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AMENDMENTS TO THE IGF CODE AND DEVELOPMENT OF GUIDELINES FOR ALTERNATIVE FUELS AND RELATED TECHNOLOGIES

Analysis of gaps within the requirements of the IGF Code for the use of hydrogen as fuel

Submitted by IACS

SUMMARY

Executive summary:	This document provides the outcome of an analysis performed to identify the applicability and gaps in the requirements of the IGF Code in respect of the use of hydrogen as fuel.
Strategic direction, if applicable:	2
Output:	2.3
Action to be taken:	Paragraph 6
Related documents:	None

Introduction

1 The development of interim guidelines for the safety of ships using hydrogen as fuel is ongoing since CCC 7. It is noted that, in general, the draft guidelines follow the structure of the IGF Code. In this regard, IACS has performed a gap analysis of the requirements provided in the IGF Code to determine those aspects of the IGF Code which may need to be clarified regarding the use of hydrogen as fuel as well as the aspects which the IGF Code does not address for the use of hydrogen as fuel.

2 For the purpose of the gap analysis, the version of the IGF Code which was considered is resolution MSC.391(95), as amended by resolutions MSC.422(98), MSC.458(101) and MSC.475(102).

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Discussion

Key aspects of the use of hydrogen as marine fuel

3 The following major aspects regarding the use of hydrogen as marine fuel were identified during the gap analysis:

.1 the use of hydrogen as marine fuel would need consideration of hazards specific to hydrogen related to its properties as fuel. A list of such hazards is provided in annex 1 to this document;

.2 it was noted that the safety distances for liquefied hydrogen fuel tanks and pressure vessels, cylinders (compressed hydrogen gas) from ship sides and bottom may need possible evaluation with risk analysis. In this regard, it may need to be confirmed whether the probabilistic approach in paragraph 5.3.4 of the IGF Code is adequate to be applied to hydrogen as fuel;

.3 emergency shut-down (ESD) arrangements for machinery spaces should not be permitted at present for hydrogen. This is also justified considering the limited experience available with use of LNG as fuel for the same;

.4 storage of hydrogen as fuel is preliminary envisaged within type C independent tanks (liquefied hydrogen) and pressure vessels and cylinders (compressed hydrogen). This would not preclude consideration of the use of other types of fuel storage tanks for hydrogen using the alternative design approach;

.5 exposure of materials to hydrogen atmosphere can lead to fatigue and strength degradation of the materials. The design, construction and testing of containment system in Sections 6.4 and 16 of the IGF Code should take this into account;

.6 as regards the use of portable liquefied hydrogen tanks or hydrogen gas cylinders certified as per recognized international/national standards carrying liquefied or compressed hydrogen or cryo-compressed tanks, it can be considered whether existing standards for land-based applications (e.g., ADR Agreement, pressure equipment Codes) could be referred to while ensuring that such tanks would need to be robust and certified for marine applications in accordance with the requirements of the IGF Code. The durability, installation speed, and compatibility with hydrogen for portable fuel tanks, connecting valves and pipelines should be taken into account;

.7 storage of hydrogen fuel within metal hydride systems is not covered within the IGF Code. This would need to be considered given that ships are being designed for the use of hydrogen as fuel with the above fuel storage systems;

.8 venting of hydrogen during normal operations to atmosphere should not be permitted. However, it may be considered whether the venting of hydrogen may be permitted during bunkering operations. Venting of hydrogen, if carried out, should be accompanied with purging with inert gas so as to prevent development of flammable mixtures in the vent mast;

.9 the location and extent of hazardous area zones in the present IGF Code for LNG may *prima-facie* be conservative for hydrogen considering its low density and ability to disperse quickly (however, the wide flammability limits and low ignition energy for hydrogen should also be kept in view). Hence direct analysis should be permitted using the procedure provided in IEC 60079-10-1:2020 (Section 5.2) to determine the size of the hazardous area zones for selection of electrical equipment to be installed in the respective zones;

.10 oxygen enrichment may be possible in spaces which are concerned with storage of liquefied hydrogen or spaces which contain pipes carrying liquefied hydrogen. IEC 60079-14 (Explosive atmospheres) specifically mentions that for scenarios pertaining to oxygen enrichment, the requirements of the standard may not be appropriate;

.11 the limitations with inert gas to be used onboard especially for liquefied hydrogen containment systems should be considered keeping in view that all applicable gases other than helium would liquefy and/or solidify at the boiling point of liquid hydrogen (-253ºC) (helium is not so abundantly available as nitrogen);

.12 design of pressure relief vent system for hydrogen would need special consideration. It was identified that there are specific standards such as CGA 5.5 – Hydrogen Vent Systems (USA) and GDR DVGW G 442:2015-07 (*Potentially explosive atmosphere at exhaust openings of venting lines at gas plants or systems*) (Germany) which may be referred for this purpose. Vent mast exits should be arranged to safely disperse any release, to prevent its ignition, and limit the consequences of ignited gas (i.e., thermal radiation and fire impingement). Safe distances should be determined from gas dispersion analysis and heat radiation analysis;

.13 lightning strikes have the potential to ignite a fire at the gas vent (as was conveyed within document CCC 2/INF.20). This should also be taken into account when developing regulations for hydrogen as marine fuel. The aspect of correct earthing solutions should also be taken into account as related mitigation measure; and

.14 hazards posed due to liquefied hydrogen as enumerated in resolution MSC.420(97) need to be reflected in the IGF Code when liquefied hydrogen as marine fuel is being considered.

4 Risk assessment would be an important process for approval of the fuel system for hydrogen. In addition to the topics already contained within Section 4.2 of the IGF Code, additional topics were identified for consideration within the risk assessment. A list of possible additional topics is presented in annex 3 of this document.

Gap analysis

5 The detailed outcome of the gap analysis of the IGF Code when considering the use of hydrogen as marine fuel is present in the annex 2 of this document for consideration in the development of the draft interim guidelines.

