CRYSTAL TRINITY 84,000 m³ LPG Carrier 9

Contents By Builder By Ship Type

Kawasaki Heavy Industries, Ltd.

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CRYSTAL TRINITY 84,000 m³ LPG Carrier 9

January 26, 2022 — Kawasaki Heavy Industries, Ltd. announced it has delivered the 84,000 m³ capacity Liquefied Petroleum Gas (LPG) carrier CRYSTAL TRINITY (HN:1750) for KUMIAI NAVIGATION (PTE) LTD. This is the 65th LPG carrier built by the company.

This vessel is a dual-fuel LPG carrier using LPG and low-sulfur fuel oil, and Kawasaki's second 84,000 m³ LPG carrier adopting a dual-fuel main engine.

In recent years, in order to effectively reduce emissions of greenhouse gases from international shipping, more vessels are adopting liquefied gases as an alternative to heavy fuel oil on a global scale. This very large LPG carrier is powered by LPG, which reduces greenhouse gas emissions and is expected to significantly reduce environmental impact. It is the fruit of the Kawasaki Group's accumulated knowledge in building LPG and Liquefied Natural Gas (LNG) carriers, and LNG-fueled vessels.

Kawasaki plans to develop and build more LPG-fueled LPG carriers and other commercial vessels that meet environmental standards, as well as to develop and offer other eco-friendly marine technologies, to contribute to the establishment of a low-carbon/decarbonized society. These products include vessels for transporting liquefied hydrogen, considered to be the next-generation energy source.

Features

1. This LPG carrier operates using both LPG and low-sulfur fuel oil. Use of LPG as fuel greatly reduces emission volumes of sulfur oxides (SOx), CO_2 and other pollutants compared with use of marine fuel oil. In this way, the new vessel will meet SOx emission standards*1 which were strengthened in January 2020, and EEDI*2 Phase 3 regulations which will further strengthen CO_2 emission standards in 2022.
2. In order to satisfy restrictions on NOx Tier III controls*3 emissions which is implemented by the International Maritime Organization (IMO), the main engine and generator are equipped with a Selective Catalytic Reduction (SCR) System, An exhaust gas purification system to reduce NOx, which allows the ship to navigate in Emission Control Area (ECA).
3. Installation of LPG fuel tanks on the ship's upper deck makes it possible to load fuel-use LPG separate from the ship's cargo LPG. Moreover, a piping system connecting the LPG fuel tanks and LPG cargo tanks enables transferring of extra LPG to the LPG fuel tanks if necessary.
4. This vessel adopts the Kawasaki Rudder Bulb System with Fins (RBS-F) and the Semi-Duct System with contra Fins (SDS-F) contribute to reducing fuel consumption.

Remarks

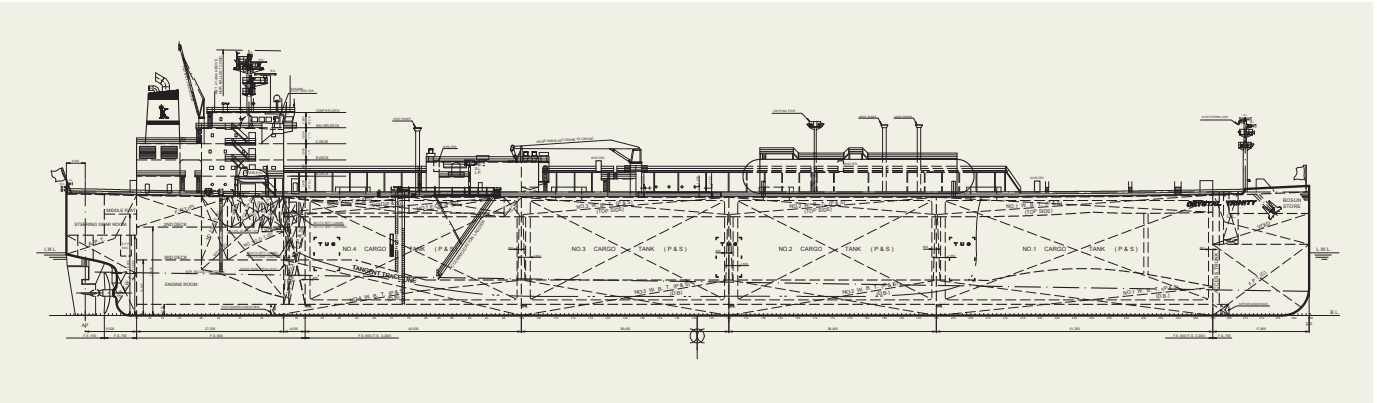
***1 SOx emission standards: Since January 2015, SOx emission restrictions in North American and European Emission Control Areas (ECAs) have limited sulfur content in fuels to 0.1% or less. Starting in January 2020, regulations have required ships operating in all other parts of the world to use fuel with sulfur content levels of 0.5% or less, or alternatively use equipment to reduce SOx in exhaust gases to an equivalent level.**

***2 Energy Efficiency Design Index: Compulsory international regulations requiring energy-efficiency compliance in newly built ships based on EEDI values, which specify CO_2 emissions in grams for transporting one ton of cargo for one mile. EEDI regulation values apply in increasingly strict phases based on the construction-contract conclusion date and finished-ship delivery date. Phase 3 regulations (30% CO_2 emissions reduction compared with baseline levels) will be introduced for certain ship types including large LPG carriers and LNG carriers contracted to be built in 2022 or later.**

***3 The Tier III controls apply only to the specified ships while operating in Emission Control Areas (ECA), requiring 80% NOx emissions reduction compared with Tier I controls.**

PRINCIPAL PARTICULARS

Length (o.a.)	229.90 m
Length (b.p.)	226.50 m
Breadth (mld.)	37.20 m
Depth (mld.)	21.90 m
Draft (mld.)	11.60 m
Gross tonnage	49,943
Deadweight	55,068 t
Main engine	KAWASAKI-MAN B&W 7S60ME-C10.5-LGIP
Complement	29 persons
Classification	Nippon Kaiji Kyokai (ClassNK)
Loading capacity (tank)	84,222.2 m³
Builder	Kawasaki Heavy Industries, Ltd.



CALLUNA GAS 84,000 m³ LPG Carrier 10

Contents By Builder By Ship Type

Kawasaki Heavy Industries, Ltd.

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CALLUNA GAS 84,000 m³ LPG Carrier 10

LPG-fueled LPG carrier CALLUNA GAS Delivered

February 28, 2022 — Kawasaki Heavy Industries, Ltd. announced today it has delivered the 84,000 m³ capacity Liquefied Petroleum Gas (LPG) carrier CALLUNA GAS (HN:1751) for IINO KAIUN KAISHA, LTD. This is the 66th LPG carrier built by the company.

This vessel is a dual-fuel LPG carrier using LPG and low-sulfur fuel oil, and their third 84,000 m³ LPG carrier adopting a dual-fuel main engine.

In recent years, in order to effectively reduce emissions of greenhouse gases from international shipping, more vessels are adopting liquefied gases as an alternative to heavy fuel oil on a global scale. This very large LPG carrier is powered by LPG, which reduces greenhouse gas emissions and is expected to significantly reduce environmental impact. It is the fruit of the Kawasaki Group's accumulated knowledge in building LPG and Liquefied Natural Gas (LNG) carriers, and LNG-fueled vessels.

Kawasaki plans to develop and build more LPG-fueled LPG carriers and other commercial vessels that meet environmental standards, as well as to develop and offer other eco-friendly marine technologies, to contribute to the establishment of a low-carbon/decarbonized society. These products include vessels for transporting liquefied hydrogen, considered to be the next-generation energy source.

Features

1. This LPG carrier operates using both LPG and low-sulfur fuel oil. Use of LPG as fuel greatly reduces emission volumes of sulfur oxides (SOx), CO_2 and other pollutants compared with use of marine fuel oil. In this way, the new vessel will meet SOx emission standards*1 which were strengthened in January 2020, and EEDI*2 Phase 3 regulations which will further strengthen CO_2 emission standards in 2022.
2. In order to satisfy restrictions on NOx Tier III controls*3 emissions which is implemented by the International Maritime Organization (IMO), the main engine and generator are equipped with a Selective catalytic reduction (SCR) System, An exhaust gas purification system to reduce NOx, which allows the ship to navigate in Emission Control Area (ECA).
3. Installation of LPG fuel tanks on the ship's upper deck makes it possible to load fuel-use LPG separate from the ship's cargo LPG. Moreover, a piping system connecting the LPG fuel tanks and LPG cargo tanks enables transferring of extra LPG to the LPG fuel tanks if necessary.
4. This vessel adopts the Kawasaki Rudder Bulb System with Fins (RBS-F) and the Semi-Duct System with contra Fins (SDS-F) contribute to reducing fuel consumption.

