SUB-COMMITTEE ON CARRIAGE OF CARGOES AND CONTAINERS
3rd session
(5 to 9 September 2016)

SAFETY REQUIREMENTS FOR CARRIAGE OF LIQUEFIED HYDROGEN IN BULK

Report of the International Workshop on Safety of Liquefied Hydrogen Carriers[1]

Submitted by Australia and Japan

1 As mentioned in Circular Letter No.3662 (29 June 2016), Japan held the International Workshop on Safety of Liquefied Hydrogen Carriers (the workshop) at the IMO Headquarters on 2 September 2016, in order to contribute to the discussion at CCC 3.

2 The workshop was attended by delegations from the following Member States:

AUSTRALIA
FRANCE
GERMANY
JAPAN
LIBERIA
MARSHALL ISLANDS
NORWAY
REPUBLIC OF KOREA
SPAIN
UNITED KINGDOM
UNITED STATES

and the following non-governmental organizations:

INTERNATIONAL CHAMBER OF SHIPPING (ICS)
INTERNATIONAL ASSOCIATION OF CLASSIFICATION SOCIETIES (IACS)
OIL COMPANIES INTERNATIONAL MARINE FORUM (OCIMF)
INTERNATIONAL ASSOCIATION OF INDEPENDENT TANKER OWNERS (INTERTANKO)
SOCIETY OF INTERNATIONAL GAS TANKER AND TERMINAL OPERATORS LIMITED (SIGTTO)

3 The presentations and opening and closing remarks are outlined in the annex. Various issues related to safety measures for liquefied hydrogen carriers were actively discussed at the workshop. The workshop noted that the draft interim recommendations and explanatory notes should be finalized at CCC 3, as agreed by MSC 94 and proposed by the Correspondence Group established at CCC 2, and that the draft interim recommendations were developed for a pilot ship, not for commercial vessels.

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[1] This report is provided to facilitate the discussions.

ANNEX

OUTLINE OF PRESENTATIONS, AND OPENING AND CLOSING REMARKS IN THE INTERNATIONAL WORKSHOP ON SAFETY OF LIQUEFIED HYDROGEN CARRIERS

Opening remarks

1 Mr. M. Ito, Ministry of Land, Infrastructure, Transport and Tourism, in the opening remarks, emphasised that the interim recommendations were developed for a pilot ship, not for commercial vessels.

The importance of the HESC (Hydrogen Energy Supply Chain) Project for Victoria

2 Ms. S. Gibson, State Government of Victoria, explained the importance of the Hydrogen Energy Supply Chain Project for Victoria, after a brief introduction by the State of Victoria, as follows:

> "Brown coal has some disadvantages to use as fuel, while Victoria has the second largest brown coal resource in the world. One of the disadvantages of brown coal is low transportation efficiency owing to high water content of the material. Another disadvantage is high possibility of spontaneous ignition when dry. For these reasons, brown coal has not been used widely.
>
> Victorian Government has been investigating the potential uses of brown coal, such as for hydrogen. Hydrogen is generated by reacting brown coal with water vapour at a high temperature. Carbon dioxide, i.e., the by-product in the reaction process, is captured and stored underground in Victoria.
>
> Hydrogen is: liquefied; exported to Japan by a liquefied hydrogen carrier; and consumed for fuel cell vehicles and power generation plants.
>
> In 2014, the Victorian Government and a Japanese company established a joint work programme to progress the Hydrogen Energy Supply Chain (HESC) opportunity. The pilot project of HSEC will be a full supply chain from Victoria to Japan, including liquefied hydrogen carriers. Australian government financially supports this pilot project.
>
> Australia and Japan actively develop hydrogen energy supply chain project. Under such circumstances, state government of Victoria assists the project by providing regulatory coordination, introduction to project partners and linkages with research institutions."

Safety Measures in Design of Liquefied Hydrogen Carriers

3 Dr. H. Kagaya, HySTRA[2], introduced the concept of the pilot CO_2-free hydrogen supply chain and the design of pilot liquefied hydrogen carriers as follows:

> "Figures 1 and 2 show the concept of the pilot CO_2-free hydrogen supply chain and the overall schedule of the 6 year project, respectively. In fiscal year 2020, a demonstration test by the ship and the terminal will be conducted.
>
> Figure 3 shows the current plan of the pilot carrier. The size of the carrier is 107 m length, 19 m width, 10.6 m depth and about 8,000 GRT. It has two tanks of independent tank type 'C' and each tank has 1,250 m^3 capacity with vacuum insulation. The carrier is designed for 20 days voyage.
>
> Figure 4 shows a sectional view of the cargo containment system. In vacuum space, multi-layer insulation is provided on the outer surface of inner vessel, in order to prevent heat transfer due to radiation. The inner vessel is supported by saddle pillars from the outer vessel. These pillars are made of FRP having low thermal conductivity. A panel insulation system is shown in yellow in the figure. This insulation is provided on the outer surface of outer shell in addition to vacuum insulation system, as a supplementary insulation for the case of deterioration of vacuum insulation. The design pressure of inner vessel is 0.4 MPa. Then boil-off gas will be accumulated in the vessel during the voyage.