Action requested of the Sub-Committee

6 The Sub-Committee is invited to note the information provided in this paper and take action as appropriate.

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ANNEX 1

HYDROGEN RELATED HAZARDS/RISKS

Hazard/Risk	Liquefied hydrogen	Compressed hydrogen
Ortho-Hydrogen to Para-Hydrogen conversion	X	
Condensed Air near Hydrogen tanks & piping	X	
Cleanliness of Pipes, Tanks	X	
Formation of Ice or Water blocking PRVs & Exhausts/Vents	X	
Cryogenic Temperatures (-253ºC)	X	
Hydrogen Embrittlement		X
High Temperature Hydrogen Attack (HTHA)		X
Testing of Tanks, Piping for Tightness	X	X
Inert gas to be used		X
Low density	X	X
High Diffusivity		X
Permeability		X
Low energy of ignition		X
Wide Flammability Limits		X
Nearly invisible Hydrogen Fires		X
Oxygen Depletion & Asphyxiation due to leakage of hydrogen in enclosed space	X	X
Static Electricity		X
Lightning Protection	X	X
Low Temperature Hazards to Humans on Exposure to Liquefied Hydrogen (e.g. Cryogenic Burns and Frostbite)	X	
High Boil-off rates	X	
High Burning Velocity		X
Boiling liquid expanding vapor explosion, rapid phase transition, and vapor cloud explosion (deflagration and detonation)	X	
Roll Over of LH2 containment system	X	
Very High Pressure Equipment(which may exacerbate tendency for leakage)		X
Explosive mixtures development in enclosed space		X

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ANNEX 2

GAP ANALYSIS OF THE IGF CODE CONSIDERING HYDROGEN AS FUEL

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
1	IGF Code	2.2.4	Footnote for Certified Safe Type references the IEC 60079 series, Explosive Atmospheres (IEC 60079-14). However, it is mentioned in Section 1 of the above standard that the requirements of the standard apply only to use of equipment under standard atmospheric conditions. Oxygen enrichment conditions are not covered by the above. There could be potential of oxygen enrichment in spaces with storage of liquefied hydrogen or which contain pipes carrying liquefied hydrogen. This may influence the fire risk	Identify a suitable standard for electrical equipment which may be installed in spaces with potential for oxygen enrichment (NFPA 53 may possibly be useful to address this gap).
2	IGF Code	NEW	Additional definitions require to be introduced	The following additional definitions need to be included, such as: 'Explosion Analysis' refers to analysis of the likelihood and consequence(s) of explosion(s). 'Fuel' in the context of these requirements means hydrogen (H_2) either its liquefied and/or gaseous phase. 'Hazard' an event with the potential to cause harm (e.g. a source, act or situation) to personnel, or damage or impairment to the asset or equipment.

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
				'Inherently safer design' means to eliminate all hazards or where this is not possible and hazards can still be realised, reduce their likelihood and/or severity. 'LEL' means the lower explosive limit, as per Part A, 2, 2.2 Definitions, also commonly referred to as the lower flammable limit (LFL). It is the lowest concentration of the gas/vapour in air that will produce a flash fire when an ignition source is present. 'Portable fuel storage tanks' means an independent tank being able to be: easily connected and disconnected from ship systems; and easily removed from ship and installed on board ship. 'Reasonably foreseeable': • an event that has occurred and could occur again; • an event that has not occurred but is considered possible; and • an event that is planned for (e.g. emergency actions cover such a situation, maintenance is undertaken to prevent it). 'Safety distance' means the minimum separation distance which will mitigate the effects of a reasonably foreseeable incident and help prevent escalation.
3	IGF Code	3.2.1	Demonstration of safety, reliability and dependability of Hydrogen Fuel Systems	Failure Modes Effects Analysis (FMEA) should be performed for the hydrogen fuel system

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
4	IGF Code	3.2.2	Fuel related hazards need further clarification or elaboration	Please refer Annex 1 for a detailed list of hazards which would be applicable considering hydrogen fuel. Reference may also be made to ISO TR 15916 for more detailed description
5	IGF Code	3.2.3	The paragraph mentions "gas fuel installation". "Gas" can be replaced with "Hydrogen"	Propose to replace "gas" with "Hydrogen"
6	IGF Code	3.2.6	Hydrogen is not a toxic gas for humans. Hence the word "toxic" can be removed from this paragraph	Propose to delete the word "toxic" from the functional requirement
7	IGF Code	3.2.9	Venting of Hydrogen is not permitted during normal operation. However, such venting should be permitted during bunkering operations	Clarify that the venting of Hydrogen is permitted during bunkering operations
8	IGF Code	3.2.X	Oxygen enrichment due to condensation of liquid air or oxygen coming in contact with damaged insulation or poor insulation of hydrogen tank is not considered by the functional requirements	[Option 1] Include a new functional requirement highlighting the hazard of Oxygen enrichment due to Liquefied Hydrogen [Option 2] This is already addressed by the proposed solution for 3.2.2
9	IGF Code	3.2.11	HAZOP study should be performed for the fuel system in order to ensure that the functional requirement is addressed	HAZOP study should be performed for the fuel system
10	IGF Code	3.2.16	The Commissioning, trials and maintenance of fuel systems should draw inputs from the FMEA and HAZOP Study recommendations	The outcome of the FMEA, HAZOP and the Risk assessment should be reflected in the commissioning, trials and maintenance manuals as applicable
11	IGF Code	3.2.17	Ensure that the outcome of HAZOP and FMEA studies is considered when developing technical documentation	The outcome of FMEA, HAZOP and Risk assessment should be reflected in the technical documentation where appropriate
12	IGF Code	4.2.1	The regulation is for Hydrogen as fuel. Low flashpoint fuel is not relevant here	Replace the "low flashpoint fuel" with "Hydrogen"

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
13	IGF Code	4.2.2	The topics described in this regulation may not be enough considering properties of hydrogen when compared to LNG. A Risk Analysis in totality should be recommended and when necessary a specific risk-assessment.	Recommend that risk assessment be performed (preferably quantitative risk assessment where possible) Develop recommendations for performing risk assessment considering properties and hazards from hydrogen..
14	IGF Code	4.3	It is mentioned in the footnote to Section 4.3 that double wall pipes are not considered as sources of release. However during accident, there may be potential for double wall pipes to be damaged. It should be clarified that Double Wall Pipes are not "normally" considered as sources of release	Propose amendment to the footnote as below: "Double Wall Pipes are not **normally** considered as sources of release"
15	IGF Code	4.3.7	The term "bunker oil" may not be relevant if hydrogen is to be used onboard as fuel	Delete the words "bunker oil" from this paragraph
16	IGF Code	5.2.1.3	Hydrogen is not considered a toxic gas and hence this functional requirement should be suitably re-worded to reflect the same	Revise IGF Code 5.2.1.3 to reflect that Hydrogen is not a toxic gas.
17	IGF Code	5.2.1.6	It may be clearly mentioned that the "gas" in this paragraph refers to "Hydrogen". Likewise "Low Flashpoint fuelled Machinery" is not relevant in this case	Revised IGF Code 5.2.1.6 to reflect that that the gas to be considered is hydrogen and remove "low flashpoint fuelled machinery" from this clause.
18	IGF Code	5.3.3	The draft interim guidelines for hydrogen state that case by case risk analysis may be required for tanks complying with the safety distance requirements in IGF 5.3.3. However the risk assessment method and criterion need to be agreed by the administration	[Option 1] Develop recommendation to address the topic of safety distances of the tank from the bottom and sides considering collision and grounding events. I [Option 2] If possible, attempt to provide safety distances