Remarks

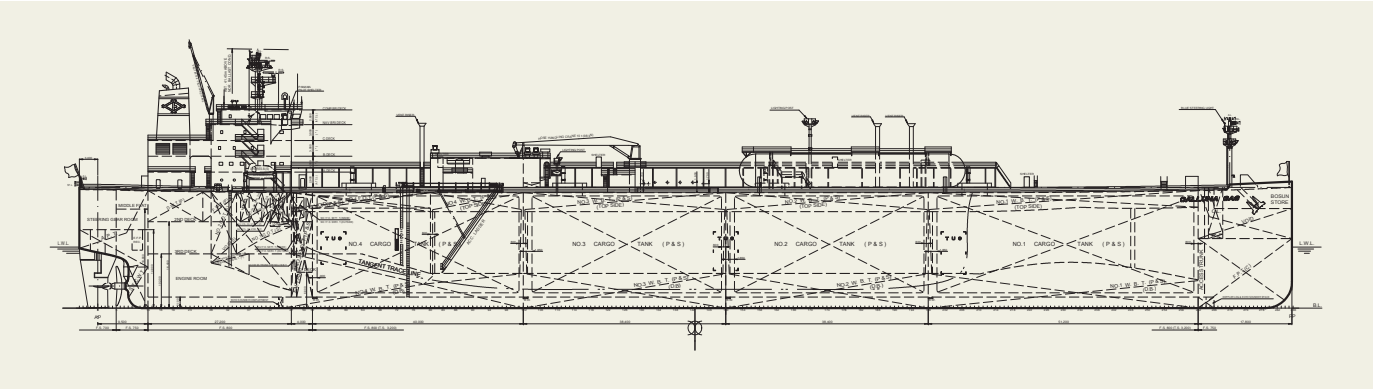
***1 SOx emission standards: Since January 2015, SOx emission restrictions in North American and European emission control areas (ECAs) have limited sulfur content in fuels to 0.1% or less. Starting in January 2020, regulations have required ships operating in all other parts of the world to use fuel with sulfur content levels of 0.5% or less, or alternatively use equipment to reduce SOx in exhaust gases to an equivalent level.**

***2 Energy Efficiency Design Index: Compulsory international regulations requiring energy-efficiency compliance in newly built ships based on EEDI values, which specify CO_2 emissions in grams for transporting one ton of cargo for one mile. EEDI regulation values apply in increasingly strict phases based on the construction-contract conclusion date and finished-ship delivery date. Phase 3 regulations (30% CO_2 emissions reduction compared with baseline levels) will be introduced for certain ship types including large LPG carriers and LNG carriers contracted to be built in 2022 or later.**

***3 The Tier III controls apply only to the specified ships while operating in Emission Control Areas (ECA), requiring 80% NOx emissions reduction compared with Tier I controls.**

PRINCIPAL PARTICULARS

Length (o.a.)	229.90 m
Length (b.p.)	226.50 m
Breadth (mld.)	37.20 m
Depth (mld.)	21.90 m
Draft (mld.)	11.60 m
Gross tonnage	49,943
Deadweight	55,086 t
Main engine	KAWASAKI-MAN B&W 7S60ME-C10.5-LGIP
Complement	30 persons
Classification	Nippon Kaiji Kyokai (ClassNK)
Loading capacity (tank)	84,174.8 m³
Builder	Kawasaki Heavy Industries, Ltd.



CRYSTAL OASIS 84,000 m³ LPG Carrier 11

Contents By Builder By Ship Type

LPG-fueled LPG carrier CRYSTAL OASIS Delivered

June 29, 2022 — Kawasaki Heavy Industries, Ltd. announced today it has delivered the 84,000 m³ capacity Liquefied Petroleum Gas (LPG) carrier CRYSTAL OASIS (HN:1752) for KUMIAI NAVIGATION (PTE) LTD. This is the 67th LPG carrier built by the company.

This vessel is a dual-fuel LPG carrier using LPG and low-sulfur fuel oil, and their fourth 84,000 m³ LPG carrier adopting a dual-fuel main engine.

CRYSTAL OASIS 84,000 m³ LPG Carrier 11

In recent years, in order to effectively reduce emissions of greenhouse gases from international shipping, more vessels are adopting liquefied gases as an alternative to heavy fuel oil on a global scale. This very large LPG carrier is powered by LPG, which reduces greenhouse gas emissions and is expected to significantly reduce environmental impact. It is the fruit of the Kawasaki Group's accumulated knowledge in building LPG and Liquefied NaturalGgas (LNG) carriers, and LNG-fueled vessels.

Kawasaki plans to develop and build more LPG-fueled LPG carriers, LPG/NH3 carrier, and other commercial vessels that meet environmental standards, as well as to develop and offer other eco-friendly marine technologies, to contribute to the establishment of a low-carbon/decarbonized society. These products include vessels for transporting liquefied hydrogen, considered to be the next-generation energy source.

Features

1. This LPG carrier operates using both LPG and low-sulfur fuel oil. Use of LPG as fuel greatly reduces emission volumes of sulfur oxides (SOx), CO_2 and other pollutants compared with use of marine fuel oil. In this way, the new vessel will meet SOx emission standards*1 which were strengthened in January 2020, and EEDI*2 Phase 3 regulations which will further strengthen CO_2 emission standards.
2. In order to satisfy restrictions on NOx Tier III controls*3 emissions which is implemented by the International Maritime Organization (IMO), the main engine and generator are equipped with a Selective catalytic reduction (SCR) System, An exhaust gas purification system to reduce NOx, which allows the ship to navigate in Emission Control Area (ECA).
3. Installation of LPG fuel tanks on the ship's upper deck makes it possible to load fuel-use LPG separate from the ship's cargo LPG. Moreover, a piping system connecting the LPG fuel tanks and LPG cargo tanks enables transferring of extra LPG to the LPG fuel tanks if necessary.
4. This Vessel has successfully achieved very flexible and practical design through the combination of shallow draft hull form and high compatibility with terminals and their land facility as the result of complying with OCIMF Mooring Equipment Guidance 4th Edition and ExxonMobil Criteria MESQAC 2017 as practical as possible.
5. This vessel adopts the Kawasaki Rudder Bulb System with Fins (RBS-F) and the Semi-Duct System with contra Fins (SDS-F) which contribute to reducing fuel consumption.

Remarks

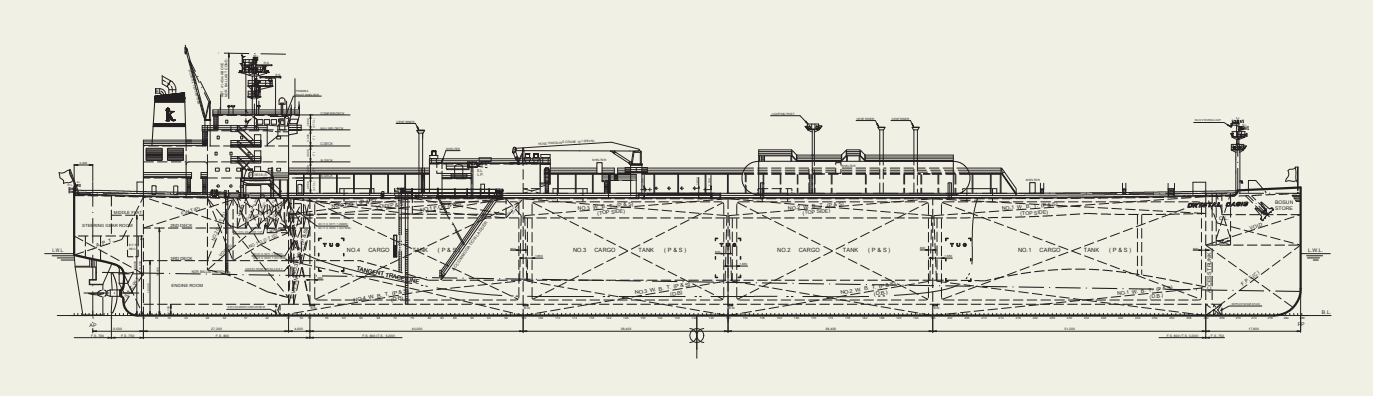
***1 SOx emission standards: Since January 2015, SOx emission restrictions in North American and European emission control areas (ECAs) have limited sulfur content in fuels to 0.1% or less. Starting in January 2020, regulations have required ships operating in all other parts of the world to use fuel with sulfur content levels of 0.5% or less, or alternatively use equipment to reduce SOx in exhaust gases to an equivalent level.**

***2 Energy Efficiency Design Index: Compulsory international regulations requiring energy-efficiency compliance in newly built ships based on EEDI values, which specify CO_2 emissions in grams for transporting one ton of cargo for one mile. EEDI regulation values apply in increasingly strict phases based on the construction-contract conclusion date and finished-ship delivery date. Phase 3 regulations (30% CO_2 emissions reduction compared with baseline levels) will be introduced for certain ship types including large LPG carriers and LNG carriers contracted to be built in 2022 or later.**

***3 The Tier III controls apply only to the specified ships while operating in Emission Control Areas (ECA), requiring 80% NOx emissions reduction compared with Tier I controls.**

PRINCIPAL PARTICULARS

Length (o.a.)	229.90 m
Length (b.p.)	226.50 m
Breadth (mld.)	37.20 m
Depth (mld.)	21.90 m
Draft (mld.)	11.60 m
Gross tonnage	49,943
Deadweight	55,090 t
Main engine	KAWASAKI-MAN B&W 7S60ME-C10.5-LGIP
Complement	29 persons
Classification	Nippon Kaiji Kyokai (ClassNK)
Loading capacity (tank)	84,244.3 m³
Builder	Kawasaki Heavy Industries, Ltd.



LUPINUS PLANET 84,000 m³ LPG Carrier 12

Contents By Builder By Ship Type

Kawasaki Heavy Industries, Ltd.

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LUPINUS PLANET 84,000 m³ LPG Carrier 12

Kawasaki Heavy Industries, Ltd. announced it has delivered the 84,000 m³ capacity Liquefied Petroleum Gas (LPG) carrier LUPINUS PLANET (HN:1753) for Nippon Yusen Kabushiki Kaisha. This is the 68th LPG carrier built by the company.
This vessel is a dual-fuel LPG carrier using LPG and low-sulfur fuel oil, and their fifth 84,000 m³ LPG carrier adopting a dual-fuel main engine.
In recent years, in order to effectively reduce emissions of greenhouse gases from international shipping, more vessels are adopting liquefied gases as an alternative to heavy fuel oil on a global scale. This very large LPG carrier is powered by LPG, which reduces greenhouse gas emissions and is expected to significantly reduce environmental impact. It is the fruit of the Kawasaki Group's accumulated knowledge in building LPG and Liquefied Natural Gas (LNG) carriers, and LNG-fueled vessels.
Kawasaki plans to develop and build more LPG-fueled LPG carriers, LPG/NH3 carrier, and other commercial vessels that meet environmental standards, as well as to develop and offer other eco-friendly marine technologies, to contribute to the establishment of a low-carbon/decarbonized society. These products include vessels for transporting liquefied hydrogen, considered to be the next-generation energy source.

