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Request for a recommendation on the use of hydrogen fuel cells for the propulsion of the vessel "FPS Waal"/"H2Barge2"

Transmitted by the Government of the Netherlands

Annexes to document ECE/ADN/2024/5

Annex I

FutureProof Shipping

FPS WAAL – ADN Cargo Approval Application

Contents

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1. Introduction

The goal of this document is to support the ADN application process of a hydrogen powered inland vessel named “FPS Waal”. The document presents main aspects of the project and related safety features installed on board. In addition, the interaction between the hydrogen installation and ADN cargo is highlighted in the document.

This document is supplemented by the drawing: ‘FPS WAAL – ADN Cargo Approval Drawing’.

2. Project description

This scope of the project is the retrofit of an inland waterway container vessel. In this project, the original diesel propulsion system is replaced by a newly built hydrogen power generation system.

The original ship name is ‘FPS WAAL’ and the new ship name will become ‘H2Barge2’ as a result of the retrofitting process. Considering that the ADN cargo application has already been submitted for the FPS Waal, and to keep the consistency in the document, the name ‘FPS WAAL’ will be used here. The FPS WAAL's new power generation system was designed in accordance with the most current regulations for inland waterways vessels, ESTRIN rules and LR rules.

The FPS WAAL is equipped with six PEM fuel cells produced by Ballard. These six ‘Ballard FCwave’ fuel cell modules have maritime type approval and are installed as the primary source of energy generation plant. The new energy generation plant produces 1200 kW of net power while the original on-board diesel engine had around 1000 kW. Besides the PEM fuel cells, two separate battery racks, with 316.8kWh and 475.2kWh capacity, were installed.

The FPS WAAL has a maximum of two hydrogen fuel storage 40ft containers. The containers are provided by Air Liquide and are designed in accordance with ISO11515, EC406 and EC79 and have the ADR approved standards. Each container is connected to the ship hydrogen fuel system, holds approximately 500kg hydrogen under 300bar, and has two separate areas: one operator’s space and one hydrogen tubes space. The hydrogen containers are swapable fuel tanks, with swapping being done full-for-empty at the container terminal.

From the hydrogen container, a multi-connector with the clean breakaway couplings is used for the connection to the ship hydrogen system. The connection is remotely controlled through compressed air valves. The piping fuel system has single wall pipes from the hydrogen container to the ‘herft’ and, from there to fuel cells, it has double wall pipes inside the enclosed space.

The new power generation and distribution equipment is installed in a new separate space located in the lowest layer of the aftmost part of the cargo hold. The new space is separated into new compartments: fuel cell room dedicated to the six ‘Ballard FCwave’ power modules, the technical space for switchboard and accompanied auxiliary systems, and the battery room. Those areas are separated by a bulkhead and each of those has its own safety system. An additional battery room is installed into a new structure in the port side of the fore cargo hold.

This ship complies with the ADN regulations and no deviations were identified from the class.

3 Safety Features of FPS Waal

This section gives an overview of safety features on FPS Waal in relation to ADN cargo.

3.1. Safety aspects of the propulsion room and bow-thruster room

- The propulsion room and bow-thruster room are equipped with fire safety systems.

3.2. Safety aspects of the fuel cell room

- The fuel cell room is equipped with Novec firefighting system, fire and gas detection system.
- The fuel cell room is equipped with exhaust ventilation system.
- The fuel cell room ceiling is shielded with A60 insulation.
- The bulkhead between the fuel cell room and technical space is shielded with A60 insulation.
- The fuel cell room external bulkheads towards the cargo hold are shielded with A0 insulation.
- Each fuel cell is fully type approved and suitable for maritime application.
- Each fuel cell has its own gastight enclosure that is fully equipped with active hydrogen ventilation, fire, smoke and hydrogen detectors.
- The fuel cell room is considered as safe space.

3.3. Safety aspects of the technical space

- The technical space is equipped with safety systems.
- The technical space ceiling is shielded with A60 insulation.
- The external bulkhead towards the cargo hold is shielded with A0 insulation.

