Towards a standardised fuel cell module

DELIVERABLE D6.1

RCS Overview Report

PUBLIC

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Towards a standardised fuel cell module

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Abstract: This document describes the literature search (the approach used and its analysis), associated with the regulations, codes and standards (RCS) at the global and European level that may be relevant to the fuel cell module developed in the StasHH project. It also defines the links between the legal and non-legal bodies for each of the applications concerned. The aim of this research is to propose a synthesis of the RCSs by application in order to identify those that could be applicable to all of these applications and in conclusion the potential "New Work Item Proposals".

Revision History

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1 Introduction of Deliverable D6.1 in the StasHH project

This document describes the literature search (the approach used and its analysis), associated with the Regulations, Codes and Standards (RCS) at the global and European level that may be relevant for the fuel cell module developed in the StasHH project for different Heavy Duty applications.

The present work aims to provide a synthesis of RCSs guidelines and requirements for each Heavy Duty application defined in this document. Finally, the most conservative data are extracted to propose a generic standard for the design of the fuel cell module (FCM).

Despite the care that was taken while preparing this document, the following disclaimer applies: The information in this document are based on a bibliographical analysis. The partners have to be critical as to it use. The report reflects only the authors' views. The CEA is not liable for any use that may be made of the information contained herein.

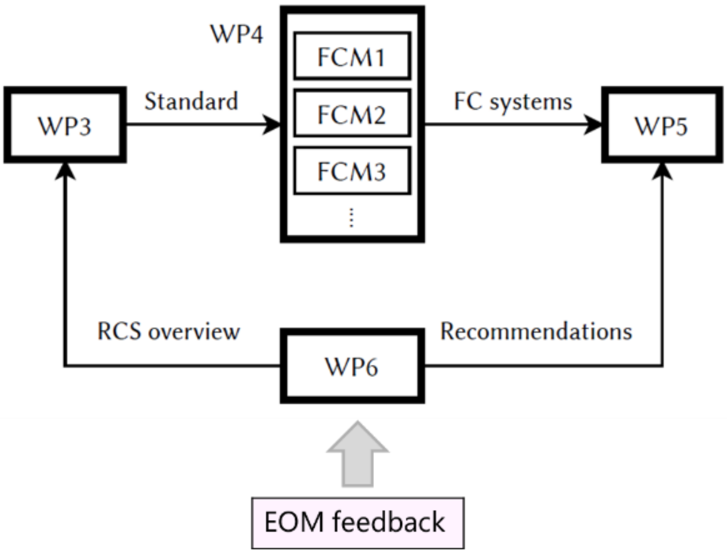
1.1 Objectives of Work Package 6

Reminder of all the objectives of Work Package 6 defined in the submission:

1. Analysis of relevant Regulations, Codes and Standards and their applicability in StasHH.
2. Formulate recommendations for assessment of performance, environment and safety properties of FCMs in StasHH' experimental testing campaign.
3. Develop safety plan for project activities, especially FCM testing.
4. Promote the StasHH FC module standard to relevant authorities in EU and worldwide.

See in Figure 1 the WP6 interface with other work package.

Figure 1 WP6 interfaces



Where:

- WP 3: defines standards for the size and interfaces (physical and digital) of fuel cell modules.
- WP 4: FCM suppliers build their prototypes in-house
- WP 5: defines and executes standardized tests of fuel cell modules produced by fuel cell module suppliers (WP4)

1.2 Scope of the task 6.1: RCS Overview

The main purpose of task 6.1 (RCS Overview) is to define generic guidelines and propose them for the establishment of EU future regulations applicable to FCM design of Heavy Duty applications.

Task T6.1: RCS Overview (M1-M10)	Leader: CEA	Contributors: FPS, FCM suppliers
CEA will analyse and compile relevant existing regulations, codes and standards for the operation of hydrogen fuel cell systems, with focus on the EU and other important markets for project participants. FPS will assist CEA in the specific domain of inland and sea navigation, while CEA will be responsible for land-based applications. FCM suppliers will share with CEA their experience and best practice on RCS, including external functional specifications, risk analyses, datasheets and user manuals for their currently certified fuel-cell systems.		

2 Part I: Definition and Methodology

The objective of this task is to search the specific and non-specific mandatory texts on all aspects of hydrogen for use in design and testing. It also covers requirements and guidelines or specifications dedicated to the design of hydrogen and fuel cell related technologies.

However, before starting this research, it is important to define what the acronym RCS covers at global, European and national level. Part of this chapter covers this and thereafter the exercise focuses on the different types of vehicles, ships, and others. Indeed, the requirements take into account the environmental conditions to maintain safety in use, during maintenance operations, etc.

In summary, therefore, the following is provided in the remainder of this chapter:

- The definition of what the acronym RCS stands for, with some examples (see 0),
- Governmental and non-governmental bodies involved in RCS, particularly in the area of hydrogen technology (see 2.4).
- The differentiation between the types of means of transport which, because of their particular characteristics (mass, whether or not they are open to the public, their power, etc.), may have consequences for their design, whether in terms of performance or operating safety, depending on their mission profile. (see 2.5),
- The means used for bibliographic research into all aspects of design, the tests to be carried out (see 2.6).

But before dealing with each of the points below, it is necessary to recall the scope of the bibliographic research of the StasHH project (see 2.1 and 2.2):

- Design, development and testing of a fuel cell module for heavy-duty applications,
- The applications concerned by the project.

Concerning 2.1 and 2.2, the scope represents the initial RCS domains of research, however the lack of relevant bibliography has led to not taking all the sub-categories.

2.1 Applications of the StasHH project

The applications of the StasHH project concerned by the RCS studies are in Table 1.

Domain		Sub categories and examples
Other Land-based applications	Road	City/regional bus, coach
		Long-haul truck trailer and semi-trailer
		Delivery truck,
		Refuse truck, sweepers
		Other
	Off-road	Specific applications
		Mining
		Construction equipment: *(excavator, backhoe loader, aerial bucket, etc)*
		Snow groomers
		Other
		Railway *(Train, tramway)*
		Airport operations
		Harbour operations
		Other
	Gensets	Roadworks, festivals
		Ship – Harbour connection
		Semi transportable power unit (container included)
		Other
Waterborne applications	Inland waters	Commercial vessels (bulk and freight vessels)
		Passenger vessels
		Pleasure crafts
	Sea/ ocean	Commercial vessels *(length > 110m)*
		Passenger vessels
		Pleasure crafts

Table 1 Applications included into StasHH Project

2.2 Applications excluded to the StasHH project

The applications of the StasHH project excluded by the RCS studies are listed in Table 2.

Domain		Sub-categories and exapmles
Land-based applications	Off road	Race cars
Airborn applications	Aerial	Aircrafts (plane, helicopter, drones)
	Space	Aerospace
Waterborne applications	Sea/Ocean	Submarines

Table 2 Applications excluded to StasHH Project

2.3 RCS definitions

The term "regulations, codes and standards" (RCS) is widely used in Europe and other parts of the world to refer in some way to regulatory aspects in general. However, the scope of these regulations, codes and standards is different. In APPENDIX 1 are specified the definitions to be considered in the next Hydrogen Europe multi-year work plan.

See in Table 3, 4 and 5 the synthesis of the definitions associated with RCS:

Regulation	
What is it?	A regulation specifies **WHAT** should be done. Regulation is a government imposed requirement, which specifies product, process or service characteristics, including the applicable administrative provision, with which compliance is mandatory. A regulation is mandated by a government body and requires that—by law—those in the industry comply. The regulation can incorporate codes or standards, or be created completely on its own. Unlike a code or standard, a regulation does not necessarily require any industry consensus or knowledgeable body to put it in affect.
Written by whom?	Written by EU and government
In which form?	Community Directive→ is a legislative act that sets out a goal that all EU countries must achieve. However, it is up to the individual countries to devise their own laws on how to reach these goals. Community Regulation→ is a binding legislative act. It must be applied in its entirety across the EU. Countries Regulation → Enforceable directly.
Examples	Regulation: Regulation (EC) No 1406/2002 of the European Parliament and of the Council of 27 June 2002 establishing a **E**uropean **M**aritime **S**afety **A**gency (Text with EEA relevance) Directive: • Directives 2014/34/EU or ATEX 95: on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (recast) • Directive 1999/92/EC or ATEX 137: on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres (15th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC) • Directive 2012/18/EU (SEVESO III Directive)

Table 3 Definition and example of Regulation

Codes	
What is it?	The codes will have “will” and “shall” which is mandatory language. A code is a set of rules that experts in the field recommend people to follow; it is a model. Although it is not a law, it can be adopted into law. A code tells you what needs to be done, but it doesn’t explain how it should be done. When a standard has been adopted by governmental bodies and has the force of law, it becomes a code. A standard also becomes a code when it has been incorporated into a business contract.
Written by whom?	Written by government or government approved body
In which form?	Legislative and regulatory guidelines for design, fabrication, construction and installation
Examples	Code examples include: •International Building Code, ASME Boiler and Vessel Code, and AWS D1.1. •BS, IS, DIN Key Electrical Code: In the U.S., local codes have almost entirely adopted NFPA 70 standard as the National Electrical Code (NEC) in full, or based their own requirements on it. The NEC lays out required practices for all aspects of residential and commercial electrical installation. Every three years the NEC is revised (in 2017, most recently), but because local jurisdictions have the final say on whether each edition is law, adoption can be slow.

Table 4 Definition and example of Codes

Standards	
What is it?	Standards are volontary support and clarifies **HOW** something should be done. They function as instructions for designers, manufacturers, operators, or users of equipment. If you are building something, a standard tells you about the materials, process, designs, structure, etc. In brief, standards tell you how to do something. They serve as a common language for defining quality and establishing safety criterias. Standards are distinguished into 2 categories: • statutory while includes in law (will have “will” and “shall” which is mandatory language • non-statutory for the others (words like “may”, recommended language
Written by whom?	Standards are usually created by individual companies, organizations (SDO; Standardization Developing Organizations) or countries. They are not legalized. A standard develops into a code when it is adopted by a set of government bodies and gets legalized. International level: ISO, IEC, etc. European level: CEN/CENELEC, etc. National level: DIN, BS, NF, etc.
In which form?	Consists of technical definitions and guidelines that function as instructions for designers/manufacturers and operators/users of equipment
Examples	ASTM International standards ISO standard ASME (American Society of Mechanical Engineers) promotes the art, science & practice of multidisciplinary engineering around the globe. IEC standard SAE (SAE International, formerly named the Society of Automotive Engineers) One important electrical standard is IEEE Standard 142. This standard, which applies to industrial and commercial power systems, introduces basic grounding theory and goes on to provide the in-depth information needed to help develop effective grounding systems. Another example is the OSHA electrical standards, which became adopted regulations in 1990 and are based on NFPA 70E, Electrical Safety Requirements for Employee Workplaces. Most of these standard details required safety procedures, with the goal of keeping electrical workers safe from the hazards of shock, electrocution, arc flash and arc blast.

Table 5 Definition and example of Standards

2.4 RCS organisation: World, Europe, Countries

2.4.1 RCS organisation of Vehicles

In Figure 2, the regulations that were applicable before the start of the StasHH project (in 2021) and those that will become applicable during the course of the project are recalled. At the time of writing this deliverable D6.1, the evolutions of the UN/ECE regulations until August 2021 were taken into account.

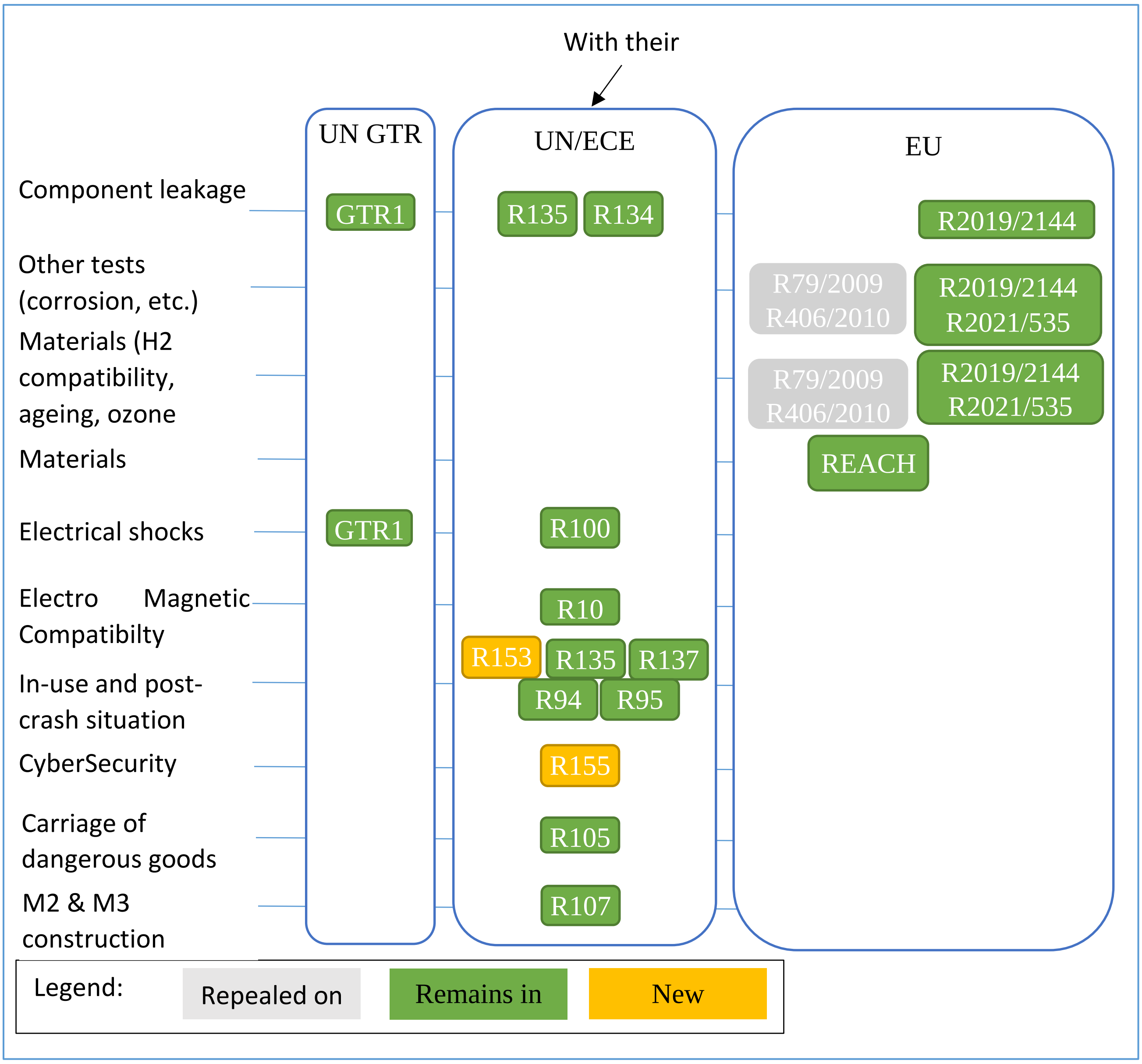


Figure 2 Regulation synthesis associated with the vehicle

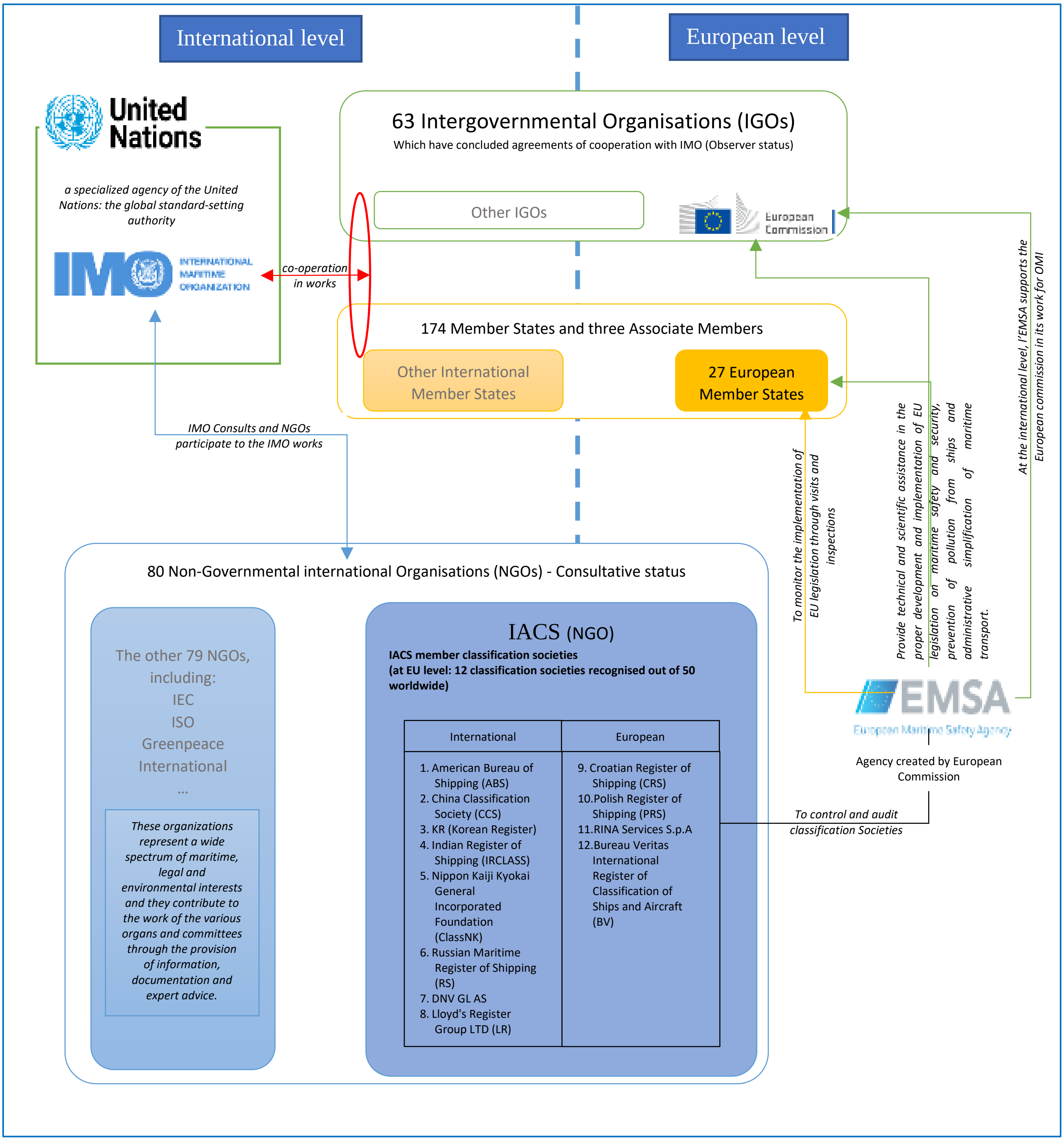
Associated with these regulations (Figure 2), and as noted in Figure 7, non-governmental organizations are working on the standardization of hydrogen and fuel cell technologies: ISO, IEC, …. The standards relevant to the StasHH project have been analyzed and a sheet for each is available in this deliverable, see chapter 3.

2.4.2 RCS organisation of Maritime transports

2.4.2.1 For Maritime transport by sea or ocean

The organisation of the international and European bodies involved in maritime for sea or ocean regulation is shown in the Figure 3.

The IMO is a specialised agency of the United Nations which is the global standard-setting authority for the safety, security and environmental performance of international shipping. Its primary role is to create a regulatory framework for the shipping industry that is fair and effective, universally adopted and universally implemented.



These organizations represent a wide spectrum of maritime, legal and environmental interests and they contribute to the work of the various organs and committees through the provision of information, documentation and expert advice.

IACS member classification societies
(at EU level: 12 classification societies recognised out of 50 worldwide)

International	European
1. American Bureau of Shipping (ABS)	9. Croatian Register of Shipping (CRS)
2. China Classification Society (CCS)	10. Polish Register of Shipping (PRS)
3. KR (Korean Register)	11. RINA Services S.p.A
4. Indian Register of Shipping (IRCLASS)	12. Bureau Veritas International Register of Classification of Ships and Aircraft (BV)
5. Nippon Kaiji Kyokai General Incorporated Foundation (ClassNK)	
6. Russian Maritime Register of Shipping (RS)	
7. DNV GL AS	
8. Lloyd's Register Group LTD (LR)	

Figure 3 European and international organizations for sea or ocean transports

For the classification of ships using gases or other low flash point fuels, the classification societies work with IMO committees and propose a number of rules and regulations. They are based on, and incorporate, the IMO International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (IGF Code).

Currently the IGF Code only include detailed prescriptive requirements for the use of natural gas (methane) as fuel. The use of all other gases or fuels with a flashpoint less than 60°C is to be approved by the National Administration based on an engineering analysis. For Fuel Cells and Hydrogen, the requirement for an engineering analysis is incorporated into « alternative design process ».

The engineering analysis is to be conducted in accordance with SOLAS Reg. II-1/55 Alternative Design and Arrangements and demonstrate that any applicable goals and functional requirements are satisfied and that the arrangements provide for an « equivalent level of safety ».

To support the application of SOLAS Reg. II-1/55, the IMO has issued guidelines published in:

- MSC.1/Circular.1212 Guidelines on Alternative Design and Arrangements for SOLAS Chapters II-1 and III, and
- MSC.1/Circular.1455 Guidelines for the Approval of Alternatives and Equivalents as Provided for in Various IMO Instruments.

In IMO, requirements for Fuel Cell installations are work in progress, and acceptance of such installations will therefore need to follow an Alternative Design process. Several Classification Societies have developed their own rules for FC installations. Their rules are normally more detailed and specific to reflect the safety level of international regulations such as the SOLAS Convention.

Note: During the 7th session, held from 6 to 10 September 2021 and organized by the IMO subcommittee on Carriage of Cargoes and Containers (CCC), the discussion about the amendments to IGF Code and development of guidelines for low-flash point fuels:

- The Draft Interim Guidelines for the safety of ships using fuel cell power installations has been finalized and will come into force after adoption at the MSC 105 in April 2022).
  The goal of the interim guidelines is to provide an international standard for the arrangement and installation of fuel cell power installations on board ships. It covers the different aspects from the fuel inlet of the fuel cell space up to the exhaust gas system. For the fuel storage and the fuel supply to the fuel cell space, the specific chapters of the IGF Code applies.
  Requirements for equipment-protected fuel cell spaces were also discussed. Due to missing requirements for the fuel cell stack, CCC concluded for this fuel cell space concept that all electrical equipment should be certified for zone 1. The fuel cell stack is not considered as a source of ignition if the surface temperature is below 300 °C and the stack can be isolated in case of deviating operational condition.
- CCC agreed on a work plan for the development of provisions for new low-flashpoint fuels under the IGF Code, including hydrogen, ammonia, LPG and methyl/ethyl alcohols.

2.4.2.2 For inland waterway transport

According to the UN/ECE website and the results of the survey initiated in the framework of the StasHH project, the following figure briefly presents the articulation between the different European and international organizations that introduce the studied RCSs specifically associated with inland waterway transport.

The organisation of the international and European bodies involved in inland waterway regulation is shown in the Figure 4.

Note: The temporary working group on technical requirements for fuel cell, organized by the European Committee for drawing up Standards in the field of Inland Navigation (CESNI), will be held on October 20, 2021.
It is planned that the "CESNI/ESTRIN" reference document will include a chapter associated with fuel cells in its future version expected in 2023 for implementation in 2024.

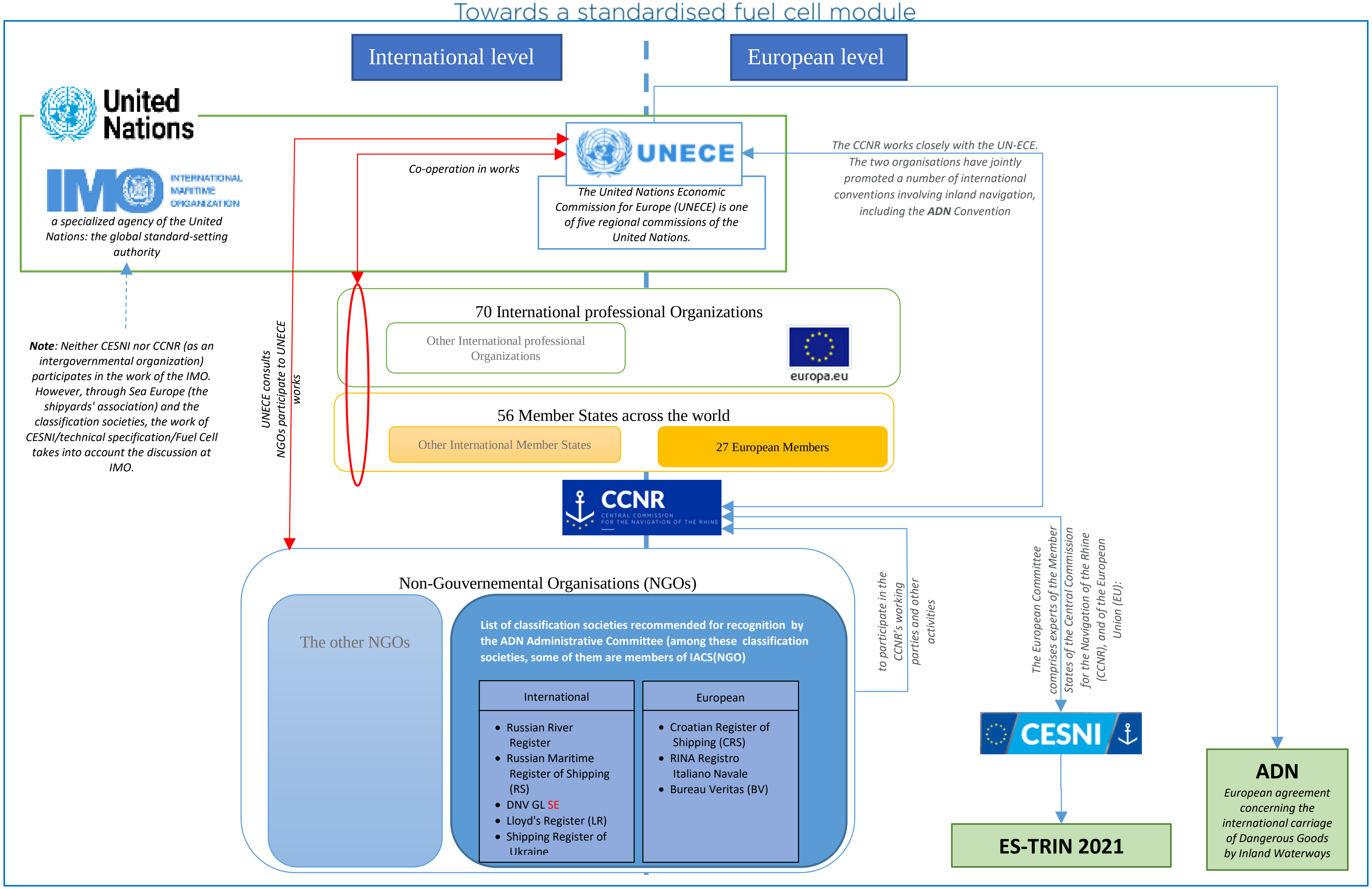


Figure 4 European and international organizations for inland waterway

2.4.3 RCS organisation of railway rolling stock

The bibliographic search of this topic gives less outcomes as expected. Currently, one draft standard exist on the fuel cell topic for railway (IEC 63341). Concerning European regulations, the topics deal with the interoperability between countries.

The organisation of the international and European bodies involved in railway regulation is shown in the Figure 5.

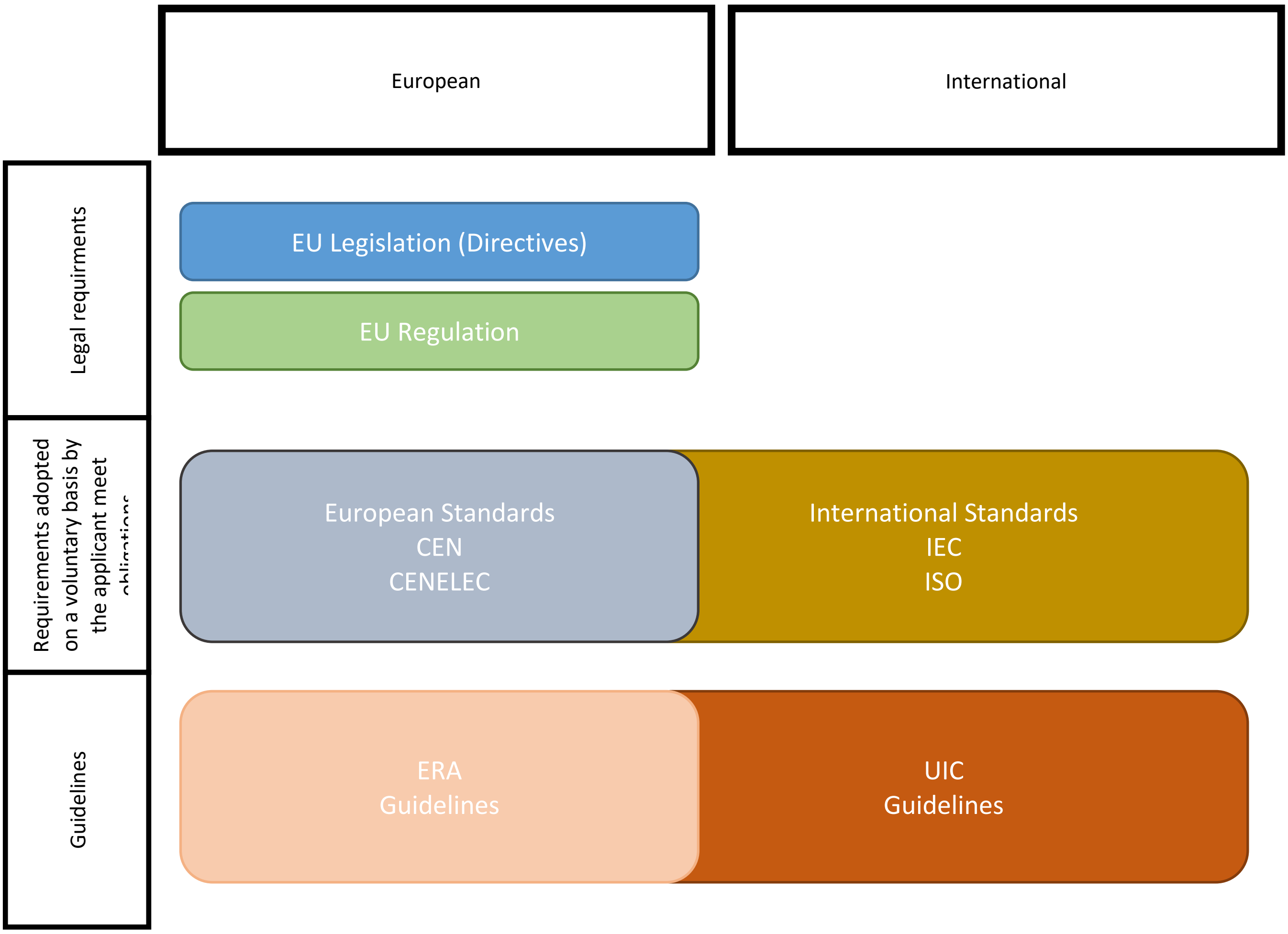


Figure 5 RCS railway organization

ERA: European Railway Agency, the missions are to make the railway system work better for society and contributes to the effective functioning of a Single European Railway Area without frontiers.

UIC: International Union of Railway, the missions are to promote railway transport at international level, develop the facility around the world and promote the interoperability of railway.

2.5 Classification of types of road vehicles, off-road vehicles, types of ships, etc...

2.5.1 Vehicle type categories

The definition of vehicle categories comes from Consolidated Resolution on the Construction of Vehicles (R.E.3). The last version is ECE/TRANS/WP.29/78/Rev.6 (june 2017): https://unece.org/resolutions.

Article 2 of the Regulation of 27 November 2019 specifies that the definitions of vehicle categories are those cited in Article 4 of Regulation 2018/858 of 30 may 2018.

Vehicles are classified in M for passenger transport, N for cargo of goods, O for trailers, see the detail in table 6, 7 and 8

Categories	From Consolidated Resolution on the Construction of Vehicles (R.E.3), June 2017	
Category M_1:	**Category M: Motor vehicles with at least four wheels designed and constructed for the carriage of passengers.**	Vehicles designed and constructed for the carriage of passengers and comprising no more than eight seats in addition to the driver's seat. *From regulation (EU) 2018/858 of the European Parliament and of the Council od 30 May 2018:* *Motor vehicles with no more than eight seating positions in addition to the driver's seating position and without space for standing passengers, regardless of whether the number of seating positions is restricted to the driver's seating position*
Category M_2:		Vehicles designed and constructed for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass not exceeding 5 tonnes. *From regulation (EU) 2018/858 of the European Parliament and of the Council od 30 May 2018:* *Motor vehicles with more than eight seating positions in addition to the driver's seating position and having a maximum mass not exceeding 5 tonnes, regardless of whether those motor vehicles have space for standing passengers*
Category M_3:		Vehicles designed and constructed for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass exceeding 5 tonnes. *From regulation (EU) 2018/858 of the European Parliament and of the Council od 30 May 2018:* *Motor vehicles with more than eight seating positions in addition to the driver's seating position and having a maximum mass exceeding 5 tonnes, regardless of whether those motor vehicles have space for standing passenger*

Table 6 Categories “M” definitions

Between these two sources, the definitions are more or less the same except for the M category.

Categories	From Consolidated Resolution on the Construction of Vehicles (R.E.3) June 2017	
Category N_1:	**Category N: Motor vehicles with at least four wheels designed and constructed for the carriage of goods.**	Vehicles designed and constructed for the carriage of goods and having a maximum mass not exceeding 3.5 tonnes.
Category N_2:		Vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 3.5 tonnes but not exceeding 12 tonnes.
Category N_3:		Vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 12 tonnes.

Table 7 Categories “N” definitions

Categories	From Consolidated Resolution on the Construction of Vehicles (R.E.3), June 2017	
Category O_1:	**Category O: Trailers (including semi-trailers).**	Trailers with a maximum mass not exceeding 0.75 tonnes
Category O_2:		Trailers with a maximum mass exceeding 0.75 tonnes but not exceeding 3.5 tonnes.
Category O_3:		Trailers with a maximum mass exceeding 3.5 tonnes but not exceeding 10 tonnes.
Category O_4:		Trailers with a maximum mass exceeding 10 tonnes.

Table 8 Categories “O” definitions

2.5.2 Ship type categories

The classification by type of vessels depends on a large number of parameters such as passengers/freight, length, tonnage, nature of the carriage of goods, etc. This fact makes it difficult to develop a summary by type of vessels. From an RCS point of view, the relevance for StasHH is to differentiate between inland navigation vessels and maritime navigation.

2.5.3 Railway rolling stock type categories

There is no common rule for the train category classification in Europe, all the European country have different characteristics, however we can differentiate the city train (tramway type), the low speed train and the high-speed train. From an RCS point of view, the relevance for StasHH is no make categories differentiation but to study the legal framework in his overall.

2.6 Methodology adopted and databases consulted in the search for RCSs relevant to the StasHH project.

Before describing the methodology adopted, it is important to note that the regulations were analysed first and not the directives, because, as explained in the chapter on the definition of the RCS (see 0), European directives are not mandatory as soon as they are issued and have to be translated into the law of member country. Furthermore, national regulations and standards have not been analysed in the framework of this European project.

The methodology adopted was to:

- Interview the project partners on the RCSs they rely on to design, develop and integrate hydrogen technologies in their fields of expertise. This interview was carried out through a survey, (see 2.6.1.).
- Consult the members of the standardisation working groups in order to have a current overview of the standards associated with hydrogen and fuel cell technology that are currently being revised and those being created, (see 0).
- Consult the various websites of the European Union and international organisations for texts related to RCSs and understand how the various European and international bodies cooperate with each other, see 2.6.3).
- Consult the European databases and accessible deliverables of European hydrogen projects, see 0).

The approach was to focus on texts dealing with hydrogen and/or fuel cell technology and to look for requirements and specifications relative to the fuel cell module subsystem refering to performance, safety, testing protocols environmental conditions.

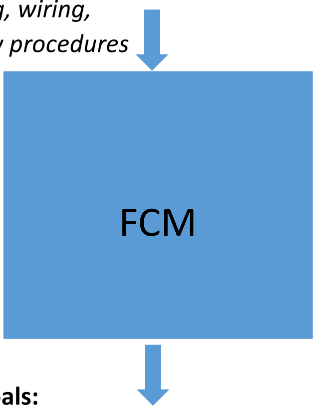
However, in some mandatory or non-mandatory texts, the boundaries between the elements, device or components making up hydrogen systems are not straightforward (for exemple for hydrogen storage systems between the outlet of the tank and the inlet of the fuel cell module). Where the boundaries were not clearly specified, it was considered that the requirements given for the system also apply to module inputs/outputs.

Other RCSs not especially focused on Heavy Duty vehicle application were studied to extract valuable data that could be useful to elaborate a generic standard (e.g. Generic transport, explosive atmosphere, …).

Below, in Figure 6, a synthetic representation on the items expected and objectives of this approach:

Main topics:

- *Environmental parameters:*
    - *temperature,*
    - *pressure,*
    - *humidity,*
    - *vibrations…*
- *Performances criteria*
    - *nominal, start/stop/dynamic,*
    - *response,*
    - *lifetime and efficiency;*
- *Safety requirements for construction and tests type:*
    - *as enclosure ventilation,*
    - *piping, wiring,*
    - *safety procedures*



Important points:

- *FCM considered as a BLACK BOX*
- *All information from FCM suppliers will remain anonymous!*

Goals:

- *common basic rules and regulations,*
    - *But inherent differences due to specific applications will be considered as options.*
- *Inputs for WP3*

Figure 6 Synthetic representation on the items expected and objectives of the approach used

2.6.1 Survey of RCS bodies

CEA has sent a survey to all partners with the main objective of obtaining the national, European and international RCSs used for the design and marketing of each partner's products and/or applications.

The partners who shared their knowledge with us through the survey are: FPS, SYMBIO, VOLVO, Nuvera Fuel Cells, FST, ALSTOM, Toyota Motor Europe and DAMEN.

The model for this survey is presented in APPENDIX 2.

The table 9, 10 and 11 summarises the bibliography for regulation, codes and standards used by the StasHH project partners who responded to CEA survey:

2.6.1.1 Regulations

Application	RCS		Purpose of the RCS
Inland waterways	ADN - 2021	European	European agreement concerning the international Carriage of Dangerous Goods by inland waterways (ADN)
Vehicle	ADR - 2021	European	European agreement concerning the International Carriage of Dangerous Goods by Road
EMC	Decision 2009/19/EC	European	Amending, for the purposes of its adaptation to technical progress, Council Directive 72/245/EEC relating to the radio interference (electromagnetic compatibility) of vehicles
EMC	Decree n° 2015-1084	France	On the electromagnetic compatibility of electrical and electronic equipment
Noise emission	Directive 2000/14/EC	European	On the approximation of the laws of the Member States relating to the noise emission in the environment by equipment for use outdoors
Machinery	Directive 2006/42/EC	European	Machinery Directive (safety)
Vehicle	Directive 2007/46/EC	European	Establishing a framework for the approval of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles (tests)
Hazardous substances in EEE	Directive 2011/65/EU	European	Restriction of Hazardous Substances Directive (RoHS) (safety)
EMC	Directive 2014/30/EU	European	Electromagnetic Compatibility Directive (EMC) (safety)
Electrical equipment	Directive 2014/35/EU	European	On the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits. *Electrical equipment designed for use with a voltage rating of between 50 and 1 000 V for alternating current and between 75 and 1 500 V for direct current*
Electrical equipment	Directive 2014/353EU	European	Low Voltage Directive (LVD) (safety)
Pressure equipment	Directive 2014/68/EU	European	Pressure Equipment Directive (PED) (safety)
Railway	Directive 2016/797	European	On the interoperability of the rail system within the European Union
Railway	Directive 2016/798	European	On railway safety
Ship	LR web site for download files	International	The Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels July 2021, includes the following Parts: Preamble • Part A • Part A-1 • Part B-1 • Part C-1 • Part D

			Note: Lloyd's Register is a classification society recognized by European Commission
Inland waterways	LR web site for download files	International	Rules and Regulations for the Classification of Inland Waterways Ships. July 2021, includes the following Parts: • Part 1 Regulations • Rules for the Manufacture, Testing and Certification of Materials (formerly known as Part 2) • Part 3 Ship Structures (General) • Part 4 Ship Structures (Ship Types) • Part 5 Main and Auxiliary Machinery • Part 6 Control, Electrical and Fire *Note: Lloyd's Register is a classification society recognized by European Commission*
Chemistry	Regulation 1907/2006/EC	European	Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC (Text with EEA relevance)
Railway	Regulation 2016/796	European	On the European Union Agency for Railways: ERA
Vehicle	Regulation 2018/858	European	On the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles, amending Regulations (EC) No 715/2007 and (EC) No 595/2009 and repealing Directive 2007/46/EC
Vehicle	Regulation 2019/2144	European	On type-approval requirements for motor vehicles and their trailers, and systems, components and separate technical units intended for such vehicles, as regards their general safety and the protection of vehicle occupants and vulnerable road users
Vehicle	Regulation 406/2010 *Repealed on July 2022*	European	Implementing Regulation (EC) No 79/2009 of the European Parliament and of the Council on type-approval of hydrogen-powered motor vehicles Note: this regulation will repealed on July 2022.
Vehicle	Regulation 79/2009/EC *Repealed on July 2022*	European	On type-approval of hydrogen-powered motor vehicles, and amending Directive 2007/46/EC (safety – Approval) Note: this regulation will repealed on July 2022.
Vehicle	Regulation R10	UN/ECE	Approval of an electronic subassembly (HV power train and battery) (safety)
Vehicle	Regulation R100	UN/ECE	Approval of an electronic subassembly (EMV) (safety)
Vehicle	Regulation R134	UN/ECE	Global technical regulation n°13: Hydrogen and Fuel Cell Vehicles (safety)

Vehicle	Regulation R153	UN/ECE	Approval of vehicles with regard to fuel system integrity and safety of electric power train in the event of a rear-end collision

Table 9 Regulations currently used by StasHH partners

2.6.1.2 Codes

Application	RCS		Purpose of the RCS
Ship	ABS Guide	International	Fuel cell power systems for marine and offshore applications November 2019 *Note: ABS is a classification society recognized by European commission*
Ship	BV rules	International	Environmental condition – section 2 January 2020 with amendment January 2021 *Note: BV is a classification society recognized by European commission*
Ship	BV rules	International	System design (electrical) – section 3 January 2020 with amendment January 2021 *Note: BV is a classification society recognized by European commission*
Ship	DNV-GL Rules	International	Part 6 Additional class notations Chapter 2 Propulsion, power generation and auxiliary systems *Note: DNV-GL is a classification society recognized by European commission*
Ship	IACS protocols	International	Test Specification for Type Approval – section E10 – rev 7 Attention an update (rev 8) has been published since *Note: IACS is a NGO of IMO*
Ship	LR procedure	International	ShipRight Design and Construction: Risk Based Design – January 2018 *Note: Lloyd's Register is a classification society recognized by European Commission*
Ship	IMO code	International	International Code of Safety for Ship Using Gases or Other Low-flashpoint Fuels (IGF Code)
Ship	IMO Guideline	International	IMO CCC 6-WP Annex 2: Draft Interim Guidelines for the Safety of Ships Using Fuel Cell Power Installations

Table 10 Codes and Rules currently used by StasHH partners

2.6.1.3 Standards

Application	RCS		Purpose of the RCS
Inland waterways	CESNI ES-TRIN – 2021/1	European	European Standard laying down Technical Requirements for Inland Navigation vessels (ES-TRIN)
Vehicle	ISO 23828	International	Fuel cell road vehicles — Energy consumption measurement — Vehicles fuelled with compressed hydrogen
Vocabulary	IEC 60050-485	International	International Electrotechnical Vocabulary (IEV)

Application	RCS		Purpose of the RCS
Fuel cell	IEC 62282-2-100	International	Fuel cell technologies. Fuel cell modules
Vehicle	ISO 20474-1	International	Earthmoving Machinery - Safety - Part 1: General Requirements.
Vehicle	ISO 20474-3	International	Earthmoving Machinery - Safety - Part 3: Requirements for Loaders.
Vehicle	ISO 20474-5	International	Earthmoving Machinery - Safety - Part 5: Requirements for Excavators.
Vehicle	ISO 20474-6	International	Earthmoving Machinery - Safety - Part 6: Requirements for Haulers.
Vehicle	ISO 14687	International	Hydrogen fuel — Product specification — Part 2: Proton exchange membrane (PEM) fuel cell applications for road vehicles
Machinery	EN ISO 12100	European	Safety of machinery - General principles for design - Risk assessment and risk reduction
Machinery	ISO 13849-1	International	Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design
Fuel cell	GB/T 29838	Chinese standard	Fuel cell modules
Fuel cell	GB/T 33978	Chinese standard	Proton exchange membrane fuel cell modules for road vehicles
Vehicle	ISO 23273	International	Fuel cell road vehicles — Safety specifications — Protection against hydrogen hazards for vehicles fuelled with compressed hydrogen (safety)
Vehicle	ISO 26262-9	International	Road vehicles — Functional safety — Part 9: Automotive safety integrity level (ASIL)-oriented and safety-oriented analyses (safety)
Vehicle	SAE J 2719	International	Hydrogen quality (fuel quality requirements)
Fuel cell	EN IEC 62282-2-100	European	Fuel cell technologies - Part 2-100: Fuel cell modules – Safety
Machinery	EN 474-1	European	Earthmoving Machinery - Safety - Part 1: General Requirements.
Machinery	EN 474-3	European	Earth-moving machinery Safety - Part 3 requirements for loaders
Machinery	EN 474-5	European	Earth-moving machinery - Safety - Part 5: requirements for hydraulic excavators
Machinery	EN 474-6	European	Earth-moving machinery - Safety - Part 6: requirements for dumpers

Table 11 Standards currently used by StasHH partners

2.6.2 International and European standardization working groups

The International and European standardisation bodies and technical committees involved in the development of standards associated with hydrogen technology are exposed hereafter in Figure 7

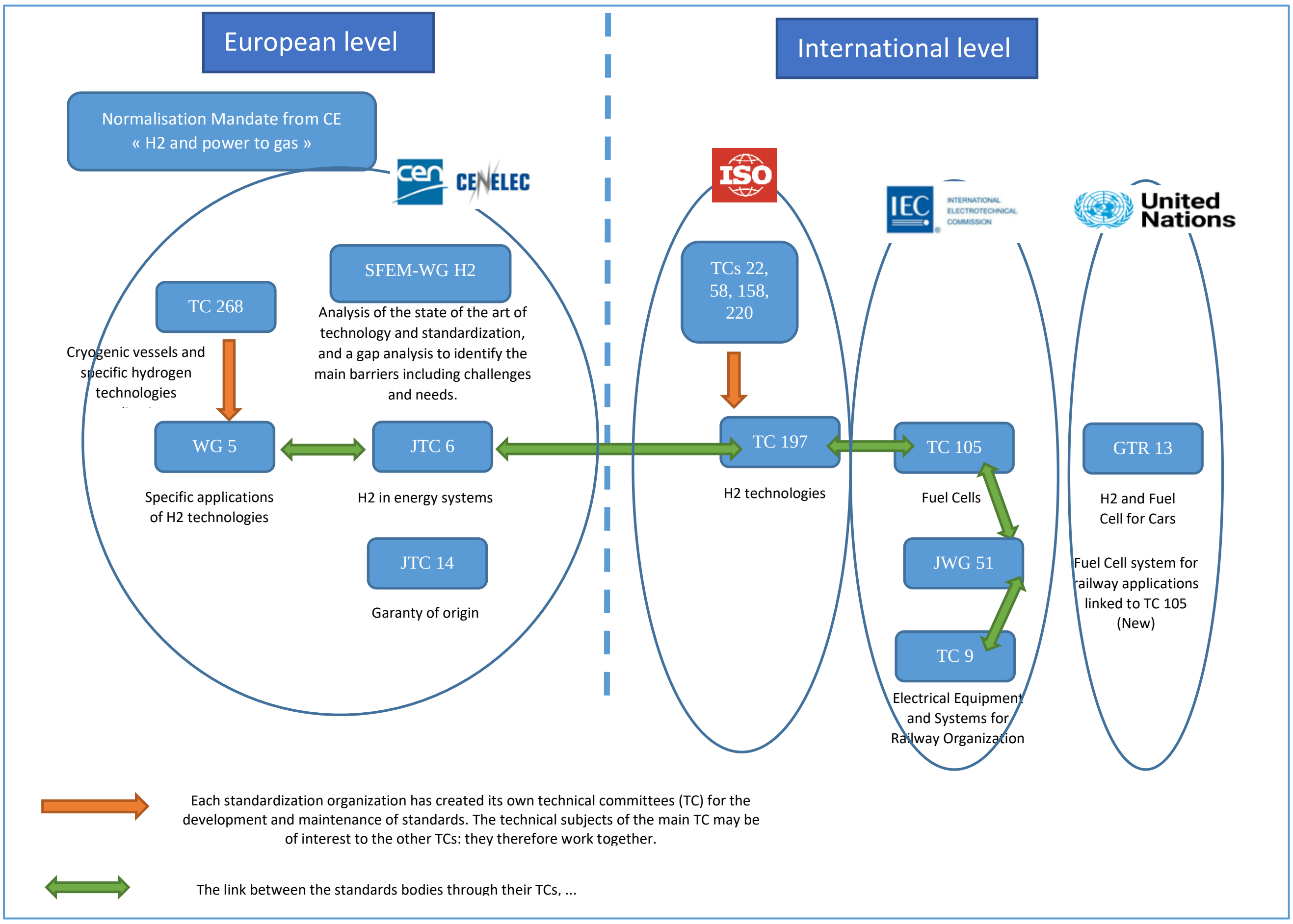


Figure 7 International and European standardisation bodies and technical committees involved in the development of standards associated with hydrogen technology

In the APPENDIX 3, the areas of action of the technical committees listed in the Figure 7 are specified.

2.6.3 European Union and international organisations for texts related to RCSs

At the european union level, it is possible to know the list of institutions, bodies and agencies, particularly, ERA, EMSA, FCH-JU: https://europa.eu/european-union/contact/institutions-bodies_en#agencies

2.6.3.1 *Website Regulations*

- TRANS/WP.29/1045 - Special Resolution No. 1 concerning the common definitions of vehicle categories, masses and dimensions (S.R.1): https://unece.org/classification-and-definition-vehicles
- UN/ECE Regulations from R0 to R160, (Addenda to the 1958 Agreement, with their revisions and amendments): https://unece.org/un-regulations-addenda-1958-agreement
- Consolidated Resolution on the Construction of Vehicles (R.E.3) - Consolidated Resolution on the Construction of Vehicles (R.E.3): https://unece.org/DAM/trans/main/wp29/wp29resolutions/ECE-TRANS-WP.29-78r6e.pdf
- Terms of reference from UN/ECE website: https://unece.org/terms-reference-19
- Regulation, directive,…from European Union: Access to European Union Law
- International Maritime Organization (IMO): https://www.imo.org/
- Central Commission for the Navigation of the Rhine (CCNR): https://www.ccr-zkr.org/

2.6.3.2 *Website Codes and rules*

- International Maritime Organization (IMO): code IGF
- DNVL-GL: DNV-GL website and Rules and standards in maritime transports
- Lloyd's Register (LR): LR website and Rules and regulations
- Bureau Veritas (BV): https://www.bureauveritas.fr/
- American Bureau of Shipping (ABS): ABS website and Overview of Rules and Guides
- IACS: For specific classification requirements for fuel cells, IACS recommends to contact one or more classification societies: https://www.iacs.org.uk/about/members/
- EMSA: http://www.emsa.europa.eu/
- ERA: https://www.era.europa.eu/
- UIC: https://uic.org/Website Standards

ISO and IEC maintain terminology databases for use in standardization:

- IEC Electropedia available a: https://www.iec.ch/electropedia
- ISO Online browsing platform available at: https://www.iso.org/obp/ui

Standards websites:

- ISO Standards database: https://www.iso.org/standards.html
- IEC Standards database: https://www.iec.ch/homepage
- CEN/CENELEC: https://www.cencenelec.eu/european-standardization/
- CESNI: https://www.cesni.eu/a-propos-cesni/ (European Committee For Drawing Up Standards In The Field Of Inland Navigation (CESNI). The CESNI was set up in 2015 in order to adopt technical standards in various fields, in particular as regards vessels, crew and information technology. The respective regulations at the European and international level, including those of the European Union and the Central Commission for the Navigation of the Rhine (CCNR), may refer to these standards with a view to their application).

2.6.4 European databases and accessible deliverables of European hydrogen projects

- Fuel Cell and Hydrogen Joint Undertaking (projects): https://www.fch.europa.eu/page/fch-ju-projects

  Among all the FCH JU projects, Hylaw (European project from 2017-2018) focuses on hydrogen law and the removal of legal barriers to the deployment of fuel cells and hydrogen applications. Hylaw provides a baseline of known data up to 2018:

  - Hylaw database: https://www.hylaw.eu/database
  - Hylaw deliverables: https://www.hylaw.eu/info-centre

D4.1 Analysis of differences and commonalities between countries	
D4.2 List of legal barriers	
D4.3 Horizontal position papers:	
	Production, Storage and Hydrogen Refueling Stations
	Transport and Distribution of Hydrogen by Road
	Road Vehicles (Cars, Vans, Trucks, Buses)
	Assessment of rolling stock
	Gas Grid issues (Power to Gas)
	Stationary Fuel Cells
D4.4 EU regulations and directives which impact the deployment of FCH technologies	

- Additional data may be found at the website from FCH Observatory, section Policy and RCS: https://www.fchobservatory.eu/observatory/Policy-and-RCS

3 Part II: RCS Analysed

In the following subchapters, 47 RCSs that have been analysed for the StasHH project are listed. The detailed analysis is summarised in *ad hoc* RCS sheets that include:

- Identity card of the RCS, with dates, topics, domain exclusion, etc.,
- All requirements and procedures used to comply with each RCS,
- Parts relevant to the StasHH project.

These sheets can be consulted in the annex 1 to 47.The list of all RCSs that have been analysed is given in the §3.1. Some RCSs does not provide data of interest for StasHH project but they were kept in the list to record that they were analysed. The RCSs that were used to establsih the generic standard are marked with the letter “U[1]”.

Note 1: Concerning the RCS that are available on the internet, the result of their analysis is fully available in the file attached to deliverable D6.1.
Concerning the file associated to a standard, only their identity sheet is available. The content of the analysis has been used to build the synthesis in the sub-chapter 4.1, however the result of their analysis is not integrated (Standards are protected by copyright law).

Note 2: For the ADN and ADR agreements and the RID convention, the United Nations and expert groups have harmonized the regulations on the transport of dangerous goods. The analysis of the 2021 version for each agreement or convention and concerning the StasHH project shows that the requirements and the classes of dangerous goods are the same. These three documents have been analysed but their requirements have not been included in the synthesis because no parameters or requirements were identified as relevant. However, each sheet associated with these documents is available in the attached file dedicated to RCSs analysed.

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[1] “U“ stands for Use in RCSs synthesis

3.1 Regulation

All these references were considered relevant to the StasHH project (see table 12).

N°	Name - Description	Domain	U: Use in RCS synthesis	Annex
2014 34 (EU)	Regulation (EU) of the european parliament and of the council: On the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres	Genset		Annex 1: DIRECTIVE N° 2014/34 (EU)
1301 2014 (EU)	Regulation (EU) of the european parliament and of the council: Technical specifications for interoperability relating to the energy subsystem of the rail system in the Union	Railway		Annex 2: REGULATION N° 1301/2014 (EU)
2018 858 (EU)	Regulation (EU) of the european parliament and of the council: on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles, amending Regulations (EC) No 715/2007 and (EC) No 595/2009 and repealing Directive 2007/46/EC (Text with EEA relevance)	Road vehicles		Annex 3: REGULATION N° 2018/858 (EU)
2019 2144 (EU)	Regulation (EU) of the European Parliament and of the Council: on type-approval requirements for motor vehicles and their trailers, and systems, components and separate technical units intended for such vehicles, as regards their general safety and the protection of vehicle occupants and vulnerable road users	Road vehicles		Annex 4: REGULATION N° 2019/2144
2020 683 (EU)	Regulation (EU) of 15 April 2020 implementing Regulation (EU) 2018/858 of the European Parliament and of the Council with regards to the administrative requirements for the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles	Road vehicles		Annex 5: REGULATION N° 2020/683
2021 535 (EU)	Regulation (EU) of 31 March 2021 laying down rules for the application of Regulation (EU) 2019/2144 of the European Parliament and of the Council as regards uniform procedures and technical specifications for the type-approval of vehicles, and of systems, components and separate technical units intended for such vehicles, as regards their general construction characteristics and safety (Text with EEA relevance)	Road vehicles	U	Annex 6: REGULATION N° 2021/535
ADN (UNE/ECE)	European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways	Inland waterway		Annex 7: REGULATION ADN-2021-VOLUMES 1&2 (UN/ECE)
ADR (UNE/ECE)	European Agreement concerning the International Carriage of Dangerous Goods by road	Road vehicles		Annex 8: REGULATION ADR-2021 (UN/ECE)
R10 (UN/ECE)	Electromagnetic compatibility	Road vehicles	U	Annex 9: REGULATION N° 10 (UN/ECE)

N°	Name - Description	Domain	U: Use in RCS synthesis	Annex
R26 (UN/ECE)	Uniform provisions concerning the approval of vehicles with regard to their external projections	Road vehicles <3.5T		Annex 10: REGULATION N° 26 (UN/ECE)
R94 (UN/ECE)	Uniform provisions concerning the approval of vehicles with regard to the protection of the occupants in the event of a frontal collision	Road vehicles <3.5T	U	Annex 11: REGULATION N°94 (UN/ECE)
R95 (UN/ECE)	Uniform provisions concerning the approval of vehicles with regard to the protection of the occupants in the event of a lateral collision	Road vehicles <3.5T	U	Annex 12: REGULATION N° 95 (UN/ECE)
R100 (UN/ECE)	Uniform provisions concerning the approval of vehicles with regard to specific requirements for the electric power train	Road vehicles	U	Annex 13: REGULATION N° 100 (UN/ECE)
R105 (UN/ECE)	Uniform provisions concerning the approval of vehicles intended for the carriage of dangerous goods with regard to their specific construction features	Road vehicles	U	Annex 14: REGULATION N° 105 (UN/ECE)
R107 (UN/ECE)	Uniform provisions concerning the approval of category M2 and M3 vehicles with regard to their general construction	Road vehicles >3.5T	U	Annex 15: REGULATION N° 107 (UN/ECE)
R118 (UN/ECE)	Uniform technical prescriptions concerning the burning behaviour and/or the capability to repel fuel or lubricant of materials used in the construction of certain categories of motor vehicles	Road vehicles >3.5T	U	Annex 16: REGULATION N° 118 (UN/ECE)
R134 (UN/ECE)	Uniform provisions concerning the approval of motor vehicles and their components with regard to the safety-related performance of hydrogen-fuelled vehicles (HFCV)	Road vehicles	U	Annex 17: REGULATION N° 134 (UN/ECE)
R135 (UN/ECE)	Uniform provisions concerning the approval of vehicles with regard to their Pole Side Impact performance (PSI)	Road vehicles <3.5T	U	Annex 18: REGULATION N° 135 (UN/ECE)

N°	Name - Description	Domain	U: Use in RCS synthesis	Annex
R137 (UN/ECE)	Uniform provisions concerning the approval of passenger cars in the event of a frontal collision with focus on the restraint system	Road vehicles <3.5T	U	Annex 19: REGULATION N° 137 (UN/ECE)
R153 (UN/ECE)	Uniform provisions concerning the approval of vehicles with regard to fuel system integrity and safety of electric power train in the event of a rear-end collision	Road vehicles <3.5T	U	Annex 20: REGULATION N°153 (UN/ECE)
R155 (UN/ECE)	Uniform provisions concerning the approval of vehicles with regards to cybersecurity and cybersecurity management system	Road vehicles	U	Annex 21: REGULATION N° 155 (UN/ECE)
RID (COTIF)	Regulations concerning the International Carriage of Dangerous Goods by Rail	Railway		Annex 22: REGULATION RID-2021 (COTIF)

Table 12 List of Regulations analyzed

3.2 Codes

All these references were considered relevant to the StasHH project (see table 13).

N°	Name - Description	Domain	U: Use in RCS synthesis	Annex
IMO 6th session agenda item 14: CCC 6/14	Report to the maritime safety committee and the marine environment protection committee	Maritime	U	Annex 23: REPORT CCC6/14 (IMO)
IGF Code	Annex 1: RESOLUTION MSC.391(95) adoption of the international code of safety for ships using gases or other low-flashpoint fuels (IGF code)	Maritime	U	Annex 24: IGF CODE (IMO)
Guideline MSC.1/Circ.1212	1212 Alternative design and arrangements for SOLAS Chapters II-1 and III	Maritime	U	Annex 25: GUIDELINE MSC.1/CIRC.1212 ALTERNATIVE DESIGN (IMO)
Guideline MSC.1/Circ.1455	1455 Guidelines for the approval of alternatives and equivalents as provided for in various IMO instruments	Maritime	U	Annex 26: GUIDELINE MSC.1/CIRC.1455 APPROVAL ALTERNATIVE AND:OR EQUIVALENCY DESIGNS (IMO)
American Bureau Shipping guide (ABS)	Guide for fuel cell power systems for marine and offshore applications	Maritime	U	Annex 27: GUIDE FUEL CELL POWER SYSTEM FOR MARITIME AND OFFSHORE APPLICATIONS (ABS)
DNV-RU-SHIP Pt.6 Ch.2.	Rules For Classification - Ships Part 6: Additional Class Notations Chapter 2: Propulsion, Power Generation And Auxiliary Systems Section 3: Fuel Cell Installations - FC	Maritime	U	Annex 28: RULES FOR CLASSIFICATION – DNV – PART 6 – CHAPTER 2 – SECTION 3

N°	Name - Description	Domain	U: Use in RCS synthesis	Annex
Bureau Veritas guideline: NI 547 DR R00 E (BV)	Guideline for Fuel cell systems on board commercial ships – Bureau Veritas	Maritime	U	Annex 29: GUIDELINE OF BUREAU VERITAS FOR FUEL CELL SYSTEMS ONBOARD COMMERCIAL SHIPS
Lloyd's Register guidance notes (LR Safety Hydrogen)	Guidance Notes for Fuel System Risk Assessment, Hazard identification - Hydrogen	Maritime	U	Annex 30: GUIDANCE NOTES FOR FUEL SYSTEM RISK ASSESSMENT, HAZARD IDENTIFICATION - HYDROGEN (LR)
Lloyd's Register Rules and Regulations (LR R&R IGF)	Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint (Lloyd’s Register)	Maritime	U	Annex 31: RULES AND REGULATIONS FOR THE CLASSIFICATION OF SHIPS USING GASES OR OTHER LOW-FLASHPOINT (LR)
Lloyd’s Register Specification (LR test)	Specifications – Type Approval Test Specifications (Lloyd’s Register)	Maritime	U	Annex 32: SPECIFICATION – TYPE APPROVAL TEST SPECIFICATIONS (LR)
Lloyd’Register identification: 2021-ENG007 (IMO/LR)	Rule proposal 2021-ENG007 - Rules for fuel cell installations Proposol for amendment to Part 5, Chapter 26 (New)	Maritime	U	Annex 33: RULE PROPOSAL 2021-ENG007 (LR)
Lloyd’Register RBD	Risk Based Design (Lloyd’Register)	Maritime		Annex 34: GUIDE RISK BASED DESIGN (LR)

Table 13 List of Codes analyzed

3.3 Standards

All these references were considered relevant to the StasHH project (see table 14).

N°	Name - Description	Domain	U: Use in RCS synthesis	Annex
AFNOR 60079[2]	Explosive atmospheres Part 10-1: Classification of area - Gaseous explosive atmospheres	All		Annex 36: STANDARD NF EN IEC 60079-10-1 (AFNOR)
IEC 62282-2-100	Fuel cell technologies – Part 2-100: Fuel cell modules - Safety	All except road vehicle	U	Annex 35: STANDARD IEC 26282-2-100
IEC 62282-3-100	Fuel cell technologies – Part 3-100: Stationary fuel cell power systems - Safety	Genset	U	Annex 37: STANDARD IEC 62282-3-100
IEC 62282-4-101	Fuel cell technologies – Part 4-101: Fuel cell power systems for propulsion other than road vehicles and auxiliary power units (APU) – Safety of electrically powered industrial trucks	Off-road (Forklif) and Railway	U	Annex 38: STANDARD IEC 62282-4-101
IEC 63341	Railway applications – Rolling stock – Fuel cell systems for propulsion – Part 1: Fuel Cell Power System	Railway	U	Annex 39: STANDARD IEC 63341-1
ISO 6469-2	Electrically propelled road vehicles - safety specifications Part 2:Vehicle operational safety	Road vehicles	U	Annex 40: STANDARD ISO 6469-2
ISO 6469-3	Electrically propelled road vehicles — Safety specifications Part 2: Electrical safety	Road vehicles	U	Annex 41: STANDARD ISO 6469-3
ISO 6469-4	Electrically propelled road vehicles — Safety specifications Part 4: Post crash electrical safety	Road vehicles	U	Annex 42: STANDARD ISO 6469-4
ISO 12619-1	Road vehicles — Compressed gaseous hydrogen (CGH2) and hydrogen/ natural gas blend fuel system components — Part 1: General requirements and definitions	Road vehicles	U	Annex 43: STANDARD ISO 12619-1
ISO 12619-2	Road vehicles — Compressed gaseous hydrogen (CGH2) and hydrogen/ natural gas blend fuel system components —Part 2: Performance and general test methods	Road vehicles	U	Annex 44: STANDARD ISO 12619-2
ISO 12619-3	Road vehicles — Compressed gaseous hydrogen (CGH2) and hydrogen/ natural gas blend fuel system components — Part 3: Pressure regulator	Road vehicles	U	Annex 45: STANDARD ISO 12619-3

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[2] This standard is a same of IEC 60079-10-1

N°	Name - Description	Domain	U: Use in RCS synthesis	Annex
ISO 23273	Fuel cell road vehicles — Safety specifications — Protection against hydrogen hazards for vehicles fuelled with compressed hydrogen	Road vehicles	U	Annex 46: STANDARD ISO 23273
CESNI ES-TRIN	European Standard laying down Technical Requirements for Inland Navigation vessels	Inland waterway	U	Annex 47: STANDARD ESTRIN-2021 (CESNI)

Table 14 List of Standards analysed

4 Part III: RCS synthesis

The table 15 concern the RCS synthesis.
On each column there is the domains of application

- **Road vehicle <3.5T (M1/N1)**
- **Road vehicle >3.5T**
- **Off-Road vehicle**
- **Rolling stock railway**
- **Ship Sea/ocean** (and if it is specified Inland waterway)
- **Genset**

On each row there is the item used

- **Environmental conditions:** Humidity, temperature, vibration, acceleration, inclination, salt mist, chemical (pollution), UV radiation, IP indices
- **Performance assessment:** Power density, lifetime, efficiency, rate of availability, other
- **Design/material:** All, pipes, pipe connection, components, wire/cableair or oxidant inlet, cooling, exhaust, pressure
- **Safety:** Design, electrical isolation, EMC, electro static discharge, electrical shock, electrical design, electrical connection, shutdown, concentration H2 in exhaust, leakage, fire/explosion risk, monitoring

RCS such as SAE, JIS references, national and regional are not considered due to lack of documents and time.

4.1 Differences between applications

To facilitate the analysis, a code is added to specify the importance of the RCSs:

- Regulations (underlined in full line),
- Standards (underlined with dotted line),
- Codes (nothing).

Parameters or requirements included in the generic StasHH table (Table 16)

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
Environmental conditions						
Humidity				**IEC 63341:** RH ≤ 95 %	**LR test:** RH ≤ 95 %	
Operating temperature	**R134:** No specific values concerning the FCM, but temperature range is given for the compressed hydrogen storage system: -40°C to +85°C **ISO 12619 -1 and ISO 12619 -2:** On board components: •Cold: -40 °C to +85 °C	**R134:** No specific values concerning the FCM, but temperature range is given for the compressed hydrogen storage system: -40°C to +85°C **ISO 12619 -1 and ISO 12619 -2:** On board components: •Cold: -40 °C to +85 °C		**IEC 63341:** •On the roof: +85°C •In train: +70°C	**ABS:** •Inside: 0 °C to +45 °C •Outside: -25 °C to +45 °C **BV:** -40 °C to +85 °C **LR test:** Outside -25 °C to +70 °C	**IEC 62282-3-100:** -25 °C to +55 °C and for short period <24 h +70 °C

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	**Ship Sea/ocean** It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	**>3.5T**				
	•Moderate: -20 °C to +85 °C	•Moderate: -20 °C to +85 °C				
Vibration	**R134:** No specific values concerning the FCM but test protocol concerning shut-off valves and check valves: vibration on the 3 axes during 30min for the most severe resonant frequencies recorded between 10 to 40Hz. **ISO 12619-2:** Vibration on the 3 axes during 6h for the most severe resonant frequencies recorded between 10 to 500Hz.	**R134:** No specific values concerning the FCM but test protocol concerning TPRD, shut-off valves and check valves: vibration on the 3 axes during 30min for the most severe resonant frequencies recorded between 10 to 40Hz. **ISO 12619-2:** Vibration on the 3 axes during 6h for the most severe resonant frequencies recorded between 10 to 500Hz.		**IEC 61373**	**LR test:** Vibration during 90min for each resonant frequencies where an amplification factor Q < 2 is recorded between 2 to 2000Hz	
Crash test	**R134:**	**R134:**		**IEC 61373**[*]		

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[*] New potential opportunities to analyse new parameters or requirements were found to complete the table below. They are, however, just mentioned in the form of RCS references.