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
19	IGF Code	5.3.4	The probabilistic methodology is recommended not to be followed for hydrogen fuel tanks as per the working draft after CCC 8 (CCC 8/WP.3, Annex 2)	This is addressed by the solution proposed for 5.3.3
20	IGF Code	5.4.1.2	The fundamental question here is whether ESD Machinery Spaces should be permitted for Hydrogen as fuel at this stage	ESD Spaces should not be permitted.
21	IGF Code	5.6	Same as above	ESD Spaces should not be permitted
22	IGF Code	5.7.1	Considering item in Sr.no 13 above, this distance also may need to be reviewed and risk analysis may be required	The safe distance of the hydrogen piping systems (including master gas valve) should also be addressed in the solution for 5.3.3
23	IGF Code	5.8	Reference to the requirements for Tank Connection Spaces (TCS) for application to Fuel Preparation Rooms is not sufficient. Fuel Preparation Rooms may be subject to leakage from Hydrogen gas released under high pressure or from cryogenic leaks. The prescriptive requirements for forced mechanical ventilation in the IGF Code may not be adequate	Consider development for requirements for mechanical forced ventilation of fuel preparation taking into account that there could be a high pressure hydrogen gas leak or from a cryogenic leak
24		5.10	Drip Trays Regulations do not account for potential safety issues arising from Oxygen enrichment and vaporization of Hydrogen gas	Oxygen enrichment in the vicinity of the drip tray should be considered. The evaporation and dispersion of vaporized hydrogen gas should also be addressed (in the context of whether this can pose an unacceptable risk) and requirements developed to address this.
25	IGF Code	5.11.4	If ESD Machinery Spaces are not permitted on Hydrogen Fuelled Ships, then this regulation is not relevant	ESD Spaces should not be permitted

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
26	IGF Code		Specification of content of ortho and para hydrogen should be provided in this Section	Specification of content of ortho and para hydrogen should be provided in this section. A separate paragraph may be used for this as below: Hydrogen with content of para hydrogen > 95% should be stored.
27	IGF Code	6.2.1	Oxygen enrichment and Hydrogen Embrittlement are not covered under this regulation	Review the requirements in 6.2 with fuel related properties/hazards of hydrogen to include all relevant hazards/attributes of Hydrogen within this. MSC.420(97) and ISO TR 15916 can be also referred to for this.
28	IGF Code	6.3.1	Not relevant here as Hydrogen fuel is to be considered	Delete "natural gas" and replace with "hydrogen"
29	IGF Code	6.3.1	MARVS above 1 MPa is not covered or permitted. While this may be relevant to LNG, this may be too restrictive for Hydrogen considering the low density. Higher MARVS should be permitted provided a Risk Assessment is performed	Permit MARVS > 1 MPa provided a risk assessment is performed to satisfactorily address all hazards arising from the higher MARVS. Scenarios to be considered within the Risk assessment to be further defined.
30	IGF Code	6.3.3	The requirements for gas tightness can be further elaborate for Hydrogen Storage Tanks located in an enclosed space. Additional text for clarification can be proposed as below "When the fuel storage tank is in an enclosed space, the tank connection space is to be gastight toward other spaces."	Consider additional text to be incorporated: "When the fuel storage tank is in an enclosed space, the tank connection space is to be gastight toward other spaces."
31	IGF Code	6.3.7 – 6.3.8	Maximum Probable Leakage Scenario (s) needs further elucidation as to its evaluation	Guidance on evaluation of maximum probable leakage scenarios is required.
21	IGF Code	6.3.9	Secondary barrier applied to piping connected below the liquid level of the tank upto the first valve	Secondary barrier should be recommended for all liquid and hydrogen piping systems except vent masts

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
33	IGF Code	6.3.10	It may be possible to load sub-cooled Liquefied Hydrogen (i.e at lower temperatures than the boiling point at atmospheric pressure)	Material should have a design temperature appropriate to the storage temperature of the fuel
34	IGF Code	6.3.12	The clause does not take into account warming of the tank prior to inert gas admission to prevent condensation/solidification of inert gas during the process	The clause should include warming up of the tank prior to inerting.
35		6.4.2.1	The requirement should also consider prevention of lowering of temperature of the air in the proximity of the storage tank which may lead to oxygen enrichment	Revise the requirement to ensure that temperature of air in the vicinity of the tank is not lowered excessively so as to prevent oxygen enrichment or take appropriate steps to ensure that hazards from oxygen enrichment are addressed.
36	IGF Code	6.4.2.3	For Liquefied Hydrogen, a partial secondary barrier and/or leakage protection should not be permitted	Storage of Hydrogen is envisaged at present in Independent Type C tanks. For other tank types, alternative design approach may be utilized
37	IGF Code	6.4.3	For Liquefied Hydrogen, storage should only be permitted in Type C or Membrane type tanks for the interim	Storage of Hydrogen is envisaged at present in Independent Type C tanks. For other tank types, alternative design approach may be utilized
38	IGF Code	6.4.5	For Liquefied Hydrogen, storage should only be permitted in Type C or Membrane type tanks for the interim	Storage of Hydrogen is envisaged at present in Independent Type C tanks. For other tank types, alternative design approach may be utilized
39	IGF Code	6.4.8.1	The evaluation of Vacuum Insulation Performance is to the satisfaction of the administration. A guideline is necessary to ensure consistency in application	Develop guidance for evaluation of Vacuum Insulation Performance
40	IGF Code	6.4.9.3.3.2	For vacuum insulated tanks, the presence of vacuum should also be considered when evaluating the pressure loads for the inner and outer shells	Consider the presence of vacuum when evaluating the pressure loads for the inner and outer shells

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
41	IGF Code	6.4.9.4.1.3	It would be helpful if there is a guideline for enumerating the procedure for the evaluation of sloshing considering Hydrogen	Develop guidance for evaluation of sloshing pressure in Type C and Membrane Tanks considering increase in hydrogen gas pressure in the tank due to boil-off
42	IGF Code	6.4.9.5	Loss of Vacuum should also be considered in accidental load	Recommend to consider Loss of Vacuum within accidental loads. Also, recommend other events (e.g. collision, grounding, dropped object, explosion etc.) to be considered for this.
43	IGF Code	6.4.10.1.1	The "adequate margin" of safety needs to be specified in order to ensure consistent application of this clause especially considering Hydrogen and its properties	Consider this issue to address if quantitative value of "adequate margin of safety" can be provided. Else, a guideline/procedure can be provided to illustrate what is "adequate margin of safety"
44	IGF Code	6.4.12.1.3-4	Enhanced yield and tensile strength at lower temperature is to be subject to special consideration by the administration	Develop guidance to outline principles to be considered when using enhanced yield and tensile strength as is being permitted by this requirement
45	IGF Code	6.4.12.2.2	The value of "N_loading" (1000 cycles) may need to be relooked, since hydrogen fuel may possibly be bunkered more frequently as compared to conventional oil fuels. Hence the number of loading and unloading cycles may increase (especially when considering the energy storage density)	Consider if N_loading of 1000 cycles is sufficient for hydrogen given the fact that it may need to be bunkered more frequently.
46	IGF Code	6.4.12.2.4	The Design S-N Curves should also take into account that the material is continuously exposed to a hydrogen atmosphere. This needs to be considered as fatigue properties typically degrade in continuous exposure to hydrogen atmosphere	The requirement should also clearly specify that the design SN Curves should take into account degradation in properties due to continuous exposure to hydrogen
47	IGF Code	6.4.12.2.6 - 9	This paragraph applies to provision of a partial secondary barrier. This is recommended not to be permitted for Hydrogen in the interim	Storage of Hydrogen is envisaged at present in Independent Type C tanks. For other tank types, alternative design approach may be utilized