Features

1. This LPG carrier operates using both LPG and low-sulfur fuel oil. Use of LPG as fuel greatly reduces emission volumes of sulfur oxides (SOx), CO_2 and other pollutants compared with use of marine fuel oil. In this way, the new vessel will meet SOx emission standards*1 which were strengthened in January 2020, and EEDI*2 Phase 3 regulations which will further strengthen CO_2 emission standards.
2. In order to satisfy restrictions on NOx Tier III controls*3 emissions which is implemented by the International Maritime Organization (IMO), the main engine and generator are equipped with a Selective catalytic reduction (SCR) System, An exhaust gas purification system to reduce NOx, which allows the ship to navigate in Emission Control Area (ECA).
3. Installation of LPG fuel tanks on the ship's upper deck makes it possible to load fuel-use LPG separate from the ship's cargo LPG. Moreover, a piping system connecting the LPG fuel tanks and LPG cargo tanks enables transferring of extra LPG to the LPG fuel tanks if necessary.
4. This vessel adopts the Kawasaki Rudder Bulb System with Fins (RBS-F) and the Semi-Duct System with contra Fins (SDS-F) which contribute to reducing fuel consumption.

Remarks

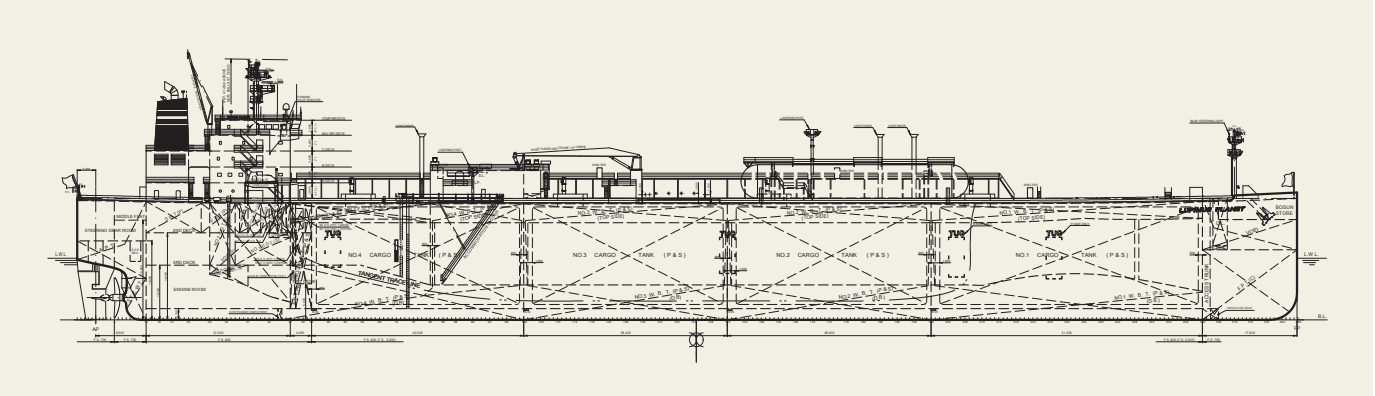
***1 SOx emission standards: Since January 2015, SOx emission restrictions in North American and European emission control areas (ECAs) have limited sulfur content in fuels to 0.1% or less. Starting in January 2020, regulations have required ships operating in all other parts of the world to use fuel with sulfur content levels of 0.5% or less, or alternatively use equipment to reduce SOx in exhaust gases to an equivalent level.**

***2 Energy Efficiency Design Index: Compulsory international regulations requiring energy-efficiency compliance in newly built ships based on EEDI values, which specify CO_2 emissions in grams for transporting one ton of cargo for one mile. EEDI regulation values apply in increasingly strict phases based on the construction-contract conclusion date and finished-ship delivery date. Phase 3 regulations (30% CO_2 emissions reduction compared with baseline levels) will be introduced for certain ship types including large LPG carriers and LNG carriers contracted to be built in 2022 or later.**

***3 The Tier III controls apply only to the specified ships while operating in Emission Control Areas (ECA), requiring 80% NOx emissions reduction compared with Tier I controls.**

PRINCIPAL PARTICULARS

Length (o.a.)	229.90 m
Length (b.p.)	226.50 m
Breadth (mld.)	37.20 m
Depth (mld.)	21.90 m
Draft (mld.)	11.60 m
Gross tonnage	49,943
Deadweight	55,091 t
Main engine	KAWASAKI-MAN B&W 7S60ME-C10.5-LGIP
Complement	30 persons
Classification	Nippon Kaiji Kyokai (ClassNK)
Loading capacity (tank)	84,171.8 m³
Builder	Kawasaki Heavy Industries, Ltd.



LANTANA PLANET 84,000 m³ LPG Carrier 13

Contents By Builder By Ship Type

Kawasaki Heavy Industries, Ltd.

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LANTANA PLANET 84,000 m³ LPG Carrier 13

LPG-fueled LPG carrier LANTANA PLANET Delivered

January 23, 2023 — Kawasaki Heavy Industries, Ltd. announced today it has delivered the 84,000 m³ capacity Liquefied Petroleum Gas (LPG) carrier LANTANA PLANET (HN:1754) for Nippon Yusen Kabushiki Kaisha. This is the 69th LPG carrier built by the company.

This vessel is a dual-fuel LPG carrier using LPG and low-sulfur fuel oil, and their fourth 84,000 m³ LPG carrier adopting a dual-fuel main engine.

In recent years, in order to effectively reduce emissions of greenhouse gases from international shipping, more vessels are adopting liquefied gases as an alternative to heavy fuel oil on a global scale. This very large LPG carrier is powered by LPG, which reduces greenhouse gas emissions and is expected to significantly reduce environmental impact. It is the fruit of the Kawasaki Group's accumulated knowledge in building LPG and Liquefied Natural Gas (LNG) carriers, and LNG-fueled vessels.

Kawasaki plans to develop and build more LPG-fueled LPG carriers, LPG/NH3 carrier, and other commercial vessels that meet environmental standards, as well as to develop and offer other eco-friendly marine technologies, to contribute to the establishment of a low-carbon/decarbonized society. These products include vessels for transporting liquefied hydrogen, considered to be the next-generation energy source.

Features

1. This LPG carrier operates using both LPG and low-sulfur fuel oil. Use of LPG as fuel greatly reduces emission volumes of sulfur oxides (SOx), CO_2 and other pollutants compared with use of marine fuel oil. In this way, the new vessel will meet SOx emission standards*1 which were strengthened in January 2020, and EEDI*2 Phase 3 regulations which will further strengthen CO_2 emission standards.
2. In order to satisfy restrictions on NOx Tier III controls*3 emissions which is implemented by the International Maritime Organization (IMO), the main engine and generator are equipped with a Selective catalytic reduction (SCR) System, An exhaust gas purification system to reduce NOx, which allows the ship to navigate in Emission Control Area (ECA).
3. Installation of LPG fuel tanks on the ship's upper deck makes it possible to load fuel-use LPG separate from the ship's cargo LPG. Moreover, a piping system connecting the LPG fuel tanks and LPG cargo tanks enables transferring of extra LPG to the LPG fuel tanks if necessary.
4. This vessel adopts the Kawasaki Rudder Bulb System with Fins (RBS-F) and the Semi-Duct System with contra Fins (SDS-F) which contribute to reducing fuel consumption.

Remarks

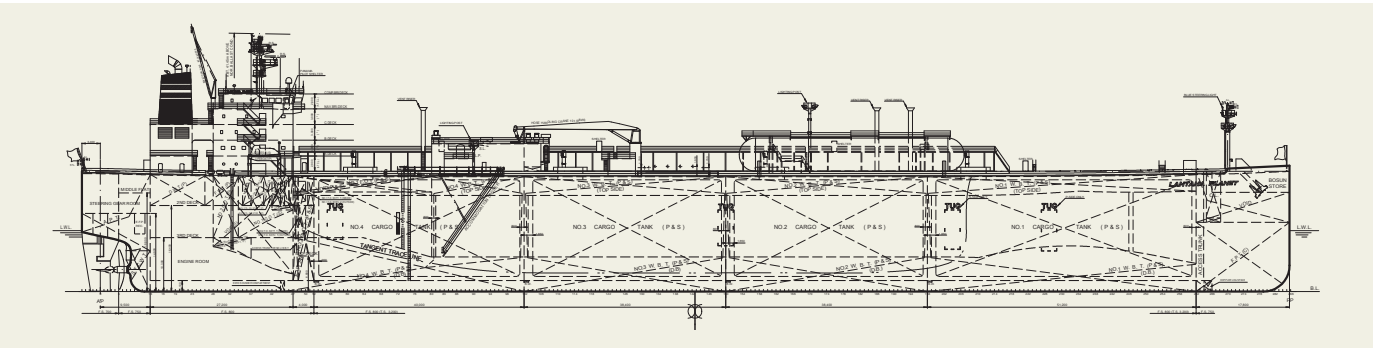
***1 SOx emission standards: Since January 2015, SOx emission restrictions in SOx emission standards: Since January 2015, SOx emission restrictions in North American and European emission control areas (ECAs) have limited sulfur content in fuels to 0.1% or less. Starting in January 2020, regulations have required ships operating in all other parts of the world to use fuel with sulfur content levels of 0.5% or less, or alternatively use equipment to reduce SOx in exhaust gases to an equivalent level.**

***2 Energy Efficiency Design Index: Compulsory international regulations requiring energy-efficiency compliance in newly built ships based on EEDI values, which specify CO_2 emissions in grams for transporting one ton of cargo for one mile. EEDI regulation values apply in increasingly strict phases based on the construction-contract conclusion date and finished-ship delivery date. Phase 3 regulations (30% CO_2 emissions reduction compared with baseline levels) will be introduced for certain ship types including large LPG carriers and LNG carriers contracted to be built in 2022 or later.**

***3 The Tier III controls apply only to the specified ships while operating in Emission Control Areas (ECA), requiring 80% NOx emissions reduction compared with Tier I controls.**

PRINCIPAL PARTICULARS

Length (o.a.)	229.90 m
Length (b.p.)	226.50 m
Breadth (mld.)	37.20 m
Depth (mld.)	21.90 m
Draft (mld.)	11.60 m
Gross tonnage	49,943
Deadweight	55,153 t
Main engine	KAWASAKI-MAN B&W 7S60ME-C10.5-LGIP
Complement	30 persons
Classification	Nippon Kaiji Kyokai (ClassNK)
Loading capacity (tank)	84,169.8 m³
Builder	Kawasaki Heavy Industries, Ltd.



