E

MARITIME SAFETY COMMITTEE 105th session Agenda item 2	MSC 105/2/2 15 February 2022 Original: ENGLISH Pre-session public release: ☒

DECISIONS OF OTHER IMO BODIES

The development of safety requirements at the needed pace and detail to support the achievement of a decarbonization goal

Submitted by IACS

SUMMARY

Executive summary:	This document follows up on the document by IACS to the thirty-second Assembly of IMO, and considers aspects of an approach and offers preliminary views on the risks associated with the options currently researched and trialled to deliver a safe zero-CO_2-emitting ship
Strategic direction, if applicable:	3
Output:	Not applicable
Action to be taken:	Paragraph 37
Related document:	A 32/12/2

Introduction

1 IMO's strategy on the reduction of GHG emissions from shipping has set an ambitious target. Since the adoption of that strategy, there are calls to go further and quicker. IACS is fully supportive of IMO's central role in this process and appreciates the hard work of all parties in advancing the Organization through such a complex endeavour.

2 In its document A 32/12/2, IACS has offered its initial thoughts on the urgency of holistically addressing the safety of shipping deploying the technical solutions and new fuels in pursuance of GHG reduction targets as set by IMO (subject to review).

Discussion

3 Acknowledging the prerogative of the IMO Member States in organizing the work of the Committee, IACS opines that the challenge of offering a progressive regulatory certainty to the industry so that the investment could be made in projects utilizing new fuels and technologies can be broken into two main areas:

.1 the "new output" process in Committee/Sub-Committees; and

.2 the technical substance, as an input into regulatory development on technological solutions which are yet unproven.

4 In the normal course of the work, the first aspect is largely a procedural and administrative one due to the governance of the regulatory development process at IMO, where the agreement on a new output needs to be sought and agenda items would be allocated to future sessions of the Sub-Committees. In attempting to proactively address the risks of technological solutions, which have not yet received a critical mass of uptake by industry, MSC could look at a nimble approach to accommodate current and future discussions about solutions, which may in a longer term not survive market choice. It is suggested that MSC consider if a standing agenda item could be allocated to MSC sessions, under which the Committee will receive, evaluate and prioritize potential solutions. The scope of that evaluation would need to determine the feasibility of the uptake of the technology/fuel (technology readiness), the state of knowledge of risks and, for example, the below discussed technical considerations (paragraphs 9 to 36). This should create a "gravity pull" of the results of various trials and projects into a structured process of review by the Committee to determine the most appropriate course of action. Considering the multifaceted nature of the work, the Committee would need to manage strands of work of its various Sub-Committees (SSE, HTW, SDC, etc.) and coordinate the progress with MEPC, where measures enabling the transition are being considered. In its conceptual approach, the process may take inspiration from the work the Committee has performed, and is progressing, on MASS, where the education and sharing of common understanding is a major bi-product of that effort.

5 The second area of the challenge relating to the technical consideration of new fuels and technologies relates to the degree of the input of data and the quality of studies to identify the breadth of risks, suggest Risk Control Options (RCOs) and draft needed regulations. The Formal Safety Assessment (FSA) – a well-established tool of IMO regulatory development – offers a transparent route to determining holistic and specific risks, assess ways of mitigating them and look at the regulatory barriers and the need for new instruments, in a cost-efficient way. This is where the industry's input, as discussed in document A 32/12/2, would be appropriate and critical to the success. The above-discussed "evaluation" by MSC may include the receipt of reports on those studies before they are formally submitted for review by the group of FSA experts and results are put through into the sub-committees to initiate regulatory drafting.

6 Combining the two areas discussed above, IACS believes that at a certain stage the Committee could consider establishing an MSC working group (WG), which would perform the detailed evaluation, develop and maintain the road map towards safe decarbonization, propose to the Committee aspects to coordinate with MEPC, liaise with other organizations, invite sub-committees to undertake certain tasks and hold intersessional meetings, if deemed necessary, keeping in mind a distinction between energy storage (fuels), converters (e.g. engines, fuel cells, reactors) and abatement technologies (e.g. carbon capture and storage).

7 Specific terms of reference for the work of the MSC WG will have to be agreed by the Committee before a meeting of the Group could take place. Since most of the sub-committees to be involved in this work are already overloaded, a mechanism to consider the work in sub-committees in order to streamline their work and manage expectations regarding the delivery of the requested products may be necessary. To inform the deliberations at MEPC on the pace of change by presenting realistically achievable safety objectives, and thus add to the transparency of decisions, the coordination with MEPC is deemed to be beneficial.

8 Considering the state of research and progress in various projects, it is suggested, as an example, that MSC consider the progress with the work on, review of, or initiating preliminary work on selected solutions such as: ammonia, hydrogen, biofuels, LPG/DME

(Dimethyl ether), nuclear and carbon capture and storage (CCS). To assist the Committee with its considerations (while noting the work at the CCC Sub-Committee), a synopsis of the risks to safety from the use of potential GHG reduction solutions, as these impact ship's structure, materials, mechanical and engineering systems, fire safety, safety management, training, etc. is below.