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	**Ship Sea/ocean** It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	**>3.5T**				
	Crash test protocol gives for a vehicle (see R94 and R95) •20 g on axis •8 g perpendicularly	Crash test protocol gives for a vehicle (see R94 and R95) M2/N2: •10 g on axis •5 g perpendicularly M3/N3: •6.6 g on axis •5 g perpendicularly				
Inclination					**ABS:** Test protocols: Dynamic •7.5° on axis •22.5 ° perpendicularly Static •5° on axis •15 ° perpendicularly **LR Test:** Test protocols: Static and dynamic •22.5 ° all axis	

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
Salt mist	**R134:** Salt resistance for valves (The saline solution consists of 5 % NaCl and 95 % distilled water, by weight.) **ISO 12619-2:** Support salt mist (The saline solution shall consist of 5 % NaCl and 95 % distilled water, by weight)	**R134:** Salt resistance for valves (The saline solution consists of 5 % NaCl and 95 % distilled water, by weight.) **ISO 12619-2:** Support salt mist (The saline solution shall consist of 5 % NaCl and 95 % distilled water, by weight)			**IMO/LR:** All the part of the system sensitive to air quality 0are to be sealed **LR test:** Only concern open deck installation Support salt mist (The saline solution shall consist of 7,6 % NaCl and 92,4 % distilled water, by weight)	
Chemical (Pollution)	**R134:** Chemical resistance of connection and external surface of components: •Sulphuric acid (19 % in V) •Sodium hydroxide (25 % in M) •Ammonium nitrate (28 % in M)	**R134:** Chemical resistance of connection and external surface of components: •Sulphuric acid (19 % in V) •Sodium hydroxide (25 % in M) •Ammonium nitrate (28 % in M)		**IEC 63341:** For first start-up: FCPS supports 1 % nitrogen		

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
	•Windshield washer fluid (50 % in V) **ISO 12619-2:** Chemical resistance of external component: •Sulfuric acid (19 % in V) •Methanol/gasoline (5 %/95 % in V) •Windshield washer fluid(50 % in V) •N-pentane **R134:** non-metallic components: •Resistance of atmospher (Ozone, oxygen) **ISO 12619-2:** Resistant to oxygen and ozone exposition **ISO 12619-1:**	•Windshield washer fluid (50 % in V) **ISO 12619-2:** Chemical resistance of external component: •Sulfuric acid (19 % in V) •Methanol/gasoline (5 %/95 % in V) •Windshield washer fluid(50 % in V) •N-pentane **R134:** non-metallic components: •Resistance of atmospher (Ozone, oxygen) **ISO 12619-2:** Resistant to oxygen and ozone exposition **ISO 12619-1:**				

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
	Components subject to weather exposure and other corrosive conditions shall be made of corrosion resistant material or protected **ISO 12619-1:** Compatibility of oxygen for non-metallic materials used in seals and diaphragms	Components subject to weather exposure and other corrosive conditions shall be made of corrosion resistant material or protected **ISO 12619-1:** Compatibility of oxygen for non-metallic materials used in seals and diaphragms				
UV Radiation	**ISO 12619-2** UV resistant for non-metallic surfaces			IEC 60721-365[*]		
IP (Ingress Protection) rating					**LR test:** Shall support water (more IP56)	**IEC 62282-3-100:** Shall support water (IP23) and wind

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Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
Performance assessment						
Power density			**NWIP Proposed by Symbio Oct 21:** Calculation of Rated Power and Power Density of a Stack			**IEC 62282-3-200:**[*] Efficiency/power calculation
Lifetime						
Efficiency	**ISO 23828:2013:** Fuel cell road vehicles - Energy consumption measurement - Vehicles fuelled with compressed hydrogen	**ISO 23828:2013:*** Fuel cell road vehicles - Energy consumption measurement - Vehicles fuelled with compressed hydrogen		**IEC 63341:** FC stack level FCM level FCPS level		
Rate of availability						
Other	**ISO/TR 11954:2008:** Fuel cell road vehicles - Maximum speed measurement	**ISO/TR 11954:2008:*** Fuel cell road vehicles - Maximum speed measurement				
Design / material						
All	**2021 535 and ISO 12619-1:**	**2021/535 and ISO 12619-1:**	**IEC 62282-2-100:**	**IEC 62282-4-101:**	**IEC 62282-2-100:**[†]	**IEC 62282-2-100:**

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[†] Concern also Inland waterway

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
	Compatibility of hydrogen for all materials in contact with hydrogen **ISO 12619-2:** Compatibility of hydrogen for non-metallic material **R118:** No using adhesive agent to fix material	Compatibility of hydrogen for all materials in contact with hydrogen **ISO 12619-2:** Compatibility of hydrogen for non-metallic material	Compatibility of hydrogen and oxygen for all union material **IEC 62282-4-101:** Compatibility of hydrogen for all materials in contact with hydrogen. **See ISO 15916-Table C2 (hydrogen embrittlement)**	Compatibility of hydrogen for all materials in contact with hydrogen. **See ISO 15916-Table C2 (hydrogen embrittlement)** **IEC 62282-2-100:** Compatibility of hydrogen and oxygen for all union material **IEC 63341:** Protected against corrosive effects for all material in contact with liquid cooling **IEC 63341:** Asbestos containing material shall not be used. **IEC 63341:** Lifting interfaces for FCPS >20 kg	Compatibility of hydrogen and oxygen for all union material **ABS, BV and IMO/LR:** **:** Compatibility of hydrogen for all materials in contact with hydrogen **ABS and BV:** No sharp edge on accessible part	Compatibility of hydrogen and oxygen for all union material **IEC 62282-3-100:** Lifting interface for FCPS **IEC 62282-3-100:** Asbestos containing material shall not be used. **IEC 62282-3-100:** No sharp edge on accessible part

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
				IEC 63341: Good fixing point to avoid noise IEC 63341: FCPS shall allow light maintenance operations		
Pipes			IEC 62282-4-101: Flexible pipe of +1,5 m shall have a stainless steel wire braid reinforcement IEC 62282-2-100: Polymeric and elastomeric piping are permitted if they are protected against mechanical damage IEC 62282-2-100: Formed piping bends shall be made to	IEC 62282-4-101: Flexible pipe of +1,5 m shall have a stainless steel wire braid reinforcement IEC 62282-2-100: Polymeric and elastomeric piping are permitted if they are protected against mechanical damage IEC 62282-2-100: Formed piping bends shall be made to	**DNV-RU-SHIP:** H2 pipe shall not passed in enclosed area outside of FC IEC 62282-2-100:[*] Polymeric and elastomeric piping are permitted if they are protected against mechanical damage IEC 62282-2-100:[†] Formed piping bends shall be made to	IEC 62282-2-100: Polymeric and elastomeric piping are permitted if they are protected against mechanical damage IEC 62282-3-100: Non-metallic piping shall be protected against overheating and mechanical damage IEC 62282-2-100:

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[*] Concern also Inland waterway
[†] Concern also Inland waterway

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	**Ship Sea/ocean** It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
			respect mechanical constraints	respect mechanical constraints	respect mechanical constraints **ABS and BV:** The pipe shall have the colour in accordance of that they contain **IMO/LR:** H2 pipe section which can be isolated are provided of relief valves **BV:** Piping for fuel shall not have a melting point <925 °C except the short pipe isolated with class A-60 **BV:**	Formed piping bends shall be made to respect mechanical constraints ISO 15649[*]

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Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
					The double ducting should be required also for gas pipes on the fuel cell system itself **BV and ABS:** Pipe wall thickness calculation **IMO/LR:** Fuel pipe +220 °C	
Pipe connections			**IEC 62282-2-100 and ISO 23550** For H2 connections: •Threaded connections, •Welded connections •Fitting connections with a defined sealing area **IEC 62282-2-100:**	**IEC 62282-2-100 and ISO 23550** For H2 connections: •Threaded connections, •Welded connections •Fitting connections with a defined sealing area **IEC 62282-2-100:**	**IEC 62282-2-100 and ISO 23550**[*] For H2 connections: •Threaded connections, •Welded connections •Fitting connections with a defined sealing area **IEC 62282-2-100:**[†]	**IEC 62282-2-100 and ISO 23550** For H2 connections: •Threaded connections, •Welded connections •Fitting connections with a defined sealing area **IEC 62282-2-100:**

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[*] Concern also Inland waterway

[†] Concern also Inland waterway

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
			For H2 and Oxygen joint: •Ground-joint type, •Flanged-joint type, •Compression-joint type having packing	For H2 and Oxygen joint: •Ground-joint type, •Flanged-joint type, •Compression-joint type having packing	For H2 and Oxygen joint: •Ground-joint type, •Flanged-joint type, •Compression-joint type having packing **DNV-RU-SHIP,BV and IMO/LR:** For H2 at maximum be fully welded as possible **DNV-RU-SHIP, BV and IMO/LR:** For H2 minimise the number of connection	For H2 and Oxygen joint: •Ground-joint type, •Flanged-joint type, •Compression-joint type having packing ISO 15649[*]
Components (valve, sensors…)	**R134:** This document does not required any H2 sensors	**R134:** This document does not required any H2 sensors	**IEC 62282-2-100 and 62282-4-101:** This document does not required any H2 sensors	**IEC 62282-2-100:** This document does not required any H2 sensors	**IEC 62282-2-100:**[†] This document does not required any H2 sensors	**IEC 62282-2-100:** This document does not required any H2 sensors

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[†] Concern also Inland waterway

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
					IMO/LR, DNV-RU-SHIP, IGF code, LR R&R IGF and BV: Fixed H2 detector for spaces or area of the fuel cell **IMO/LR:** All area where is H2 pipe connection have fixed leakage detection **ABS:** Area of fuel cell shall have hydrogen and smoke detector	
Wire / cable	**ISO 12619-1:** Electrical equipment and circuit wiring in a component => Automotive quality (mechanical strength, insulation and	**R105:** No cable in an electrical circuit => carry a current in excess of that for which the cable is designed.		IEC EN 50343*		

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Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
	current carrying capacity, in accordance with either ISO 6722-1 or ISO 6722-2).	**R105:** Cable => secure and protected against mechanical and thermal stresses. ISO 6722-1:2011*				
Air or oxidant Inlet				**IEC 63341:** In case of rotative equipment, a particle filter shall be installed	**BV:** Filter are not mandatory	
Cooling				**IEC 63341:** Thermal management system sizing for high temperature able for the FC **IEC 63341:** Thermal management system sizing to avoid overpressure on cavitation effects		

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<table>
<tr><th rowspan="2">Item</th><th colspan="2">Road vehicle</th><th rowspan="2">Off-Road vehicle</th><th rowspan="2">Rolling stock railway</th><th rowspan="2">Ship Sea/ocean
It is specified if this also concerns Inland waterway</th><th rowspan="2">Genset</th></tr>
<tr><th><3.5T (M1/N1)</th><th>>3.5T</th></tr>
<tr><td></td><td></td><td></td><td></td><td>IEC 63341:
The selection of the coolant and the coolant management system should be designed to limit the electrical conductivity of the coolant
IEC 63341:
In case of rotative equipment, a particle filter shall be installed</td><td></td><td></td></tr>
<tr><td>Exhaust</td><td></td><td>R105:
Protection against any danger to the load through heating or ignition</td><td></td><td>IEC 63341:
The water in exhaust should be drained.
IEC 63341:
Protection against the icing formation</td><td>IMO/LR and BV:
Gas and air exhaust shall be separated
IMO/LR:
The water in exhaust should be drained.
BV:
•CO < 0.03 %</td><td>IEC 62282-3-100:
•CO < 0.03 %
IEC 62282-3-100:
The water in exhaust should be drained.
No gas should escape through the drain lines</td></tr>
</table>

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
Pressure	**R134:** MAWP ≥ Overpressure protection device **R134:** Valves must support 2,5 X the Nominal Working Pressure **ISO 12619-2 and ISO 12619-3** Shall support 1.5 X the MAWP **ISO 23273:** All the low pressure section shall be capable of withstanding or be protected against an extraordinary pressure increase due to the failure of the first pressure regulator	**R134:** MAWP ≥ Overpressure protection device **R134:** Valves must support 2,5 X the Nominal Working Pressure **ISO 12619-2 and ISO 12619-3** Shall support 1.5 X the MAWP **ISO 23273:** All the low pressure section shall be capable of withstanding or be protected against an extraordinary pressure increase due to the failure of the first pressure regulator	**IEC 62282-4-101 and IEC 62282-2-100:** Shall support 1.5 X the MAWP	**IEC 62282-2-100:** All liquid and gas device shall support 1.5 X MAWP **IEC 63341:** Air inlet and H2 Inlet, and coolant shall support 1,5 X MWAP	**IMO/LR:** MAWP of pipe ≥ Overpressure protection device **IMO/LR:** MAWP of pipe •>5 barg for open-ended pipe •> 10barg in other case **LR test:** Shall support 1.5 X the MAWP except sensors, intruments and control devices shall support 2 X the MAWP	**IEC 62282-3-100:** All liquid and gas device shall support 1.5 X MAWP

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
Safety						
Design	**ISO 23273:** The fuel system shall be equipped by a main hydrogen shut-off valve **ISO 23273:** All components shall be securely mounted or supported in the vehicle to minimise damage and prevent leakage and/or malfunction. **ISO 12619-1:** Fuel shut-off valve shall be normally closed.	**ISO 23273:** The fuel system shall be equipped by a main hydrogen shut-off valve **ISO 23273:** All components shall be securely mounted or supported in the vehicle to minimize damage and prevent leakage and/or malfunction. **ISO 12619-1:** Fuel shut-off valve shall be normally closed. **R107:** No contact between all electrical cable and any fuel line or	**IEC 62282-4-101:** H2 pipe design to minimize chafing **IEC 62282-4-101:** H2 pipe shall maintain less 51mm from exhaust and electrical system **IEC 62282-2-100:** Electrical contact for electrical protection shall be protected against corrosion	**IEC 63341:** At least a main contactor to disconnect the FCPS (Fuel Cell Power System) from FCCH (FCCH: chopper for Fuel cell) **IEC 62282-4-101:** H2 pipe design to minimize chafing **IEC 62282-4-101:** H2 pipe shall maintain less 51mm from exhaust and electrical system **IEC 62282-2-100:** Electrical contact for electrical protection shall be protected against corrosion	**DNV-RU-SHIP:** Outgoing circuit shall have a switch disconnector. **IMO/LR:** Means to remove, in security, H2 inside the fuel cell shall be provided **IEC 62282-2-100:**[*] Electrical contact for electrical protection shall be protected against corrosion **CESNI:**[*] In case of drop of power a warning must be display in the wheelhouse	**IEC 62282-2-100:** Electrical contact for electrical protection shall be protected against corrosion

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[*] Concern also Inland waterway

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	**Ship Sea/ocean** It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	**>3.5T**				
		any part of the exhaust system or in excessive heat part unless suitable special insulation and protection is provided				
Electrical isolation	**ISO 6469-3:** For cable insulation (Clearance, creepage distance, solid insulation and wiring) compliance with IEC 60664 or safety equivalent	**ISO 6469-3:** For cable insulation (Clearance, creepage distance, solid insulation and wiring) compliance with IEC 60664 or safety equivalent				
Electromagnetic compatibility (EMC)	**R10:** Vehicle emission: 30 to 1000 MHz (E in dB.µV/m and F in MHz) •3 m: 30/75 MHz => E=42	**R10:** Vehicle emission: 30 to 1000 MHz (E in dB.µV/m and F in MHz) •3 m: 30/75 MHz => E=42 75/400 MHz => E=42*15.13*log(F/75) 400/1000 MHz => E=53	**IEC 62282-4-101:** ISO/TS3691-7 and ISO/TS3691-8	IEC 61000-3-2 EN 50121-3-2[*]	LR test: See guideline for equipment immunity and emission	IEC 61000[*]

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Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
	75/400MHz => E=42*15.13*log(F/75) 400/1000 MHz => E=53 •10 m: 30/230MHz => E=28 230/1000 MHz => E=35 **R10:** Vehicle immunity: The field strength In over 90 % of the 20 to 2,000 MHz: •30 volts/m rms (root mean squared) •All 20 to 2,000 MHz: > 25 volts/m rms **ISO 6469-2:** All electric and electronic functions shall be functionally tolerant of the electromagnetic environment to	•10 m: 30/230 MHz => E=28 230/1000 MHz => E=35 **R10:** Vehicle immunity: The field strength In over 90 % of the 20 to 2,000 MHz: •30 volts/m rms (root mean squared) •All 20 to 2,000 MHz: > 25 volts/m rms **ISO 6469-2:** All electric and electronic functions shall be functionally tolerant of the electromagnetic environment to which the vehicle will normally be exposed (fluctuating voltage and load conditions, and electric transients)				

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
	which the vehicle will normally be exposed (fluctuating voltage and load conditions, and electric transients)					
Electro Static Discharge	**ISO 23273:** All electrically components shall be bonded to the electric chassis	**ISO 23273:** All electrically components shall be bonded to the electric chassis	**IEC 62282-2-100:** Pipe made of plastic or elastomeric materials shall be electrically conductive or designed to avoid static charge build-up **IEC 62282-4-101:** The non-metallic pipe of hydrogen shall be conductive **IEC 62282-2-100 and IEC 62282-4-101:** Accessible metal shall have a protected earthing or be	**IEC 62282-2-100:** Plastic or elastomeric materials shall be electrically conductive or designed to avoid static charge build-up **IEC 62282-4-101:** The non-metallic pipe of hydrogen shall be conductive **IEC 62282-2-100:** Accessible metal shall have a protected earthing or be bonded to a common point	**IEC 62282-2-100:**[*] Plastic or elastomeric materials shall be electrically conductive or designed to avoid static charge build-up **IEC 62282-2-100:**[*] Accessible metal shall have a protected earthing or be bonded to a common point **ABS:**	**IEC 62282-2-100:** Plastic or elastomeric materials shall be electrically conductive or designed to avoid static charge build-up **IEC 62282-2-100:** Accessible metal shall have a protected earthing or be bonded to a common point

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[*] Concern also Inland waterway

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
			bonded to a common point		All fuel pipe shall be bonded to the ship hull (resistance <10 Ohm) **IMO/LR:** Pipe have electrical continuity and earth bonded to the hull **LR test:** Plastic or elastomeric materials shall be electrically conductive or designed to avoid static charge build-up	
Electrical-Shock	**R94, R95, ISO 6469-3 and ISO 6469-4:** High voltage shall be isolated with protection degree IPXXB for all cases (even after impact)	**ISO 6469-3 and ISO 6469-4:** High voltage shall be isolated with protection degree IPXXB for all cases (even after impact)		**IEC 63341:** High voltage protected against accidental contact by user		

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
	R100 and ISO 6469-3: High voltage shall be isolated with protection degree IPXXD for passenger compartment or luggage compartment **R100** High voltage shall be isolated with protection degree IPXXB for the others cases **R94, R95, R100 and ISO 6469-4:** Resistance between all exposed conductive parts and electrical chassis: <0.1 Ω for 0.2 A	**R100 and ISO 6469-3:** High voltage shall be isolated with protection degree IPXXD for passenger compartment or luggage compartment **R100** High voltage shall be isolated with protection degree IPXXB for the others cases **R100 and ISO 6469-4:** Resistance between all exposed conductive parts and electrical chassis: <0.1 Ω for 0.2 A **ISO 6469-4**		IEC 61991[*]		

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Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
	ISO 6469-4 Resistance between two exposed conductive separated at less of 2.5 m: <0.1 Ω for 0.2 A **R100:** ISO 6469-4 Resistance between two exposed conductive separated at less of 2.5 m: <0.2 Ω for 0.2 A **ISO 6469-3:** The isolation resistance < 100 Ω/V for DC and 500 Ω/V for AC, if AC and DC are galvanically connected < 500 Ω/V **R100:** Against indirect contact all the exposed conductive	Resistance between two exposed conductive separated at less of 2.5 m: <0.1 Ω for 0.2 A **R100:** ISO 6469-4 Resistance between two exposed conductive separated at less of 2.5 m: <0.2 Ω for 0.2 A **ISO 6469-3:** The isolation resistance < 100 Ω/V for DC and 500 Ω/V for AC, if AC and DC are galvanically connected < 500 Ω/V **R100:** Against indirect contact all the exposed conductive part shall be				

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
	part shall be galvanically connected to the electrical chassis **R100:** DC high voltage buses => warning to the driver if the isolation resistance ≥ 100 Ω/V **R137:** High voltage isolated IPXXB + the resistance between all exposed conductive and the electrical chassis: <0.1 Ω for 0.2 A + the galvanic connection should be welded -Or the isolation resistance between high voltage bus and electrical chassis: ≤ 100 Ω/V (for AC and DC galvanically	galvanically connected to the electrical chassis **R100:** DC high voltage buses => warning to the driver if the isolation resistance ≥ 100 Ω/V **R137:** High voltage isolated IPXXB + the resistance between all exposed conductive and the electrical chassis: <0.1 Ω for 0.2 A + the galvanic connection should be welded -Or the isolation resistance between high voltage bus and electrical chassis: ≤ 100 Ω/V (for AC and DC galvanically isolated from each				

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
	isolated from each other) or ≤ 500 Ω/V (for AC and DC galvanically connected) **R100:** Protection against direct contact; Electrical protection barriers, enclosures, solid insulators and connectors => not opened, separated, disassembled, removed without the use of tools* **ISO 6469-3:** The following measures => basic and fault protection: •double insulation;	other) or ≤ 500 Ω/V (for AC and DC galvanically connected) **R100:** Protection against direct contact; Electrical protection barriers, enclosures, solid insulators and connectors => not opened, separated, disassembled, removed without the use of tools **ISO 6469-3:** The following measures => basic and fault protection: •double insulation; •reinforced insulation;				

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* Connectors can separated without use of tools if: IPXXD or IPXXB, locking mechanism with at least two distinct actions to separate connectors, or the voltage part becomes ≤60VDC within 1s after the connector is separated.

<table>
<tr><th rowspan="2">Item</th><th colspan="2">Road vehicle</th><th rowspan="2">Off-Road vehicle</th><th rowspan="2">Rolling stock railway</th><th rowspan="2">Ship Sea/ocean
It is specified if this also concerns Inland waterway</th><th rowspan="2">Genset</th></tr>
<tr><th><3.5T (M1/N1)</th><th>>3.5T</th></tr>
<tr><td></td><td>•reinforced insulation;
•protective barriers in addition to the basic protection;
•protective enclosures in addition to the basic protection;
•conductive protective barrier with equipotential bonding in addition to basic insulation;
•conductive protective enclosure with equipotential bonding in addition to basic insulation;
•rigid protective barriers with sufficient mechanical robustness and durability over the vehicle service life
•rigid protective enclosures with</td><td>•protective barriers in addition to the basic protection;
•protective enclosures in addition to the basic protection;
•conductive protective barrier with equipotential bonding in addition to basic insulation;
•conductive protective enclosure with equipotential bonding in addition to basic insulation;
•rigid protective barriers with sufficient mechanical robustness and durability over the vehicle service life
•rigid protective enclosures with sufficient mechanical robustness and</td><td></td><td></td><td></td><td></td></tr>
</table>

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
	sufficient mechanical robustness and durability, over the vehicle service life.	durability, over the vehicle service life.				
Electrical design	**R94:** In case of crash the high voltage must be disconnected **ISO 6469-4:** Potential overcurrent shall not lead to a hazardous situation after a crash **ISO 6469-3:** Overcurrent protection shall be provided for live conductors according to their cross sectional area. **ISO 6469-3:**	**R105:** In normal condition of use of vehicles, no unintended ignition or short-circuit **ISO 6469-4:** Potential overcurrent shall not lead to a hazardous situation after a crash **ISO 6469-3:** Overcurrent protection shall be provided for live conductors according to their cross sectional area.	**IEC 62282-2-100:** Electrical component shall be suitable with ATEX area	**IEC 62282-2-100:** Electrical component shall be suitable with ATEX area	**DNV-RU-SHIP:** The electrical system shall be ensured that the fuel cell high buses can be disconnected at any load condition. **IEC 62282-2-100,[*] IMO/LR, IGF Code and LR R&R IGF:** Electrical component shall be suitable with ATEX area **IMO/LR, IGF Code and LR R&R IGF:** Minimise the electrical component in hazardous area	**IEC 62282-2-100:** Electrical component shall be suitable with ATEX area

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[*] Concern also Inland waterway

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
	Overload protection for live conductors according to their cross sectional area.	**ISO 6469-3:** Overload protection for live conductors according to their cross sectional area.				
Electrical connection			**IEC 62282-2-100:** •Fixed to their mountings with no possibility of self-loosing •Constructed in such a way the conductors cannot slip out from their intended location. •Such that proper contact is ensured without damage to the conductors that would impair the ability of the conductors to fulfil their function	**IEC 62282-2-100:** •Fixed to their mountings with no possibility of self-loosing •Constructed in such a way the conductors cannot slip out from their intended location. •Such that proper contact is ensured without damage to the conductors that would impair the ability of the conductors to fulfil their function	**IEC 62282-2-100:**[*] •Fixed to their mountings with no possibility of self-loosing •Constructed in such a way the conductors cannot slip out from their intended location. •Such that proper contact is ensured without damage to the conductors that would impair the ability of the conductors to fulfil their function	**IEC 62282-2-100:** •Fixed to their mountings with no possibility of self-loosing •Constructed in such a way the conductors cannot slip out from their intended location. •Such that proper contact is ensured without damage to the conductors that would impair the ability of the conductors to fulfil their function

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[*] Concern also Inland waterway

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
			•So secured against turning, twisting or permanently deforming during normal tightening onto the conductor	•So secured against turning, twisting or permanently deforming during normal tightening onto the conductor	•So secured against turning, twisting or permanently deforming during normal tightening onto the conductor	•So secured against turning, twisting or permanently deforming during normal tightening onto the conductor
Shutdown	ISO 6469-3: Protection measure de-energisation, shall have one of the following conditions: •< 50 V AC and <75 V DC; •<0,2 J on the total stored energy •< 5 mA AC or <25 mA DC between two accessible conductive parts	ISO 6469-3: Protection measure de-energisation, shall have one of the following conditions: •< 50 V AC and <75 V DC; •<0,2 J on the total stored energy •< 5 mA AC or <25 mA DC between two accessible conductive parts	IEC 62282-2-100: The failure of a component within a safety control system shall cause the FCM	IEC 63341: No chemical or electrical energy inside the FCPS after shutdown IEC 63341: During shutdown: Hydrogen located inside FCPS perimeter shall be eliminated by purging and/or electrochemical consumed IEC 63341: At the end of shutdown: stack voltage < 50 V	**DNV-RU-SHIP:** FC not certified for zone 1 shall be de-energized in case of gas detection. IEC 62282-2-100:[*] The failure of a component within a safety control system shall cause the FCM to initiate a controlled shut-down **ABS:** The shutdown of fuel cell consist to stop the fuel supply and	IEC 62282-2-100: The failure of a component within a safety control system shall cause the FCM to initiate a controlled shut-down IEC 62282-3-100: During shutdown: Hydrogen located inside FCPS perimeter shall be purge, but intended to do a non-hazardous situation IEC 62282-3-100: Activated with an action of a limiter, a

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[*] Concern also Inland waterway

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
				IEC 62282-2-100: The failure of a component within a safety control system shall cause the FCM to initiate a controlled shut-down	disconnect all electrical equipment not use for safety **BV:** The shutdown of fuel cell consist to: Stop dangerous condition without creating additional hazards, trigger of certain safeguard actions where necessary, override all other functions and operations in all modes, prevent reset from initialling a restart, be fitted with restart lock outs **ABS:** If a leak is detected or the limit value of control process (e.g. T, Pressure, voltage ,…) are in hazardous	cut-out, the detection of an internal fault of the system or manually activated **IEC 62282-3-100:** The shutdown of fuel cell consist to stop the fuel supply and de-energization of the cells

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
					level the fuel cell shall be automatically shutdown **IMO/LR:** Out of limit values of Temperature in fuel cell (80% of the self-ignition), Pressure, voltage, gas concentration, loss of coolant and leak of the gas in the coolant shall automatically shutdown	
Concentration H2 (exhaust…)	**R134:** In the exhaust • < 4 % in volume during 3 seconds • < 8 % in volume all time **ISO 23273:**	**R134:** • < 4 % in volume during 3 seconds • < 8 % in volume all time **ISO 23273:** Normal discharges from the vehicle shall be non-flammable	**IEC 62282-4-101:** Use IEC 60079-10-1 to determine the hazardous area **IEC 62282-4-101:** Near the exhaust •< 25 % of Low Flammable Limit in normal condition	**IEC 63341:** Near the exhaust • < 25 % of Low Flammable Limit in normal condition • < 50 % in all other cases	**ABS:** The release area of the gaseous exhaust is graded as a zone 1 (ATEX) **ABS, IMO/LR and BV:** The fuel cell space is graded as a	**IEC 62282-3-100:** Near the exhaust • < 25 % of Low Flammable Limit in normal condition

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
	Normal discharges from the vehicle shall be non-flammable		•< 50 % in all other cases		hazardous area zone 1 (ATEX) **IMO:** The fuel cell space is classified as a hazardous area zone 1, or use IEC 60079-10-1 to determine the hazardous area **IMO/LR and BV:** Near the exhaust •Alarm at 20 % Low Explosiv Limit (LEL) •Shutdown at 40 % LEL	
Leakage	**R134:** No leak downstream the shut-off valve to the fuel cell system (e.g. piping, joint, etc.) **R134:** • < 10 NmL/h accepted for valves	**R134:** Not leak downstream the shut-off valve of FC system **R134:** • < 10 NmL/h accepted for valves **R134:**				**IEC 62282-3-100:** No rate of leak requirement for all part of segment of gas

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
	R134, R153 and R135: Post-crash: • < 118 NL/min	Post-crash: • < 118 NL/min				
Fire/ explosion risk		**R118:** Components, electric, cables, cable sleeves or cable conduits shall be made and install to minimize the risk of flame development and propagation	**IEC 62282-2-100:** Component and materials are design to avoid the propagation of fire and ignition outside the FCM **IEC 62282-2-100:** Within the FC stack volume: mass of material without flame spread ratings shall be less than 10 % of the total mass of the FCM **IEC 62282-2-100:**	**IEC 62282-2-100:** Component and materials are design to avoid the propagation of fire and ignition outside the FCM **IEC 62282-2-100:** Within the FC stack volume: mass of material without flame spread ratings shall be less than 10 % of the total mass of the FCM **IEC 62282-2-100:**	**IEC 62282-2-100:**[*] Component and materials are design to avoid the propagation of fire and ignition outside the FCM **IEC 62282-2-100:**[†] Within the FC stack volume: mass of material without flame spread ratings shall be less than 10 % of the total mass of the FCM	**IEC 62282-2-100:** Component and materials are design to avoid the propagation of fire and ignition outside the FCM **IEC 62282-2-100:** Within the FC stack volume: mass of material without flame spread ratings shall be less than 10 % of the total mass of the FCM **IEC 62282-2-100:**

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[*] Concern also Inland waterway

[†] Concern also Inland waterway

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
			Any plastic or elastomeric enclosure used to convey flammable gases (e.g. fluidic end plate) shall be protected of overheating. **IEC 62282-2-100** The FCM shall be protected by means (e.g. ventilation, gas detectors, controlled oxidation, operating temperatures higher than the auto-ignition temperature) such that leaking gases from, or inside, the FCM cannot form explosive concentrations.	Any plastic or elastomeric enclosure used to convey flammable gases (e.g. fluidic end plate) shall be protected of overheating. **IEC 62282-2-100** The FCM shall be protected by means (e.g. ventilation, gas detectors, controlled oxidation, operating temperatures higher than the auto-ignition temperature) such that leaking gases from, or inside, the FCM cannot form explosive concentrations.	**IEC 62282-2-100:**[*] Any plastic or elastomeric enclosure used to convey flammable gases (e.g. fluidic end plate) shall be protected of overheating. **DNV-RU-SHIP:** Minimized the use of flammable materials **IEC 62282-2-100**[†] The FCM shall be protected by means (e.g. ventilation, gas detectors, controlled oxidation, operating temperatures higher than the auto-ignition temperature) such	Any plastic or elastomeric enclosure used to convey flammable gases (e.g. fluidic end plate) shall be protected of overheating. **IEC 62282-2-100** The FCM shall be protected by means (e.g. ventilation, gas detectors, controlled oxidation, operating temperatures higher than the auto-ignition temperature) such that leaking gases from, or inside, the FCM cannot form explosive concentrations.

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[*] Concern also Inland waterway

[†] Concern also Inland waterway

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	**Ship Sea/ocean** It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	**>3.5T**				
					that leaking gases from, or inside, the FCM cannot form explosive concentrations. **IMO/LR, IGF Code and LR R&R IGF:** Sources of ignition in hazardous area shall be minimize	
Monitoring				**IEC 63341:** Mandatory monitoring: •The current state of the FCPS: startup mode, operation, shutdown mode, … •The fault status of the FCPS •The power delivered by the FCPS •The hydrogen consumption •The measures from sensors needed to safely operate the	**ABS:** Mandatory monitoring: •Cell voltage; •Cell voltage deviations •Exhaust gas temperature •Fuel Cell temperature •Electric current Option monitoring: •Air flow •Air pressure	

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
				FCPS (current, voltage, flow, pressure, temperature, …) •A lack of cooling liquid pressure must be detected	•Cooling medium flow, pressure, temperature •Fuel flow •Fuel temperature •Fuel pressure •Gas detection based on the risk assessment; •Water system level; •Water system pressure; •Water system purity; •Parameters necessary to monitor lifetime/ deterioration. **IMO/LR:** Mandatory monitoring: •Voltage of fuel cells •Temperature of exhaust gas and exhaust air	

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	**Ship Sea/ocean** It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	**>3.5T**				
					•The internal temperature of the fuel cell •Purity of the reformed fuel •Output current •Contamination of air into fuel cell fuel lines, or of fuel cell fuel into air pipes. Option monitoring: •Air flow; •Air pressure; •Flow rate, pressure and temperature of cooling medium; •Fuel flow; •Fuel temperature; •Fuel pressure; •Gas detection of exhaust fuel and exhaust air •Liquid level, pressure and purity of water system;	

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
					BV: Mandatory monitoring: •Cell stack or process fault, •Ground fault, •Low voltage fault, •Overcurrent fault **DNV-RU-SHIP:** •Cell V •Cell V deviations •T exhaust gas •T in FC stack •Electric current •Process air flow •Process air P •Cooling medium flow, level, pressure, temperature •Fuel flow •Fuel temperature •Fuel pressure •Gas detection in exhaust gas	

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	Ship Sea/ocean It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
					•Process water system level, pressure, purity •Parameters necessary to monitor lifetime/ deterioration	
Cyber-Security	**R155**	**R155**[*]			**DNV-CP-0231 and DNV-CG-0325***	
Marking				**IEC 63341:** Degree protection (IP) shall be specified on FCPS		
Risk analysis	**ISO 6469-3:** As an alternative to the requirements of Fault protection and additional measures, the vehicle manufacturer shall conduct an appropriate hazard analysis and establish	**ISO 6469-3:** As an alternative to the requirements of Fault protection and additional measures, the vehicle manufacturer shall conduct an appropriate hazard analysis and establish	**IEC 62282-2-100** The manufacturer shall perform in written form a risk analysis including the assessment of: Temperature, voltage, pressure.	**IEC 62282-2-100** The manufacturer shall perform in written form a risk analysis including the assessment of: Temperature, voltage, pressure. **IEC 60529**	**DNV-RU-SHIP:** A risk analysis examining all possible faults affecting the fuel cell operation and safety shall be carried out. **See MSC 1212 and MSC 1455**	

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[*] New potential opportunities to analyse new parameters or requirements were found to complete the table below. They are, however, just mentioned in the form of RCS references.

<table>
<tr><th rowspan="2">Item</th><th colspan="2">Road vehicle</th><th rowspan="2">Off-Road vehicle</th><th rowspan="2">Rolling stock railway</th><th rowspan="2">Ship Sea/ocean
It is specified if this also concerns Inland waterway</th><th rowspan="2">Genset</th></tr>
<tr><th><3.5T (M1/N1)</th><th>>3.5T</th></tr>
<tr><td></td><td>a set of measures which give sufficient protection against electric shock under single fault conditions.</td><td>a set of measures which give sufficient protection against electric shock under single fault conditions

ISO 26262*</td><td></td><td>Shall be protected against external damages</td><td>Currently, maritime regulations do not incorporate fuel cells (work is ongoing in this regard). However, to compensate for this lack, there are guidelines for the application of safe engineering design to provide technical justification for alternative designs and arrangements to Chapters II-1 (Parts C, D and E) and III of the SOLAS Convention. These guidelines use a robust and proven methodology, which will not be repeated here: see the sheet</td><td></td></tr>
</table>

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* New potential opportunities to analyse new parameters or requirements were found to complete the table below. They are, however, just mentioned in the form of RCS references.

Item	Road vehicle		Off-Road vehicle	Rolling stock railway	**Ship Sea/ocean** It is specified if this also concerns Inland waterway	Genset
	<3.5T (M1/N1)	>3.5T				
					associated with alternative designs. **IGF Code and LR R&R IGF:** A risk analysis focus on explosion and source of release **LR Safety Hydrogen:** Tools to complete a risk analysis focus on hydrogen hazard: Hazardous event and consequences **IMO/LR, IGF Code and LR R&R IGF:** Safety components shall be protected against external damages	

Table 15 Synthesis table of RCSs analysed for all applications

4.2 Proposal of generic guidelines extracted from RCS

The generic parameters and requirements table below synthetise the analysis performed in the prevous chapter. It has been built considering a conservative approach.

It has not been kept in the generic StasHH, the requirements or parameters isolated for an application, which represent more the implementation of good practices than an obligation (some good practices of a classification society for the classification of a vessel that is not found in the guides of other classification societies).

The elements proposed for the StasHH generic table were discussed during a workshop

Item	StasHH Generic
Environmental conditions	
Humidity	RH ≤ 95 %
Operating temperature	-40 °C to 85 °C
Vibration	Vibration during 90min for each resonant frequencies where an amplification factor Q < 2 is recorded between 2 to 2000Hz
Crash test	Crash test protocol gives for a vehicle (see R94 and R95) •20 g Axis •8 g Perpendicular
Inclination	Static and dynamic: 22.5° in all axis
Salt mist	Support salt mist (The saline solution shall consist of 7,6 % NaCl and 92,4 % distilled water, by weight)
Chemical (Pollution)	Chemical resistance of connection and external surface of components: •Sulphuric acid (19 % in V) •Sodium hydroxide (25 % in weight) •Ammonium nitrate (28 % in weight) •Windshield washer fluid (50 % in V) •Methanol/gasoline (5 % / 95 % in V) •N-pentane Resistant to oxygen and ozone exposition specially for non-metallic components
UV Radiation	UV resistant for non-metallic surfaces
IP (Ingress Protection rating)	Protection against water > IP56
Performance assessment	
Power density	See with NWIP Proposed by Symbio Oct 21 (Working group TC105)
Lifetime	
Efficiency	Comply with ISO/TR 11954:2008 or IEC 62282-3-200 or ISO 23828:2013
Rate of availability	
Other	Comply with ISO/TR 11954:2008
Design/material	
All	Compatibility of hydrogen for all materials in contact with hydrogen

Item	StasHH Generic
	Lifting interface Good fixing point to avoid noise No sharp edge on accessible part No asbestos in the choose of material No using adhesive agent to fix material
Pipes	Non-metallic piping shall be protected against overheating and mechanical damage The H2 pipe shall not passed in enclosed area before entering in the fuel cells spaces The pipe shall have a colour identification in accordance of that they contain => Colour should be defined (eg. for H2 => red) Inlet H2 pipes section that can be isolated (closed) => manually and/or automatic Inlet H2 pipes are provided with relief valves
Pipe connections	For H2 connections: •Welded as possible •Threaded connections, •Fitting connections with a defined sealing area For pipe joint: •Ground-joint type •Flanged-joint type •Compression-joint type having packing Minimise the number of pipe connections
Components (valve, sensors…)	No H2 sensor are specified on RCS, but the hydrogen concentration must be checked at the outlet
Wire / cable	Cables are secure and protected against mechanical and thermal stresses. Wire are on automotive quality
Air or oxidant Inlet	A particle filter shall be installed in air or oxidant inlet
Cooling	The selection of the coolant and the coolant management system should be designed to limit the electrical conductivity of the coolant In case of rotative equipment, a particle filter shall be installed

Item	StasHH Generic
	Thermal management system sizing to avoid overpressure on cavitation effects
Exhaust	Water in exhaust should be drained without the gas escape the drain line Protection against icing formation CO < 0.03 %
Pressure	Valves shall support 2.5X Nominal Working Pressure Sensors, instruments and control devices shall support 2X MAWP? Other gas or liquid device shall support 1.5X MAWP All the low pressure section shall be capable of withstanding or be protected against an extraordinary pressure increase due to the failure of the first pressure regulator
Safety	
Design	The fuel system shall be equipped by a main hydrogen shut-off valve Fuel shut-off valve shall be normally closed. All components shall be securely mounted or supported in the vehicle to minimize damage and prevent leakage and/or malfunction. Spacing H2 pipe from exhaust and electrical system No contact of electrical cable and exhaust system
Electrical isolation	IEC 60664 applicable
Electromagnetic compatibility (EMC)	Emission: 30 to 1,000 MHz Immunity: 20 to 2,000 MHz Comply with R10 or IEC 61000 or LR test => procedure and values TBC
Electro Static Discharge	All electrically components shall be bonded to the electric chassis The non-metallic pipe of hydrogen shall be conductive
Electrical-Shock	High voltage shall be isolated with protection degree IPXXD for passenger compartment or luggage compartment and IPXXB for all cases (even after crash) Resistance between all exposed conductive parts and electrical chassis: <0.1 Ω for 0.2 A Resistance between two exposed conductive separated at less of 2.5 m: <0.1 Ω for 0.2 A

Item	StasHH Generic
	Protection against direct contact; Electrical protection barriers, enclosures, solid insulators and connectors => not opened, separated, disassembled, removed without the use of tools[30] The isolation resistance < 100 Ω/V for DC and 500 Ω/V for AC, if AC and DC are galvanically connected < 500 Ω/V
Electrical design	Electrical component shall be suitable with ATEX area Minimize the electrical component in hazardous area In case of crash the high voltage must be disconnected and no possibility of overcurrent
Electrical connection	Secure and solid electrical connection
Shutdown	Protection measure de-energisation, shall have one of the following conditions: • < 50 V AC and < 75 V DC; • < 0,2 J on the total stored energy • < 5 mA AC or < 25 mA DC between two accessible conductive parts The shutdown of fuel cell consist of the following parts: Stoping of the fuel supply, H2 line purging or electrochemical consumption, and disconnection of all electrical equipment not used for safety If a leak is detected or the limit value of control process (e.g. T, Pressure, voltage ,…) are in hazardous level the fuel cell shall be automatically shutdown
Concentration H2 (exhaust…)	In the exhaust: • < 4 % in volume during 3 seconds and • < 8 % in volume all (any) time Near the exhaust: • < 25 % of Low Flammable Limit in normal condition • < 50 % in all other cases The release area of the gaseous exhaust and the fuel cell space are graded as a zone 1 (ATEX)
Leakage	< 10 NmL/h accepted for valves No leak for the rest of the module Post-crash leak: < 118 Nl/min
Fire/ explosion risk	Component and materials are design and install to avoid the propagation of fire and ignition outside the FCM

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[30] Connectors can separated without use of tools if: IPXXD or IPXXB, locking mechanism with at least two distinct actions to separate connectors, or the voltage part becomes ≤60VDC within 1 s after the connector is separated.

Item	StasHH Generic
	Minimized the use of flammable materials (mass of flammable material shall be less of 10 % of the total mass of the FCS) Sources of ignition in hazardous area shall be minimize The fuel cell space is classified as a hazardous area zone 1
Monitoring	Not generic, extract from railway and marine applications (not exhaustive and poorly defined). •Cell voltage; •Cell voltage deviations •Exhaust gas temperature •Fuel Cell temperature •Fuel pressure •Electric current •The current state of the FCM: startup mode, operation, shutdown mode, … •The fault status of the FCM •The power delivered by the FCM •The hydrogen flow and pressure •The hydrogen consumption •Cooling loss detection (flow, level, pressure, temperature) •Air inlet flow and pressure •Gas detection based on the risk assessment •Parameters necessary to monitor lifetime/deterioration …
Cyber-Security	See R155
Marking	Requested labelling
Risk analysis	Harmonization of methodology

Table 16: Generic requirements and parameters for FCM to StasHH project

The definition of generic parameters and requirements for the fuel cell modules, complying to the StasHH standard, poses the following challenges:

- The differentiation of the level of responsibility for each item (FCM, integrator, ...)
- Lack of information on certain items for each of the fields of application
- The required levels on each item can vary greatly depending on the area

The parameters which emerge from this table allow to have an overall idea of the most conservative requirements requested by the RCS.

This table also highlights the absence of certain basic information:

- Topic 1 - Size of the FCM and connections: what are the main concern of StasHH project
- Topic 2 - Specifications about performances such as
    - Minimum / maximum / nominal power
    - Transient load and ramp up duration
    - Efficiency calculation method
    - Power densities calculation

Topic 3 - List and format of minimum data or key performances indicators for the master controller. E.g. For safety management the minimum mandatory monitoring data should be:

- Coolant inlet temperature
- Coolant outlet temperature
- Coolant flow detection
- Coolant inlet pressure
- Hydrogen inlet pressure
- Oxidant inlet pressure
- FCM current
- FCM voltage
- Cell average voltage (measurement or calculation)

This information can be the basis for the construction of a New Working Item Proposal in the technical committees of IEC (TC 105) and ISO (TC 22).

5 Conclusion

This document aims to analyse the existing Regulations Codes, Standards and Safety (RCSS) in the StasHH project context devoted to Standard Sized FC module for Heavy Duty applications. This synthesis has been prepared by the Atomic Energy and Alternatives Energies Commission Atomic (CEA) in collaboration with StasHH partners and Future Proof of Shipping (FPS) company. The analysis has been extended to other domains such as off-road, railway, maritime/inland waterway and gensets for an exhaustive analysis. The main prupose is to find common basic rules and requirements that StasHH can address for the greatest number of applications.

Part I describes the methodology used and the RCS definitions commonly used. The International and European standardization bodies are presented and their roles is detailled for each applications. These 350 references coming from global standardizations and guideline bodies (ISO, IEC, IMO, IUC) or regional ones (CEN, CENELEC, CESNI, ERA, EMSA) have been analysed.

Sorting of the documents is done in part II according to the references, names, domains and their applicability for each applications. Then, the relevant RCSS have been extracted and 47 separated sheets have been established.

Moreover, the part III compares the relevant references between the applications. In particular, 38 items have been used to list environnemental requirements, performances assessments, as well as design & material and safety criteria. Finally, a table with suitable and conservative criteria has been proposed for the Standard Sized FC module for Heavy Duty applications.

Nevertheless, this analysis highlights the lack of RCS elements regarding:

- Topic 1 - Size of the FCM and connections: what is the paramount objective of the StasHH project
- Topic 2 - Specifications about performances such as
  - Minimum / maximum / nominal power
  - Transient load and ramp up duration
  - Efficiency calculation method
  - Power densities calculation
- Topic 3- List and format of minimum data or key performances indicators for the master controller

On the basis of these elements, the authors propose to the technical committees of IEC (TC 105) and ISO (TC 22) bodies for building a New Working Item Proposal in order to advance the three main topics suggested.

APPENDIX 1. RCSs term definition as consider in the next Multi Annual Workplan from Hydrogen Europe.

The implementation of suitable and hydrogen-specific regulatory and enabling frameworks is crucial for the EU-wide deployment of hydrogen, fuel cells and hydrogen-based technologies and meet the goals set out in the EU Hydrogen Strategy. Indeed, setting up these frameworks is one of the major priorities in the first phase of the Strategy (2020-2024).

The term "Regulations, Codes and Standards" (RCS) is widely used in Europe and other regions of the world to somehow refer to regulatory aspects in general, but it is important to underline some few remarks on each of them, particularly within the European context.

The European Union is based on the rule of law and relies on law to ensure that its policies and priorities are realised in the Member States [1]. Regulations, directives, decisions, recommendations, etc. are types of EU legal acts [2] putting EU policies into practice.

Regulations in the EU apply automatically and uniformly to all EU countries as soon as they enter into force, without needing to be transposed into national law. Regulations are binding in their entirety on all EU countries and are distinguished from directives in which the latter must be incorporated by EU countries into their national legislation. In general terms, regulations and directives can refer to codes or standards, or be created completely on their own. And unlike a code or a standard, a regulation does not necessarily require an industry consensus to put it in effect. It serves to the general interest.

In the EU, the European Commission is responsible for planning, preparing and proposing new EU laws and policies. In addition, the effective application, implementation and enforcement of the law is a responsibility entrusted to the Commission. With regards to international regulatory cooperation, the Commission cooperates closely with international partners, both in multilateral dialogues, for instance with the United Nations (UN), the Organisation for Economic Co-operation and Development (OECD) or the World Bank, as well as in bilateral dialogues [3].

On the other hand, in an industrial context, a code, in general, is a set of rules or norms that serve as generally accepted guidelines recommended for the industry to follow. They exist for the purpose of safety, quality or another benefit. On its own, a code is not a law that must be followed, but compliance is often a best practice. Industry codes can be voluntary or mandatory and can be developed by the industry on its own or by public institutions. The intent of a code is for it to apply widely across the industry within the economic sector at the scope, but can be adopted into law, or included in a business contract.

Standards are part of the knowledge economy that underpins industry and society [4]. Standards are, in essence, an agreed way of achieving a set objective. In simple terms, a regulation or a code sets out "what" is required, and a standard sets out "how" to do it. Standards can be used to improve safety and performance, protect consumers, workers and the environment, etc. Overall, the majority of standards are initiated by business and developed in partnership with other stakeholders either in sectoral associations, or in Standardization Developing Organizations, such as the International Standardization Organization (ISO) [5] and International Electrotechnical Commission (IEC) [6] at international level, or the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC) [7] at the European level, to name but a few. The use of *standards by market players can in addition support the implementation of public authorities' policy and legislation and help stakeholders to comply with legislation. For example, about 30 % of European Standards are mandated by the European Commission in the framework of EU legislation and perform this supplementary function [8]. Among the different manners to classify standards, standards can fall into two general categories:*

•Non-statutory standards: This type of standards, also named as voluntary, is generally established by a private sector and made available to persons or organizations, whether private or public, to use. Also considered voluntary standards are those known as "industry standards" or "consensus standards".

•Statutory standards. This type of standards, also named as mandatory, requires compliance because of a European regulation or national statue, an organization internal policy or contractual requirement. Failure to comply with a mandatory standard's guidelines can cause legal repercussions.

The implementation of suitable and hydrogen-specific regulatory and enabling frameworks requires a strategic approach, which focuses, especially during the timeframe referred in the first phase of the hydrogen strategy, on aspects where enforcement action can make a real difference to streamline the rollout of hydrogen technologies in Europe. In this sense, the term 'regulation' means both legislation and other policy actions. To this end, this approach necessitates a structured, systematic and effective coordination and assessment of the existing gaps and barriers in the current (and upcoming) regulatory framework in order to identify the needs and prioritize actions.

The Clean Hydrogen JU will contribute to supporting the implementation of hydrogen-specific regulatory and enabling frameworks by a strategic and coordinated approach to RCS issues within the Programme, which will mostly be implemented through PNR activities. To this end, PNR activities will encompass research activities and desk research activities in view of supporting RCS developments.

Whilst the Regulations, Codes and Standards Strategy Coordination group [9] set up by the FCH 2 JU has certainly contributed for better coordination in the last years, in the light of experience, these activities need for an even more strategic approach in the JU's Programme. To this end, a RCS Strategy Coordination Task Force composed of the Commission, Hydrogen Europe and Hydrogen Europe Research, and the JU Programme Office will be set up.

The main goal of the RCS SC Task Force will be the definition, coordination and monitoring of the strategy related to RCS within the Programme with the ultimate goal of increasing the EU impact in RCS development in Europe and beyond, with the main focus but not limited to Standards. The RCS SCG Task Force will ensure the Clean Hydrogen JU will speak with one single voice and will coordinate synergies related to RCS with other partnerships.

Regulatory policy is a responsibility entrusted to the Commission and while the JU can contribute to its development, the main contribution and impact of the Programme is envisaged on supporting the development of technical regulations. In this respect, it is important to remark that the European Union can only act in those areas where its member countries have authorised it to do so, which makes unrealistic the adoption of EU unified, harmonised documents valid everywhere. For example, aspects like the permitting and/or licensing processes for HRS in the EU depend on local authorities, which apply Member States rules, codes, and/or regulations.

On standards, the Programme activities will mostly focus on supporting the development as well as the actual use of harmonised performance-based standards for hydrogen and hydrogen-based *technologies at European and international level. The goal is to provide rigorous, fact-based and scientifically sound evidences to establish and/or further develop standards that can be referred to in regulatory documents while facilitating the hydrogen market deployment.*

To this end, it is envisaged that RCS SC Task Force prioritises the coordination of the following activities:

1.Follow up of RCS development related to hydrogen, fuel cells and hydrogen technologies through a continuous global watch function with the main focus but not limited to standards. To this end, the RCS SCG Task Force will explore the possibilities to cooperate with regulatory bodies, such as policy DGs of the Commission or the United Nations (e.g. with the United Nations Economic Commission for Europe (UNECE)), international organizations like IPHE, or bilaterally with the US, Japan, etc., and with standardization developing organizations at both, international and European level. With respect to the latter, the possibilities of formal liaisons will be explored, for instance, through participating in the Technical Advisory Boards.

1.Assessment of RCS development needs of strategic importance in Europe. Building on the monitoring activities mentioned previously and in consultation with relevant stakeholders, the RCS SC Task Force will assess what RCS developments could contribute the most to foster a regulatory friction-less EU-wide hydrogen market, while meeting the EU Hydrogen Strategy goals and the interests of the European industry and research organizations. This will facilitate to lay down the RCS strategy in the Programme.

2.Identification and prioritization of the requirements and needs for research and innovation, and coordination actions to support the RCS development identified as strategic for Europe and that standardization and regulatory aspects are appropriately addressed in the Programme. The majority of the targeted actions in the Programme will be conducted through PNR activities and will encompass but not limited to research activities and desk research activities in view of supporting RCS developments. This will contribute to the development of the Annual Work Plans of the JU.

3.Follow up and support the research and innovation, and coordination actions undertaken in the Programme contributing to ensure to best possible the actual use of PNR results in RCS developments. This support can encompass the establishment of a systematic and structured approach to supporting formal liaison between SDOs and projects, financial support to entities for participation in SDOs, etc.

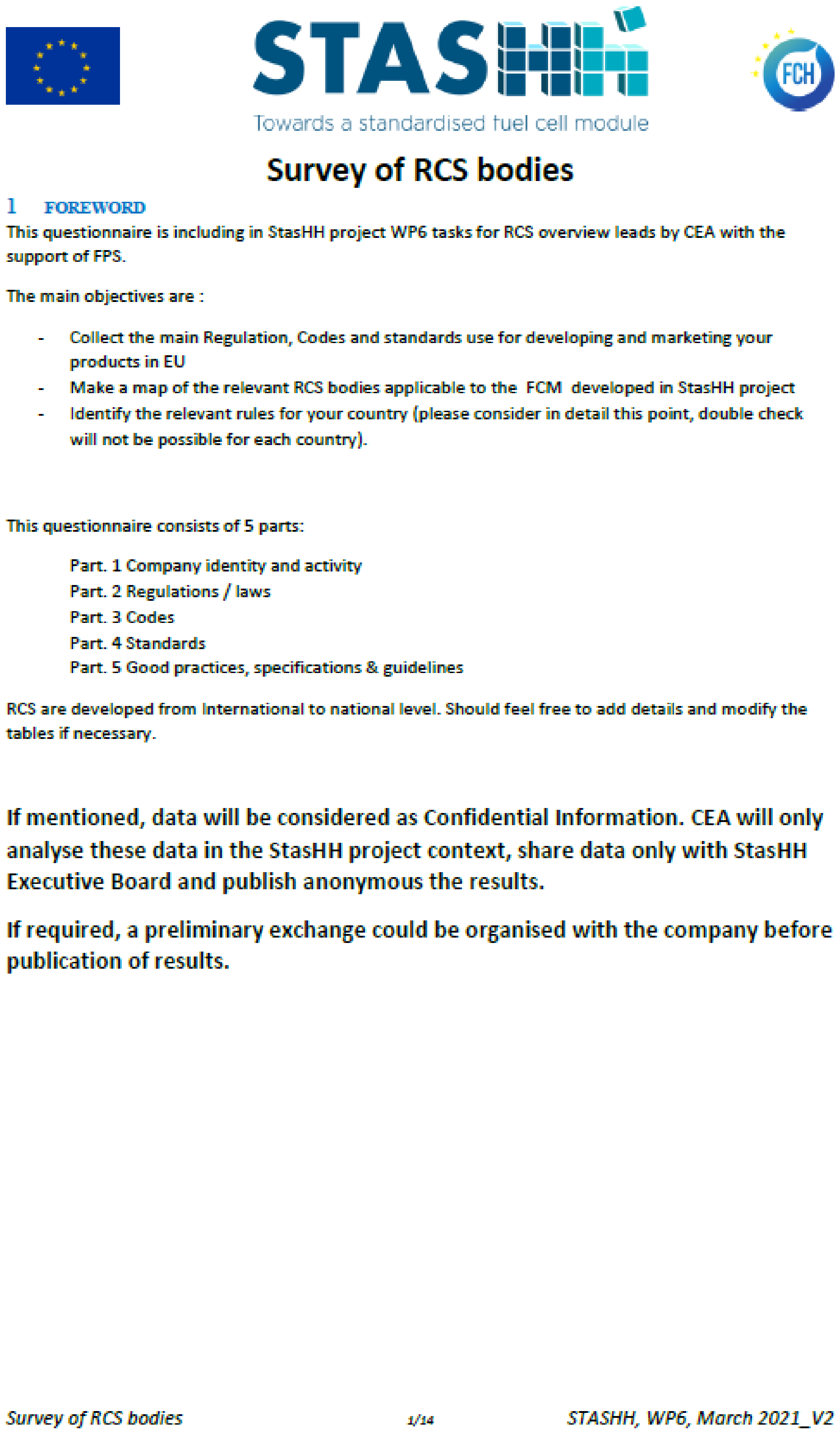
4.Dissemination of results. This could include the collection and effective transfer of RCS-relevant results in regulatory and standardization bodies; targeted communication actions, awareness workshops, development of training content, etc.

Altogether, the RCS SC Task Force will contribute to coordinating and establishing an approach to enhance European participation and contribution in international and European RCS bodies while contributing to lay down a regulatory friction-less hydrogen market in Europe and beyond if possible.

[1] Treaty on the Functioning of the European Union (TFEU). Art. 2.
[2] https://ec.europa.eu/info/law/law-making-process/types-eu-law_en
[3] https://ec.europa.eu/info/law/law-making-process/planning-and-proposing-law/better-regulation-why-and-how_en
[4] https://www.cencenelec.eu/standards/Pages/default.aspx
[5] https://www.iso.org
[6] https://www.iec.ch

[7] https://www.cencenelec.eu/
[8] https://www.cencenelec.eu/STANDARDS/Pages/default.aspx
[9] https://www.fch.europa.eu/page/rcs-strategy-coordination-group

APPENDIX 2. Model of survey



Towards a standardised fuel cell module

Survey of RCS bodies

1 FOREWORD

This questionnaire is including in StasHH project WP6 tasks for RCS overview leads by CEA with the support of FPS.

The main objectives are :

- Collect the main Regulation, Codes and standards use for developing and marketing your products in EU
- Make a map of the relevant RCS bodies applicable to the FCM developed in StasHH project
- Identify the relevant rules for your country (please consider in detail this point, double check will not be possible for each country).

This questionnaire consists of 5 parts:

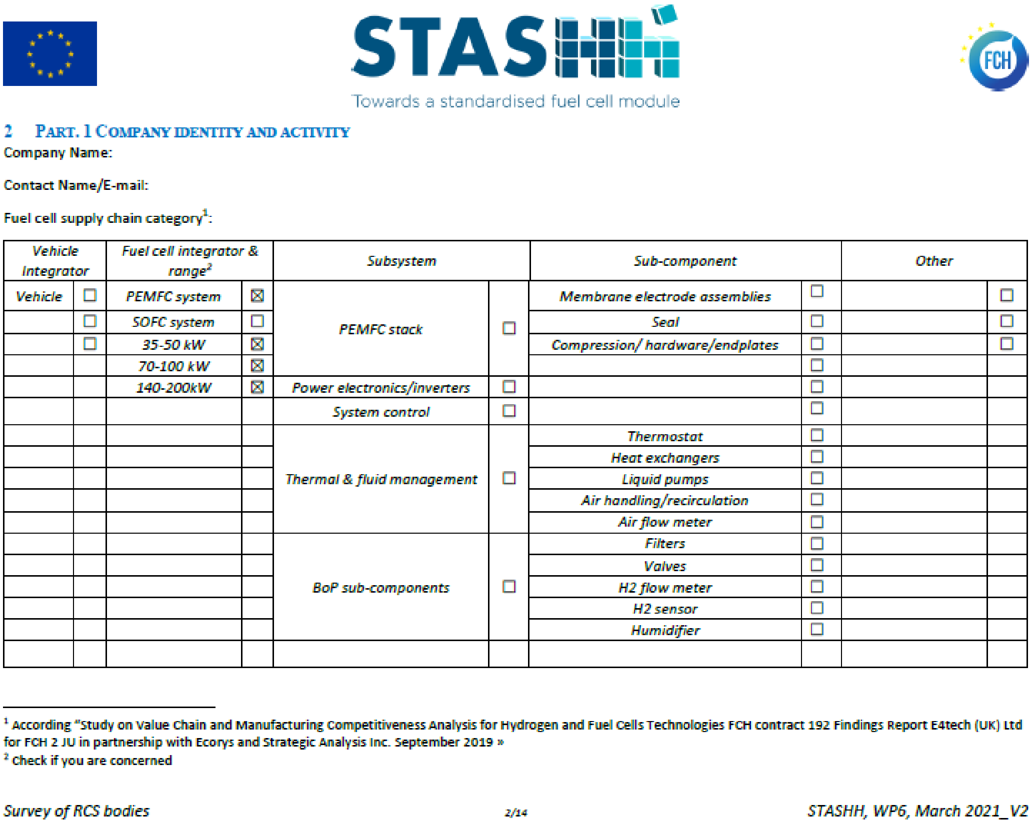
Part. 1 Company identity and activity
Part. 2 Regulations / laws
Part. 3 Codes
Part. 4 Standards
Part. 5 Good practices, specifications & guidelines

RCS are developed from International to national level. Should feel free to add details and modify the tables if necessary.

If mentioned, data will be considered as Confidential Information. CEA will only analyse these data in the StasHH project context, share data only with StasHH Executive Board and publish anonymous the results.

If required, a preliminary exchange could be organised with the company before publication of results.

Survey of RCS bodies 1/14 *STASHH, WP6, March 2021_V2*



2 PART. 1 COMPANY IDENTITY AND ACTIVITY

Company Name:

Contact Name/E-mail:

Fuel cell supply chain category[1]:

Vehicle Integrator		Fuel cell integrator & range[2]		Subsystem		Sub-component		Other	
Vehicle	☐	PEMFC system	☒	PEMFC stack	☐	Membrane electrode assemblies	☐		☐
	☐	SOFC system	☐			Seal	☐		☐
	☐	35-50 kW	☒			Compression/ hardware/endplates	☐		☐
		70-100 kW	☒				☐		
		140-200kW	☒	Power electronics/inverters	☐		☐		
				System control	☐		☐		
				Thermal & fluid management	☐	Thermostat	☐		
						Heat exchangers	☐		
						Liquid pumps	☐		
						Air handling/recirculation	☐		
						Air flow meter	☐		
				BoP sub-components	☐	Filters	☐		
						Valves	☐		
						H2 flow meter	☐		
						H2 sensor	☐		
						Humidifier	☐		

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[1] According "Study on Value Chain and Manufacturing Competitiveness Analysis for Hydrogen and Fuel Cells Technologies FCH contract 192 Findings Report E4tech (UK) Ltd for FCH 2 JU in partnership with Ecorys and Strategic Analysis Inc. September 2019 »

[2] Check if you are concerned

Towards a standardised fuel cell module

Domain		Sub categories and examples	Include
Other land-based applications	Road	City/regional bus, coach	☐
		Long-haul trucktrailer and semi-trailer	☐
		Delivery truck,	☐
		Refuse truck, Sweepers	☐
		Other *(please detail)*	☐
	Off-road	Specific applications	
		Mining	☐
		Construction equipment: *(excavator, backhoe loader, aerial bucket…)*	☐
		Snow groomers	☐
		Other *(please detail)*	☐
		Railway *(Train, tramway)*	☐
		Airport operations	☐
		Harbour operations	☐
		Other *(please detail)*	☐
	Gensets	Roadworks, festivals	☐
		Ship – Harbour connection	☐
		Semi transportable power unit (container included)	☐
		Other *(please detail)*	☐
Waterborne applications	Inland	Commercial vessels (bulk and freight vessels)	☐
		Passenger vessels	☐
		Pleasure crafts	☐
	Sea / ocean	Commercial vessels *(length >110m)*	☐
		Passenger vessels	☐
		Pleasure crafts	☐
		Other *(please detail)*	☐

STASHH
Towards a standardised fuel cell module

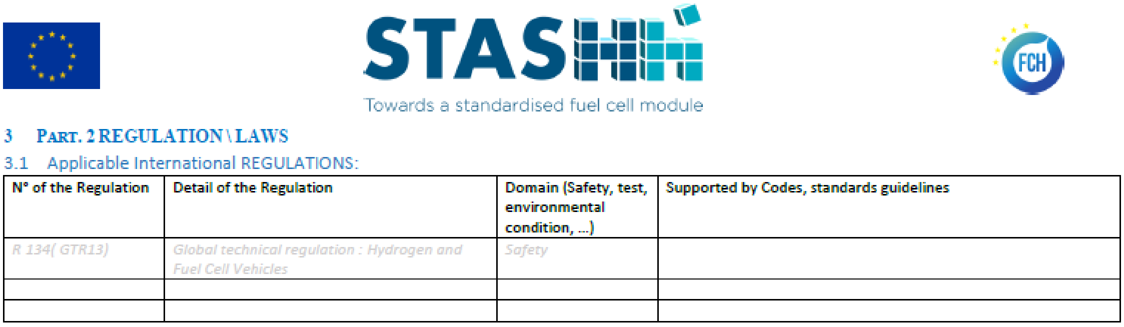
Documents:

As mentioned in Grant Agreement, please send the document to CEA (mailto: didier.bouix@cea.fr; maximilien.martin@cea.fr; laurence.sourdet@cea.fr).

Extension of MS files (.docx; .xlsx, .pptx), Zip, pdf….

Documentation requires:

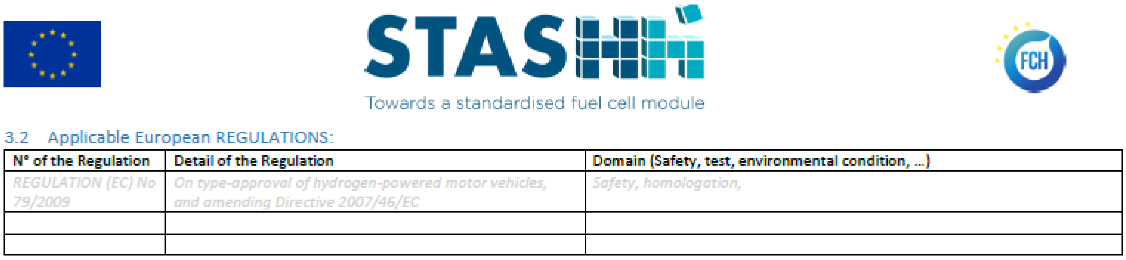
- ⇨ Product datasheet
- ⇨ Risk analyses
- ⇨ External functional specifications
- ⇨ List of RCS used
- ⇨ any documents related to
  - Safety
  - Performances (including environmental conditions, acceptance tests)
  - Installation / integration
  - Service and maintenance
  - Approval type?



3 PART. 2 REGULATION \ LAWS

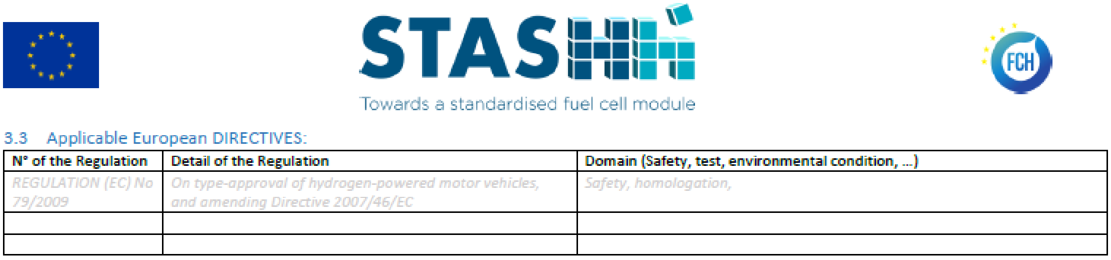
3.1 Applicable International REGULATIONS:

N° of the Regulation	**Detail of the Regulation**	**Domain (Safety, test, environmental condition, …)**	**Supported by Codes, standards guidelines**
R 134(GTR13)	*Global technical regulation : Hydrogen and Fuel Cell Vehicles*	*Safety*	



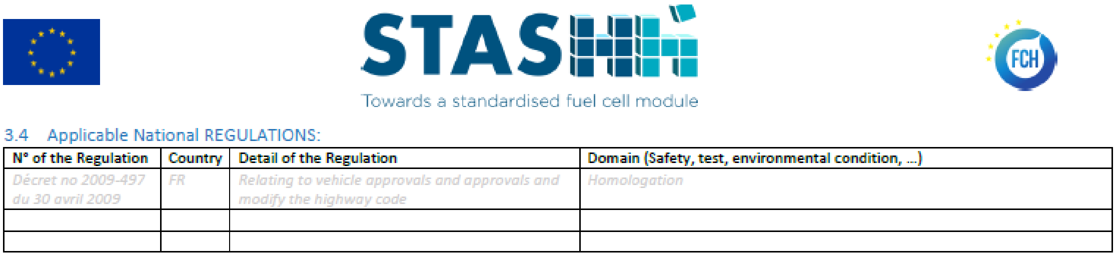
3.2 Applicable European REGULATIONS:

N° of the Regulation	**Detail of the Regulation**	**Domain (Safety, test, environmental condition, …)**
REGULATION (EC) No 79/2009	*On type-approval of hydrogen-powered motor vehicles, and amending Directive 2007/46/EC*	*Safety, homologation,*



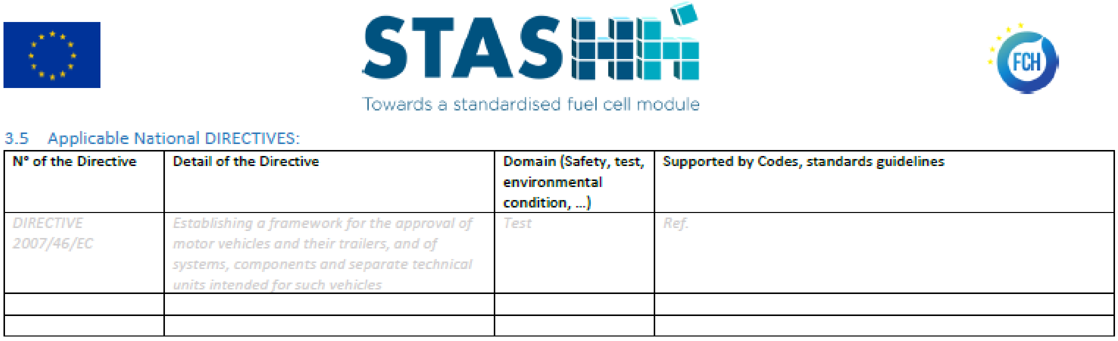
3.3 Applicable European DIRECTIVES:

N° of the Regulation	**Detail of the Regulation**	**Domain (Safety, test, environmental condition, …)**
REGULATION (EC) No 79/2009	*On type-approval of hydrogen-powered motor vehicles, and amending Directive 2007/46/EC*	*Safety, homologation,*



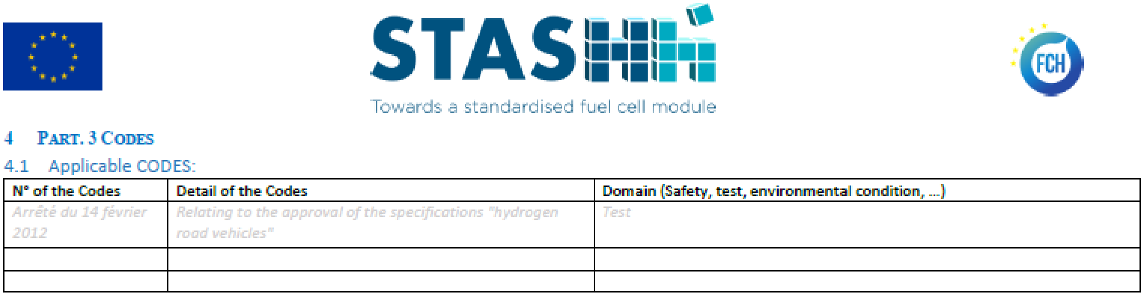
3.4 Applicable National REGULATIONS:

N° of the Regulation	**Country**	**Detail of the Regulation**	**Domain (Safety, test, environmental condition, …)**
Décret no 2009-497 du 30 avril 2009	*FR*	*Relating to vehicle approvals and approvals and modify the highway code*	*Homologation*



3.5 Applicable National DIRECTIVES:

N° of the Directive	**Detail of the Directive**	**Domain (Safety, test, environmental condition, …)**	**Supported by Codes, standards guidelines**
DIRECTIVE 2007/46/EC	*Establishing a framework for the approval of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles*	*Test*	*Ref.*



4 PART. 3 CODES

4.1 Applicable CODES:

N° of the Codes	Detail of the Codes	Domain (Safety, test, environmental condition, …)
Arrêté du 14 février 2012	*Relating to the approval of the specifications "hydrogen road vehicles"*	*Test*

5 PART. 4 STANDARDS

5.1 Applicable International Standards:

N° of the Standards	Stability date	Detail of the Standards	Domain (Safety, test, environmental condition, …)	Statutory[3]/ Non-statutory
ISO 23273 : 2013	*Eg 2016*	*Fuel cell road vehicles — Safety specifications — Protection against hydrogen hazards for vehicles fuelled with compressed hydrogen*	*Safety*	
ISO 26262 : 2018		*Road vehicles — Functional safety — Part 9: Automotive safety integrity level (ASIL)-oriented and safety-oriented analyses*	*Safety*	

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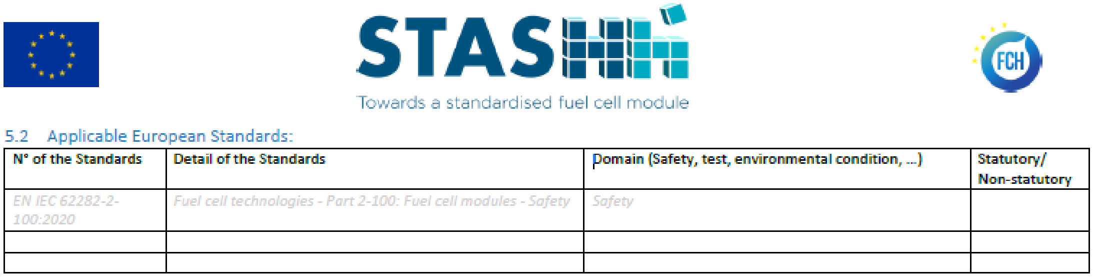
[3] Non-statutory standards: This type of standards, also named as voluntary, is generally established by a private sector and made available to persons or organizations, whether private or public, to use. Also considered voluntary standards are those known as "industry standards" or "consensus standards".

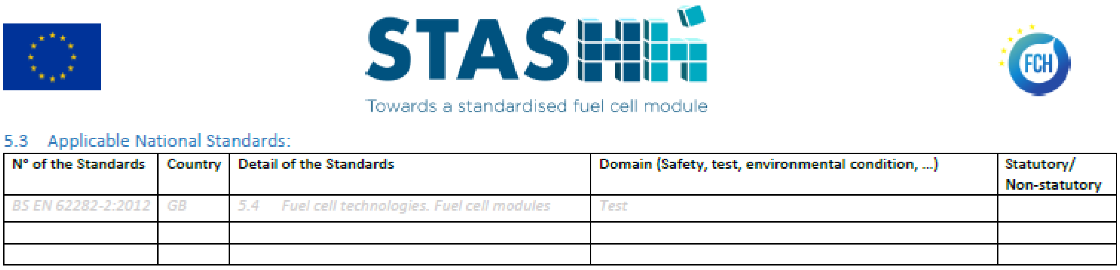
Statutory standards. This type of standards, also named as mandatory, requires compliance because of a European regulation or national statue, an organization internal policy or contractual requirement. Failure to comply with a mandatory standard's guidelines can cause legal repercussions.