CAPTAIN MARKOS 84,000 m³ LPG Carrier 14

Contents By Builder By Ship Type

LPG-fueled LPG carrier CAPTAIN MARKOS Delivered

March 31, 2023 — Kawasaki Heavy Industries, Ltd. announced today it has delivered the 84,000 m³ capacity Liquefied Petroleum Gas (LPG) carrier CAPTAIN MARKOS (HN:1755). This is the 70th LPG carrier built by the company. This vessel is a dual-fuel LPG carrier using LPG and low-sulfur fuel oil, and their seventh 84,000 m³ LPG carrier adopting a dual-fuel main engine.

In recent years, in order to effectively reduce emissions

CAPTAIN MARKOS 84,000 m³ LPG Carrier 14

of greenhouse gases from international shipping, more vessels are adopting liquefied gases as an alternative to heavy fuel oil on a global scale. This very large LPG carrier is powered by LPG, which reduces greenhouse gas emissions and is expected to significantly reduce environmental impact. It is the fruit of the Kawasaki Group's accumulated knowledge in building LPG and Liquefied Natural Gas (LNG) carriers, and LNG-fueled vessels.

Kawasaki plans to develop and build more LPG-fueled LPG carriers, LPG/NH3 carrier, and other commercial vessels that meet environmental standards, as well as to develop and offer other eco-friendly marine technologies, to contribute to the establishment of a low-carbon/decarbonized society. These products include vessels for transporting liquefied hydrogen, considered to be the next-generation energy source.

Features

1. This LPG carrier operates using both LPG and low-sulfur fuel oil. Use of LPG as fuel greatly reduces emission volumes of sulfur oxides (SOx), CO_2 and other pollutants compared with use of marine fuel oil. In this way, the new vessel will meet SOx emission standards*1 which were strengthened in January 2020, and EEDI*2 Phase 3 regulations which will further strengthen CO_2 emission standards.
2. In order to satisfy restrictions on NOx Tier III controls*3 emissions which is implemented by the International Maritime Organization (IMO), the main engine and generator are equipped with a Selective catalytic reduction (SCR) System, An exhaust gas purification system to reduce NOx, which allows the ship to navigate in Emission Control Area (ECA).
3. Installation of LPG fuel tanks on the ship's upper deck makes it possible to load fuel-use LPG separate from the ship's cargo LPG. Moreover, a piping system connecting the LPG fuel tanks and LPG cargo tanks enables transferring of extra LPG to the LPG fuel tanks if necessary.
4. This vessel adopts the Kawasaki Rudder Bulb System with Fins (RBS-F) and the Semi-Duct System with contra Fins (SDS-F) which contribute to reducing fuel consumption.

Remarks

***1 SOx emission standards: Since January 2015, SOx emission restrictions in North American and European emission control areas (ECAs) have limited sulfur content in fuels to 0.1% or less. Starting in January 2020, regulations have required ships operating in all other parts of the world to use fuel with sulfur content levels of 0.5% or less, or alternatively use equipment to reduce SOx in exhaust gases to an equivalent level.**

***2 Energy Efficiency Design Index: Compulsory international regulations requiring energy-efficiency compliance in newly built ships based on EEDI values, which specify CO_2 emissions in grams for transporting one ton of cargo for one mile. EEDI regulation values apply in increasingly strict phases based on the construction-contract conclusion date and finished-ship delivery date. Phase 3 regulations (30% CO_2 emissions reduction compared with baseline levels) will be introduced for certain ship types including large LPG carriers and LNG carriers contracted to be built in 2022 or later.**

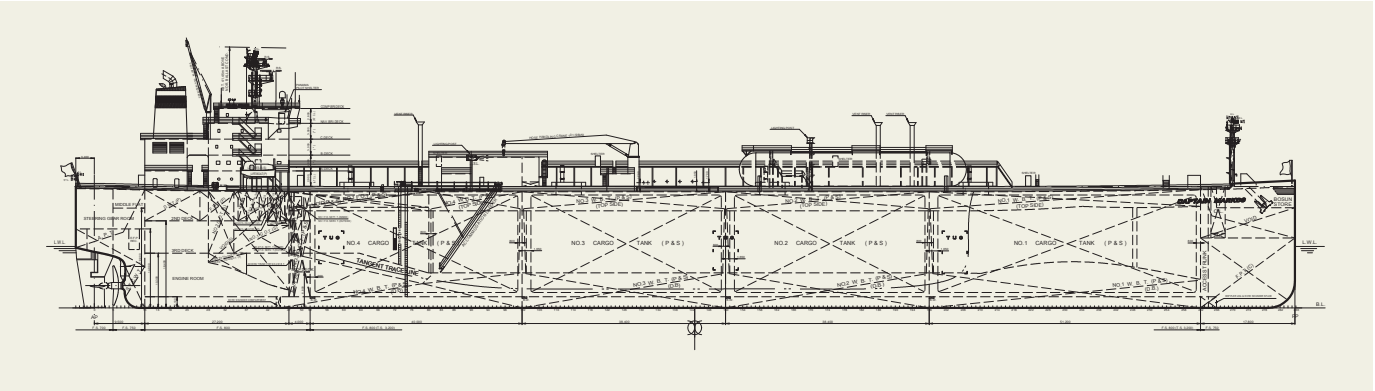
***3 The Tier III controls apply only to the specified ships while operating in Emission Control Areas (ECA), requiring 80% NOx emissions reduction compared with Tier I controls.**

***4 Exhaust Gas Recirculation System (EGR): This device reduces NOx emissions by cleaning a portion of the main engine's exhaust gas with fresh water and returning it to the main engine as combustion air, thereby lowering the oxygen concentration and combustion temperature of the combustion air and suppressing the oxidation reaction of nitrogen at high temperatures. In addition, the washing water used to clean exhaust gases removes soot and oil and is treated harmlessly and discharged overboard.**

***5 Selective Catalytic Reduction (SCR): When urea water is sprayed on the hot exhaust gas of a power generation engine, it is broken down into ammonia, which reacts with NOx in the exhaust gas via a titanium/vanadium catalyst to reduce NOx emissions by reducing to nitrogen and water.**

PRINCIPAL PARTICULARS

Length (o.a.)	229.90 m
Length (b.p.)	226.50 m
Breadth (mld.)	37.20 m
Depth (mld.)	21.90 m
Draft (mld.)	11.60 m
Gross tonnage	49,976
Deadweight	55,206 t
Main engine	KAWASAKI-MAN B&W 7S60ME-C10.5-LGIP
Complement	29 persons
Classification	American Bureau of Shipping (ABS)
Loading capacity (tank)	84,273.7 m³
Builder	Kawasaki Heavy Industries, Ltd.



AXIS RIVER 86,700 m³ LPG/NH3 Carrier 15

Contents By Builder By Ship Type

Delivery of the LPG-powered "AXIS RIVER" LPG/NH3 Carrier

June 30, 2023 — Kawasaki Heavy Industries, Ltd. announced today its delivery of the "AXIS RIVER" (HN:1756), an 86,700 m³ Liquefied Petroleum Gas (LPG) and ammonia (NH3) carrier powered by LPG.

The "AXIS RIVER" - an LPG-powered LPG/NH3 carrier

The "AXIS RIVER" is the first of Kawasaki's newest-design 86,700 m³ capacity, LPG-fueled LPG/NH3 carrier, with the increased cargo capacity from the existing 84,000 m³ LPG Carrier as well as ammonia loading capability. As for LPG-powered vessels, Kawasaki has completed eight vessels to date, and the "AXIS RIVER" is its seventy-first LPG carrier in total..

This latest LPG/NH3 carrier has a capability of simultaneous transportation of LPG, which is already widely used as a low-carbon-emission energy source, and ammonia, which may be expected to be utilized as a new fuel in the low- and zero-carbon-emission societies. Furthermore, this vessel is designed to increase cargo tank capacity, with

AXIS RIVER 86,700 m³ LPG/NH3 Carrier 15

keeping its principal dimensions like LOA and beam similar to conventional-type vessels so that the carrier can be berthed at major LPG terminals around the world.
In consideration of the strengthening of environmental regulations around the world and action plans for the Sustainable Development Goals (SDGs), Kawasaki will continue to develop and provide customers with environmental-friendly ship technologies with a focus on LPG carriers and LPG/NH3 carriers powered by LPG, as well as other types merchant vessels in comply with the latest environmental regulations,— including liquefied hydrogen carriers, the cargo of which is expected to be a fuel that is gaining popularity as a next-generation energy source. In this way, Kawasaki will contribute toward the realization of low- and zero-carbon-emission societies.