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
48	IGF Code	6.4.12.3.1	It would be helpful if the "low probability of occurrence" was defined so as to ensure consistency in application of this requirement	Consider to recommend a value for "low probability of occurrence" if possible (e.g. 10^-4)
49	IGF Code	6.4.13	In general, the section would need to be aligned considering materials of tank construction which are compatible with Hydrogen	Develop guidance for materials of tank construction for hydrogen, taking into account MSC.420(97), ISO TR 15916 and other relevant standards
50	IGF Code	6.4.13.2.1	Tables 7.1-7.3 consider requirements for materials with design temperature not below -165 degrees Celsius. This will not be suitable for Liquid Hydrogen whose storage temperature is -253 degrees Celsius	Develop guidance for materials of tank construction for hydrogen, taking into account MSC.420(97), ISO TR 15916 and other relevant standards
51	IGF Code	6.4.13.2.2	Tables 7.1-7.3 consider requirements for materials with design temperature not below -165 degrees Celsius. This will not be suitable for Liquid Hydrogen whose storage temperature is -253 degrees Celsius	Develop guidance for materials of tank construction for hydrogen, taking into account MSC.420(97), ISO TR 15916 and other relevant standards
52	IGF Code	6.4.13.2.4	Tables 7.1-7.3 consider requirements for materials with design temperature not below -165 degrees Celsius. This will not be suitable for Liquid Hydrogen whose storage temperature is -253 degrees Celsius	Develop guidance for materials of tank construction for hydrogen, taking into account MSC.420(97), ISO TR 15916 and other relevant standards
53	IGF Code	6.4.13.2.6	Potential Oxygen Enrichment and the consequences due to the same should also be considered	Amend the requirement to take into account possibility of oxygen enrichment and consider proposing preventive and mitigative measures
54	IGF Code	6.4.13.3.3	This will not be suitable for Liquid Hydrogen whose storage temperature is -253 degrees Celsius	For Hydrogen, this requirement has to be amended to reflect the boiling point of liquid hydrogen at -253 degrees Celsius
55	IGF Code	6.4.13.3.4	Potential Oxygen Enrichment and the consequences due to the same should also be considered	Amend the requirement to take into account possibility of oxygen enrichment and consider proposing preventive and mitigative measures
56	IGF Code	6.4.13.3.5	Potential Oxygen Enrichment and the consequences due to the same should also be considered	Amend the requirement to take into account possibility of oxygen enrichment and consider proposing preventive and mitigative measures

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
57	IGF Code	6.4.14. 1.2	Type B independent tanks should not be considered for storage of liquid hydrogen	Storage of Hydrogen is envisaged at present in Independent Type C tanks. For other tank types, alternative design approach may be utilized
58	IGF Code	6.4.15. 3.2.1.2	The allowable dynamic membrane stress amplitudes must be specified for austenitic stainless steels and those aluminium alloys which are suitable for continuous exposure hydrogen (e.g. please refer table in ISO TR 15916).	Study the background of this requirement and check if allowable dynamic membrane stress values can be specified (also see solution proposed for 6.4.15.3.2.4
59	IGF Code	6.4.15. 3.2.1.2-3	All steels mentioned in this section may not be appropriate for compatibility for storage of hydrogen. The paragraph should reflect the correct materials which are appropriate for storage of hydrogen.	Study the background of this requirement and check if the values are adequate/appropriate for hydrogen (minimum thickness, type of steels, weld joint efficiency factor etc.) considering hydrogen embrittlement
60	IGF Code	6.4.15. 3.2.4	"Accepted Pressure Vessel Theory" should be elaborated. This is significant considering that ASME has specific requirements for pressure vessels used for storage of hydrogen	Review the Procedure in ASME BPVC, Section VIII, Division 3, Article KD-10 and decide if this used to develop guidance for sizing the scantlings of the hydrogen storage tank
61	IGF Code	6.4.15. 3.2.5.3	This evaluation should be performed mandatorily and not be left to the discretion of the administration considering that Liquid Hydrogen is to be carried at very low temperatures	Recommend that thermal stresses should be evaluated which includes condition for loss of vacuum insulation or damage to insulation
62	IGF Code	6.4.15. 3.3.1	All steels in the table (with A and B values) may not be appropriate for hydrogen. This Table hence needs to be adapted for Hydrogen after suitable modifications	Study the background behind the values of A & B in the table based upon the various steel types. Also take into account the outcome of Solution proposed for 6.4.15.3.2.4
63	IGF Code	6.4.15. 3.4.1	Fatigue analysis should be performed since fatigue properties degrade in exposure to hydrogen atmosphere. This should hence not be left to the discretion of the administration	Recommend that fatigue analysis should be performed taking into account the degraded SN curve properties owing due to continuous exposure to Hydrogen

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
64	IGF Code	6.4.15.3.4.2	The requirement mentions "special attention" but is not clear enough in what aspect of the fatigue strength or how should this special attention be given	Develop understanding of the issues which need "special attention" to be used as common understanding (or unified requirement) for IACS members
65	IGF Code	6.4.15.4.1.4	It should be checked whether the values of Po would be appropriate for Hydrogen	Study the technical background behind this requirement and propose suitable action
66	IGF Code	6.4.15.4.1.5	Should non-metallic membranes be permitted for membrane tanks for carriage of liquid hydrogen?	At present, consider only metallic membranes compatible with hydrogen
67	IGF Code	6.4.15.4.1.7	The carriage of liquefied hydrogen at -253 degrees Celsius poses a unique challenge since nitrogen (commonly used as inert gas) freezes at -210 degrees Celsius. Helium is a good candidate for inert gas, but the availability of helium poses an issue as it cannot be conveniently generated onboard like nitrogen. Hence it has to be decided as to what would be a suitable inert gas if Liquid Hydrogen were to be carried in Membrane Tanks at -253 degrees Celsius	Impose a condition on the temperature at the outer side of the insulation such that this is not lower than the boiling point of the inert gas (e.g. nitrogen, helium etc.)
68	IGF Code	6.4.15.4.2.1.1	Embrittlement or degradation of properties due to exposure to hydrogen may also be possible. These effects should also be kept in view while checking this requirement	Recommend to consider degradation of properties due to exposure to hydrogen
69	IGF Code	6.4.15.4.2.1.2	The degradation of fatigue properties should be considered for the primary membrane due to exposure to hydrogen atmosphere.	Recommend to consider fatigue degradation for primary membrane which will be exposed continuously to hydrogen
70	IGF Code	6.4.15.4.6.3-5	The analyses and tests should however consider exposure of materials to hydrogen atmosphere and any possible degradation	Recommend that the analyses and tests take into account any possible degradation due to exposure to Hydrogen