Survey of RCS bodies 11/14 *STASHH, WP6, March 2021_V2*



5.2 Applicable European Standards:

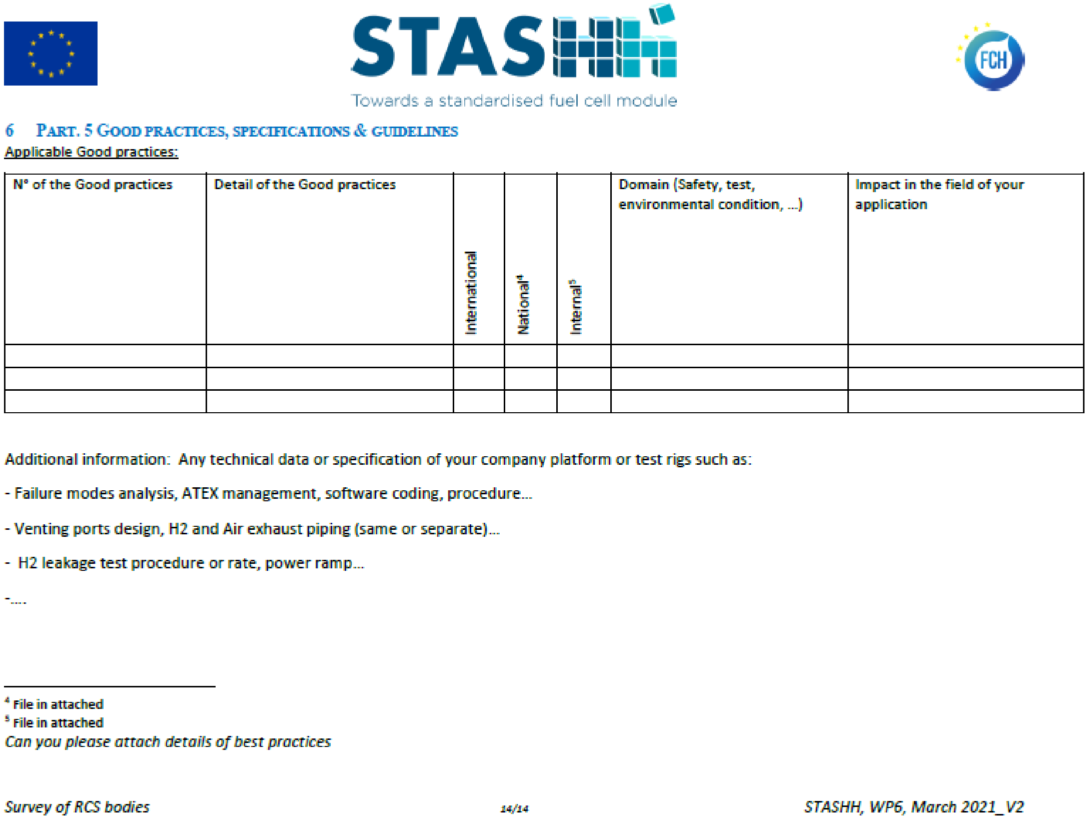
N° of the Standards	Detail of the Standards	Domain (Safety, test, environmental condition, …)	Statutory/ Non-statutory
EN IEC 62282-2-100:2020	*Fuel cell technologies - Part 2-100: Fuel cell modules - Safety*	*Safety*	



Towards a standardised fuel cell module

5.3 Applicable National Standards:

N° of the Standards	Country	Detail of the Standards	Domain (Safety, test, environmental condition, …)	Statutory/ Non-statutory
BS EN 62282-2:2012	GB	5.4 Fuel cell technologies. Fuel cell modules	Test	



Towards a standardised fuel cell module

6 PART. 5 GOOD PRACTICES, SPECIFICATIONS & GUIDELINES

Applicable Good practices:

N° of the Good practices	Detail of the Good practices	International	National[4]	Internal[5]	Domain (Safety, test, environmental condition, …)	Impact in the field of your application

Additional information: Any technical data or specification of your company platform or test rigs such as:

- Failure modes analysis, ATEX management, software coding, procedure…
- Venting ports design, H2 and Air exhaust piping (same or separate)…
- H2 leakage test procedure or rate, power ramp…

-….

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[4] File in attached
[5] File in attached

Can you please attach details of best practices

Survey of RCS bodies 14/14 *STASHH, WP6, March 2021_V2*

APPENDIX 3.The areas of action of the technical committees listed in the Figure 7

- CEN/TC 268:
  Domain: Cryogenic vessels and specific hydrogen technologies applications
  Scope: Standardization in the field of insulated vessels (vacuum or non- vacuum) for the storage and the transport of refrigerated liquefied gases, as defined in Class 2 of "Recommendations on the Transport of dangerous goods - Model regulation", in particular concerning the design of the vessels and their safety accessories, gas/materials compatibility, insulation performance, the operational requirements of the equipment and accessories. The preparation of standards for hydrogen refuelling points. *(source CEN/TC 268)*
  In the hydrogen application for transport, CEN/ TC 268 'Cryogenic vessels and specific hydrogen technologies applications (WG5)' will complete the revision of the standard EN 17124, dedicated to product specification and quality assurance for Proton exchange membrane (PEM) fuel cell applications for hydrogen propelled road vehicles. *(source CEN-CENELEC Work Programme 2021-UK)*

- IEC/TC 105:
  Domain: Fuel cell technologies.
  Scope: To prepare international standards regarding fuel cell (FC) technologies for all FC types and various associated applications such as stationary FC power systems for distributed power generators and combined heat and power systems, FCs for transportation such as propulsion systems (see note below), range extenders, auxiliary power units, portable FC power systems, micro FC power systems, reverse operating FC power systems, and general electrochemical flow systems and processes.
  NOTE: Projects with applications in the field of road vehicles will be coordinated with ISO TC 22 and its relevant SCs using the cooperation modes defined in the ISO/IEC Directives.
  (source: https://www.iec.ch/ords/f?p=103:7:506868810341805::::FSP_ORG_ID:1309)

- IEC/TC 9:
  Domain: Electrical equipment and systems for railways
  Scope: To prepare international standards for the railways field which includes rolling stock, fixed installations, management systems (including communication, signalling and processing systems) for railway operation, their interfaces and their ecological environment. These standards cover railway networks, metropolitan transport networks (including metros, tramways, trolleybuses and fully automated transport systems) and magnetic levitated transport systems.
  These standards relate to systems, components and software and they will deal with electrical, electronic and mechanical aspects, the latter being limited to items depending on electrical factors.
  These standards deal with electromechanical and electronic aspects of power components as well as with electronic hardware and software components.
  (source: https://www.iec.ch/dyn/www/f?p=103:7:::::FSP_ORG_ID:1248)

- ISO/TC 197:
  Domain: Hydrogen technology.
  Scope: Standardization in the field of systems and devices for the production, storage, transport, measurement and use of hydrogen.

(source: https://www.iso.org/committee/54560.html).

- ISO/TC 22:
  Domain: Road vehicle.
  Scope: All questions of standardization concerning compatibility, interchangeability and safety, with particular reference to terminology and test procedures (including the characteristics of instrumentation) for evaluating the performance of the following types of road vehicles and their equipment as defined in the relevant items of Article 1 of the convention on Road Traffic, Vienna in 1968 concluded under the auspices of the United Nations:
    - ☞ mopeds (item m);
    - ☞ motor cycles (item n);
    - ☞ motor vehicles (item p);
    - ☞ trailers (item q);
    - ☞ semi-trailers (item r);
    - ☞ light trailers (item s);
    - ☞ combination vehicles (item t);
    - ☞ articulated vehicles (item u).

  (source https://www.iso.org/committee/46706.html).

- ISO/TC 58:
  Domain: Gas cylinders
  Scope: Standardization of gas cylinders and other pressure receptacles, their fittings and requirements relating to their manufacture and use.
  Excluded: Cryogenic vessels (ISO/TC 220) and aerosol containers.
  NOTE: Pressure receptacles, cryogenic receptacles and aerosols are defined in the international regulations for the transport of dangerous goods by sea, air, road and rail and in the United Nations Recommendations on the Transport of Dangerous Goods, Model Regulations (ST/SG/AC.10/1 as amended from time to time).
  (Source: https://www.iso.org/committee/49008.html)

- ISO/TC 158:
  Domain: Analysis of gases
  Scope: Standardization in the field of analysis of gases, including:
    - ☞ terminology;
    - ☞ preparation of gas mixtures;
    - ☞ sampling;
    - ☞ transfer lines;
    - ☞ analytical methods including evaluation of characteristics of the analysers.

  Excluded:
    - ☞ subjects falling within the scope of any other ISO technical committee (e.g. ISO / TC 28, ISO / TC 146 and ISO / TC 193) unless specifically requested.

  (Source: https://www.iso.org/committee/53314.html)

- ISO/TC 220:
  Domain: Cryogenic vessels

Scope: Standardization in the field of insulated vessels (vacuum or non-vacuum) for the storage and the transport of refrigerated liquefied gases of class 2 of "Recommendations on the Transport of Dangerous Goods - Model regulations - of the United Nations", in particular concerning the design of the vessels and their safety accessories, gas / materials compatibility, insulation performance, the operational requirements of the equipment and accessories. *(Source: https://www.iso.org/committee/54990.html)*

- UN/ECE/GTR13 - Global Technical Regulation No.13:
  Domain: Hydrogen and fuel cell vehicles. (Global Regulations (1998 agreement)).

APPENDIX 4.Terminology – Glossary

ABS	American Bureau of Shipping (one of classification Societies)
ADN	European agreement concerning the international Carriage of Dangerous Goods by inland waterways
ADR	European agreement concerning the International Carriage of Dangerous Goods by Road
ASTM	International Association for Testing and Materials (American)
ATEX	Explosive atmosphere (EU Directive)
BS	British Standards
BV	Bureau Veritas (One of Classification Societies)
CCC	Sub-Committee on Carriage of Cargoes and Containers
CCNR	Central Commission for the Navigation of the Rhine (CCNR
CEA	Atomic Energy and Alternatives Energies Commission
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CESNI	European Committee For Drawing Up Standards In The Field Of Inland Navigation
DIN	Deutsches Institut für Normung: German standardization body
DNV-GL	Norwegian service company for quality and risk management (One of classification Societies - On 1 March 2021,DNV GL becomes DNV)
EC	European Commission
EEA	The European Economic Area was established via the Agreement on the European Economic Area, an international agreement which enables the extension of the European Union's single market to member states of the European Free Trade Association.
EMC	ElectroMagnetic Compatibility
EMSA	European Maritime Safety Agency
ERA	European Railway Agency
ES-TRIN	European Standard laying down technical requirements for inland navigation (vessels)
EU	European Union
FC	Fuel Cell
FCH	Fuel Cells and Hydrogen
FCH JU	Fuel Cells and Hydrogen Joint Undertaking
FCM	Fuel Cell Module
FCPS	Fuel Cell Power System
FPS	Future Proof of Shipping
GO	Governmental Organization
GTR	Global Technical Regulations (UN/ECE)
HVFC	Hydrogen Vehicle Fuel Cell
IACS	International Association of classification Societies: DNV, LR, ABS, RL are members

IEC	International Electrotechnical Commission
IMO	International Maritime Organization
IS	Italian Standard
ISO	International Organization for Standardization
JTC	Joint Technical Committee
JU	Joint Undertaking
LPG	Liquefied Petroleum Gas
LR	Lloyd’s Register (One of classification Societeies)
MSC.	Maritime Safety Committee
NF	French Standard
NGO	Non-Governmental Organization
NWP	NWP = Nominal Working Pressure (SAE/EC regulation terminology) - WP = Working Pressure (ISO terminology)
PNR	Passenger Name Record
RCS	Regulations, Codes and Standards
RCSS	Regulations, Codes, Standards and Safety
RCS SC	Regulations, Codes and Standards Strategy Coordination
RID	Convention of the International Carriage of Dangerous Goods by Rail
SOLAS	International Convention for the Safety of Life at Sea (IMO)
StasHH	Standard-Sized Heavy-duty Hydrogen
STU	Separate Technical Unit
TC	Technical Committee (for developments of IEC and ISO standards)
U. S.	United States
UIC	International Union of Railway
UN	Union Nation
UN/ECE	Economic Commission for Europe of the United Nations (UN/ECE)
WG	Working Group
WP	Work Package

ANNEX

RCS sheet

DIRECTIVE N° 2014/34 (EU)

A. IDENTITY CARD OF DIRECTIVE N° 2014/34 (EU)

RCS	Number of RCS	Title	Date	Stability date	Statutory
DIRECTIVE	2014/34/EU	On the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres	26/02/2014	OJ L 96, 29.3.2014, p. 309–356	Yes

Scope:

- (a) equipment and protective systems intended for use in potentially explosive atmospheres;
- (b) safety devices, controlling devices and regulating devices intended for use outside potentially explosive atmospheres but required for or contributing to the safe functioning of equipment and protective systems with respect to the risks of explosion;
- (c) components intended to be incorporated into equipment and protective systems referred to in point (a)

Domain/category: ATEX

Specifed exclusion:

- (a) medical devices intended for use in a medical environment;
- (b) equipment and protective systems where the explosion hazard results exclusively from the presence of explosive substances or unstable chemical substances;
- (c) equipment intended for use in domestic and non-commercial environments where potentially explosive atmospheres may only rarely be created, solely as a result of the accidental leakage of fuel gas;
- (d) personal protective equipment covered by Council Directive 89/686/EEC of 21 December 1989 on the approximation of the laws of the Member States relating to personal protective equipment (9);
- (e) seagoing vessels and mobile offshore units together with equipment on board such vessels or units;
- (f) means of transport, i.e. vehicles and their trailers intended solely for transporting passengers by air or by road, rail or water networks, as well as means of transport in so far as such means are designed for transporting goods by air, by public road or rail networks or by water. Vehicles intended for use in a potentially explosive atmosphere shall not be excluded from the scope of this Directive;

(g) the equipment covered by point (b) of Article 346(1) of the Treaty on the Functioning of the European Union.

Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

Conditions	Item	Documentation	Additional Description	Information
Annex I Criteria determining the classification of equipment-groups into categories	2. Equipment-group II		(a) Equipment category 1 comprises equipment designed to be capable of functioning in conformity with the operational parameters established by the manufacturer and ensuring a very high level of protection. Equipment in this category is intended for use in areas in which explosive atmospheres caused by mixtures of air and gases, vapours or mists or by air/dust mixtures are present continuously, for long periods or frequently. Equipment in this category must ensure the requisite level of protection, even in the event of rare incidents relating to equipment, and is characterised by means of protection such that: — either, in the event of failure of one means of protection, at least an independent second means provides the requisite level of protection, — or the requisite level of protection is assured in the event of two faults occurring independently of each other. Equipment in this category must comply with the supplementary requirements referred to in point 2.1 of Annex II. (b) Equipment category 2 comprises equipment designed to be capable of functioning in conformity with the operational parameters established by the manufacturer and of ensuring a high level of protection. Equipment in this category is intended for use in areas in which explosive atmospheres caused by gases, vapours, mists or air/dust mixtures are likely to occur occasionally. The means of protection relating to equipment in this category ensure the requisite level of protection, even in the event of frequently occurring	

Conditions	Item	Documentation	Additional Description	Information
			disturbances or equipment faults which normally have to be taken into account. Equipment in this category must comply with the supplementary requirements referred to in point 2.2 of Annex II. (c) Equipment category 3 comprises equipment designed to be capable of functioning in conformity with the operating parameters established by the manufacturer and ensuring a normal level of protection. Equipment in this category is intended for use in areas in which explosive atmospheres caused by gases, vapours, mists, or air/dust mixtures are unlikely to occur or, if they do occur, are likely to do so only infrequently and for a short period only. Equipment in this category ensures the requisite level of protection during normal operation. Equipment in this category must comply with the supplementary requirements referred to in point 2.3 of Annex II.	
Annex II essential health and safety requirements relating to the design and construction of equipment and protective	1. Common requirements for Equipment and protective systems	1.1. Selection of materials	1.1.1. The materials used for the construction of equipment and protective systems must not trigger off an explosion, taking into account foreseeable operational stresses. 1.1.2. Within the limits of the operating conditions laid down by the manufacturer, it must not be possible for a reaction to take place between the materials used and the constituents of the potentially explosive atmosphere which could impair explosion protection. 1.1.3. Materials must be so selected that predictable changes in their characteristics and their compatibility in combination with other materials will not lead to a reduction in the protection afforded; in particular, due account	

Conditions	Item	Documentation	Additional Description	Information
systems intended for use in potentially explosive atmospheres			must be taken of the material's corrosion and wear resistance, electrical conductivity, mechanical strength, ageing resistance and the effects of temperature variations.	
Annex II	1. Common requirements for Equipment and protective systems	1.2. Design and construction	1.2.1. Equipment and protective systems must be designed and constructed with due regard to technological knowledge of explosion protection so that they can be safely operated throughout their foreseeable lifetime. 1.2.2. Components to be incorporated into or used as replacements in equipment and protective systems must be so designed and constructed that they function safely for their intended purpose of explosion protection when they are installed in accordance with the manufacturer's instructions.	
Annex II	1. Common requirements for Equipment and protective systems	1.2. Design and construction 1.2.3. Enclosed structures and prevention of leaks	Equipment which may release flammable gases or dusts must wherever possible employ enclosed structures only. If equipment contains openings or non-tight joints, these must as far as possible be designed in such a way that releases of gases or dusts cannot give rise to explosive atmospheres outside the equipment. Points where materials are introduced or drawn off must, as far as possible, be designed and equipped so as to limit releases of flammable materials during filling or draining	
Annex II	1. Common requirements for Equipment and protective systems	1.2. Design and construction 1.2.4. Dust deposits	Equipment and protective systems which are intended to be used in areas exposed to dust must be so designed that deposit dust on their surfaces is not ignited.	

Conditions	Item	Documentation	Additional Description	Information
			In general, dust deposits must be limited where possible. Equipment and protective systems must be easily cleanable. The surface temperatures of equipment parts must be kept well below the glow temperature of the deposit dust. The thickness of deposit dust must be taken into consideration and, if appropriate, means must be taken to limit the temperature in order to prevent a heat build up.	
Annex II	1. Common requirements for Equipment and protective systems	1.2. Design and construction 1.2.7. Protection against other hazards	Equipment and protective systems must be so designed and manufactured as to: (a) avoid physical injury or other harm which might be caused by direct or indirect contact; (b) assure that surface temperatures of accessible parts or radiation which would cause a danger, are not produced; (c) eliminate non-electrical dangers which are revealed by experience; (d) assure that foreseeable conditions of overload do not give rise to dangerous situations. Where, for equipment and protective systems, the risks referred to in this point are wholly or partly covered by other Union legislation, this Directive shall not apply or shall cease to apply in the case of such equipment and protective systems and of such risks upon application of that specific Union legislation.	
Annex II	1. Common requirements for Equipment and protective systems	1.2. Design and construction 1.2.8. Overloading of equipment	Dangerous overloading of equipment must be prevented at the design stage by means of integrated measurement, regulation and control devices, such as over-current cut-off switches, temperature limiters, differential pressure switches, flowmeters, time-lag relays, overspeed monitors and/or similar types of monitoring devices.	

Conditions	Item	Documentation	Additional Description	Information
Annex II	1. Common requirements for Equipment and protective systems	1.2. Design and construction 1.2.9. Flameproof enclosure systems	If parts which can ignite an explosive atmosphere are placed in an enclosure, measures must be taken to ensure that the enclosure withstands the pressure developed during an internal explosion of an explosive mixture and prevents the transmission of the explosion to the explosive atmosphere surrounding the enclosure.	
Annex II	1. Common requirements for Equipment and protective systems	1.3 Potential ignition sources 1.3.1. Hazards arising from different ignition sources	Potential ignition sources such as sparks, flames, electric arcs, high surface temperatures, acoustic energy, optical radiation, electromagnetic waves and other ignition sources must not occur.	
Annex II	1. Common requirements for Equipment and protective systems	1.3 Potential ignition sources 1.3.2. Hazards arising from static electricity	Electrostatic charges capable of resulting in dangerous discharges must be prevented by means of appropriate measures.	
Annex II	1. Common requirements for Equipment and protective systems	1.3 Potential ignition sources 1.3.3. Hazards arising from stray electric and leakage currents	Stray electric and leakage currents in conductive equipment parts which could result in, for example, the occurrence of dangerous corrosion, overheating of surfaces or sparks capable of provoking an ignition must be prevented.	

Conditions	Item	Documentation	Additional Description	Information
Annex II	1. Common requirements for Equipment and protective systems	1.3 Potential ignition sources 1.3.4. Hazards arising from overheating	Overheating caused by friction or impacts occurring, for example, between materials and parts in contact with each other while rotating or through the intrusion of foreign bodies must, as far as possible, be prevented at the design stage.	
Annex II	1. Common requirements for Equipment and protective systems	1.3 Potential ignition sources 1.3.5. Hazards arising from pressure compensation operations	Equipment and protective systems must be so designed or fitted with integrated measuring, control and regulation devices that pressure compensations arising from them do not generate shock waves or compressions which may cause ignition.	
Annex II	1. Common requirements for Equipment and protective systems	1.4. Hazards arising from external effects	Equipment and protective systems must be so designed and constructed as to be capable of performing their intended function in full safety, even in changing environmental conditions and in the presence of extraneous voltages, humidity, vibrations, contamination and other external effects, taking into account the limits of the operating conditions established by the manufacturer. Equipment parts used must be appropriate to the intended mechanical and thermal stresses and capable of withstanding attack by existing or foreseeable aggressive substances.	
Annex II	2. Supplementary requirements in respect of equipment	2.1. Requirements applicable to equipment category 1 of	2.1.1.1. Equipment must be so designed and constructed that sources of ignition do not become active, even in event of rare incidents relating to equipment. It must be equipped with means of protection such that:	

Conditions	Item	Documentation	Additional Description	Information
		equipment-group II 2.1.1. Explosive atmospheres caused by gases, vapours or mists	— either, in the event of failure of one means of protection, at least an independent second means provides the requisite level of protection, — or, the requisite level of protection is ensured in the event of two faults occurring independently of each other. 2.1.1.2. For equipment with surfaces which may heat up, measures must be taken to ensure that the stated maximum surface temperatures are not exceeded even in the most unfavourable circumstances. Temperature rises caused by heat build-ups and chemical reactions must also be taken into account. 2.1.1.3. Equipment must be so designed that the opening of equipment parts which might be sources of ignition is possible only under non-active or intrinsically safe conditions. Where it is not possible to render equipment non-active, the manufacturer must affix a warning label to the opening part of the equipment. If necessary, equipment must be fitted with appropriate additional interlocking systems.	
Annex II	2. Supplementary requirements in respect of equipment	2.2. Requirements applicable to equipment category 2 of equipment-group II	2.2.1.1. Equipment must be so designed and constructed as to prevent ignition sources arising, even in the event of frequently occurring disturbances or equipment operating faults, which normally have to be taken into account. 2.2.1.2. Equipment parts must be so designed and constructed that their stated surface temperatures are not exceeded, even in the case of risks arising from abnormal situations anticipated by the manufacturer.	

Conditions	Item	Documentation	Additional Description	Information
		2.2.1. Explosive atmospheres caused by gases, vapours or mists	2.2.1.3. Equipment must be so designed that the opening of equipment parts which might be sources of ignition is possible only under non-active conditions or via appropriate interlocking systems. Where it is not possible to render equipment non-active, the manufacturer must affix a warning label to the opening part of the equipment.	
Annex II	2. Supplementary requirements in respect of equipment	2.3. Requirements applicable to equipment category 3 of equipment-group II 2.3.1. Explosive atmospheres caused by gases, vapours or mists	2.3.1.1. Equipment must be so designed and constructed as to prevent foreseeable ignition sources which can occur during normal operation. 2.3.1.2. Surface temperatures must not exceed the stated maximum surface temperatures under intended operating conditions. Higher temperatures in exceptional circumstances may be allowed only if the manufacturer adopts special additional protective measures.	

REGULATION N° 1301/2014 (EU)

A. IDENTITY CARD OF REGULATION N° 1301/2014 (EU)

RCS	N°	Title	Date	Stability date	Statutory
Regulation	1301/2014	Commission Regulation (EU) on Technical specifications for interoperability relating to the "energy" subsystem of the rail system in the Union	18/11/2014	OJ L 356, 12.12.2014, p. 179–227	Y

Scope: This TSI concerns the energy subsystem and part of the maintenance subsystem of the Union rail system in accordance with Article 1 of Directive (EU) 2016/797.

Domain/category: Railway in Europe

Specifed exclusion: /

Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

Conditions	Item	Documentation	Additional Description	Information
4. CHARACTERISATION OF THE SUBSYSTEM 4.2. Functional and technical specifications of the subsystem	4.2.3. Voltage and frequency		*(1) The voltage and frequency of the energy subsystem shall be one of the four systems, specified in accordance with Section 7:* *(a) AC 25 kV, 50 Hz;* *(b) AC 15 kV, 16,7 Hz;* *(c) DC 3 kV;* *(d) DC 1,5 kV.* *(2) The values and limits of the voltage and frequency shall comply with EN 50163:2004, clause 4 for the selected system.*	
4. CHARACTERISATION OF THE SUBSYSTEM 4.2. Functional and technical specifications of the subsystem	4.2.4. Parameters relating to supply system performance		*The following parameters shall be taken in consideration:* *(a) maximum train current (4.2.4.1);* *(b) power factor of trains and the mean useful voltage (4.2.4.2).*	
4. CHARACTERISATION OF THE SUBSYSTEM 4.2. Functional and technical specifications of the subsystem	4.2.4. Parameters relating to supply system performance	4.2.4.1. Maximum train current	*The energy subsystem design shall ensure the ability of the power supply to achieve the specified performance and allow the operation of trains with a power less than 2 MW without power or current limitation*	
4. CHARACTERISATION OF THE SUBSYSTEM 4.2. Functional and technical specifications of the subsystem	4.2.4. Parameters relating to supply system performance	4.2.4.2. Mean useful voltage	*The calculated mean useful voltage 'at the pantograph' shall comply with EN 50388:2012, clause 8 (except clause 8.3 that is replaced by point C.1 of Appendix C). Simulation shall take into account values of the real power factor of trains. Point C.2 of Appendix C provides additional information to clause 8.2 of the EN 50388:2012*	

Conditions	Item	Documentation	Additional Description	Information
4. CHARACTERISATION OF THE SUBSYSTEM 4.2. Functional and technical specifications of the subsystem	4.2.5. Current at standstill (DC systems only)		*(1) The OCL of DC systems shall be designed to sustain 300 A (for a 1,5 kV supply system) and 200 A (for a 3 kV supply system), per pantograph when the train is at standstill.* *(2) The current capacity at standstill shall be achieved for the test value of static contact force given in table 4 of clause 7.2 of EN 50367:2012.* *(3) The OCL shall be designed taking into account the temperature limits in accordance with EN 50119:2009, clause 5.1.2.*	
Chapter 6: ASSESSMENT OF CONFORMITY OF THE INTEROPERABILITY CONSTITUENTS AND EC VERIFICATION OF THE SUBSYSTEMS 6.2 Energy subsystem	6.2.3. Innovative solutions		*If an innovative solution is proposed for the energy subsystem, the procedure described in Article 10 of this Regulation shall apply.* *Article 10: Innovative solutions* *1. In order to keep pace with technological progress, innovative solutions may be required, which do not comply with the specifications set out in the Annex or for which the assessment methods set out in the Annex cannot be applied.* *2. Innovative solutions may relate to the energy subsystem, its parts and its interoperability constituents.* *3. If an innovative solution is proposed, the manufacturer or his authorised representative established within the Union shall declare how it deviates from or complements the relevant provisions of this TSI and submit the deviations to the Commission for analysis. The Commission may request the opinion of the Agency on the proposed innovative solution.* *4. The Commission shall deliver an opinion on the proposed innovative solution. If this opinion is positive, the appropriate functional and interface specifications and the assessment method, which need to be included in the TSI in order to allow the use of this innovative solution,*	

Conditions	Item	Documentation	Additional Description	Information
			shall be developed and subsequently integrated in the TSI during the revision process pursuant to ►M2 Article 5 of Directive (EU) 2016/797 ◄ . If the opinion is negative, the innovative solution proposed cannot be used. *5. Pending the review of the TSI, the positive opinion delivered by the Commission shall be considered as an acceptable means of compliance with the essential requirements of ►M2 Directive (EU) 2016/797 ◄ and may be used for the assessment of the subsystem.*	
Chapter 6: ASSESSMENT OF CONFORMITY OF THE INTEROPERABILITY CONSTITUENTS AND EC VERIFICATION OF THE SUBSYSTEMS	6.2.4. Particular assessment procedures for energy subsystem	6.2.4.1. Assessment of mean useful voltage	*(1) The assessment shall be demonstrated in accordance with EN 50388:2012, clause 15.4.* *(2) The assessment shall be demonstrated only in the case of newly build or upgraded sub-systems.*	
6.2 Energy subsystem	6.2.4. Particular assessment procedures for energy subsystem	6.2.4.3. Assessment of electrical protection coordination arrangements	*The assessment shall be demonstrated for design and operation of substations in accordance with EN 50388:2012, clause 15.6.*	
Chapter 6: ASSESSMENT OF CONFORMITY OF THE INTEROPERABILITY CONSTITUENTS AND EC VERIFICATION OF THE SUBSYSTEMS	6.2.4. Particular assessment procedures for energy subsystem	6.2.4.5. Assessment of dynamic behaviour and quality of current collection (integration	*(1) The main goal of this test is to identify allocation design and construction errors but not to assess the basic design in principle.* *(2) Measurements of the interaction parameters shall be carried out in accordance with EN 50317:2012.* *(3) These measurements shall be carried out with an interoperability constituent pantograph, exhibiting the mean contact force*	

Conditions	Item	Documentation	Additional Description	Information
		into a subsystem)	*characteristics as required by point 4.2.11 of this TSI for the design speed of the line considering aspects related to minimum speed and siding tracks.* *(4) The installed overhead contact line shall be accepted if the measurement results comply with the requirements in point 4.2.12.* *(5) For operational speeds up to 120 km/h (AC systems) and up to 160 km/h (DC systems), measurement of the dynamic behaviour is not mandatory. In this case alternative methods of identifying construction errors shall be used, such as measurement of OCL geometry according to point 4.2.9.* *(6) Assessment of dynamic behaviour and quality of current collection for integration of the pantograph into rolling stock subsystem are set out in point 6.2.3.20 of LOC & PAS TSI*	

Annex 3: REGULATION N° 2018/858 (EU)

REGULATION N° 2018/858 (EU)

A. IDENTITY CARD OF REGULATION N° 2018/858

RCS	Number of RCS (with link)	Title	Date	Stability date	Statutory
Regulation	2018/858	Regulation (EU) 2018/858 of the european parliament and of the council: on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles, amending Regulations (EC) No 715/2007 and (EC) No 595/2009 and repealing Directive 2007/46/EC (Text with EEA relevance)	30 May 2018	OJ L 151 du 14.6.2018, p. 1–218	Yes

Scope: This Regulation applies to motor vehicles of categories M and N and their trailers of category O, that are intended to be used on public roads, including those designed and constructed in one or more stages, and to systems, components and separate technical units, as well as to parts and equipment, designed and constructed for such vehicles and their trailers.

The regulation 2018/858 is linked to the Directive 2007/46/EC of the European Parliament and of the Council, which establishes a comprehensive EU framework for the approval of motor vehicles and their trailers, and of the systems, components and separate technical units intended for such vehicles. Prototypes of vehicles used on the road under the responsibility of a manufacturer to perform a specific test programme provided they have been specifically designed and constructed for that purpose

Domain/category: M (carriage of passengers), N (carriage of goods), O (their trailers), systems, composants et STU (separate technical units).

Specified exclusion: (Chapter I, Article 2, Paragraph 2) This Regulation does not apply to the following vehicles:

- Agricultural or forestry vehicles, as defined in Regulation (EU) No 167/2013 of the European Parliament and of the Council

- Two- or three-wheel vehicles and quadricycles, as defined in Regulation (EU) No 168/2013 of the European Parliament and of the Council
- Track-laying vehicles
- Vehicles designed and constructed or adapted for use by the armed services only.

Reference included in this RCS: /

Note: annex II to Regulation (EU) 2018/858 of the European Parliament and of the Council will be updated to incorporate the various developments identified in Regulation (EU) 2019/2144 of the European Parliament and of the Council. These modifications in future version of regulation 2018/858 are summarized at the end of the sheet concerning the regulation (EU) 2019/2144.

For this last, this Regulation shall enter into force on the twentieth day following that of its publication in the Official Journal of the European Union. It shall apply from 6 July 2022.

B. RELEVANT PARTS FOR STASHH PROJECT

Note: The list of regulatory acts setting out the requirements for the purpose of EU type-approval of special purpose vehicles comes from the part III of annex II, following appendix are not taken into account for:

- Appendix1: “Motor-caravans, ambulances and hearses”
- Appendix 2: “Armoured vehicles”
- Appendix 3: “Wheelchair accessible vehicles”

Conditions	Item	Documentation	Additional Description	Information
Chapter II General obligations	Technical requirements	Chapter II, article 5, paragraph 1	*Vehicles, systems, components and separate technical units shall comply with the requirements of the regulatory acts listed* ***in Annex II*** See later in this table, the elements of Annex II relevant to the StasHH project The annex II of 2018/858 regulation will be modified. As it explains at the beginning of this sheet, a synthesis table of relevant modifications to the StasHH project, is reminded in sheet of the regulation 2019/2144	
Chapter II General obligations	Technical requirements	Chapter II, article 5, paragraph 2	*Vehicles, systems, components and separate technical units shall be considered not to comply with this Regulation in the following cases in particular:* *(a) if they deviate from the particulars in the EU type-approval certificates and their attachments or from the descriptive particulars in the test reports more than is permitted in the relevant regulatory act;* *(b) if the performance criteria or limit values for series production laid down in the relevant regulatory act have not been fulfilled under all the conditions set out in the relevant regulatory act;* *(c) if any information given by the manufacturer in the information document is not reproducible under all the conditions set out in the relevant regulatory act by approval authorities, market surveillance authorities or the Commission.*	

Conditions	Item	Documentation	Additional Description	Information
			Only checks, tests, inspections and assessments conducted by or carried out on behalf of the approval authorities, market surveillance authorities or the Commission shall be taken into account when assessing compliance for the purposes of this paragraph.	
Chapter II General obligations	Obligation of member states	Chapter II, article 6, paragraph 5	*Member States shall not prohibit, restrict or impede the placing on the market, the registration or the entry into service of vehicles, systems, components or separate technical units that comply with this Regulation, except in the cases provided for in Chapter XI.* *By way of derogation from the first subparagraph of this paragraph, Member States may decide not to allow the circulation on the road, the placing on the market, the registration or the entry into service of vehicles that have been type-approved in accordance with this Regulation, but that exceed the harmonised dimensions, weights and axle loads laid down in Annex I to Council Directive 96/53/EC*	Chapter XI of regulation 2018/858: ”Safeguard clauses”, Article 53: “Corrective and restrictive measures at Union level”, paragraph 2 Derogation
Chapter II, General obligations	Obligations of approval authorities	Chapter II, article 7, paragraph 1	*Approval authorities shall only approve vehicles, systems, components or separate technical units that comply with this Regulation.*	
Chapter II General obligations	General obligations of manufacturers	Chapter II, article 13, paragraph 1	*Manufacturers shall ensure that the vehicles, systems, components and separate technical units that they have manufactured and that are placed on the market have been manufactured and approved in accordance with the requirements laid down in this Regulation, and in particular, those in Article 5.*	
Chapter III Procedures for EU type-approval	Procedures for EU type-approval	Chapter III, article 22, paragraph 1	*Where applying for a whole-vehicle type-approval, the manufacturer may choose one of the following procedures:* *(a) step-by-step type-approval* *(b) single-step type-approval* *(c) mixed type-approval* *In addition, the manufacturer may choose a multi-stage type-approval for an incomplete or completed vehicle.*	The relevant procedure in the StasHH project remains to be determined

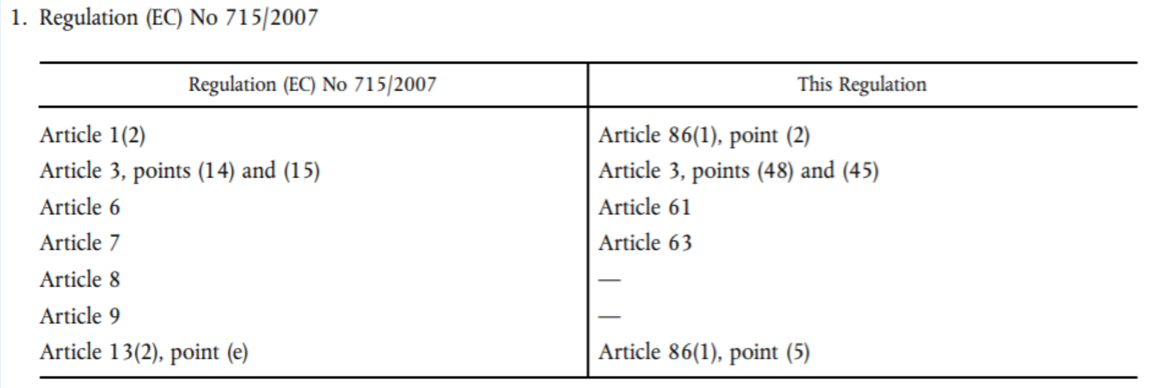
Conditions	Item	Documentation	Additional Description	Information
Chapter III Procedures for EU type-approval	Procedures for EU type-approval	Chapter III, article 22, paragraph 2	*Without prejudice to the requirements of the regulatory acts listed in Annex II, for system type-approval, component type-approval and separate technical unit type-approval only* ***the single-step type-approval*** *is applicable.*	In link with article 22, paragraph 1
Chapter III Procedures for EU type-approval	Procedures for EU type-approval	Chapter III, article 22, paragraph 4	*The EU type-approval for the final stage of completion shall only be granted after the approval authority has verified, in accordance with the procedures laid down in Annex IX, that the type of vehicle approved at the final stage meets all applicable technical requirements at the time of the approval. Verification shall include a documentary check of all requirements covered by an EU type-approval for an incomplete type of vehicle granted in the course of a multi-stage procedure, including where the EU type-approval was granted for a different category of vehicle.*	
Chapter III Procedures for EU type-approval	Procedures for EU type-approval	Chapter III, article 22, paragraph 6	*Multi-stage type-approval may also be used by a single manufacturer, provided it is not used to circumvent the requirements applicable to vehicles built in a single stage. Vehicles built by a single manufacturer are not considered to have been built in multiple stages for the purposes of Articles 41, 42 and 49*	
Chapter iv Conduct of procedures for EU type-approval	General provisions on conduct of procedures for EU type-approval	Chapter IV, Article 26, Paragraph 2	*An approval authority, having received an application in accordance with Article 23, shall only grant an EU type-approval after having verified all of the following:* *…* *(c) the compliance of the type of vehicle, system, component or separate technical unit with the applicable requirements* *(d) in the case of whole-vehicle type-approvals in accordance with the step-by-step, mixed or multi-stage type-approval procedures, the approval authority shall verify, in accordance with Article 22(4), that the systems, components and separate technical units are covered by separate and valid type-approvals that have been granted pursuant to the requirements applicable at the time of the granting of the whole-vehicle type-approval.*	Sub-paragraph (d) in link with article 22, paragraph 4, if requirement is maintained
Chapter iv Conduct of procedures for EU type-approval	General provisions on conduct of procedures for EU type-approval	Chapter IV, Article 26, Paragraph 3	*The procedures with respect to EU type-approval, that are set out in Annex III, and the procedures with respect to multi-stage type-approval, set out in Annex IX, shall apply.*	Chapter XVI Delegated and implementing powers

Conditions	Item	Documentation	Additional Description	Information
				Article 82 - exercise of the delegation
Chapter iv Conduct of procedures for EU type-approval	Tests required for EU type-approval	Chapter IV, Article 30, Paragraph 5	*The required tests shall be performed on vehicles, systems, components and separate technical units that are representative of the type to be approved.*	
Chapter VII New Technologies Or New Concepts	Exemptions for new technologies or new concepts	Chapter VII, article 39, paragraph 1	*The manufacturer may apply for an EU type-approval in respect of a type of vehicle, system, component or separate technical unit that incorporates new technologies or new concepts that are incompatible with one or more regulatory acts listed in Annex II.*	
Chapter VII New Technologies Or New Concepts	Exemptions for new technologies or new concepts	Chapter VII, article 39, paragraph 2	*The approval authority shall grant the EU type-approval referred to in paragraph 1 where all of the following conditions are met:* *(a) the application for the EU type-approval states the reasons why the new technologies or new concepts make the vehicles, systems, components or separate technical units incompatible with one or more regulatory acts listed in Annex II* *(b) the application for the EU type-approval describes the safety and environmental implications of the new technology or new concept and the measures taken in order to ensure at least an equivalent level of safety and environmental protection to that provided by the requirements in respect of which an exemption is sought* *(c) test descriptions and results are presented proving that the condition in point (b) is met.*	
Chapter VII New Technologies Or New Concepts	Exemptions for new technologies or new concepts	Chapter VII, article 39, paragraph 3	*The granting of EU type-approvals exempting new technologies or new concepts shall be subject to the authorisation by the Commission.*	
Chapter VII New Technologies	Exemptions for new technologies	Chapter VII, article 39, paragraph 4	*Pending adoption of implementing acts referred to in paragraph 3, the approval authority may grant a provisional EU type-approval, valid only in the territory of the Member State of that approval authority, in respect of a type of vehicle covered by the exemption sought. The*	

Conditions	Item	Documentation	Additional Description	Information
Or New Concepts	or new concepts		*approval authority shall inform the Commission and the other Member States thereof without delay by means of a file containing the information referred to in paragraph 2.* *The provisional nature and the limited territorial validity of the EU type-approval shall be apparent from the heading of the EU type-approval certificate and the heading of the certificate of conformity*	
Chapter IX Individual vehicle approvals	EU individual vehicle approvals	Chapter IX, article 44, paragraph 1	*Member States shall grant an EU individual vehicle approval for a vehicle that complies with the requirements laid down in Appendix 2 to Part I of Annex II or, for special purpose vehicles, in Part III of Annex II.* Part III of Annex II for special purpose concerns special purpose vehicles. But, in StasHH project, only these following appendixes are taken into account: - Appendix 4: Other special purpose vehicles (including special group, multi-equipment carrier and trailer caravans - Appendix 5: Mobile cranes - Appendix 6: Exceptional load transport vehicles Following special purpose vehicles are not taken into account in StasHH project: - Appendix 1: Motor-caravans, ambulances and hearses - Appendix 2: Armoured vehicles - Appendix 3: Wheelchair accessible vehicles	Appendix 2 to Part I of Annex II: this part concerns only vehicle categories M1 and N1. These categories are not into account in StasHH project
Chapter IX Individual vehicle approvals	Specific provisions	Chapter IX, Article 47, Paragraph 1	*The procedures set out in Article 44 may apply to a particular vehicle built in multiple stages.*	
Chapter IX Individual vehicle approvals	Specific provisions	Chapter IX, Article 47, Paragraph 2	*The procedures set out in Article 44 shall not replace an intermediate stage within the normal sequence of a multi-stage type-approval, and shall not apply for the purposes of obtaining the first-stage approval of a vehicle.*	
Chapter X making	Making available on	Chapter X, Article 50,	*Components and separate technical units, including those intended for the aftermarket, may only be made available on the market or entered into service if they comply with the*	

Conditions	Item	Documentation	Additional Description	Information
available on the market, registration or entry into service	the market or entry into service of components and separate technical units	Paragraph 1	*requirements of the relevant regulatory acts listed in Annex II and are marked in accordance with Article 38.*	
Chapter X making available on the market, registration or entry into service	Making available on the market or entry into service of components and separate technical units	Chapter X, Article 50, Paragraph 2	*Paragraph 1 shall not apply to components or separate technical units that are specifically constructed or designed for vehicles that are not covered by this Regulation.*	
Chapter X making available on the market, registration or entry into service	Making available on the market or entry into service of components and separate technical units	Chapter X, Article 50, Paragraph 3	*Member States may permit the making available on the market or the entry into service of components and separate technical units that are exempted under Article 39 or that are to be used on vehicles covered by approvals granted under Article 42 concerning the component or separate technical unit in question.*	
Chapter XII International regulations	UN Regulations required for EU type-approval	Chapter XI, Article 57, Paragraph 1	*UN Regulations or amendments thereto which the Union has voted in favour of, or that the Union applies and that are listed in Annex II, shall be part of the requirements for the EU type-approval of vehicles, systems, components or separate technical units.*	
Chapter XII International regulations	UN Regulations required for	Chapter XI, Article 57, Paragraph 2	*Where the Union has voted in favour of a UN Regulation or amendments thereto for the purpose of whole-vehicle type-approval, the Commission shall adopt delegated acts in accordance with Article 82, supplementing this Regulation by making that UN Regulation or the amendments thereto compulsory or amending this Regulation.*	Article 82: *Exercise of the delegation*

Conditions	Item	Documentation	Additional Description	Information
	EU type-approval			
Chapter XII International regulations	Equivalence of UN Regulations for the purpose of EU type-approval	Chapter XI, Article 58, Paragraph 1	*The UN Regulations listed in Part II of Annex II are recognised as being equivalent to the corresponding regulatory acts to the extent that they share the same scope and subject matter.*	
Chapter XII International regulations	Equivalence of UN Regulations for the purpose of EU type-approval	Chapter XI, Article 58, Paragraph 2	*The approval authorities of the Member States shall accept type-approvals granted in accordance with the UN Regulations referred to in paragraph 1 and, where applicable, shall accept the relevant approval marks in place of the corresponding type-approvals and approval marks that were granted in accordance with this Regulation and the regulatory acts listed in Annex II.*	
Chapter XIV access to vehicle obd information and vehicle repair and maintenance information	Obligations with regard to holders of several type-approvals	Chapter XIV, Article 62, Paragraph 1	*The manufacturer responsible for the respective type-approval of a system, component or separate technical unit or for a particular stage of a vehicle shall be responsible, in the event of a mixed type-approval, a step-by-step type approval or a multi-stage type-approval, for communicating to both the final manufacturer and the independent operators the repair and maintenance information relating to the particular system, component or separate technical unit or to the particular stage.*	
Chapter XIV access to vehicle obd information and vehicle repair and maintenance information	Obligations with regard to holders of several type-approvals	Chapter XIV, Article 62, Paragraph 2	*In the case of multi-stage type-approval, the final manufacturer shall be responsible for providing access to vehicle OBD information and vehicle repair and maintenance information regarding its own manufacturing stage or stages and the link to the previous stage or stages.*	

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr>
<td>Chapter XVII Final provisions</td>
<td>Amendments to Regulation (EC) No 715/2007</td>
<td>Chapter XVII Article 86, Paragraph 1</td>
<td>
Regulation (EC) No 715/2007 is amended as follows:
(1) The title is replaced by the following: ‘Regulation (EC) No 715/2007 of the European Parliament and of the Council of 20 June 2007 on type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6)
(2) In Article 1, paragraph 2 is replaced by the following: ‘2. In addition, this Regulation lays down rules for in-service conformity, the durability of pollution control devices, vehicle on-board diagnostic (OBD) systems and the measurement of fuel consumption.’;
(3) In Article 3, points 14 and 15 are deleted
(4) Chapter III is deleted
(5) In Article 13(2), point (e) is deleted. 2. References to the deleted provisions of Regulation (EC) No 715/2007 shall be construed as references to this Regulation and shall be read in accordance with the correlation table set out in point 1 of Annex XI to this Regulation
Annex XI: *Correlation Table*

1. Regulation (EC) No 715/2007
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<tr><th>Regulation (EC) No 715/2007</th><th>This Regulation</th></tr>
<tr><td>Article 1(2)</td><td>Article 86(1), point (2)</td></tr>
<tr><td>Article 3, points (14) and (15)</td><td>Article 3, points (48) and (45)</td></tr>
<tr><td>Article 6</td><td>Article 61</td></tr>
<tr><td>Article 7</td><td>Article 63</td></tr>
<tr><td>Article 8</td><td>—</td></tr>
<tr><td>Article 9</td><td>—</td></tr>
<tr><td>Article 13(2), point (e)</td><td>Article 86(1), point (5)</td></tr>
</table>
</td>
<td></td>
</tr>
<tr>
<td>Annex I General definitions, criteria for vehicle categorisation,</td>
<td>PART A Criteria for vehicle categorisation</td>
<td>Annex I,
Part A,
3- Criteria for the categorisation</td>
<td>
3.6 *Vehicles shall show a goods-carrying capacity equal or higher than the person-carrying capacity expressed in kg.*
• *3.6.1. For such purposes, the following equations shall be satisfied in all configurations, in particular when all seating positions are occupied:*
○ *(a) when* $N = 0$: $P - M \geq 100$ *kg*
○ *(b) when* $0 < N \leq 2$: $P - (M + N \times 68) \geq 150$ *kg;*
</td>
<td></td>
</tr>
</table>

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td>types of vehicle and types of bodywork</td><td></td><td>of vehicles in category N</td><td>○ <i>(c) when N > 2: P – (M + N × 68) ≥ N × 68;</i>
<i>where the letters have the following meaning:</i>
○ <i>‘P’ is the technically permissible maximum laden mass;</i>
○ <i>‘M’ is the mass in running order;</i>
○ <i>‘N’ is the number of seating positions excluding the driver's seating position.</i>
• <i>3.6.2. The mass of equipment that is fitted to the vehicle in order to accommodate goods (e.g. tank, bodywork, etc.), to handle goods (e.g. crane, lift, etc.) and to secure goods (e.g. cargo securing devices) shall be included in M.</i>
• <i>3.6.3. The mass of equipment that is not used for the purposes referred to in point 3.6.2 (such as a compressor, a winch, an electric power generator, broadcasting equipment, etc.) shall not be included in M for the purposes of the application of the formulae referred to in point 3.6.1.</i></td><td></td></tr>
<tr><td>Annex II Requirements for the purpose of eu type-approval of vehicles, systems, components or separate technical units</td><td></td><td></td><td>This annex will be modified like is explained in regulation (EU) n°2019/2144. See the tables at the end of the regulation n°2019/2144 sheet.
The Annex II content of the regulation (EU) n°2018/858 is reminded below:
<table>
<tr><th>Annex II</th><th>Requirements for the purpose of EU type-approval of vehicles, systems, components or separate technical units</th><th>Regulation UN/ECE taken into account in [StasHH] project</th></tr>
<tr><td>Part I</td><td>Regulatory acts for EU type-approval of vehicles produced in unlimited series</td><td>R26, R10, R28, R97, R100, R105, R107, R134,</td></tr>
<tr><td>Part II</td><td>List of UN Regulations recognised as an alternative to the Directives or Regulations referred to in Part I</td><td>R51, R138, R59</td></tr>
</table>
<table>
<tr><th>Annex II</th><th>Requirements for the purpose of EU type-approval of vehicles, systems, components or separate technical units</th><th>Regulation UN/ECE taken into account in [StasHH] project</th></tr>
<tr><td>Part III</td><td>List of regulatory acts setting out the requirements for the purpose of EU type-approval of special purpose vehicles</td><td></td></tr>
<tr><td>Appendix 4:</td><td>Other special purpose vehicles (including special group, multi-equipment carrier and trailer caravans)</td><td>R10, R28, R97, R100, R105, R107, R134</td></tr>
</table></td><td></td></tr>
</table>

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td><table><tr><td></td><td>Appendix 5:</td><td>Mobile cranes</td><td>R10, R28, R100, R134</td></tr><tr><td></td><td>Appendix 6:</td><td>Exceptional load transport vehicles</td><td>R10, R28, R100, R134</td></tr></table></td><td></td></tr>
<tr><td>Annex IX Procedures to be followed during multi-stage type-approval</td><td>Chapter 3 Applicable requirements</td><td>Annex IX Chapter 3, Paragraph 3.2.2</td><td>*Where a type of system has been modified at the subsequent stage of completion of the vehicle, to the extent that the system has to be retested for type-approval purposes, that retesting shall be limited to only those parts of the system that have been modified or affected by the changes*</td><td>In link with Chapter IV, Article 26, Paragraph 3</td></tr>
<tr><td>Annex X Access to vehicle OBD information and vehicle repair and maintenance information</td><td>Annex C Types of vehicles, system, components or separate technical unit</td><td>Annex X, Annex C, Appendix 2 Vehicle OBD information, paragraph 2.3</td><td>A comprehensive document describing all sensed components with the strategy for fault detection and MI activation (fixed number of driving cycles or statistical method), including a list of relevant secondary sensed parameters for each component monitored by the OBD system and a list of all OBD output codes and format used (with an explanation of each code and format) associated with individual emission-related power-train components and individual non-emission related components, where monitoring of the component is used to determine MI activation. In particular, in the case of types of vehicles that use a communication link in accordance with ISO 15765-4 ‘Road vehicles — Diagnostics on controller area network (CAN) — Part 4: Requirements for emissions-related systems’, a comprehensive explanation for the data given in service $ 05 Test ID $ 21 to FF and the data given in service $ 06, and a comprehensive explanation for the data given in service $ 06 Test ID $ 00 to FF, for each OBD monitor ID supported, shall be provided.
In case other communication protocols standards are used, equivalent comprehensive explanation shall be provided.
This information may be provided in the form of a table, with the following column and row headings:
Component Fault code; Monitoring strategy; Fault detection criteria; MI activation criteria; Secondary parameters; Preconditioning Demonstration test.</td><td></td></tr>
</table>

Conditions	Item	Documentation	Additional Description	Information
			Catalyst P0420 Oxygen sensor; 1 and 2 signals; Difference between sensor 1 and sensor 2 signals; 3rd cycle Engine speed; engine load; A/F mode; catalyst temperature; Two Type 1 cycles; Type 1.	

REGULATION N° 2019/2144

A. IDENTITY CARD OF REGULATION ° 2019/2144

RCS	Number of RCS (with link)	Title	Date	Stability date	Statutory
Regulation EU	2019/2144	Regulation (EU) 2019/2144 of the European Parliament and of the Council: on type-approval requirements for motor vehicles and their trailers, and systems, components and separate technical units intended for such vehicles, as regards their general safety and the protection of vehicle occupants and vulnerable road users	27/11/2019	OJ L 325 du 16.12.2019, p. 1–40	Yes

Scope: This Regulation applies to vehicles of categories M, N and O, as defined in Article 4 of Regulation (EU) 2018/858, and to systems, components and separate technical units designed and constructed for such vehicles. Therefore, Annex II to Regulation (EU) 2018/858 should be amended accordingly.

In order to further simplify the Union legislation in the field of vehicle safety, the following Regulations should be repealed and replaced by implementing acts adopted under this Regulation: (EC) No 78/2009, (EC) No 79/2009 and (EC) No 661/2009 of the European Parliament and of the Council and Commission Regulations (EC) No 631/2009, (EU) No 406/2010, (EU) No 672/2010, (EU) No 1003/2010, (EU) No 1005/2010, (EU) No 1008/2010, (EU) No 1009/2010, (EU) No 19/2011, (EU) No 109/2011, (EU) No 458/2011, (EU) No 65/2012, (EU) No 130/2012, (EU) No 347/2012, (EU) No 351/2012, (EU) No 1230/2012 and (EU) 2015/166.

Domain/category: Vehicles of categories M, N and O

Specified exclusion:

Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

Conditions	Item	Documentation	Additional Description	Information
Chapter II Obligations of manufacturers	Article 4 General obligations and technical requirements	Chapter II, Article 4, paragraph 2	*Type-approval in accordance with the UN Regulations listed in Annex I shall be considered as EU type-approval in accordance with the requirements of this Regulation and of the delegated acts and implementing acts adopted pursuant to it*	Annex I of this regulation: List of UN/ECE Regulations referred to in Article 4(2)
Obligations of manufacturers	General obligations and technical requirements	Chapter II, Article 4, paragraph 3	*The Commission is empowered to adopt delegated acts in accordance with Article 12 to amend* ***Annex I*** *in order to take account of technical progress and regulatory developments by introducing and updating references to the UN Regulations, and relevant series of amendments, that apply on a compulsory basis*	
Chapter II Obligations of manufacturers	Article 4 General obligations and technical requirements	Chapter II, Article 4, paragraph 4	*Manufacturers shall ensure that vehicles are designed, constructed and assembled so as to minimise the risk of injury to vehicle occupants and vulnerable road users*	
Chapter II Obligations of manufacturers	Article 4 General obligations and technical requirements	Chapter II, Article 4, paragraph 5	*Manufacturers shall also ensure that vehicles, systems, components and separate technical units comply with the applicable requirements listed in Annex II with effect from the dates specified in that Annex, with the detailed technical requirements and test procedures laid down in the delegated acts and with the uniform procedures and technical specifications laid down in the implementing acts adopted pursuant to this Regulation, including the requirements relating to:* *(a) crash testing, fuel system integrity and high voltage electrical safety* *(b) on-board instruments, electrical system, protection against unauthorised use including cyberattacks* *(c) driver and system behaviour; and* *(d) general vehicle construction and features*	

Conditions	Item	Documentation	Additional Description	Information
Chapter II Obligations of manufacturers	Article 4 General obligations and technical requirements	Chapter II, Article 4, paragraph 6	*The Commission is empowered to adopt delegated acts in accordance with Article 12 to amend Annex II in order to take account of technical progress and regulatory developments, in particular in relation to the matters listed in points (a) to (f) of paragraph 5 of this Article as well as those referred to in points (a) to (g) of Article 6(1), and with a view to ensuring a high level of general safety of vehicles, systems, components and separate technical units and a high level of protection of vehicle occupants and vulnerable road users, by introducing and updating references to UN Regulations, as well as to delegated acts and implementing acts.*	Regulation 2019/2144 (EU) shall apply from 5 January 2020.
Chapter II Obligations of manufacturers	Article 4 General obligations and technical requirements	Chapter II, Article 4, paragraph 7	*The Commission shall by means of implementing acts adopt provisions concerning uniform procedures and technical specifications for the type-approval of vehicles, systems, components and separate technical units with regard to the requirements listed in Annex II.* Is stated in the implementing regulation 2021/535	Regulation 2019/2144 (EU) shall apply from 5 January 2020.
Chapter II Obligations of manufacturers	Article 6 Advanced vehicle systems for all motor vehicle categories	Chapter II, Article 6, paragraph 1	*Motor vehicles shall be equipped with the following advanced vehicle systems* … *(g) Event data recorder*	
Chapter II Obligations of manufacturers	Article 6 Advanced vehicle systems for all motor vehicle categories	Chapter II, Article 6, paragraph 6	*The Commission shall adopt delegated acts in accordance with Article 12 supplementing this Regulation by laying down detailed rules concerning the specific test procedures and technical requirements for:* *(a) the type-approval of vehicles with regard to the advanced vehicle systems listed in paragraph 1* *(b) the type-approval of the advanced vehicle systems listed in points ~~(a), (f)~~ and (g) of paragraph 1 as* ***separate technical units***	See chapter III, Article 19, Paragraph 2 *"It shall apply from 6 July 2022"*
Chapter II Obligations of manufacturers	Article 10 Specific requirements relating to	Chapter II, Article 10, paragraph 1	*In addition to the other requirements of this Regulation and of the delegated acts and implementing acts adopted pursuant to it that are also applicable to vehicles of categories M and N, hydrogen-powered vehicles of those categories, their hydrogen*	

Conditions	Item	Documentation	Additional Description	Information
	hydrogen-powered vehicles		*systems and components of such systems shall comply with the technical specifications set out in the implementing acts referred to in paragraph 3.*	
Chapter II Obligations of manufacturers	Article 10 Specific requirements relating to hydrogen-powered vehicles	Chapter II, Article 10, paragraph 2	*Manufacturers shall ensure that hydrogen systems and hydrogen components are installed in accordance with the technical specifications set out in the implementing acts referred to in paragraph 3. Manufacturers shall also make available, if necessary information for the purposes of inspection of hydrogen systems and components during the service life of hydrogen-powered vehicles.*	
Chapter II Obligations of manufacturers	Article 10	Chapter II, Article 10, paragraph 3	*The Commission shall by means of implementing acts adopt provisions concerning uniform procedures and technical specifications for the type-approval of hydrogen-powered vehicles with regard to their hydrogen systems, including those with regard to material compatibility and fuelling receptacles, and for the type-approval of hydrogen components, including technical specifications for their installation.* Is stated in the implementing regulation 2021/535	See chapter III, Article 19, Paragraph 2 *"It shall apply from 6 July 2022"*
Chapter III Final provisions	Committee procedure	Chapter III, Article 13, Paragraph 2	*Where reference is made to this paragraph, Article 5 of Regulation (EU) No 182/2011 shall apply.* Article 5 of Regulation (EU) n° 182/2011 deals with the examination procedure: *"By way of derogation from paragraph 4, the following procedure shall apply for the adoption of draft definitive anti-dumping or countervailing measures, where no opinion is delivered by the committee and a simple majority of its component members opposes the draft implementing act"*	See chapter III, Article 19, Paragraph 2 *"It shall apply from 6 July 2022"*
Chapter III Final provisions	Amendments to Regulation (EU) 2018/858	Chapter III, article 17	*Annex II to Regulation (EU) 2018/858 is amended in accordance with Annex III to this Regulation*	

Conditions	Item	Documentation	Additional Description	Information
Chapter III Final provisions	Repeal	Chapter III, Article 18, paragraph 1	*Regulations (EC) No 78/2009, (EC) No 79/2009 and (EC) No 661/2009 and Regulations (EC) No 631/2009, (EU) No 406/2010, (EU) No 672/2010, (EU) No 1003/2010, (EU) No 1005/2010, (EU) No 1008/2010, (EU) No 1009/2010, (EU) No 19/2011, (EU) No 109/2011, (EU) No 458/2011, (EU) No 65/2012, (EU) No 130/2012, (EU) No 347/2012, (EU) No 351/2012, (EU) No 1230/2012 and (EU) 2015/166 are repealed with effect from the date of application of this Regulation*	
Chapter III Final provisions	Repeal	Chapter III, Article 18, paragraph 2	*References to Regulations (EC) No 78/2009, (EC) No 79/2009 and (EC) No 661/2009 shall be construed as references to this Regulation*	
Chapter III Final provisions	Entry into force and date of application	Chapter III, Article 19, paragraph 2	*This Regulation shall enter into force on the twentieth day following that of its publication in the Official Journal of the European Union.* *It shall apply from 6 July 2022* *However,* • *Article 4 (6) and (7),* • *Article 6(6),* • *Article 10(3),* • *Article 13* *shall apply from 5 January 2020*	
Annex I	List of UN/ECE Regulations referred to in Article 4(2)	UN/ECE regulation number:	R10 ➔ “electromagnetic compatibility” A sheet has been edited for this regulation.	Scope covered by the UN/ECE Regulation: M, N, O
Annex I	List of UN/ECE Regulations referred to in Article 4(2)	UN/ECE regulation number:	R94 ➔ “Protection of occupants in the event of a frontal collision” A sheet has been edited for this regulation. The topic which is relevant for StasHH project is the requirements on the electrical power train operating on high voltage, and the high voltage components and systems, which are galvanically connected to the high voltage bus of the electric power train (requirements ensuring the protection of the occupant in case of frontal collision)	Scope covered by the UN/ECE Regulation: M1, N1

Conditions	Item	Documentation	Additional Description	Information
Annex I	List of UN/ECE Regulations referred to in Article 4(2)	UN/ECE regulation number:	R100 ➔ “Electric safety” A sheet has been edited for this regulation.	Scope covered by the UN/ECE Regulation: M, N
Annex I	List of UN/ECE Regulations referred to in Article 4(2)	UN/ECE regulation number:	R95 ➔ Protection of occupants in the event of a lateral collision” A sheet has been edited for this regulation. The topic which is relevant for StasHH project is the requirements on the electrical power train operating on high voltage, and the high voltage components and systems, which are galvanically connected to the high voltage bus of the electric power train (requirements ensuring the protection of the occupant in case of lateral collision)	Scope covered by the UN Regulation: M1, N1
Annex I	List of UN/ECE Regulations referred to in Article 4(2)	UN/ECE regulation number:	R105 ➔ “Vehicles for the carriage of dangerous goods” A sheet has been edited for this regulation.	Scope covered by the UN/ECE Regulation: N, O
Annex I	List of UN/ECE Regulations referred to in Article 4(2)	UN/ECE regulation number:	R107 ➔ “General construction of category M2 and M3 vehicles” A sheet has been edited for this regulation.	Scope covered by the UN/ECE Regulation: M2, M3
Annex I	List of UN Regulations referred to in Article 4(2)	UN/ECE regulation number:	R118 ➔ “Fire resistance of interior materials in buses” A sheet has been edited for this regulation. The relevant part for the StasHH project concerns only electrical cables with regard to their burning behaviour.	Scope covered by the UN/ECE Regulation: M3
Annex I	List of UN/ECE Regulations referred to in Article 4(2)	UN/ECE regulation number:	R134 ➔ “Hydrogen safety” A sheet has been edited for this regulation.	Scope covered by the UN/ECE Regulation: M, N

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td>Annex I</td><td>List of UN/ECE Regulations referred to in Article 4(2)</td><td>UN/ECE regulation number:</td><td>R135 ➔ “Pole side impact”
A sheet has been edited for this regulation.
Relevant to the StasHH project is the integrity of the fuel system that is retained after a side impact on a pole (procedure and tests conditions): chapter 5 and its annexes.</td><td>Scope covered by the UN/ECE Regulation: M1, N1</td></tr>
<tr><td>Annex I</td><td>List of UN/ECE Regulations referred to in Article 4(2)</td><td>UN/ECE regulation number:</td><td>R137 ➔ “Frontal full-width impact”
A sheet has been edited for this regulation.
The part relevant in StasHH project concerns the requirements on the electrical power train operating on high voltage, and the high voltage components and systems, which are galvanically connected to the high voltage bus of the electric power train (requirements ensuring the protection of the occupant in case of frontal collision)</td><td>Scope covered by the UN/ECE Regulation: M1</td></tr>
<tr><td>Annexe II</td><td>List of the requirements referred to in Article 4(5)</td><td>A - restraint systems, crash testing, fuel system integrity and high voltage electrical safety</td><td>A17 Hydrogen safety
<table>
<tr><th>Regulatory acts</th><th>Additional specific technical provisions</th><th>M1</th><th>M2</th><th>M3</th><th>N1</th><th>N2</th><th>N3</th><th>O1</th><th>O2</th><th>O3</th><th>O4</th><th>STU</th><th>Components</th></tr>
<tr><td>UN/ECE regulation n°134</td><td></td><td>A</td><td>A</td><td>A</td><td>A</td><td>A</td><td>A</td><td></td><td></td><td></td><td></td><td></td><td>A</td></tr>
</table>
A: Date for the prohibition of the registration of vehicles, as well as the placing on the market and entry into service of components and separate technical units: 6 July 2022</td><td>M1, M2, M3, N1, N2, N3, components</td></tr>
<tr><td>Annexe II</td><td>List of the requirements referred to in Article 4(5)</td><td>A - restraint systems, crash testing, fuel system integrity and high voltage electrical safety</td><td>A18 Hydrogen system material qualification
<table>
<tr><th>Regulatory acts</th><th>Additional specific technical provisions</th><th>M1</th><th>M2</th><th>M3</th><th>N1</th><th>N2</th><th>N3</th><th>O1</th><th>O2</th><th>O3</th><th>O4</th><th>STU</th><th>Components</th></tr>
<tr><td></td><td></td><td>A</td><td>A</td><td>A</td><td>A</td><td>A</td><td>A</td><td></td><td></td><td></td><td></td><td></td><td>A</td></tr>
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A: Date for the prohibition of the registration of vehicles, as well as the placing on the market and entry into service of components and separate technical units: 6 July 2022</td><td>M1, M2, M3, N1, N2, N3, components</td></tr>
<tr><td>Annexe II</td><td>List of the requirements referred to in Article 4(5)</td><td>A - restraint systems, crash testing, fuel system integrity and</td><td>A19 In-use electric safety
<table>
<tr><th>Regulatory acts</th><th>Additional specific technical provisions</th><th>M1</th><th>M2</th><th>M3</th><th>N1</th><th>N2</th><th>N3</th><th>O1</th><th>O2</th><th>O3</th><th>O4</th><th>STU</th><th>Components</th></tr>
<tr><td>UN/ECE regulation n°100</td><td></td><td>A</td><td>A</td><td>A</td><td>A</td><td>A</td><td>A</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table></td><td>M1, M2, M3, N1, N2, N3</td></tr>
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<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td>high voltage electrical safety</td><td>A: Date for the prohibition of the registration of vehicles, as well as the placing on the market and entry into service of components and separate technical units: 6 July 2022</td><td></td></tr>
<tr><td>Annex II</td><td>List of the requirements referred to in Article 4(5)</td><td>D - on-board instruments, electrical system, and protection against unauthorised use, including cyberattacks</td><td>D2 Radio interference (electromagnetic compatibility)
<table>
<tr><th>Regulatory acts</th><th>Additional specific technical provisions</th><th>M1</th><th>M2</th><th>M3</th><th>N1</th><th>N2</th><th>N3</th><th>O1</th><th>O2</th><th>O3</th><th>O4</th><th>STU</th><th>Components</th></tr>
<tr><td>UN/ECE regulation n°10</td><td></td><td>A</td><td>A</td><td>A</td><td>A</td><td>A</td><td>A</td><td>A</td><td>A</td><td>A</td><td>A</td><td>A</td><td>A</td></tr>
</table>
A: Date for the prohibition of the registration of vehicles, as well as the placing on the market and entry into service of components and separate technical units: 6 July 2022</td><td>M1, M2, M3, N1, N2, N3, O1, O2, O3, O4, STU, components</td></tr>
<tr><td>Annex II</td><td>List of the requirements referred to in Article 4(5)</td><td>D - on-board instruments, electrical system and protection against unauthorised use, including cyberattacks</td><td>D3 Protection against unauthorised use, immobiliser and alarm systems
<table>
<tr><th>Regulatory acts</th><th>Additional specific technical provisions</th><th>M1</th><th>M2</th><th>M3</th><th>N1</th><th>N2</th><th>N3</th><th>O1</th><th>O2</th><th>O3</th><th>O4</th><th>STU</th><th>Components</th></tr>
<tr><td>UN/ECE regulation n°116</td><td></td><td>A</td><td>A<i>(1)</i></td><td>A<i>(1)</i></td><td>A</td><td>A<i>(1)</i></td><td>A<i>(1)</i></td><td></td><td></td><td></td><td></td><td>A</td><td>A</td></tr>
</table>
(i)A: Date for the prohibition of the registration of vehicles, as well as the placing on the market and entry into service of components and separate technical units: 6 July 2022
<i>(1) Compliance is required if fitted</i></td><td>M1, M2, M3, N1, N2, N3, STU, components</td></tr>
<tr><td>Annex II</td><td>List of the requirements referred to in Article 4(5)</td><td>D - on-board instruments, electrical system and protection against unauthorised use, including cyberattacks</td><td>D4 Protection of vehicle against cyberattacks (*)
<table>
<tr><th>Regulatory acts</th><th>Additional specific technical provisions</th><th>M1</th><th>M2</th><th>M3</th><th>N1</th><th>N2</th><th>N3</th><th>O1</th><th>O2</th><th>O3</th><th>O4</th><th>STU</th><th>Components</th></tr>
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B: Date for refusal to grant EU type-approval: 6 July 2022 Date for the prohibition of the registration of vehicles, as well as the placing on the market and entry into service of components and separate technical units: 7 July 2024
(*):
The new regulation dealing with CyberSecurity (UN/ECE n°155) has been edited on 21.01.2021 and has been published in the Official Journal of the European Union on 09.03.2021</td><td>M1, M2, M3, N1, N2, N3? STU and components</td></tr>
</table>

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<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td>Annex II</td><td>List of the requirements referred to in Article 4(5)</td><td>D - on-board instruments, electrical system and protection against unauthorised use, including cyberattacks</td><td>D16 Emergency Stop Signal
<table>
<tr><td>Regulatory acts</td><td>Additional specific technical provisions</td><td>M1</td><td>M2</td><td>M3</td><td>N1</td><td>N2</td><td>N3</td><td>O1</td><td>O2</td><td>O3</td><td>O4</td><td>STU</td><td>Components</td></tr>
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B: Date for refusal to grant EU type-approval: 6 July 2022 Date for the prohibition of the registration of vehicles, as well as the placing on the market and entry into service of components and separate technical units: 7 July 2024</td><td>M1, M2, M3, N1, N2, N3</td></tr>
<tr><td>Annex II</td><td>List of the requirements referred to in Article 4(5)</td><td>E - driver and system behaviour</td><td>E5 Event data recorder
<table>
<tr><td>Regulatory acts</td><td>Additional specific technical provisions</td><td>M1</td><td>M2</td><td>M3</td><td>N1</td><td>N2</td><td>N3</td><td>O1</td><td>O2</td><td>O3</td><td>O4</td><td>STU</td><td>Components</td></tr>
<tr><td></td><td></td><td>B</td><td>D</td><td>D</td><td>B</td><td>D</td><td>D</td><td></td><td></td><td></td><td></td><td>B</td><td></td></tr>
</table>
B: Date for refusal to grant EU type-approval: 6 July 2022 Date for the prohibition of the registration of vehicles, as well as the placing on the market and entry into service of components and separate technical units: 7 July 2024
D: Date for refusal to grant EU type-approval: 7 January 2026 Date for the prohibition of the registration of vehicles, as well as the placing on the market and entry into service of components and separate technical units: 7 January 2029</td><td>M1, N1
M2, M3, N2, N3</td></tr>
<tr><td>Annex II</td><td>List of the requirements referred to in Article 4(5)</td><td>F - general vehicle construction and features</td><td>F13 Vehicles intended for the transportation of dangerous goods:
<table>
<tr><td>Regulatory acts</td><td>Additional specific technical provisions</td><td>M1</td><td>M2</td><td>M3</td><td>N1</td><td>N2</td><td>N3</td><td>O1</td><td>O2</td><td>O3</td><td>O4</td><td>STU</td><td>Components</td></tr>
<tr><td>UN/ECE regulation n° 105</td><td></td><td></td><td></td><td></td><td>A</td><td>A</td><td>A</td><td>A</td><td>A</td><td>A</td><td>A</td><td></td><td></td></tr>
</table>
A: Date for the prohibition of the registration of vehicles, as well as the placing on the market and entry into service of components and separate technical units: 6 July 2022</td><td>N1, N2, N3, O1, O2, O3, O4</td></tr>
<tr><td>Annex II</td><td>List of the requirements referred to in Article 4(5)</td><td>F - general vehicle construction and features</td><td>F14 General bus construction
<table>
<tr><td>Regulatory acts</td><td>Additional specific technical provisions</td><td>M1</td><td>M2</td><td>M3</td><td>N1</td><td>N2</td><td>N3</td><td>O1</td><td>O2</td><td>O3</td><td>O4</td><td>STU</td><td>Components</td></tr>
<tr><td>UN/ECE regulation n° 107</td><td></td><td></td><td>A</td><td>A</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
A: Date for the prohibition of the registration of vehicles, as well as the placing on the market and entry into service of components and separate technical units: 6 July 2022</td><td>M2, M3</td></tr>
</table>

Conditions	Item	Documentation	Additional Description	Information
Annex III	Amendments to Annex II to Regulation (EU) 2018/858		Annex II to Regulation (EU) 2018/858 is amended according to regulation 2019/2144	Identification of the updated parts of the regulation 2018/858 in accordance with this regulation. Comparaison between this annex of regulation n°2019/20144 and the regulation n°2018/858 are covered in the next table

C. COMPARAISON BETWEEN ANNEX III OF REGULATION N°2019/20144 AND THE IMPACTS ON FUTURE UPDATED OF REGULATION N°2018/858 (ITS ANNEX II)

Following tables remind the futur updated of the annex II of regulation 2018/858.

