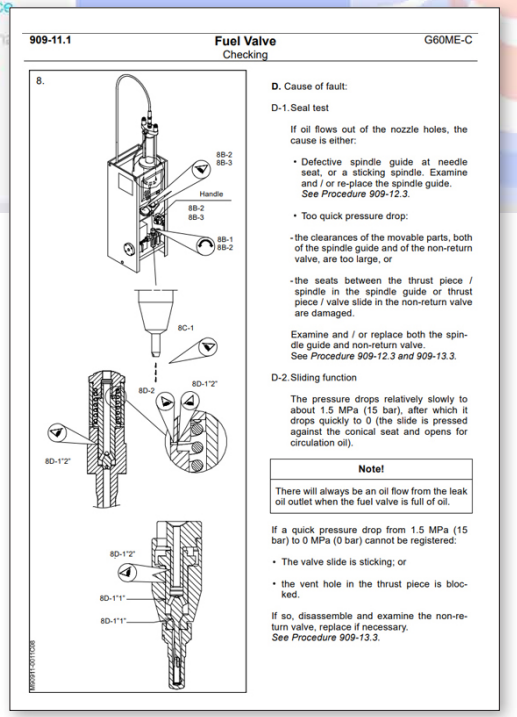
CMAXS LC-A system represents a significant advancement in marine engine monitoring technology. Using eXplainable AI (XAI) based on engineering principles, the system can detect potential engine malfunctions in their early stages and automatically identify problematic components and factors. This capability enables ship crews to perform rapid trouble-shooting and preventive maintenance, reducing the risk of unexpected breakdowns during voyage operations.



Condition diagnosis

ClassNK IE P&S Certification for Marine Engine Monitoring System CMAXS LC-A 96





909-11.1 Fuel Valve Checking G60ME-C

8.

D. Cause of fault:

D-1. Seal test

If oil flows out of the nozzle holes, the cause is either:

- Defective spindle guide at needle seat, or a sticking spindle. Examine and / or re-place the spindle guide. *See Procedure 909-12.3.*
- Too quick pressure drop:
  - the clearances of the movable parts, both of the spindle guide and of the non-return valve, are too large, or
  - the seats between the thrust piece / spindle in the spindle guide or thrust piece / valve slide in the non-return valve are damaged.

Examine and / or replace both the spindle guide and non-return valve. *See Procedure 909-12.3 and 909-13.3.*

D-2. Sliding function

The pressure drops relatively slowly to about 1.5 MPa (15 bar), after which it drops quickly to 0 (the slide is pressed against the conical seat and opens for circulation oil).

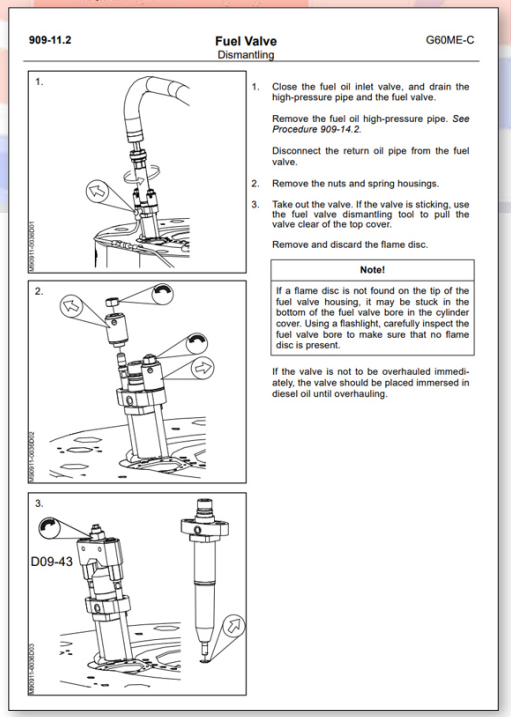
Note!

There will always be an oil flow from the leak oil outlet when the fuel valve is full of oil.

If a quick pressure drop from 1.5 MPa (15 bar) to 0 MPa (0 bar) cannot be registered:

- The valve slide is sticking; or
- the vent hole in the thrust piece is blocked.

If so, disassemble and examine the non-return valve, replace if necessary. *See Procedure 909-13.3.*



909-11.2 Fuel Valve Dismantling G60ME-C

1. Close the fuel oil inlet valve, and drain the high-pressure pipe and the fuel valve.

   Remove the fuel oil high-pressure pipe. *See Procedure 909-14.2.*

   Disconnect the return oil pipe from the fuel valve.
2. Remove the nuts and spring housings.
3. Take out the valve. If the valve is sticking, use the fuel valve dismantling tool to pull the valve clear of the top cover.

   Remove and discard the flame disc.

Note!