Ammonia

9 Ammonia may be used as fuel for fuel cells, internal combustion engines, gas turbines or boilers, with different technology readiness levels. Ammonia is gaseous at the atmospheric pressure and temperature above -33.3°C, and, according to the literature, the equilibrium points between gas and liquid occur at: 10.25 bar at 25°C; 11.67 bar at 30°C; 15.56 bar at 40°C; 20.34 bar at 50°C.

10 Therefore, practically ammonia may be stored in a liquified form, either by cooling, pressurization or a combination of both. Gaseous ammonia is much lighter than air (0.696 g/m^3 vs 1.225 kg/m^3).

11 Ammonia is soluble in water (340 g/l at 25°C) and creates an alkaline solution (pH 11.3 for 1M solution corresponding to about 17 g ammonia per litre of water). It is highly toxic to humans and, according to the National Institute for Occupational Safety and Health (NIOSH), the Recommended Exposure Limit (REL) for ammonia is 25 ppm (averaged over an 8-hour workday), with a maximum allowable Short Term Exposure Level (STEL) of 35 ppm during any 15-minute period in the day, and an IDLH (Immediately Dangerous to Life and Health) value of 300 ppm.

12 Ammonia is hard to ignite (minimum ignition energy is generally estimated to be in the range of 12-50 mJ, vs hydrogen with only 0.016 mJ), has low flame speed (0.07 m/s), and low flame temperature. Such properties, together with the possible dependence of the flashpoint on the method used to determine it (e.g. ISO 1523, ISO 2719, ISO 2592, ISO 3679, ISO 13736), have introduced uncertainty in determining its flashpoint (reported with different values between 11°C and 650°C). However, being a combustible gas at standard conditions, most of the methods and definitions for flashpoint are not applicable.

13 Irrespective of the above, it is a consolidated knowledge that ammonia may create explosive atmosphere when its concentration in the air is between 15% (LEL) and 28% (UEL). Therefore, it appears that, regardless of the definition of low flash point fuel given in SOLAS regulation II-1/2.30, precautions should be taken in respect of the possible formation of both toxic and explosive atmosphere for its safe use as a fuel. Ammonia is corrosive to some materials, especially copper and its alloys.

14 Due to the above properties, the risks to the onboard use of ammonia are mainly:

- toxic effects, both for shipboard and nearby personnel, in case of release (also noting that ammonia is toxic to marine life);
- explosion;
- frost bite (when ammonia is stored or handled at low temperature); and
- corrosion.

Hydrogen

15 Hydrogen may be used as fuel for fuel cells, reciprocating internal combustion engines, gas turbines or boilers, but these technologies are still under development. Hydrogen is gaseous at atmospheric pressure and at temperature above -253°C. Hydrogen may be liquified only at temperature below its critical temperature (about -240°C). Gaseous hydrogen is much lighter than air (0.08988 g/m^3 vs 1.225 kg/m^3).

16 Hydrogen is very easy to ignite (minimum ignition energy of only 0.016 mJ) and shows the unusual property that the expansion is exothermal (hydrogen is heated by expansion). The flammability/explosivity range of hydrogen in the air is very wide, between 4% (LEL) and 74% (UEL). Hydrogen is typically stored as a compressed gas, or in a liquified form by cooling, or may be stored in metal hydrides at ambient temperature and little pressure (values depending on the specific metal).

17 Hydrogen, in contact with certain metals, may cause their embrittlement. In case of some steels operating at elevated temperatures (typically above 400°C) in hydrogen-rich atmosphere, a phenomenon named High Temperature Hydrogen Attack (HTHA) needs to be taken into consideration as well.

18 As most materials (metals and polymers) are permeable to hydrogen, hydrogen diffusion in metallic materials is difficult to grasp owing to the non-uniform compositions and material structures; further research would be necessary to enable safe application of hydrogen in future ship propulsion as well as energy storage and conversion machinery.

19 In case of liquefied hydrogen, the low temperatures may cause condensation of air on exposed parts of the containment system, with a possibility of localized oxygen enrichment due to the condensation from the atmosphere.

20 Due to the above properties, the risks to the onboard use of hydrogen are mainly:

- leak due to permeability of materials;
- fire and explosion;
- frost bite;
- material embrittlement; and
- oxygen enrichment.