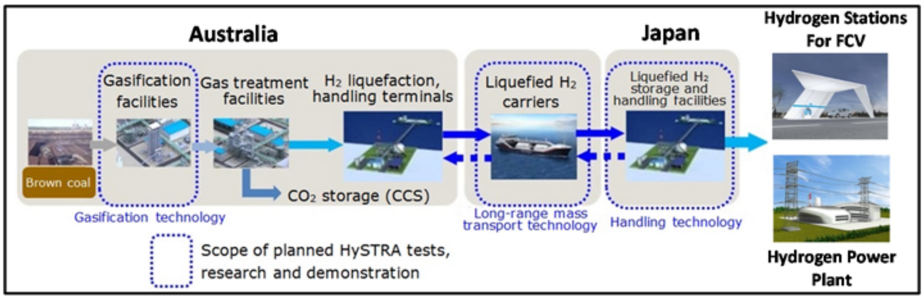

Fig.1 Concept of CO_2-Free Hydrogen Energy Supply-Chain

[2] CO_2-free Hydrogen Energy Supply-chain Technology Research Association (HySTRA) is a research association authorised by the Japanese government for the purpose of development of hydrogen supply chain.

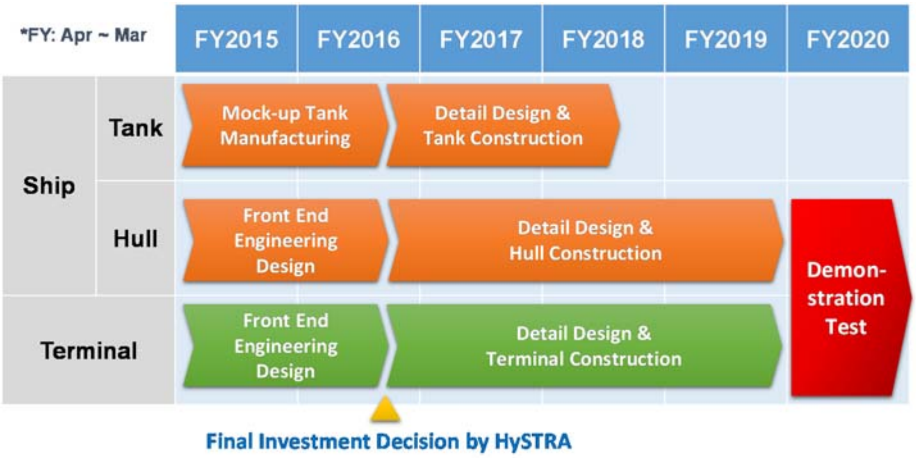

Fig.2 Overall schedule of the 6 year project

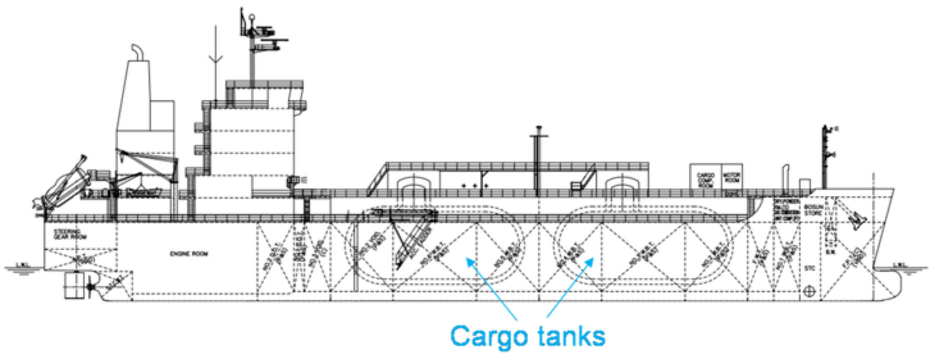

Fig.3 Plan of the pilot LH2 Gas Carrier

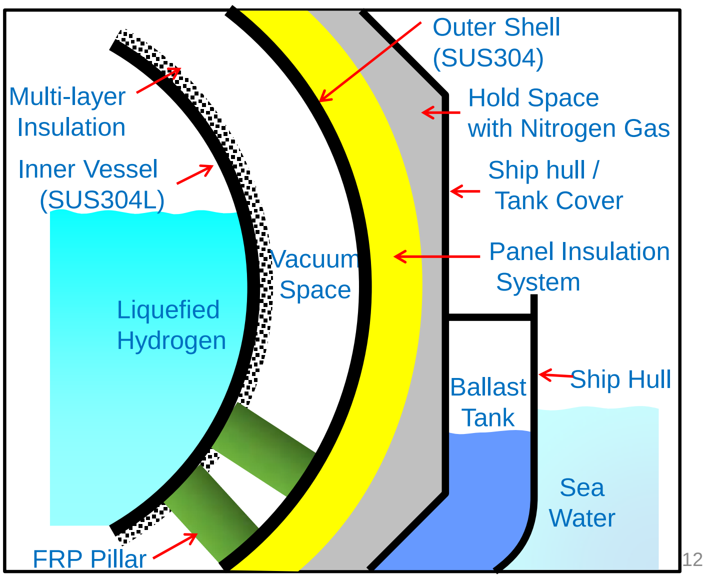

Fig.4 Sectional view of the cargo containment system"