If a flame disc is not found on the tip of the fuel valve housing, it may be stuck in the bottom of the fuel valve bore in the cylinder cover. Using a flashlight, carefully inspect the fuel valve bore to make sure that no flame disc is present.

If the valve is not to be overhauled immediately, the valve should be placed immersed in diesel oil until overhauling.

D09-43

Troubleshoot support

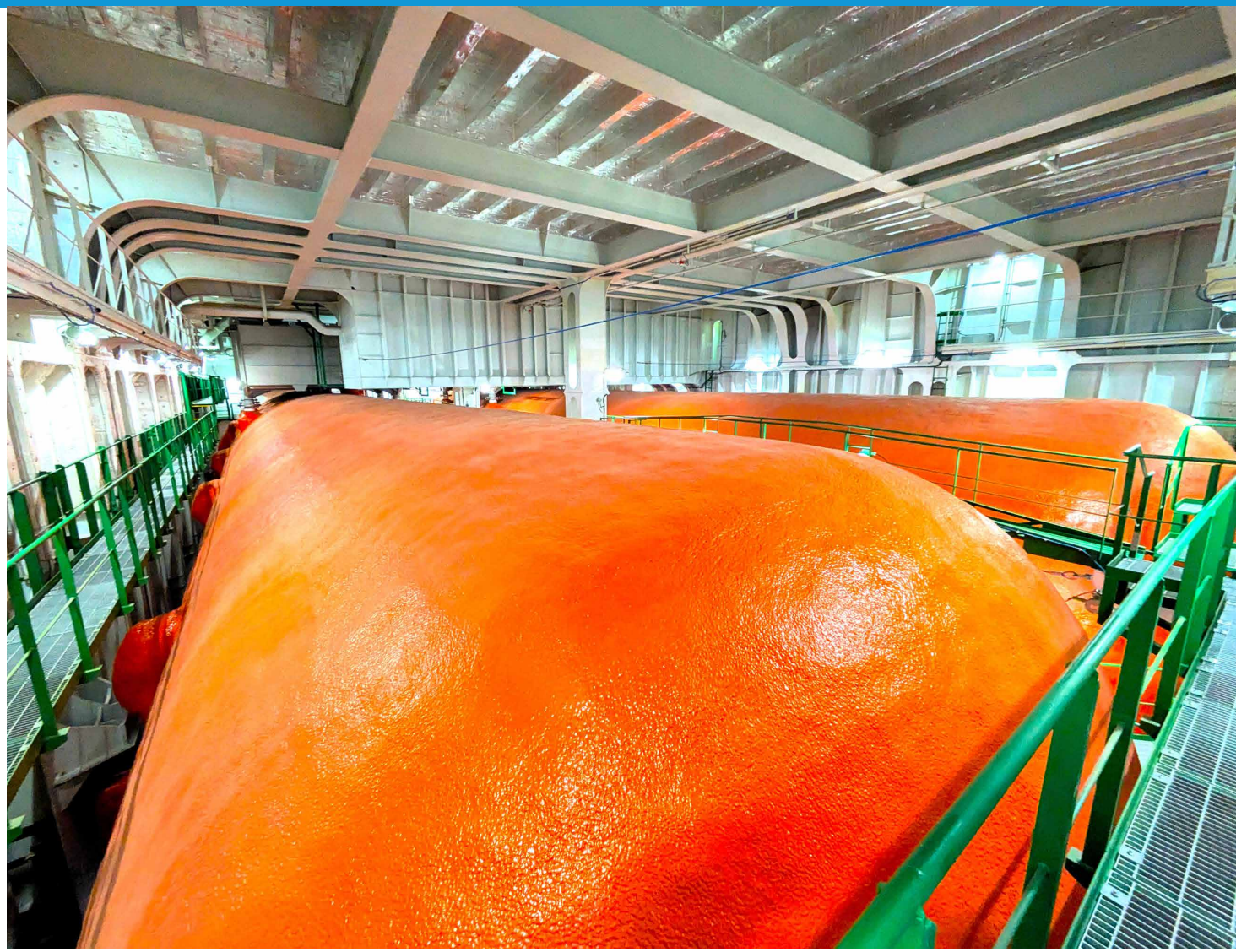
Shin Kurushima Sanoyas Shipbuilding deliveries of FGSS for PCC 97

Shin Kurushima Sanoyas Shipbuilding have recently delivered FGSS(Fuel Gas Supply System) to 6,900-unit LNG fueled car carrier built by Shin Kurushima Toyohashi Shipbuilding. This vessel is equipped with dual fuel engine capable of using both LNG and MGO as its main engine. Operating on LNG fuel reduces GHG emissions compared to conventional vessel is fueled MGO.