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
71	IGF Code	6.5.1	Design of the tank complying with international or recognized standards which have been utilized for land-based portable liquefied gas while duly considering marine loads should also be acceptable	Tanks certified in accordance with International or recognized standards cryogenic pressure vacuum can be used provided they are checked against the marine loads as specified in the Section 6.4. Compatibility of materials should also be checked.
72	IGF Code	NEW	No adequate regulations for addressing safety aspects for hydrogen portable tank, container swapping arrangements etc.	Develop an guidance for Portable and Swappable Hydrogen Tanks/Containers. The guidance may address the following aspects: .1 Recognized Standards to be used for Portable Tank or Cylinder Certification (including periodic renewal of certification). .2 Arrangement of the Portable Tank/Cylinders onboard (i.e. on open deck or in holds). .3 Safeguards for addressing possible leakage scenarios. .4 Connections of the tank/cylinders to the vent system .5 Inerting Arrangements. .6 Fire Safety Arrangements. .7 Other relevant aspects (e.g. dropped objects, lifting etc.).
73	IGF Code	6.5.5	Acceptable standards for such flexible hoses carrying Liquefied Hydrogen should be specified so that there is consistency in application	Identify and recommend recognized ISO or EN standards which address flexible hoses carrying Liquefied and/or Compressed hydrogen
74	IGF Code	6.5.6	Liquid Hydrogen Spill due to inadvertent disconnection should not be permitted	Recommend use of dry couplings to safeguard against liquid hydrogen spill due to inadvertent disconnection.
75	IGF Code	6.6.1	This should be changed to "CH2" indicating compressed hydrogen and not natural gas In addition, standards for the approval should be specified. E.g. ISO 19881, ISO 11114	Recommend recognized standards such as ISO 19881 and ISO 11114 for compressed hydrogen tanks

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
76	IGF Code	6.7.2.1	The rationale behind the acceptance of direct release into atmosphere not exceeding the size of 40 ft container needs to be explored in relation to hydrogen fuel with view to confirm if this is appropriate for Hydrogen	Identify the rationale behind this requirement (this is not specifically for portable liquefied gas tanks). This paragraph should be modified as below "Adequate measures shall be provided in the design of the fuel tank to prevent leakage of Hydrogen Fuel into vacuum insulation space".
77	IGF Code	6.7.2.7-3	The magnitude of the height of vent exits need to be confirmed whether they are appropriate for hydrogen gas released from opening of the PRV. This can be checked by performing analyses	It should be recommended to perform gas dispersion and thermal radiation analysis to ensure that adequate heights of the vent exits are selected. This may also form an aspect of the risk assessment to be carried out. The vent system design should also be appropriate and in accordance with recognized standards.
78	IGF Code	6.7.3	Recommend to check whether the philosophy of sizing of the vent pipe system is in accordance with the CGA standard 5.5 - Hydrogen Vent Systems; whether any additional factors need to be considered	Review the CGA Standard 5.5 - Hydrogen Vent Systems and recommend any further necessary actions. Velocity of release to be considered as one of the criteria of verification (sonic) especially for CH2. Loss of vacuum insulation of the tank should be considered during the pressure relief valve sizing calculations (for all vacuum insulated designs).
79	IGF Code	6.8.2-6.8.3	Filling Limit exceeding 98% should not be permitted (please also see MSC.420(97)	Filling limit beyond 98% at reference temperature should not be permitted
80	IGF Code	6.9.1.1	The period of 15 days may be checked for its appropriateness. This can be studied within the Risk assessment	Recommend to examine this aspect in the Risk assessment. Guidance can be developed for this purpose
81	IGF Code	6.9.1.2	This clause precludes the venting of Hydrogen during the bunkering operation	Clarify that the venting of hydrogen during bunkering operation is permissible so as to ensure integrity of the tank and piping
82	IGF Code	6.9.3.2.4	"Methane" used in the clause should be replaced with "Hydrogen"	Replace "Methane" with "Hydrogen". The composition of the Hydrogen produced from the reliquefaction process in ortho-para terms should also be specified.

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
83	IGF Code	6.9.4.1	Hydrogen boil-off may also result during violent sloshing of the ship in heavy weather. This must also be taken into account for sizing of the GCU	Recommend to consider sloshing keeping in view that the fuel tank level may vary based upon the stage of the voyage; and its implications on generation of boil-off gas
84	IGF Code	6.9.5	Is this clause practicable for application to Liquefied Hydrogen?	Relevance of this clause may be considered whether it is practicable at present to have re-liquefaction systems onboard the ship
85	IGF Code	6.11.1	The choice of the inert gas will play a role here. Also, the requirement for 30 days needs to be checked if it is in order. This can be considered within the Risk assessment	Recommend to examine this aspect in the Risk assessment
86	IGF Code	6.12.1	The clause needs to specify as to condensation of what (e.g. moisture). For poor or damaged insulation, the air including oxygen and nitrogen around the tank may condense	Text can be proposed to recommend to consider condensation of moisture, air, oxygen and nitrogen (including the possibility of these substances solidifying, since their freezing points are also higher than boiling point of hydrogen). The loss of vacuum may further exacerbate such condensation and should be considered.
87	IGF Code	6.13.3	Hydrogen gas may be released during removal of non-permanent connections	Dry Coupling should be recommended to be used.
88	IGF Code	6.14.1	The LEL of Hydrogen is 4% (and may be even lower in oxygen rich atmosphere). This requirement needs to be relooked	5% oxygen in inert gas would be unacceptable. A value lower than 4%, e.g. 2% can be recommended..
89	IGF Code	6.14.3	Number of air changes may be reviewed in context of use of hydrogen as fuel	Recommend to examine this aspect in the Risk assessment
90	IGF Code	6.14.4	Definition of "well ventilated spaces" should be provided (in terms of the minimum air changes per hour)	A common understanding of "well ventilated spaces" can be developed