The annex II of regulation 2018/858 defines the *“requirements for the purpose of EU type-approval of vehicles, systems, components or separate technical units”*

Item, part on regulation 2018/858 concerned by its future update and relevant for the StasHH project								
Parts and items (2018/858)		subject	Regulatory act reference		Applicability		STU and Component	
Annex II - Part I: Regulatory acts for U type-approval of vehicles produced in unlimited series	Item: 62	Hydrogen system	*79/2009*	*Deletion (which will be repealed)*	M1, M2, M3, N1, N2, N3	Unchanged	STU and component	Addition
			2019/2144	Addition				
			R134	Unchanged				
	Item: 63	General safety	*661/2009*	*Deletion (which will be repealed)*	M1(15), M2(15), M3(15), N1(15), N2(15), N3(15), O1(15), O2(15), O3(15), O4(15) see *Note* (15)	Unchanged	STU and component	Addition
			2019/2144	Addition				
			Note (15)	*Compliance with Regulation (EC) No 661/2009 is mandatory, however, type-approval under this item number is not foreseen as it represents the collection of individual items 3A, 3B, 4A, 5A, 6A, 6B, 7A, 8A, 9A, 9B, 10A, 12A, 13A, 13B, 14A, 15A, 15B, 16A, 17A, 17B, 18A, 19A, 20A, 21A, 22A, 22B, 22C, 23A, 24A, 25A, 25B, 25C, 25D, 25E, 25F, 26A, 27A, 28A, 29A, 30A, 31A, 32A, 33A, 34A, 35A, 36A, 37A, 38A, 42A, 43A, 44A, 45A, 46A, 46B, 46C, 46D, 46E, 47A, 48A, 49A, 50A, 50B, 51A, 52A, 52B, 53A, 54A, 56A, 57A and 64 to 71. The series of amendments of the UN Regulations which apply on a compulsory basis are listed in Annex IV to Regulation (EC) No 661/2009. The series of amendments adopted subsequently are accepted as an alternative.* Modified by: *Compliance with Regulation (EU) 2019/2144 is mandatory. However, type-approval under this specific item is not envisaged as it merely represents the collection of individual items listed elsewhere in the table that make reference to Regulation (EU) 2019/2144*				

Item, part on regulation 2018/858 concerned by its future update and relevant for the StasHH project							
Parts and items (2018/858)		subject	Regulatory act reference		Specific issues	Applicability and specific requirements	
Annex II - Part I - Appendix I: Regulatory acts for EU type-approval of vehicles produced in small series pursuant to Article 41 **Table I: M1 vehicles** **Table 2: N1 vehicles**	62	Hydrogen system	*79/2009*	*Deletion (which will be repealed)*		X[31]	Unchanged
			2019/2144	Addition			
			R134	Unchanged			
	63	General safety	*661/2009*	*Deletion (which will be repealed)*		See explanatory note (15) of the table in this Part with regulatory acts for EU type-approval of vehicles produced in unlimited series	Modified by: Compliance with Regulation (EU) 2019/2144 is mandatory. However, type-approval under this specific item is not envisaged as it merely represents the collection of individual items listed elsewhere in the table that make reference to Regulation (EU) 2019/2144.
			2019/2144	Addition			

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[31] X: Full application of the regulatory act as follows:

- (a) A type-approval certificate shall be issued
- (b) Tests and checks shall be conducted by the technical service or the manufacturer under the conditions laid down in Articles 67 to 81
- (c) A test report shall be drafted in accordance with Annex III
- (d) Conformity of Production (COP) shall be ensured.

Item, part on regulation 2018/858 concerned by its future update and relevant for the StasHH project					
Parts and items (2018/858)		Regulatory act reference		Alternative requirements	
Annex II - Part I - Appendix 2 requirements for EU individual vehicle approval pursuant to article 44 4. technical requirements **Part I: Vehicles belonging to category M1** **Part II: Vehicles belonging to category N1**	62 (Hydrogen system)	R134	Addition	The requirements of UN Regulation No 134 shall apply. Alternatively, it shall be demonstrated that the vehicle complies with: —Substantive requirements of Regulation (EC) No 79/2009 in its version applicable on 5 July 2022; —Attachment 100 – Technical Standard For Fuel Systems Of Motor Vehicle Fueled By Compressed Hydrogen Gas (Japan); —GB/T 24549-2009 Fuel cell electric vehicles – safety requirements (China); —International standard ISO 23273:2013 Part 1: Vehicle functional safety and Part 2: Protection against hydrogen hazards for vehicles fuelled with compressed hydrogen; or —SAE J2578 – General Fuel Cell Vehicle Safety’;	Addition
		(ii)2019/2144	Addition		

Item, part on regulation 2018/858 concerned by its future update and relevant for the StasHH project											
Parts and items (2018/858)		Regulatory act reference		M1 ≤ 2 500 kg		M1 > 2 500kg		M2		M3	
ANNEX II - PART III List of regulatory acts setting out the requirements for the purpose of EU type-approval of special purpose vehicles **Appendix 1** Motor-caravans, ambulances and hearses	62 (Hydrogen system)	(iii)*79/2009*	*Deletion (which will be repealed)*	Q[32]	Modified by X	G[33] +Q	Modified by X[34]	G+ Q	Modified by X	G+Q	Modified by X
		2019/2144	Addition								
		R134	Addition								
	63 (General safety)	(iv)*661/2009*	*Deletion (which will be repealed)*	X(15)	Unchanged	X(15)	Unchanged	X(15)	Unchanged	X(15)	Unchanged
		2019/2144	Addition								
		Note (15)	*Compliance with Regulation (EC) No 661/2009 is mandatory, however, type-approval under this item number is not foreseen as it represents the collection of individual items 3A, 3B, 4A, 5A, 6A, 6B, 7A, 8A, 9A, 9B, 10A, 12A, 13A, 13B, 14A, 15A, 15B, 16A, 17A, 17B, 18A, 19A, 20A, 21A, 22A, 22B, 22C, 23A, 24A, 25A, 25B, 25C, 25D, 25E, 25F, 26A, 27A, 28A, 29A, 30A, 31A, 32A, 33A, 34A, 35A, 36A, 37A, 38A, 42A, 43A, 44A, 45A, 46A, 46B, 46C, 46D, 46E, 47A, 48A, 49A, 50A, 50B, 51A, 52A, 52B, 53A, 54A, 56A, 57A and 64 to 71. The series of amendments of the UN Regulations which apply on a compulsory basis are listed in Annex IV to Regulation (EC) No 661/2009. The series of amendments adopted subsequently are accepted as an alternative.* Modified by: *Compliance with Regulation (EU) 2019/2144 is mandatory. However, type-approval under this specific item is not envisaged as it merely represents the collection of individual items listed elsewhere in the table that make reference to Regulation (EU) 2019/2144*							

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[32] Q: Modification of exhaust system length after the last silencer not exceeding 2 m is permissible without any further test. An EU type-approval granted to the most representative base vehicle remains valid irrespective of change in the reference weight.

[33] G: In case of multi-stage type-approval, requirements according to the category of the base/incomplete vehicle (e.g. the chassis of which was used to build the special purpose vehicle) may also be used.

[34] X The requirements set out in the relevant regulatory act are applicable

Item, part on regulation 2018/858 concerned by its future update and relevant for the StasHH project									
Parts and items (2018/858)		Regulatory act reference		M1, M2, M3		N1, N2, N3		O1, O2, O3, O4	
ANNEX II - PART III List of regulatory acts setting out the requirements for the purpose of EU type-approval of special purpose vehicles	62 (Hydrogen system)	(v)*79/2009*	*Deletion (which will be repealed)*	A[35]	Modified by X (Full application of the regulatory act)	A	Modified by X (Full application of the regulatory act)		
		2019/2144	Addition						
		R134	Addition						
	63 (General safety)	(vi)*661/2009*	*Deletion (which will be repealed)*	X(15)	Unchanged	X(15)	Unchanged	X(15)	Unchanged
		2019/2144	Addition						
		Note (15)	*Compliance with Regulation (EC) No 661/2009 is mandatory, however, type-approval under this item number is not foreseen as it represents the collection of individual items 3A, 3B, 4A, 5A, 6A, 6B, 7A, 8A, 9A, 9B, 10A, 12A, 13A, 13B, 14A, 15A, 15B, 16A, 17A, 17B, 18A, 19A, 20A, 21A, 22A, 22B, 22C, 23A, 24A, 25A, 25B, 25C, 25D, 25E, 25F, 26A, 27A, 28A, 29A, 30A, 31A, 32A, 33A, 34A, 35A, 36A, 37A, 38A, 42A, 43A, 44A, 45A, 46A, 46B, 46C, 46D, 46E, 47A, 48A, 49A, 50A, 50B, 51A, 52A, 52B, 53A, 54A, 56A, 57A and 64 to 71. The series of amendments of the UN Regulations which apply on a compulsory basis are listed in Annex IV to Regulation (EC) No 661/2009. The series of amendments adopted subsequently are accepted as an alternative.* Modified by: *Compliance with Regulation (EU) 2019/2144 is mandatory. However, type-approval under this specific item is not envisaged as it merely represents the collection of individual items listed elsewhere in the table that make reference to Regulation (EU) 2019/2144*						

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[35] The approval authority may only grant exemption(s) if the manufacturer demonstrates that the vehicle cannot meet the requirements due to its special purpose. The exemptions granted are to be described on the vehicle type- approval certificate and the certificate of conformity.

Item, part on regulation 2018/858 concerned by its future update and relevant for the StasHH project									
Parts and items (2018/858)		Regulatory act		M1, M2, M3		N1, N2, N3		O1, O2, O3, O4	
ANNEX II - PART III List of regulatory acts setting out the requirements for the purpose of EU type-approval of special purpose vehicles **Appendix 3**: Wheelchair accessible vehicles	62 (Hydrogen system)	(vii)*79/2009*	*Deletion (which will be repealed)*	X	Unchanged	X	Unchanged		
		2019/2144	Addition						
		R134	Addition						
	63 (General safety)	(viii)*661/2009*	*Deletion (which will be repealed)*	X(15)	Unchanged	X(15)	Unchanged	X(15)	Unchanged
		2019/2144	Addition						
		Note (15)	*Compliance with Regulation (EC) No 661/2009 is mandatory, however, type-approval under this item number is not foreseen as it represents the collection of individual items 3A, 3B, 4A, 5A, 6A, 6B, 7A, 8A, 9A, 9B, 10A, 12A, 13A, 13B, 14A, 15A, 15B, 16A, 17A, 17B, 18A, 19A, 20A, 21A, 22A, 22B, 22C, 23A, 24A, 25A, 25B, 25C, 25D, 25E, 25F, 26A, 27A, 28A, 29A, 30A, 31A, 32A, 33A, 34A, 35A, 36A, 37A, 38A, 42A, 43A, 44A, 45A, 46A, 46B, 46C, 46D, 46E, 47A, 48A, 49A, 50A, 50B, 51A, 52A, 52B, 53A, 54A, 56A, 57A and 64 to 71. The series of amendments of the UN Regulations which apply on a compulsory basis are listed in Annex IV to Regulation (EC) No 661/2009. The series of amendments adopted subsequently are accepted as an alternative.* Modified by: *Compliance with Regulation (EU) 2019/2144 is mandatory. However, type-approval under this specific item is not envisaged as it merely represents the collection of individual items listed elsewhere in the table that make reference to Regulation (EU) 2019/2144*						

Item, part on regulation 2018/858 concerned by its future update and relevant for the StasHH project					
Parts and items (2018/858)		Regulatory act		M1, N3, O4	
ANNEX II - PART III List of regulatory acts setting out the requirements for the purpose of EU type-approval of special purpose vehicles **Appendix 4**: Other special purpose vehicles (including special group, multi-equipment carrier and trailer caravans) = **M1** **Appendix 5:** Mobile cranes = **N3** **Appendix 6**: Exceptional load transport vehicles = **N3, O4**	62 (Hydrogen system)	(ix)*79/2009*	*Deletion (which will be repealed)*	X	Unchanged
		2019/2144	Addition		
		R134	Addition		
	63 (General safety)	(x)*661/2009*	*Deletion (which will be repealed)*	X(15)	Unchanged
		2019/2144	Addition		
		Note (15)	*Compliance with Regulation (EC) No 661/2009 is mandatory, however, type-approval under this item number is not foreseen as it represents the collection of individual items 3A, 3B, 4A, 5A, 6A, 6B, 7A, 8A, 9A, 9B, 10A, 12A, 13A, 13B, 14A, 15A, 15B, 16A, 17A, 17B, 18A, 19A, 20A, 21A, 22A, 22B, 22C, 23A, 24A, 25A, 25B, 25C, 25D, 25E, 25F, 26A, 27A, 28A, 29A, 30A, 31A, 32A, 33A, 34A, 35A, 36A, 37A, 38A, 42A, 43A, 44A, 45A, 46A, 46B, 46C, 46D, 46E, 47A, 48A, 49A, 50A, 50B, 51A, 52A, 52B, 53A, 54A, 56A, 57A and 64 to 71. The series of amendments of the UN Regulations which apply on a compulsory basis are listed in Annex IV to Regulation (EC) No 661/2009. The series of amendments adopted subsequently are accepted as an alternative.* Modified by: *Compliance with Regulation (EU) 2019/2144 is mandatory. However, type-approval under this specific item is not envisaged as it merely represents the collection of individual items listed elsewhere in the table that make reference to Regulation (EU) 2019/2144*		

REGULATION N° 2020/683

A. IDENTITY CARD OF REGULATION N° 2020/683

RCS	Number of RCS	Title	Date	Stability date	Statutory
Regulation	2020/683 OJ L 163, 26.5.2020, p. 1–226	*Commission Implementing Regulation (EU) 2020/683 of 15 April 2020 implementing Regulation (EU) 2018/858 of the European Parliament and of the Council with regards to the administrative requirements for the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles*	15.04.2020	05.06.2020	Yes

Scope: Harmonization about necessary documents with regards to the administrative requirements for the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles

This regulation is an implementing Regulation (EU) 2018/858 of the European Parliament and of the Council with regards to the administrative requirements for the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles.

Domain/category: vehicle categories M, N, O, systems, components and separate technical units

Specifed exclusion: /

Reference included in this RCS: Regulation (EU) 2018/858 of the European Parliament and of the Council of 30 May 2018 on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles.

B. RELEVANT PARTS FOR STASHH PROJECT

The Regulation (EU) n° 2020/683 gives the templates for EU type approval certificates.

In the following table, only elements involving hydrogen-powered vehicles (either hybrid or all-hydrogen propulsion) are listed.

Conditions	Item	Documentation	Additional Description	Information
Article 1: templates for the information document	Paragraph 1		The template laid down in Annex I to this Regulation shall be used for the information document referred to in Article 24(1)(a) of Regulation (EU) 2018/858 for the purposes of the following EU type-approvals: (a) the whole-vehicle single-step type-approval; (b) the whole-vehicle mixed type-approval; (c) the whole-vehicle multi-stage type-approval; (d) the type-approval of systems, components or separate technical units.	Annex I
Article 1: templates for the information document	Paragraph 2		The template laid down in Annex II to this Regulation shall be used for the information document referred to in Article 24(1)(a) of Regulation (EU) 2018/858 for the purposes of the EU whole-vehicle step-by-step type-approval.	Annex II
Annex I The template laid down	Explanatory notes	Note n° (38)	In the case of a vehicle that can run either on petrol, diesel, etc., or also in combination with another fuel, items shall be repeated. In the case of non-conventional engines and systems, particulars equivalent to those referred to here shall be supplied by the manufacturer.	
Annex I The template laid down	Explanatory notes	Note n° (136)	The unit ‘l/100km’ is replaced by ‘m^3/100km’ for vehicles fuelled with NG and H2NG, and by ‘kg/100km’ for vehicles fuelled with hydrogen.	
Annex I The template laid down	Chapter 3: propulsion energy converter	Subchapter 3.9: Hydrogen propulsion	The necessary elements to provide are listed in the template	

Conditions	Item	Documentation	Additional Description	Information
Annex VI: template for the test result sheet	Chapter 3: Results of the CO_2 emission, fuel/electric energy consumption, and electric range tests		Please provide the number of the regulatory act laying down the applicable requirements or, where amended, the number of its latest amendment.	
Annex VI: template for the test result sheet	Chapter 3: Results of the CO_2 emission, fuel/electric energy consumption, and electric range tests	subchapter 3.1: Internal combustion engines, including not externally chargeable hybrid electric vehicles (NOVC)	The necessary elements to provide are listed in the template	
Annex VI: template for the test result sheet	Chapter 3: Results of the CO_2 emission, fuel/electric energy consumption, and electric range tests	Subchapter 3.2: Externally chargeable hybrid electric vehicles (OVC)	The necessary elements to provide are listed in the template	
Annex VI: template for the test result sheet	Chapter 3: Results of the CO_2 emission, fuel/electric energy consumption,	Subchapter 3.4: Hydrogen fuel cell vehicles	The necessary elements to provide are listed in the template	

Conditions	Item	Documentation	Additional Description	Information
	and electric range tests			

REGULATION N° 2021/535

A. IDENTITY CARD OF REGULATION N° 2021/535

RCS	Number of RCS	Title	Date	Stability date	Statutory
Regulation	2021/535	Commission Implementing Regulation (EU) 2021/535 of 31 March 2021 laying down rules for the application of Regulation (EU) 2019/2144 of the European Parliament and of the Council as regards uniform procedures and technical specifications for the type-approval of vehicles, and of systems, components and separate technical units intended for such vehicles, as regards their general construction characteristics and safety (Text with EEA relevance)	31/03/2021	OJ L 117, 6.4.2021, p. 1	Yes

Scope: This Regulation lays down provisions for uniform procedures and technical specifications for EU type-approval of vehicles of categories M, N and O, as well as of systems, components and separate technical units in accordance with Articles 4(7), ~~8(3),~~ and 10(3) of Regulation (EU) 2019/2144 of the European Parliament and of the Council.

This Regulation also provides for uniform procedures allowing type-approval in one or more of the following cases:

- Of vehicle systems where components and separate technical units bearing an EU type-approval mark are applied instead of an UN type-approval mark in the context of the requirements set out in the UN regulations listed in Annex II to Regulation (EU) 2019/2144. Annex II to Regulation (EU) 2019/2144: List of the requirements referred to in Article 4(5) and Article 5(3) as well as the dates referred to in Article 16

Domain/category: vehicles of categories M, N and O, as well as of systems, components and separate technical units

Specifed exclusion:

Reference included in this RCS: this regulation n°2021/535 is in link with:

Regulation (EU) 2019/2144 of 29.11.2019, which will modify the annex II of the regulation (EU) 2018/858

B. RELEVANT PARTS FOR STASHH PROJECT

The main topic interesting the StasHH project is into the annex XIV (specifications of material comptability of hydrogen components, hydrogen system in case of hydrogen-powered vehicles, the vehicle fuel system of which incorporates compressed hydrogen storage system (CHSS)).

Conditions	Item	Documentation	Additional Description	Information
Chapter I - Subject matter and definitions	Artcle 1 subject matter	Chapter 1, article 1, prargraph 1	*This Regulation lays down provisions for uniform procedures and technical specifications for EU type-approval of vehicles of categories M, N and O, as well as of systems, components and separate technical units in accordance with Articles 4(7) and 10(3) of Regulation (EU) 2019/2144 of the European Parliament and of the Council.*	In link with Regulation (EU) 2019/2144
Chapter I - Subject matter and definitions	Artcle 1 subject matter	Chapter 1, article 1, prargraph 2	*This Regulation also provides for uniform procedures allowing type-approval in one or more of the following cases:* *a) of vehicle systems where components and separate technical units bearing an EU type-approval mark are applied instead of an UN type-approval mark in the context of the requirements set out in the UN regulations listed in Annex II to Regulation (EU) 2019/2144 and* *b) where a manufacturer is designated as technical service in accordance with Article 72(1) and Annex VII to Regulation (EU) 2018/858 of the European Parliament and of the Council, with regard to the requirements set out in the UN regulations listed in Annex II to Regulation (EU) 2019/2144, and* *c) where virtual testing in accordance with Article 30(7) and Annex VIII to Regulation (EU) 2018/858 of the European Parliament and of the Council, with regard to the requirements set out in the UN regulations listed in Annex II to Regulation (EU) 2019/2144, has been applied.*	In link with Regulation (EU) 2019/2144 **Only point a) concerns the StasHH project**
Chapter III EU vehicle type-approval with regard to certain	Article 5 Application for the EU type-approval of a	Chapter III, Article 5, paragraph 1	*A separate application for EU type-approval of a vehicle type as regards each of the following items shall be submitted to the type-approval authority by manufacturers or their representatives, using the respective*	In link with: Regulation (EU) 2020/683 (utilization of model information)

Conditions	Item	Documentation	Additional Description	Information
specific construction and safety requirements	vehicle type as regards certain vehicle systems		*model information document in accordance with Article 24(1)(a) of Regulation (EU) 2018/858* *(a) the lay-out and the location of the statutory plate and the composition and the location of the vehicle identification number, using the model containing the information listed in Part 1 of Annex II* *(b) the space for mounting and fixing of front and rear registration plates, using the model containing the information listed in Part 1 of Annex III* *(c) the windscreen wiper and washer systems, using the model containing the information listed in Annex IV, Part 1, Section A* *(d) the wheel guards, using the model containing the information listed in Part 1 of Annex V* *(e) the windscreen defrosting and demisting systems, using the model containing the information listed in Part 1 of Annex VI* *(f) the towing devices, using the model containing the information listed in Part 1 of Annex VII* *(g) the spray suppression system, using the model containing the information listed in Annex VIII, Part 1, Section A* *(h) the gear shift indicator, using the model containing the information listed in Part 1 of Annex IX* *(i) the vehicle access, using the model containing the information listed in Part 1 of Annex X* *(j) the reversing motion, using the model containing the information listed in Part 1 of Annex XI* *(k) the vehicle masses and dimensions, using the model containing the information listed in Annex XIII, Part 1, Section A* *(l) in case of hydrogen-powered vehicles, the vehicle fuel system of which incorporates compressed hydrogen storage system (CHSS), using the model containing the information listed in Annex XIV, Part 1, Section A* Annex XIV - Part 1 - Section A:	**Only point (l) concerns the StasHH project: for the part of compressed hydrogen**

Conditions	Item	Documentation	Additional Description	Information
			Information document relating to the EU type-approval of a vehicle with regard to its hydrogen system. This section is a model: ➔ *Explanatory note:* *This information document is based on the template laid down in Annex I to Commission Implementing Regulation (EU) 2020/683 and shall be completed with the relevant information under the point numbers listed above as defined in that template.*	
Chapter III EU vehicle type-approval with regard to certain specific construction and safety requirements	Article 5 Application for the EU type-approval of a vehicle type as regards certain vehicle systems	Chapter III, Article 5, paragraph 3	*The manufacturer shall, when requested by the approval authority or the technical service, make available, for* ***test purposes, a vehicle representative of the type to be approved***	
Chapter III EU vehicle type-approval with regard to certain specific construction and safety requirements	Article 6 Granting the EU type-approval of a vehicle type as regards certain vehicle systems	Chapter III, Article 6, paragraph 2	*The EU type-approval certificate, referred to in Article 28(1) of Regulation (EU) 2018/858, shall be drawn up in accordance with:* *(a) Part 3 of Annex II for the item referred to in point (a) of Article 5(1)* *(b) Part 3 of Annex III for the item referred to in point (b) of Article 5(1) Annex IV,* *(c) Part 3, Section A for the item referred to in point (c) of Article 5(1)* *(d) Part 3 of Annex V for the item referred to in point (d) of Article 5(1)* *(e) Part 3 of Annex VI for the item referred to in point (e) of Article 5(1)* *(f) Part 3 of Annex VII for the item referred to in point (f) of Article 5(1)* *(g) Annex VIII, Part 3, Section A for the item referred to in point (g) of Article 5(1)* *(h) Part 3 of Annex IX for the item referred to in point (h) of Article 5(1)* *(i) Part 3 of Annex X for the item referred to in point (i) of Article 5(1)* *(j) Part 3 of Annex XI for the item referred to in point (j) of Article 5(1) Annex XIII,*	Link with: Annex XIV, Part 3, Section A of this regulation (EU) 2021/535 Recall of point (l) of Article 5(1.): *(l) "in case of hydrogen-powered vehicles, the vehicle fuel system of which incorporates compressed hydrogen storage system (CHSS), using the model containing the information listed*

Conditions	Item	Documentation	Additional Description	Information
			(k) *Part 3, Section A for the item referred to in point (k) of Article 5(1)* (l) *Annex XIV, Part 3, Section A for the item referred to in point (l) of Article 5(1)* Annex XIV – Part 3 – Section A: *EU type-approval certificate (vehicle system).* Of which the *addendum - to EU type-approval certificate number* ➔ *Additional information* *Type-approval numbers in accordance with UN Regulation 134 and Regulation (EU) 2021/535 of the hydrogen system and each component installed on the vehicle type:* *1. Safety-related performance of a hydrogen-fuelled vehicle when equipped with compressed hydrogen storage system(s):* *UN Regulation No 134:* *2. Automatic shut-off valve(s):* *UN Regulation No 134:* *Regulation (EU) 2021/535:* *3. Check valve(s) or non-return valve(s):* *UN Regulation No 134:* *Regulation (EU) 2021/535:*	*in Annex XIV, Part 1, Section A* **Only point (l) of this Article 6 concerns the StasHH project: for the part of compressed hydrogen**
Chapter IV EU separate technical unit and eu component type-approvals with regard to certain vehicle systems and components	Article 9 Application for the EU component type-approval	Chapter IV, article 9	*Applications for EU component type-approval with regard to the following hydrogen components shall be drawn up in accordance with the respective model information document as referred to in Article 24(1)(a) of Regulation (EU) 2018/858 and contain the information listed in Annex XIV, Part 1, Section B:* *(a) the liquefied hydrogen storage systems (LHSS), including their containers, pressure relief and shut-off devices, with respect to their safety performance and material compatibility* *(b) the compressed hydrogen storage systems (CHSS), including their containers and primary closing devices, comprising TPRD, check valve*	In link with Article 24(1)(a) of Regulation (EU) 2018/858 **Only point (b) of this Article 9 concerns the StasHH project: for the part of compressed hydrogen**

Conditions	Item	Documentation	Additional Description	Information
			and automatic shut-off valves, with respect to their material compatibility Annex XIV – Part 1 – Section B: *Information document relating to the EU type-approval of hydrogen components.* This section is a model:	
Chapter IV EU separate technical unit and eu component type-approvals with regard to certain vehicle systems and components	Article 10 Granting the EU component type-approval	Chapter IV, article 10, paragrah 1	*In accordance with Article 29 of Regulation (EU) 2018/858, where the technical specifications set out Section F, for components referred to in point (b) of that Article, with regard to the respective requirements listed in Annex II to Regulation (EU) 2019/2144 are met, the type-approval authority shall grant an EU component type-approval for the type of hydrogen component and issue a type-approval certificate number in accordance with the method set out in Annex IV to Commission Implementing Regulation (EU) 2020/683.* Annex XIV – Part 2 - Section F: *Technical specifications for hydrogen components on material compatibility: see the detail of this section at the end of this sheet.*	See Article 29 of Regulation (EU) 2018/858 which concerns: “Specific provisions concerning EU type-approvals for systems, components and separate technical units” This article 29 does not appear in the sheet of the Regulation (EU) 2018/858. See the sheet of the Regulation (EU) 2019/2144 concerning the points retained in its Annex I according to the UN/ECE regulations and applicable in the StasHH project.
CHAPTER V Final provisions	Article 14 Entry into force	Chapter V, article 14	*This Regulation shall enter into force on the twentieth day following that of its publication in the Official Journal of the European Union.* *It shall apply from 6 July 2022.*	

Conditions	Item	Documentation	Additional Description	Information
Annex XIV: Hydrogen system material compatibility and fuelling receptacle	Part 2 – Section A		This section recalls the existing definitions in UN/ECE Regulation 134. However, two new definitions have been included in Regulation (EU) 2021/535: - *'hydrogen-powered vehicle' means any motor vehicle that uses hydrogen as a fuel to propel the vehicle, including fuel cell and internal combustion engine vehicles. Hydrogen fuel for passenger vehicles is specified in ISO 14687-2: 2012 and SAE J2719: (September 2011 Revision);* - *'liquefied hydrogen storage system (LHSS)' means liquefied hydrogen storage container(s) PRDs, shut-off device, a boil-off system and the interconnection piping (if any) and fittings between the above components;*	ISO 14687-2: 2012 SAE J2719
Annex XIV: Hydrogen system material compatibility and fuelling receptacle	Part 2 - Section F: Technical specifications for hydrogen components on material compatibility	Annex XIV, Part 2 - Section F, paragraph 1: Requirements	*1.1. This section sets out the requirements and test procedures for storage system and components of CHSS and LHSS with respect to material compatibility. It does not apply to materials that do not come in contact with hydrogen under normal conditions.*	
Annex XIV: Hydrogen system material compatibility and fuelling receptacle	Part 2 - Section F: Technical specifications for hydrogen components on material compatibility	Annex XIV, Part 2 - Section F, paragraph 2: Specific requirements	*2.1.The materials used in CHSS shall be compatible with hydrogen when they are in contact with hydrogen in liquid and/or gaseous state. Incompatible materials shall not be in contact with each other.*	

Conditions	Item	Documentation	Additional Description	Information
Annex XIV: Hydrogen system material compatibility and fuelling receptacle	Part 2 - Section F: Technical specifications for hydrogen components on material compatibility	Annex XIV, Part 2 - Section F, paragraph 2: Specific requirements (steels)	*2.2.1. Steels used in CHSS shall conform to the material requirements of sections 6.1. to 6.4. of standard EN 9809-1:2018 or sections 6.1. to 6.3. of standard EN 9809-2:2018 as appropriate.*	EN 9809-1:2018
Annex XIV: Hydrogen system material compatibility and fuelling receptacle	Part 2 - Section F: Technical specifications for hydrogen components on material compatibility	Annex XIV, Part 2 - Section F, paragraph 2: Specific requirements (Stainless steels)	*2.3.1. Stainless steels used in CHSS shall conform to sections 4.1. to 4.4. of standard EN 1964-3:2000*	EN 1964-3:2000
Annex XIV: Hydrogen system material compatibility and fuelling receptacle	Part 2 - Section F: Technical specifications for hydrogen components on material compatibility	Annex XIV, Part 2 - Section F, paragraph 2: Specific requirements (Stainless steels)	*2.3.2. Welded stainless steels for liners of containers shall conform to sections 4.1. to 4.3. as well as sections 6.1., 6.2. and 6.4. of standard EN 13322-2:2006 as appropriate.*	EN 13322-2:2006
Annex XIV: Hydrogen system material compatibility and fuelling receptacle	Part 2 - Section F: Technical specifications for hydrogen components on	Annex XIV, Part 2 - Section F, paragraph 2: Specific requirements	*2.4.1. Aluminium alloys used in CHSS shall conform to the material requirements of sections 6.1. and 6.2. of international standard ISO 7866:2012.*	ISO 7866:2012

Conditions	Item	Documentation	Additional Description	Information
	material compatibility	(aluminium alloys)		
Annex XIV: Hydrogen system material compatibility and fuelling receptacle	Part 2 - Section F: Technical specifications for hydrogen components on material compatibility	Annex XIV, Part 2 - Section F, paragraph 3: Hydrogen compatibility test	*3.1. For metallic materials used in CHSS, hydrogen compatibility of the material, including that of welds, shall be demonstrated in accordance with international standards ISO 11114-1:2017 and ISO 11114-4:2017, with the tests carried out in hydrogen environments as anticipated in service (e.g. in case of 70 MPa systems, the hydrogen compatibility testing is carried out in 70 Mpa environment at the temperature of -40 °C). Alternatively, in agreement with the technical service and the type-approval authority, compliance may be demonstrated in accordance with the standard SAE J2579:2018.*	ISO 11114-1:2017 ISO 11114-4:2017 SAE J2579:2018
Annex XIV: Hydrogen system material compatibility and fuelling receptacle	Part 2 - Section F: Technical specifications for hydrogen components on material compatibility	Annex XIV, Part 2 - Section F, paragraph 3: Hydrogen compatibility test	*3.2. Demonstration of compliance with the provisions of point 3.1. is not required for:* *(a) steels that conform to paragraphs 6.3. and 7.2.2. of standard EN 9809-1:2018* *(b) aluminium alloys that conform to paragraph 6.1. of international standard ISO 7866:2012;*	EN 9809-1:2018 ISO 7866:2012

REGULATION ADN-2021-VOLUMES 1&2 (UN/ECE)

A. IDENTITY CARD OF REGULATION ADN-2021-VOLUMES 1&2 (UN/ECE)

RCS	Number of RCS	Title	Date	Stability date	Statutory
Regulation	ADN-2021 (UN/ECE)	European Agreement concerning the Carriage of Goods by Inland Waterways (ADN) – Volume I[36]	2021	01/01/2021	Y

Scope: The Regulations annexed to the ADN contain provisions concerning dangeous susbstances and articles, provisiopns concerning their carriage in packagaes and in bulk on board inland navigatins vessels or tank vessels, as well as provisions concerning the construction and operation of such vessels.

In sub-chapter 1.1.3.3 *"Exemptions related to dangerous goods used for the propulsion of vessels, vehicles, wagons or non-road mobile machinery carried, for the operation of their special equipment, for their safety"*, it is stated that this ADN agreement does not apply to substances used for the propulsion of ships, ...

It is written in this chapter: *"the requirements of ADN do not apply to substances used*

- *For the propulsion of vessels, vehicles, wagons or non-road mobile machinery carried"*.

And

In sub-chapter 1.1.3.7: *"Exemptions related to the carriage of electric energy storage and production systems"*:

"The provisions laid down in ADN do not apply to electric enegy storage and production systems (e.g. ....and fuel cell:

(a) installed in a mean of transport, performing a transport operation and destined for its propulsion or for the operation of its equipment"

However, for the StasHH project, the requirements and regulations associated with compressed gas tanks may be, in part, relevant to the StasHH project. This sheet has been analyzed in this sense.

Domain/category: Danderous googs by inland waterways

Specifed exclusion: Shall not apply:

- to the carriage of dangerous goods by seagoing vessels on matitime waterways forming part of inland waterways.
- The carriage of dangerous goods by warships or auxiliary warships or other vessels belonging to or operated by a State, provided such vessels are used by the State exclusively for govenmental and non-governemental purposes.

Reference included in this RCS: /

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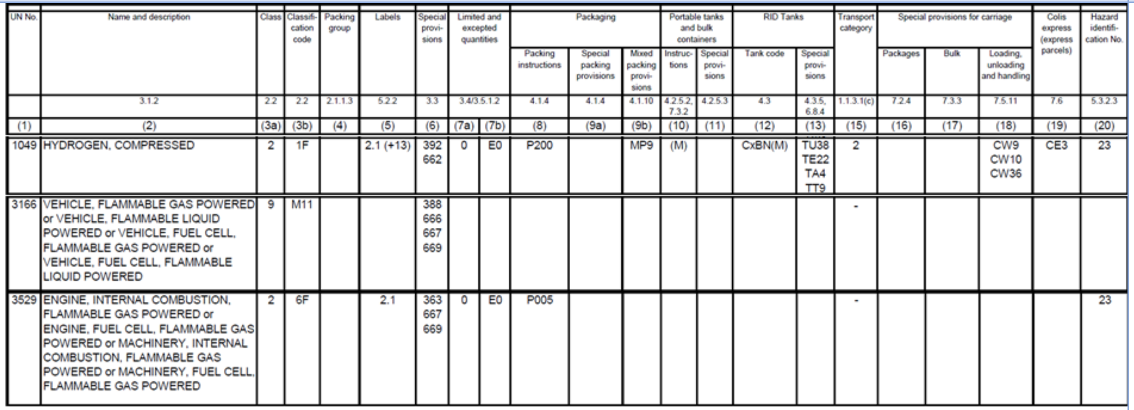
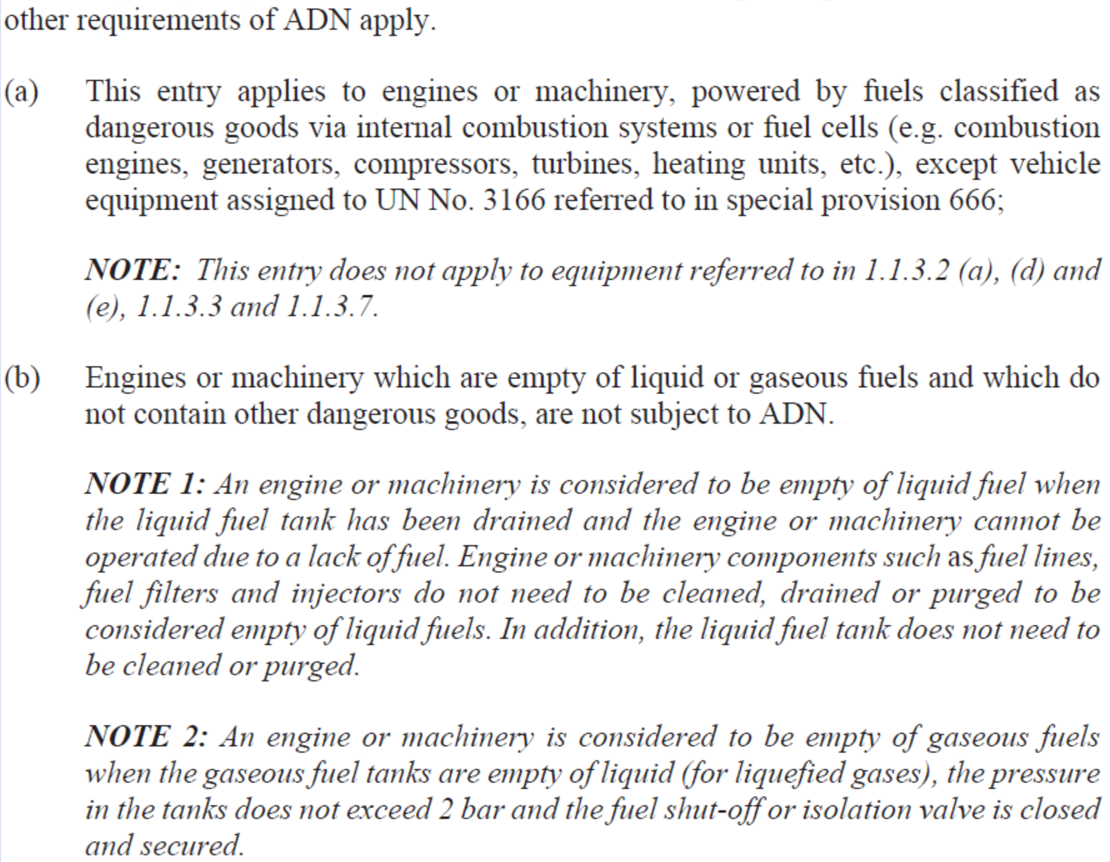
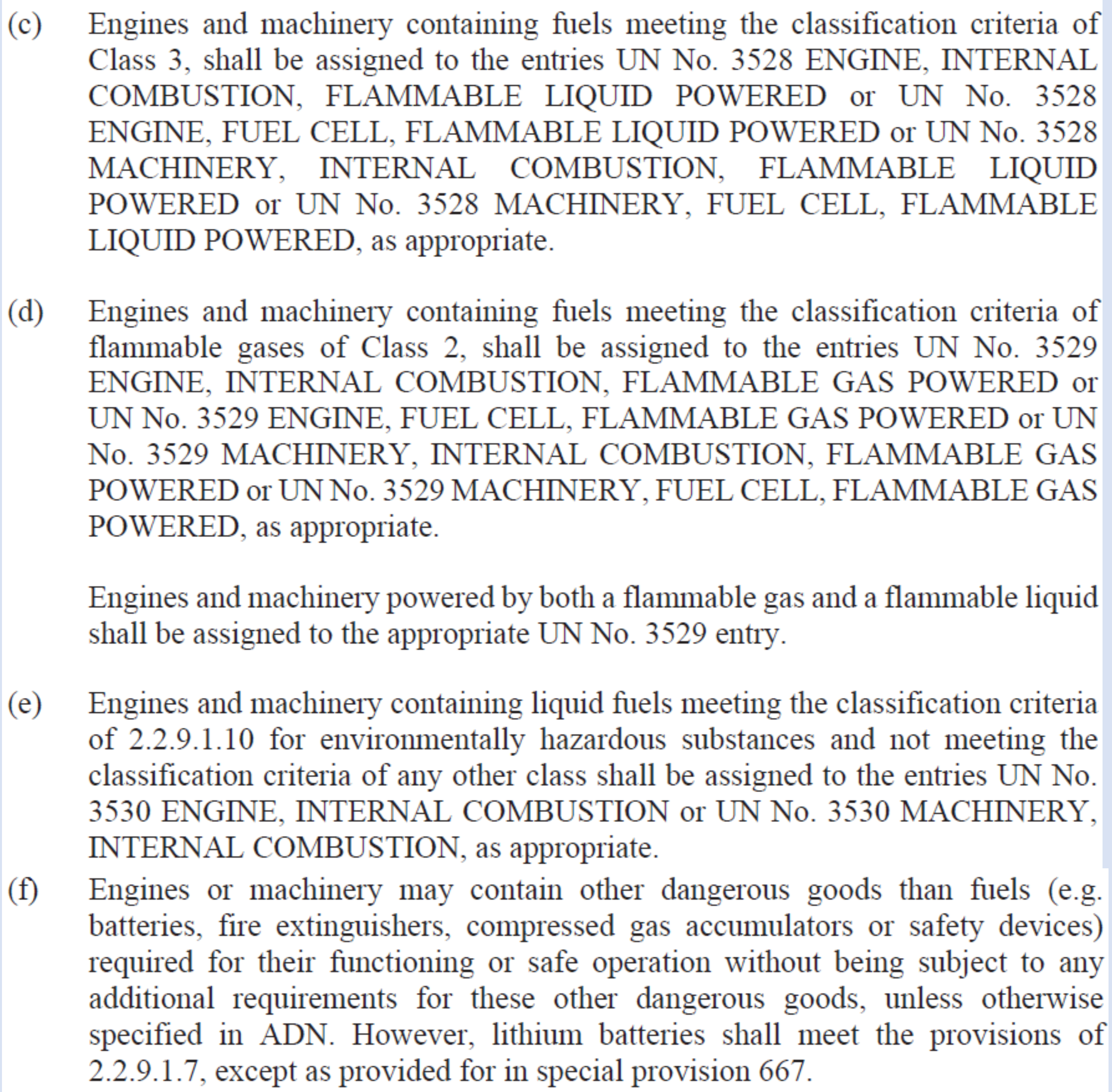
[36] ADN-2021 volume 1 includes volume 2 also

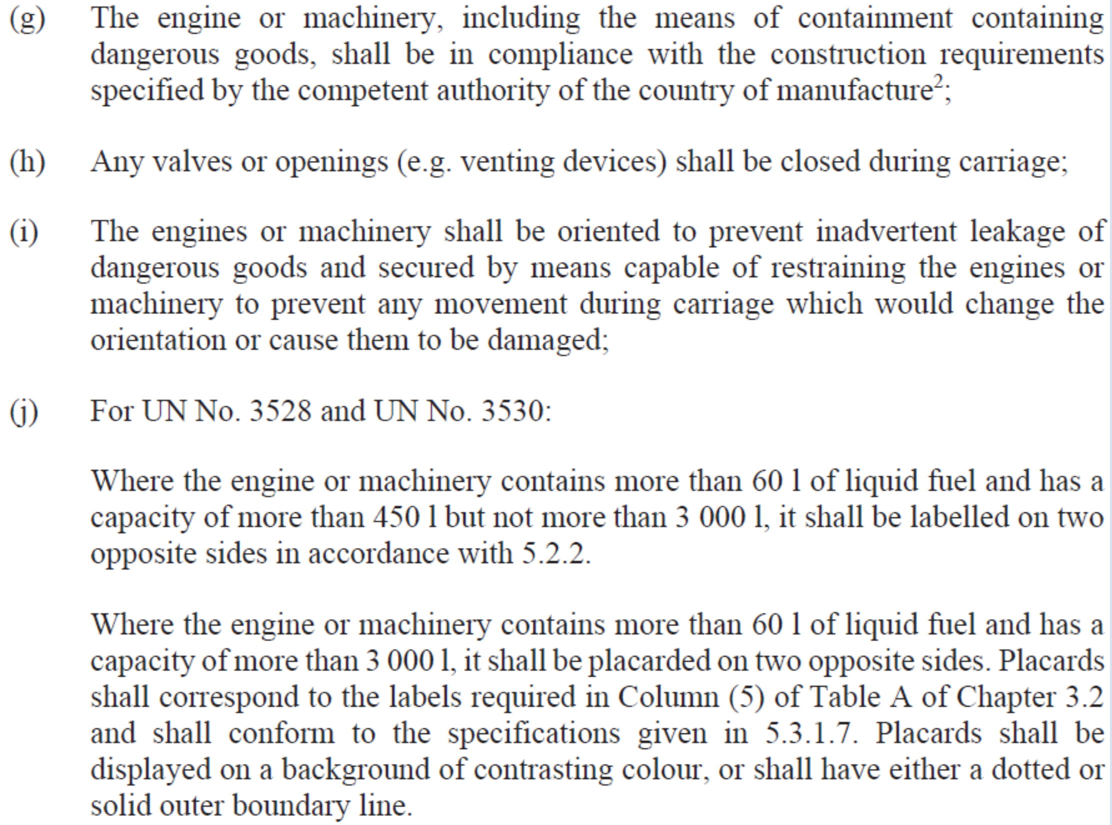
B. RELEVANT PARTS FOR STASHH PROJECT

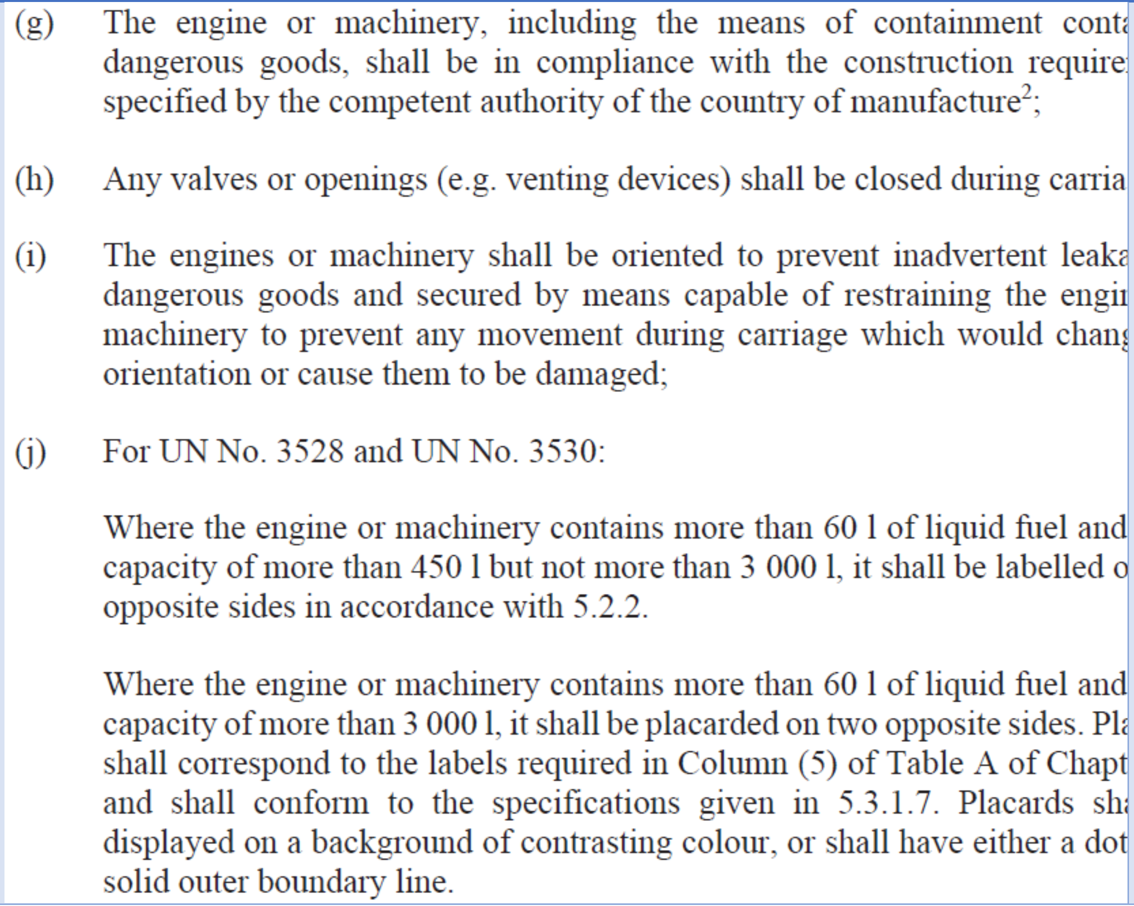
Conditions	Item	Documentation	Additional Description	Information
Part 3: Dangerous goods list, special provisions and exemptions related to limited and excepted quantities	Chapter 3.2 Dangerous goods list	Table A: List of dangerous goods in numerical order	 The explanations concerning Table A: see page 861 onwards.	

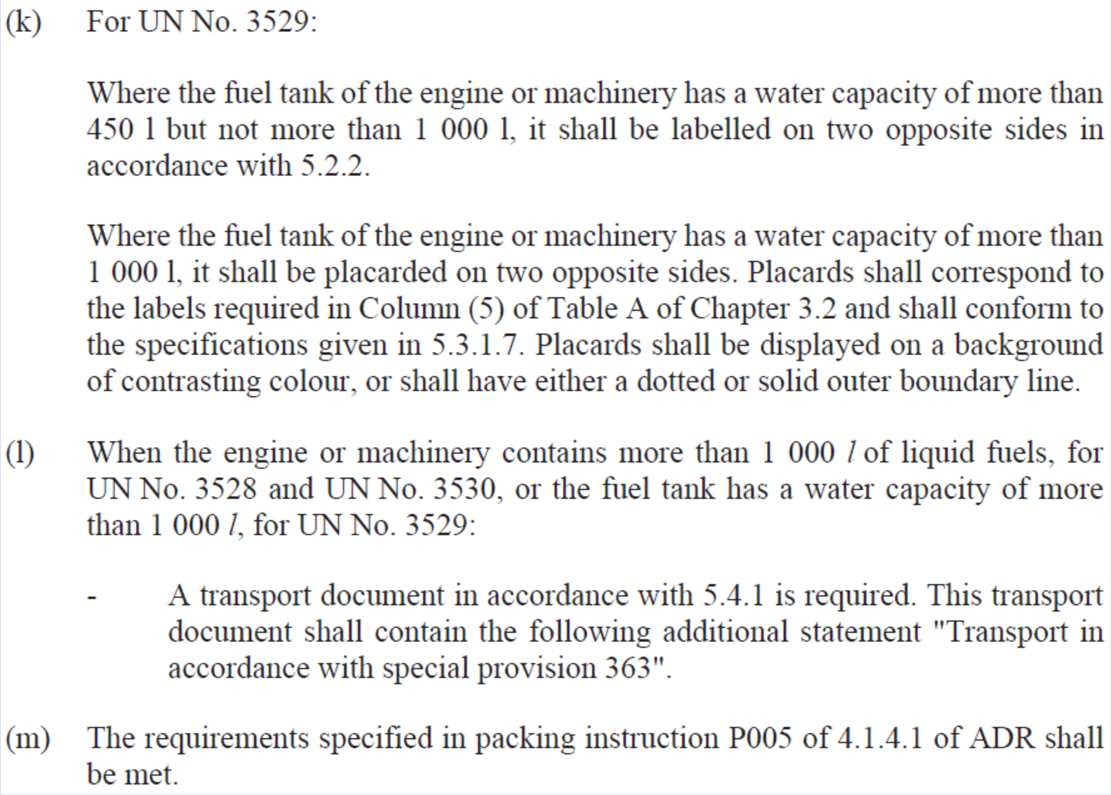
UN No.	Name and description	Class	Classification code	Packing group	Labels	Special provisions	Limited and excepted quantities		Packaging			Portable tanks and bulk containers		RID Tanks		Transport category	Special provisions for carriage			Colis express (express parcels)	Hazard identification No.
									Packing instructions	Special packing provisions	Mixed packing provisions	Instructions	Special provisions	Tank code	Special provisions		Packages	Bulk	Loading, unloading and handling		
	3.1.2	2.2	2.2	2.1.1.3	5.2.2	3.3	3.4/3.5.1.2		4.1.4	4.1.4	4.1.10	4.2.5.2, 7.3.2	4.2.5.3	4.3	4.3.5, 6.8.4	1.1.3.1(c)	7.2.4	7.3.3	7.5.11	7.6	5.3.2.3
(1)	(2)	(3a)	(3b)	(4)	(5)	(6)	(7a)	(7b)	(8)	(9a)	(9b)	(10)	(11)	(12)	(13)	(15)	(16)	(17)	(18)	(19)	(20)
1049	HYDROGEN, COMPRESSED	2	1F		2.1 (+13)	392 662	0	E0	P200		MP9	(M)		CxBN(M)	TU38 TE22 TA4 TT9	2			CW9 CW10 CW36	CE3	23
3166	VEHICLE, FLAMMABLE GAS POWERED or VEHICLE, FLAMMABLE LIQUID POWERED or VEHICLE, FUEL CELL, FLAMMABLE GAS POWERED or VEHICLE, FUEL CELL, FLAMMABLE LIQUID POWERED	9	M11			388 666 667 669										-					
3529	ENGINE, INTERNAL COMBUSTION, FLAMMABLE GAS POWERED or ENGINE, FUEL CELL, FLAMMABLE GAS POWERED or MACHINERY, INTERNAL COMBUSTION, FLAMMABLE GAS POWERED or MACHINERY, FUEL CELL, FLAMMABLE GAS POWERED	2	6F		2.1	363 667 669	0	E0	P005							-					23

Conditions	Item	Documentation	Additional Description	Information
Part 3: Dangerous goods list, special provisions and exemptions related to limited and excepted quantities	Chapter 3.3 Special provisions applicable to certain articles or substances	Special provisions number: 363	 This entry may only be used when the conditions of this special provision are met. No other requirements of ADN apply. (a) This entry applies to engines or machinery, powered by fuels classified as dangerous goods via internal combustion systems or fuel cells (e.g. combustion engines, generators, compressors, turbines, heating units, etc.), except vehicle equipment assigned to UN No. 3166 referred to in special provision 666; ***NOTE:*** *This entry does not apply to equipment referred to in 1.1.3.2 (a), (d) and (e), 1.1.3.3 and 1.1.3.7.* (b) Engines or machinery which are empty of liquid or gaseous fuels and which do not contain other dangerous goods, are not subject to ADN. ***NOTE 1:*** *An engine or machinery is considered to be empty of liquid fuel when the liquid fuel tank has been drained and the engine or machinery cannot be operated due to a lack of fuel. Engine or machinery components such as fuel lines, fuel filters and injectors do not need to be cleaned, drained or purged to be considered empty of liquid fuels. In addition, the liquid fuel tank does not need to be cleaned or purged.* ***NOTE 2:*** *An engine or machinery is considered to be empty of gaseous fuels when the gaseous fuel tanks are empty of liquid (for liquefied gases), the pressure in the tanks does not exceed 2 bar and the fuel shut-off or isolation valve is closed and secured.*	

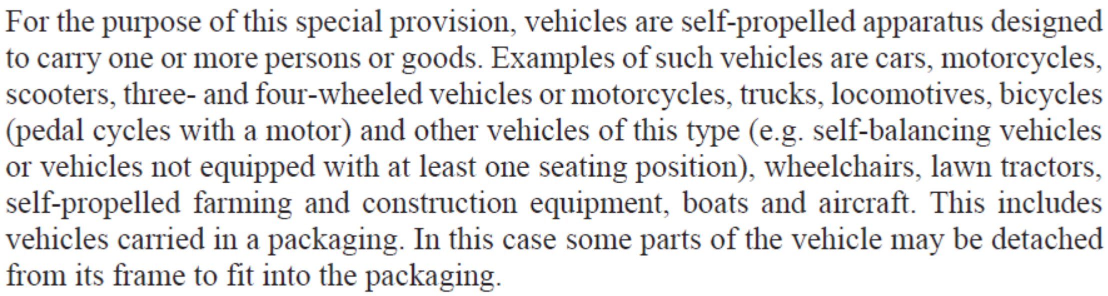
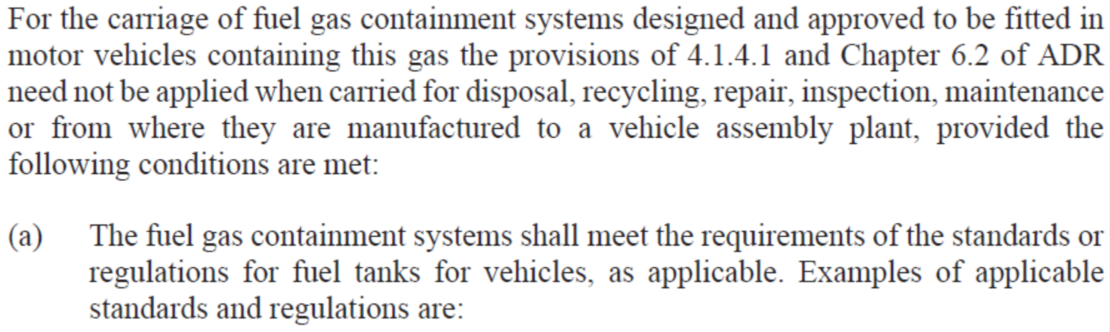
Conditions	Item	Documentation	Additional Description	Information
			 (c) Engines and machinery containing fuels meeting the classification criteria of Class 3, shall be assigned to the entries UN No. 3528 ENGINE, INTERNAL COMBUSTION, FLAMMABLE LIQUID POWERED or UN No. 3528 ENGINE, FUEL CELL, FLAMMABLE LIQUID POWERED or UN No. 3528 MACHINERY, INTERNAL COMBUSTION, FLAMMABLE LIQUID POWERED or UN No. 3528 MACHINERY, FUEL CELL, FLAMMABLE LIQUID POWERED, as appropriate. (d) Engines and machinery containing fuels meeting the classification criteria of flammable gases of Class 2, shall be assigned to the entries UN No. 3529 ENGINE, INTERNAL COMBUSTION, FLAMMABLE GAS POWERED or UN No. 3529 ENGINE, FUEL CELL, FLAMMABLE GAS POWERED or UN No. 3529 MACHINERY, INTERNAL COMBUSTION, FLAMMABLE GAS POWERED or UN No. 3529 MACHINERY, FUEL CELL, FLAMMABLE GAS POWERED, as appropriate. Engines and machinery powered by both a flammable gas and a flammable liquid shall be assigned to the appropriate UN No. 3529 entry. (e) Engines and machinery containing liquid fuels meeting the classification criteria of 2.2.9.1.10 for environmentally hazardous substances and not meeting the classification criteria of any other class shall be assigned to the entries UN No. 3530 ENGINE, INTERNAL COMBUSTION or UN No. 3530 MACHINERY, INTERNAL COMBUSTION, as appropriate. (f) Engines or machinery may contain other dangerous goods than fuels (e.g. batteries, fire extinguishers, compressed gas accumulators or safety devices) required for their functioning or safe operation without being subject to any additional requirements for these other dangerous goods, unless otherwise specified in ADN. However, lithium batteries shall meet the provisions of 2.2.9.1.7, except as provided for in special provision 667.	

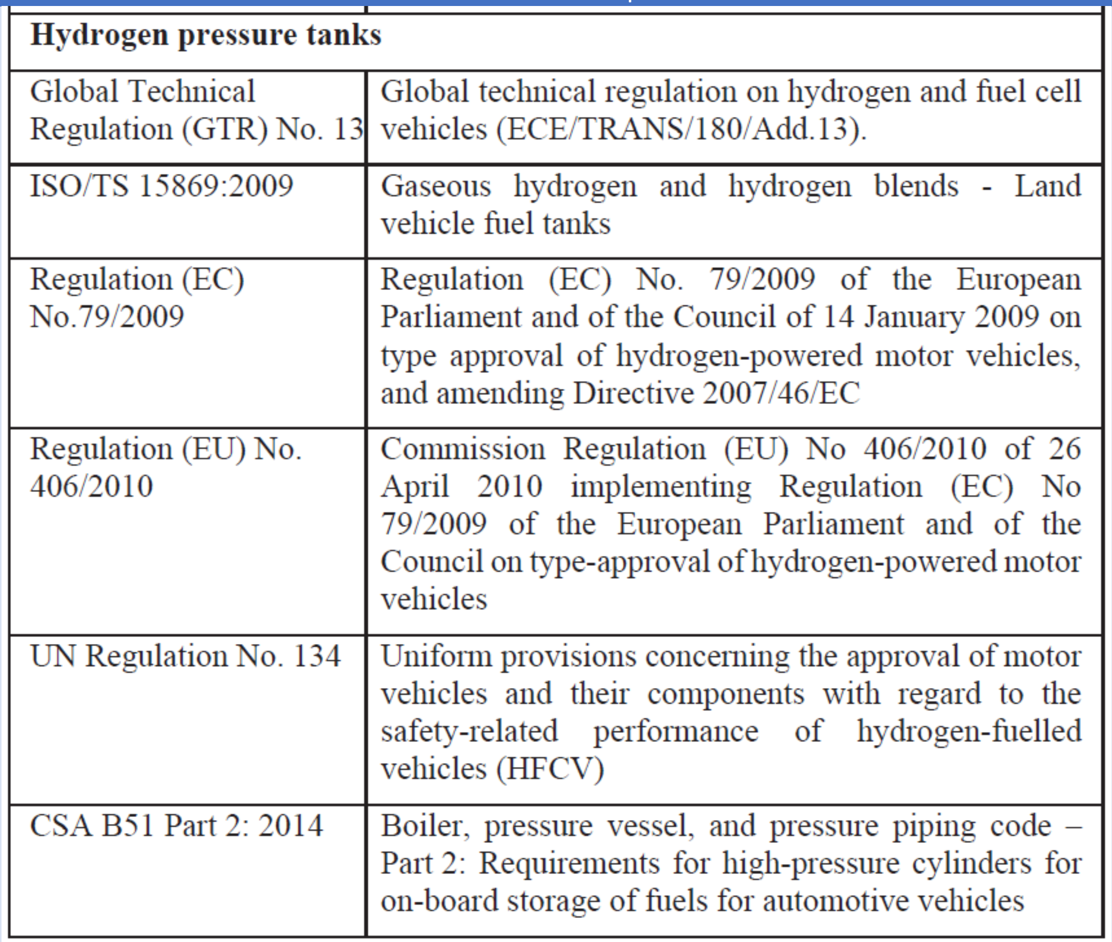
Conditions	Item	Documentation	Additional Description	Information
			 (g) The engine or machinery, including the means of containment containing dangerous goods, shall be in compliance with the construction requirements specified by the competent authority of the country of manufacture[2]; (h) Any valves or openings (e.g. venting devices) shall be closed during carriage; (i) The engines or machinery shall be oriented to prevent inadvertent leakage of dangerous goods and secured by means capable of restraining the engines or machinery to prevent any movement during carriage which would change the orientation or cause them to be damaged; (j) For UN No. 3528 and UN No. 3530: Where the engine or machinery contains more than 60 l of liquid fuel and has a capacity of more than 450 l but not more than 3 000 l, it shall be labelled on two opposite sides in accordance with 5.2.2. Where the engine or machinery contains more than 60 l of liquid fuel and has a capacity of more than 3 000 l, it shall be placarded on two opposite sides. Placards shall correspond to the labels required in Column (5) of Table A of Chapter 3.2 and shall conform to the specifications given in 5.3.1.7. Placards shall be displayed on a background of contrasting colour, or shall have either a dotted or solid outer boundary line.	

Conditions	Item	Documentation	Additional Description	Information
			 (g) The engine or machinery, including the means of containment conta dangerous goods, shall be in compliance with the construction require specified by the competent authority of the country of manufacture[2]; (h) Any valves or openings (e.g. venting devices) shall be closed during carria (i) The engines or machinery shall be oriented to prevent inadvertent leaka dangerous goods and secured by means capable of restraining the engi machinery to prevent any movement during carriage which would chang orientation or cause them to be damaged; (j) For UN No. 3528 and UN No. 3530: Where the engine or machinery contains more than 60 l of liquid fuel and capacity of more than 450 l but not more than 3 000 l, it shall be labelled o opposite sides in accordance with 5.2.2. Where the engine or machinery contains more than 60 l of liquid fuel and capacity of more than 3 000 l, it shall be placarded on two opposite sides. Pla shall correspond to the labels required in Column (5) of Table A of Chapt and shall conform to the specifications given in 5.3.1.7. Placards sha displayed on a background of contrasting colour, or shall have either a dot solid outer boundary line.	

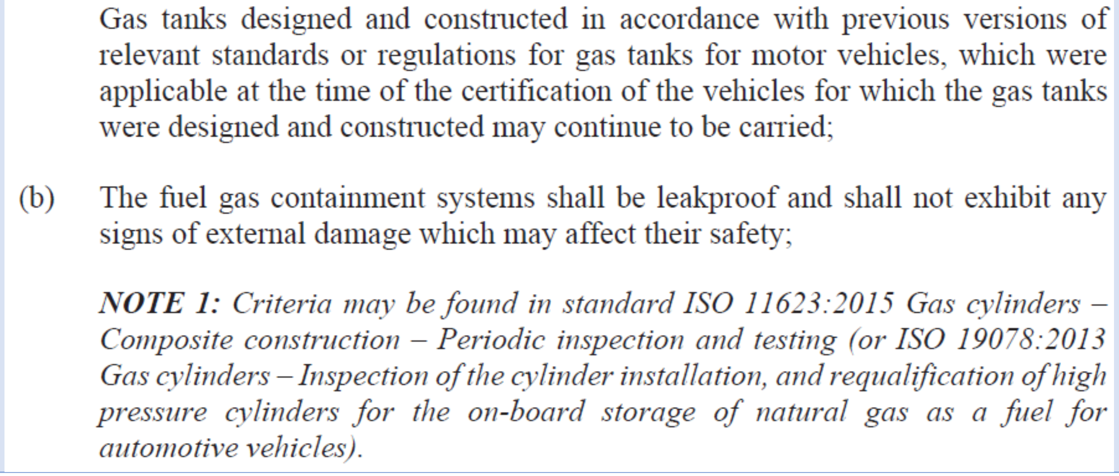
Conditions	Item	Documentation	Additional Description	Information
			 (k) For UN No. 3529: Where the fuel tank of the engine or machinery has a water capacity of more than 450 l but not more than 1 000 l, it shall be labelled on two opposite sides in accordance with 5.2.2. Where the fuel tank of the engine or machinery has a water capacity of more than 1 000 l, it shall be placarded on two opposite sides. Placards shall correspond to the labels required in Column (5) of Table A of Chapter 3.2 and shall conform to the specifications given in 5.3.1.7. Placards shall be displayed on a background of contrasting colour, or shall have either a dotted or solid outer boundary line. (l) When the engine or machinery contains more than 1 000 *l* of liquid fuels, for UN No. 3528 and UN No. 3530, or the fuel tank has a water capacity of more than 1 000 *l*, for UN No. 3529: - A transport document in accordance with 5.4.1 is required. This transport document shall contain the following additional statement "Transport in accordance with special provision 363". (m) The requirements specified in packing instruction P005 of 4.1.4.1 of ADR shall be met.	

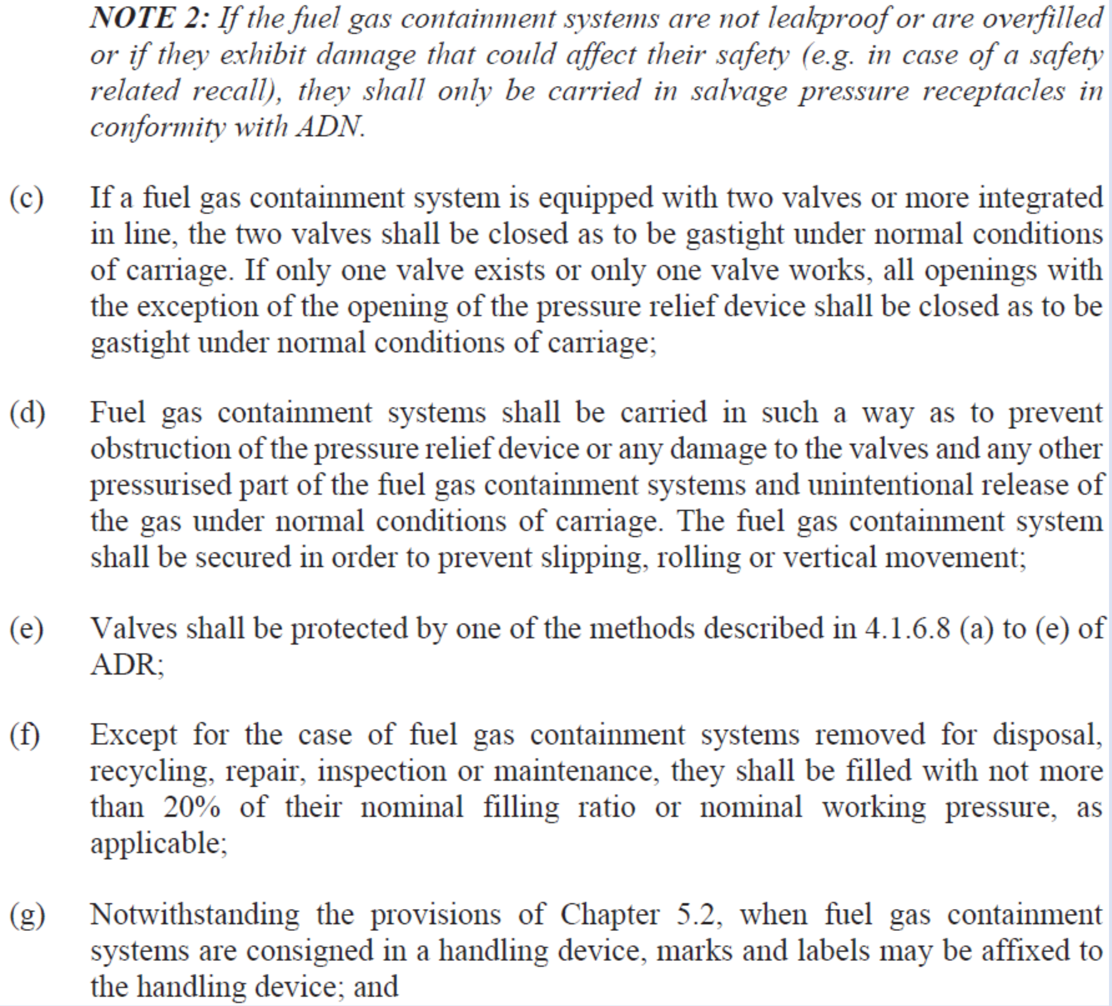
Conditions	Item	Documentation	Additional Description	Information
Part 3: Dangerous goods list, special provisions and exemptions related to limited and excepted quantities	Chapter 3.3 Special provisions applicable to certain articles or substances	Special provisions number: 388	UN No. 3166 entries apply to vehicles powered by flammable liquid or gas internal combustion engines or fuel cells. Vehicles powered by a fuel cell engine shall be assigned to the entries UN No. 3166 VEHICLE, FUEL CELL, FLAMMABLE GAS POWERED or UN No. 3166 VEHICLE, FUEL CELL, FLAMMABLE LIQUID POWERED, as appropriate. These entries include hybrid electric vehicles powered by both a fuel cell and an internal combustion engine with wet batteries, sodium batteries, lithium metal batteries or lithium ion batteries, carried with the battery(ies) installed. Other vehicles which contain an internal combustion engine shall be assigned to the entries UN No. 3166 VEHICLE, FLAMMABLE GAS POWERED or UN No. 3166 VEHICLE, FLAMMABLE LIQUID POWERED, as appropriate. These entries include hybrid electric vehicles powered by both an internal combustion engine and wet batteries, sodium batteries, lithium metal batteries or lithium ion batteries, carried with the battery(ies) installed. If a vehicle is powered by a flammable liquid and a flammable gas internal combustion engine, it shall be assigned to UN No. 3166 VEHICLE, FLAMMABLE GAS POWERED. Entry UN No. 3171 only applies to vehicles powered by wet batteries, sodium batteries, lithium metal batteries or lithium ion batteries and equipment powered by wet batteries or sodium batteries carried with these batteries installed.	