3.4. Safety aspects of the battery rooms (aft and forward)

- Batteries installed on FPS Waal are fully compliant with ESTRIN requirements (article 10.11, 10.20 and 11.01)
- Battery rooms are equipped with water sprinkler firefighting system, fire and gas detection system.

- Each battery module has its own pressure relieve vent directly connected to a dedicated extraction duct from the battery bank. In case of thermal runaway event, any gases are extracted outside of the ship.
- Each battery module has its own water mist valve directly connected to water manifold from the battery bank. In case of thermal runaway event, the battery smoke detector trigger the water misters which will flood the affected module.
- Battery rooms boundaries, including all bulkheads and the ceiling, are shielded with A60 insulation.

3.5. Safety aspects of the hydrogen container

- Each fuel container has its own main emergency shutdown system.
- In case of collision, the hydrogen tanks are located at more than B/5 away from the starboard and portside.
- Cylinders containing hydrogen are made of steel (Type II) and are highly resilient to fire loads, demonstrated by the bonfire tests.
- Additional fire-fighting monitors (water cooling fire load) are installed on the bridge to support the cooling of the hydrogen containers.

3.6. Safety aspects of the hydrogen system

- All components of the hydrogen supply system are placed in the 'herft' area that is protected by surrounding steel structures and open toward environment.
- The hydrogen system is equipped with a vent mast and pressure relief valves that protect the system from overpressure conditions.
- On the deck area, DNV type approved acoustic sensors for leakage detection and UV fire alarm sensors ensures safety of the 'herft' area and operator space inside the hydrogen containers.
- All pipes inside the fuel cell room are double wall pipes.

4. Relevant passage from the existing documentation in relation to the ADN transport

The document 'HAZID Report for FPS Waal' (ENI 4607390) issued by Lloyd's Register identifies the hazardous events and describes the system safeguards and control measures taken to mitigate or to eliminate the risk level. The interaction between dangerous goods and hydrogen system was not explicitly investigated in the HAZID document. Rather, a list of general risks and stemming from off-design conditions of the neighbouring containers was investigated. Therefore, passages related to the hydrogen fuel container interaction with other cargo containers is presented in below paragraphs.

4.1. Dropped cargo containers during loading / unloading

This investigation showed the cargo containers cannot be dropped and hit the hydrogen container during the loading/unloading process. A cargo container will not be lifted above the hydrogen container and cargo containers will be handled by the trained crane operators personnel. Also, the cranes are designed to prevent the container dropping with redundant lifting points and cables. The conducted level risk for this event is medium, broadly acceptable, and the above mentioned risk mitigation measures implementation has been demonstrated.

4.2. Dropped H2 container during unloading

This investigation showed the hydrogen container cannot be dropped during the unloading process and cause a detonation. The container will be lifted and handled only be the trained personal and using cranes that are designed to prevent the dropping. The conducted level risk for this event is medium, broadly acceptable, and risk mitigation measures implementation has been demonstrated.

4.3. External fire in an adjacent container

This investigation showed the hydrogen containers can be protected from fire loads of 30 kW/m2 using fire monitors, and the higher fire loads can be taken place in the adjacent of the hydrogen container. The conducted level risk for this event is medium, broadly acceptable, and risk mitigation measures implementation has been demonstrated.

4.4. Heat generated during emergency venting

This investigation showed that the hydrogen container can be emptied on request in case of emergency and that hydrogen containers and all other cargo containers will be at safe distance. In case of emergency, all hydrogen can be vented from the aft of the vessel. The activation of the venting is done on-demand and no uncontrolled venting takes place. Thanks to the additionally installed fire monitors, there is always enough time to place the ship in a safe position for venting. During the emergency venting, in case of hydrogen self-ignition, the heat load potentially generated will not affect any cargo. The wheelhouse will also be a safe space and will not be affected by the heat potentially generated. The conducted level risk for this event is medium, broadly acceptable, and risk mitigation measures implementation has been demonstrated.

5. Interaction between hydrogen fuel system and ADN cargo

FPS WAAL is designed for ADN and fulfils all requirements for ADN vessels. As it is indicated in 'FPS WAAL – ADN Cargo Approval Drawing' and considering all loading scenarios, the ADN cargo containers will not be loaded on-board in the adjacent of hydrogen fuel containers. Therefore, no interaction between those two container will take place.