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
91	IGF Code	7.3.2.1	This can be compared with ASME B31.12 to check if special requirements (if any) due to Hydrogen need to be considered and incorporated	Review ASME B31.12 to identify any specific aspects which should be considered for piping systems conveying hydrogen. Based upon the outcome, develop a Recommendation or UR
92	IGF Code	7.3.3.1	This can be compared with ASME B31.12 to check if special requirements (if any) due to Hydrogen need to be considered and incorporated	Review ASME B31.12 to identify any specific aspects which should be considered for piping systems conveying hydrogen. Based upon the outcome, develop a Recommendation or UR
93	IGF Code	7.3.4.2	The factors Rm (2.7) and Re (1.8) should be investigated to check if they are appropriate for piping for carriage of Hydrogen (also keeping in view the compatibility of Hydrogen with the material)	Review of the ASME B31.12. will help in identifying whether these factors can be used without change
94	IGF Code	7.3.6.4.2	The requirements for flanged joints need to be checked if they are appropriate for Hydrogen	Review of ASME B31.12 should be able to contribute to addressing this gap. Check if bayonet connections can be considered for acceptance.
95	IGF Code	7.4.1.3	"CNG" may be replaced by "Compressed Hydrogen"	Replace CNG by "Compressed Hydrogen"
96	IGF Code	7.4.1.5	Tables 7.1-7.5 and this section in general needs to be aligned in order to ensure that the material and thicknesses are appropriate for Boiling point of Hydrogen at -253 degrees Celsius	Develop Recommendation/Unified Requirement for materials of pipe, valves, joints etc. for hydrogen, taking into account MSC.420(97), ISO TR 15916, ASME B31.12 and other relevant standards
97	IGF Code	8.3.1.6	This requirement should be examined for compressed hydrogen	CNG may be replaced with Hydrogen
98	IGF Code	8.3.2.2	This would be only applicable to liquid hydrogen	Clarify that this requirement would be applicable only to liquid hydrogen. Further, the hoses should be double walled and insulated.
99		NEW	Guidance regarding the procedures, equipment and responsibilities of persons involved in Hydrogen (liquid and compressed) bunkering is needed.	Guidelines for Hydrogen Bunkering (both compressed and liquefied) can be developed.

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
100	IGF Code	8.5.2	Venting of Hydrogen during bunkering operation is precluded by this clause	Clarify that the venting of hydrogen during bunkering operation is permissible so as to ensure integrity of the tank and piping
101		NEW	Onboard generation of hydrogen may be a possibility (e.g. using electrolysers)	Request advise whether onboard hydrogen generators should also be taken into account for the study.
102	IGF Code	9.4.4	The venting of the hydrogen from the bleed valve to open air has to be specially considered	Risk assessment to consider the scenario of venting of the hydrogen from the bleed valve to a safe location
103	IGF Code	9.4.10	It has to be decided if ESD spaces are permitted. If yes, then risk assessment should be carried out to determine the requirements	Please see solution for 5.4.1.2
104	IGF Code	9.5.1	It has to be checked if 30 air changes per hour will be adequate considering hydrogen gas (low density, high flammability, low ignition energy etc.)	Recommend to perform dispersion analysis considering leak of hydrogen gas in enclosed space
105	IGF Code	9.6.1.1	Please see comment regarding Inert Gas in item above	
106	IGF Code	9.6.1.2	It has to be checked if 30 air changes per hour will be adequate considering hydrogen gas (low density, high flammability, low ignition energy etc.)	Recommend to perform dispersion analysis considering leak of hydrogen gas in enclosed space (impact of the provided ventilation on the gas detection capability should also be considered). The target should be to ensure ventilation or possible inerting so that Hydrogen concentration does not exceed 0.25 LEL.
107	IGF Code	9.7.1	It should be checked if this pressure is appropriate or if lower/higher pressures can be permitted	To decide based upon a risk assessment
108	IGF Code	9.7.2	It should be checked if this pressure is appropriate or if lower/higher pressures can be permitted	To decide based upon a risk assessment
109	IGF Code	9.8.1	It should be checked if this pressure is appropriate or if lower/higher pressures can be permitted	To decide based upon a risk assessment

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
110	IGF Code	9.8.2.2	The k value is provided for methane, it will need to be provided considering Hydrogen	Identify suitable 'k' factor for Hydrogen
111	IGF Code	10.3.1.2	This should be considered in the risk assessment	Provide guidance for this topic
112	IGF Code	10.3.4	In general, it needs to be checked if there are technical solutions which will use multi-fuel engines presently to justify inclusion of these requirements	To check if this is a relevant at present considering the technology available and in development taking into account hydrogen
113	IGF Code	10.5.2	The requirement needs to be checked if it is appropriate for hydrogen (considering ESD and pressure 1 Mpa)	ESD Spaces should not be permitted
114	IGF Code	10.5.3	Same as above	ESD Spaces should not be permitted
115	IGF Code	10.5.4	Same as above	ESD Spaces should not be permitted
116		NEW	The materials used for the pipes where heated hydrogen would be carried should be appropriate for High Temperature Hydrogen Attack	The materials used for the pipes where heated hydrogen would be carried should be appropriate to withstand High Temperature Hydrogen Attack
117	IGF Code	11.1	Natural gas should be replaced with Hydrogen	Replace "Natural Gas" with Hydrogen in the text
118	IGF Code	11.3.5	Considering the high diffusity, leakage likelihood, wide explosive range it is considered not appropriate to route hydrogen pipe sin a ro-ro space where nowdays also e-vehicles and chargers may be present.	Recommend that Hydrogen fuel pipes should not pass through ro-ro spaces in general and if these are to be permitted then Risk Assessment should be performed to decide the prevention and mitigation options (e.g. use of double wall pipes and upon detection of fire in the ro-rop space, the hydrogen system would be shut down and purged)
119	IGF Code	11.3.7	It has to be confirmed whether ESD spaces will be permitted. Accordingly this requirement needs to be considered	ESD Spaces should not be permitted

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
120	IGF Code	11.5.1	Suitability of water spray systems for Hydrogen fires	For liquid hydrogen tanks and piping, the water spray can freeze, blocking the leakage path and lead to increase in tank pressure. Water spray should not be used close to hydrogen tank vent openings
121	IGF Code	11.6.1	Capacity of the dry chemical powder extinguishing system has to be checked if it is appropriate for hydrogen fire	Include this aspect to be studied in the Risk Assessment
122	IGF Code	11.7.2	It should be clearly identified which type of detectors to be used for the purpose additionally to smoke detector (e.g. thermal camera, UV/IR flame detectors etc..)	Provide guidance on selection of suitable detectors for hydrogen
123	IGF Code	12.2	Explosion risks considering Hydrogen properties specifically need to be introduced in the functional requirements	Guidance for performing a proper Explosion Response Analysis can be developed or suitable ISO/EN standard which addresses this can be suggested (the cue can be taken from Offshore Field, where such analyses are regularly performed) Deflagration and Detonation scenarios should be considered
124	IGF Code	NEW	Design & Arrangements should minimize the inventory of leaked hydrogen to the extent practicable	Propose new requirement in the Interim draft guidelines
125	IGF Code	NEW	Reduce number and extent of hazardous zones to the extent practicable	Propose new requirement in the Interim draft guidelines
126	IGF Code	12.3.3	It has to be confirmed whether ESD spaces will be permitted. Accordingly, this requirement needs to be considered	ESD Spaces should not be permitted
127	IGF Code	12.5	Size and extent of the Hazardous Area zones may not be appropriate of Hydrogen and should be determined considering the properties of Hydrogen based upon actual analyses	Hazardous area zones should be decided based upon the procedure described in Section 5.2 of IEC 60079-10-1:2020. This should also be proposed to be addressed in the Risk