Features

1. This carrier is equipped with the Kawasaki-MAN B&W 6G60ME-C10.5-LGIP, a Kawasaki-made, electronically controlled, LPG-injection marine diesel engine (ME-LGIP engine). By utilizing LPG as fuel, it is possible to significantly reduce sulfur oxide (SOx) and CO_2 emissions in exhaust gases compared with ships running on conventional marine fuel oil, enabling compliance with SOx emission standards*1 and EEDI phase 3 regulations.*2
2. The propulsion system is compliant with nitrogen oxide (NOx) Tier III requirements*3 and utilizes EGR*4 and SCR*5 equipment. Thanks to this system, the vessel is able to travel in NOx emission control areas (ECAs) even when operating on conventional low-sulfur fuel.
3. Fuel consumption amounts are reduced through the inclusion of the Kawasaki RBS-F (Rudder Bulb System with Fins), the Kawasaki SDS-F (Semi-Duct System with contra Fins), and energy-saving fins around the propeller.
4. The concept design for a system that utilizes ammonia as fuel on this vessel has been approved by Nippon Kaiji Kyokai (ClassNK). Therefore, it is possible to modify ship design specifications to enable the use of ammonia as fuel in the future.

Remarks

***1 SOx emission standards:**
Since January 2015, International Maritime Organization (IMO) SOx emission restrictions in North American and European ECAs have limited sulfur content in fuels to 0.1% or less. Starting in January 2020, regulations have required ships operating in all other parts of the world to use fuel with sulfur content levels of 0.5% or less, or alternatively use equipment to reduce SOx in exhaust gases to an equivalent level.

***2 Energy Efficiency Design Index:**
Compulsory international regulations requiring energy-efficiency compliance in newly built ships based on EEDI values, which specify CO_2 emissions in grams for transporting one ton of cargo for one mile. EEDI regulation values apply in increasingly strict phases based on the construction-contract conclusion date and finished-ship delivery date. Phase 3 regulations (30% CO_2 emissions reduction compared with baseline levels) apply for certain ship types, including large LPG carriers and LNG (liquefied natural gas) carriers, contracted to be built in 2022 or later.

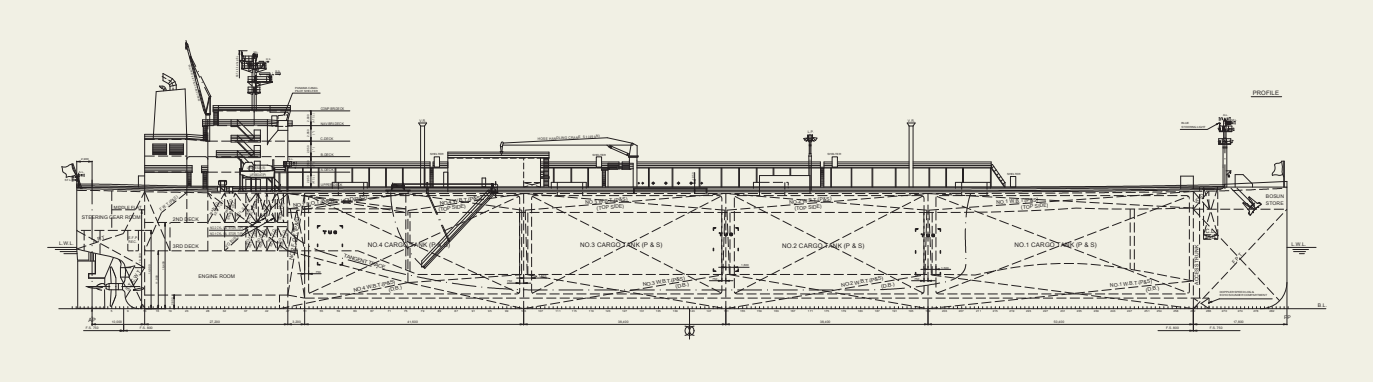
***3 NOx emission standards:**
The IMO regulates ship NOx emissions. Tier III regulations, which were enacted in 2016, specify controls for North American and European ECAs only, and stipulate an 80% NOx reduction over the Tier I value.

***4 Exhaust gas recirculation:**
An EGR system cleans a portion of exhaust gases using wash water and recirculates them as air for use in the combustion process within the propulsion system. This reduces oxygen concentrations in combustion air and lowers combustion temperature, mitigating the oxidation reaction of nitrogen at high temperatures to reduce resulting NOx emissions. The water used to clean the exhaust gases is treated to remove soot, oils and other contaminants, rendering it safe before its release into the sea outside the vessel.

***5 Selective catalytic reduction:**
The SCR system sprays urea water into high-temperature exhaust gases from the generator, decomposing the ammonia contained therein. By using this together with catalysts such as titanium and vanadium, it is possible to trigger a reaction with the NOx in exhaust gases, converting them into nitrogen and water and thus reducing NOx emissions.

PRINCIPAL PARTICULARS

Length (o.a.)	229.90 m
Length (b.p.)	227.00 m
Breadth (mld.)	37.20 m
Depth (mld.)	21.90 m
Draft (mld.)	11.65 m
Gross tonnage	49,542
Deadweight	56,503 t
Main engine	KAWASAKI-MAN B&W 6G60ME-C10.5-LGIP
Complement	35 persons
Classification	Nippon Kaiji Kyokai (ClassNK)
Loading capacity (tank)	86,919.1 m³
Builder	Kawasaki Heavy Industries, Ltd.



KHI's Education, Training Program for KICS® Operators Certified by ClassNK 79

An education and training program for ship dynamic positioning system (DPS)*1 operators developed by Kawasaki Heavy Industries, Ltd. (KHI) has been certified by Nippon Kaiji Kyokai (ClassNK).

DPS-equipped vessels are playing more and more important roles in offshore construction projects requiring highly accurate work, such as those for generating electric power with wind and other renewable energy. The education and training program certified by ClassNK is designed for the operators of the Kawasaki Integrated Control System (KICS®)*2, which has also been developed by KHI. The program is made up of classroom lectures, onshore training with simulators and on-board training. Those completing it receive certificates endorsed by both KHI and ClassNK. By providing systematic education and training to KICS® operators, the program contributes to improving the safety and reliability of domestic offshore construction projects in Japan.

KICS® is available in two series: the DPS series for self-elevating platform (SEP) vessels*3, cable layers and others engaged in specialized operations and the joystick ship operation series for ferries, roll-on/roll-off (Ro/Ro) ships*4 and others having more than one propulsion systems. To date, KICS® has been employed on board more than 100 vessels in total.

As a ship propulsion system integrator, KHI continues to work to realize safe and secure maritime mobility by providing propulsion system packages suitable for all types of vessels.

Certification ceremony

KICS® simulator

***1 A dynamic positioning system (DPS) helps detect hull conditions with the global positioning system (GPS) and other sensors and automatically control propulsion systems and rudders so as to keep hulls from currents, winds, waves and other external factors and in designated positions.**

***2 The Kawasaki Integrated Control System (KICS®) helps collectively operate several systems, such as variable-pitch propellers, rotating thrusters, side thrusters and rudders. Refer to: https://www.khi.co.jp/mobility/marine/machinery/kics.html.**

***3 A self-elevating platform (SEP) vessel has both a platform and a self-elevating system. A platform is lifted above the sea surface with a self-evaluating system, on which crane and other operations are made. It is mainly deployed for installing offshore windmills and other tasks.**

***4 A roll-on/roll-off (Ro/Ro) ship a type of cargo freighter that has boarding ramps as ferries do and a deck for accommodating automobiles and other commodities.**

Contents By Builder By Ship Type

Proposal by KHI, YPT, J-ENG Adopted as NEDO's Green Innovative Fund Project

Step Taken Forward to Realize Zero-Emission Ships 82

A joint proposal made by Kawasaki Heavy Industries, Ltd. (KHI), Yanmar Power Technology Co, Ltd. (YPT) and Japan Engine Corp. (J-ENG) has been adopted by the New Energy and Industrial Technology Development Organization (NEDO) for its Green Innovation Fund Projects*1 and Next-Generation Ship Development.

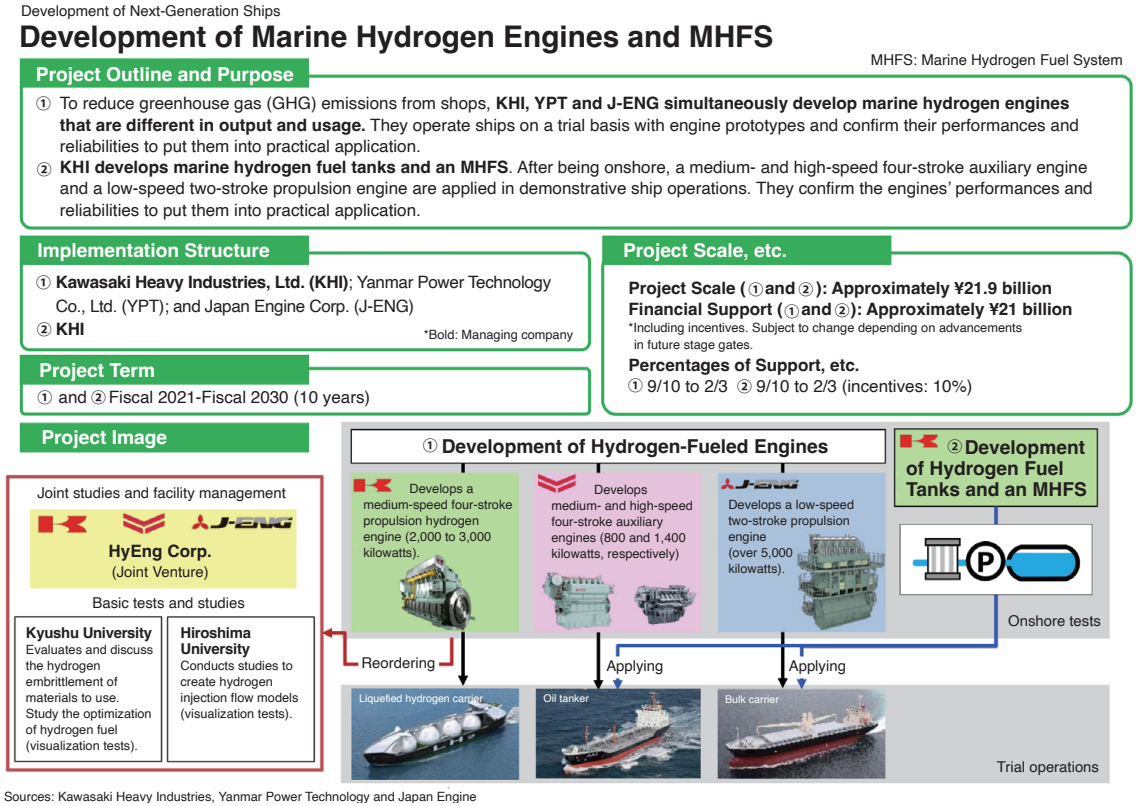
The proposal, the development of marine hydrogen engines and a marine hydrogen fuel system (MHFS), was made to contribute to realizing the Virtuous Cycle of Environment and Economy, an initiative to bring about innovative industrial structure and socioeconomic changes to accomplish further growth by taking active measure to global warming. The initiative is set forth in the Green Growth Strategy through Achieving Carbon Neutrality in 2050, which was formulated by the Ministry of Economy, Trade and Industry (METI) and other relevant governmental organizations on Dec. 25, 2020.