Risk Assessment of Liquefied Hydrogen Carriers

4 Mr. K. Nishifuji, Nippon Kaiji Kyokai, explained the outline of Hazard Identification (HAZID) studies performed by two different approaches and a detailed analysis of risk reducing measures identified by the studies comparing with the special requirements proposed in document CCC 3/4 as follows:

> "For ships of new types, safety of design should be verified by risk assessment in the design spiral. As a part of risk assessment of a liquefied hydrogen carrier, "hazard identification studies" using Front End Engineering Design of the pilot ship were conducted twice, completely independent from the discussion of the Correspondence Group. The purpose of the second study was to identify hazards, as much as possible, including hazards associated with shore based facilities and natural disasters. As the result of the study, 89 hazards were identified.
>
> Then, the hazards identified in these studies and the safety measures against the hazards were analysed, in comparison with draft special requirements developed by the Correspondence Group. As the result of comparison, it was found that one safety measure was not covered by the draft special requirements provided by the correspondence group. That was "bolted flange connections of hydrogen piping should be minimized". Furthermore, seven items for the risk assessment in design stage were identified."

Safety Measures in Operations of Liquefied Hydrogen Carriers

5 Mr. A. Saeed, HySTRA, explained hazards specific to liquefied hydrogen in relation to personal safety and process safety, after a brief explanation on the operational history of liquefied hydrogen, as follows:

> "Major areas to be addressed by the pilot liquefied hydrogen carrier will be:
>
> .1 novel technologies such as cargo containment systems and ship/shore interface, e.g. loading arms, etc.; and
>
> .2 crew training and development of cargo operations manual.
>
> Appropriate procedures will be established for normal operations (Loading - Seagoing - Unloading) and for pre/post dry dock operations (Warm up - Inerting (H_2 to N_2) - Aeration - Inerting (Air to N_2) - Gasification (N_2 to H_2) - Cool down), taking into account the following existing practices of LNG carriers:
>
> .1 vapour return arrangement;
>
> .2 emergency shut down;
>
> .3 level/temp/pressure monitoring; and
>
> .4 manned cargo operations,

and additional considerations on the following issues:

.1 purging/draining open to atmosphere;

.2 cargo tank overfill protection;

.3 cargo piping leaks;

.4 rate of temperature change in cargo piping; and

.5 emergency preparedness and way forward.

The following emergency scenarios will be considered:

.1 overpressure scenarios (PRV's, Vent safety);

.2 loss of vacuum (CCS, Piping), liquid nitrogen/oxygen formation;

.3 grounding and collision;

.4 protection against loss of containment, jettisoning; and

.5 gas detection, fire detection and fire fighting."

Results of the Correspondence Group on Development of Safety Requirements for Carriage of Liquefied Hydrogen in Bulk

6 Dr. S. Ota, National Maritime Research Institute, introduced the results of the Correspondence Group on Development of Safety Requirements for Carriage of Liquefied Hydrogen in Bulk. He mentioned the background of the Correspondence Group and results of discussions about general requirements and special requirements for carrying Liquefied Hydrogen in bulk, mainly based on the consideration of the difference between LNG and liquefied hydrogen.

Closing remarks

7 Mr. A. Schultz-Altmann, Australian Maritime Safety Authority noted that Hydrogen offers great potential as a clean energy source but reflected that the problem is that, until now, hydrogen has only ever been carried by sea as packaged dangerous goods, as a compressed gas in packages complying with packing instruction P200. For the full potential of hydrogen to be realised, shipment needs to be more efficient. Shipment in bulk in liquefied form is the only truly viable option for a large volume shipment by sea.

8 It was further noted that the technology behind the storage and transfer of bulk liquefied hydrogen is not new, with land and barge based facilities supporting the space industry being in place since the 1950's. The same technology and standards can be applied to carriage by sea, albeit with modifications to suit shipborne operations. This approach underpins the proposed carriage requirements detailed in the report of the correspondence group.

9 It was noted there are some areas where the behaviour of the cargo cannot be determined with absolute certainty. To finally resolve this, it is necessary to undertake seaborne trials to derive the data needed to refine the requirements and to develop processes that will be necessary to support large scale commercial shipments at some stage after 2020.

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