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
				Assessment. Possibility to inert a space should also be considered in the assessment.
128	IGF Code	13.3.3.1	It has to be checked whether the tip clearance mentioned is adequate for Hydrogen	To be checked if these requirements are OK or some additional requirements may be necessary considering properties of hydrogen (low ignition energy, flammability limits etc.)
129	IGF Code	13.3.3.2	It has to be checked whether the tip clearance mentioned is adequate for Hydrogen	To be checked if these requirements are OK or some additional requirements may be necessary considering properties of hydrogen (low ignition energy, flammability limits etc.)
130	IGF Code	13.3.3.5	It has to be checked whether the distance of the air inlets from hazardous zones is appropriate for Hydrogen	Recommend to perform dispersion analysis considering leak of hydrogen
131	IGF Code	13.3.9.1	It has to be checked if the purging (atleast 5 air changes) is adequate for Hydrogen or whether higher quantity is required. If measurements are to be used in lieu, then it may be elaborated as to measurements of what?	To be checked if these requirements are OK or some additional requirements may be necessary considering properties of hydrogen (low ignition energy, flammability limits etc.)
132	IGF Code	13.4.1	It has to be checked whether 30 air changes per hour will be sufficient for Hydrogen?	Recommend to perform dispersion analysis considering leak of hydrogen gas in enclosed space. Alternatively, consideration should also be given to inert the TCS. Detailed requirements can be developed for this aspect.
133	IGF Code	13.5.2	It has to be confirmed if ESD spaces are to be permitted. If yes, then the air changes requirements may be reviewed in relation to Hydrogen	ESD Spaces should not be permitted
134	IGF Code	13.5.3	Same as above in reference to permission for ESD spaces	ESD Spaces should not be permitted

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
135	IGF Code	13.5.4	Same as above in reference to permission for ESD spaces	ESD Spaces should not be permitted
136	IGF Code	13.6.1	It has to be checked whether 30 air changes per hour will be sufficient for Hydrogen?	Recommend to perform dispersion analysis considering leak of hydrogen gas in enclosed space
137	IGF Code	13.8.1	It has to be checked whether 30 air changes per hour will be sufficient for Hydrogen?	The adequacy of ventilation of double wall pipes is to be considered. Inerted or vacuum space in the double pipe or duct should be permitted.
138	IGF Code	13.8.4	It has to be checked this requirement will be adequate for Hydrogen	We recommend to perform dispersion analysis considering leak of hydrogen gas in enclosed space
139	IGF Code	14.3.3	Consideration should be given to possibility of oxygen enrichment when selecting the equipment	Equipment should be of Type IIC and T1. Consider also the possibility of oxygen enrichment in the space and consequent impact
140		NEW	Lightning Protection	Lightning protection should be provided for hydrogen equipment which may exposed to lightning strikes
141	IGF Code	15.2.2	It has to be decided whether ESD spaces will be permitted for Hydrogen	ESD Spaces should not be permitted
142	IGF Code	15.8.1	It should be clearly identified which type of detectors to be used for the purpose additionally to smoke detector (e.g. thermal camera, UV/IR flame detectors etc.)	It should be clearly identified which type of detectors to be used for the purpose additionally to smoke detector (e.g. thermal camera, UV/IR flame detectors etc.) The location of the detectors may be identified based upon an F&G Mapping Study which takes into account possible scenarios (such studies are performed typically to determine optimal locations for installation of detectors in FPSOs)
143	IGF Code	15.8.2	It has to be decided whether ESD spaces will be permitted for Hydrogen	ESD Spaces should not be permitted

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
144	IGF Code	15.10.2	It has to be decided whether ESD spaces will be permitted for Hydrogen	ESD Spaces should not be permitted
145	IGF Code	15.8.6-15.8.7	It has to be checked whether these requirements are suitable for Hydrogen	Check the suitability of these requirements for hydrogen as regards to activation of alarm and safe shutdown and propose any revisions if necessary.
146	IGF Code	NEW	There are no requirements for providing means of monitoring the vacuum in vacuum insulated tanks	The regulations should include requirements for means of monitoring the vacuum in tanks with vacuum insulation.
147	IGF Code	NEW	Gas detectors should be arranged to facilitate their testing and calibration in their installed positions	The regulations should include requirements for adequate arrangements so as to enable testing and calibration of gas detectors in their installed positions
148	IGF Code	NEW	Considering the hazards of hydrogen, it should be required to have a SIL (Safety Integrity Level) study performed to ensure that all safety instrumented functions have an adequate level of reliability to respond on demand	Section 15 should have requirement for performance of a SIL study in accordance with IEC 61508 to determine the SIL for safety instrumented systems.
149	IGF Code	NEW	Table 1 should be checked as regards applicability to Hydrogen	Table 1 is to be checked and suitable recommendations made to adapt it for Hydrogen
150	IGF Code	16.1.2	Reference to applicable table of chapter 7 is to be adapted in order to ensure that materials are appropriate for hydrogen	Develop the appropriate reference to the Tables of Chapter 7 (after these Tables are adapted with materials suitable and compatible for storage of hydrogen
151	IGF Code	16.2.2	It is difficult or impossible to perform Charpy Impact Tests at temperature of -253 degrees Celsius (boiling point of liquid hydrogen)	Reference to "ISO 21028-1:2016 Cryogenic vessels – Toughness requirements for materials at cryogenic temperature-Part 1: Temperature below -80°C" article 4.2.3-b) for working temperature colder than -196°C. Reference to ASME B31.12:2019 Table GR-2-1.2-1 Requirements for low temperature Toughness tests for metals ; GR-2.1.2 ; GR-2.1.3