KHI, YPT and J-ENG will simultaneously develop medium-speed four-stroke, medium- and high-speed four-stroke and low-speed two-stroke engines, respectively, aiming to complete a lineup of engines for a wide variety of purposes around 2026. By collaborating with shipping and shipbuilding companies, in addition, they will run engine prototypes on a trial basis on board real vessels, hoping they will actually be implemented in the real world.

KHI will be responsible for the development of marine hydrogen fuel tanks and an MHFS as well. Together with the other members, it will strive to complete a hydrogen fuel propulsion system.

KHI, YPT and J-ENG will also join hands—through HyEng Corp., a joint venture they have set up—in conducting a basic combustion analysis; developing raw material and seal technologies as well as common technology components, such as compliance with classification society rules; and using shared test facilities.

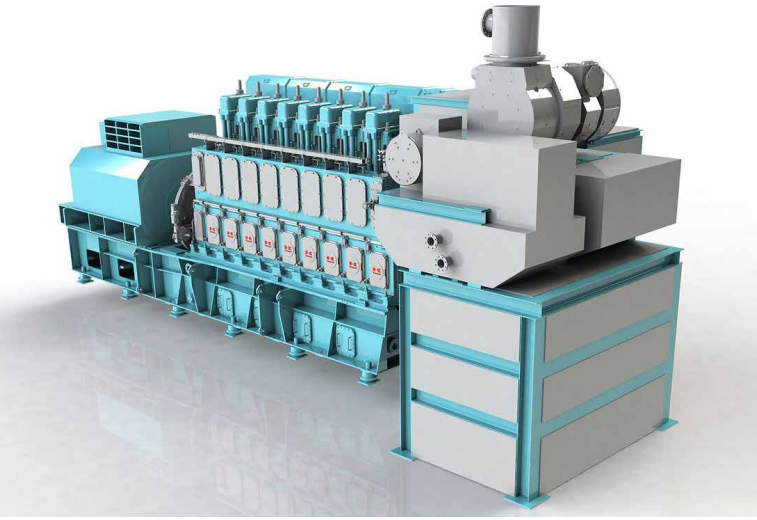
KHI, YPT and J-ENG will endeavor to develop marine hydrogen engines and an MHFS by combining the technologies and knowledge that they have accumulated. They will also work on a project to verify the commercialization of a liquefied hydrogen supply chain, proposed by KHI to further reduce costs for supplying hydrogen. By advancing the project, which has been adopted separately, they will contribute to realizing carbon neutrality by 2050.



Sources: Kawasaki Heavy Industries, Yanmar Power Technology and Japan Engine

*1 The Green Innovation Fund is a program in which the government of Japan financially supports the enterprises and others that make efforts to address business challenges to realize carbon neutrality by 2050. Financial support is provided for a period of 10 years to allow enterprises and other organizations to research, develop, demonstrate and implement outcomes. A total of 14 sectors are eligible, including hydrogen, fuel ammonia and other energy-; transport- and manufacturing-; and home- and office-related industries.

World's First AiP Granted to Kawasaki's 2.4 MW Class Dual Fuel Engine Using Hydrogen Gas as Fuel 83



Artist's rendition of a DF engine using hydrogen gas as fuel

Artist's rendition of the 160,000 m³ liquefied hydrogen carrier

November 30, 2022 — Kawasaki Heavy Industries, Ltd. announced today that an Approval in Principle (AiP)*1 was granted by Nippon Kaiji Kyokai (ClassNK) for Kawasaki's dual fuel (DF) engine using hydrogen gas as fuel, which will be installed on a 160,000 m³ liquefied hydrogen carrier developed by Kawasaki.

This DF engine allows operators to flexibly alternate between the use of hydrogen fuel and conventional low-sulfur fuel oil. When hydrogen fuel is selected, the boil-off gas that evaporates naturally from the vessel's liquefied hydrogen cargo tanks is used as the main fuel at a calorie-based ratio of 95% or higher*2, which results in a significant reduction of greenhouse gas emissions.

Kawasaki has a track record of selling more than 200 units of engines fueled solely by natural gas. To expand its product portfolio, Kawasaki developed combustion technologies tailored to hydrogen's properties — a fast combustion speed, which often results in backfire, and a high combustion temperature — and in a demonstration test using a single-cylinder test engine, the Company achieved stable combustion of hydrogen without causing abnormal combustion or the overheating of parts in the combustion chamber. Kawasaki is developing hydrogen powered engine for propulsion as a Green Innovation Fund Project of the New Energy and Industrial Technology Development Organization (NEDO). Kawasaki intends to conduct a demonstration test of this engine after installing it as a generator engine on a large-scale liquefied hydrogen carrier which is planned to be commercialized in the mid-2020s.

As Kawasaki foresees a significant increase in the use of hydrogen energy in the future, which will play a vital role in achieving a decarbonized society, the Company is developing a range of technologies for a hydrogen supply chain (production, transportation, storage, and utilization). The technology used for this engine serves the "transportation" and "utilization" stages, covering both the demand and supply aspects of the supply chain. Moving forward, Kawasaki will continue to develop more products that capitalize on hydrogen energy, contributing to the realization of carbon neutrality.

Specifications of DF generator engine using hydrogen gas as fuel

Rated output: 2,400 kWe (when hydrogen fuel is used)
Cylinder diameter: 300 mm

***1 At the initial stage of designing or before a decision is made regarding which ship on which the product will be used, the product's design is examined based on existing regulations, such as international treaties and ship classification rules, and an Approval in Principle (AiP) is issued as proof of conformity with such requirements. This time, an AiP was granted by ClassNK based on the result of a risk assessment using the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (the IGC Code, to which all liquefied gas carriers built during and after 1986 must conform, and which is included in ClassNK's rules for steel ships) and the Hazard Identification Study (HAZID, a method of assessing risks which are determined by experts based on the frequency with which potential hazards in a system arise, and aimed at identifying ways to minimize that frequency).**

***2 A calorie-based ratio of hydrogen boil-off gas to low-sulfur fuel oil.**

Contents By Builder By Ship Type

Liquefied Hydrogen Carrier -SUISO FRONTIER- Receives Classification from Nippon Kaiji Kyokai

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© HySTRA

Kawasaki Heavy Industries, Ltd. announced that its world's first liquefied hydrogen carrier -the SUISO FRONTIER- has received a classification from Nippon Kaiji Kyokai (ClassNK), recognizing that it complies with International Maritime Organisation（IMO）standards.

The SUISO FRONTIER can carry 75 tonnes of liquefied hydrogen in one trip. The liquefied hydrogen is produced by cooling gaseous hydrogen to minus 253° C therefore reducing its volume to 1/800.

The vessel was inspected for its hull structure, machinery, onboard equipment and materials and more, in accordance with its class rules and the requirements for the safe transport of hydrogen by sea, formulated by ClassNK, based on the provisional recommendations of IMO. The vessel was then added to ClassNK's register on 3 December, 2021.

Hydrogen is a clean energy source that emits no CO^2 when burned, and when used as a fuel it can generate power, cars, motorcycles, ships and aircrafts. Various initiatives are underway in many countries to build a supply chain for the realization of a hydrogen society.

In order to realize a future in which hydrogen is used as commonly as oil and natural gas, Kawasaki aims to build a supply chain that produces, stores, transports and uses hydrogen in cooperation with various partners.

Kawasaki Heavy Industries, Ltd.

Dawn of Australia's Hydrogen Industry 92

Contents By Builder By Ship Type

Arrival of the world's first liquified hydrogen carrier on January 21,2022, the Suiso Frontier, in Victoria marks the success of the Hydrogen Energy Supply Chain(HESC) Pilot Project and the dawn of the Australis's hydrogen industry.

HESC's vision is to produce carbon neutral hydrogen through extraction from a mix of Latrobe Valley coal and biomass, capturing and storing CO_2 via CarbonNet and optimizing energy efficiency in the ZHESC supply chain. The 225,000 tonnes of carbon neutral liquefied hydrogen (LH2) produced by HESC in a commercial phase will contribute to reducing global CO_2 emissions by some 1.8 million tonnes per year (equivalent to the emission of about 350,000 petrol-driven cars), while providing valuable infrastructure for other hydrogen projects in the region.

In a commercial phase, the project will create 30,000 full-time jobs across the Gippsland and Mornington Peninsula regions over the life of the project. During the Pilot Project, 99.999% pure hydrogen has been produced from Latrobe Valley coal and biomass via gasification, trucked to Hastings, cooled to -253 degrees and subsequently liquified to less than 800 times its gaseous volume to create highly valuable liquefied hydrogen.

The loading of liquefied hydrogen onto the Suiso Frontier for the return journey to Kobe, Japan, makes the HESC Project the most advanced and scalable hydrogen project in Australia and the first project in the world to make, liquefy and transport liquid hydrogen by sea to an international market.