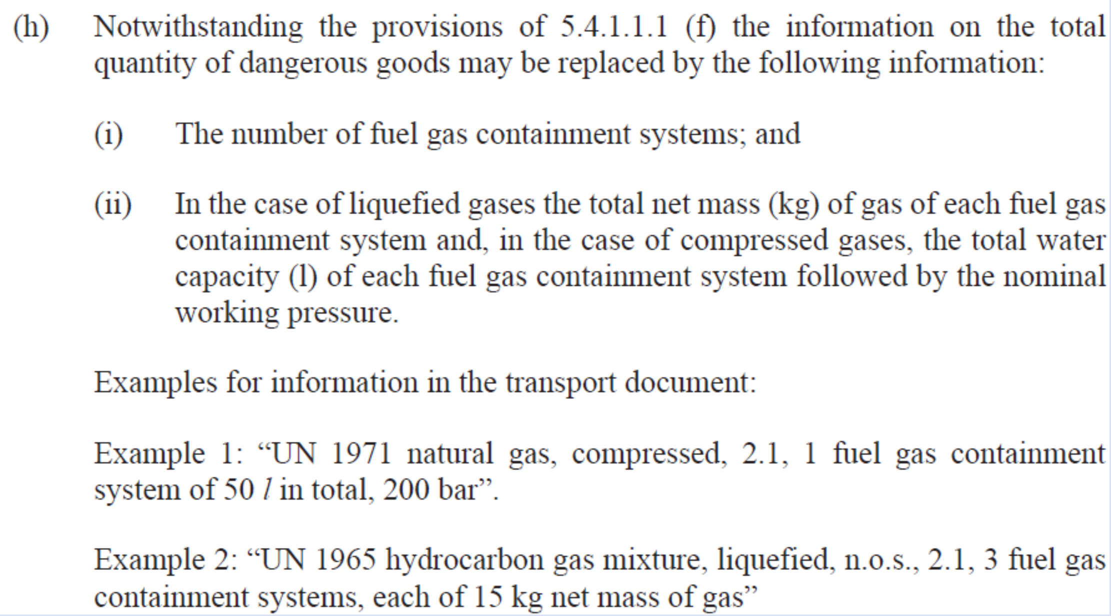
Conditions	Item	Documentation	Additional Description	Information
			 For the purpose of this special provision, vehicles are self-propelled apparatus designed to carry one or more persons or goods. Examples of such vehicles are cars, motorcycles, scooters, three- and four-wheeled vehicles or motorcycles, trucks, locomotives, bicycles (pedal cycles with a motor) and other vehicles of this type (e.g. self-balancing vehicles or vehicles not equipped with at least one seating position), wheelchairs, lawn tractors, self-propelled farming and construction equipment, boats and aircraft. This includes vehicles carried in a packaging. In this case some parts of the vehicle may be detached from its frame to fit into the packaging.	
Part 3: Dangerous goods list, special provisions and exemptions related to limited and excepted quantities	Chapter 3.3 Special provisions applicable to certain articles or substances	Special provisions number: 392	 For the carriage of fuel gas containment systems designed and approved to be fitted in motor vehicles containing this gas the provisions of 4.1.4.1 and Chapter 6.2 of ADR need not be applied when carried for disposal, recycling, repair, inspection, maintenance or from where they are manufactured to a vehicle assembly plant, provided the following conditions are met: (a) The fuel gas containment systems shall meet the requirements of the standards or regulations for fuel tanks for vehicles, as applicable. Examples of applicable standards and regulations are:	Regulations (EC) 2010/410 and (EC) 2009/79 will be repealed in july 2022

Conditions	Item	Documentation	Additional Description	Information
				

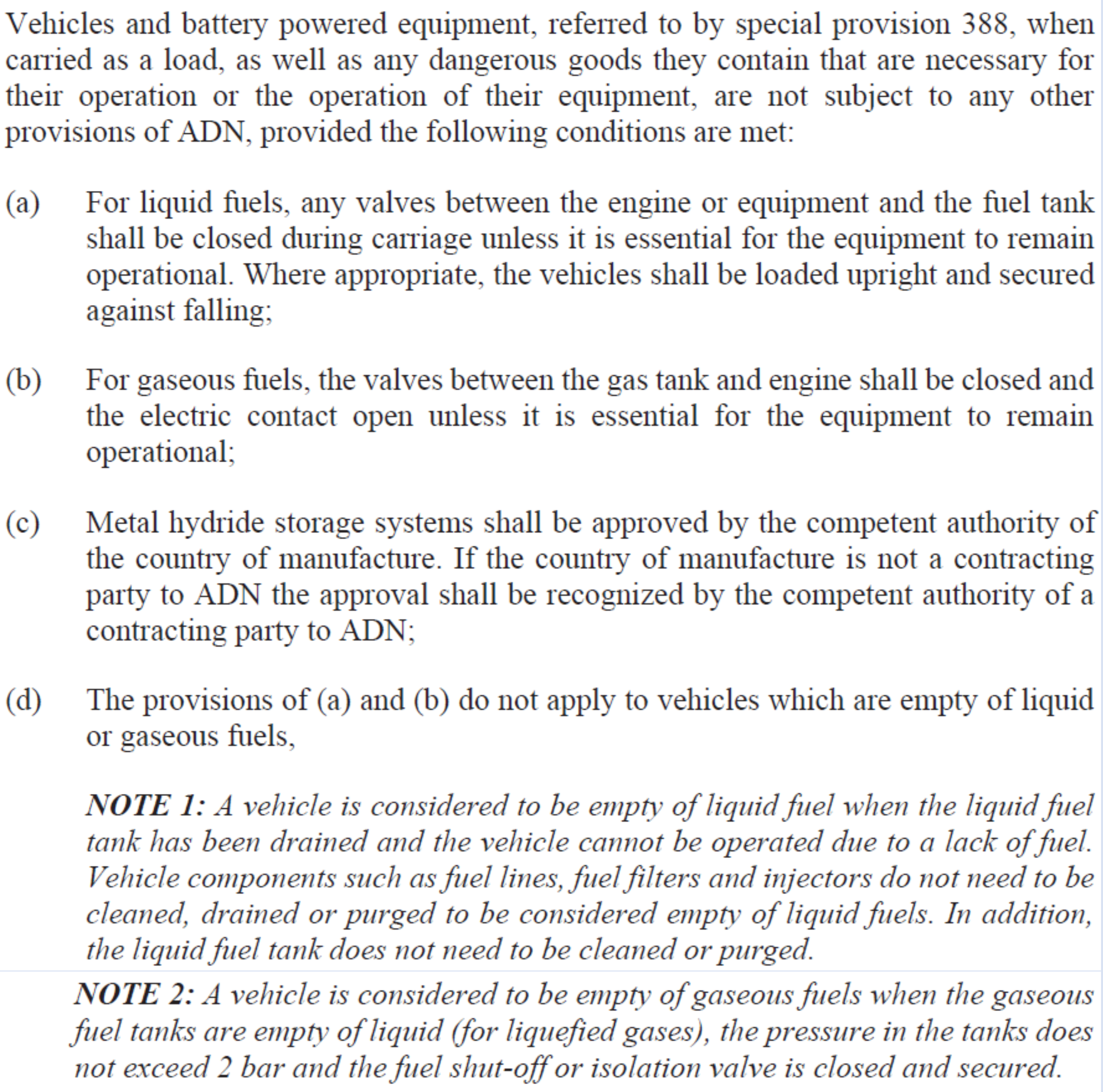
Hydrogen pressure tanks	
Global Technical Regulation (GTR) No. 13	Global technical regulation on hydrogen and fuel cell vehicles (ECE/TRANS/180/Add.13).
ISO/TS 15869:2009	Gaseous hydrogen and hydrogen blends - Land vehicle fuel tanks
Regulation (EC) No.79/2009	Regulation (EC) No. 79/2009 of the European Parliament and of the Council of 14 January 2009 on type approval of hydrogen-powered motor vehicles, and amending Directive 2007/46/EC
Regulation (EU) No. 406/2010	Commission Regulation (EU) No 406/2010 of 26 April 2010 implementing Regulation (EC) No 79/2009 of the European Parliament and of the Council on type-approval of hydrogen-powered motor vehicles
UN Regulation No. 134	Uniform provisions concerning the approval of motor vehicles and their components with regard to the safety-related performance of hydrogen-fuelled vehicles (HFCV)
CSA B51 Part 2: 2014	Boiler, pressure vessel, and pressure piping code – Part 2: Requirements for high-pressure cylinders for on-board storage of fuels for automotive vehicles

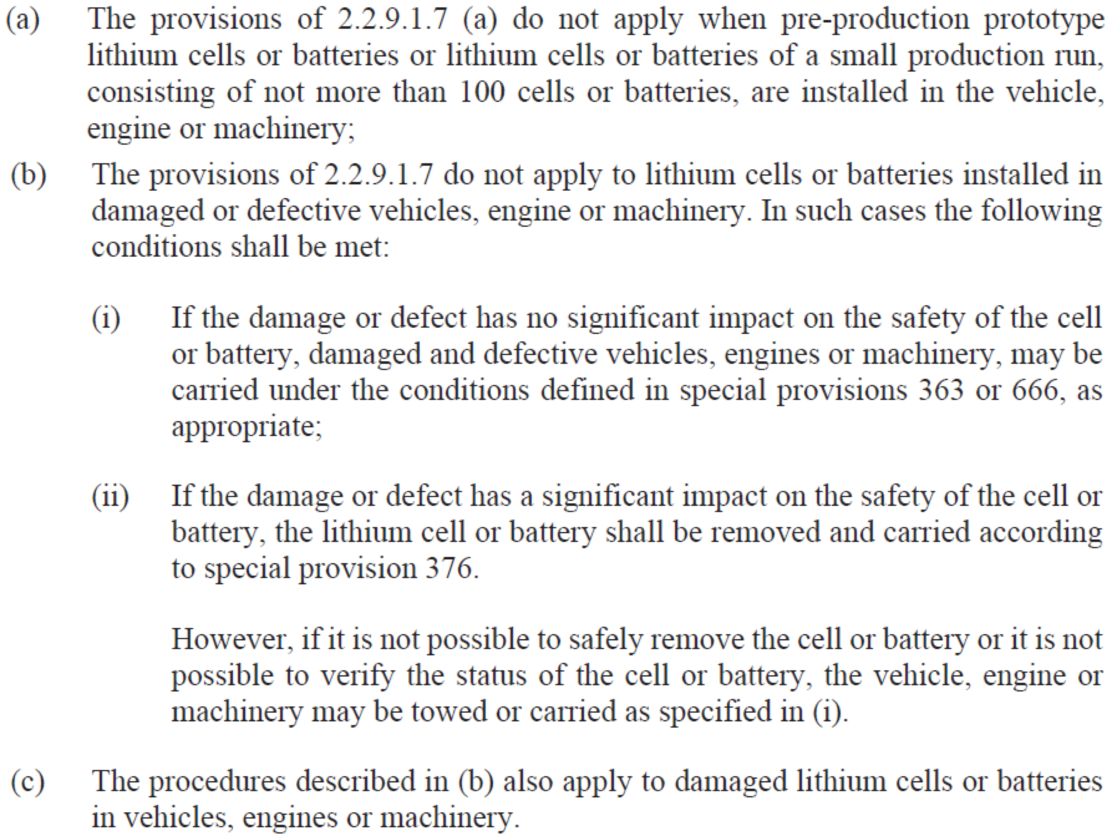
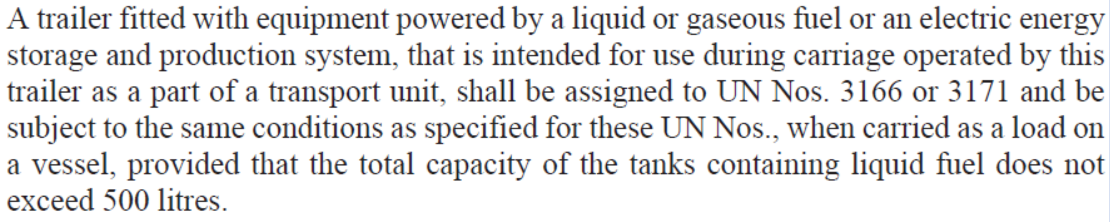
Conditions	Item	Documentation	Additional Description	Information
			Gas tanks designed and constructed in accordance with previous versions of relevant standards or regulations for gas tanks for motor vehicles, which were applicable at the time of the certification of the vehicles for which the gas tanks were designed and constructed may continue to be carried; (b) The fuel gas containment systems shall be leakproof and shall not exhibit any signs of external damage which may affect their safety; ***NOTE 1:*** *Criteria may be found in standard ISO 11623:2015 Gas cylinders – Composite construction – Periodic inspection and testing (or ISO 19078:2013 Gas cylinders – Inspection of the cylinder installation, and requalification of high pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles).*	

Conditions	Item	Documentation	Additional Description	Information
			 ***NOTE 2:*** *If the fuel gas containment systems are not leakproof or are overfilled or if they exhibit damage that could affect their safety (e.g. in case of a safety related recall), they shall only be carried in salvage pressure receptacles in conformity with ADN.* (c) If a fuel gas containment system is equipped with two valves or more integrated in line, the two valves shall be closed as to be gastight under normal conditions of carriage. If only one valve exists or only one valve works, all openings with the exception of the opening of the pressure relief device shall be closed as to be gastight under normal conditions of carriage; (d) Fuel gas containment systems shall be carried in such a way as to prevent obstruction of the pressure relief device or any damage to the valves and any other pressurised part of the fuel gas containment systems and unintentional release of the gas under normal conditions of carriage. The fuel gas containment system shall be secured in order to prevent slipping, rolling or vertical movement; (e) Valves shall be protected by one of the methods described in 4.1.6.8 (a) to (e) of ADR; (f) Except for the case of fuel gas containment systems removed for disposal, recycling, repair, inspection or maintenance, they shall be filled with not more than 20% of their nominal filling ratio or nominal working pressure, as applicable; (g) Notwithstanding the provisions of Chapter 5.2, when fuel gas containment systems are consigned in a handling device, marks and labels may be affixed to the handling device; and	

Conditions	Item	Documentation	Additional Description	Information
			 (h) Notwithstanding the provisions of 5.4.1.1.1 (f) the information on the total quantity of dangerous goods may be replaced by the following information: (i) The number of fuel gas containment systems; and (ii) In the case of liquefied gases the total net mass (kg) of gas of each fuel gas containment system and, in the case of compressed gases, the total water capacity (l) of each fuel gas containment system followed by the nominal working pressure. Examples for information in the transport document: Example 1: "UN 1971 natural gas, compressed, 2.1, 1 fuel gas containment system of 50 *l* in total, 200 bar". Example 2: "UN 1965 hydrocarbon gas mixture, liquefied, n.o.s., 2.1, 3 fuel gas containment systems, each of 15 kg net mass of gas"	

Conditions	Item	Documentation	Additional Description	Information
Part 3: Dangerous goods list, special provisions and exemptions related to limited and excepted quantities	Chapter 3.3 Special provisions applicable to certain articles or substances	Special provisions number: 662	Cylinders not conforming to the provisions of Chapter 6.2 which are used exclusively on board a ship or aircraft, may be carried for the purpose of filling or inspection and subsequent return, provided the cylinders are designed and constructed in accordance with a standard recognized by the competent authority of the country of approval and all the other relevant requirements of ADN and other conditions are met including: (a) The cylinders shall be carried with valve protection in conformity with 4.1.6.8; (b) The cylinders shall be marked and labelled in conformity with 5.2.1 and 5.2.2; and (c) All the relevant filling requirements of packing instruction P200 of 4.1.4.1 of ADR are complied with. The transport document shall include the following statement: "Carriage in accordance with Special Provision 662".	

Conditions	Item	Documentation	Additional Description	Information
Part 3: Dangerous goods list, special provisions and exemptions related to limited and excepted quantities	Chapter 3.3 Special provisions applicable to certain articles or substances	Special provisions number: 666	 Vehicles and battery powered equipment, referred to by special provision 388, when carried as a load, as well as any dangerous goods they contain that are necessary for their operation or the operation of their equipment, are not subject to any other provisions of ADN, provided the following conditions are met: (a) For liquid fuels, any valves between the engine or equipment and the fuel tank shall be closed during carriage unless it is essential for the equipment to remain operational. Where appropriate, the vehicles shall be loaded upright and secured against falling; (b) For gaseous fuels, the valves between the gas tank and engine shall be closed and the electric contact open unless it is essential for the equipment to remain operational; (c) Metal hydride storage systems shall be approved by the competent authority of the country of manufacture. If the country of manufacture is not a contracting party to ADN the approval shall be recognized by the competent authority of a contracting party to ADN; (d) The provisions of (a) and (b) do not apply to vehicles which are empty of liquid or gaseous fuels, ***NOTE 1:*** *A vehicle is considered to be empty of liquid fuel when the liquid fuel tank has been drained and the vehicle cannot be operated due to a lack of fuel. Vehicle components such as fuel lines, fuel filters and injectors do not need to be cleaned, drained or purged to be considered empty of liquid fuels. In addition, the liquid fuel tank does not need to be cleaned or purged.* ***NOTE 2:*** *A vehicle is considered to be empty of gaseous fuels when the gaseous fuel tanks are empty of liquid (for liquefied gases), the pressure in the tanks does not exceed 2 bar and the fuel shut-off or isolation valve is closed and secured.*	

Conditions	Item	Documentation	Additional Description	Information
Part 3: Dangerous goods list, special provisions and exemptions related to limited and excepted quantities	Chapter 3.3 Special provisions applicable to certain articles or substances	Special provisions number: 667	 (a) The provisions of 2.2.9.1.7 (a) do not apply when pre-production prototype lithium cells or batteries or lithium cells or batteries of a small production run, consisting of not more than 100 cells or batteries, are installed in the vehicle, engine or machinery; (b) The provisions of 2.2.9.1.7 do not apply to lithium cells or batteries installed in damaged or defective vehicles, engine or machinery. In such cases the following conditions shall be met: (i) If the damage or defect has no significant impact on the safety of the cell or battery, damaged and defective vehicles, engines or machinery, may be carried under the conditions defined in special provisions 363 or 666, as appropriate; (ii) If the damage or defect has a significant impact on the safety of the cell or battery, the lithium cell or battery shall be removed and carried according to special provision 376. However, if it is not possible to safely remove the cell or battery or it is not possible to verify the status of the cell or battery, the vehicle, engine or machinery may be towed or carried as specified in (i). (c) The procedures described in (b) also apply to damaged lithium cells or batteries in vehicles, engines or machinery.	
Part 3: Dangerous goods list, special provisions and exemptions related to	Chapter 3.3 Special provisions applicable to certain articles or substances	Special provisions number: 669	 A trailer fitted with equipment powered by a liquid or gaseous fuel or an electric energy storage and production system, that is intended for use during carriage operated by this trailer as a part of a transport unit, shall be assigned to UN Nos. 3166 or 3171 and be subject to the same conditions as specified for these UN Nos., when carried as a load on a vessel, provided that the total capacity of the tanks containing liquid fuel does not exceed 500 litres.	

Conditions	Item	Documentation	Additional Description	Information
limited and excepted quantities				

REGULATION ADR-2021 (UN/ECE)

A. IDENTITY CARD OF REGULATION ADR-2021 (UN/ECE)

RCS	Number of RCS	Title	Date	Stability date	Statutory
Agreement	ADR-2021 (UN/ECE)	ADR Agreement Concerning the International Carriage of Dangerous Goods by Road	2020	01/01/2021	Y

Scope: Carriage of dangerous goods by road

In sub-chapter 1.1.3.2 *"Exemptions related to the carriage of gases"*, it is stated that this ADR agreement does not apply to substances used for the propulsion of vehicles, ...
It is written in this chapter: *"The provisions laid down in ADR do not apply to the carriage of:*

- *(a) "Gases contained in the fuel tanks or cylinders of a vehicle performing a transport operation and destined for its propulsion or for operation of any of its equipment used or intended for use during carriage".*

And
In sub-chapter 1.1.3.7: *"Exemptions related to the carriage of electric energy storage and production systems"*:
"The provisions laid down in ADR do not apply to electric enegy storage and production systems (e.g. ....and fuel cell:

- *(b) installed in a vehicle, performing a transport operation and destined for its propulsion or for the operation of its equipment"*

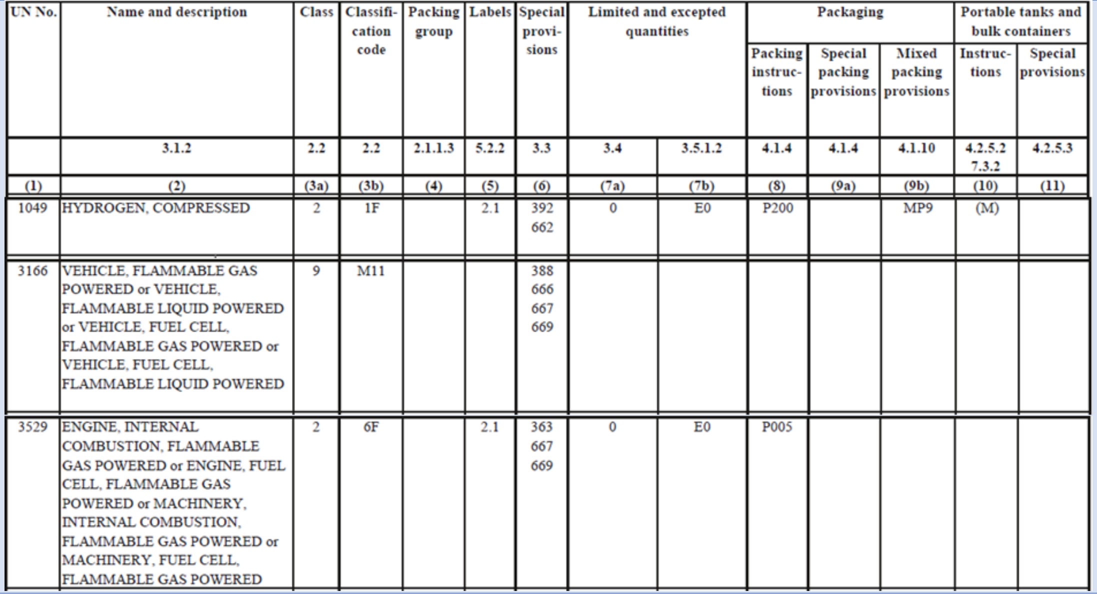
However, for the StasHH project, the requirements and regulations associated with compressed gas tanks may be, in part, relevant to the StasHH project. This sheet has been analyzed in this sense.

Domain/category: carriage of gases in road vehicle

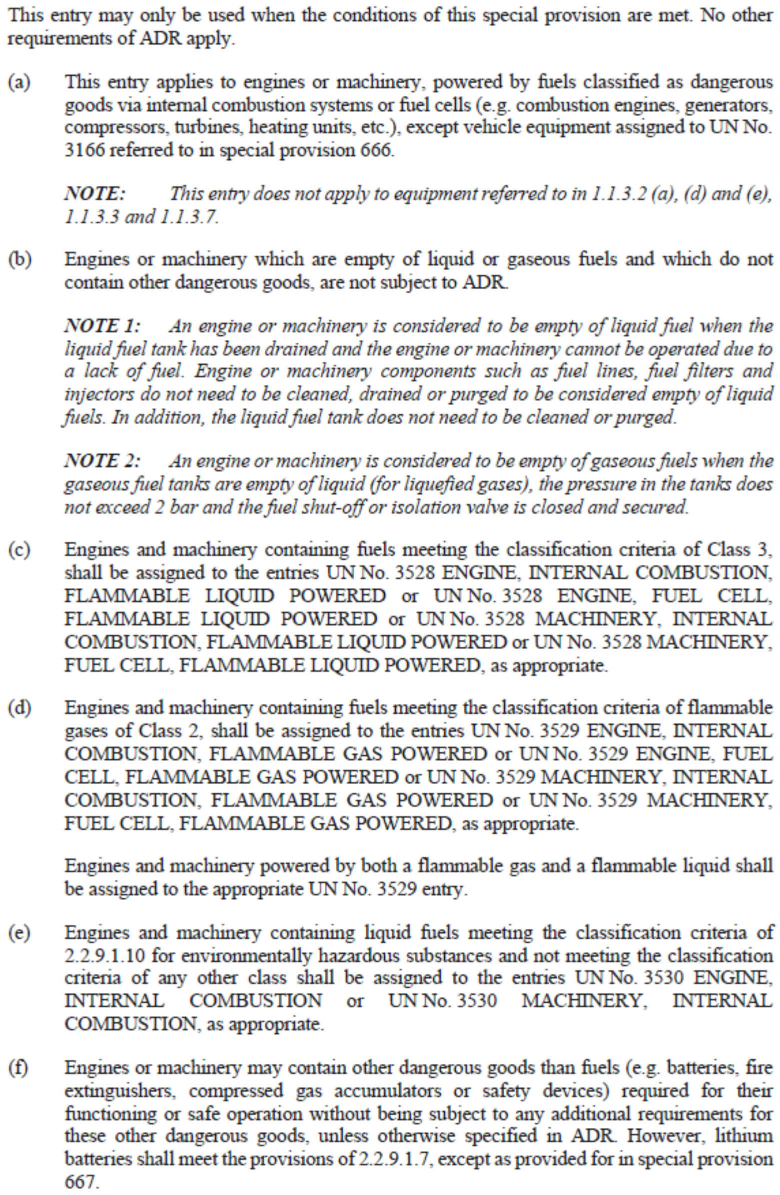
Specifed exclusion: see above concerning the main exemptions related to the carriage of gases (Interesting about the StasHH project).

Reference included in this RCS: /

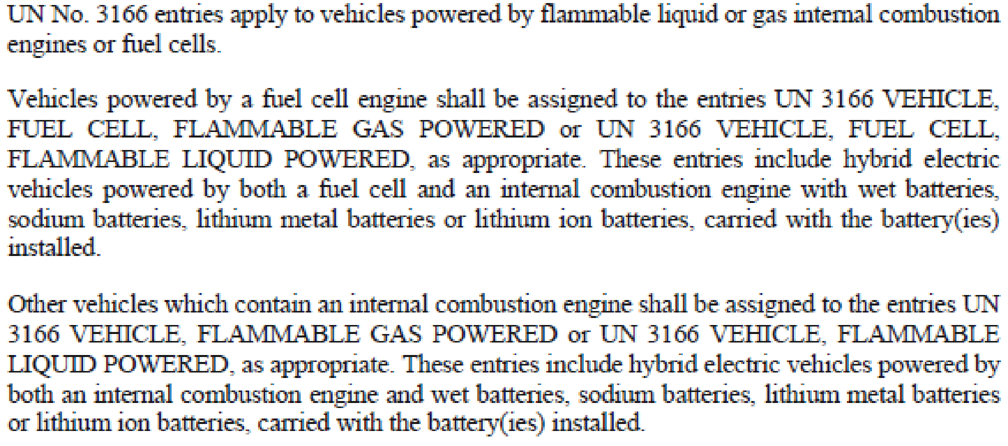
B. RELEVANT PARTS FOR STASHH PROJECT

Conditions	Item	Documentation	Additional Description	Information
Part 3: Dangerous goods list, special provisions and exemptions related to limited and excepted quantities	Chapter 3.2 Dangerous goods list	Sub-chapter 3.2.1: Table A: Dangerous goods list		The explanations concerning Table A: see page 275 onwards.

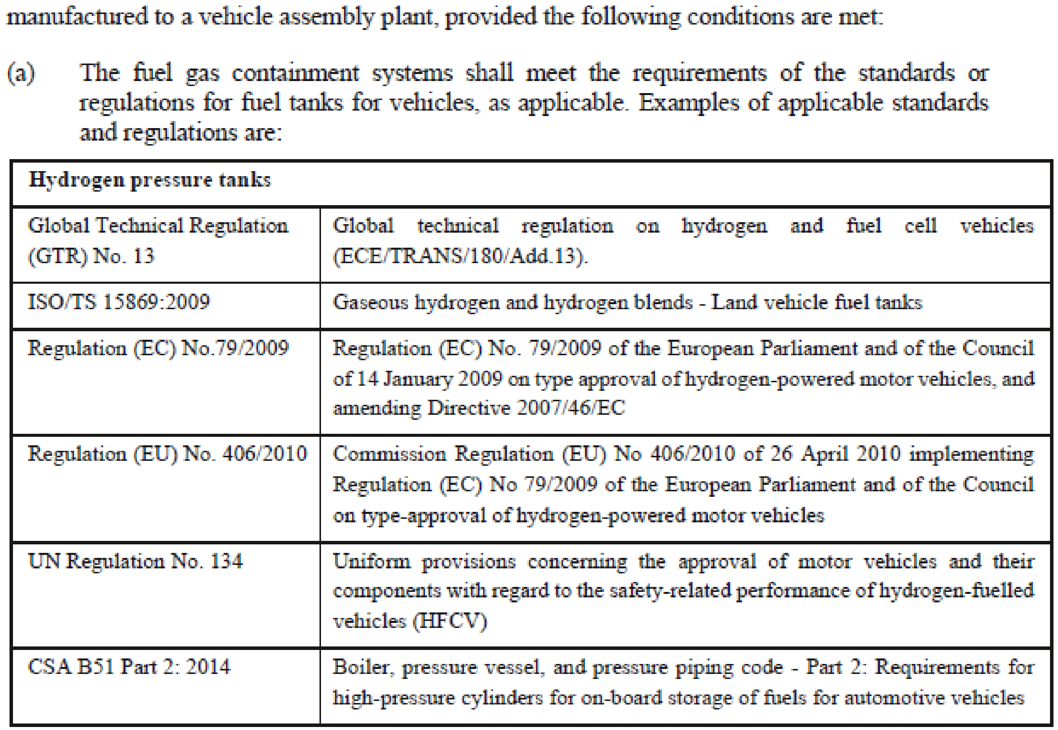
UN No.	Name and description	Class	Classification code	Packing group	Labels	Special provisions	Limited and excepted quantities		Packaging			Portable tanks and bulk containers	
									Packing instructions	Special packing provisions	Mixed packing provisions	Instructions	Special provisions
	3.1.2	2.2	2.2	2.1.1.3	5.2.2	3.3	3.4	3.5.1.2	4.1.4	4.1.4	4.1.10	4.2.5.2 7.3.2	4.2.5.3
(1)	(2)	(3a)	(3b)	(4)	(5)	(6)	(7a)	(7b)	(8)	(9a)	(9b)	(10)	(11)
1049	HYDROGEN, COMPRESSED	2	1F		2.1	392 662	0	E0	P200		MP9	(M)	
3166	VEHICLE, FLAMMABLE GAS POWERED or VEHICLE, FLAMMABLE LIQUID POWERED or VEHICLE, FUEL CELL, FLAMMABLE GAS POWERED or VEHICLE, FUEL CELL, FLAMMABLE LIQUID POWERED	9	M11			388 666 667 669							
3529	ENGINE, INTERNAL COMBUSTION, FLAMMABLE GAS POWERED or ENGINE, FUEL CELL, FLAMMABLE GAS POWERED or MACHINERY, INTERNAL COMBUSTION, FLAMMABLE GAS POWERED or MACHINERY, FUEL CELL, FLAMMABLE GAS POWERED	2	6F		2.1	363 667 669	0	E0	P005				

Part 3: Dangerous goods list, special provisions and exemptions related to limited and excepted quantities	Chapter 3.3 Special provisions applicable to certain articles or substances	Special provisions number: 363	This entry may only be used when the conditions of this special provision are met. No other requirements of ADR apply. (a) This entry applies to engines or machinery, powered by fuels classified as dangerous goods via internal combustion systems or fuel cells (e.g. combustion engines, generators, compressors, turbines, heating units, etc.), except vehicle equipment assigned to UN No. 3166 referred to in special provision 666. ***NOTE:*** *This entry does not apply to equipment referred to in 1.1.3.2 (a), (d) and (e), 1.1.3.3 and 1.1.3.7.* (b) Engines or machinery which are empty of liquid or gaseous fuels and which do not contain other dangerous goods, are not subject to ADR. ***NOTE 1:*** *An engine or machinery is considered to be empty of liquid fuel when the liquid fuel tank has been drained and the engine or machinery cannot be operated due to a lack of fuel. Engine or machinery components such as fuel lines, fuel filters and injectors do not need to be cleaned, drained or purged to be considered empty of liquid fuels. In addition, the liquid fuel tank does not need to be cleaned or purged.* ***NOTE 2:*** *An engine or machinery is considered to be empty of gaseous fuels when the gaseous fuel tanks are empty of liquid (for liquefied gases), the pressure in the tanks does not exceed 2 bar and the fuel shut-off or isolation valve is closed and secured.* (c) Engines and machinery containing fuels meeting the classification criteria of Class 3, shall be assigned to the entries UN No. 3528 ENGINE, INTERNAL COMBUSTION, FLAMMABLE LIQUID POWERED or UN No. 3528 ENGINE, FUEL CELL, FLAMMABLE LIQUID POWERED or UN No. 3528 MACHINERY, INTERNAL COMBUSTION, FLAMMABLE LIQUID POWERED or UN No. 3528 MACHINERY, FUEL CELL, FLAMMABLE LIQUID POWERED, as appropriate. (d) Engines and machinery containing fuels meeting the classification criteria of flammable gases of Class 2, shall be assigned to the entries UN No. 3529 ENGINE, INTERNAL COMBUSTION, FLAMMABLE GAS POWERED or UN No. 3529 ENGINE, FUEL CELL, FLAMMABLE GAS POWERED or UN No. 3529 MACHINERY, INTERNAL COMBUSTION, FLAMMABLE GAS POWERED or UN No. 3529 MACHINERY, FUEL CELL, FLAMMABLE GAS POWERED, as appropriate. Engines and machinery powered by both a flammable gas and a flammable liquid shall be assigned to the appropriate UN No. 3529 entry. (e) Engines and machinery containing liquid fuels meeting the classification criteria of 2.2.9.1.10 for environmentally hazardous substances and not meeting the classification criteria of any other class shall be assigned to the entries UN No. 3530 ENGINE, INTERNAL COMBUSTION or UN No. 3530 MACHINERY, INTERNAL COMBUSTION, as appropriate. (f) Engines or machinery may contain other dangerous goods than fuels (e.g. batteries, fire extinguishers, compressed gas accumulators or safety devices) required for their functioning or safe operation without being subject to any additional requirements for these other dangerous goods, unless otherwise specified in ADR. However, lithium batteries shall meet the provisions of 2.2.9.1.7, except as provided for in special provision 667.	

			(g) The engine or machinery, including the means of containment containing dangerous goods, shall be in compliance with the construction requirements specified by the competent authority of the country of manufacture[2]; (h) Any valves or openings (e.g. venting devices) shall be closed during carriage; (i) The engines or machinery shall be oriented to prevent inadvertent leakage of dangerous goods and secured by means capable of restraining the engines or machinery to prevent any movement during carriage which would change the orientation or cause them to be damaged; (j) For UN No. 3528 and UN No. 3530: Where the engine or machinery contains more than 60 *l* of liquid fuel and has a capacity of more than 450 *l* but not more than 3 000 *l*, it shall be labelled on two opposite sides in accordance with 5.2.2. Where the engine or machinery contains more than 60 *l* of liquid fuel and has a capacity of more than 3 000 l, it shall be placarded on two opposite sides. Placards shall correspond to the labels required in Column (5) of Table A of Chapter 3.2 and shall conform to the specifications given in 5.3.1.7. Placards shall be displayed on a background of contrasting colour, or shall have either a dotted or solid outer boundary line. (k) For UN No. 3529: Where the fuel tank of the engine or machinery has a water capacity of more than 450 *l* but not more than 1 000 *l*, it shall be labelled on two opposite sides in accordance with 5.2.2. Where the fuel tank of the engine or machinery has a water capacity of more than 1 000 *l*, it shall be placarded on two opposite sides. Placards shall correspond to the labels required in Column (5) of Table A of Chapter 3.2 and shall conform to the specifications given in 5.3.1.7. Placards shall be displayed on a background of contrasting colour, or shall have either a dotted or solid outer boundary line. (*l*) When the engine or machinery contains more than 1 000 l of liquid fuels, for UN No. 3528 and UN No. 3530, or the fuel tank has a water capacity of more than 1 000 l, for UN No. 3529: - A transport document in accordance with 5.4.1 is required. This transport document shall contain the following additional statement "Transport in accordance with special provision 363"; - For carriage that includes passage through restricted tunnels, the transport unit shall display orange-coloured plates according to 5.3.2 and the tunnel restrictions according to 8.6.4 apply; (m) The requirements specified in packing instruction P005 of 4.1.4.1 shall be met.	

Part 3: Dangerous goods list, special provisions and exemptions related to limited and excepted quantities	Chapter 3.3 Special provisions applicable to certain articles or substances	Special provisions number: 388	 UN No. 3166 entries apply to vehicles powered by flammable liquid or gas internal combustion engines or fuel cells. Vehicles powered by a fuel cell engine shall be assigned to the entries UN 3166 VEHICLE, FUEL CELL, FLAMMABLE GAS POWERED or UN 3166 VEHICLE, FUEL CELL, FLAMMABLE LIQUID POWERED, as appropriate. These entries include hybrid electric vehicles powered by both a fuel cell and an internal combustion engine with wet batteries, sodium batteries, lithium metal batteries or lithium ion batteries, carried with the battery(ies) installed. Other vehicles which contain an internal combustion engine shall be assigned to the entries UN 3166 VEHICLE, FLAMMABLE GAS POWERED or UN 3166 VEHICLE, FLAMMABLE LIQUID POWERED, as appropriate. These entries include hybrid electric vehicles powered by both an internal combustion engine and wet batteries, sodium batteries, lithium metal batteries or lithium ion batteries, carried with the battery(ies) installed.		

Conditions	Item	Documentation	Additional Description	Information
			If a vehicle is powered by a flammable liquid and a flammable gas internal combustion engine, it shall be assigned to UN 3166 VEHICLE, FLAMMABLE GAS POWERED. Entry UN 3171 only applies to vehicles powered by wet batteries, sodium batteries, lithium metal batteries or lithium ion batteries and equipment powered by wet batteries or sodium batteries carried with these batteries installed. For the purpose of this special provision, vehicles are self-propelled apparatus designed to carry one or more persons or goods. Examples of such vehicles are cars, motorcycles, scooters, three- and four-wheeled vehicles or motorcycles, trucks, locomotives, bicycles (pedal cycles with a motor) and other vehicles of this type (e.g. self-balancing vehicles or vehicles not equipped with at least one seating position), wheelchairs, lawn tractors, self-propelled farming and construction equipment, boats and aircraft. This includes vehicles carried in a packaging. In this case some parts of the vehicle may be detached from its frame to fit into the packaging. Examples of equipment are lawnmowers, cleaning machines or model boats and model aircraft. Equipment powered by lithium metal batteries or lithium ion batteries shall be assigned to the entries UN 3091 LITHIUM METAL BATTERIES CONTAINED IN EQUIPMENT or UN 3091 LITHIUM METAL BATTERIES PACKED WITH EQUIPMENT or UN 3481 LITHIUM ION BATTERIES CONTAINED IN EQUIPMENT or UN 3481 LITHIUM ION BATTERIES PACKED WITH EQUIPMENT, as appropriate. Lithium ion batteries or lithium metal batteries installed in a cargo transport unit and designed only to provide power external to the cargo transport unit shall be assigned to the entry UN 3536 LITHIUM BATTERIES INSTALLED IN CARGO TRANSPORT UNIT lithium ion batteries or lithium metal batteries. Dangerous goods, such as batteries, airbags, fire extinguishers, compressed gas accumulators, safety devices and other integral components of the vehicle that are necessary for the operation of the vehicle or for the safety of its operator or passengers, shall be securely installed in the vehicle and are not otherwise subject to ADR. However, lithium batteries shall meet the provisions of 2.2.9.1.7, except as otherwise provided for in special provision 667. Where a lithium battery installed in a vehicle or equipment is damaged or defective, the vehicle or equipment shall be carried in accordance with the conditions defined in special provision 667 (c).	

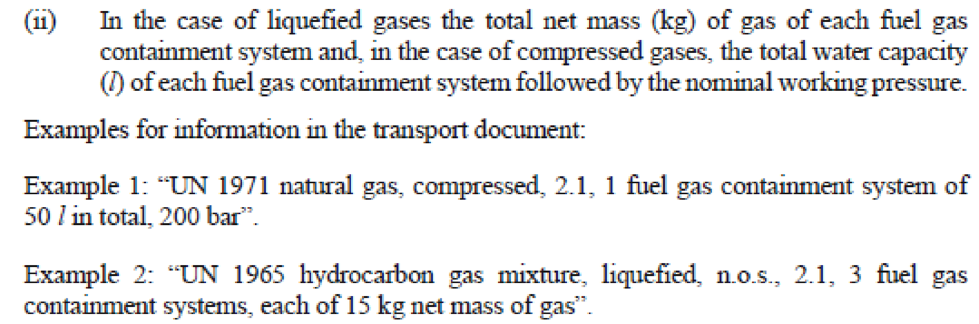
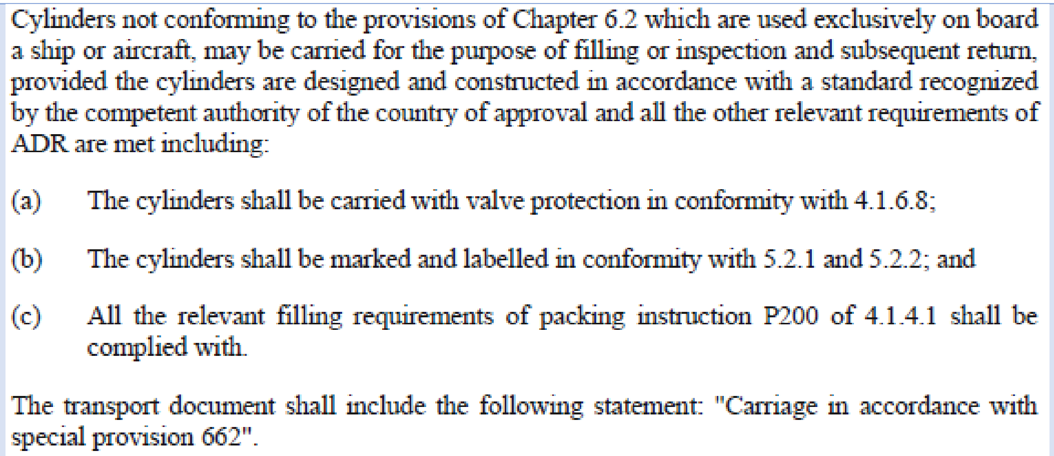
<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr>
<td>Part 3: Dangerous goods list, special provisions and exemptions related to limited and excepted quantities</td>
<td>Chapter 3.3 Special provisions applicable to certain articles or substances</td>
<td>Special provisions number: 392</td>
<td>


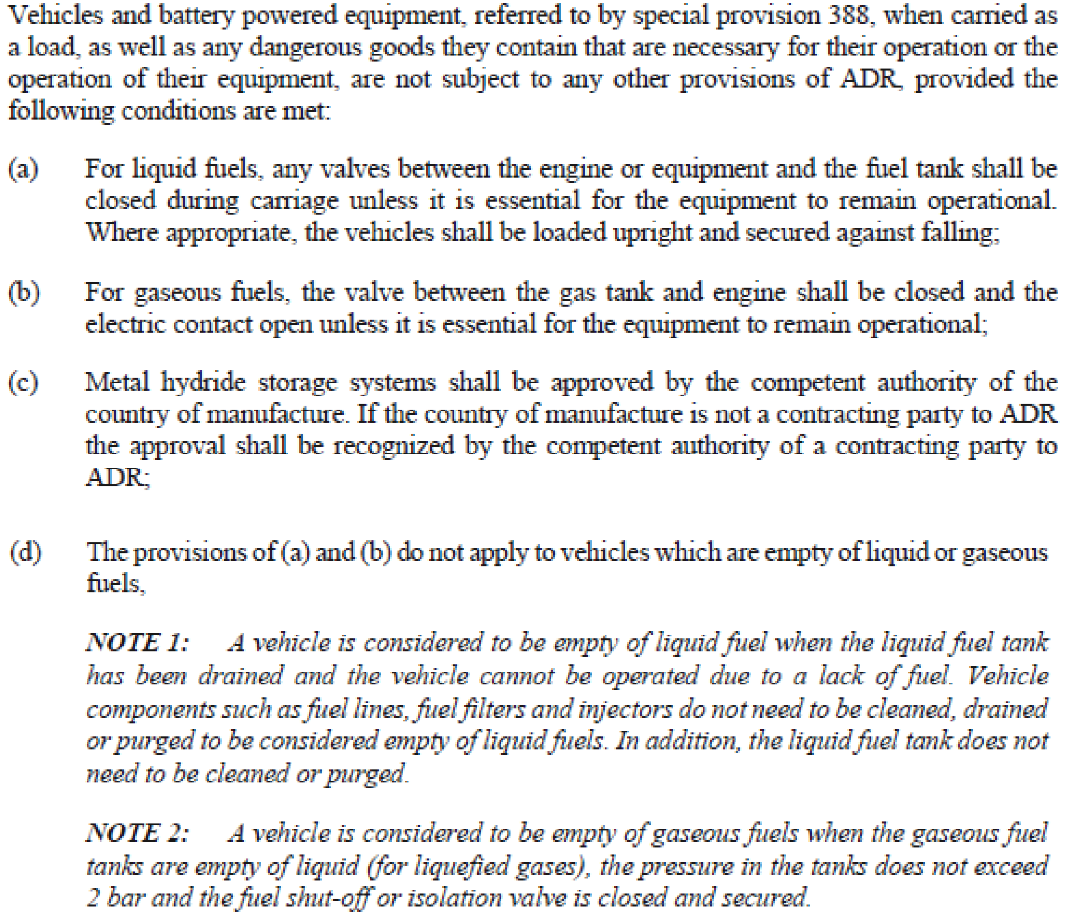
For the carriage of fuel gas containment systems designed and approved to be fitted in motor vehicles containing this gas the provisions of 4.1.4.1 and Chapter 6.2 need not be applied when carried for disposal, recycling, repair, inspection, maintenance or from where they are manufactured to a vehicle assembly plant, provided the following conditions are met:

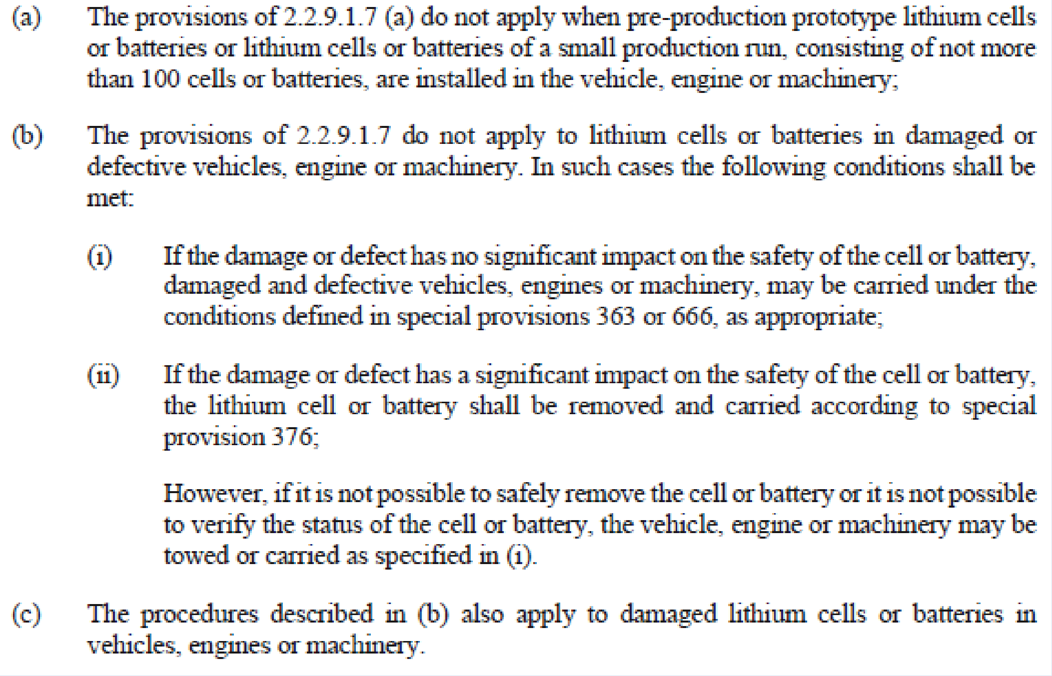
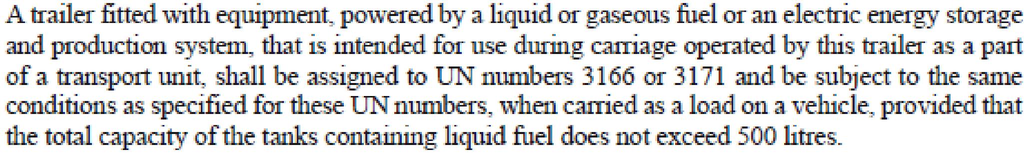
(a) The fuel gas containment systems shall meet the requirements of the standards or regulations for fuel tanks for vehicles, as applicable. Examples of applicable standards and regulations are:

<table>
<tr><th colspan="2">Hydrogen pressure tanks</th></tr>
<tr><td>Global Technical Regulation (GTR) No. 13</td><td>Global technical regulation on hydrogen and fuel cell vehicles (ECE/TRANS/180/Add.13).</td></tr>
<tr><td>ISO/TS 15869:2009</td><td>Gaseous hydrogen and hydrogen blends - Land vehicle fuel tanks</td></tr>
<tr><td>Regulation (EC) No.79/2009</td><td>Regulation (EC) No. 79/2009 of the European Parliament and of the Council of 14 January 2009 on type approval of hydrogen-powered motor vehicles, and amending Directive 2007/46/EC</td></tr>
<tr><td>Regulation (EU) No. 406/2010</td><td>Commission Regulation (EU) No 406/2010 of 26 April 2010 implementing Regulation (EC) No 79/2009 of the European Parliament and of the Council on type-approval of hydrogen-powered motor vehicles</td></tr>
<tr><td>UN Regulation No. 134</td><td>Uniform provisions concerning the approval of motor vehicles and their components with regard to the safety-related performance of hydrogen-fuelled vehicles (HFCV)</td></tr>
<tr><td>CSA B51 Part 2: 2014</td><td>Boiler, pressure vessel, and pressure piping code - Part 2: Requirements for high-pressure cylinders for on-board storage of fuels for automotive vehicles</td></tr>
</table>
</td>
<td>Regulations (EC) 2010/410 and (EC) 2009/79 will be repealed in july 2022</td>
</tr>
</table>

			Gas tanks designed and constructed in accordance with previous versions of relevant standards or regulations for gas tanks for motor vehicles, which were applicable at the time of the certification of the vehicles for which the gas tanks were designed and constructed may continue to be carried; (b) The fuel gas containment systems shall be leakproof and shall not exhibit any signs of external damage which may affect their safety; *NOTE 1: Criteria may be found in standard ISO 11623:2015 Gas cylinders – Composite construction – Periodic inspection and testing (or ISO 19078:2013 Gas cylinders – Inspection of the cylinder installation, and requalification of high pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles).* *NOTE 2: If the fuel gas containment systems are not leakproof or are overfilled or if they exhibit damage that could affect their safety (e.g. in case of a safety related recall), they shall only be carried in salvage pressure receptacles in conformity with ADR.* (c) If a fuel gas containment system is equipped with two valves or more integrated in line, the two valves shall be closed as to be gastight under normal conditions of carriage. If only one valve exists or only one valve works, all openings with the exception of the opening of the pressure relief device shall be closed as to be gastight under normal conditions of carriage; (d) Fuel gas containment systems shall be carried in such a way as to prevent obstruction of the pressure relief device or any damage to the valves and any other pressurised part of the fuel gas containment systems and unintentional release of the gas under normal conditions of carriage. The fuel gas containment system shall be secured in order to prevent slipping, rolling or vertical movement; (e) Valves shall be protected by one of the methods described in 4.1.6.8 (a) to (e); (f) Except for the case of fuel gas containment systems removed for disposal, recycling, repair, inspection or maintenance, they shall be filled with not more than 20 % of their nominal filling ratio or nominal working pressure, as applicable; (g) Notwithstanding the provisions of Chapter 5.2, when fuel gas containment systems are consigned in a handling device, marks and labels may be affixed to the handling device; and (h) Notwithstanding the provisions of 5.4.1.1.1 (f) the information on the total quantity of dangerous goods may be replaced by the following information: (i) The number of fuel gas containment systems; and	

Conditions	Item	Documentation	Additional Description	Information
			 (ii) In the case of liquefied gases the total net mass (kg) of gas of each fuel gas containment system and, in the case of compressed gases, the total water capacity (*l*) of each fuel gas containment system followed by the nominal working pressure. Examples for information in the transport document: Example 1: "UN 1971 natural gas, compressed, 2.1, 1 fuel gas containment system of 50 *l* in total, 200 bar". Example 2: "UN 1965 hydrocarbon gas mixture, liquefied, n.o.s., 2.1, 3 fuel gas containment systems, each of 15 kg net mass of gas".	
Part 3: Dangerous goods list, special provisions and exemptions related to limited and excepted quantities	Chapter 3.3 Special provisions applicable to certain articles or substances	Special provisions number: 662	 Cylinders not conforming to the provisions of Chapter 6.2 which are used exclusively on board a ship or aircraft, may be carried for the purpose of filling or inspection and subsequent return, provided the cylinders are designed and constructed in accordance with a standard recognized by the competent authority of the country of approval and all the other relevant requirements of ADR are met including: (a) The cylinders shall be carried with valve protection in conformity with 4.1.6.8; (b) The cylinders shall be marked and labelled in conformity with 5.2.1 and 5.2.2; and (c) All the relevant filling requirements of packing instruction P200 of 4.1.4.1 shall be complied with. The transport document shall include the following statement: "Carriage in accordance with special provision 662".	

Conditions	Item	Documentation	Additional Description	Information
Part 3: Dangerous goods list, special provisions and exemptions related to limited and excepted quantities	Chapter 3.3 Special provisions applicable to certain articles or substances	Special provisions number: 666	 Vehicles and battery powered equipment, referred to by special provision 388, when carried as a load, as well as any dangerous goods they contain that are necessary for their operation or the operation of their equipment, are not subject to any other provisions of ADR, provided the following conditions are met: (a) For liquid fuels, any valves between the engine or equipment and the fuel tank shall be closed during carriage unless it is essential for the equipment to remain operational. Where appropriate, the vehicles shall be loaded upright and secured against falling; (b) For gaseous fuels, the valve between the gas tank and engine shall be closed and the electric contact open unless it is essential for the equipment to remain operational; (c) Metal hydride storage systems shall be approved by the competent authority of the country of manufacture. If the country of manufacture is not a contracting party to ADR the approval shall be recognized by the competent authority of a contracting party to ADR; (d) The provisions of (a) and (b) do not apply to vehicles which are empty of liquid or gaseous fuels, *NOTE 1: A vehicle is considered to be empty of liquid fuel when the liquid fuel tank has been drained and the vehicle cannot be operated due to a lack of fuel. Vehicle components such as fuel lines, fuel filters and injectors do not need to be cleaned, drained or purged to be considered empty of liquid fuels. In addition, the liquid fuel tank does not need to be cleaned or purged.* *NOTE 2: A vehicle is considered to be empty of gaseous fuels when the gaseous fuel tanks are empty of liquid (for liquefied gases), the pressure in the tanks does not exceed 2 bar and the fuel shut-off or isolation valve is closed and secured.*	

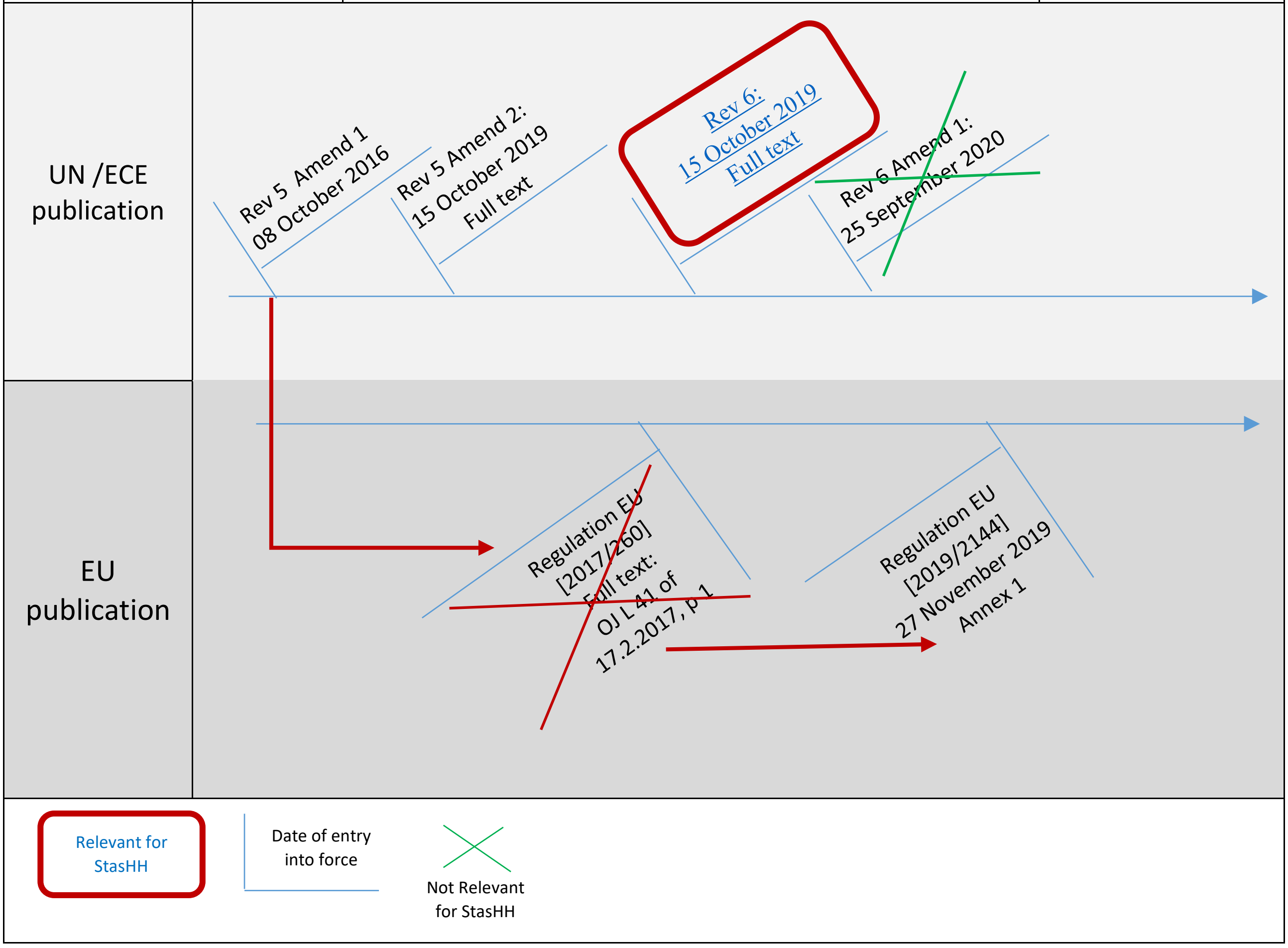
Conditions	Item	Documentation	Additional Description	Information
Part 3: Dangerous goods list, special provisions and exemptions related to limited and excepted quantities	Chapter 3.3 Special provisions applicable to certain articles or substances	Special provisions number: 669	 (a) The provisions of 2.2.9.1.7 (a) do not apply when pre-production prototype lithium cells or batteries or lithium cells or batteries of a small production run, consisting of not more than 100 cells or batteries, are installed in the vehicle, engine or machinery; (b) The provisions of 2.2.9.1.7 do not apply to lithium cells or batteries in damaged or defective vehicles, engine or machinery. In such cases the following conditions shall be met: (i) If the damage or defect has no significant impact on the safety of the cell or battery, damaged and defective vehicles, engines or machinery, may be carried under the conditions defined in special provisions 363 or 666, as appropriate; (ii) If the damage or defect has a significant impact on the safety of the cell or battery, the lithium cell or battery shall be removed and carried according to special provision 376; However, if it is not possible to safely remove the cell or battery or it is not possible to verify the status of the cell or battery, the vehicle, engine or machinery may be towed or carried as specified in (i). (c) The procedures described in (b) also apply to damaged lithium cells or batteries in vehicles, engines or machinery.	
Part 3: Dangerous goods list, special provisions and exemptions related to limited and excepted quantities	Chapter 3.3 Special provisions applicable to certain articles or substances	Special provisions number: 669	 A trailer fitted with equipment, powered by a liquid or gaseous fuel or an electric energy storage and production system, that is intended for use during carriage operated by this trailer as a part of a transport unit, shall be assigned to UN numbers 3166 or 3171 and be subject to the same conditions as specified for these UN numbers, when carried as a load on a vehicle, provided that the total capacity of the tanks containing liquid fuel does not exceed 500 litres.	

Annex 9: REGULATION N° 10 (UN/ECE)

REGULATION N° 10 (UN/ECE)

A. IDENTITY CARD OF REGULATION N°10 (UN/ECE)

RCS	N°	Title	Statutory
Regulation	R10	Electromagnetic compatibility	Y



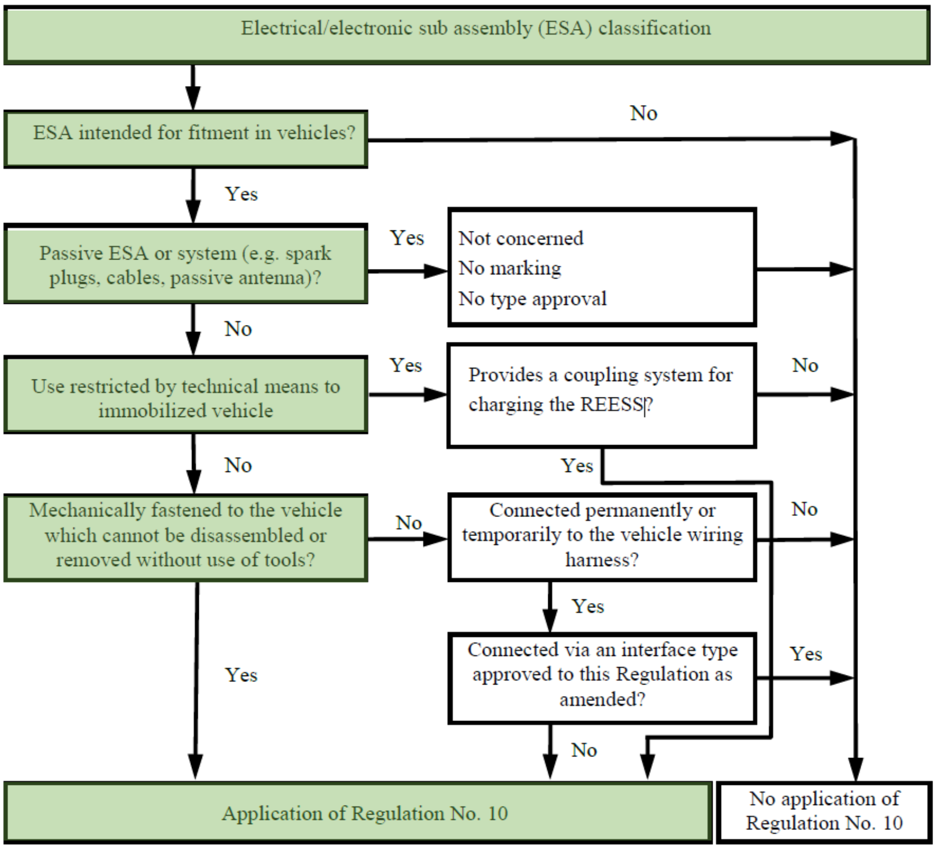
Note: As specified in the regulation published in the 2017 Official journal, the status and effective date of this regulation should be verified in the latest version of the UN/ECE status document. In relation to the regulation published in the official journal on 17.02.2017, the UN/ECE regulation in its revision 6 on 15.10.19 brings a change concerning the vehicle broadband type-approval limits. The texts which are changed: 6.3.2.1 and 6.3.2.2 with their appendixes n°4 and n°5.

Scope: This regulation covers,

> *(a) Requirements regarding the immunity to radiated and conducted disturbances for functions related to direct control of the vehicle, related to driver, passenger and other road users' protection, related to disturbances, which would cause confusion to the driver or other road users, related to vehicle data bus functionality, related to disturbances, which would affect vehicle statutory data.*
>
> *(b) Requirements regarding the control of unwanted radiated and conducted emissions to protect the intended use of electrical or electronic equipment at own or adjacent vehicles or nearby, and the control of disturbances from accessories that may be retrofitted to the vehicle.*
>
> *(c) Additional requirements for vehicles and ESAs providing coupling systems for charging the REESS regarding the control of emissions and immunity from this connection between vehicle and power grid.*

Domain/category:

- Vehicles of categories L, M, N O, T, R and S1 with regard to electromagnetic Compatibility
- Components and Separate Technical Units - (STU) intended to be fitted in these vehicles with the limitation given in this graph:



Specifed exclusion: No specified exclusion

Reference included in this RCS: See the appendix entitled “list of documents cited in R10 (UN/ECE).

Some parts of the chapter 6 (Specifications in configurations other than ‘REESS charging mode coupled to the power grid’) and associated annexes are relevant in StasHH project.

B. RELEVANT PARTS FOR STASHH PROJECT

FCM is considered as an ESA (*Electrical/electronic sub-assembly*) and not as a REESS (Rechargeable Electrical Energy Storage System).