Since there are no ADN containers placed near hydrogen containers, **this chapter describes** the interaction of hydrogen containers with the **general cargo fire loads**, corresponding safety philosophy and risk mitigation methods applied.

The hydrogen containment philosophy is based on the risk evaluation considering the potential sources which could conduct to a pressure increasing, the external fire on the deck having the highest risk. This philosophy is described by a three layered safety strategies that consists in: passive heat absorption, active heat dissipation and controlled hydrogen release.

In case of fire on the deck or in the neighbouring container, approximately 90 minutes are necessary until the pressure reaches unwanted level. This passive heat absorption safety component is based on the hydrogen cylinder type II and the material properties of the tanks.

The active heat dissipation is based on the fire-fighting system. A water cooling fire system is installed on-board in order to combat the 'worst-case' heat rate release and to prevent an over-pressurisation event of the fuel cylinders.

The water cooling fire system is designed for a fire event that produces a heat radiation of 30 kW/m2 on the longitudinal side of the hydrogen fuel container. A conservative approach was used for fire system calculation where the 'worst-case' heating moment appears only in the first 200 seconds. As a result, the total required water flowrate to absorb the heat and to keep safe the container pressure is 160 l/min.

The ship water cooling system is composed of one main fire pump, two backup pumps, and two fire monitors. The monitors are installed on the bridge and have a total capacity of 750 l/min constant coolant flow to maintain the whole container area within temperature limits.

The last means of safety is the emergency release. During the emergency releasing process, the hydrogen would be vented to the aft extremity of the vessel. This is a preferred option over uncontrolled hydrogen release close to the source of fire.

6. Bunkering procedure

The bunkering process consists of swapping the empty containers with the new fully filled containers by trained terminal personal that is certified for lifting and handling ADN/ADR containers.

The bunkering procedure that will be applied for FPS WAAL , was already approved by responsible authorities and is the same procedure that was carried out on the first inland H2 powered barge: 'H2Barge1' during a period of 8 months with an average of 6 swapping's every week (more than 200 by January 2024) and with no incident reported.

The main swapping steps are the following:

- The hydrogen fuel storage container will be transported from the filling site to the terminal by road transport.
- The empty hydrogen fuel storage container will be lifted from the vessel by the container terminal crane.
- The fulfilled hydrogen fuel storage container will be lifted onto the vessel by the container terminal crane.

7. Crew training

The crew training has been developed by the responsible authority for hydrogen fuel, fuel cells and Li-Ion batteries and includes inland shipping regulations and lectures from the key technology manufacturer, the supplier and the integrator.