The Australia-Japan HESC partnership is at the cutting edge of creating new technology, cleaner energy, and jobs for both countries. The learnings from the Pilot will form the basis for further work towards delivering HESC at a commercial scale. Specifically, the team will undertake extensive research and development into the technical and operational requirements that delivery of a commercial-scale project will entail.

Activities that will be undertaken include:

- Continuing to test and demonstrate the transport of liquid hydrogen across the ocean with further return trips of the Suiso Frontier between Australia and Japan.
- Undertaking regulatory approval activities.
- Ongoing discussion and monitoring of CarbonNet.
- Investigations on the economics of the commercial-scale project and its business model.
- Engagement with potential 'off-takers' in Australia and Japan.
- Further refining and testing of biomass feed stock for hydrogen production (blending with Latrobe Valley coal).
- Improving technologies to reduce costs and carbon intensity across the supply chain. This includes further development of the ortho-para conversion catalyst for creating LH2 in partnership with CSIRO.
- mplementing a comprehensive stakeholder engagement program to continue building social licence among impacted communities.

The HESC Project Partners are: Kawasaki Heavy Industries, Ltd (KHI), Electric Power Development Co., Ltd. (J-POWER), Iwatani Corporation (Iwatani), Marubeni Corporation (Marubeni), AGL Energy (AGL) and Sumitomo Corporation (Sumitomo). Royal Dutch Shell (Shell), ENEOS Corporation and Kawasaki Kisen Kaisha, Ltd. (K-Line) are also involved in the Japanese portion of the project.

Liquefied Hydrogen Carrier -SUISO FRONTIER- Wins PM Award at Japan Industrial Technology Awards 93

The world's first liquefied hydrogen carrier, developed and built by Kawasaki Heavy Industries, Ltd. (KHI), won the Prime Minister' Award at the 51st Japan Industrial Technology Awards on April 6, 2022.

The Japan Industrial Technology Awards, presented by The Nikkan Kogyo Shimbun, Ltd., boasts a long history as they were established in 1972. The awards are granted every year to products and others—such as large innovative industrial facilities and cutting-edge technologies—that are turned into practical application and contribute to industrial and/or social development.

The Suiso Frontier was constructed to establish a technology to transport hydrogen, a promising next-generation energy resource, efficiently and stably from overseas to Japan. Having highly insulated tanks of a total capacity of some 1,250 cubic meters, it can carry as much as 75 tons of liquefied hydrogen by refrigerating hydrogen to minus 253 degrees Celsius to diminishing it to one eight hundredths in volume.

The construction of the Suiso Frontier began in 2015 as a demonstration project to establish a supply chain for transporting unused brown coal-based hydrogen in large quantities by sea, which was promoted by the New

Then Education, Culture, Sports, Science and Technology State Minister Tanaka Hideyuki (left) and KHI President and CEO Hashimoto Yasuhiko (right)

President Imizu Haruhiko of The Nikkan Kogyo Shimbun (left) and KHI President and CEO Hashimoto Yasuhiko (right)

KHI President and CEO Hashimoto Yasuhiko gives an address as the Suiso Frontier receives the Prime Minister's Award.

Executive members of KHI's Suiso Frontier development team (*)

(*) From left: Manager Mizumukai Kentaro of the Hydrogen Strategy Division's Project Group; Chief Executive Staff Officer Komura Atsushi, General Manager Imamura Keigo and Deputy General Manager Motoi Tatsuya of the Ship and Offshore Structure Business Division; and Chief Executive Staff Officer Kameno Yuichi of the Hydrogen Strategy Division's Project Group

Contents By Builder By Ship Type

Liquefied Hydrogen Carrier -SUISO FRONTIER- Wins PM Award at Japan Industrial Technology Awards

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Energy and Industrial Technology Development Organization (NEDO). In 2016, KHI joined forces with Iwatani Corp., Shell Japan Ltd. and Electric Power Development Co., Ltd. (J-POWER) to set up a joint venture, the CO_2-free Hydrogen Energy Supply-chain Technology Research Association (HySTRA). The association then accelerated the Suiso Frontier development by beginning to review safety from a viewpoint of hydrogen users and so on. In fiscal 2017, full-scale design and construction work was kicked off. In December 2019, the liquefied hydrogen carrier newbuilding was launched at KHI's Kobe Works, and in December 2020, it obtained a ship classification from Nippon Kaiji Kyokai (ClassNK). KHI successfully conducted trial transport of liquefied hydrogen produced in Australia to the Port of Kobe from Dec. 24, 2021 to Feb. 25, 2022.

KHI has been developing hydrogen technologies for 35 years, or since 1987. For example, it has produced and manages tanks for storing liquefied hydrogen for rocket fuel at the Japan Aerospace Exploration Agency (JAXA)'s Tanegashima Space Center. KHI has also made it possible to transport large quantities of hydrogen in ships by developing cargo tanks for safely carrying liquefied hydrogen, which is extremely low in temperature at minus 253 degrees Celsius; a plumbing system for cargo handling; and so forth. Not only has it constructed the world's first liquefied hydrogen carrier, but KHI also has participated in the formulation of international standards for safely moving liquefied hydrogen as well. Developing a supply chain to safely transport hydrogen from overseas, KHI has been highly rated, as it will contribute considerably to realizing carbon neutrality, one of the world's social agendas.

To realize a hydrogen society, KHI will develop a much larger liquefied hydrogen carrier having a tank capacity of 160,000 cubic meters, 128 times as great as the Suiso Frontier's, and endeavor to reduce costs for supplying hydrogen. Hoping that hydrogen will be consumed as commonly as natural gas and petroleum in the future, it will strive to build larger liquefied hydrogen carriers by making the most of the technologies and know-how that it has gained from the construction of the Suiso Frontier. In partnership with various enterprises, KHI will build a supply chain to produce, transport, store and consume hydrogen, a next-generation energy resource.

About The Nikkan Kogyo Shimbun's 51st Japan Industrial Technology Awards: **https://corp.nikkan.co.jp/p/honoring/nihonsangyogijyutsutaishou**

HySTRA celebrates completion of world's first liquefied hydrogen vessel voyage in Japan 94

Kawasaki Heavy Industries, Ltd.

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HySTRA celebrates completion of world's first liquefied hydrogen vessel voyage in Japan 94

A ceremony to mark the completion of the world's first maritime transport of liquefied hydrogen, including its loading and unloading has been held in Kobe, Japan.
The demonstration voyage by the world's first liquefied hydrogen carrier, Suiso Frontier, proved that an international liquefied hydrogen supply chain is possible, marking a significant step towards the utilization of hydrogen as a new energy source.
The HySTRA*1 joint venture, comprising Iwatani Corporation, Kawasaki Heavy Industries, Ltd., Shell Japan Ltd., Electric Power Development Co., Ltd.(J-POWER), Marubeni Corporation, ENEOS Corporation, and Kawasaki Kisen Kaisha, Ltd. with support from NEDO*2, is exploring the development of a large-scale marine transport supply chain.
Ceremony for completing the demonstration test
The joint venture developed technologies to produce and transport large volumes of liquefied hydrogen, conducting demonstration tests between Japan and Australia to establish processes around the safe loading, offloading and storage of hydrogen. Insights from the demonstration voyage will also guide the development of international safety standards and codes for transporting liquefied hydrogen.
Suiso Frontier, the world's first liquefied hydrogen carrier, departed Japan in December 2021 and arrived in Australia in January 2022. The ship was loaded with liquefied hydrogen produced from coal in Victoria, Australia, and returned to Japan in February 2022, unloading the cargo to a landside storage tank.
The HySTRA joint venture partners will continue to gather data and findings, and collaborate with various parties to promote this project and contribute to the development of a commercial hydrogen supply chain, as more industries explore hydrogen as a new energy source.

The HySTRA joint venture comprises:

Iwatani Corporation	Operation of Hy touch Kobe, a liquefied hydrogen cargo handling demonstration terminal
Kawasaki Heavy Industries	Design and construction of "Suiso Frontier", a liquefied hydrogen carrier, and the Hy touch Kobe, a liquefied hydrogen cargo handling demonstration terminal
Shell Japan	Operation and crewing of Suiso Frontier
J-POWER	Construction and operation of the facilities to produce hydrogen gas using Victorian coal in Latrobe Valley, Victoria
Marubeni	Examination of implementation of CO_2-free hydrogen supply chain technologies by leveraging knowhow cultivated as a general trading company
ENEOS	Feasibility study of CO_2-free Hydrogen Supply Chain
Kawasaki Kisen Kaisha	Assistance for safe transportation of liquid hydrogen by using its knowledge and experience acquired through the operation of LNG carriers.

The project had input from Japanese and Australian government agencies, including the Ministry of Economy, Trade and Industry and NEDO, and companies in Japan and Australia.

Japan-Australia Supply Chain Pilot Diagram

※HySTRA business supported by NEDO(New Energy and Industrial Technology Development Organization) is written in red.
※Consortium business supported by Commonwealth of Australia and Victoria State Government is written in white.
※KHI=Kawasaki Heavy Industries, Ltd.
※STASCO=Shell International Trading and Shipping Company Limited

*1 An abbreviation of the Japan CO_2 Free Hydrogen Energy Supply-chain Technology Research Association. The company was established by Iwatani, Kawasaki Heavy Industries, Shell Japan and J-POWER to establish and demonstrate technologies for hydrogen production using Victorian coal, transportation and storage for the commercialization of a CO_2-free hydrogen supply chain. Marubeni Corporation, ENEOS Corporation, and Kawasaki Kisen Kaisha joined the project later.

*2 New Energy and Industrial Technology Development Organization

Reference

In Australia, Iwatani Corporation, Kawasaki Heavy Industries Group, J-POWER Group, Marubeni Corporation, Sumitomo Corporation, and AGL Energy Limited formed a consortium to build a gas refining facility, hydrogen liquefaction and loading terminal with subsidies from the Australian and Victorian governments. A local industrial gas company oversees ground transportation of hydrogen.