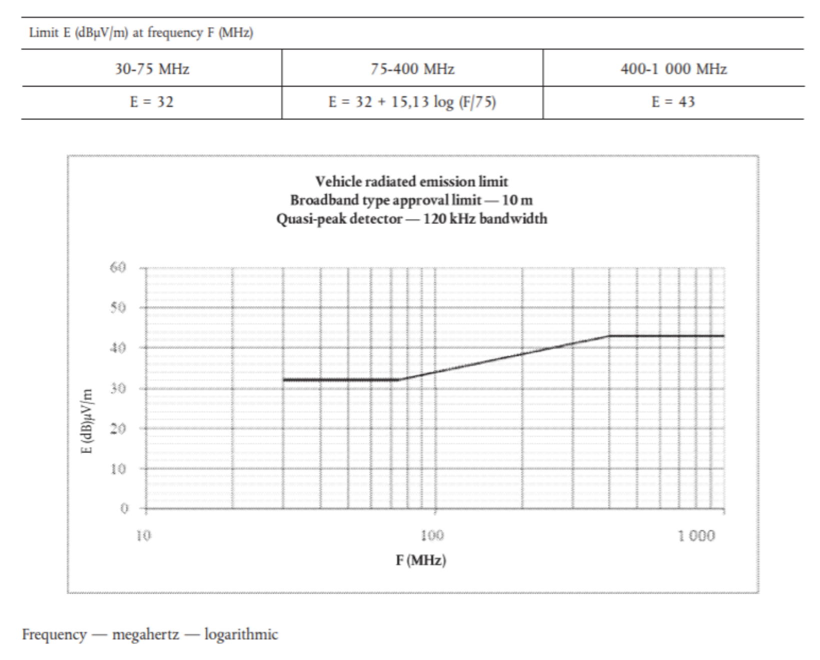
STASHH impact	Sections 6.1	Section 6.2 to 6.4	Section 6.5 to 6.10	Methodology Annex 4 to 6	Methodology Annex 7 to 10
FCM Manufacturers	X	X		X	
EOM (Vehicles type **L, M, N O, T, R, S1)**	X		X		X

C. COMMON PARTS

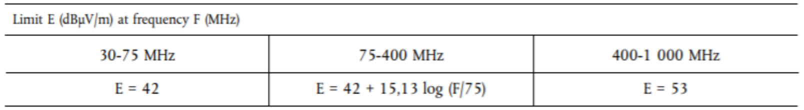
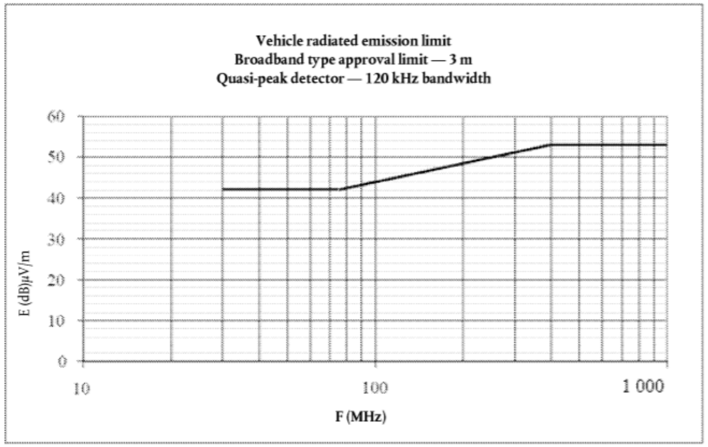
Conditions	Item	Documentation	Additional Description	Information
Chapter 6 Specification in configurations other than REESS charging mode coupled to the power grid	Sub-chapter 6.1 General specifications	Chapter 6, sub-chapter 6.1 paragraph 6.1.1	*A vehicle and its electrical/electronic system(s) or ESA(s) shall be so designed, constructed and fitted as to enable the vehicle, in normal conditions of use, to comply with the requirements of this Regulation.*	Concerns "normal conditions of use"
Chapter 6 Specification in configurations other than REESS charging mode coupled to the power grid	Sub-chapter 6.1 General specifications	Chapter 6, sub-chapter 6.1 paragraph 6.1.1 sub-paragraph 6.1.1.1	*A vehicle shall be tested for radiated emissions and for immunity to radiated disturbances. No tests for conducted emissions or immunity to conducted disturbances are required for vehicle type approval*	Refers to the restricted scope of the tests to be performed: *radiated emissions and for immunity to radiated disturbances*

Conditions	Item	Documentation	Additional Description	Information
Chapter 6 Specification in configurations other than REESS charging mode coupled to the power grid	Sub-chapter 6.1 General specifications	Chapter 6, sub-chapter 6.1 paragraph 6.1.1 sub-paragraph 6.1.1.2	‘Electrical/electronic sub-assembly’- *ESA(s) shall be tested for radiated and conducted emissions, for immunity to radiated and conducted disturbances.*	

E. RELEVANT PARTS FOR FCM MANUFACTURERS

Conditions	Item	Documentation	Additional Description	Information
Chapter 6 Specification in configurations other than REESS charging mode coupled to the power grid	Sub-chapter 6.2 Specifications concerning broadband electromagnetic radiation from vehicles	Chapter 6, sub-chapter 6.2 paragraph 6.2.2 Vehicle broadband type-approval limits sub-paragraph 6.2.2.1	Method of measurement: see Annex 4. *-If measurements are made using the method described in Annex 4 using a vehicle-to-antenna spacing of 10.0 ± 0.2 m, the limits shall be 32 dB microvolts/m in the 30 to 75 MHz frequency band and 32 to 43 dB microvolts/m in the 75 to 400 MHz frequency band, this limit increasing logarithmically with frequencies above 75 MHz as shown in Appendix 2 to this Regulation. In the 400 to 1,000 MHz frequency band the limit remains constant at 43 dB microvolts/m.* Appendix 2: Vehicle broadband reference limits — Antenna-vehicle separation: 10 m  Limit E (dBµV/m) at frequency F (MHz) 30-75 MHz: E = 32 75-400 MHz: E = 32 + 15,13 log (F/75) 400-1 000 MHz: E = 43 Vehicle radiated emission limit Broadband type approval limit — 10 m Quasi-peak detector — 120 kHz bandwidth Frequency — megahertz — logarithmic	Annex 4: Method of measurement of radiated broadband electromagnetic emissions from vehicles

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr>
<td>Chapter 6 Specification in configurations other than REESS charging mode coupled to the power grid</td>
<td>Sub-chapter 6.2 Specifications concerning broadband electromagnetic radiation from vehicles</td>
<td>Chapter 6,
sub-chapter 6.2
paragraph 6.2.2 Vehicle broadband type-approval limits
sub-paragraph 6.2.2.2</td>
<td>Method of measurement: see Annex 4.
-*If measurements are made using the method described in Annex 4 using a vehicle-to-antenna spacing of 3.0 ± 0.05 m, the limits shall be 42 dB microvolts/m in the 30 to 75 MHz frequency band and 42 to 53 dB microvolts/m in the 75 to 400 MHz frequency band, this limit increasing logarithmically with frequencies above 75 MHz as shown in Appendix 3 to this Regulation. In the 400 to 1,000 MHz frequency band the limit remains constant at 53 dB microvolts/m.*

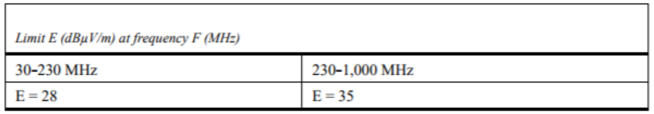
Appendix 3: Vehicle broadband reference limits — Antenna-vehicle separation: 3 m

<table>
<tr><th colspan="3">Limit E (dBμV/m) at frequency F (MHz)</th></tr>
<tr><td>30-75 MHz</td><td>75-400 MHz</td><td>400-1 000 MHz</td></tr>
<tr><td>E = 42</td><td>E = 42 + 15,13 log (F/75)</td><td>E = 53</td></tr>
</table>


Frequency — megahertz — logarithmic</td>
<td>Annex 4: Method of measurement of radiated broadband electromagnetic emissions from vehicles</td>
</tr>
</table>

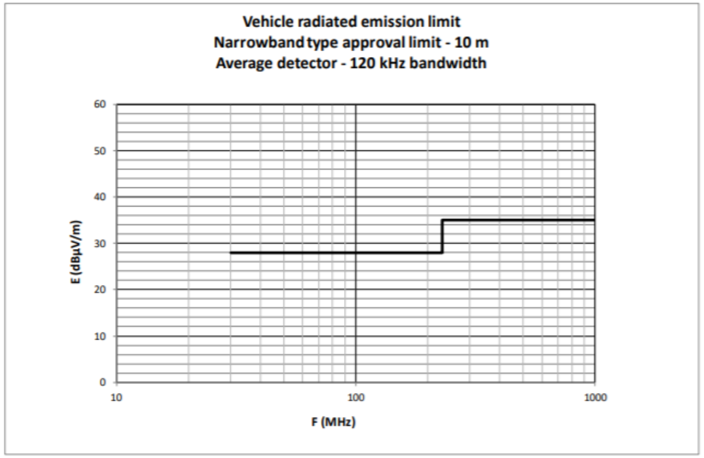
Conditions	Item	Documentation	Additional Description	Information
Chapter 6 Specification in configurations other than REESS charging mode coupled to the power grid	Sub-chapter 6.2 Specifications concerning broadband electromagnetic radiation from vehicles	Chapter 6, sub-chapter 6.2 paragraph 6.2.2 Vehicle broadband type-approval limits sub-paragraph 6.2.2.3	*On the vehicle representative of its type, the measured values, expressed in dB microvolts/m* ***shall be below the type-approval limits****.*	
Chapter 6 Specification in configurations other than REESS charging mode coupled to the power grid	Sub-chapter 6.3 Specifications concerning narrowband electromagnetic radiation from vehicles	Chapter 6, sub-chapter 6.3 paragraph 6.3.2 Vehicle narrowband type approval limits sub-paragraph 6.3.2.1	Method of measurement: see Annex 5. UNECE R10: rev 6 on 2019 ➔ If measurements are made using the method described in Annex 5 using a vehicle-to-antenna spacing of 10.0 ± 0.2 m, the limits shall be 28 dB microvolts/m in the 30 to 230 MHz frequency band and 35 dB microvolts/m in the 230 to 1,000 MHz frequency band. Appendix 4: Vehicle narrowband reference limits — Antenna-vehicle separation: 10 m	Annex 5: Method of measurement of radiated narrowband electromagnetic emissions from vehicles

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td>

Picture updated by UNECE 2019:



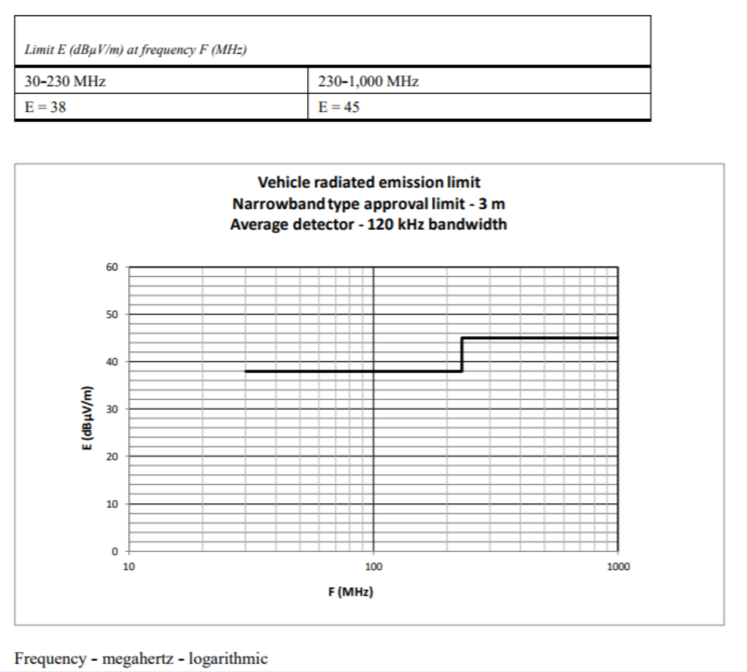
Limit E (dBµV/m) at frequency F (MHz)	
30-230 MHz	230-1,000 MHz
E = 28	E = 35



Frequency - megahertz - logarithmic

</td><td></td></tr>
<tr><td>Chapter 6 Specification in configurations other than REESS charging mode coupled to the power grid</td><td>Sub-chapter 6.3 Specifications concerning narrowband electromagnetic radiation from vehicles</td><td>Chapter 6,
sub-chapter 6.3
paragraph 6.3.2
Vehicle narrowband type approval limits
sub-paragraph 6.3.2.2</td><td>Method of measurement: see Annex 5.
Appendix 5: Vehicle narrowband reference limits — Antenna-vehicle separation: 3 m

Picture updated by UNECE 2019</td><td>Annex 5: Method of measurement of radiated narrowband electromagnetic emissions from vehicles</td></tr>
</table>

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td>
<i>Limit E (dBµV/m) at frequency F (MHz)</i>
<table><tr><td>30-230 MHz</td><td>230-1,000 MHz</td></tr><tr><td>E = 38</td><td>E = 45</td></tr></table>
Vehicle radiated emission limit
Narrowband type approval limit - 3 m
Average detector - 120 kHz bandwidth

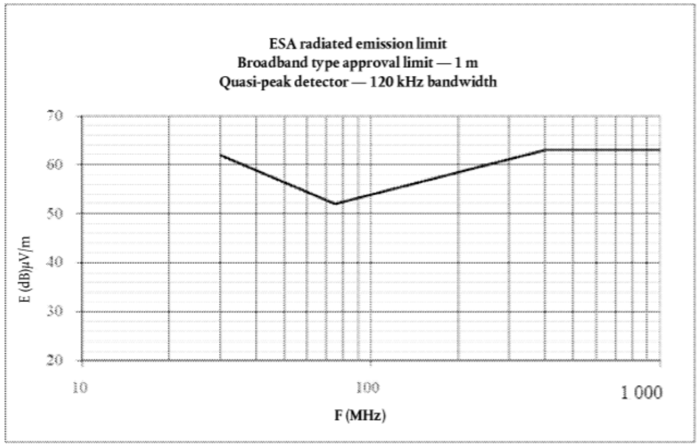
Frequency - megahertz - logarithmic</td><td></td></tr>
<tr><td>Chapter 6 Specification in configurations other than REESS charging mode coupled to the power grid</td><td>Sub-chapter 6.3 Specifications concerning narrowband electromagnetic radiation from vehicles</td><td>Chapter 6,
sub-chapter 6.3
paragraph 6.3.2
Vehicle narrowband type approval limits
sub-paragraph 6.3.2.3</td><td><i>On the vehicle representative of its type, the measured values, expressed in dB microvolts/m, shall be below the type-approval limit</i></td><td></td></tr>
<tr><td>Chapter 6 Specification in configurations</td><td>Sub-chapter 6.3 Specifications concerning</td><td>Chapter 6,
sub-chapter 6.3</td><td><i>Notwithstanding the limits defined in paragraphs 6.3.2.1., 6.3.2.2. and 6.3.2.3. of this Regulation, if, during the initial step described in paragraph 1.3. of Annex 5, the signal strength measured at the vehicle broadcast radio</i></td><td>Annex 5: Method of measurement of radiated</td></tr>
</table>

Conditions	Item	Documentation	Additional Description	Information
other than REESS charging mode coupled to the power grid	narrowband electromagnetic radiation from vehicles	paragraph 6.3.2 Vehicle narrowband type approval limits sub-paragraph 6.3.2.4	*antenna is less than 20 dB micro-volts over the frequency range 76 to 108 MHz measured with an average detector, then the vehicle shall be deemed to comply with the limits for narrowband emissions and no further testing will be required.*	narrowband electromagnetic emissions from vehicles
Chapter 6 Specification in configurations other than REESS charging mode coupled to the power grid	Sub-chapter 6.4 Specifications concerning immunity of vehicles to electromagnetic radiation	Chapter 6, sub-chapter 6.4 paragraph 6.4.2 Vehicle immunity type-approval limits sub-paragraph 6.4.2.1	Method of measurement: see Annex 6. - *If tests are made using the method described in Annex 6, the field strength shall be 30 volts/m rms (root mean squared) in over 90 per cent of the 20 to 2,000 MHz frequency band and a minimum of 25 volts/m rms over the whole 20 to 2,000 MHz frequency band.*	Annex 6: Method of testing for immunity of vehicles to electromagnetic radiation
Chapter 6 Specification in configurations other than REESS charging mode coupled to the power grid	Sub-chapter 6.4 Specifications concerning immunity of vehicles to electromagnetic radiation	Chapter 6, sub-chapter 6.4 paragraph 6.4.2 Vehicle immunity type-approval limits sub-paragraph 6.4.2.2	Method of measurement: see Annex 6. - *The vehicle representative of its type shall be considered as complying with immunity requirements if, during the tests performed in accordance with Annex 6, there shall be no degradation of performance of "immunity related functions", according to paragraph 2.1. of Annex 6.* Paragraph 2.1 of Annex 6:	Annex 6: Method of testing for immunity of vehicles to electromagnetic radiation

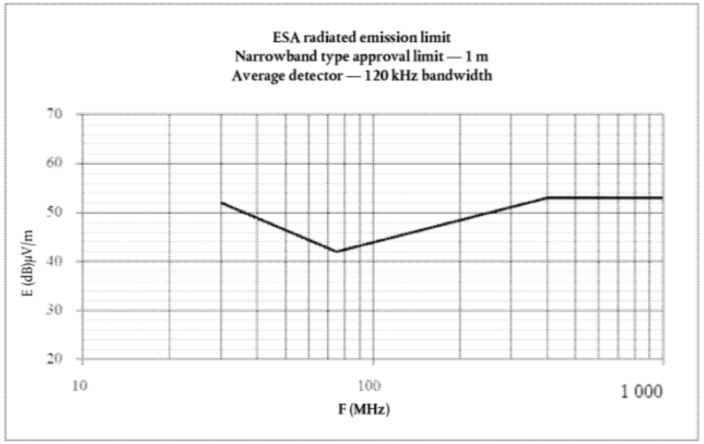
F.

H. RELEVANT PARTS FOR EOM

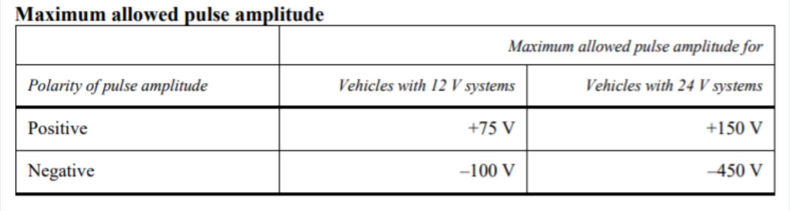
Conditions	Item	Documentation	Additional Description	Information
Chapter 6 Specification in configurations other than REESS charging mode coupled to the power grid	Sub-chapter 6.5 Specification concerning broadband electromagnetic interference generated by ESAs	Chapter 6, sub-chapter 6.5 paragraph 6.5.2 ESA broadband type-approval limits paragraph 6.5.2.1	Method of measurement: see Annex 7. - *If measurements are made using the method described in Annex 7, the limits shall be 62 to 52 dB microvolts/m in the 30 to 75 MHz frequency band, this limit decreasing logarithmically with frequencies above 30 MHz, and 52 to 63 dB microvolts/m in the 75 to 400 MHz band, this limit increasing logarithmically with frequencies above 75 MHz as shown in Appendix 6 to this Regulation. In the 400 to 1,000 MHz frequency band the limit remains constant at 63 dB microvolts/m*. Appendix 6: Electrical/electronic sub-assembly — Broadband reference limits	Annex 7: Method of measurement of radiated broadband electromagnetic emissions from electrical/electronic sub-assemblies (ESAs)

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td>
<table>
<tr><th colspan="3">Limit E (dBμV/m) at frequency F (MHz)</th></tr>
<tr><td>30-75 MHz</td><td>75-400 MHz</td><td>400-1 000 MHz</td></tr>
<tr><td>E = 62 − 25,13 log (F/30)</td><td>E = 52 + 15,13 log (F/75)</td><td>E = 63</td></tr>
</table>


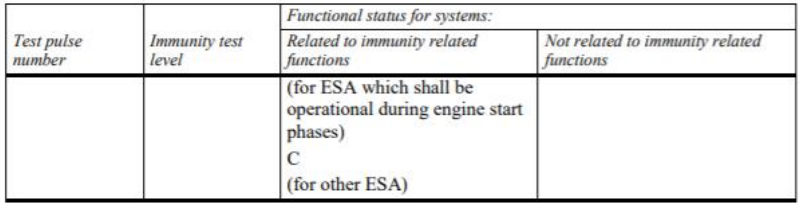
Frequency — megahertz — logarithmic
</td><td></td></tr>
<tr><td>Chapter 6 Specification in configurations other than REESS charging mode coupled to the power grid</td><td>Sub-chapter 6.5 Specification concerning broadband electromagnetic interference generated by ESAs</td><td>Chapter 6, sub-chapter 6.5 paragraph 6.5.2 ESA broadband type-approval limits paragraph 6.5.2.2</td><td>*On the ESA representative of its type, the measured values, expressed in dB microvolts/m, **shall be below the type-approval limits***</td><td></td></tr>
<tr><td>Chapter 6</td><td>Sub-chapter 6.6</td><td>Chapter 6, sub-chapter 6.6</td><td>Method of measurement: see Annex 8.</td><td>Annex 8: Method of measurement of</td></tr>
</table>

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr>
<td>Specification in configurations other than REESS charging mode coupled to the power grid</td>
<td>Specifications concerning narrowband electromagnetic interference generated by ESAs</td>
<td>paragraph 6.6.2 ESA narrowband type-approval limits
paragraph 6.6.2.1</td>
<td>- <i>If measurements are made using the method described in Annex 8, the limits shall be 52 to 42 dB microvolts/m in the 30 to 75 MHz frequency band, this limit decreasing logarithmically with frequencies above 30 MHz, and 42 to 53 dB microvolts/m in the 75 to 400 MHz band, this limit increasing logarithmically with frequencies above 75 MHz as shown in Appendix 7. In the 400 to 1,000 MHz frequency band the limit remains constant at 53 dB microvolts/m.</i>
Appendix 7: Electrical/electronic sub-assembly — Narrowband reference limits
<table>
<tr><th colspan="3">Limit E (dBµV/m) at frequency F (MHz)</th></tr>
<tr><td>30-75 MHz</td><td>75-400 MHz</td><td>400-1 000 MHz</td></tr>
<tr><td>E = 52 – 25,13 log (F/30)</td><td>E = 42 + 15,13 log (F/75)</td><td>E = 53</td></tr>
</table>


Frequency — megahertz — logarithmic</td>
<td>radiated narrowband electromagnetic emissions from electrical/electronic sub-assemblies (ESAs)</td>
</tr>
<tr>
<td>Chapter 6
Specification in</td>
<td>Sub-chapter 6.6
Specifications concerning</td>
<td>Chapter 6,
sub-chapter 6.6</td>
<td><i>On the ESA representative of its type, the measured value, expressed in dB microvolts/m shall be below the type-approval limits.</i></td>
<td></td>
</tr>
</table>

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td>configurations other than REESS charging mode coupled to the power grid</td><td>narrowband electromagnetic interference generated by ESAs</td><td>paragraph 6.6.2 ESA narrowband type-approval limits paragraph 6.6.2.2</td><td></td><td></td></tr>
<tr><td>Chapter 6 Specification in configurations other than REESS charging mode coupled to the power grid</td><td>Sub-chapter 6.7 Specifications concerning the emission of transient conducted disturbances generated by ESAs on 12/24 V supply lines</td><td>Chapter 6, sub-chapter 6.7 paragraph 6.7.1 Method of testing</td><td><i>The emission of ESA representative of its type shall be tested by the method(s) according to ISO 7637-2 as described in Annex 10 for the levels given in Table 1.</i>
Table 1:

Maximum allowed pulse amplitude
<table>
<tr><th></th><th colspan="2"><i>Maximum allowed pulse amplitude for</i></th></tr>
<tr><th><i>Polarity of pulse amplitude</i></th><th><i>Vehicles with 12 V systems</i></th><th><i>Vehicles with 24 V systems</i></th></tr>
<tr><td>Positive</td><td>+75 V</td><td>+150 V</td></tr>
<tr><td>Negative</td><td>–100 V</td><td>–450 V</td></tr>
</table></td><td>Annex 10: Method(s) of testing for immunity to and emission of transients of electrical/ electronic sub-assemblies</td></tr>
<tr><td>Chapter 6 Specification in configurations other than REESS charging mode coupled to the power grid</td><td>Sub-chapter 6.8 Specifications concerning immunity of ESAs to electromagnetic radiation</td><td>Chapter 6, sub-chapter 6.8 paragraph 6.8.2 ESA immunity type-approval limits Sub-paragraph 6.8.2.1</td><td>Method of measurement: see Annex 9.

- <i>If tests are made using the methods described in Annex 9, the immunity test levels shall be 60 volts/m root-mean-square (rms) for the 150 mm stripline testing method, 15 volts/m rms for the 800 mm stripline testing method, 75 volts/m rms for the Transverse Electromagnetic Mode (TEM) cell testing method, 60 mA rms for the bulk current injection (BCI) testing method and 30 volts/m rms for the free field testing method in over 90 per cent of the 20 to 2,000 MHz frequency band, and to a minimum of 50 volts/m rms for the 150 mm stripline testing method, 12.5 volts/m rms for the 800 mm stripline testing method, 62.5 volts/m rms, for the TEM cell testing method, 50 mA rms for the bulk current injection (BCI) testing method and 25 volts/m rms for the free field testing method over the whole 20 to 2,000 MHz frequency band.</i></td><td>Annex 9: Method(s) of testing for immunity of electrical/electronic sub-assemblies to electromagnetic radiation</td></tr>
</table>

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td>Chapter 6 Specification in configurations other than REESS charging mode coupled to the power grid</td><td>Sub-chapter 6.8 Specifications concerning immunity of ESAs to electromagnetic radiation</td><td>Chapter 6,
sub-chapter 6.8
paragraph 6.8.2
ESA immunity type-approval limits
Sub-paragraph 6.8.2.2</td><td><i>The ESA representative of its type shall be considered as complying with immunity requirements if, during the tests performed in accordance with Annex 9, there shall be no degradation of performance of ‘immunity related functions’.</i></td><td></td></tr>
<tr><td>Chapter 6 Specification in configurations other than REESS charging mode coupled to the power grid</td><td>Sub-chapter 6.9 Specifications concerning immunity of ESAs to transient disturbances conducted along 12/24 V supply line</td><td>Chapter 6,
sub-chapter 6.9
paragraph 6.9.1
Method of testing</td><td>The immunity of ESA representative of this type shall be tested by the method(s) according to ISO 7637-2 as described in Annex 10 with the test levels given in Table 2.
Table 2:

<table>
<tr><th rowspan="2"><i>Test pulse number</i></th><th rowspan="2"><i>Immunity test level</i></th><th colspan="2"><i>Functional status for systems:</i></th></tr>
<tr><th><i>Related to immunity related functions</i></th><th><i>Not related to immunity related functions</i></th></tr>
<tr><td></td><td></td><td>(for ESA which shall be operational during engine start phases)
C
(for other ESA)</td><td></td></tr>
</table></td><td>Annex 10: Method(s) of testing for immunity to and emission of transients of electrical/ electronic sub-assemblies</td></tr>
<tr><td>Chapter 6 Specification in configurations other than REESS charging mode coupled</td><td>Sub-chapter 6.10 Exceptions</td><td>Chapter 6,
sub-chapter 6.10
paragraphs 6.10.1</td><td><i>Where a vehicle or electrical/electronic system or ESA does not include an electronic oscillator with an operating frequency greater than 9 kHz, it shall be deemed to comply with paragraph 6.3.2. or 6.6.2. and with Annexes 5 and 8.</i></td><td></td></tr>
</table>

Conditions	Item	Documentation	Additional Description	Information
to the power grid				
Chapter 6 Specification in configurations other than REESS charging mode coupled to the power grid	Sub-chapter 6.10 Exceptions	Chapter 6, sub-chapter 6.10 paragraphs 6.10.2	*Vehicles which do not have electrical/electronic systems with "immunity related functions" need not be tested for immunity to radiated disturbances and shall be deemed to comply with paragraph 6.4. and with Annex 6 to this Regulation.*	
Chapter 6 Specification in configurations other than REESS charging mode coupled to the power grid	Sub-chapter 6.10 Exceptions	Chapter 6, sub-chapter 6.10 paragraphs 6.10.3	*ESAs with no immunity related functions need not be tested for immunity to radiated disturbances and shall be deemed to comply with paragraph 6.8. and with Annex 9 to this Regulation.*	
Chapter 6 Specification in configurations other than REESS charging mode coupled	Sub-chapter 6.10 Exceptions	Chapter 6, sub-chapter 6.10 paragraphs 6.10.4 Electrostatic discharge	For *vehicles fitted with tyres, the vehicle body/chassis can be considered to be an electrically isolated structure. Significant electrostatic forces in relation to the vehicle's external environment only occur at the moment of occupant entry into or exit from the vehicle. As the vehicle is stationary at these moments, no type approval test for electrostatic discharge is deemed necessary.*	

Conditions	Item	Documentation	Additional Description	Information
to the power grid				
Chapter 6 Specification in configurations other than REESS charging mode coupled to the power grid	Sub-chapter 6.10 Exceptions	Chapter 6, sub-chapter 6.10 paragraphs 6.10.5 Emission of transient conducted disturbances generated by ESAs on 12/24 V supply lines.	*Emission of transient conducted disturbances generated by ESAs on 12/24 V supply lines. ESAs that are not switched, contain no switches or do not include inductive load need not be tested for transient conducted emission and shall be deemed to comply with paragraph 6.7.*	
Chapter 6 Specification in configurations other than REESS charging mode coupled to the power grid	Sub-chapter 6.10 Exceptions	Chapter 6, sub-chapter 6.10 paragraphs 6.10.6	*The loss of function of receivers during the immunity test, when the test signal is within the receiver bandwidth (RF exclusion band) as specified for the specific radio service/product in the harmonized international EMC standard, does not necessarily lead to fail criteria.*	
Chapter 6 Specification in configurations other than REESS charging mode coupled	Sub-chapter 6.10 Exceptions	Chapter 6, sub-chapter 6.10 paragraphs 6.10.7	*RF transmitters shall be tested in the transmit mode. Wanted emissions (e.g. from RF transmitting systems) within the necessary bandwidth and out of band emissions are disregarded for the purpose of this Regulation. Spurious emissions are subject to this Regulation.*	

Conditions	Item	Documentation	Additional Description	Information
to the power grid				
Chapter 6 Specification in configurations other than REESS charging mode coupled to the power grid	Sub-chapter 6.10 Exceptions	Chapter 6, sub-chapter 6.10 paragraphs 6.10.7.1	*"Necessary bandwidth": For a given class of emission, the width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions (Article 1, No. 1.152 of the International Telecommunication Union (ITU) Radio Regulations).*	
Chapter 6 Specification in configurations other than REESS charging mode coupled to the power grid	Sub-chapter 6.10 Exceptions	Chapter 6, sub-chapter 6.10 paragraphs 6.10.7.2.	*"Out-of-band Emissions": Emission on a frequency or frequencies immediately outside the necessary bandwidth which results from the modulation process, but excluding spurious emissions (Article 1, No. 1.144 of the ITU Radio Regulations).*	
Chapter 6 Specification in configurations other than REESS charging mode coupled	Sub-chapter 6.10 Exceptions	Chapter 6, sub-chapter 6.10 paragraphs 6.10.7.3.	*"Spurious emission": In every modulation process additional undesired signals exist. They are summarized under the expression "spurious emissions". Spurious emissions are emissions on a frequency or frequencies, which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions (Article 1 No. 1.145 of the ITU Radio Regulations).*	

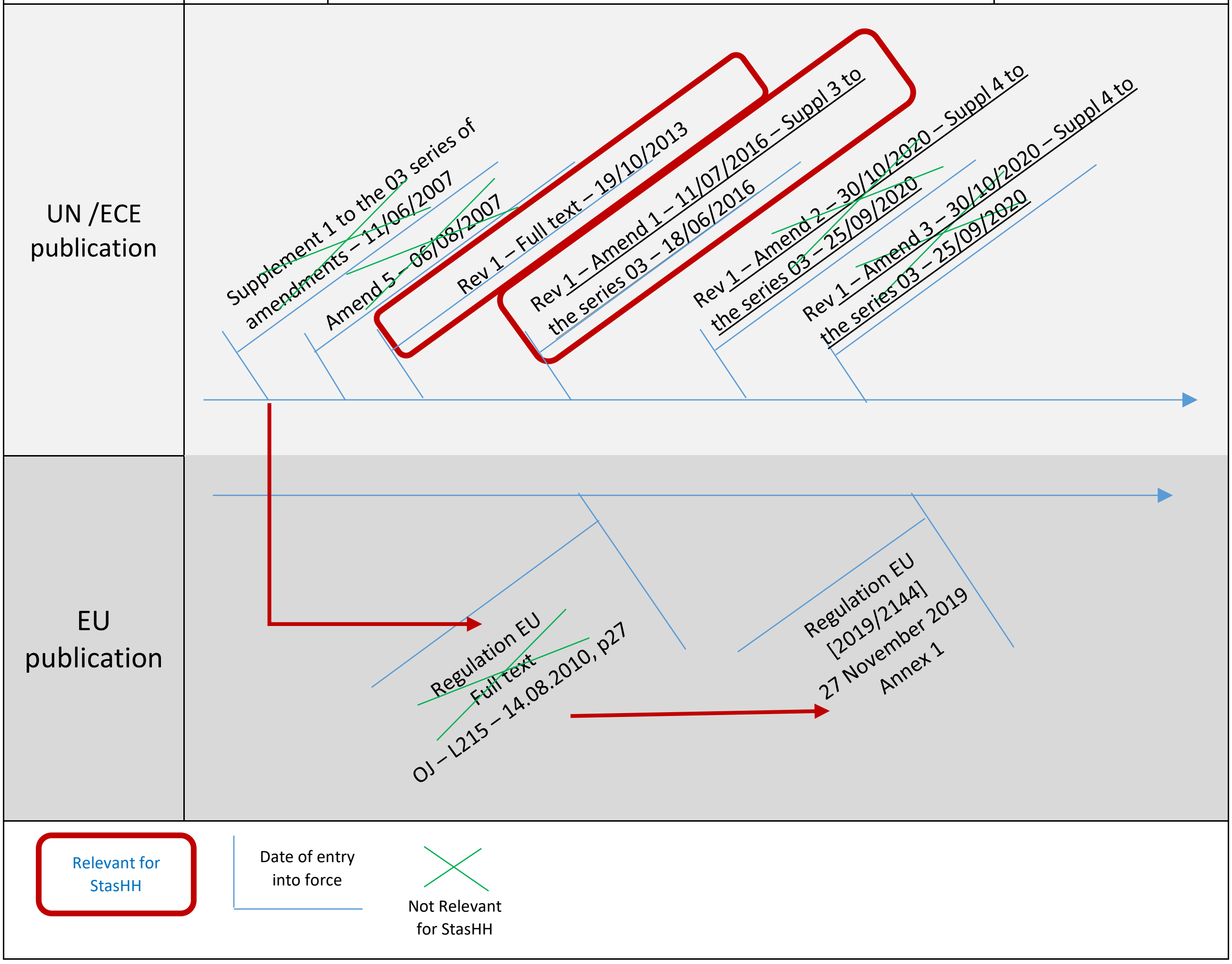
Conditions	Item	Documentation	Additional Description	Information
to the power grid				

Annex 10: REGULATION N° 26 (UN/ECE)

REGULATION N° 26 (UN/ECE)

A. IDENTITY CARD OF REGULATION N° 26 (UN/ECE)

RCS	N°	Title	Statutory
Regulation	R26	Uniform provisions concerning the approval of vehicles with regard to their external projections	Y



Scope: This Regulation applies to external projections of category M_1 vehicles. It does not apply to exterior devices for indirect vision or to the ball of towing devices." (see revision 1, Amendment 1 of regulation n°26 – 11/07/2016) The purpose of this Regulation is to reduce the risk or seriousness of bodily injury to a person hit by the bodywork or brushing against it in the event of a collision. This is valid both when the vehicle is stationary and in motion.

Domain/category: Road only category M1

Specifed exclusion:

The provisions of this Regulation shall not apply to those parts of the external surface which, with the vehicle in the laden condition, with all doors, windows and access lids etc., in the closed position, are either:

- At a height of more than 2 metres, or
- Below the floor line, or
- So located that, in their static condition as well as when in operation, they cannot be contacted by a sphere 100 mm in diameter

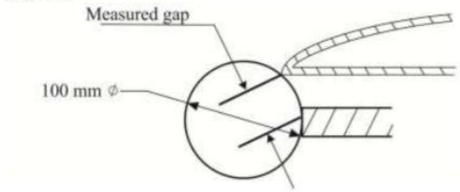
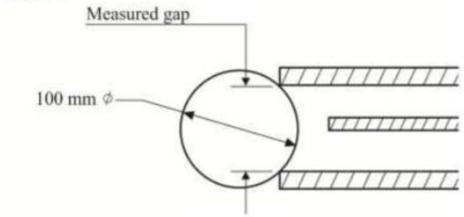
Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

Some general specifications from chapter 5 of this regulation are relevant for StasHH project and the dimensional requirements associated with the grilles, gaps, Air intake and outlet flaps (chapter 6).

Conditions	Item	Documentation	Additional Description	Information
Chapter 5: General specifications		Chapter5, Subchapter 5.2	The external surface of vehicles shall not exhibit, directed outwards, any pointed or sharp parts or any projections of such shape, dimensions, direction or hardness as to be likely to increase the risk or seriousness of bodily injury to a person hit by the external surface or brushing against it in the event of a collision.	Integrator or FCM supplier Mechanical design requirements Safety
Chapter 5: General specifications		Chapter5, Subchapter 5.3	The external surface of vehicles shall not exhibit, directed outwards, any part likely to catch on pedestrians, cyclists or motor cyclists.	Integrator or FCM supplier Mechanical design requirements Safety
Chapter 5: General specifications		Chapter5, Subchapter 5.4	No protruding part of the external surface shall have a radius of curvature less than 2.5 mm. This requirement shall not apply to parts of the external surface which protrude less than 5 mm, but the outward facing angles of such parts shall be blunted, save where such parts protrude less than 1.5 mm	Integrator or FCM supplier Mechanical design requirements Safety
Chapter 5: General specifications		Chapter5, Subchapter 5.5	Protruding parts of the external surface, made of a material of hardness not exceeding 60 shore A, may have a radius of curvature less than 2.5 mm. The hardness measurement shall be taken with the component as installed on the vehicle. Where it is impossible to carry out a hardness measurement by the Shore A procedure, comparable measurements shall be used for evaluation.	Integrator or FCM supplier Mechanical design requirements Safety

Conditions	Item	Documentation	Additional Description	Information
Chapter 5: General specifications		Chapter5, Subchapter 5.6	The provisions of the above paragraphs 5.1 to 5.5 shall apply in addition to the particular specifications of the following paragraph 6, except where these particular specifications expressly provide otherwise.	
Chapter 6: Particular specifications	Subchapter 6.3: Grilles and gaps	Chapter5, Subchapter 6, paragraph 6.3.1	The requirements of paragraph 5.4. above shall not apply to gaps between fixed or movable elements, including those forming part of air intake or outlet grilles and radiator grilles, provided that the distance between consecutive elements does not exceed 40 mm and provided that the grilles and gaps have a functional purpose. For gaps of between 40 mm and 25 mm the radiance of curvature shall be 1 mm or more. However, if the distance between two consecutive elements is equal to or less than 25 mm, the radiance of curvature of external faces of the elements shall not be less than 0.5 mm. The distance between two consecutive elements of grilles and gaps shall be determined according to the method described in paragraph 4. of Annex 3 to this Regulation. Annex 3 paragraph 4.: Method of determining the dimension of a gap or the space between elements of a grille. The dimension of a gap or space between elements of a grille shall be determined by the distance between two planes passing through the points of contact of the sphere and perpendicular to the line joining those points of contact. Figures 5 and 6 show examples of the use of this procedure.	Integrator or FCM supplier Mechanical design requirements Safety

Conditions	Item	Documentation	Additional Description	Information
			Figure 5  Figure 6  	
Chapter 6: Particular specifications	Subchapter 6.12: Air intake and outlet flaps		Air intake and outlet flaps shall meet the requirements of paragraphs 5.2., 5.3. and 5.4. above in all positions of use.	Integrator or FCM supplier Mechanical design requirements Safety

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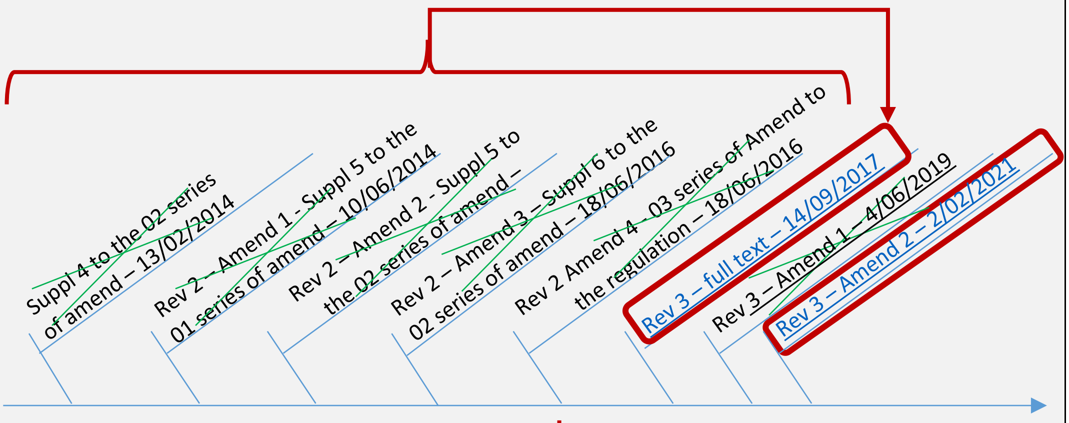
REGULATION N°94 (UN/ECE)

A. IDENTITY CARD OF REGULATION N° 94 (UN/ECE)

<table>
<tr><th>RCS</th><th>N°</th><th>Title</th><th>Statutory</th></tr>
<tr><td>Regulation</td><td>R94</td><td>Uniform provisions concerning the approval of vehicles with regard to the protection of the occupants in the event of a frontal collision</td><td>Y</td></tr>
<tr><td>UN /ECE publication</td><td colspan="3">
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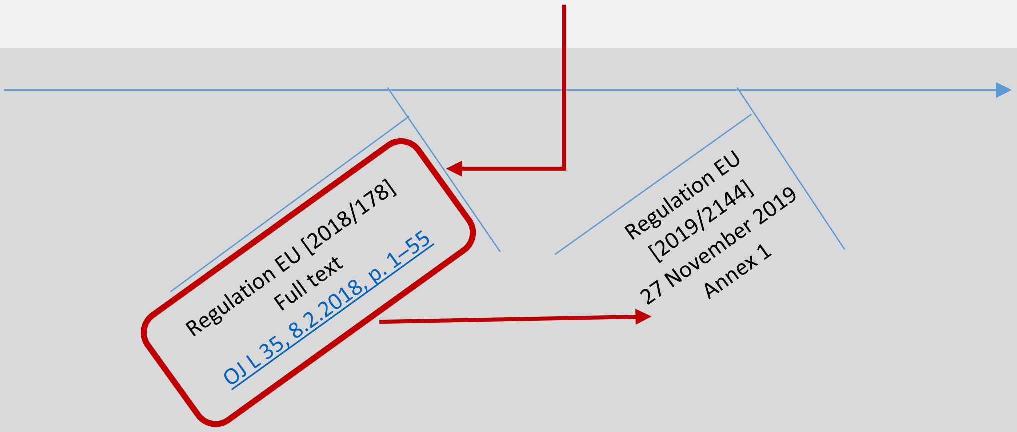
<tr><td>EU publication</td><td colspan="3">
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<tr><td colspan="4">Relevant for StasHH
Date of entry into force
Not Relevant for StasHH</td></tr>
</table>

Scope: this rregulation applies to vehicles of category M1[37]of a total permissible mass not exceeding 3,500 kg and to vehicles of category N1 of a total permissible mass not exceeding 2,500 kg; other vehicles may be approved at the request of the manufacturer."

Domain/category: M1, N1

Specifed exclusion: /

Reference included in this RCS: /

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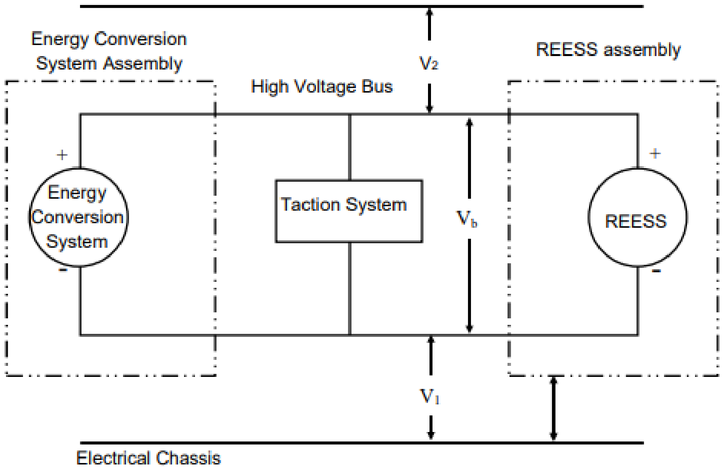
[37] As defined in the Consolidated Resolution on the Construction of Vehicles (R.E.3.), document ECE/TRANS/WP.29/78/Rev.2, paragraph 2.

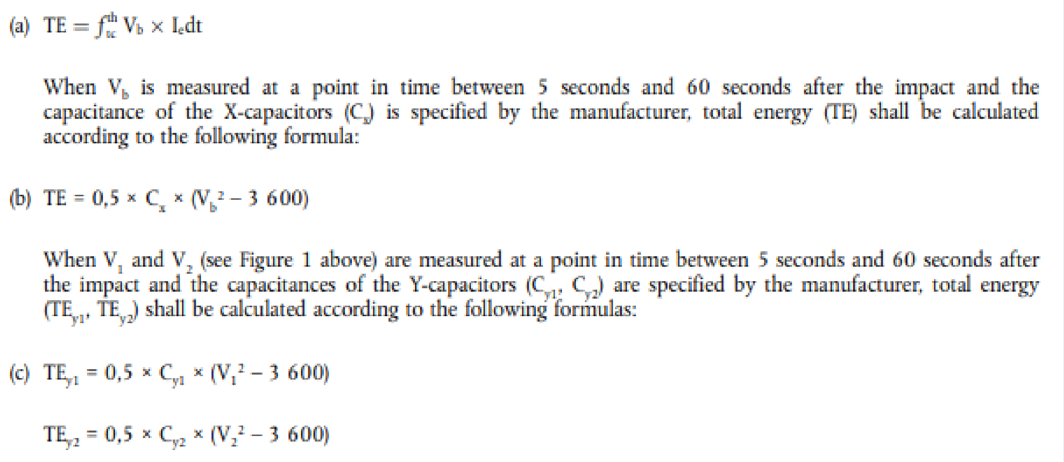
B. RELEVANT PARTS FOR STASHH PROJECT

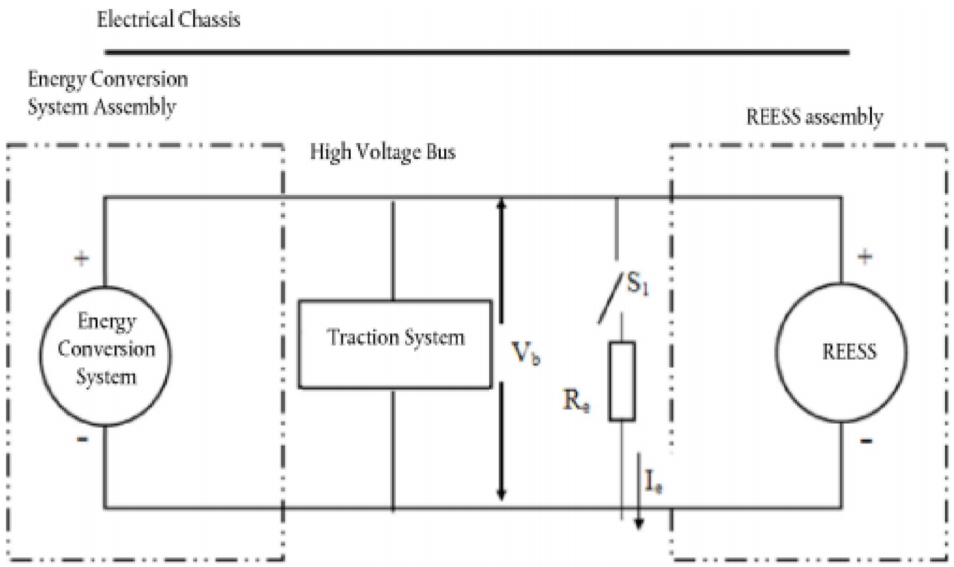
The part relevant in StasHH project concerns the requirements on the electrical power train operating on high voltage, and the high voltage components and systems, which are galvanically connected to the high voltage bus of the electric power train (requirements ensuring the protection of the occupant in case of frontal collision): chapter 5.2.8 and its annex.

Conditions	Item	Documentation	Additional Description	Information
Chapter 5: Specifications	Subchapter 5.2: Specifications		*Additionally, vehicles equipped with electric power train shall meet the requirements of paragraph 5.2.8 below. This can be met by a separate impact test at the request of the manufacturer and after validation by the Technical Service, provided that the electrical components do not influence the occupant protection performance of the vehicle type as defined in paragraphs 5.2.1 to 5.2.5 of this Regulation. In case of this condition the requirements of paragraph 5.2.8 shall be checked in accordance with the methods set out in Annex 3 to this Regulation, except paragraphs 2, 5 and 6 of Annex 3.*	Vehicle integration Test protocols Integrator or FCM supplier
Chapter 5: Specifications	Subchapter 5.2: Specifications, Paragraph 5.2.8		*Following the test conducted in accordance with the procedure defined in Annex 3 to this Regulation, the electrical power train operating on high voltage, and the high voltage components and systems, which are galvanically connected to the high voltage bus of the electric power train, shall meet the following requirements:* (see following lines)	Vehicle integration Test protocols Integrator or FCM supplier Electrical design requirements
Chapter 5: Specifications	Subchapter 5.2: Specifications, Paragraph 5.2.8	Subparagraph 5.2.8.1: Protection against electrical shock	*After the impact at least one of the four criteria specified in paragraph 5.2.8.1.1 through paragraph 5.2.8.1.4.2 below shall be met.* *If the vehicle has an automatic disconnect function, or device(s) that galvanically divide the electric power train circuit during driving condition, at least one of the following criteria shall apply to the disconnected circuit or to each divided circuit individually after the disconnect function is activated.*	Vehicle integration Test protocols Integrator or FCM supplier Electrical design requirements

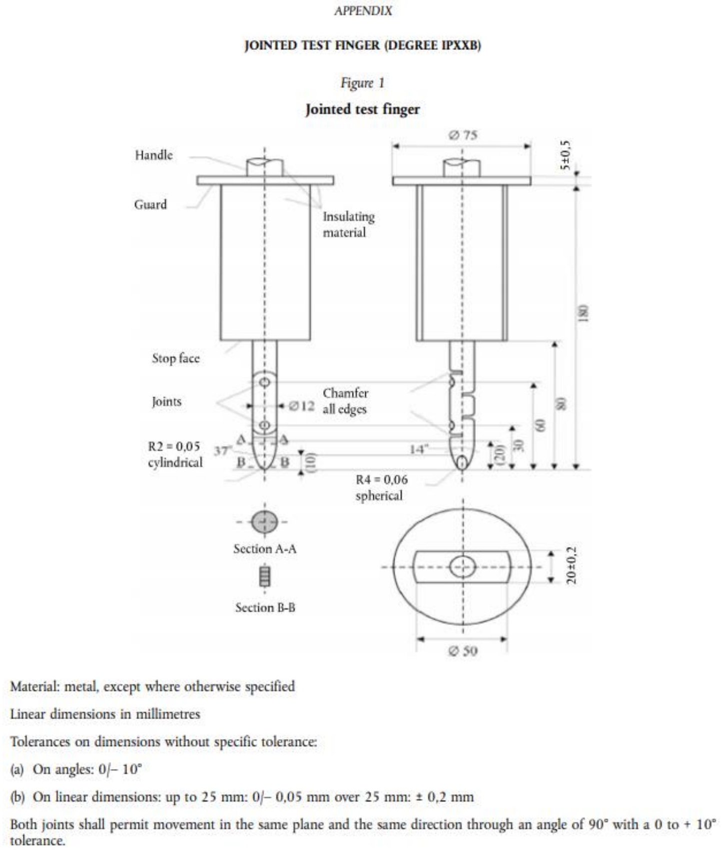
Conditions	Item	Documentation	Additional Description	Information
			However criteria defined in paragraph 5.2.8.1.4 below shall not apply if more than a single potential of a part of the high voltage bus is not protected under the conditions of protection degree IPXXB. *If the test is performed under the condition that part(s) of the high voltage system are not energized, the protection against electrical shock shall be proved by either paragraph 5.2.8.1.3 or 5.2.8.1.4 below for the relevant part(s).*	
Chapter 5: Specifications	Subchapter 5.2: Specifications, Paragraph 5.2.8 Subparagraph 5.2.8.1: Protection against electrical shock	5.2.8.1.1 Absence of High Voltage	*The voltages Vb, V1 and V2 of the high voltage buses shall be equal or less than 30 VAC or 60 VDC as specified in paragraph 2 of Annex 11.* See Annex 11: **Test procedures for the protection of the occupants of vehicles operating on electrical power from high voltage and electrolyte spillage**  *This annex describes test procedures to demonstrate compliance to the electrical safety requirements of paragraph 5.2.8 of this Regulation. For example, megohmmeter or oscilloscope measurements are an appropriate alternative to the procedure described below*	Vehicle integration Test protocols Integrator or FCM supplier Electrical design requirements

Conditions	Item	Documentation	Additional Description	Information
			for measuring isolation resistance. In this case it may be necessary to deactivate the on-board isolation resistance monitoring system. *Before the vehicle impact test conducted, the high voltage bus voltage (Vb) (see Figure 1 below) shall be measured and recorded to confirm that it is within the operating voltage of the vehicle as specified by the vehicle manufacturer.*	
Chapter 5: Specifications	Subchapter 5.2: Specifications, Paragraph 5.2.8 Subparagraph 5.2.8.1: Protection against electrical shock	5.2.8.1.2 Low electrical energy	*The total energy (TE) on the high voltage buses shall be less than 2,0 joules when measured according to the test procedure as specified in paragraph 3 of Annex 11 with the formula (a).* *Alternatively the total energy (TE) may be calculated by the measured voltage Vb of the high voltage bus and the capacitance of the X-capacitors (Cx) specified by the manufacturer according to formula (b) of paragraph 3 of Annex 11.* *The energy stored in the Y-capacitors (TEy1, TEy2) shall also be less than 2,0 joules. This shall be calculated by measuring the voltages V1 and V2 of the high voltage buses and the electrical chassis, and the capacitance of the Y-capacitors specified by the manufacturer according to formula (c) of paragraph 3 of Annex 11.* *Annex 11:* **Test procedures for the protection of the occupants of vehicles operating on electrical power from high voltage and electrolyte spillage** ***Paragraph 3 of annex 11:*** **ASSESSMENT PROCEDURE FOR LOW ELECTRICAL ENERGY** *Prior to the impact a switch S1 and a known discharge resistor Re is connected in parallel to the relevant capacitor (ref. Figure 2 below). Not earlier than 5 seconds and not later than 60 seconds after the impact the switch S1 shall be closed while the voltage Vb and the current Ie are measured and recorded. The product of the voltage Vb and the current Ie shall be integrated over the period of time, starting from the moment when the switch S1 is closed (tc) until the voltage Vb falls below the high voltage threshold of 60 V DC (th). The resulting integration equals the total energy (TE) in joules.*	Vehicle integration Test protocols Integrator or FCM supplier Electrical design requirements

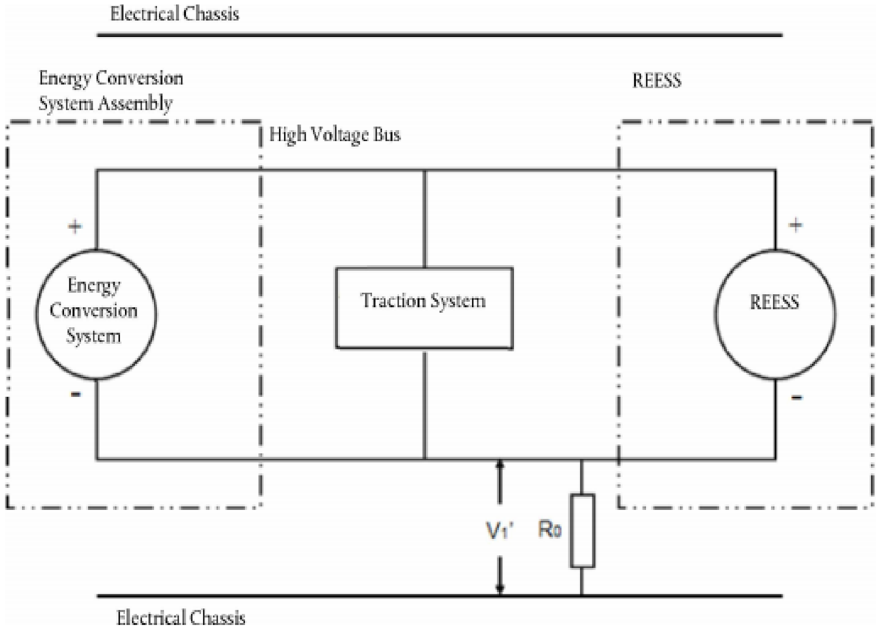
Conditions	Item	Documentation	Additional Description	Information
			Formulas (a), (b), (c):  (a) $TE = \int_{tc}^{th} V_b \times I_e dt$ When V_b is measured at a point in time between 5 seconds and 60 seconds after the impact and the capacitance of the X-capacitors (C_x) is specified by the manufacturer, total energy (TE) shall be calculated according to the following formula: (b) $TE = 0,5 \times C_x \times (V_b^2 - 3\ 600)$ When V_1 and V_2 (see Figure 1 above) are measured at a point in time between 5 seconds and 60 seconds after the impact and the capacitances of the Y-capacitors (C_{y1}, C_{y2}) are specified by the manufacturer, total energy (TE_{y1}, TE_{y2}) shall be calculated according to the following formulas: (c) $TE_{y1} = 0,5 \times C_{y1} \times (V_1^2 - 3\ 600)$ $TE_{y2} = 0,5 \times C_{y2} \times (V_2^2 - 3\ 600)$ *This procedure is not applicable if the test is performed under the condition where the electric power train is not energized*	

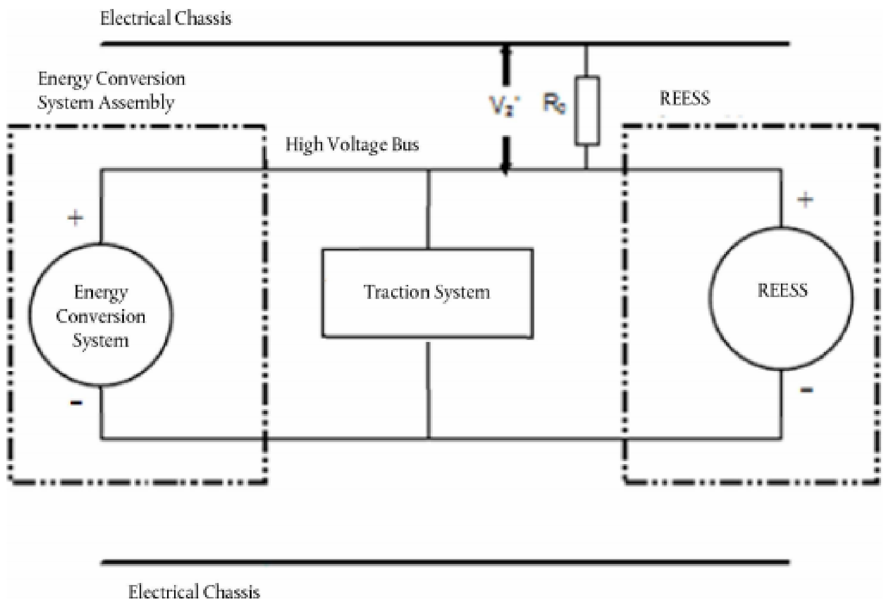
Conditions	Item	Documentation	Additional Description	Information
			Figure 2 **E.g. measurement of high voltage bus energy stored in X-capacitors** 	
Chapter 5: Specifications	Subchapter 5.2: Specifications, Paragraph 5.2.8 Subparagraph 5.2.8.1:	5.2.8.1.3 Physical protection	*For protection against direct contact with high voltage live parts, the protection degree IPXXB shall be provided.* *In addition, for protection against electrical shock which could arise from indirect contact, the resistance between all exposed conductive parts and the electrical chassis shall be lower than 0,1 ohm when there is current flow of at least 0,2 ampere.*	Vehicle integration Test protocols Integrator or FCM supplier Electrical design requirements

Conditions	Item	Documentation	Additional Description	Information
	Protection against electrical shock		*This requirement is satisfied if the galvanic connection has been made by welding.* **Paragraph 4 of annex 11:** *4. PHYSICAL PROTECTION* *Following the vehicle impact test any parts surrounding the high voltage components shall be, without the use of tools, opened, disassembled or removed. All remaining surrounding parts shall be considered part of the physical protection.* *The jointed test finger described in Figure 1 of Appendix 1 shall be inserted into any gaps or openings of the physical protection with a test force of 10 N ± 10 per cent for electrical safety assessment. If partial or full penetration into the physical protection by the jointed test finger occurs, the jointed test finger shall be placed in every position as specified below.* *Starting from the straight position, both joints of the test finger shall be rotated progressively through an angle of up to 90 degrees with respect to the axis of the adjoining section of the finger and shall be placed in every possible position.* *Internal electrical protection barriers are considered part of the enclosure* *If appropriate a low-voltage supply (of not less than 40 V and not more than 50 V) in series with a suitable lamp should be connected, between the jointed test finger and high voltage live parts inside the electrical protection barrier or enclosure.* *4.1. Acceptance conditions* *The requirements of paragraph 5.2.8.1.3 of this Regulation shall be considered to be met if the jointed test finger described in figure 1 of Appendix 1, is unable to contact high voltage live parts.*	

Conditions	Item	Documentation	Additional Description	Information
			If necessary a mirror or a fiberscope may be used in order to inspect whether the jointed test finger touches the high voltage buses. *If this requirement is verified by a signal circuit between the jointed test finger and high voltage live parts, the lamp shall not light.*  APPENDIX **JOINTED TEST FINGER (DEGREE IPXXB)** *Figure 1* **Jointed test finger** Material: metal, except where otherwise specified Linear dimensions in millimetres Tolerances on dimensions without specific tolerance: (a) On angles: 0/– 10° (b) On linear dimensions: up to 25 mm: 0/– 0,05 mm over 25 mm: ± 0,2 mm Both joints shall permit movement in the same plane and the same direction through an angle of 90° with a 0 to + 10° tolerance.	

Conditions	Item	Documentation	Additional Description	Information
Chapter 5: Specifications	Subchapter 5.2: Specifications, Paragraph 5.2.8 Subparagraph 5.2.8.1: Protection against electrical shock	5.2.8.1.4 Isolation resistance	*The criteria specified in the paragraphs 5.2.8.1.4.1 and 5.2.8.1.4.2 below shall be met.* *The measurement shall be conducted in accordance with paragraph 5 of Annex 11.* **Paragraph 5 of annex 11:ISOLATION RESISTANCE** *The isolation resistance between the high voltage bus and the electrical chassis may be demonstrated either by measurement or by a combination of measurement and calculation.* *The following instructions should be used if the isolation resistance is demonstrated by measurement.* *Measure and record the voltage (Vb) between the negative and the positive side of the high voltage bus (see Figure 1 above); Measure and record the voltage (V1) between the negative side of the high voltage bus and the electrical chassis (see Figure 1 above);* *Measure and record the voltage (V2) between the positive side of the high voltage bus and the electrical chassis (see Figure 1 above);* *If V1 is greater than or equal to V2, insert a standard known resistance (Ro) between the negative side of the high voltage bus and the electrical chassis. With Ro installed, measure the voltage (V1') between the negative side of the high voltage bus and the vehicle electrical chassis (see Figure 3 below).* Calculate the isolation resistance (Ri) according to the formula shown below $R_i = R_o * (V_b/V_1' - V_b/V_1)$ or $R_i = R_o * V_b * (1/V_1' - 1/V_1)$ Divide the result Ri , which is the electrical isolation resistance value in ohm (Ω), by the working voltage of the high voltage bus in volt (V).	Vehicle integration Test protocols Integrator or FCM supplier Electrical design requirements

Conditions	Item	Documentation	Additional Description	Information
			$R_i\ (\Omega/V) = R_i\ (\Omega)/\text{Working voltage}\ (V)$ *Figure 3* **Measurement of V_1'**  *If V2 is greater than V1, insert a standard known resistance (Ro) between the positive side of the high voltage bus and the electrical chassis. With Ro installed, measure the voltage (V2') between the positive side of the high voltage bus and the electrical chassis (see Figure 4 below).* *Calculate the isolation resistance (Ri) according to the formula shown below.* $R_i = R_o * (V_b/V_2' - V_b/V_2)$ or $R_i = R_o * V_b * (1/V_2' - 1/V_2)$	

Conditions	Item	Documentation	Additional Description	Information
			Divide the result Ri , which is the electrical isolation resistance value in ohm (Ω), by the working voltage of the high voltage bus in volt (V). R_i (Ω/V) = R_i (Ω)/Working voltage (V) *Figure 4* **Measurement of V_2'**  *Note:* The standard known resistance R_o (in Ω) should be the value of the minimum required isolation resistance (Ω/V) multiplied by the working voltage (V) of the vehicle plus/minus 20 per cent. R_o is not required to be precisely this value since the equations are valid for any R_o; however, a R_o value in this range should provide a good resolution for the voltage measurements.	
Chapter 5: Specifications	Subchapter 5.2: Specifications, Paragraph 5.2.8	5.2.8.1.4.1 Electrical power train consisting of	*If the AC high voltage buses and the DC high voltage buses are galvanically isolated from each other, isolation resistance between the high voltage bus and the electrical chassis (Ri , as defined in paragraph 5 of Annex 11) shall have a minimum value of 100 Ω/V of the*	Vehicle integration Test protocols

Conditions	Item	Documentation	Additional Description	Information
	Subparagraph 5.2.8.1: Protection against electrical shock 5.2.8.1.4 Isolation resistance	separate DC- or AC-buses	*working voltage for DC buses, and a minimum value of 500 Ω/V of the working voltage for AC buses.*	Integrator or FCM supplier Electrical design requirements
Chapter 5: Specifications	Subchapter 5.2: Specifications, Paragraph 5.2.8 Subparagraph 5.2.8.1: Protection against electrical shock 5.2.8.1.4 Isolation resistance	5.2.8.1.4.2 Electrical power train consisting of combined DC- and AC-buses	*If the AC high voltage buses and the DC high voltage buses are galvanically connected isolation resistance between the high voltage bus and the electrical chassis (Ri , as defined in paragraph 5 of Annex 11) shall have a minimum value of 500 Ω/V of the working voltage.* *However, if the protection degree IPXXB is satisfied for all AC high voltage buses or the AC voltage is equal or less than 30 V after the vehicle impact, the isolation resistance between the high voltage bus and the electrical chassis (Ri, as defined in paragraph 5 of Annex 11) shall have a minimum value of 100 Ω/V of the working voltage.*	Vehicle integration Test protocols Integrator or FCM supplier Electrical design requirements

Annex 12: REGULATION N° 95 (UN/ECE)

REGULATION N° 95 (UN/ECE)

A. IDENTITY CARD OF REGULATION N° 95 (UN/ECE)

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<tr><th>RCS</th><th>N°</th><th>Title</th><th>Statutory</th></tr>
<tr><td>Regulation</td><td>R95</td><td>Uniform provisions concerning the approval of vehicles with regard to the protection of the occupants in the event of a lateral collision</td><td>Y</td></tr>
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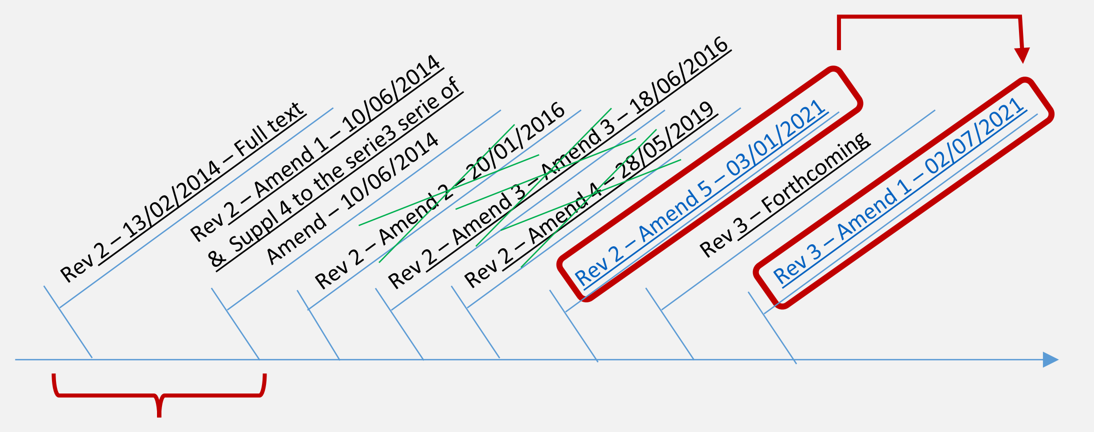

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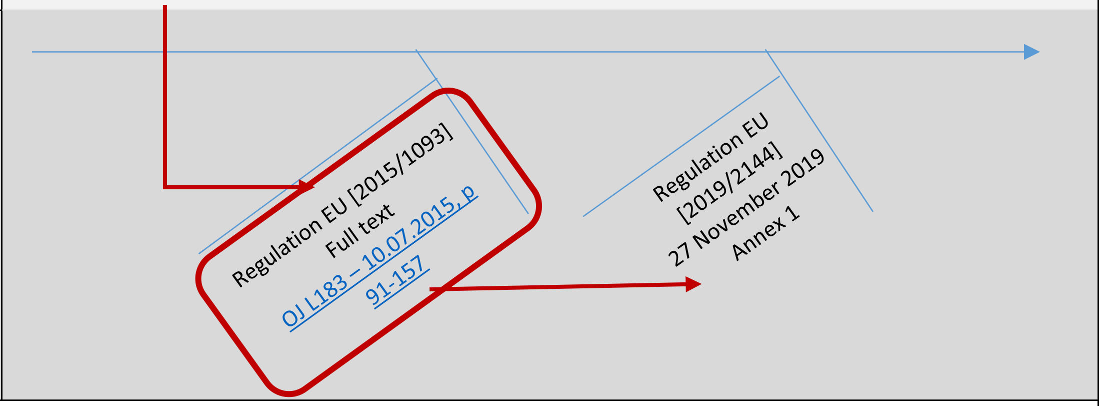

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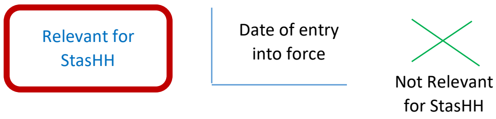

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Scope: This Regulation applies to vehicles of category M1 with a maximum permissible mass not exceeding 3,500 kg and to vehicles of category N1."

Domain/category: M1, N1

Specifed exclusion: /

Reference included in this RCS: /

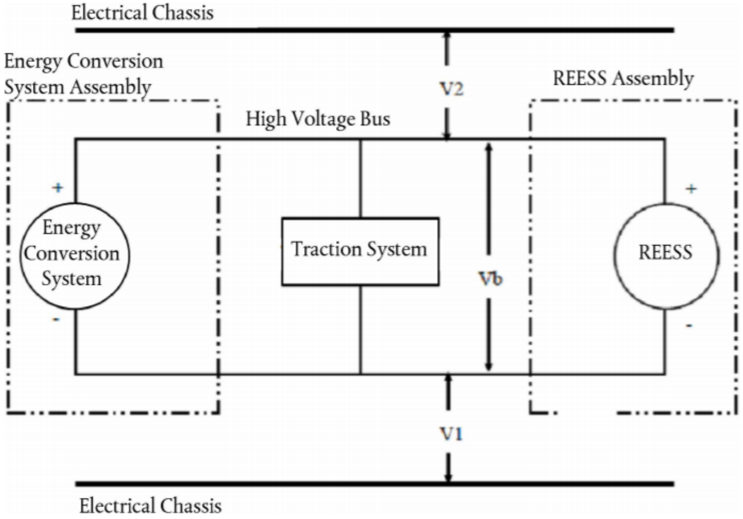
B. RELEVANT PARTS FOR STASHH PROJECT

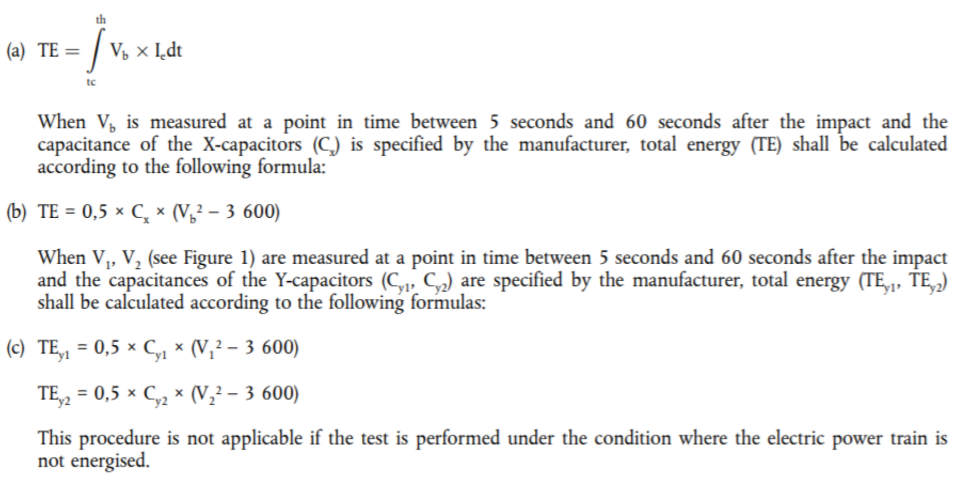
The part relevant in StasHH project concerns the requirements on the electrical power train operating on high voltage, and the high voltage components and systems, which are galvanically connected to the high voltage bus of the electric power train (requirements ensuring the protection of the occupant in case of lateral collision)

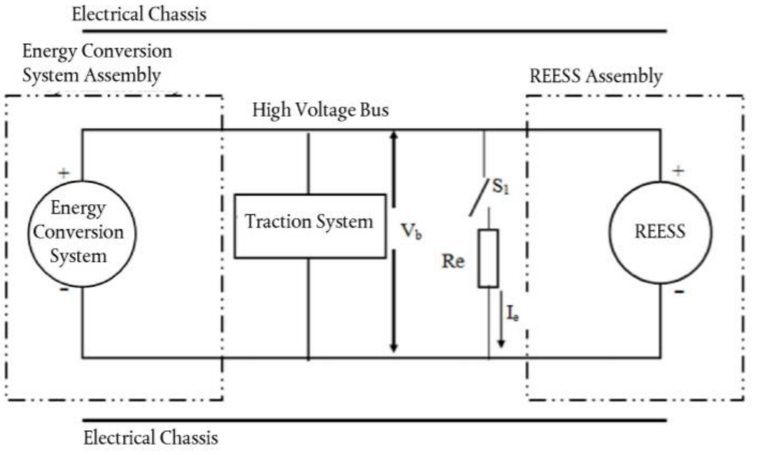
Conditions	Item	Documentation	Additional Description	Information
Chapter 5: specifications and tests	Subchapter 5.2: performance criteria		*Additionally, vehicles equipped with electric power train shall meet the requirements of paragraph 5.3.7 below. This can be met by a separate impact test at the request of the manufacturer and after validation by the Technical Service, provided that the electrical components do not influence the occupant protection performance of the vehicle type as defined in paragraphs 5.2.1 to 5.3.5 of this Regulation. In case of this condition the requirements of paragraph 5.3.7 shall be checked in accordance with the methods set out in Annex 4 to this Regulation, except paragraphs 6, 7 and Appendices 1 and 2. But the side-impact dummy shall be installed in the front seat on the impact side.* **Annex 4 to this Regulation, except paragraphs 6, 7 and Appendices 1 and 2:** *5.11 Electrical power train adjustment* *5.11.2. The electrical power train shall be energised with or without the operation of the original electrical energy sources (e.g. engine-generator, REESS or electric energy conversion system), however:* *5.11.2.1. By the agreement between Technical Service and manufacturer it shall be permissible to perform the test with all or parts of the electrical power train not being energised insofar as there is no negative influence on the test result. For parts of the electrical power train not energised, the protection against electrical shock shall be proved by either physical protection or isolation resistance and appropriate additional evidence.*	Vehicle integration Test protocols Integrator or FCM supplier

Conditions	Item	Documentation	Additional Description	Information
			5.11.2.2. In the case where an automatic disconnect is provided, at the request of the manufacturer it shall be permissible to perform the test with the automatic disconnection being triggered. In this case it shall be demonstrated that the automatic disconnect would have operated during the impact test. This includes the automatic activation signal as well as the galvanic separation considering the conditions as seen during the impact.	
Chapter 5: specifications and tests	Subchapter 5.3: Particular requirements	5.3.7	*Following the test conducted in accordance with the procedure defined in Annex 4 to this Regulation, the electrical power train operating on high voltage, and the high voltage components and systems, which are galvanically connected to the high voltage bus of the electric power train, shall meet the following requirements:*	Vehicle integration Test protocols Integrator or FCM supplier Electrical design requirements
Chapter 5: specifications and tests	Subchapter 5.3: Particular requirements	5.3.7.1 Protection against electrical shock	*After the impact at least one of the four criteria specified in paragraph 5.3.7.1.1 through paragraph 5.3.7.1.4.2 shall be met.* *If the vehicle has an automatic disconnect function, or device(s) that galvanically divide the electric power train circuit during driving condition, at least one of the following criteria shall apply to the disconnected circuit or to each divided circuit individually after the disconnect function is activated.* *However criteria defined in 5.3.7.1.4 shall not apply if more than a single potential of a part of the high voltage bus is not protected under the conditions of protection degree IPXXB.* *If the test is performed under the condition that part(s) of the high voltage system are not energised, the protection against electrical shock shall be proved by either paragraph 5.3.7.1.3 or 5.3.7.1.4 below for the relevant part(s).*	Vehicle integration Test protocols Integrator or FCM supplier Electrical design requirements
Chapter 5: specifications and tests	Subchapter 5.3: Particular requirements	5.3.7.1.1 abscence of high voltage	The voltages Vb, V1 and V2 of the high voltage buses shall be equal or less than 30 VAC or 60 VDC as specified in paragraph 2 of Annex 9.	Vehicle integration Test protocols

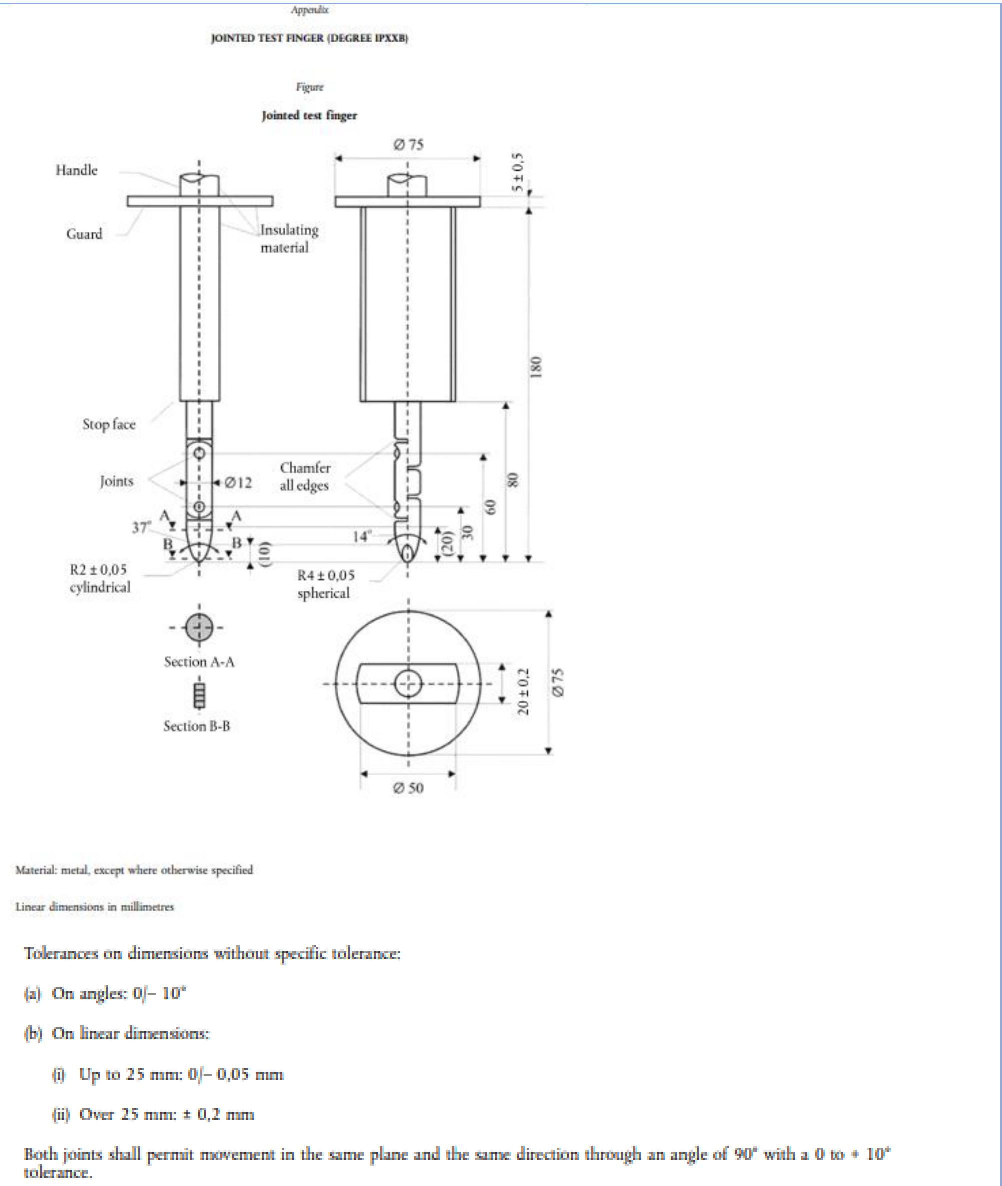
Conditions	Item	Documentation	Additional Description	Information
	5.3.7.1 Protection against electrical shock		**Paragraph 2 of Annex 9:** Test procedures for the protection of the occupants of vehicles operating on electrical power high voltage and electrolyte spillage *This annex describes test procedures to demonstrate compliance to the electrical safety requirements of paragraph 5.3.7. For example, megohmmeter or oscilloscope measurements are an appropriate alternative to the procedure described below for measuring isolation resistance. In this case it may be necessary to deactivate the on-board isolation resistance monitoring system.* *Before the vehicle impact test conducted, the high voltage bus voltage (Vb) (see Figure 1) shall be measured and recorded to confirm that it is within the operating voltage of the vehicle as specified by the vehicle manufacturer.* *2. THE FOLLOWING INSTRUCTIONS MAY BE USED IF VOLTAGE IS MEASURED.* *After the impact test, determine the high voltage bus voltages (Vb, V1, V2) (see Figure 1).* *The voltage measurement shall be made not earlier than 5 seconds, but, not later than 60 seconds after the impact.* *This procedure is not applicable if the test is performed under the condition where the electric power train is not energised.*	Integrator or FCM supplier Electrical design requirements

Conditions	Item	Documentation	Additional Description	Information
			Figure 1 **Measurement of V_b, V_1, V_2** 	
Chapter 5: specifications and tests	Subchapter 5.3: Particular requirements 5.3.7.1 Protection against electrical shock	5.3.7.1.2 Low electrical energy	*The total energy (TE) on the high voltage buses shall be less than 2,0 joules when measured according to the test procedure as specified in paragraph 3 of Annex 9 with the formula (a). Alternatively the total energy (TE) may be calculated by the measured voltage Vb of the high voltage bus and the capacitance of the X-capacitors (Cx) specified by the manufacturer according to formula (b) of paragraph 3 of Annex 9.* *The energy stored in the Y-capacitors (TEy1, TEy2) shall also be less than 2,0 joules. This shall be calculated by measuring the voltages V1 and V2 of the high voltage buses and the electrical chassis, and the capacitance of the Y-capacitors specified by the manufacturer according to formula (c) of paragraph 3 of Annex 9.*	Vehicle integration Test protocols Integrator or FCM supplier Electrical design requirements

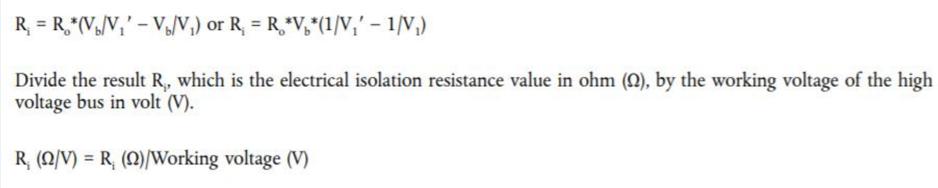
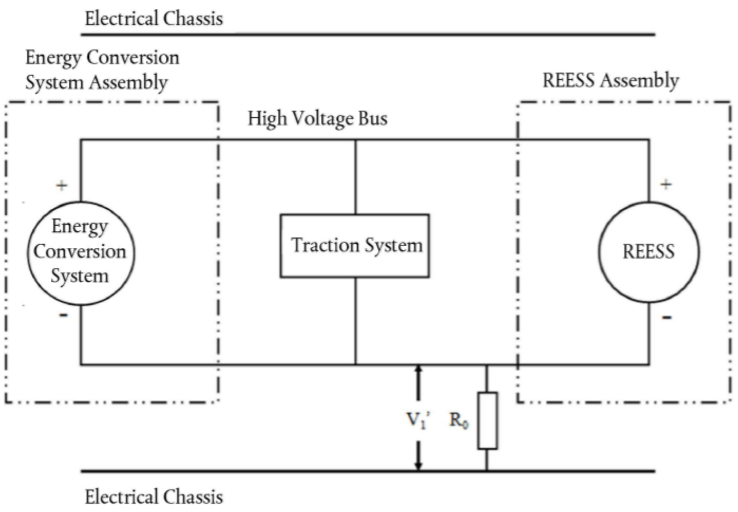
Conditions	Item	Documentation	Additional Description	Information
			Paragraph 3 of Annex 9: *3. ASSESSMENT PROCEDURE FOR LOW ELECTRICAL ENERGY* *Prior to the impact a switch S1 and a known discharge resistor Re is connected in parallel to the relevant capacitance (see Figure 2).* *Not earlier than 5 seconds and not later than 60 seconds after the impact the switch S1 shall be closed while the voltage Vb and the current Ie are measured and recorded. The product of the voltage Vb and the current Ie shall be integrated over the period of time, starting from the moment when the switch S1 is closed (tc) until the voltage Vb falls below the high voltage threshold of 60 V DC (th). The resulting integration equals the total energy (TE) in joules.*  (a) $TE = \int_{tc}^{th} V_b \times I_e dt$ When V_b is measured at a point in time between 5 seconds and 60 seconds after the impact and the capacitance of the X-capacitors (C_x) is specified by the manufacturer, total energy (TE) shall be calculated according to the following formula: (b) $TE = 0,5 \times C_x \times (V_b^2 - 3\ 600)$ When V_1, V_2 (see Figure 1) are measured at a point in time between 5 seconds and 60 seconds after the impact and the capacitances of the Y-capacitors (C_{y1}, C_{y2}) are specified by the manufacturer, total energy (TE_{y1}, TE_{y2}) shall be calculated according to the following formulas: (c) $TE_{y1} = 0,5 \times C_{y1} \times (V_1^2 - 3\ 600)$ $TE_{y2} = 0,5 \times C_{y2} \times (V_2^2 - 3\ 600)$ This procedure is not applicable if the test is performed under the condition where the electric power train is not energised.	