The FGSS vaporizes LNG from the fuel tank, and supplies the vaporized fuel gas to the dual fuel engine. Our FGSS modularizes key components into a single unit, minimizing installation space and improving operability and maintainability by integrating them into the hull. Furthermore, our original FGSS control system automatically controls operations from start to shut down, reducing crew workload and enabling integrated security monitoring, contributing to safe operation.

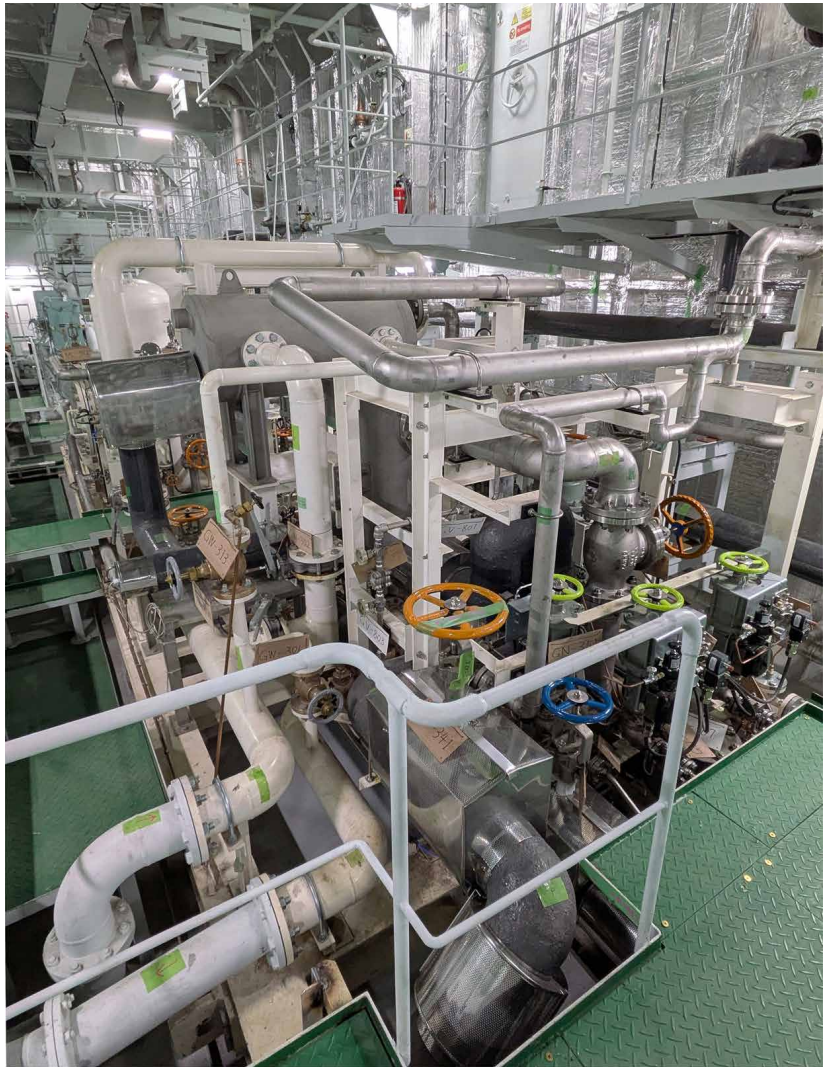
The vessel is installed with two LNG fuel tanks, enabling longer voyage. The tanks are made of 9% nickel steel, which can withstand extremely low temperature of -162℃ . The tank surfaces are also insulated in a dedicated insulation shop, This facility is equipped with air conditioning to control temperature and humidity, and is isolated from dust. This quality allows for long-term, low temperature storage of LNG throughout the voyage.

Our gas tank division manufactures LNG fuel tanks and FGSS for LNG-fueled vessel that are suitable for all ship types, equipment layouts and operation methods.



LNG Fuel Tank

Shin Kurushima Sanoyas Shipbuilding deliveries of FGSS for PCC 97



FGSS(Fuel Gas Supply System)

Development and Design of LFSS(MeOH) 98

Introducing T-SOL LFSS: A Compact and Reliable Methanol Fuel Supply System for Marine Engines