Kawasaki Obtains AiP for Large, 160,000 m³ Liquefied Hydrogen Carrier 95

AiP issuance ceremony

April 22, 2022 — Kawasaki Heavy Industries, Ltd. announced its obtainment of approval in principle (AiP) from Nippon Kaiji Kyokai (ClassNK) for a large, 160,000 m³ liquefied hydrogen carrier.

The liquefied hydrogen carrier that received the AiP is a large-sized vessel equipped with a cargo containment system ("CCS") comprising four liquefied hydrogen tanks having a combined capacity of 160,000 m³. The CCS received its own AiP in April 2021. The carrier is designed to transport cryogenic liquefied hydrogen, cooled down to a temperature of –253° C and reduced to one eight-hundredth its initial volume, by sea in large amounts on each voyage, helping to reduce hydrogen supply costs. In order to build this large-sized carrier, Kawasaki leveraged design and shipbuilding technologies as well as safety-related technologies and knowledge utilized in the construction of the globally pioneering, 1,250 m³ liquefied hydrogen carrier SUISO FRONTIER,*1 while also calling upon its many years of experience in building liquefied natural gas (LNG) carriers and other liquefied-gas transport vessels.

ClassNK
NIPPON KAIJI KYOKAI

Document No. KF-22HE04387
Date: 19 April 2022

APPROVAL IN PRINCIPLE

160,000m3 Liquefied Hydrogen Carrier
developed by KAWASAKI HEAVY INDUSTRIES, LTD.

THIS IS TO CERTIFY THAT Approval in Principle is granted to KAWASAKI HEAVY INDUSTRIES, LTD.

The AiP is for the design concept of the captioned vessel including the following systems:

- Cargo Containment System
- Cargo Handling System
- Dual Fuel Main Boiler using Boil-Off Gas

The AiP is based on the current Society's Rules and Guidance for the Survey and Construction of Steel Ships (hereinafter "the Rules") and Guidelines *"Part N: Ships Carrying Liquefied Gases in Bulk"* incorporating *"the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)"*, *"Guidelines for Liquefied Hydrogen Carriers"* incorporating *"INTERIM RECOMMENDATIONS FOR CARRIAGE OF LIQUEFIED HYDROGEN IN BULK (RESOLUTION MSC.420 (97))"* and other relevant requirements as applicable.

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

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

(Akio Usami
General Manager of Hull Department
NIPPON KAIJI KYOKAI

AiP certificate

Before the vessel's AiP was issued by ClassNK following examinations to confirm that the vessel satisfies the IGC Code*2 and the International Maritime Organization (IMO) Interim Recommendations for Carriage of Liquefied Hydrogen in Bulk,*3 and also clears Class regulations as well as a risk assessment based on Hazard Identification Study (HAZID)*4 methods.

The main features of Kawasaki's carrier are as follows.

1. The vessel contains four 40,000 m³ liquefied hydrogen carrying tanks for a combined total capacity of 160,000 m3. These tanks utilize a newly developed, high-performance insulation system that minimizes boil-off gas (BOG), which occurs in response to heat ingress, in order to enable large-quantity transport of cryogenic liquefied hydrogen.
2. The propulsion system includes a boiler and steam turbine plant capable of operating using hydrogen as fuel, and a dual-fuel propulsion system that makes use of natural BOG as fuel to power the ship. Utilizing hydrogen, which does not emit CO_2 during combustion, as a fuel for propulsion contributes to reduced CO_2 emissions from liquefied hydrogen transport operations. Furthermore, the vessel is equipped with a hydrogen-gas-fuel supply system comprising hydrogen gas compression equipment, hydrogen gas heat exchanger equipment and other components in order to enable supply of BOG from the CCS to the propulsion system.
3. The vessel uses a cargo handling system designed to load large amounts of liquefied hydrogen onto the vessel in just a short time, and it is equipped with vacuum insulated double wall pipes in order to efficiently and safely transfer hydrogen in its cryogenic, liquefied state from

Kawasaki Obtains AiP for Large, 160,000 m³ Liquefied Hydrogen Carrier 95

onshore storage facilities to the vessel tanks minimizing vaporization.

4. The hull and draft of the vessel were designed with consideration for the low specific gravity of the liquefied hydrogen cargo, and horsepower required for propulsion was kept low in response, resulting in higher-efficiency propulsion performance. Moreover, risk assessments were carried out for the vessel's propulsion system, cargo handling system and other elements in relation to liquefied hydrogen, and suitable safety measures were implemented in response. This eliminates liquefied-hydrogen-caused risk to the ship's crew, the ship environment, structural strength, and overall ship soundness while ensuring safety.

Kawasaki developed this vessel as part of a subsidized project by NEDO*5 and is currently carrying out more in-depth design with an eye to commercial operations starting in the mid-2020s. Amid global calls for the early achievement of carbon neutrality targets, the company is striving to achieve large-volume transport of liquefied hydrogen—for which demand is expected to grow as a clean energy source—in order to promote the use of hydrogen energy and thus help achieve decarbonization, working as one for the good of the planet.

Main Specifications of Kawasaki's Large, 160,000 m³ Liquefied Hydrogen Carrier

Length: approx. 346 m; width: approx. 57 m; draft: 9.5m
Cargo tank capacity: 160,000 m³ (40,000 m³ × 4 tanks, enabling carrying of approx. 10,000 tons of liquefied hydrogen)

Simulated appearance of the completed 160,000 m³ liquefied hydrogen carrier

*1 Constructed by Kawasaki as a member of the CO_2-free Hydrogen Energy Supply-chain Technology Research Association (HySTRA; website: http://www.hystra.or.jp/en/), as part of the Demonstration Project for Establishment of Mass Hydrogen Marine Transportation Supply Chain Derived from Unused Brown Coal by the New Energy and Industrial Technology Development Organization (NEDO).

*2 International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk. A set of international regulations governing the constructions and equipment of such ships. All ships that carry liquefied gases and that were built in or after 1986 are required to adhere to the code, and ClassNK incorporates the code as part of its Rules and Guidance for the Survey and Construction of Steel Ships.

*3 Provisional recommendations adopted by the IMO for bulk transport of liquefied hydrogen.

*4 Method of assessing risk, which is determined by experts based on the frequency with which potential hazards in a system arise, and aimed at identifying ways to minimize that frequency.

*5 NEDO Technology Development Project for Building a Hydrogen-based Society / Technology Development Project for Large-Scale Utilization of Hydrogen / Project for Enlargement of Liquefied Hydrogen Cargo Tank Facilities and Development of Unloading Terminal Equipment.

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Kawasaki Heavy Industries, Ltd.

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Liquefied Hydrogen Carrier -SUISO FRONTIER- Chosen for Ship of the Year 2021 96

From left: Chief Executive Staff Officer Muragishi Osamu of KHI's Ship and Marine Structure Business Division, General Manager Harada Eiichi of KHI's Hydrogen Strategy Division, then JASNAOE President Fujikubo Masahiko, KHI President and CEO Hashimoto Yasuhiko and General Manager Imamura Keigo of KHI's Ship and Offshore Structure Business Division

The world's first liquefied hydrogen carrier, developed and constructed by Kawasaki Heavy Industries, Ltd. (KHI), was chosen for the Ship of the Year 2021 on July 25, 2022 at the 32nd Ship of the Year Awards, presented by the Japan Society of Naval Architects and Ocean Engineers (JASNAOE). The Ship of the Year award, the highest honor for the domestic shipbuilding industry, is given every year to the most prominent product in accordance with technical, artistic and social considerations about high-profile ships built in Japan.

The Suiso Fronter was developed in a demonstration experiment to handle and transport brown coal-based hydrogen by sea on a liquefied hydrogen carrier between Japan and Australia. The project was conducted by the CO_2-free Hydrogen Energy Supply-chain Technology Research Association (HySTRA)*1 in a demonstration project to establish a supply chain for transporting unused brown coal-based hydrogen in large quantities by sea, which was promoted by the New Energy and Industrial Technology Development Organization (NEDO). The Suiso Frontier left Japan in December 2021; arrived in Australia in January 2022, where it was loaded with hydrogen produced from brown coal; and returned to Japan in February 2022.

In receiving the Ship of the Year award, the Suiso Frontier was highly rated as it had been developed and constructed ahead of the rest of the world as a liquefied hydrogen carrier prototype for transporting hydrogen, a promising next-generation energy resource that does not emit CO_2, by liquefying it at a temperature of minus 253 degrees Celsius and reducing it to one eight hundredths in volume. Other reasons for which it was acclaimed were the facts that it had attained success in transporting hydrogen from Australia and that it would lead to the development of larger freighters. The award review committee recommended by an overwhelming majority that the Suiso Frontier be the Ship of the Year.

The technologies for handling liquefied hydrogen, assessing risks, ensuring safety and so on that have been obtained from the development of the Suiso Frontier are being applied to the ongoing development of a 160,000-cubic-meter-capacity liquefied hydrogen carrier, which is being advanced to transport hydrogen in large quantities. Nippon Kaiji Kyokai (ClassNK) approved its basic design in April 2022.

Hoping that hydrogen will be consumed as commonly as natural gas and petroleum, KHI will work to establish a supply chain to produce, transport, store and use hydrogen, a next-generation energy resource by making the most of the technologies and know-how that we have gained from the construction of the Suiso Frontier and cooperating with various partners.

***1 The CO_2-free Hydrogen Energy Supply-chain Technology Research Association (HySTRA) was set up by KHI together with Iwatani Corp., Shell Japan Ltd. and Electric Power Development Co., Ltd. (J-POWER) mainly to develop technologies to produce hydrogen from brown coal; transport and store it; and conduct verifications to establish and commercialize a CO_2-free supply chain. Marubeni Corp., ENEOS Corp. and Kawasaki Kisen Kaisha, Ltd. ("K" Line) have since joined HySTRA.**

About the 32nd Ship of the Year Awards, presented by the JASNAOE : **https://www.jasnaoe.or.jp/soy/2021.html**