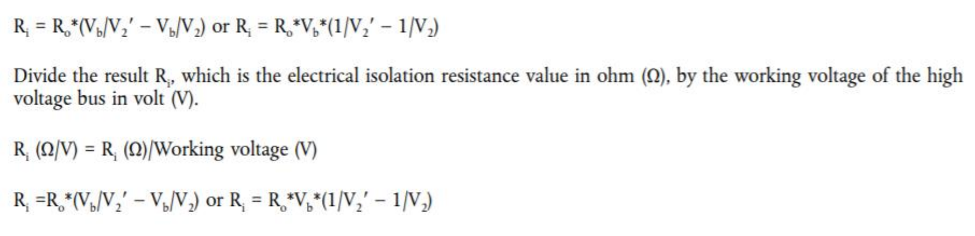
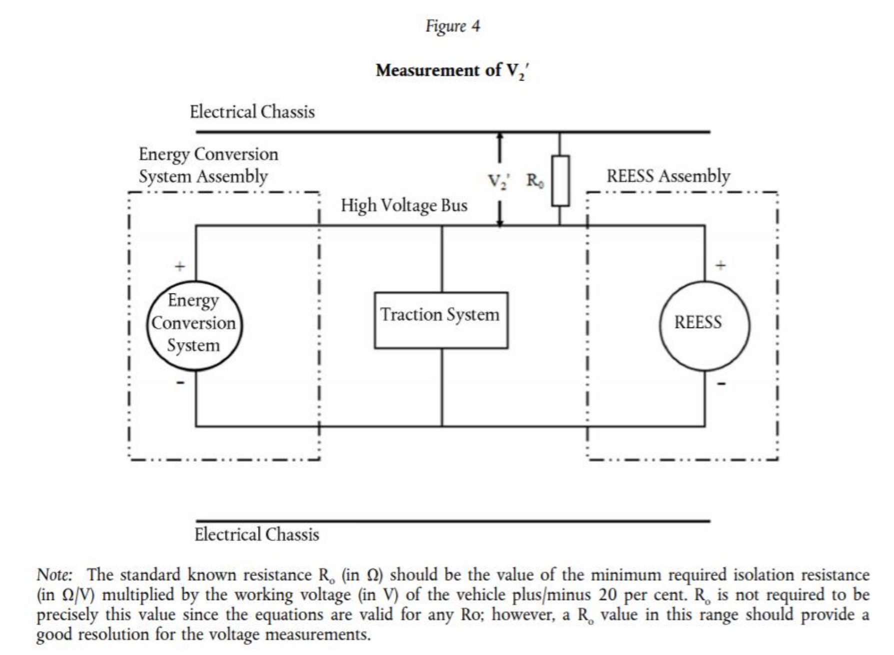
Conditions	Item	Documentation	Additional Description	Information
			Figure 2 **E.g. measurement of high voltage bus energy stored in X-capacitors**  	
Chapter 5: specifications and tests	Subchapter 5.3: Particular requirements 5.3.7.1 Protection against electrical shock	5.3.7.1.3 Physical protection	*For protection against direct contact with high voltage live parts, the protection degree IPXXB shall be provided.* *In addition, for protection against electrical shock which could arise from indirect contact, the resistance between all exposed conductive parts and the electrical chassis shall be lower than 0,1 ohm when there is current flow of at least 0,2 ampere.* *This requirement is satisfied if the galvanic connection has been made by welding.* **Paragraph 4 of Annex 9:** *Following the vehicle impact test any parts surrounding the high voltage components shall be, without the use of tools, opened, disassembled or removed. All remaining surrounding parts shall be considered part of the physical protection.*	Vehicle integration Test protocols Integrator or FCM supplier Electrical design requirements

Conditions	Item	Documentation	Additional Description	Information
			The jointed test finger described in the figure of the appendix to this annex shall be inserted into any gaps or openings of the physical protection with a test force of 10 N ± 10 per cent for electrical safety assessment. If partial or full penetration into the physical protection by the jointed test finger occurs, the jointed test finger shall be placed in every position as specified below. *Starting from the straight position, both joints of the test finger shall be rotated progressively through an angle of up to 90° with respect to the axis of the adjoining section of the finger and shall be placed in every possible position.* *Internal electrical protection barriers are considered part of the enclosure.* *If appropriate a low-voltage supply (of not less than 40 V and not more than 50 V) in series with a suitable lamp should be connected, between the jointed test finger and high voltage live parts inside the electrical protection barrier or enclosure.* *4.1. Acceptance conditions* *The requirements of paragraph 5.3.7.1.3 shall be considered to be met if the jointed test finger described in the figure of the appendix to this annex is unable to contact high voltage live parts.* *If necessary a mirror or a fiberscope may be used in order to inspect whether the Jointed Test Finger touches the high voltage buses.* *If this requirement is verified by a signal circuit between the jointed test finger and high voltage live parts, the lamp shall not light.*	

			 *Appendix* **JOINTED TEST FINGER (DEGREE IPXXB)** *Figure* **Jointed test finger** Material: metal, except where otherwise specified Linear dimensions in millimetres Tolerances on dimensions without specific tolerance: (a) On angles: 0/− 10° (b) On linear dimensions: (i) Up to 25 mm: 0/− 0,05 mm (ii) Over 25 mm: ± 0,2 mm Both joints shall permit movement in the same plane and the same direction through an angle of 90° with a 0 to + 10° tolerance.	

Conditions	Item	Documentation	Additional Description	Information
Chapter 5: specifications and tests	Subchapter 5.3: Particular requirements 5.3.7.1 Protection against electrical shock	5.3.7.1.4 Isolation resistance	*The criteria specified in the paragraphs 5.3.7.1.4.1 and 5.3.7.1.4.2 below shall be met. The measurement shall be conducted in accordance with paragraph 5 of Annex 9.* **Paragraph 5 of Annex 9:** *5. ISOLATION RESISTANCE* *The isolation resistance between the high voltage bus and the electrical chassis may be demonstrated either by measurement or by a combination of measurement and calculation.* *The following instructions should be used if the isolation resistance is demonstrated by measurement.* *Measure and record the voltage (Vb) between the negative and the positive side of the high voltage bus (see Figure 1);* *Measure and record the voltage (V1) between the negative side of the high voltage bus and the electrical chassis (see Figure 1);* *Measure and record the voltage (V2) between the positive side of the high voltage bus and the electrical chassis (see Figure 1);* *If V1 is greater than or equal to V2, insert a standard known resistance (Ro) between the negative side of the high voltage bus and the electrical chassis. With Ro installed, measure the voltage (V1') between the negative side of the high voltage bus and the vehicle electrical chassis (see Figure 3). Calculate the isolation resistance (Ri) according to the formula shown below.*	Vehicle integration Test protocols Integrator or FCM supplier Electrical design requirements

Conditions	Item	Documentation	Additional Description	Information
			 $R_i = R_o*(V_b/V_1' - V_b/V_1)$ or $R_i = R_o*V_b*(1/V_1' - 1/V_1)$ Divide the result R_i, which is the electrical isolation resistance value in ohm (Ω), by the working voltage of the high voltage bus in volt (V). R_i (Ω/V) = R_i (Ω)/Working voltage (V) *Figure 3* **Measurement of V_1'**  *If V2 is greater than V1, insert a standard known resistance (Ro) between the positive side of the high voltage bus and the electrical chassis. With Ro installed, measure the voltage (V2') between the positive side of the high voltage bus and the electrical chassis (see Figure 4).* *Calculate the isolation resistance (Ri) according to the formula shown below.*	

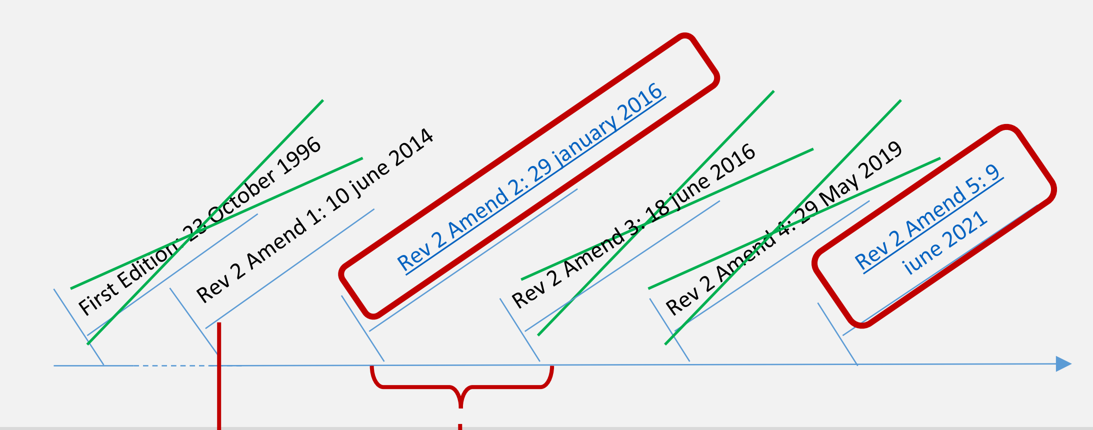
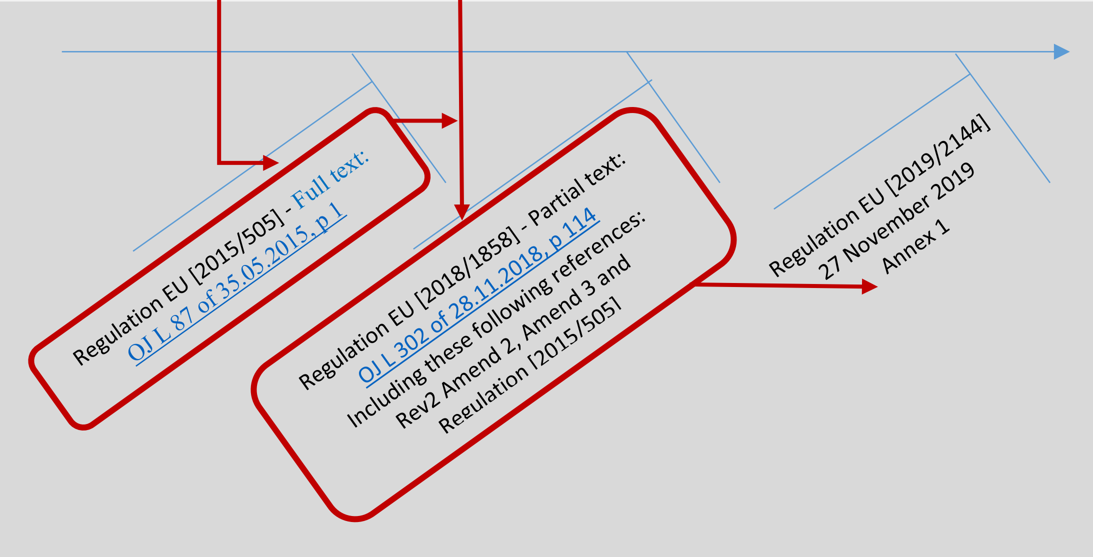
Conditions	Item	Documentation	Additional Description	Information
			 $R_i = R_o*(V_b/V_2' - V_b/V_2)$ or $R_i = R_o*V_b*(1/V_2' - 1/V_2)$ Divide the result R_i, which is the electrical isolation resistance value in ohm (Ω), by the working voltage of the high voltage bus in volt (V). R_i (Ω/V) = R_i (Ω)/Working voltage (V) $R_i = R_o*(V_b/V_2' - V_b/V_2)$ or $R_i = R_o*V_b*(1/V_2' - 1/V_2)$  *Figure 4* **Measurement of V_2'** *Note:* The standard known resistance R_o (in Ω) should be the value of the minimum required isolation resistance (in Ω/V) multiplied by the working voltage (in V) of the vehicle plus/minus 20 per cent. R_o is not required to be precisely this value since the equations are valid for any Ro; however, a R_o value in this range should provide a good resolution for the voltage measurements.	
Chapter 5: specifications and tests	Subchapter 5.3: Particular requirements 5.3.7.1	5.3.7.1.4.1 Electrical power train consisting of	*If the AC high voltage buses and the DC high voltage buses are galvanically isolated from each other, isolation resistance between the high voltage bus and the electrical chassis (Ri , as defined in paragraph 5 of Annex 9) shall have a minimum value of 100 Ω/V of the working voltage for DC buses, and a minimum value of 500 Ω/V of the working voltage for AC buses.*	Vehicle integration Test protocols Integrator or FCM supplier

Conditions	Item	Documentation	Additional Description	Information
	Protection against electrical shock 5.3.7.1.4 Isolation resistance	separate DC- or AC-buses	**Paragraph 5 of Annex 9:** See details above	Electrical design requirements
Chapter 5: specifications and tests	Subchapter 5.3: Particular requirements 5.3.7.1 Protection against electrical shock 5.3.7.1.4 Isolation resistance	5.3.7.1.4.2 Electrical power train consisting of combined DC- and AC-buses	*If the AC high voltage buses and the DC high voltage buses are galvanically connected isolation resistance between the high voltage bus and the electrical chassis (Ri , as defined in paragraph 5 of Annex 9) shall have a minimum value of 500 Ω/V of the working voltage.* *However, if the protection degree IPXXB is satisfied for all AC high voltage buses or the AC voltage is equal or less than 30 V after the vehicle impact, the isolation resistance between the high voltage bus and the electrical chassis (Ri , as defined in paragraph 5 of Annex 9) shall have a minimum value of 100 Ω/V of the working voltage.* **Paragraph 5 of Annex 9:** See details above	Vehicle integration Test protocols Integrator or FCM supplier Electrical design requirements
Chapter 5: specifications and tests	Subchapter 5.3: Particular requirements	5.3.8	The fuel system and high voltage system shall be assessed for all configurations or worst-case configuration for left-hand drive and right-hand drive vehicles, when applicable."	Safety

Annex 13: REGULATION N° 100 (UN/ECE)

REGULATION N° 100 (UN/ECE)

A. IDENTITY CARD OF REGULATION N° 100 (UN/ECE)

RCS	N°	Title	Statutory
Regulation	R100	Uniform provisions concerning the approval of vehicles with regard to specific requirements for the electric power train	Y
UN /ECE publication			
EU publication			
Relevant for StasHH	Date of entry into force	Not Relevant for StasHH	

Scope:

Part I: Safety requirements with respect to the electric power train of road vehicles of categories M and N1 , with a maximum design speed exceeding 25 km/h, equipped with electric power train, excluding vehicles permanently connected to the grid.

Part II: Safety requirements with respect to the Rechargeable Electrical Energy Storage System (REESS), of road vehicles of categories M and N equipped with electric power train, excluding vehicles permanently connected to the grid.

Part II of this Regulation does not apply to REESS(s) whose primary use is to supply power for starting the engine and/or lighting and/or other vehicle auxiliaries systems.

Domain/category: Vehicle categories M and N

Specifed exclusion:

Part I of this regulation does not cover:

- *(a) Post-crash safety requirements of road vehicles*
- *(b) High voltage components and systems which are not galvanically connected to the high voltage bus of the electric power train.*

Part II of this Regulation does not apply to a battery whose primary use is to supply power for starting the engine and/or lighting and/or other vehicle auxiliaries' systems."

Reference included in this RCS: /

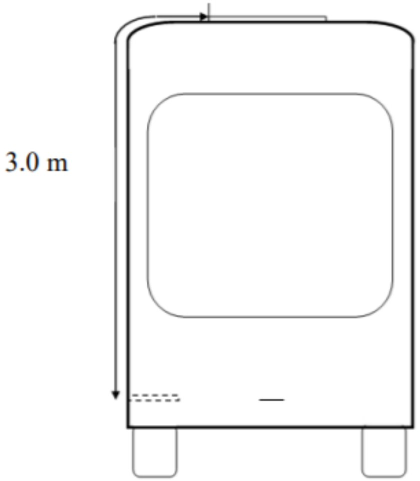
B. RELEVANT PARTS FOR STASHH PROJECT

Only Part I is applicable. Part II is dedicated to REESS (......), the “Hydrogen storage and FC” system is not considered as an Electrical storage. Such as the definition 2.31 ” ‘Service disconnect’ means the device for deactivation of the electrical circuit when conducting checks and services of the REESS, fuel cell stack, etc

Note: The requirements of amendment 5 of revision 2, which came into force in June 2021, are integrated in this sheet (only for the points relevant for StasHH, i.e.: some points of part I of chapter 5 and associated annexes). Indeed, this chapter 5 is partly reworked to specify the requirements of a vehicle with regard to the specific requirements of the electric power train and not only the requirements of a vehicle with regard to its electrical safety.

Conditions	Item	Documentation	Additional Description	Information
Chapter 5, PART I: Requirements of a vehicle with regard to specific requirements for the electric power train	Subchapter 5.1 Protection against electrical shock		*These electrical safety requirements apply to high voltage buses of electric power train and electrical components which are galvanically connected to the high voltage bus of electric power train under conditions where they are not connected to external high voltage power supplies.*	Electrical design requirements Safety
Chapter 5, PART I: Requirements of a vehicle with regard to specific requirements for the electric power train	Subchapter 5.1 Protection against electrical shock	Paragraph 5.1.1 Protection against direct contact	*Live parts shall comply with paragraphs 5.1.1.1. and 5.1.1.2. for protection against direct contact. Electrical protection barriers, enclosures, solid insulators and connectors shall not be able to be opened, separated, disassembled or removed without the use of tools or, for vehicles of categories N2, N3, M2 and M3, an operator controlled activation/deactivation device or equivalent* *However, connectors (including the vehicle inlet) are allowed to be separated without the use of tools, if they meet one or more of the following requirements:*	Electrical design requirements Safety Test protocols

Conditions	Item	Documentation	Additional Description	Information
			(a) They comply with paragraphs 5.1.1.1. and 5.1.1.2. when separated, or *(b) They are provided with a locking mechanism (at least two distinct actions are needed to separate the connector from its mating component). Additionally, other components, not being part of the connector, shall be removable only with the use of tools or, for vehicles of categories N2, N3, M2 and M3, an operator controlled activation/deactivation device or equivalent in order to be able to separate the connector, or* *(c) The voltage of the live parts becomes equal or below 60 V DC or equal or below 30 V AC (rms) within 1 s after the connector is separated.* *For vehicles of categories N2, N3, M2 and M3, conductive connection devices not energized except during charging of the REESS are exempted from this requirement if located on the roof of the vehicle out of reach for a person standing outside of the vehicle and, for vehicles of category M2 and M3, the minimum wrap around distance from the instep of the vehicle to the roof mounted charging devices is 3 m. In case of multiple steps due to an elevated floor inside the vehicle, the wrap around distance is measured from the bottom most step at entry, as illustrated in Figure 1.*	

Conditions	Item	Documentation	Additional Description	Information
			 Figure 1 Schematic to Measure Wrap-Around Distance	
Chapter 5, PART I: Requirements of a vehicle with regard to specific requirements for the electric power train	Subchapter 5.1 Protection against electrical shock	Paragraph 5.1.1 Protection against direct contact Subparagraph 5.1.1.1	*For high voltage live parts inside the passenger compartment or luggage compartment, the protection degree IPXXD shall be provided.*	Electrical design requirements Electrical installation inside vehicle Safety Test protocols
Chapter 5, PART I: Requirements of a vehicle with regard to specific requirements	Subchapter 5.1 Protection against electrical shock	Paragraph 5.1.1 Protection against direct contact, Subparagraph 5.1.1.2	*For high voltage live parts in areas other than the passenger compartment or luggage compartment, the protection degree IPXXB shall be provided.*	Electrical design requirements Electrical installation inside vehicle Safety Test protocols

Conditions	Item	Documentation	Additional Description	Information
for the electric power train				
Chapter 5, PART I: Requirements of a vehicle with regard to specific requirements for the electric power train	Subchapter 5.1 Protection against electrical shock	Paragraph 5.1.1 Protection against direct contact, Subparagraph 5.1.1.3 : Service disconnect	*For a high voltage service disconnect which can be opened, disassembled or removed without tools, or for vehicles of categories N2, N3, M2 and M3, an operator controlled activation/deactivation device or equivalent, protection degree IPXXB shall be satisfied when it is opened, disassembled or removed.*	Electrical design requirements Electrical installation inside vehicle Safety Test protocols
Chapter 5, PART I: Requirements of a vehicle with regard to specific requirements for the electric power train	Subchapter 5.1 Protection against electrical shock	Paragraph 5.1.2 Protection against indirect contac Sub-paragraph 5.1.2.1	*For protection against electrical shock which could arise from indirect contact, the exposed conductive parts, such as the conductive electrical protection barrier and enclosure, shall be galvanically connected securely to the electrical chassis by connection with electrical wire or ground cable, or by welding, or by connection using bolts, etc. so that no dangerous potentials are produced.*	Electrical design requirements Electrical installation inside vehicle Safety Test protocols
Chapter 5, PART I: Requirements of a vehicle with regard to specific requirements for the electric power train	Subchapter 5.1 Protection against electrical shock	Paragraph 5.1.2 Protection against indirect contac Sub-paragraph 5.1.2.2	*The resistance between all exposed conductive parts and the electrical chassis shall be lower than 0.1 ohm when there is current flow of at least 0.2 amperes.* *The resistance between any two simultaneously reachable exposed conductive parts of the electrical protection barriers that are less than 2.5 m from each other shall not exceed 0.2 Ω. This resistance may be calculated using the separately measured resistances of the relevant parts of electric path.*	Electrical design requirements Electrical installation inside vehicle Safety Test protocols

Conditions	Item	Documentation	Additional Description	Information
			This requirement is satisfied if the galvanic connection has been established by welding. In case of doubt or if the connection is established by other means than welding, a measurement shall be made by using one of the test procedures described in Annex 4. See Annex 4 (new annex integrated in the publication of Amend 5 of revision 2), which deals with the verification of potential equalization. This new annex is composed of: • Test method and test procedure using a resistance tester or DC power supply, voltmeter and ammeter Thus, the annex 4A and annex 4B (former), renumber as annex 5A and annex 5B.	
Chapter 5, PART I: Requirements of a vehicle with regard to specific requirements for the electric power train	Subchapter 5.1 Protection against electrical shock	Paragraph 5.1.3 Isolation resistance, Subparagraph 5.1.3.3 Fuel cell vehicles	*In fuel cell vehicles, DC high voltage buses shall have an on-board isolation resistance monitoring system together with a warning to the driver if the isolation resistance drops below the minimum required value of 100 Ω/V. The function of the on-board isolation resistance monitoring system shall be confirmed as described in Annex 6.* See Annex 6 below for the confirmation method for the function of an on-board isolation resistance monitoring system: The on-board isolation resistance monitoring system shall be tested using the following procedure: (a) Determine the isolation resistance, Ri, of the electric power train with the electrical isolation monitoring system using the procedure outlined Annex 5A. (b) If the minimum isolation resistance value required in accordance with paragraphs 5.1.3.1. or 5.1.3.2. is 100 Ω/V, insert a resistor with resistance Ro between either side of the high voltage bus that exhibit lower value in U1 or U2 measured in accordance with paragraph 2.2.3. of Annex 5A	Vehicle integration Signal report from FCM Safety Test protocols

Conditions	Item	Documentation	Additional Description	Information
			and the electrical chassis. The magnitude of the resistor, Ro, shall be such that: 1/(1/(95xU) – 1/Ri) ≤ Ro < 1/(1/(100xU) – 1/Ri) where U is the working voltage of the electric power train. (c) If the minimum isolation resistance value required in accordance with paragraphs 5.1.3.1. or 5.1.3.2. is 500 Ω/V, insert a resistor with resistance Ro between either side of the high voltage bus that exhibit lower value in U1 or U2 measured in accordance with paragraph 2.2.3. of Annex 5A and the electrical chassis. The magnitude of the resistor, Ro, shall be such that: 1/(1/(475xU) – 1/Ri) ≤ Ro < 1/(1/(500xU) – 1/Ri) where U is the working voltage of the electric power train." Annex 6 - Part 1 (former), renumber as Annex 1 – Appendix 1: not relevant for StasHH.	
Chapter 5, PART I: Requirements of a vehicle with regard to specific requirements for the electric power train	Subchapter 5.1 Protection against electrical shock	Paragraph 5.1.4: Protection against water effects	*The vehicles shall maintain isolation resistance after exposure to water (e.g. washing, driving through standing water). This paragraph shall not apply to electrical circuits that are galvanically connected to each other, where the DC part of these circuits is connected to the electrical chassis and the specific voltage condition is fulfilled.* *"Specific voltage condition" means the condition that the maximum voltage of a galvanically connected electrical circuit between a DC live part and any other live part (DC or AC) is ≤ 30 V AC (rms) and ≤ 60 V DC.* *Note: When a DC live part of such an electrical circuit is connected to chassis and the specific voltage condition applies, the maximum voltage between any live part and the electrical chassis is ≤ 30 V AC (rms) and ≤ 60 V DC."*	Electrical design requirements Safety

Conditions	Item	Documentation	Additional Description	Information
Chapter 5, PART I: Requirements of a vehicle with regard to specific requirements for the electric power train	Subchapter 5.1 Protection against electrical shock	Paragraph 5.1.4: Protection against water effects Subparagraph 5.1.4.3	*If the test procedures specified in Annex 7B are performed, just after each exposure, and with the vehicle still wet, the vehicle shall then comply with isolation resistance test given in Annex 5A, and the isolation resistance requirements given in paragraph 5.1.3. shall be met. In addition, after a 24 hour pause, the isolation resistance test specified in Annex 5A shall again be performed, and the isolation resistance requirements given in paragraph 5.1.3. shall be met* See Annex 5A: Partial text comes from Amendment 5 of Revision 2 of 2021 (renamed in replacement of the former Annex 4). For the text, which is not modified by this Amendment 5 of Revision 2, take text of the annex4 published in the official journal of 2015 [2015/505]. See Annex 7B (new annex in publication of Amend 5 revision 2): Vehicle-based test procedure for protection against water effects	Safety Test protocols
Chapter 5, PART I: Requirements of a vehicle with regard to specific requirements for the electric power train	Subchapter 5.1 Protection against electrical shock	Paragraph 5.1.4: Protection against water effects Subparagraph 5.1.4.4	*If an isolation resistance monitoring system is provided, and the isolation resistance less than the requirements given in paragraph 5.1.3. is detected, a warning shall be indicated to the driver. The function of the on-board isolation resistance monitoring system shall be confirmed as described in Annex 6."* See Annex 6 below for the confirmation method for the function of an on-board isolation resistance monitoring system: The on-board isolation resistance monitoring system shall be tested using the following procedure: (a) Determine the isolation resistance, Ri, of the electric power train with the electrical isolation monitoring system using the procedure outlined Annex 5A. (b) If the minimum isolation resistance value required in accordance with paragraphs 5.1.3.1. or 5.1.3.2. is 100 Ω/V, insert a resistor with resistance Ro between either side of	Vehicle integration Signal report from FCM Safety Test protocols

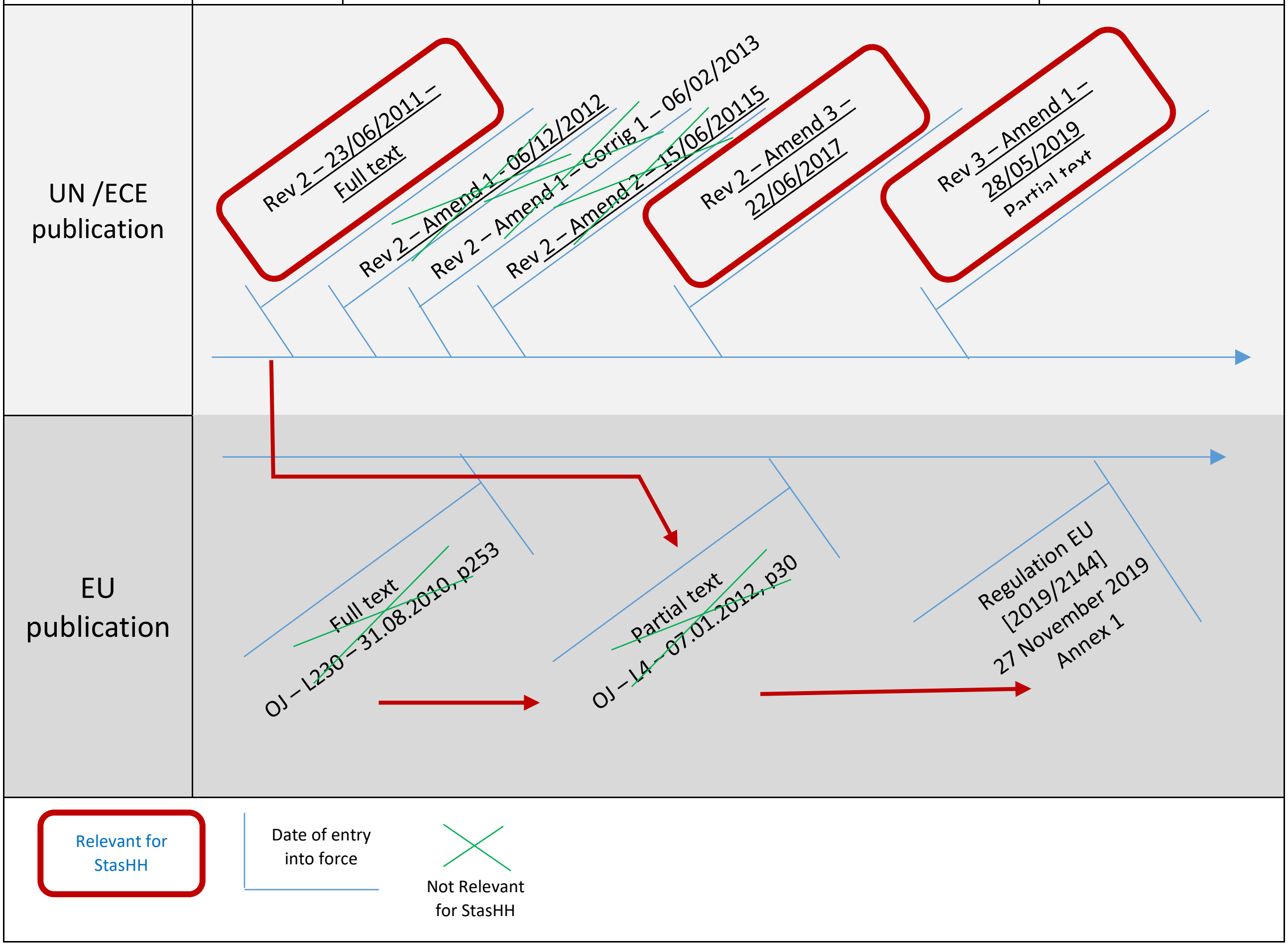
Conditions	Item	Documentation	Additional Description	Information
			the high voltage bus that exhibit lower value in U1 or U2 measured in accordance with paragraph 2.2.3. of Annex 5A and the electrical chassis. The magnitude of the resistor, Ro, shall be such that: 1/(1/(95xU) – 1/Ri) ≤ Ro < 1/(1/(100xU) – 1/Ri) where U is the working voltage of the electric power train. (c) If the minimum isolation resistance value required in accordance with paragraphs 5.1.3.1. or 5.1.3.2. is 500 Ω/V, insert a resistor with resistance Ro between either side of the high voltage bus that exhibit lower value in U1 or U2 measured in accordance with paragraph 2.2.3. of Annex 5A and the electrical chassis. The magnitude of the resistor, Ro, shall be such that: 1/(1/(475xU) – 1/Ri) ≤ Ro < 1/(1/(500xU) – 1/Ri) where U is the working voltage of the electric power train." Annex 6 - Part 1 (former), renumber as Annex 1 – Appendix 1: not relevant for StasHH.	

Annex 14: REGULATION N° 105 (UN/ECE)

REGULATION N° 105 (UN/ECE)

A. IDENTITY CARD OF REGULATION N° 105 (UN/ECE)

RCS	N°	Title	Statutory
Regulation	R105	Uniform provisions concerning the approval of vehicles intended for the carriage of dangerous goods with regard to their specific construction features	Y



Scope: The provisions of this Regulation apply to the construction of base vehicles of motor vehicles of category N and their trailers of category O, intended for the transport of dangerous goods and subject to section 9.1.2 of Annex B to the European Agreement concerning the international Carriage of Dangerous Goods by Road (ADR).

Domain/category: Vehicle category N and O1, only with the carriage of dangerous Goods by Road

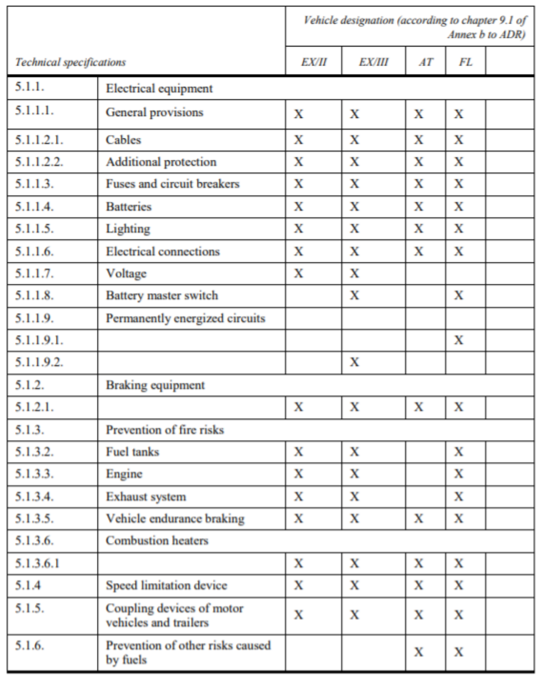
Specifed exclusion:

Reference included in this RCS:

- IEC Standard 529 for the protection for battery master swich
- the European Agreement concerning the international Carriage of Dangerous Goods by Road (ADR).

B. RELEVANT PARTS FOR STASHH PROJECT

Conditions	Item	Documentation	Additional Description	**Information**
Chapter 5: Technical provision-	Subchapter 5.1.1 Electrical equipment	Paragraph 5.1.1.1: General Provisions	*The installation shall be so designed, constructed and protected that it cannot provoke any unintended ignition or short-circuit under normal conditions of use of vehicles. The electrical installation as a whole shall meet the provisions of paragraphs 5.1.1.2. to 5.1.1.9. in accordance with the table of paragraph 5.1."* (the text above comes from revision 2 – Amendment 3 on 22.06.2017) The table below comes from revision 2 – Amendment 3 on 22.06.2017)	Vehicle integration Electrical design requirements Safety

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td>
<table>
<tr><th colspan="2"></th><th colspan="5">Vehicle designation (according to chapter 9.1 of Annex b to ADR)</th></tr>
<tr><th colspan="2">Technical specifications</th><th>EX/II</th><th>EX/III</th><th>AT</th><th>FL</th><th></th></tr>
<tr><td>5.1.1.</td><td colspan="6">Electrical equipment</td></tr>
<tr><td>5.1.1.1.</td><td>General provisions</td><td>X</td><td>X</td><td>X</td><td>X</td><td></td></tr>
<tr><td>5.1.1.2.1.</td><td>Cables</td><td>X</td><td>X</td><td>X</td><td>X</td><td></td></tr>
<tr><td>5.1.1.2.2.</td><td>Additional protection</td><td>X</td><td>X</td><td>X</td><td>X</td><td></td></tr>
<tr><td>5.1.1.3.</td><td>Fuses and circuit breakers</td><td>X</td><td>X</td><td>X</td><td>X</td><td></td></tr>
<tr><td>5.1.1.4.</td><td>Batteries</td><td>X</td><td>X</td><td>X</td><td>X</td><td></td></tr>
<tr><td>5.1.1.5.</td><td>Lighting</td><td>X</td><td>X</td><td>X</td><td>X</td><td></td></tr>
<tr><td>5.1.1.6.</td><td>Electrical connections</td><td>X</td><td>X</td><td>X</td><td>X</td><td></td></tr>
<tr><td>5.1.1.7.</td><td>Voltage</td><td>X</td><td>X</td><td></td><td></td><td></td></tr>
<tr><td>5.1.1.8.</td><td>Battery master switch</td><td></td><td>X</td><td></td><td>X</td><td></td></tr>
<tr><td>5.1.1.9.</td><td>Permanently energized circuits</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>5.1.1.9.1.</td><td></td><td></td><td></td><td></td><td>X</td><td></td></tr>
<tr><td>5.1.1.9.2.</td><td></td><td></td><td>X</td><td></td><td></td><td></td></tr>
<tr><td>5.1.2.</td><td colspan="6">Braking equipment</td></tr>
<tr><td>5.1.2.1.</td><td></td><td>X</td><td>X</td><td>X</td><td>X</td><td></td></tr>
<tr><td>5.1.3.</td><td colspan="6">Prevention of fire risks</td></tr>
<tr><td>5.1.3.2.</td><td>Fuel tanks</td><td>X</td><td>X</td><td></td><td>X</td><td></td></tr>
<tr><td>5.1.3.3.</td><td>Engine</td><td>X</td><td>X</td><td></td><td>X</td><td></td></tr>
<tr><td>5.1.3.4.</td><td>Exhaust system</td><td>X</td><td>X</td><td></td><td>X</td><td></td></tr>
<tr><td>5.1.3.5.</td><td>Vehicle endurance braking</td><td>X</td><td>X</td><td>X</td><td>X</td><td></td></tr>
<tr><td>5.1.3.6.</td><td colspan="6">Combustion heaters</td></tr>
<tr><td>5.1.3.6.1</td><td></td><td>X</td><td>X</td><td>X</td><td>X</td><td></td></tr>
<tr><td>5.1.4</td><td>Speed limitation device</td><td>X</td><td>X</td><td>X</td><td>X</td><td></td></tr>
<tr><td>5.1.5.</td><td>Coupling devices of motor vehicles and trailers</td><td>X</td><td>X</td><td>X</td><td>X</td><td></td></tr>
<tr><td>5.1.6.</td><td>Prevention of other risks caused by fuels</td><td></td><td></td><td>X</td><td>X</td><td></td></tr>
</table>
The fuel cell vehicle who contain a tank superior of 1 m3 has a vehicle designation FL.</td><td></td></tr>
<tr><td>Chapter 5: Technical provision-</td><td>Subchapter 5.1.1 Electrical equipment</td><td>Paragraph 5.1.1.2, Wiring
Subparagraph 5.1.1.2.1: Cables</td><td>*No cable in an electrical circuit shall carry a current in excess of that for which the cable is designed. Conductors shall be adequately insulated.*

The cables shall be suitable for the conditions in the area of the vehicle, such as temperature range and fluid compatibility conditions as they are intended to be used are intended to be used.

The cables shall be in conformity with standard ISO 6722-1:2011 including its Corr. 01:2012 or ISO 6722-2:2013.</td><td>Vehicle integration
Electrical design requirements
Safety</td></tr>
</table>

Conditions	Item	Documentation	Additional Description	**Information**
			Cables shall be securely fastened and positioned to be protected against mechanical and thermal stresses (the text above comes from revision 2 – Amendment 3 on 22.06.2017 and Revision 3 – Amendment 1 on 28.05.2019)	
Chapter 5: Technical provision-	Subchapter 5.1.1 Electrical equipment	Paragraph 5.1.1.2, Wiring Subparagraph 5.1.1.2.2: Additional protection	*Cables located to the rear of the driver's cab and on trailers shall be additionally protected to minimize any unintended ignition or short-circuit in the event of an impact or deformation. The additional protection shall be suitable for the conditions during normal use of the vehicle. The additional protection is complied with if multicore cables in conformity with ISO 14572:2011 are used or one of the examples in Figures 1 to 4 below or another configuration that offers equally effective protection is used. Cables of wheel speed sensors do not need additional protection. EX/II vehicles being one stage built panel vans where the wiring behind the driver's cab is protected by the body are deemed to comply with this requirement.*	Vehicle integration Electrical design requirements Safety

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td>

Figure 1

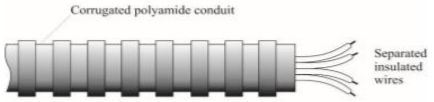


Figure 2

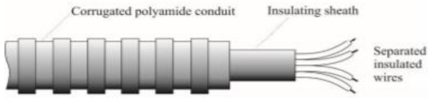


Figure 3

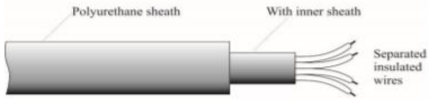
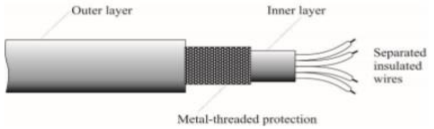


Figure 4



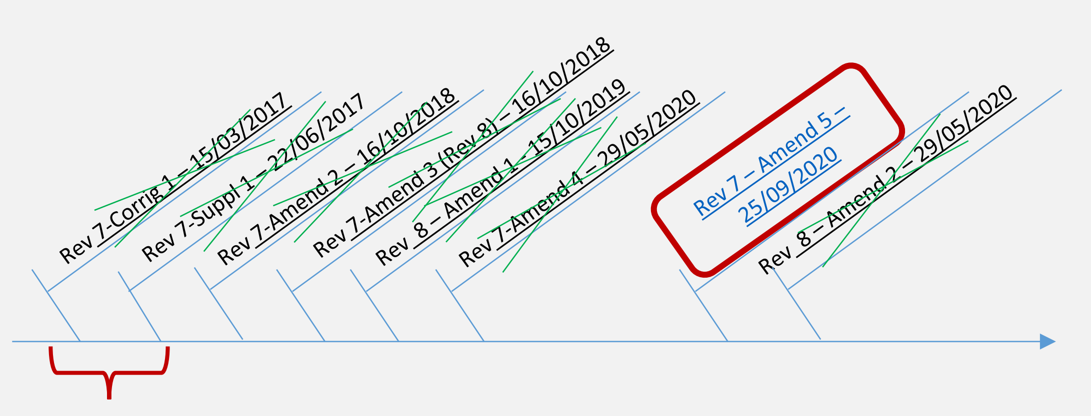
(the text and figures above come from revision 2 – Amendment 3 on 22.06.2017)

</td><td></td></tr>
</table>

Annex 15: REGULATION N° 107 (UN/ECE)

REGULATION N° 107 (UN/ECE)

A. IDENTITY CARD OF REGULATION N° 107 (UN/ECE)

<table>
<tr><td>RCS</td><td>N°</td><td>Title</td><td>Statutory</td></tr>
<tr><td>Regulation</td><td>R107</td><td>Uniform provisions concerning the approval of category M2 and M3 vehicles with regard to their general construction</td><td>Y</td></tr>
<tr><td>UN /ECE publication</td><td colspan="3">
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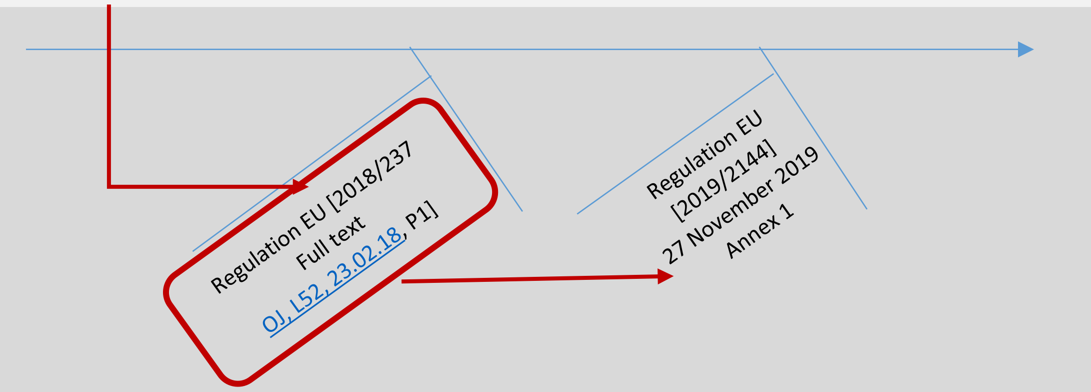
<tr><td>EU publication</td><td colspan="3">
</td></tr>
<tr><td>Relevant for StasHH</td><td>Date of entry into force</td><td>Not Relevant for StasHH</td><td>In force but other UNECE versions</td></tr>
</table>

Scope: This Regulation applies to every single-deck, double-deck, rigid or articulated vehicle of category M_2 or M_3 (general construction on buses and coaches)

Domain/category: Vehicle of category M_2 or M_3

Specifed exclusion:

The requirements of this Regulation do not apply to the following vehicles

- Vehicles designed for the secure transport of persons, for example prisoner;
- Vehicles specially designed for the carriage of injured or sick persons (ambulances);
- Off-road vehicles;
- Vehicles specially designed for the carriage of school children;

The requirements of this Regulation apply to the following vehicles only to the extent that they are compatible with their intended use and function:

- Vehicles designed for use by police, security and armed forces;
- Vehicles which contain seating intended solely for use when the vehicle is stationary, but which are not designed to carry more than 8 persons (excluding the driver) when in motion. Examples of these include mobile libraries, mobile churches and mobile hospitality units. The seats in such vehicles which are designated for use when the vehicle is in motion shall be clearly identified to users.

Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

The requirements of this regulation are set out in Annex 3. This concerns the provisions to be respected in terms of vehicle stability (potentially, the area where the FCM is positioned could have an impact on the stability of the vehicle), the necessary protection of electrical equipment and wiring, and protection against fire. Some requirements regarding the installation of hatches are mentioned and could be important depending on the installation of the FCM.

Conditions	Item	Documentation	Additional Description	Information
Chapter 5 Requirements	Subchapter 5.1		*All vehicles shall comply with the provisions set out in Annex 3 to this Regulation. Bodywork approved separately shall comply with Annex 10. The approval of a vehicle incorporating bodywork approved in accordance with Annex 10 shall be completed in accordance with Annex 3. Fire suppression systems approved separately shall comply with Annex 13, Part 1. In the case of an approval of a vehicle with a fire suppression system installed in a specific engine compartment, it shall comply with the requirements of Annex 13, Part 2.*	
Annex 3 Requirements to be met by all vehicles	Chapter 7.4 Stability test	Paragraph 7.4.1	*The stability of a vehicle shall be such that the point at which overturning occurs would not be passed if the surface on which the vehicle stands were tilted to both sides in turn to an angle of 28 degrees from the horizontal.*	Test protocols
Annex 3 Requirements to be met by all vehicles	Chapter 7.4 Stability test	Paragraph 7.4.5	*Alternatively, a calculation method can be used to show that the vehicle will not overturn under the conditions described in paragraphs 7.4.1 and 7.4.2 above. Such a calculation shall take into account the following parameters:* *7.4.5.1. Masses and dimensions* *7.4.5.2. Height of centre of gravity* *7.4.5.3.Spring rates* *7.4.5.4. Vertical and horizontal tyre rates* *7.4.5.5. Characteristics of the control of air pressure in the air springs* *7.4.5.6. Position of the centre of moments*	Test protocols

Conditions	Item	Documentation	Additional Description	Information
			7.4.5.7. Torsion resistance of the body. *The method of calculation is described in the appendix to this annex.*	
Annex 3 Requirements to be met by all vehicles	Chapter 7.5 Electrical equipment and wiring	Paragraph 7.5.2.3	*Every electrical circuit feeding an item of equipment other than the starter, the ignition circuit (positive ignition), the glow-plugs, the engine-stopping device, the charging circuit and the battery earth connection shall include a fuse or a circuit breaker. Circuits feeding other equipment may, however, be protected by a common fuse or a common circuit-breaker, provided that their sum rated capacity does not exceed the capacity of a fuse or of a circuit-breaker. In the case of multiplexing, the manufacturer shall give all the relevant technical information at the request of the technical service responsible for conducting the tests.*	Vehicle integration Electrical design requirements Test protocols safety
Annex 3 Requirements to be met by all vehicles	Chapter 7.5 Electrical equipment and wiring	Paragraph 7.5.2.5	*Where the voltage exceeds 100 V RMS (Root Mean Square) in one or more electrical circuits in a vehicle, a manually-operated isolating switch which is capable of disconnecting all such circuits from the main electrical supply shall be connected in each pole of that supply which is not electrically connected to earth, and shall be located inside the vehicle in a position readily accessible to the driver, provided that no such isolating switch shall be capable of disconnecting any electrical circuit supplying the mandatory external vehicle lights. This paragraph does not apply to high tension ignition circuits nor to self-contained circuits within a unit of equipment in the vehicle.*	Vehicle integration Electrical design requirements Test protocols safety
Annex 3 Requirements to be met by all vehicles	Chapter 7.5 Electrical equipment and wiring	Paragraph 7.5.2.6	*All electrical cables shall be so located that no part can make contact with any fuel line or any part of the exhaust system, or be subjected to excessive heat, unless suitable special insulation and protection is provided, as for example to a solenoid-operated exhaust valve.*	Vehicle integration Electrical design requirements Test protocols safety

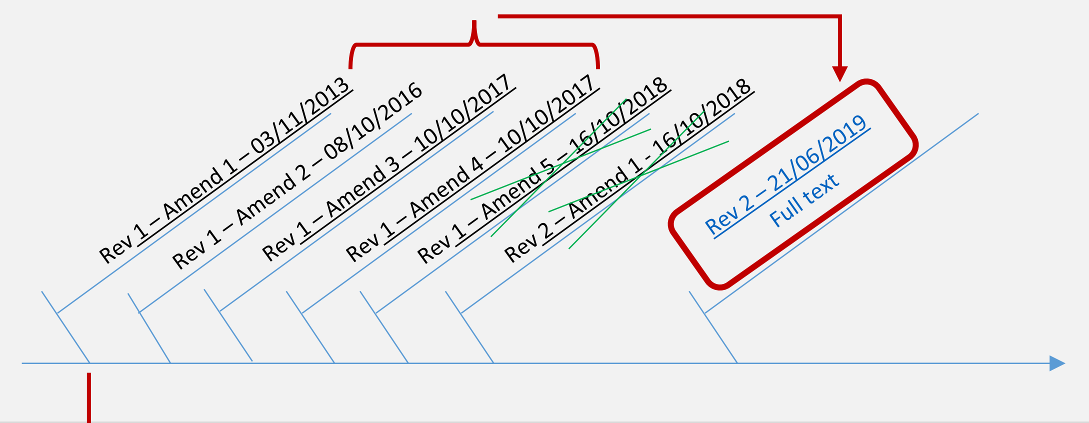
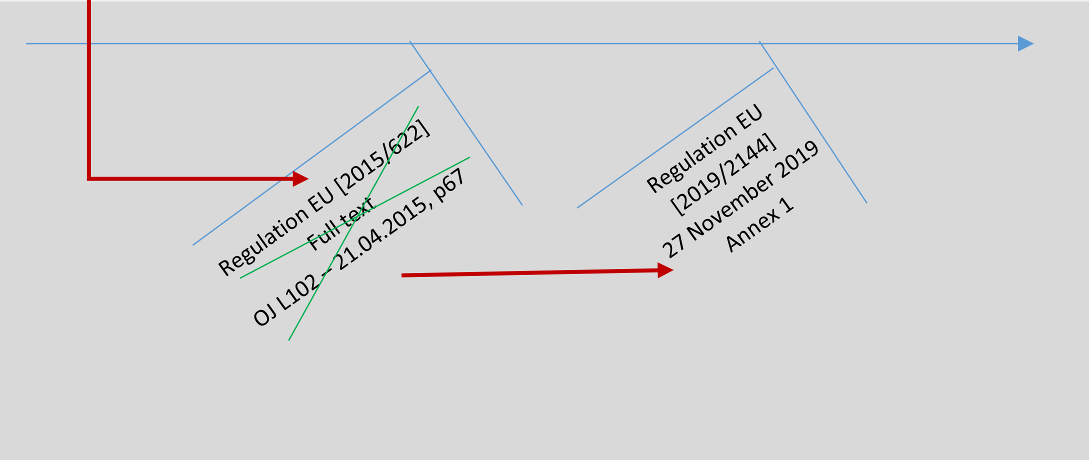
Conditions	Item	Documentation	Additional Description	Information
Annex 3 **Requirements to be met by all vehicles**	Chapter 7.5 Protection against fire risks	Annex 3, Chapter 7.5 Paragraph 7.5.5 Materials	*No flammable material shall be permitted within 100 mm of the exhaust system component, any high voltage electrical equipment or any other significant source of heat unless the material is effectively shielded. Where necessary, shielding shall be provided to prevent grease or other flammable materials coming into contact with exhaust system or other significant heat sources. For the purposes of this paragraph, a flammable material is considered to be one which is not designed to withstand the temperatures likely to be encountered in that location.*	Vehicle integration Material installation requirement in vehicle Safety
Annex 3 Requirements to be met by all vehicles	Chapter 7.5 Protection against fire risks	Paragraph 7.5.6.1 fire detection	*Vehicles shall be equipped with an alarm system detecting either an excess temperature or smoke.*	Vehicle integration Signal report Safety Test protocols
Annex 3 Requirements to be met by all vehicles	Chapter 7.5 Protection against fire risks	Paragraph 7.5.6.2 fire detection	*Upon detection, the system given in paragraph 7.5.6.1 shall provide the driver with both an acoustic and a visual signal in the driver's compartment and shall activate the hazard warning signal.*	Vehicle integration Signal report Safety Test protocols
Annex 3 Requirements to be met by all vehicles	Chapter 7.5 Protection against fire risks	Paragraph 7.5.6.3 fire detection	*The alarm system shall be at least operational whenever the engine start device is operated, until such time as the engine stop device is operated, regardless of the vehicle's attitude.*	Vehicle integration Signal report Safety Test protocols
Annex 3 Requirements to be met by all vehicles	Chapter 7.6 Exits	Paragraph 7.6.1.12	*Hatches shall not be fitted in positions where technical components are installed which present possible danger to passengers using the escape hatches (e.g. high voltage systems, systems containing dangerous liquids and/or gas, etc.).*	Vehicle integration Design requirements Safety Test protocols
Annex 3 Requirements to be met by all vehicles	Chapter 7.6 Exits	Paragraph 7.6.2.8	*For vehicles of classes I, II and III, required escape hatches shall be positioned as follows:* *(a) If there is only one hatch, it shall be situated in the middle third of the passenger compartment; or* *(b) If there are two hatches, they shall be separated by a distance of at least 2 m measured between the nearest*	

Conditions	Item	Documentation	Additional Description	Information
			edges of the apertures in a line parallel to the longitudinal axis of the vehicle." *Comes from Rev7-Amend5 (25/09/2020)*	
Annex 3 Requirements to be met by all vehicles	Chapter 7.6 Exits	Paragraph 7.6.2.9	*For vehicles of classes A and B, required escape hatches shall be positioned as follows:* *(a) If there is only one hatch, it shall be situated in the middle third of the passenger compartment. As an alternative, on vehicles with a very short passenger compartment length, the hatch may be located in the midsection of this compartment, and this mid-section shall be equally spaced longitudinally each side of the transverse centre line of the passenger compartment, with a length of no greater than 1.6m as shown in Annex 4 Figure 31;* *(b) If there are two hatches, they shall be separated by a distance of at least 2 m measured between the nearest edges of the apertures in a line parallel to the longitudinal axis of the vehicle."* *Comes from Rev7-Amend5 (25/09/2020)*	Vehicle integration Design requirements Safety Test protocols

Annex 16: REGULATION N° 118 (UN/ECE)

REGULATION N° 118 (UN/ECE)

A. IDENTITY CARD OF REGULATION N° 118 (UN/ECE)

RCS	N°	Title	Statutory
Regulation	R118	Regulation No 118 of the Economic Commission for Europe of the United Nations (UNECE) — Uniform technical prescriptions concerning the burning behaviour and/or the capability to repel fuel or lubricant of materials used in the construction of certain categories of motor vehicles	Y/N
UN /ECE publication			
EU publication			
Relevant for StasHH	Date of entry into force	Not Relevant for StasHH	

Scope:

1.1. This Regulation applies to the burning behaviour (ignitibility, burning rate and melting behaviour) and to the capability to repel fuel or lubricants of materials used in vehicles of categories M3, Classes II and III[38] *. Type approvals are granted according to:*

1.2. Part I - Approval of a vehicle type with regard to the burning behaviour and/or the capability to repel fuel or lubricant of the components used in the interior compartment, the engine compartment and any separate heating compartment and with regard to the burning behaviour of electric cables and cable sleeves or cable conduits used for protecting electric cables in the vehicle

1.3. Part II – Approval of a component with regard to its burning behaviour and/or its capability to repel fuel or lubricant installed in the interior compartment, the engine compartment or any separate heating compartment.

Domain/category: M3, Classes II and III

Specifed exclusion: /

Reference included in this RCS: /

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[38] As defined in the Consolidated Resolution on the Construction of Vehicles (R.E.3.), document ECE/TRANS/WP.29/78/Rev.6, para. 2.

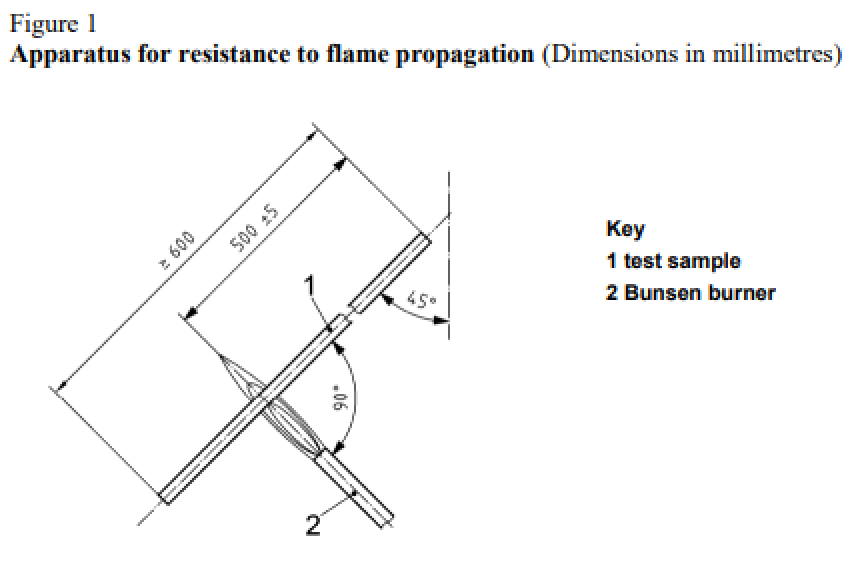
B. RELEVANT PARTS FOR STASHH PROJECT

The relevant part for the StasHH project concerns only electrical cables with regard to their burning behaviour.

Conditions	Item	Documentation	Additional Description	Information
Chapter 5. Part I (see the full title of this section under "Scope".)	Subchapter 5.2. Specifications	5.2.1	*The materials inside and no more than 13 mm beyond the interior compartment, materials of the engine compartment, materials of any separate heating compartment and electric cables, cable sleeves or cable conduits used in the vehicle to be type approved shall meet the requirements of Part II of this Regulation.*	Vehicle integration Material, equipement and Electrical installation requirements in vehicle Approval requirements
Chapter 5. Part I (see the full title of this section under "Scope".)	Subchapter 5.2. Specifications	5.2.2	*The materials and/or equipment used in the interior compartment, the engine compartment and any separate heating compartment and/or in devices approved as components, electric cables and cable sleeves or cable conduits used in the vehicle shall be so installed as to minimize the risk of flame development and flame propagation.*	Vehicle integration Material, equipement and Electrical installation requirements in vehicle Safety
Chapter 5. Part I (see the full title of this section under "Scope".)	Subchapter 5.2. Specifications	5.2.3	*Such materials and/or equipment shall only be installed in accordance with their intended purposes and the test(s) which they have undergone (see paragraphs 6.2.6 especially in relation to their burning and melting behaviour (horizontal/vertical direction) and/or their capability to repel fuel or lubricant.*	Vehicle integration Material, equipement installation requirements in vehicle Safety
Chapter 5. Part I (see the full title of this section under "Scope".)	Subchapter 5.2. Specifications	5.2.4	*Any adhesive agent used to affix the interior material to its supporting structure shall not, as far as possible, exacerbate the burning behaviour of the material.*	Vehicle integration safety
Part II (see the full title of this	Subchapter 6.2	6.2.6	*Any electrical cable exceeding a length of 100 mm used in the vehicle shall undergo the resistance to flame propagation test described in Annex 10 to this Regulation. As an alternative to these requirements, the test procedure*	Vehicle integration Electrical installation requirements in vehicle

Conditions	Item	Documentation	Additional Description	Information
section under "Scope".)			*described in ISO Standard 6722-1:2011, paragraph 5.22. may be applied. Test reports and approvals of components obtained according to ISO 6722:2006, paragraph 12. shall remain valid.* *The exposure to the test flame shall be finished:* *(1) For single-core cables:* *(a) When the conductor becomes visible, or* *(b) After 15 s for cables with conductor sizes less or equal than 2.5 mm2 , and* *(c) After 30 s for cables with conductor sizes greater than 2.5 mm2 ,* *Or* *(2) For sheathed, screened and unscreened single- or multi-core cables with a sum of conductor sizes smaller than or equal to 15 mm2:* *(a) Until a conductor becomes visible or for 30 s, for all cables, whichever comes first,* *Or* *(3) For sheathed, screened and unscreened single- or multi-core cables with a sum of conductor sizes greater than 15 mm2:* *(a) According to (1) or (2), whichever is applicable. Electrical cables according to (2) may be tested either completely or separately.* *Electrical cables according to (3) shall be tested separately.* *The result of the test shall be considered satisfactory if, taking into account the worst test result, any combustion flame of insulating material shall extinguish within 70 seconds and a minimum of 50 mm insulation at the top of the test sample shall remain unburned.* **Annex 10: Test to determine the resistance to flame propagation of electrical cables** *1. Scope*	Safety Test protocol

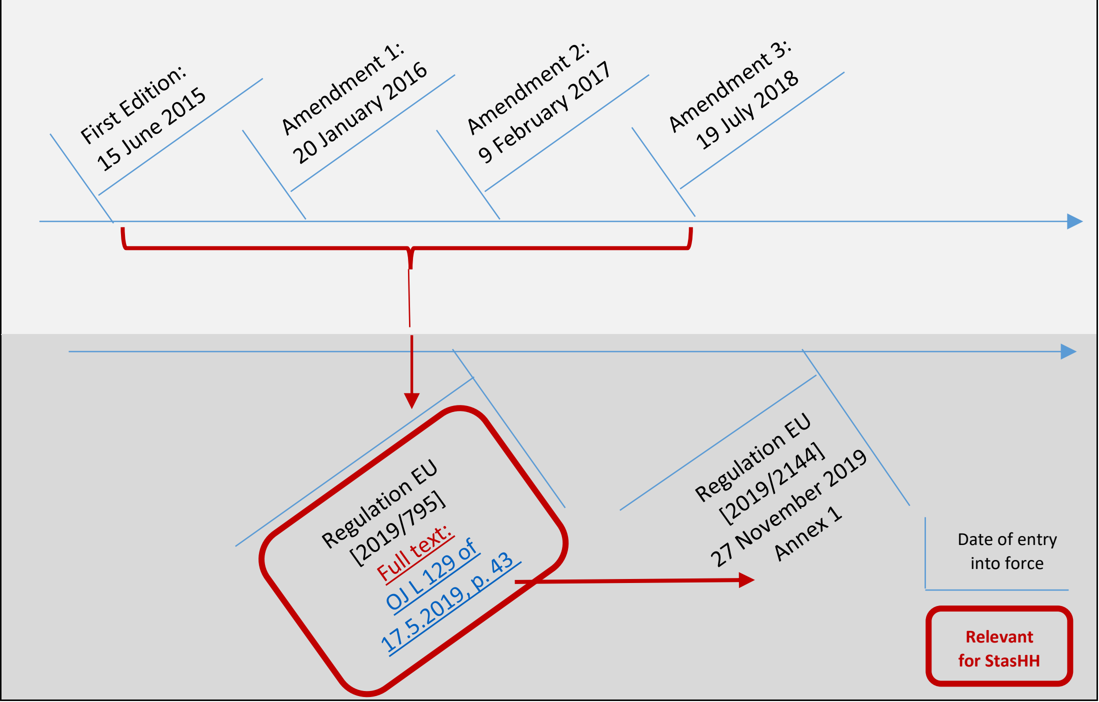
Conditions	Item	Documentation	Additional Description	Information
			This annex defines prescriptions to test the resistance to flame propagation of electrical cables used in the vehicle. *2. Sampling and principle* *2.1. Five samples shall undergo the test* *3. Samples* *3.1. Test samples shall have a length of at least 600 mm of insulation.* *4. Procedure Determine the resistance to flame propagation using a Bunsen burner with an appropriate gas, having a combustion tube of 9 mm internal diameter, where the flame temperature at the tip of the inner blue cone shall be (950 +/- 50) °C. Suspend the test sample in a draught-free chamber and expose the test sample to the tip of the inner cone of the flame, as shown in Figure 1. The upper end of the cable shall point away from the closest wall of the chamber. The sample shall be subject to a stress, e.g. by means of a weight over a pulley, in order to keep it straight at all times. The angle of the cable shall be 45° ± 1° relative to the vertical line. In any case, the shortest distance of any part of the sample shall be 100 mm minimum from any wall of the chamber. Apply the flame with the tip of the inner blue cone touching the insulation (500 ± 5) mm from the upper end of the insulation.*	

Conditions	Item	Documentation	Additional Description	Information
			 Figure 1 **Apparatus for resistance to flame propagation** (Dimensions in millimetres) **Key** **1 test sample** **2 Bunsen burner**	

Annex 17: REGULATION N° 134 (UN/ECE)

REGULATION N° 134 (UN/ECE)

A. IDENTITY CARD OF REGULATION N° 134 (UN/ECE)

RCS	N°	Title	Statutory
Regulation	R134	Uniform provisions concerning the approval of motor vehicles and their components with regard to the safety-related performance of hydrogen-fuelled vehicles (HFCV)	Y
UN /ECE publication			
EU publication			

Scope: the retained part is the part III, which deals with the specifications of a vehicle fuel system incorporating the compressed hydrogen storage system – Hydrogen fuelled vehicles of category M and N incorporating compressed hydrogen storage system on its safety-related performance.

Domain/category: M, N and components

Specifed exclusion: This Regulation does not cover the electrical safety of electric power train, the material compatibility and hydrogen embrittlement of the vehicle fuel system, and the post crash fuel system integrity in the event of full width frontal impact and rear impact.

Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

Chapter 7 of the part III of R134 specifies requirements for the vehicle fuel system which includes the compressed hydrogen storage system (not into the scope of StasHH project), but also piping, joints, and components in which hydrogen is present. Due to the lack of definition concerning the perimeter, we consider that part of III includes components between piping and the fuel cell.