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
152	IGF Code	16.3.3.5.3	It is difficult or impossible to perform Charpy Impact Tests at temperature of -253 degrees Celsius (boiling point of liquid hydrogen)	Reference to "ISO 21028-1:2016 Cryogenic vessels – Toughness requirements for materials at cryogenic temperature-Part 1: Temperature below -80°C" article 4.2.3-b) for working temperature colder than -196°C. Reference to ASME B31.12:2019 Table GR-2-1.2-1 Requirements for low temperature Toughness tests for metals ; GR-2.1.2 ; GR-2.1.4
153	IGF Code	16.3.5.2	It is difficult or impossible to perform Charpy Impact Tests at temperature of -253 degrees Celsius (boiling point of liquid hydrogen)	Reference to "ISO 21028-1:2016 Cryogenic vessels – Toughness requirements for materials at cryogenic temperature-Part 1: Temperature below -80°C" article 4.2.3-b) for working temperature colder than -196°C. Reference to ASME B31.12:2019 Table GR-2-1.2-1 Requirements for low temperature Toughness tests for metals ; GR-2.1.2 ; GR-2.1.5
154	IGF Code	16.3.6.2	It is proposed to carry Hydrogen only in Membrane or Type C tanks	Storage of Hydrogen is envisaged at present in Independent Type C tanks. For other tank types, alternative design approach may be utilized
155	IGF Code	16.4.2	It is proposed to carry Hydrogen only in Membrane or Type C tanks	Storage of Hydrogen is envisaged at present in Independent Type C tanks. For other tank types, alternative design approach may be utilized
156	IGF Code	16.5.1.5	It is proposed to carry Hydrogen only in Membrane or Type C tanks	Storage of Hydrogen is envisaged at present in Independent Type C tanks. For other tank types, alternative design approach may be utilized
157	IGF Code	16.5.1.6	This has to be revised for it's applicability to liquefied hydrogen as fuel.	It is recommended to carry out cold shock test of fuel containment systems and piping with liquid nitrogen before first bunkering with liquefied hydrogen. All performance assessment to be made during the liquid nitrogen test and qualified before proceeding with liquefied hydrogen bunkering

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
158	IGF Code	16.5.2	It is proposed to carry Hydrogen only in Membrane or Type C tanks	Storage of Hydrogen is envisaged at present in Independent Type C tanks. For other tank types, alternative design approach may be utilized
159	IGF Code	16.5.3	It is proposed to carry Hydrogen only in Membrane or Type C tanks	Storage of Hydrogen is envisaged at present in Independent Type C tanks. For other tank types, alternative design approach may be utilized
160	IGF Code	16.5.4	Testing methods for Type C tanks	Study the testing methods for liquefied hydrogen tanks used in other industries (e.g. Space) and propose further actions.
161	IGF Code	16.6.3.2	Due to Hydrogen Embrittlement hazard and possible leakage of Hydrogen, it is questioned if such reduction in UT or RT can be permitted	Reduction in NDT requirements should not be permitted. The clause should be deleted
162	IGF Code	16.6.3.3	Due to Hydrogen Embrittlement hazard and possible leakage of Hydrogen, it is questioned if such reduction in UT or RT can be permitted	Reduction in NDT requirements should not be permitted. The clause should be deleted
163	IGF Code	16.7.1 – 16.7.3 16.7.3.5	Testing regulations should be revisited to confirm if they are appropriate for liquefied hydrogen applications	Identify and Study recognized international standards/practices in this regard and propose a solution
164	IGF Code	17.1	It should be clarified as to what is implied by "gas related exercise" in relation to Hydrogen	Gas related exercises should include gas freeing and enclosed space entry procedures pertaining to those spaces which contain the hydrogen storage tanks or pipes which carry hydrogen
165	IGF Code	18.2.4	Emergency Procedures should also take into account recommendations from outcome of risk assessments in design stage. These should be reviewed from time to time and updated in case of change of any underlying connected items	Recommend the outcome of the FMEA, HAZOP, Risk Assessment be used (as appropriate) for developing emergency procedures

Sr.no	Regu-lation	Clause	Description of Gap	Solution to address the gap
166	IGF Code	18.4.6.2	The PPE should be appropriate for hydrogen. (Reference can be made to ISO TR 15916)	PPE should be selected in accordance with ISO TR 15916
167	IGF Code	18.4.6.3	There should be checks or protocols for accepting portable tanks onboard so as to ensure that damaged or improper tanks are not accepted. The Bunker Delivery Certificate should take this into account. Certificates of fitness of the portable tanks should be annexed to the LNG BDN	Ships with Portable Fuel tanks should have appropriate procedures and checks to be followed for receiving such tanks onboard
168	IGF Code	18.7.1	The system may not be contaminated by hydrocarbons alone, There may be entrapped oxygen or hydrogen gases as well	Remove the word "Hydrocarbons"
169	IGF Code	Annex	The Bunker Delivery Note needs to also address fuel within Portable Liquefied Gas Tanks and Compressed Hydrogen in Cylinders loaded directly from shore	Amend the Bunker Delivery Note considering Hydrogen as Fuel. Also consider possibility of use of Portable Tanks, Hydrogen Cylinders etc and incorporate the same in the BDN if necessary.
170	IGF Code	19.2	Training requirements	Reference can be made to ISO TR 15916 Section 7.6-7.7 in relation to this topic

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ANNEX 3

ADDITIONAL TOPICS TO BE CONSIDERED FOR RISK ASSESSMENT FOR USE OF HYDROGEN AS FUEL

The following topics are suggested to be considered for risk assessment in addition to those required by the IGF Code:

.1 HAZID, HAZOP, LOPA, etc. of fuel system to be performed (Section 3.2.1 and Section 3.2.11);

.2 safe distances of hydrogen fuel tank(s) from ship side and bottom (Section 5.3.3);

.3 permit MARVS > 1 MPa and/or pressure in fuel gas supply > 1 MPa (Sections 6.3.1, 9.7.1);

.4 Probable Maximum Leakage Scenario - Design of the bulkheads of the tank connection space and design of the tank connection space to withstand the maximum pressure buildup during such a leakage (also consider detail design, detection and shutdown systems or venting to a safe location) (Sections 6.3.7 & 6.3.8);

.5 loss or deterioration of vacuum insulation (please see Section 4.1.1 of resolution MSC.420(97));

.6 height of vent mast/exits of fuel tanks (Sections 6.7.2.7, 6.7.2.8);

.7 maintain tank temperature and pressure for 15 days or <15 days or pressure control by venting during emergency (Section 6.9.1.1 & 6.9.1.2);

.8 choice of inert gas and required minimum storage capacity (Section 6.11.1);

.9 detailed evaluation of the hazard potential of fuel gas accumulation in crank case (Section 10.3.1.2);

.10 hydrogen fuel pipes passing through ro-ro spaces where alternatively fuelled vehicles (AFVs e.g. with electric batteries, fuel cells etc.) are also carried (Section 11.3.5);

.11 explosion risk analysis (consider the possibility of detonation as well) (Section 12.2);

.12 decide size and extent of hazardous area zones (for selection of appropriate electrical equipment) in accordance with the procedure provided in Section 5.2 of IEC 60079-10-1:2020 (Section 12.5);

.13 arrangement and location of gas detection equipment for hydrogen (Fire & Gas Detection Study);

.14 gas freeing procedures and enclosed space access procedures (Section 17.1);

.15 coverage of water-spray system;

.16 provision of ventilation in spaces containing hydrogen consumers and associated piping or alternatively inerting of the space may also be considered;

.17 safety integrity level study (SIL) as per IEC 61508;

.18 safety critical elements (SCE) study;

.19 dry chemical power fire extinguishing system capacity and compatibility for suppressing hydrogen fires; and

.20 performance standards for gas detection systems.

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