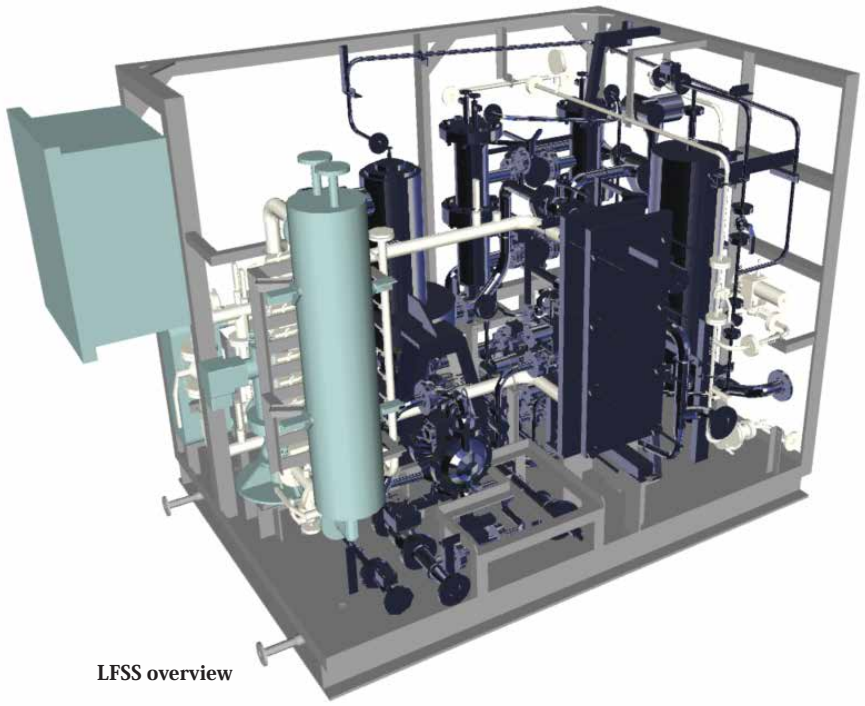
TSUNEISHI SOLUTIONS TOKYOBAY Co., Ltd. proudly presents the T-SOL LFSS — named after the company's own abbreviation "T-SOL" (Tsuneishi Solutions) — a Low Flash Point Fuel Supply System specifically engineered for methanol-fueled main engines.

Developed with simplicity and compactness as core design principles, the LFSS minimizes the number of primary components, resulting in a lightweight and space-efficient configuration. The system consists of pumps, heat exchangers, and a control unit, with manufacturing entrusted to reputable suppliers and skid assembly conducted in Japan to ensure high quality and reliability.

Key Technical Features:

- Approval in Principle (AiP) : Obtained from ClassNK in April 2024, confirming compliance with international safety standards and design guidelines.
- HAZOP Study : Conducted in December 2024 in collaboration with Prime Tech Consulting Service, verifying that potential hazards are effectively mitigated through integrated safety measures.
- Safe Maintenance Procedures : Methanol drainage and nitrogen purging before maintenance.
- Low Residual Liquid Design : Engineered to minimize methanol retention during pump and filter maintenance.
- Anti-Cavitation Measures : Optimized suction valve type, diameter, and strainer sizing to prevent pump cavitation.
- Dry-Run Prevention: Pump startup sequence based on liquid presence detection at the inlet.
- Methanol Leakage Prevention : Use of magnetic couplings or canned-type motors eliminates risks associated with shaft seal leakage.
- Inlet Strainer Configuration : Protects pumps and heat exchangers from foreign object contamination; can be used as a commissioning filter by changing the mesh size.
- System Integration Capability : All operational data can be output to the vessel's integrated monitoring system for seamless shipboard integration.
- Wide Operating Temperature Range : Compatible with methanol inlet temperatures from -10° C to 45° C.
- Accurate Fuel Consumption Monitoring : Equipped with a Coriolis mass flow meter as standard for precise fuel measurement.

The T-SOL LFSS offers a robust, efficient, and future-ready solution for vessels adopting methanol as a next-generation marine fuel.



LFSS overview

ClassNK
NIPPON KAIJI KYOKAI

Document No. KC24MC0206SH
Date: 9 April 2024

APPROVAL IN PRINCIPLE

Methanol Fuel Supply System
developed by
Mitsui E&S Shipbuilding Co., Ltd.

THIS IS TO CERTIFY THAT Approval in Principle is granted to Mitsui E&S Shipbuilding Co., Ltd.

The AIP is for the design concept of Methanol Fuel Supply System, and it is based on the relevant requirements in the Society's Rules and Guidance for the Survey and Construction of Steel Ships:

- *"Part A, Guidelines for Ships Using Alternative Fuels (Edition 2.1)"*
- *"Interim Guideline for the Safety of Ships Using Methyl/Ethyl Alcohol as Fuel, IMO Res. MSC.1/Circ.1621"*

The documents/drawings specified in the annex to this letter have been reviewed and it is verified that the conceptual design of the system is feasible for the intended application.

Conditions on this approval are set out in the Annex to letter KC24MC0206SH.
For final approval of the system, a complete set of documentation is to be approved by the Society in accordance with relevant class rule.

(Shinya Oishi)
General Manager of Machinery Department
NIPPON KAIJI KYOKAI

Form CLS (21.01)

AiP certificate