Biofuels

21 Depending on the fuel types, biofuels may be used as fuel for state-of-the-art technologies such as internal combustion engines, gas turbines or boilers, replacing fossil fuels. Biofuel is a generic term that may include all fuels derived from materials of biological origin. It may include very different liquid and gaseous fuels, as well as their blends. Biofuels may be roughly divided into different sub-groups:

.1 bio-diesels are similar to fuel oils with the added risk that, due to the biological origin and possible different sources, there could be a lack of uniformity of the products, contamination with detrimental substances and a risk of bio-degradation and fouling;

.2 alcohols (typically ethanol and methyl alcohol) (see the IMO *Interim guidelines for the use of methyl/ethyl alcohol as fuel* (MSC.1/Circ.1621)) are low-flashpoint fuels. Alcohols may be corrosive to some plastics and rubber. Methyl alcohol is also regarded as a toxic product in the IBC Code, and according to NIOSH, the REL for methyl alcohol is 200 ppm (averaged over an 8-hour workday), with a maximum allowable STEL of 250 ppm during any 15-minute period in the day, and the IDLH value of 6,000 ppm; and

.3 bio-gas may have a composition similar to natural gas, so is expected to be made mainly of methane, however, depending on the specific source, it may contain significant quantities of other gases.

22 Due to the above properties, the risks to the onboard use of biofuels are mainly:

- fire and explosion (for low flashpoint fuels like biogas and alcohols);
- toxic effects;
- instability;
- corrosion; and
- contamination.

LPG/DME (Dimethyl ether)

23 While the primary focus is on zero-CO_2-emitting options, it is recognized that a transitional fuel may be required to bridge the current and future solutions. LPG and DME may be used as a fuel for internal combustion engine, gas turbines or boilers with varying technology readiness level. LPG is considered to be a clean, energy efficient and portable fuel at an affordable price and possess the advantage of being readily available worldwide. LPG is a mixture of propane and butane, meaning that in case of leakage, vapours will accumulate in the lower portion of the surrounding area. LPG is a preferred fuel choice of LPG carriers.

24 LPG is portable and easy to handle; it can be stored in pressurized tanks; it is easily accessible across all terminals in the world and is more environmentally friendly than other fossil fuels. LPG can offer shorter payback periods, lower investment costs and lower sensitivity to fuel price scenarios.

25 The LPG quality is particularly jeopardized during the transshipment processes, when this fuel may be exposed to contamination by other substances like water and sulphur compounds. The contaminants present in LPG may cause corrosion of the structural materials being in contact with this fuel. The solid products of the corrosion process are mechanical contaminants, which may cause damage to system components.

26 Due to its properties, the risks to the onboard use and storage of LPG are mainly:

- fire and explosion;
- toxic effects;
- contamination; and
- corrosion.

27 In the case of DME, the high oxygen content, together with the absence of C–C bonds in the molecules, causes a practically smokeless combustion, which is one of the most important advantages of DME. DME is not affected by hazardous contaminants like sulphur and vanadium. Major benefits from this fuel are the large reduction of CO_2 and NO_X emissions and the absence of SO_X emissions.

28 Due to its properties, the risks to the onboard use of DME are mainly:

- low lubricity;
- high reactivity and corrosiveness; and
- toxicity.

Nuclear

29 The use of nuclear power generation in the industry since the middle of the 20th century, including merchant shipping and Navy, has shown a very high safety standard, however, due to the severity and reach of possible incidents, which may also have the potential to cause long term damage, it may raise social concerns.

30 The risks connected with the use of nuclear power generation are related to the physical and chemical properties of the materials used and the reaction taking place.

31 Current research into new types of reactors (molten salt reactors, gas cooled reactors and liquid-metal cooled reactors) are considering further safety improvements by reducing the potential severity of incidents, although existing pressurized water reactors (PWR) currently in use on many ships have proven their reliability over many years of successful operation.

32 In general, however, the potential risks connected with the use of nuclear power generation and disposal of spent fuel may be summarized as:

- radiation;
- contamination;
- loss of control;
- explosion; and
- complexity of decommissioning.

33 Noting the above-listed potential risks and a general interest shown in this solution, it is noted that resolution A.491(XII) adopted the *Code of Safety for Nuclear Merchant Ships* as a guide to Administrations on the internationally accepted safety standards for the design, construction, operation, maintenance, inspection, salvage and disposal of nuclear merchant ships. Given its adoption in 1981, it may be beneficial and timely to consider updating it.

34 A separate and significant challenge is related to the role of a human in the "nuclear propulsion systems control loop" due to potentially having great influence on risks related to nuclear technology implementation in ship propulsion system design, construction and operation, as well as all maintenance and decommissioning issues. That said, for alleviation of possible hazards associated with the human factor, the number of crew persons servicing the nuclear power plant propulsion on existing ships is significantly larger compared to ordinary ship propulsion.

Carbon capture and storage (CCS)

35 CCS is a technology, by which carbon dioxide is separated from the combustion exhaust stream, liquified by compression or cooling, and stored in containers for separate reuse or sequestration (e.g. in underground geological formation). The separation process may use a variety of technologies, including absorption, membrane gas separation and others.

36 The risks involved are typically related to the high pressure and oxygen depletion in case of leakage or release of high quantities of CO_2 in closed spaces as below:

- explosion;
- asphyxiation; and
- storage of liquid CO_2 at cryogenic temperatures.

Action requested of the Committee

37 The Committee is invited to consider the foregoing, and to take action, as appropriate.

___