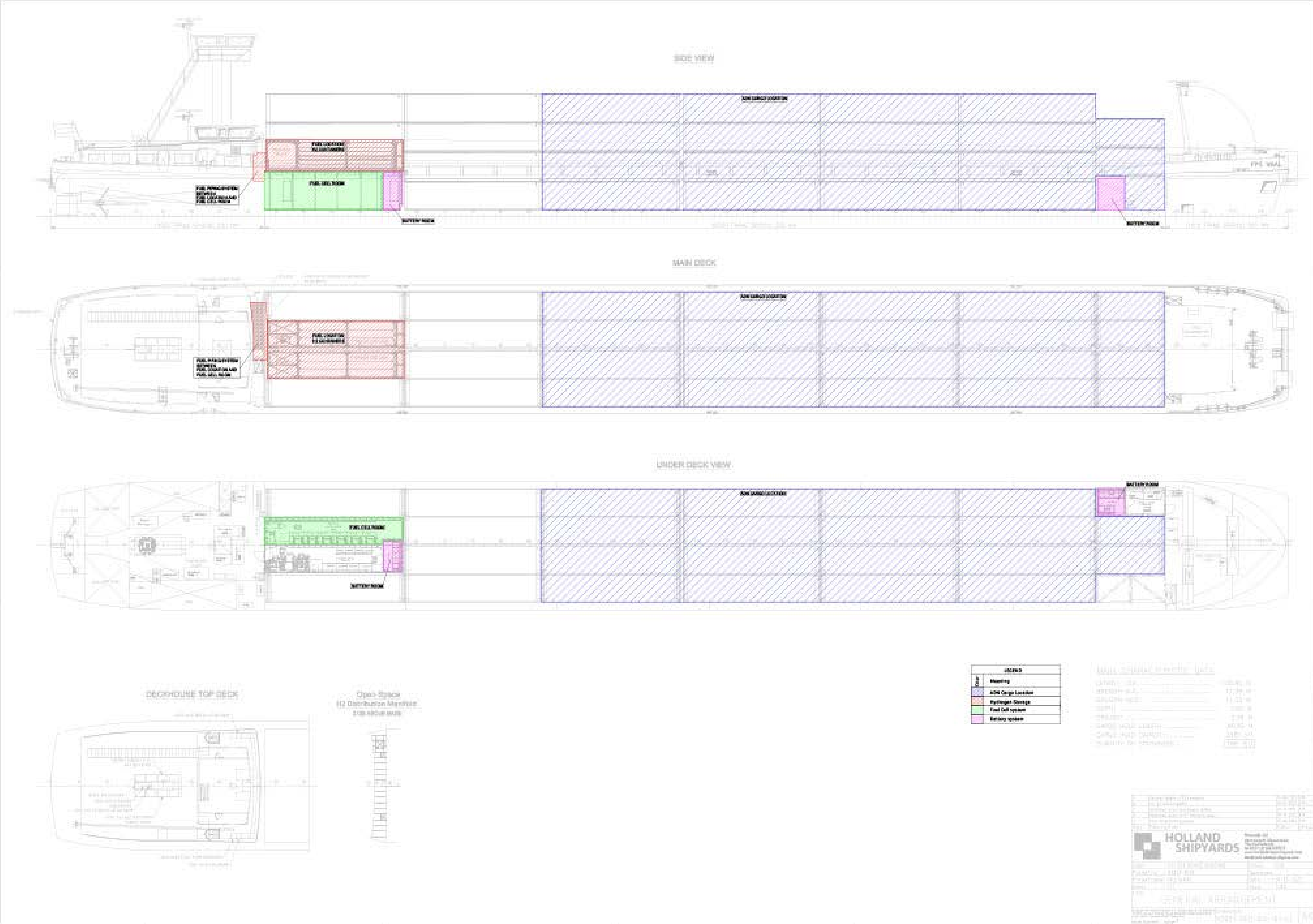
The training procedure dedicated for FPS WAAL is similar with the training procedure that was carried out on the first inland H2 powered barge: 'H2Barge1'. During a period of 8 months, 'H2Barge1' have been continuously sailing without no reported incidents. This aspect could be considered a efficiency and applicability proof of the existing crew training in real scenarios. The training content is composed by the following chapters:

- Familiarity with physical and chemical properties of fuels aboard ships subject to the ESTRIN and IGF Code.
- Operate the controls of fuel related to propulsion plant and engineering systems, services and safety devices on ships subject to the ESTRIN and IGF Code.
- Plan and monitor safe bunkering, stowage and securing of the fuel on board ships subject to the ESTRIN and IGF Code.
- Take precautions to prevent pollution of the environment from the release of fuels found on ships subject to the ESTRIN and IGF Code.
- Monitor and control compliance with legislative requirements.
- Take precautions to prevent hazards.
- Apply occupational health and safety precautions and measures on board a ship subject to the ESTRIN and IGF Code

In addition of the regular operational training, the crew has been attending the training provided by Ballard, the fuel cell provider. The main topics are the following:

- Technology & Product understanding
- Basic preventive maintenance
- Detailed system schematics
- Corrective maintenance
- Advanced troubleshooting

Annex II


SIDE VIEW
FUEL CELL ROOM
BATTERY ROOM
MAIN DECK
UNDER DECK VIEW
DECKHOUSE TOP DECK
Open Space
H2 Distribution Manifold
Hydrogen Storage
Fuel Cell system
Battery system
HOLLAND SHIPYARDS
GENERAL ARRANGEMENT