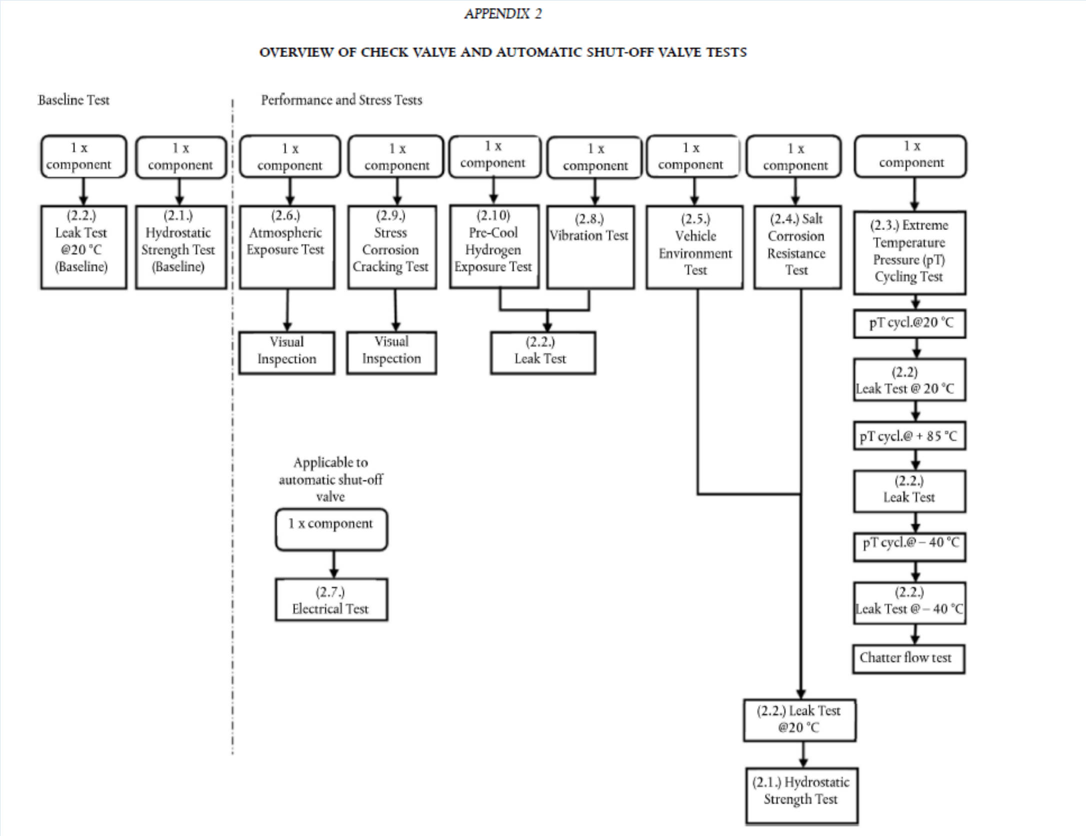
Conditions	Item	Documentation	Additional Description	Information
Chapter 7: part III – Specifications of a vehicle fuel cell sysstem incorporating the compressed hydrogen system	Sub-chapter 7.1: In-use fuel system requirements	Paragraph 7.1.2: Over-pressure protection for the low pressure system (Annex 5, paragraph 6 test procedure)	*The hydrogen system downstream of a pressure regulator shall be protected against overpressure due to the possible failure of the pressure regulator.* *The set pressure of the overpressure protection device shall be lower than or equal to the maximum allowable working pressure (MAWP) for the appropriate section of the hydrogen system.* Test procedure is prescribed in Annex 5, paragraph 6 of this Regulation, with: - Annex 5: Test procedures for a vehicle fuel system incorporating the compressed hydrogen storage system • Paragraph 6: Installation verification ➔ *The system is visually inspected for compliance*	Vehicle integration Test protocol Safety
Chapter 7: part III – Specifications of a vehicle fuel cell sysstem incorporating the compressed hydrogen system	Sub-chapter 7.1: In-use fuel system requirements Paragraph 7.1.3: Hydrogen discharge systems	7.1.3.1: Pressure relief systems (Annex 5, paragraph 6 test procedure)	*(c) Other pressure relief devices (such as a burst disc) may be used outside the hydrogen storage system. The hydrogen gas discharge from other pressure relief devices shall not be directed:* *(xi) Towards exposed electrical terminals, exposed electrical switches or other ignition sources* *(xii) Into or towards the vehicle passenger or luggage compartments* *(xiii) Into or towards any vehicle wheel housing* *(xiv) Towards hydrogen gas containers* Test procedure is prescribed in Annex 5, paragraph 6 of this Regulation, with: - Annex 5: Test procedures for a vehicle fuel system incorporating the compressed hydrogen storage system • Paragraph 6: Installation verification ➔ *The system is visually inspected for compliance*	Vehicle integration Test protocol

Conditions	Item	Documentation	Additional Description	Information
Chapter 7: part III – Specifications of a vehicle fuel cell sysstem incorporating the compressed hydrogen system	Sub-chapter 7.1: In-use fuel system requirements Paragraph 7.1.3: Hydrogen discharge systems	7.1.3.2: vehicle exhaust system (annex 5, paragraph 4 test procedure)	*At the vehicle exhaust system's point of discharge, the hydrogen concentration level shall:* *(a) Not exceed 4 % average by volume during any moving 3s time interval during normal operation including start-up and shut-down* *(b) And not exceed 8 % at any time (Annex 5, paragraph 4. test procedure)* Test procedures are prescribed in Annex 5, paragraph 3 of this Regulation, with: - Annex 5: Test procedures for a vehicle fuel system incorporating the compressed hydrogen storage system • Paragraph 4: compliance test for vehicle exhaust system	Vehicle integration Test protocol
Chapter 7: part III – Specifications of a vehicle fuel cell sysstem incorporating the compressed hydrogen system	Sub-chapter 7.1: In-use fuel system requirements Paragraph 7.1.4: Protection against flammable conditions: single failure conditions	7.1.4.2	*Any single failure downstream of the main hydrogen shut-off valve shall not result in accumulations in levels of hydrogen concentration in the passenger compartment according to test procedure in Annex 5, paragraph 3.2.* Test procedures are prescribed in Annex 5, paragraph 3 of this Regulation, with: - Annex 5: Test procedures for a vehicle fuel system incorporating the compressed hydrogen storage system • Paragraph 3.2: test procedure for integrity of enclosed spaces and detection systems.	Vehicle integration Test protocol
Chapter 7: part III – Specifications of a vehicle fuel cell sysstem incorporating	Sub-chapter 7.1: In-use fuel system requirements Paragraph 7.1.4:	7.1.4.3	*If, during operation, a single failure results in a hydrogen concentration exceeding 3,0 % by volume in air in the enclosed or semi-enclosed spaces of the vehicle, then a warning shall be provided (paragraph 7.1.6*: Tell-tale signal warning to driver*).* *If the hydrogen concentration exceeds 4,0 % by volume in the air in the enclosed or semi-enclosed spaces of the vehicle, the main shut-off valve shall be closed to isolate the storage system. (Annex 5, paragraph 3 test procedure).*	Test protocol (inside FCM)

Conditions	Item	Documentation	Additional Description	Information
the compressed hydrogen system	Protection against flammable conditions: single failure conditions		Test procedures are prescribed in Annex 5, paragraph 3 of this Regulation, with: - Annex 5: Test procedures for a vehicle fuel system incorporating the compressed hydrogen storage system • Paragraph 3. *Compliance test for single failure conditions* *Either test procedure of Annex 5, paragraph 3.1 or paragraph 3.2 shall be executed* ○ Paragraph 3.1: test procedure for vehicle equipped with hydrogen gas leakage detectors ○ Paragraph 3.2: test procedure for integrity of enclosed spaces and detection systems	
Chapter 7: part III – Specifications of a vehicle fuel cell sysstem incorporating the compressed hydrogen system	Sub-chapter 7.1: In-use fuel system requirements Paragraph 7.1.4: Protection against flammable conditions: single failure conditions	7.1.5	*The hydrogen fuelling line (e.g. piping, joint, etc.) downstream of the main shut-off valve(s) to the fuel cell system or the engine shall not leak. Compliance shall be verified at NWP (Annex 5, paragraph 5 test procedure).* Test procedure is prescribed in Annex 5, paragraph 5, with: - Annex 5: Test procedures for a vehicle fuel system incorporating the compressed hydrogen storage system. • Paragraph 5: Compliance test for fuel line leakage	Test protocol (outside FCM)
Chapter 7: part III – Specifications of a vehicle fuel cell sysstem incorporating	Sub-chapter 7.1: In-use fuel system requirements Paragraph 7.1.4:	7.1.6	*The warning shall be given by a visual signal or display text with the following properties:* *(a) Visible to the driver while in the driver's designated seating position with the driver's seat belt fastened;* *(b) Yellow in colour if the detection system malfunctions (e.g. circuit disconnection, short-circuit, sensor fault). It shall be red in compliance with section paragraph 7.1.4.3;*	Signal report from FCM

Conditions	Item	Documentation	Additional Description	Information
the compressed hydrogen system	Protection against flammable conditions: single failure conditions		*(c) When illuminated, shall be visible to the driver under both daylight and night time driving conditions.* *(d) Remains illuminated when 3,0 % concentration or detection system malfunction exists and the ignition locking system is in the 'On' ('Run') position or the propulsion system is activated*	
Chapter 7: part III – Specifications of a vehicle fuel cell sysstem incorporating the compressed hydrogen system	Sub-chapter 7.2: Post-crash fuel system integrity		*The vehicle fuel system shall comply with the following requirements after the vehicle crash tests in accordance with the following Regulations by also applying the test procedures prescribed in Annex 5 of this Regulation.* *(a) Frontal impact test in accordance with either ~~Regulation No 12~~, or Regulation No 94; and* *(b) Lateral impact test in accordance with Regulation No 95* *In case that one or both of the vehicle crash tests specified above are not applicable to the vehicle, the vehicle fuel system shall, instead, be subject to the relevant alternative accelerations specified below and the hydrogen storage system shall be installed in a position satisfying the requirements in paragraph 7.2.4. The accelerations shall be measured at the location where the hydrogen storage system is installed. The vehicle fuel system shall be mounted and fixed on the representative part of the vehicle. The mass used shall be representative for a fully equipped and filled container or container assembly.* *Accelerations for vehicles of categories* M_1 *and* N_1*:* *(a) 20 g in the direction of travel (forward and rearward direction)* *(b) 8 g horizontally perpendicular to the direction of travel (to left and right).* *Accelerations for vehicles of categories* M_2 *and* N_2*:* *(a) 10 g in the direction of travel (forward and rearward direction)* *(b) 5 g horizontally perpendicular to the direction of travel (to left and right).* *Accelerations for vehicles of categories* M_3 *and* N_3*:*	Integrators or FCM suppliers

Conditions	Item	Documentation	Additional Description	Information
			(a) *6,6 g in the direction of travel (forward and rearward direction)* (b) *5 g horizontally perpendicular to the direction of travel (to left and right).* Test procedures are described in annex 5: Test procedures for a vehicle fuel system incorporating the compressed hydrogen storage system	
Chapter 7: part III – Specifications of a vehicle fuel cell syystem incorporating the compressed hydrogen system	Sub-chapter 7.2: Post-crash fuel system integrity	Chapter 7.2.1: Fuel leakage limit	*The volumetric flow of hydrogen gas leakage shall not exceed an average of 118 NL/min for the time interval, Δt, as determined in accordance with Annex 5, paragraph 1.1 or 1.2.* Test procedures are described in annex 5, paragraph 1.1 or 1.2 with: - Annex 5: Test procedures for a vehicle fuel system incorporating the compressed hydrogen storage system • Paragraph 1.1:Post-crash leak test: compressed hydrogen storage system filled with compressed hydrogen • Paragraph 1.2: Post-crash leak test: Compressed hydrogen storage system filled with compressed helium	Integrators or FCM suppliers
Chapter 7: part III – Specifications of a vehicle fuel cell syystem incorporating the compressed hydrogen system	Sub-chapter 7.2: Post-crash fuel system integrity	R134 – Chapter 7.2.2: Concentration limit in enclosed spaces	*Hydrogen gas leakage shall not result in a hydrogen concentration in the air greater than 4,0 % by volume in the passenger and luggage compartments (Annex 5, paragraph 2 test procedures).* *The requirement is satisfied if it is confirmed that the shut-off valve of the storage system has closed within 5 s of the crash and no leakage from the storage system* Test procedures are prescribed in Annex 5, paragraph 3 of this Regulation, with: - Annex 5: Test procedures for a vehicle fuel system incorporating the compressed hydrogen storage system • Paragraph 2: Post-crash concentration test for enclosed spaces	Integrators or FCM suppliers

Conditions	Item	Documentation	Additional Description	Information
ANNEX 4 TEST PROCEDURES FOR SPECIFIC COMPONENTS FOR THE COMPRESSED HYDROGEN STORAGE SYSTEM	2. TESTS FOR CHECK VALVE AND SHUT-OFF VALVE		*Testing shall be performed with hydrogen gas having gas quality compliant with ISO 14687-2/SAE J2719. All tests are performed at ambient temperature 20 (± 5) °C unless otherwise specified. The check valve and shut-off valve qualification performance tests are specified as follows (see also Appendix 2):*  *APPENDIX 2* OVERVIEW OF CHECK VALVE AND AUTOMATIC SHUT-OFF VALVE TESTS 	

ANNEX 4 TEST PROCEDURES FOR SPECIFIC COMPONENTS FOR THE COMPRESSED HYDROGEN STORAGE SYSTEM	2. TESTS FOR CHECK VALVE AND SHUT-OFF VALVE	2.1. Hydrostatic strength test	*The outlet opening in components is plugged and valve seats or internal blocks are made to assume the open position. One unit is tested without being subjected to other design qualification tests in order to establish a baseline burst pressure, other units are tested as specified in subsequent tests of Annex 4, paragraph 2.* *(a) A hydrostatic pressure of 250 per cent NWP (+ 2/– 0 MPa) is applied to the inlet of the component for three minutes. The component is examined to ensure that rupture has not occurred;* *(b) The hydrostatic pressure is then increased at a rate of less than or equal to 1,4 MPa/sec until component failure. The hydrostatic pressure at failure is recorded. The failure pressure of previously tested units shall be no less than 80 per cent of the failure pressure of the baseline, unless the hydrostatic pressure exceeds 400 per cent NWP.*	
ANNEX 4 TEST PROCEDURES FOR SPECIFIC COMPONENTS FOR THE COMPRESSED HYDROGEN STORAGE SYSTEM	2. TESTS FOR CHECK VALVE AND SHUT-OFF VALVE	2.2. Leak test	One unit that has not undergone previous testing is tested at ambient, high and low temperatures without being subjected to other design qualification tests. The three temperature test conditions are: (a) Ambient temperature: condition the unit at 20 (± 5) °C; test at 5 per cent NWP (+ 0/– 2 MPa) and 150 per cent NWP (+ 2/– 0 MPa); (b) High temperature: condition the unit at 85 °C or higher; test at 5 per cent NWP (+ 0/– 2 MPa) and 150 per cent NWP (+ 2/– 0 MPa); (c) Low temperature: condition the unit at – 40 °C or lower; test at 5 per cent NWP (+ 0/– 2 MPa) and 100 per cent NWP (+ 2/– 0 MPa). Additional units undergo leak testing as specified in other tests in Annex 4, paragraph 2 with uninterrupted exposure at the temperatures specified in those tests. The outlet opening is plugged with the appropriate mating connection and pressurised hydrogen is applied to the inlet. At all specified test temperatures, the unit is conditioned for one minute by immersion in a temperature controlled fluid (or equivalent method). If no bubbles are observed for the specified time period, the sample passes the test. If bubbles are detected, the leak rate is measured by an appropriate method. The leak rate shall not exceed 10 Nml/hr of hydrogen gas.	
ANNEX 4 TEST PROCEDURES FOR SPECIFIC	2. TESTS FOR CHECK VALVE AND SHUT-OFF VALVE	2.3. Extreme temperature	*(a) The total number of operational cycles is 11 000 for the check valve and 50 000 for the shut-off valve. The valve unit are installed in a test fixture corresponding to the*	

COMPONENTS FOR THE COMPRESSED HYDROGEN STORAGE SYSTEM		pressure cycling test	*manufacturer's specifications for installation. The operation of the unit is continuously repeated using hydrogen gas at all specified pressures.* *An operational cycle shall be defined as follows:* *(i) A check valve is connected to a test fixture and 100 per cent NWP (+ 2/– 0 MPa) is applied in six step pulses to the check valve inlet with the outlet closed. The pressure is then vented from the check valve inlet. The pressure is lowered on the check valve outlet side to less than 60 per cent NWP prior to the next cycle;* *(ii) A shut-off valve is connected to a test fixture and pressure is applied continuously to the both the inlet and outlet sides.* *An operational cycle consists of one full operation and reset.* *(b) Testing is performed on a unit stabilised at the following temperatures:* *(i) Ambient temperature cycling. The unit undergoes operational (open/closed) cycles at 125 per cent NWP (+ 2/– 0 MPa) through 90 per cent of the total cycles with the part stabilised at 20 (± 5) °C. At the completion of the ambient temperature operational cycles, the unit shall comply with the ambient temperature leak test specified in Annex 4, paragraph 2.2;* *(ii) High temperature cycling. The unit then undergoes operational cycles at 125 per cent NWP (+ 2/– 0 MPa) through 5 per cent of the total operational cycles with the part stabilised at 85 °C or higher. At the completion of the 85 °C cycles, the unit shall comply with the high temperature (85 °C) leak test specified in Annex 4, paragraph 2.2;* *(iii) Low temperature cycling. The unit then undergoes operational cycles at 100 per cent NWP (+ 2/– 0 MPa) through 5 per cent of the total cycles with the part stabilised at – 40 °C or lower. At the completion of the – 40 °C operational cycles, the unit shall comply with the low temperature (– 40 °C) leak test specified in Annex 4, paragraph 2.2.* *(c) Check valve chatter flow test: Following 11 000 operational cycles and leak tests in Annex 4, paragraph 2.3(b), the check valve is subjected to 24 hours of chatter flow at a flow rate that causes the most chatter (valve flutter). At the completion of the test the check valve*	

			shall comply with the ambient temperature leak test (Annex 4, paragraph 2.2) and the strength test (Annex 4, paragraph 2.1).	
ANNEX 4 TEST PROCEDURES FOR SPECIFIC COMPONENTS FOR THE COMPRESSED HYDROGEN STORAGE SYSTEM	2. TESTS FOR CHECK VALVE AND SHUT-OFF VALVE	2.4. Salt corrosion resistance test	*The component is supported in its normally installed position and exposed for 500 hours to a salt spray (fog) test as specified in ASTM B117 (Standard Practice for Operating Salt Spray (Fog) Apparatus). The temperature within the fog chamber is maintained at 30-35 °C). The saline solution consists of 5 per cent sodium chloride and 95 per cent distilled water, by weight.* *Immediately after the corrosion test, the sample is rinsed and gently cleaned of salt deposits, examined for distortion, and then shall comply with the requirements of:* *(a) The component shall not show signs of physical degradation that could impair the function of the component, specifically: cracking, softening or swelling. Cosmetic changes such as pitting or staining are not failures;* *(b) The ambient temperature leak test (Annex 4, paragraph 2.2);* *(c) The hydrostatic strength test (Annex 4, paragraph 2.1).*	
ANNEX 4 TEST PROCEDURES FOR SPECIFIC COMPONENTS FOR THE COMPRESSED HYDROGEN STORAGE SYSTEM	2. TESTS FOR CHECK VALVE AND SHUT-OFF VALVE	2.5. Vehicle environment test	*Resistance to degradation by exposure to automotive fluids is determined by the following test.* *(a)The inlet and outlet connections of the valve unit are connected or capped in accordance with the manufacturers installation instructions. The external surfaces of the valve unit are exposed for 24 hours at 20 (± 5) °C to each of the following fluids:* *(i) Sulphuric acid – 19 per cent solution by volume in water;* *(ii) Sodium hydroxide – 25 per cent solution by weight in water;* *(iii)Ammonium nitrate – 28 per cent by weight in water; and* *(iv) Windshield washer fluid (50 per cent by volume methyl alcohol and water).* *The fluids are replenished as needed to ensure complete exposure for the duration of the test. A distinct test is performed with each of the fluids. One component may be used for exposure to all of the fluids in sequence.* *(b) After exposure to each chemical, the component is wiped off and rinsed with water;* *(c) The component shall not show signs of physical degradation that could impair the function of the component, specifically: cracking, softening, or swelling. Cosmetic changes such as pitting or staining are not failures. At the conclusion of all exposures, the unit(s) shall*	

			comply with the requirements of the ambient temperature leakage test (Annex 4, paragraph 2.2) and Hydrostatic Strength Test (Annex 4, paragraph 2.1).	
ANNEX 4 TEST PROCEDURES FOR SPECIFIC COMPONENTS FOR THE COMPRESSED HYDROGEN STORAGE SYSTEM	2. TESTS FOR CHECK VALVE AND SHUT-OFF VALVE	2.6. Atmospheric exposure test	*The atmospheric exposure test applies to qualification of check valve and automatic shut-off valves if the component has non-metallic materials exposed to the atmosphere during normal operating conditions.* *(a) All non-metallic materials that provide a fuel containing seal, and that are exposed to the atmosphere, for which a satisfactory declaration of properties is not submitted by the applicant, shall not crack or show visible evidence of deterioration after exposure to oxygen for 96 hours at 70 °C at 2 MPa in accordance with ASTM D572 (Standard Test Method for Rubber- Deterioration by Heat and Oxygen);* *(b) All elastomers shall demonstrate resistance to ozone by one or more of the following:* *(i) Specification of elastomer compounds with established resistance to ozone;* *(ii) Component testing in accordance with ISO 1431/1, ASTM D1149, or equivalent test methods.*	
ANNEX 4 TEST PROCEDURES FOR SPECIFIC COMPONENTS FOR THE COMPRESSED HYDROGEN STORAGE SYSTEM	2. TESTS FOR CHECK VALVE AND SHUT-OFF VALVE	*2.7. Electrical Tests*	*The electrical tests apply to qualification of the automatic shut-off valve; they do not apply to qualification of check valves.* *(a) Abnormal voltage test. The solenoid valve is connected to a variable DC voltage source. The solenoid valve is operated as follows:* *(i) An equilibrium (steady state temperature) hold is established for one hour at 1,5 times the rated voltage;* *(ii) The voltage is increased to two times the rated voltage or 60 volts, whichever is less, and held for one minute;* *(iii) Any failure shall not result in external leakage, open valve or unsafe conditions such as smoke, fire or melting. The minimum opening voltage at NWP and room temperature shall be less than or equal to 9 V for a 12 V system and less than or equal to 18 V for a 24 V system.* *(b) Insulation resistance test. 1 000 V D.C. is applied between the power conductor and the component casing for at least two seconds. The minimum allowable resistance for that component is 240 kΩ.*	
ANNEX 4 TEST PROCEDURES FOR SPECIFIC COMPONENTS	2. TESTS FOR CHECK VALVE AND SHUT-OFF VALVE	2.8. Vibration test	*The valve unit is pressurised to its 100 per cent NWP (+ 2/– 0 MPa) with hydrogen, sealed at both ends, and vibrated for 30 minutes along each of the three orthogonal axes (vertical, lateral and longitudinal) at the most severe resonant frequencies. The most severe resonant*	

FOR THE COMPRESSED HYDROGEN STORAGE SYSTEM			*frequencies are determined by acceleration of 1,5 g with a sweep time of 10 minutes within a sinusoidal frequency range of 10 to 40 Hz. If the resonance frequency is not found in this range the test is conducted at 40 Hz. Following this test, each sample shall not show visible exterior damage that indicates that the performance of the part is compromised. At the completion of the test, the unit shall comply with the requirements of the ambient temperature leak test specified in Annex 4, paragraph 2.2.*	
ANNEX 4 TEST PROCEDURES FOR SPECIFIC COMPONENTS FOR THE COMPRESSED HYDROGEN STORAGE SYSTEM	2. TESTS FOR CHECK VALVE AND SHUT-OFF VALVE	2.9. Stress corrosion cracking test	*For the valve units containing components made of a copper-based alloy (e.g. brass), one valve unit is tested. The valve unit is disassembled, all copper-based alloy components are degreased and then the valve unit is reassembled before it is continuously exposed for 10 days to a moist ammonia-air mixture maintained in a glass chamber having a glass cover.* *Aqueous ammonia having a specific gravity of 0,94 is maintained at the bottom of the glass chamber below the sample at a concentration of at least 20 ml per litre of chamber volume. The sample is positioned 35 (± 5) mm above the aqueous ammonia solution and supported in an inert tray. The moist ammonia-air mixture is maintained at atmospheric pressure at 35 (± 5) °C. Copper-based alloy components shall not exhibit cracking or delaminating due to this test.*	
ANNEX 4 TEST PROCEDURES FOR SPECIFIC COMPONENTS FOR THE COMPRESSED HYDROGEN STORAGE SYSTEM	2. TESTS FOR CHECK VALVE AND SHUT-OFF VALVE	2.10. Pre-cooled hydrogen exposure test	*The valve unit is subjected to pre-cooled hydrogen gas at – 40 °C or lower at a flow rate of 30 g/sec at external temperature of 20 (± 5) °C for a minimum of three minutes. The unit is de-pressurised and re-pressurised after a two minute hold period. This test is repeated 10 times. This test procedure is then repeated for an additional 10 cycles, except that the hold period is increased to 15 minutes. The unit shall then comply with the requirements of the ambient temperature leak test specified in Annex 4, paragraph 2.2.*	
ANNEX 5 TEST PROCEDURES FOR A VEHICLE FUEL SYSTEM INCORPORATING THE COMPRESSED HYDROGEN	3. COMPLIANCE TEST FOR SINGLE FAILURE CONDITIONS		*Either test procedure of Annex 5, paragraph 3.1 or paragraph 3.2 shall be executed*	

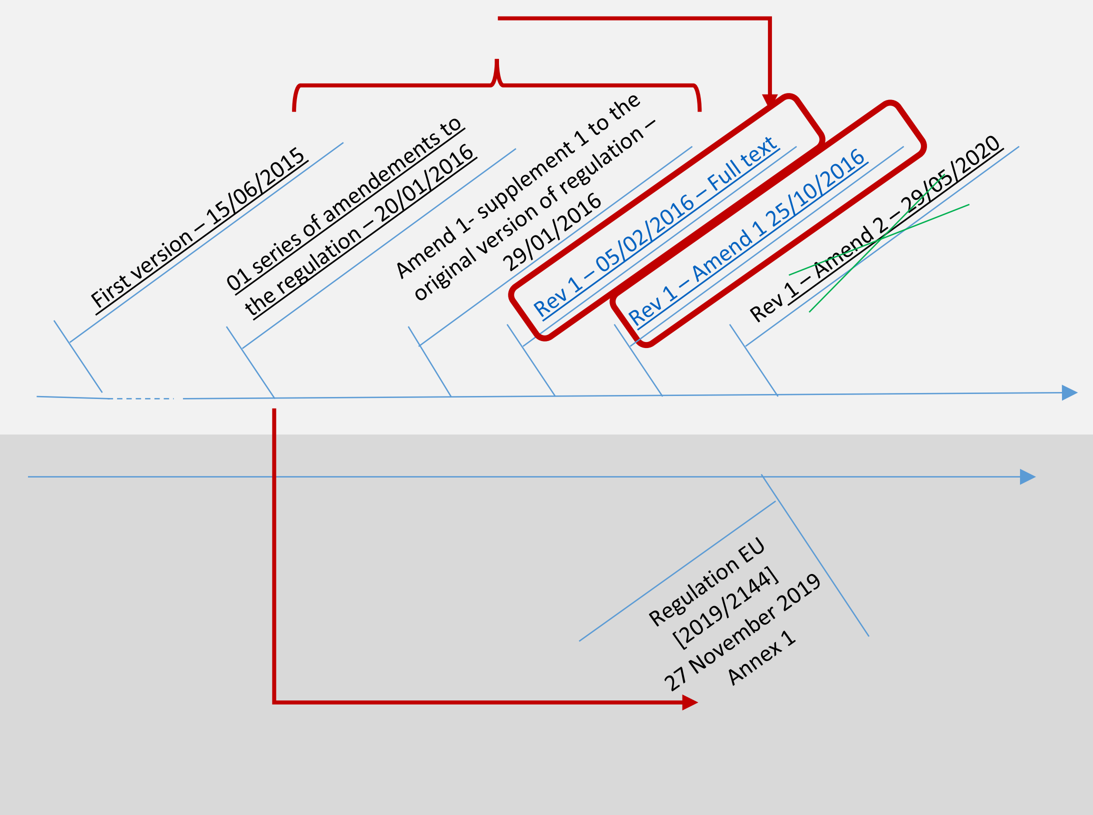
STORAGE SYSTEM				
ANNEX 5 TEST PROCEDURES FOR A VEHICLE FUEL SYSTEM INCORPORATING THE COMPRESSED HYDROGEN STORAGE SYSTEM	3.1. Test procedure for vehicle equipped with hydrogen gas leakage detectors	3.1.1. Test condition	*3.1.1.1. Test vehicle: The propulsion system of the test vehicle is started, warmed up to its normal operating temperature, and left operating for the test duration. If the vehicle is not a fuel cell vehicle, it is warmed up and kept idling. If the test vehicle has a system to stop idling automatically, measures are taken so as to prevent the engine from stopping.* *3.1.1.2. Test gas: Two mixtures of air and hydrogen gas: 3,0 per cent concentration (or less) of hydrogen in the air to verify function of the warning, and 4,0 per cent concentration (or less) of hydrogen in the air to verify the shut-down function. The proper concentrations are selected based on the recommendation (or the detector specification) by the manufacturer.*	
ANNEX 5 TEST PROCEDURES FOR A VEHICLE FUEL SYSTEM INCORPORATING THE COMPRESSED HYDROGEN STORAGE SYSTEM	3.1. Test procedure for vehicle equipped with hydrogen gas leakage detectors	3.1.2. Test method	*3.1.2.1. Preparation for the test: The test is conducted without any influence of wind by appropriate means such as:* *(a) A test gas induction hose is attached to the hydrogen gas leakage detector;* *(b) The hydrogen leak detector is enclosed with a cover to make gas stay around hydrogen leak detector.* *3.1.2.2. Execution of the test* *(a) Test gas is blown to the hydrogen gas leakage detector;* *(b) Proper function of the warning system is confirmed when tested with the gas to verify function of the warning;* *(c) The main shut-off valve is confirmed to be closed when tested with the gas to verify function of the shut- down. For example, the monitoring of the electric power to the shut-off valve or of the sound of the shut- off valve activation may be used to confirm the operation of the main shut-off valve of the hydrogen supply.*	
ANNEX 5 TEST PROCEDURES FOR A VEHICLE FUEL SYSTEM INCORPORATING THE COMPRESSED HYDROGEN STORAGE SYSTEM	3.2. Test procedure for integrity of enclosed spaces and detection systems.	3.2.1. Preparation:	*3.2.1.1. The test is conducted without any influence of wind.* *3.2.1.2. Special attention is paid to the test environment as during the test, flammable mixtures of hydrogen and air may occur.* *3.2.1.3. Prior to the test the vehicle is prepared to allow remotely controllable hydrogen releases from the hydrogen system. The number, location and flow capacity of the release points downstream of the main hydrogen shut- off valve are defined by the vehicle manufacturer taking worst case leakage scenarios under single failure condition into account. As a minimum, the total flow of all remotely controlled releases shall be adequate to trigger demonstration of the automatic 'warning' and hydrogen shut-off functions.*	

			3.2.1.4. For the purpose of the test, a hydrogen concentration detector is installed where hydrogen gas may accumulate most in the passenger compartment (e.g. near the headliner) when testing for compliance with paragraph 7.1.4.2 of this Regulation and hydrogen concentration detectors are installed in enclosed or semi enclosed volumes on the vehicle where hydrogen can accumulate from the simulated hydrogen releases when testing for compliance with paragraph 7.1.4.3 of this Regulation (see Annex 5, paragraph 3.2.1.3). *3.2.2.5. When testing for compliance with paragraph 7.1.4.2 of this Regulation, the test is successfully completed if the hydrogen concentration in the passenger compartment does not exceed 1,0 per cent. When testing for compliance with paragraph 7.1.4.3 of this Regulation, the test is successfully completed if the tell-tale warning and shut-off function are executed at (or below) the levels specified in paragraph 7.1.4.3 of this Regulation; otherwise, the test is failed and the system is not qualified for vehicle service.*	
ANNEX 5 TEST PROCEDURES FOR A VEHICLE FUEL SYSTEM INCORPORATING THE COMPRESSED HYDROGEN STORAGE SYSTEM	4. COMPLIANCE TEST FOR THE VEHICLE EXHAUST SYSTEM		*4.1. The power system of the test vehicle (e.g. fuel cell stack or engine) is warmed up to its normal operating temperature.* *4.2. The measuring device is warmed up before use to its normal operating temperature.* *4.3. The measuring section of the measuring device is placed on the centre line of the exhaust gas flow within 100 mm from the exhaust point of discharge external to the vehicle. 17.5.2019 L 129/88 Official Journal of the European Union EN* *4.4. The exhaust hydrogen concentration is continuously measured during the following steps: (a) The power system is shut-down; (b) Upon completion of the shut-down process, the power system is immediately started; (c) After a lapse of one minute, the power system is turned off and measurement continues until the power system shut-down procedure is completed.* *4.5. The measurement device shall have a measurement response time of less than 300 milliseconds.*	

Annex 18: REGULATION N° 135 (UN/ECE)

REGULATION N° 135 (UN/ECE)

A. IDENTITY CARD OF REGULATION N° 135 (UN/ECE)

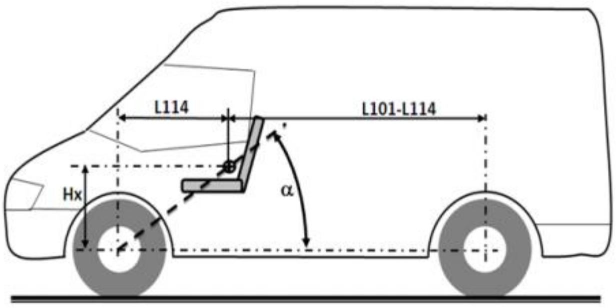
<table>
<tr><th>RCS</th><th>N°</th><th>Title</th><th>Statutory</th></tr>
<tr><td>Regulation</td><td>Rxxx</td><td>Uniform provisions concerning the approval of vehicles with regard to their Pole Side Impact performance (PSI)</td><td>Y</td></tr>
<tr><td>UN /ECE publication</td><td rowspan="2" colspan="3">
</td></tr>
<tr><td>EU publication</td></tr>
<tr><td>Relevant for StasHH</td><td colspan="2">Date of entry into force</td><td>Not Relevant for StasHH</td></tr>
</table>

Scope[39]:

1.1 This Regulation applies to:

(a) Category M1 vehicles with a gross vehicle mass of up to 3500 kg; and

(b) Category N1 vehicles where the acute angle alpha (α), measured between a horizontal plane passing through the centre of the front axle and an angular transverse plane passing through the centre of the front axle and the R-point of the driver's seat, as illustrated below, is less than 22.0 degrees; or the ratio between the distance from the driver's R-point to the centre of the rear axle (L101-L114) and the centre of the front axle and the driver's R-point (L114) is less than 1.30[40].



1.2. Other Category M and Category N vehicles with a gross vehicle mass of up to 4,500 kg may also be approved if requested by the manufacturer.

Domain/category: M1, N1

Specifed exclusion: /

Reference included in this RCS: /

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[39] In accordance with the general guidelines on the scope of UN Regulations (see document ECE/TRANS/WP.29/1044/Rev.1), Regulation No. 135 type approvals may only be granted for vehicles within the scope of this Regulation and shall be accepted by all the Contracting Parties applying this Regulation. However, decisions regarding the vehicle categories required on a regional/national basis to meet the requirements of this Regulation shall be dealt with at the regional/national level. A Contracting Party may therefore restrict application of the requirements in its national legislation if it decides that such restriction is appropriate.

[40] As defined in the Consolidated Resolution on the Construction of Vehicles (R.E.3.), document ECE/TRANS/WP.29/78/Rev.3, para. 2 - www.unece.org/trans/main/wp29/wp29wgs/wp29gen/wp29resolutions.html

B. RELEVANT PARTS FOR STASHH PROJECT

Relevant to the StasHH project is the integrity of the fuel system that is retained after a side impact on a pole (procedure and tests conditions): chapter 5 and its annexes.

Conditions	Item	Documentation	Additional Description	Information
Chapter 5: requirements		5.2.	*The results of an approval test conducted in accordance with paragraph 5.1. shall be considered satisfactory, if the requirements of paragraphs ~~5.3., 5.4. and~~ 5.5. are met.* ***Chapter 5: requirements*** ***Subchapter 5.1:*** *5.1. A vehicle, representative of the vehicle type to be approved, shall be tested in accordance with Annex 3, using a WorldSID 50th percentile adult male dummy.* *5.1.1. With the exception of vehicle types designed as described in paragraph 5.1.2. below, the approval test shall be conducted such that the vehicle impacts the pole on the driver's side.* *5.1.2. In the case of vehicle types where the side structures, front-row seats or the type of protective systems on each side of the vehicle are sufficiently different for the Approval Authority to consider they could appreciably affect performance in a test conducted in accordance with Annex 3; either of the alternatives in paragraph 5.1.2.1. or 5.1.2.2. may be used by the Approval Authority.* *5.1.2.1. The Approval Authority will require the approval test to be conducted such that the vehicle impacts the pole on the driver's side where:* *5.1.2.1.1. This is considered the least favourable side; or*	Vehicle integration Test protocols Integrator or FCM supplier Safety

Conditions	Item	Documentation	Additional Description	Information
			5.1.2.1.2. The manufacturer provides additional information (e.g. manufacturer's in-house test data) sufficient to satisfy the Approval Authority that the design differences on each side of the vehicle do not appreciably affect performance in a test conducted in accordance with Annex 3. *5.1.2.2. The Approval Authority will require the approval test to be conducted such that the vehicle impacts the pole on the side opposite the driver's side, where this is considered the least favourable side.* See relevant details of annex 3 at the end of this table.	
Chapter 5: requirements	Subcahpter 5.5: Fuel system integrity requirements 5.5.2: In the case of a compressed hydrogen-fuelled vehicle:	5.5.2.1	*The hydrogen leakage rate (VH2) determined in accordance with either, paragraph 4. of Annex 6 for hydrogen, shall not exceed an average of 118 NL per minute for the time interval, Δt minutes, after the crash;* ***Annex 6: Test conditions and procedures for the assessment of post-crash hydrogen fuel system integrity*** ***Paragraph 4 of Annex 6: Post-crash leak test measurement for a compressed hydrogen storage system filled with compressed hydrogen*** *4.1. The hydrogen gas pressure, P0 (MPa), and temperature, T0 (°C), are measured immediately before the impact and then at a time interval, Δt (min), after the impact.* *4.1.1. The time interval, Δt, starts when the vehicle comes to rest after the impact and continues for at least 60 minutes.* *4.1.2. The time interval, Δt, shall be increased if necessary in order to accommodate measurement accuracy for a storage system with a large volume operating up to 70MPa; in that case, Δt can be calculated from the following equation:*	Vehicle integration Test protocols Integrator or FCM supplier Safety

Conditions	Item	Documentation	Additional Description	Information
			$\Delta t = V_{CHSS} \times NWP / 1000 \times ((-0.027 \times NWP + 4) \times R_s - 0.21) - 1.7 \times R_s$ *where Rs = Ps / NWP, Ps is the pressure range of the pressure sensor (MPa), NWP is the Nominal Working Pressure (MPa), VCHSS is the volume of the compressed hydrogen storage system (L), and Δt is the time interval (min).* *4.1.3. If the calculated value of Δt is less than 60 minutes, Δt is set to 60 minutes.* *4.2. The initial mass of hydrogen in the storage system can be calculated as follows:* $P_o' = P_o \times 288 / (273 + T_0)$ $\rho_o' = -0.0027 \times (P_0')^2 + 0.75 \times P_0' + 0.5789$ $M_o = \rho_o' \times V_{CHSS}$ *4.3. Correspondingly, the final mass of hydrogen in the storage system, Mf , at the end of the time interval, Δt, can be calculated as follows:* $P_f' = P_f \times 288 / (273 + T_f)$ $\rho_f' = -0.0027 \times (P_f')^2 + 0.75 \times P_f' + 0.5789$ $M_f = \rho_f' \times V_{CHSS}$ *where Pf is the measured final pressure (MPa) at the end of the time interval, and Tf is the measured final temperature (°C).* *4.4. The average hydrogen flow rate over the time interval is therefore:* *VH2 = (Mf-Mo) / Δt x 22.41 / 2.016 x (Ptarget /Po)* *where VH2 is the average volumetric flow rate (NL/min) over the time interval and the term (Ptarget/Po) is used to compensate for differences between the measured initial pressure (Po) and the targeted fill pressure (Ptarget).*	
Chapter 5: requirements	Subcahpter 5.5:	5.5.2.2	*The gas (hydrogen or helium as applicable) concentration by volume in air values determined for the passenger and luggage compartments in*	Vehicle integration Test protocols

Conditions	Item	Documentation	Additional Description	Information
	Fuel system integrity requirements 5.5.2: In the case of a compressed hydrogen-fuelled vehicle:		*accordance with paragraph 6. of Annex 6, shall not exceed 4.0 per cent for hydrogen or 3.0 per cent for helium, at any time throughout the 60 minute post-crash measurement period and the container(s) (for hydrogen storage) shall remain attached to the vehicle at a minimum of one attachment point.* ***Annex 6: Test conditions and procedures for the assessment of post-crash hydrogen fuel system integrity*** ***Paragraph 6. of Annex 6: Post-crash concentration measurement for enclosed spaces*** *Post-crash data collection in enclosed spaces commences when the vehicle comes to a rest. Data from the sensors installed in accordance with paragraph 3.2. of this annex are collected at least every 5 seconds and continue for a period of 60 minutes after the test. A first-order lag (time constant) up to a maximum of 5 seconds may be applied to the measurements to provide "smoothing" and filter the effects of spurious data points.* ***Annex 6: Test conditions and procedures for the assessment of post-crash hydrogen fuel system integrity*** ***Paragraph 3.2. of Annex 6:*** *3.2. Enclosed spaces* *3.2.1. Sensors are selected to measure either the build-up of the hydrogen or helium gas or the reduction in oxygen (due to displacement of air by leaking hydrogen/helium).* *3.2.2. Sensors are calibrated to traceable references to ensure an accuracy of ±5 per cent at the targeted criteria of 4 per cent hydrogen or 3 per cent helium by volume in air, and a full scale measurement capability of at least 25 per cent above the target criteria. The sensor shall be capable of a 90 per cent response to a full scale change in concentration within 10 seconds.*	Integrator or FCM supplier safety

Conditions	Item	Documentation	Additional Description	Information
			3.2.3. Prior to the crash impact, the sensors are located in the passenger and luggage compartments of the vehicle as follows: (a) At a distance within 250 mm of the headliner above the driver's seat or near the top centre of the passenger compartment; (b) At a distance within 250 mm of the floor in front of the rear (or rear most) seat in the passenger compartment; and (c) At a distance within 100 mm of the top of luggage compartments within the vehicle that are not directly affected by the particular crash impact to be conducted. *3.2.4. The sensors are securely mounted on the vehicle structure or seats and protected for the planned crash test from debris, air bag exhaust gas and projectiles. The measurements following the crash are recorded by instruments located within the vehicle or by remote transmission.* *3.2.5. The test may be conducted either outdoors in an area protected from the wind and possible solar effects or indoors in a space that is large enough or ventilated to prevent the build-up of hydrogen to more than 10 per cent of the targeted criteria in the passenger and luggage compartments.*	
Annex 3: Dynamic pole side impact test procedure:			***Paragraph 5 of annex 3: Vehicle preparation:*** *5.2 The compressed hydrogen storage system(s) and <u>enclosed spaces of compressed hydrogen-fuelled vehicles</u> shall be prepared in accordance with paragraph 3. of Annex 6.* ***Annex 6: Test conditions and procedures for the assessment of post-crash hydrogen fuel system integrity*** ***Paragraph 3 of Annex 6: Preparation, instrumentation and test conditions*** *3.1. Compressed hydrogen storage systems and <u>downstream piping</u>* *3.1.1. Prior to conducting the crash test, instrumentation is installed in the hydrogen storage system to perform the required pressure and*	Vehicle integration Test protocols Integrator or FCM supplier safety

Conditions	Item	Documentation	Additional Description	Information
			temperature measurements if the standard vehicle does not already have instrumentation with the required accuracy. *3.1.2. The hydrogen storage system is then purged, if necessary, following manufacturer directions to remove impurities from the container before filling the storage system with compressed hydrogen ~~or helium~~ gas. Since the storage system pressure varies with temperature, the targeted fill pressure is a function of the temperature. The target pressure shall be determined from the following equation:* $P_{target} = NWP \text{ x } (273 + T_o) / 288$ *where NWP is the nominal working pressure (MPa), To is the ambient temperature to which the storage system is expected to settle, and Ptarget is the targeted fill pressure after the temperature settles.* *3.1.4. The main stop valve and shut-off valves for hydrogen gas, located in the downstream hydrogen gas piping, are in normal driving condition immediately prior to the impact.* *3.2. Enclosed spaces* *3.2.1. Sensors are selected to measure either the build-up of the hydrogen or helium gas or the reduction in oxygen (due to displacement of air by leaking hydrogen/helium).* *3.2.2. Sensors are calibrated to traceable references to ensure an accuracy of ±5 per cent at the targeted criteria of 4 per cent hydrogen or 3 per cent helium by volume in air, and a full scale measurement capability of at least 25 per cent above the target criteria. The sensor shall be capable of a 90 per cent response to a full scale change in concentration within 10 seconds.* *3.2.3. Prior to the crash impact, the sensors are located in the passenger and luggage compartments of the vehicle as follows: (a) At a distance*	

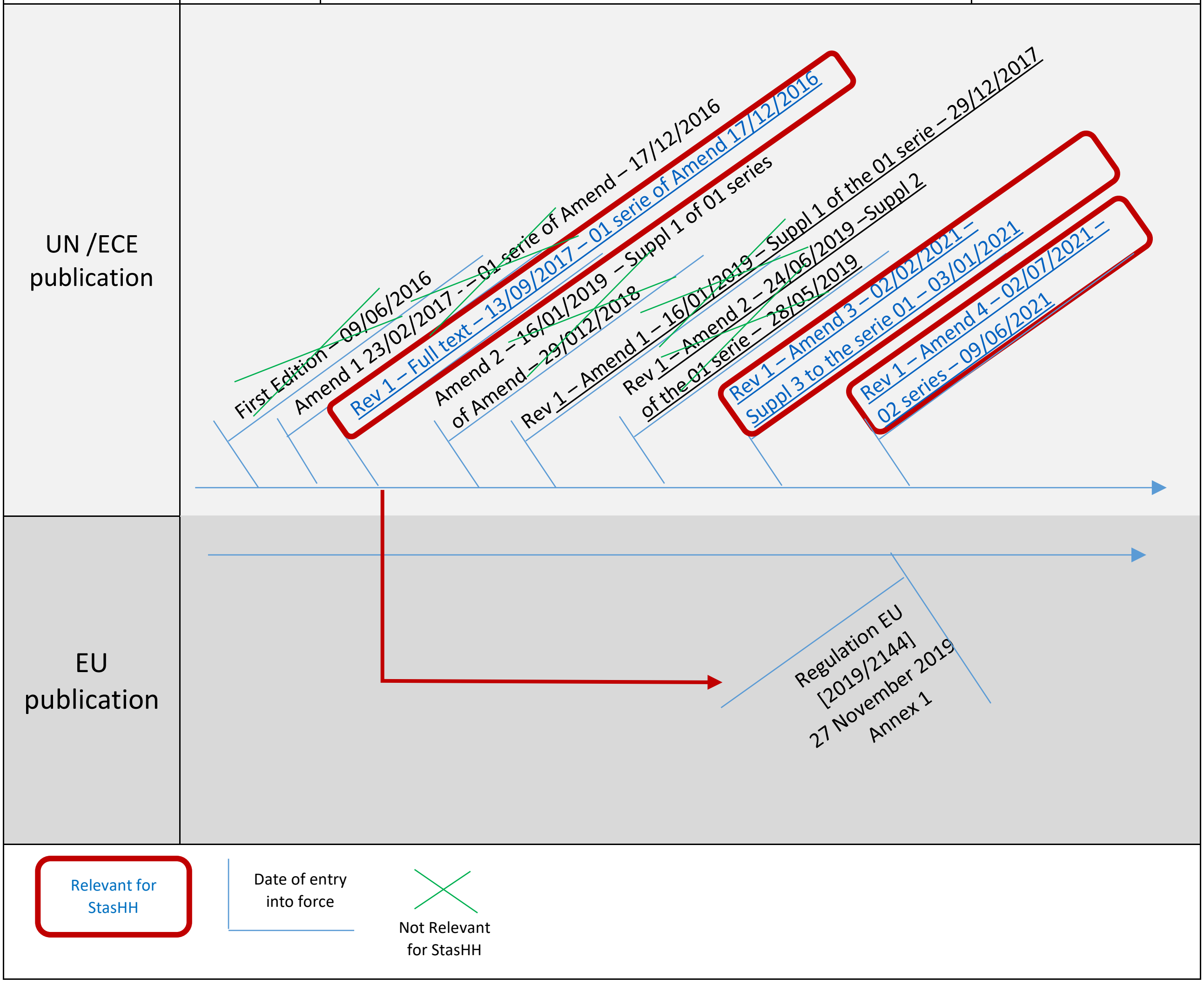
Conditions	Item	Documentation	Additional Description	Information
			within 250 mm of the headliner above the driver's seat or near the top centre of the passenger compartment; (b) At a distance within 250 mm of the floor in front of the rear (or rear most) seat in the passenger compartment; and (c) At a distance within 100 mm of the top of luggage compartments within the vehicle that are not directly affected by the particular crash impact to be conducted. *3.2.4. The sensors are securely mounted on the vehicle structure or seats and protected for the planned crash test from debris, air bag exhaust gas and projectiles. The measurements following the crash are recorded by instruments located within the vehicle or by remote transmission.* *3.2.5. The test may be conducted either outdoors in an area protected from the wind and possible solar effects or indoors in a space that is large enough or ventilated to prevent the build-up of hydrogen to more than 10 per cent of the targeted criteria in the passenger and luggage compartments.*	

Annex 19: REGULATION N° 137 (UN/ECE)

REGULATION N° 137 (UN/ECE)

A. IDENTITY CARD OF REGULATION N° 137 (UN/ECE)

B. RCS	N°	Title	Statutory
Regulation	R137	Uniform provisions concerning the approval of passenger cars in the event of a frontal collision with focus on the restraint system	Y



Scope: This Regulation applies to vehicles of category M1[41] with a maximum permissible mass not exceeding 3,500 kg and to vehicles of category N1."

Domain/category: M1, N1

Specifed exclusion: /

Reference included in this RCS: /

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[41] As defined in the Consolidated Resolution on the Construction of Vehicles (R.E.3.), document ECE/TRANS/WP.29/78/Rev.6, para. 2 - www.unece.org/trans/main/wp29/wp29wgs/wp29gen/wp29resolutions.html

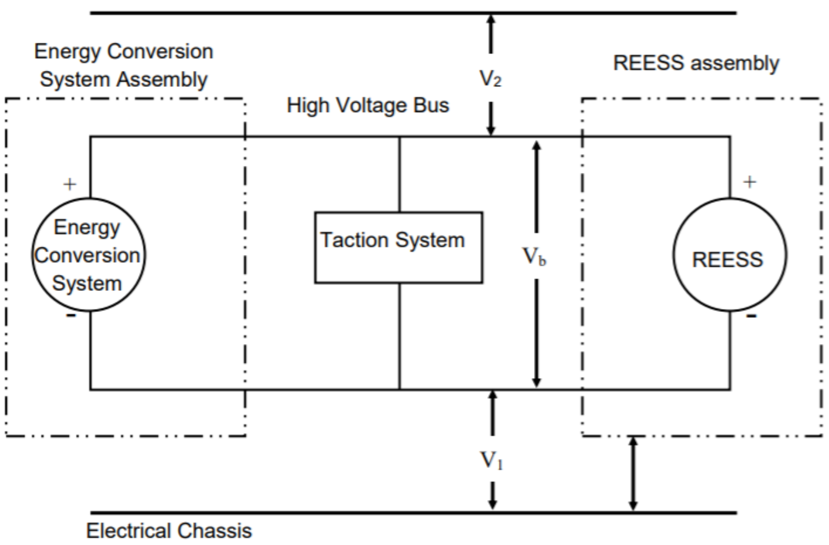
B. RELEVANT PARTS FOR STASHH PROJECT

The part relevant in StasHH project concerns the requirements on the electrical power train operating on high voltage, and the high voltage components and systems, which are galvanically connected to the high voltage bus of the electric power train (requirements ensuring the protection of the occupant in case of frontal collision): chapter 5.2.8 and its annex

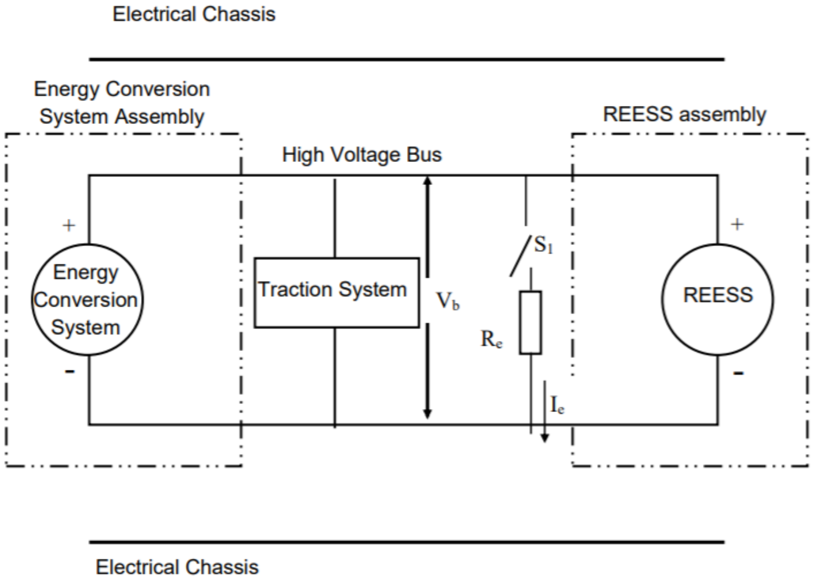
Conditions	Item	Documentation	Additional Description	Information
Chapter 5: specifications	Subchapter 5.2: Specifications for the restraint system test (Full Width Rigid Barrier test)		*The vehicle shall be tested and approved in accordance with the method described in Annex 3.* *Additionally, vehicles equipped with electric power train shall meet the requirements of paragraph 5.2.8.* *In case of this condition the requirements of paragraph 5.2.8. shall be checked in accordance with the methods set out in Annex 3 to this Regulation, except paragraphs 2., 5. and 6. of Annex 3.* **Annex 3 to this Regulation, except paragraphs 2., 5. and 6. of Annex 3.:** 1.4.4 *Electrical power train adjustment:* *1.4.4.2. The electrical power train shall be energized with or without the operation of the original electrical energy sources (e.g. engine-generator, REESS or electric energy conversion system), however:* *1.4.4.2.1. By the agreement between Technical Service and manufacturer it shall be permissible to perform the test with all or parts of the electrical power train not being energized insofar as there is no negative influence on the test result. For parts of the electrical power train not energized, the protection against electrical shock shall be proved by either physical protection or isolation resistance and appropriate additional evidence.* *1.4.4.2.2. In the case where an automatic disconnect is provided, at the request of the manufacturer it shall be permissible to perform the test with the automatic disconnect being triggered. In this case it shall be demonstrated that the automatic disconnect would have operated during the impact test.*	Vehicle integration Test protocols Integrator or FCM supplier

Conditions	Item	Documentation	Additional Description	Information
			This includes the automatic activation signal as well as the galvanic separation considering the conditions as seen during the impact. **Annex 3 to this Regulation, except paragraphs 2., 5. and 6. of Annex 3.:** 3. *Propulsion and course of vehicle* *3.1. The vehicle shall be propelled by its own engine or by any other propelling device;* *3.2. At the moment of impact the vehicle shall no longer be subject to the action of any additional steering or propelling device.*	
Chapter 5: Specifications	Subchapter 5.2: Specifications, Paragraph 5.2.8		*Following the test conducted in accordance with the procedure defined in Annex 9 to this Regulation, the electrical power train operating on high voltage, and the high voltage components and systems, which are galvanically connected to the high voltage bus of the electric power train, shall meet the following requirements:* (all 5.2.8.1) **Annex 9: Test procedures for the protection of the occupants of vehicles operating on electrical power from high voltage and electrolyte spillage** Each relevant part of this annex is recalled below.	Vehicle integration Test protocols Integrator or FCM supplier Electrical design requirements
Chapter 5: Specifications	Subchapter 5.2: Specifications, Paragraph 5.2.8	Subparagraph 5.2.8.1: Protection against electrical shock	*After the impact, the high voltage buses shall meet at least one of the four criteria specified in paragraph 5.2.8.1.1. through paragraph 5.2.8.1.4.2. below.* *If the vehicle has an automatic disconnect function, or device(s) that conductively divide the electric power train circuit during driving condition, at least one of the following criteria shall apply to the disconnected circuit or to each divided circuit individually after the disconnect function is activated.*	Vehicle integration Test protocols Integrator or FCM supplier Electrical design requirements

Conditions	Item	Documentation	Additional Description	Information
			However criteria defined in 5.2.8.1.4. below shall not apply if more than a single potential of a part of the high voltage bus is not protected under the conditions of protection degree IPXXB.	
Chapter 5: Specifications	Subchapter 5.2: Specifications, Paragraph 5.2.8 Subparagraph 5.2.8.1: Protection against electrical shock	5.2.8.1.1 Absence of High Voltage	*The voltages Ub, U1 and U2 of the high voltage buses shall be equal or less than 30 VAC or 60 VDC within 60 seconds after the impact when measured in accordance with paragraph 2. of Annex 9.* **Paragraph 2 of Annex 9:** *The following instructions may be used if voltage is measured.* *The voltages Ub, U1 and U2 of the high voltage buses shall be equal or less than 30 VAC or 60 VDC within 60 seconds after the impact when measured in accordance with paragraph 2. of Annex 9.* *The voltage measurement shall be made not earlier than 10 seconds, but, not later than 60 seconds after the impact.* *This procedure is not applicable if the test is performed under the condition where the electric power train is not energized.*	Vehicle integration Test protocols Integrator or FCM supplier Electrical design requirements

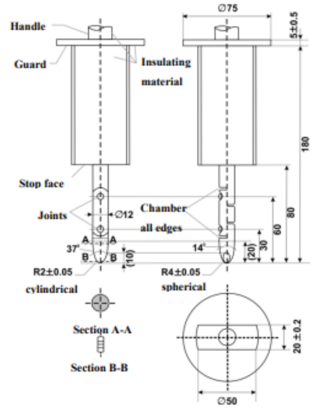
Conditions	Item	Documentation	Additional Description	Information
			Figure 1 **Measurement of V_b, V_1, V_2** 	
Chapter 5: Specifications	Subchapter 5.2: Specifications, Paragraph 5.2.8 Subparagraph 5.2.8.1: Protection against electrical shock	5.2.8.1.2 Low electrical energy	*The Total Energy (TE) on the high voltage buses shall be less than 0.2 joules when measured according to the test procedure as specified in paragraph 3. Of Annex 9 with the formula (a). Alternatively the total energy (TE) may be calculated by the measured voltage Ub of the high voltage bus and the capacitance of the X-capacitors (Cx) specified by the manufacturer according to formula (b) of paragraph 3. of Annex 9.* *The energy stored in the Y-capacitors (TEy1, TEy2) shall also be less than 0.2 joules. This shall be calculated by measuring the voltages U1 and U2 of the high voltage buses and the electrical chassis, and the capacitance of the Y-capacitors specified by the manufacturer according to formula (c) of paragraph 3. of Annex 9.* **Paragraph 3 of Annex 9:**	Vehicle integration Test protocols Integrator or FCM supplier Electrical design requirements

Conditions	Item	Documentation	Additional Description	Information
			Assessment procedure for low electrical energy *Prior to the impact a switch S1 and a known discharge resistor Re is connected in parallel to the relevant capacitance (ref. Figure 2 below)* *Not earlier than 10 seconds and not later than 60 seconds after the impact the switch S1 shall be closed while the voltage Ub and the current Ie are measured and recorded. The product of the voltage Ub and the current Ie shall be integrated over the period of time, starting from the moment when the switch S1 is closed (tc) until the voltage Ub falls below the high voltage threshold of 60 V DC (th). The resulting integration equals the Total Energy (TE) in joules* $TE = \int_{tc}^{th} U_b \times I_e dt$ *When Ub is measured at a point in time between 10 seconds and 60 seconds after the impact and the capacitance of the X-capacitors (Cx) is specified by the manufacturer, Total Energy (TE) shall be calculated according to the following formula:* $TE = 0.5 \text{ x } C_x \text{ x } U_b^2$ *WhenU1 and U2 (see Figure 1 above) are measured at a point in time between 10 seconds and 60 seconds after the impact and the capacitances of the Y-capacitors (Cy1, Cy2) are specified by the manufacturer, Total Energy (TEy1, TEy2) shall be calculated according to the following formulas:* $TE_{y1} = 0.5 \text{ x } C_{y1} \text{ x } U_1^2$ $TE_{y2} = 0.5 \text{ x } C_{y2} \text{ x } U_2^2$ *This procedure is not applicable if the test is performed under the condition where the electric power train is not energized.*	

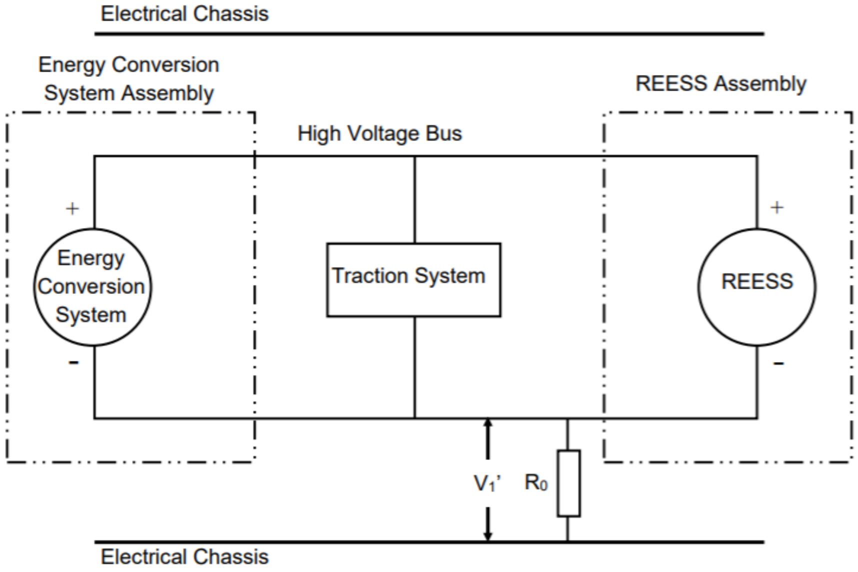
Conditions	Item	Documentation	Additional Description	Information
			Figure 2 **E.g. measurement of high voltage bus energy stored in X-capacitors** 	
Chapter 5: Specifications	Subchapter 5.2: Specifications, Paragraph 5.2.8 Subparagraph 5.2.8.1: Protection against electrical shock	5.2.8.1.3 Physical protection	For *protection against direct contact with high voltage live parts, the protection IPXXB shall be provided.* *The assessment shall be conducted in accordance with paragraph 4 of Annex 9.* *In addition, for protection against electrical shock which could arise from indirect contact, the resistance between all exposed conductive parts of electrical protection barriers/enclosures and the electrical chassis shall be lower than 0.1 Ω and the resistance between any two simultaneously reachable exposed conductive parts of electrical protection barriers/enclosures that are less than 2.5 m from each other shall be less than 0.2 Ω when there is current flow of at least 0.2 A. This*	Vehicle integration Test protocols Integrator or FCM supplier Electrical design requirements

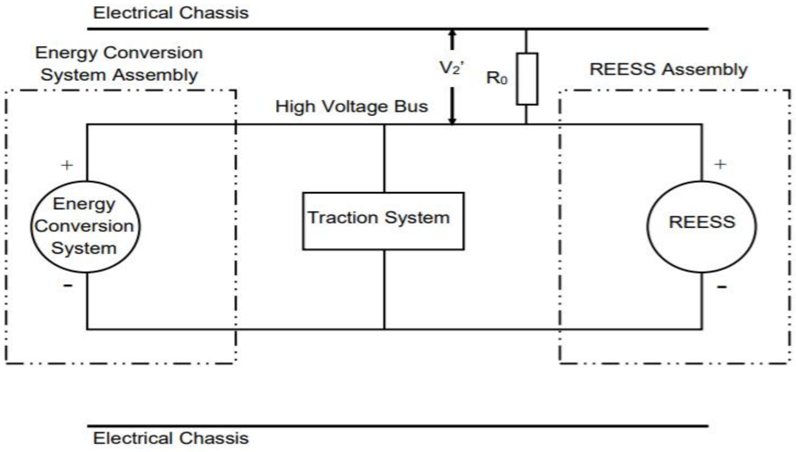
Conditions	Item	Documentation	Additional Description	Information
			resistance may be calculated using the separately measured resistances of the relevant parts of electric path. *These requirements are satisfied if the galvanic connection has been made by welding. In case of doubt or the connection is established by mean other than welding, measurements shall be made by using one of the test procedures described in paragraph 4.1. of Annex 9."* **Paragraph 4 of Annex 9:** *4. Physical protection* *Following the vehicle impact test any parts surrounding the high voltage components shall be, without the use of tools, opened, disassembled or removed. All remaining surrounding parts shall be considered part of the physical protection.* *The jointed test finger described in Figure 3 shall be inserted into any gaps or openings of the physical protection with a test force of 10 N ± 10 per cent for electrical safety assessment. If partial or full penetration into the physical protection by the jointed test finger occurs, the jointed test finger shall be placed in every position as specified below.* *Starting from the straight position, both joints of the test finger shall be rotated progressively through an angle of up to 90 degrees with respect to the axis of the adjoining section of the finger and shall be placed in every possible position.* *Internal electrical protection barriers are considered part of the enclosure If appropriate a low-voltage supply (of not less than 40 V and not more than 50 V) in series with a suitable lamp should be connected, between the jointed test finger and high voltage live parts inside the electrical protection barrier or enclosure.*	

Conditions	Item	Documentation	Additional Description	Information
			4.1. Acceptance conditions *The requirements of paragraph 5.2.8.1.3. of this Regulation shall be considered to be met if the jointed test finger described in Figure 1 of Appendix 1, is unable to contact high voltage live parts.* *If necessary a mirror or a fiberscope may be used in order to inspect whether the jointed test finger touches the high voltage buses.* *If this requirement is verified by a signal circuit between the jointed test finger and high voltage live parts, the lamp shall not light.*	

Conditions	Item	Documentation	Additional Description	Information
			Figure 3 **Jointed Test Finger** Access probe (Dimensions in mm) IPXXB Jointed text finger  Material: metal, except where otherwise specified Linear dimensions in mm. Tolerances on dimensions without specific tolerance: (a) on angles: +0/-10 seconds; (b) on linear dimensions: (i) up to 25 mm: +0/-0.05; (ii) over 25 mm: ±0.2. Both joints shall permit movement in the same plane and the same direction through an angle of 90° with a 0 to +10° tolerance. The requirements of paragraph 5.2.8.1.3. of this Regulation are met if the jointed test finger described in Figure 3, is unable to contact high voltage live parts. If necessary a mirror or a fiberscope may be used in order to inspect whether the jointed test finger touches the high voltage buses. If this requirement is verified by a signal circuit between the jointed test finger and high voltage live parts, the lamp shall not light.	
Chapter 5: Specifications	Subchapter 5.2: Specifications,	5.2.8.1.4 Isolation resistance	*The criteria specified in paragraphs 5.2.8.1.4.1. and 5.2.8.1.4.2. below shall be met.*	Vehicle integration Test protocols

Conditions	Item	Documentation	Additional Description	Information
	Paragraph 5.2.8 Subparagraph 5.2.8.1: Protection against electrical shock		*The measurement shall be conducted in accordance with paragraph 5. of Annex 9.* **Paragraph 5 of Annex 9:** See details below	Integrator or FCM supplier Electrical design requirements
Chapter 5: Specifications	Subchapter 5.2: Specifications, Paragraph 5.2.8 Subparagraph 5.2.8.1: Protection against electrical shock	5.2.8.1.4 Isolation resistance, 5.2.8.1.4.1: Electrical Power train consisting of separate DC- or AC- buses	*If the AC high voltage buses and the DC high voltage buses are galvanically isolated from each other, isolation resistance between the high voltage bus and the electrical chassis (Ri, as defined in paragraph 5. of Annex 9) shall have a minimum value of 100 Ω/V of the working voltage for DC buses, and a minimum value of 500 Ω/V of the working voltage for AC buses.* **Paragraph 5. of Annex 9:** *Isolation resistance* *The isolation resistance between the high voltage bus and the electrical chassis may be demonstrated either by measurement or by a combination of measurement and calculation.* *The following instructions should be used if the isolation resistance is demonstrated by measurement.* *Measure and record the voltage (Vb) between the negative and the positive side of the high voltage bus (see Figure 1 above);* *Measure and record the voltage (V1) between the negative side of the high voltage bus and the electrical chassis (see Figure 1 above);* *Measure and record the voltage (V2) between the positive side of the high voltage bus and the electrical chassis (see Figure 1 above);* *If V1 is greater than or equal to V2, insert a standard known resistance (Ro) between the negative side of the high voltage bus and the electrical chassis. With*	Vehicle integration Test protocols Integrator or FCM supplier Electrical design requirements

Conditions	Item	Documentation	Additional Description	Information
			Ro installed, measure the voltage (V1') between the negative side of the high voltage bus and the vehicle electrical chassis (see Figure 3 below). Calculate the isolation resistance (Ri) according to the formula shown below. $R_i = R_o x(V_b/V_1' - V_b/V_1)$ or $R_i = R_o x V_b x(1/V_1' - 1/V_1)$ Divide the result Ri, which is the electrical isolation resistance value in Ohm (Ω), by the working voltage of the high voltage bus in Volt (V). $R_i\ (\Omega / V) = R_i\ (\Omega) / \text{Working voltage}\ (V)$ Figure 3 **Measurement of V_1'**  If V2 is greater than V1, insert a standard known resistance (Ro) between the positive side of the high voltage bus and the electrical chassis. With Ro installed, measure the voltage (V2') between the positive side of the high voltage bus and the electrical chassis (see Figure 4 below).	

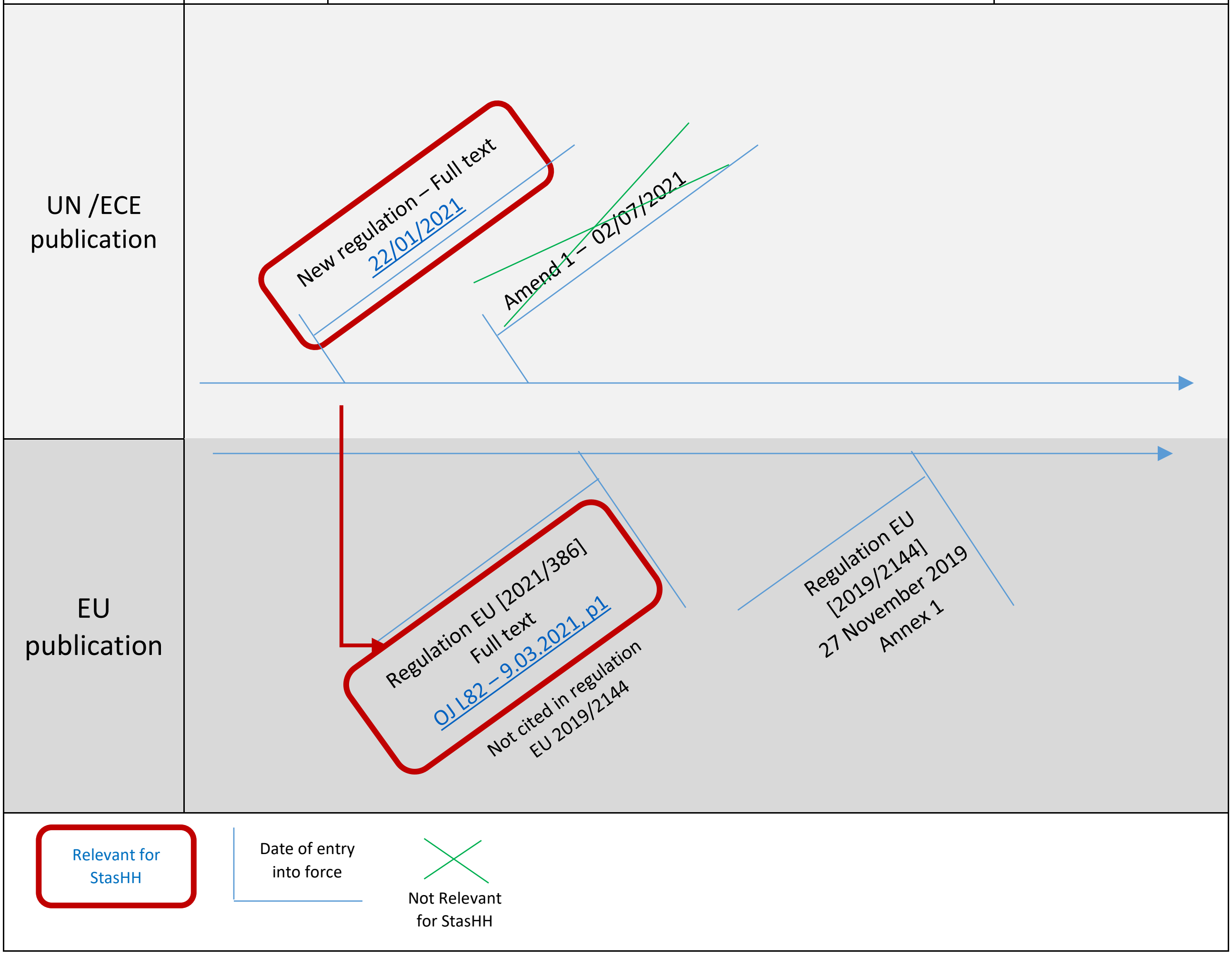
Conditions	Item	Documentation	Additional Description	Information
			Calculate the isolation resistance (Ri) according to the formula shown below. $R_i = R_o x(V_b/V_2' - V_b/V_2)$ or $R_i = R_o x V_b x(1/V_2' - 1/V_2)$ Divide the result Ri, which is the electrical isolation resistance value in Ohm (Ω), by the working voltage of the high voltage bus in Volt (V). $R_i\ (\Omega / V) = R_i\ (\Omega) / \text{Working voltage}\ (V)$ Figure 4 **Measurement of V_2'**  *Note:* The standard known resistance R_o (in Ω) should be the value of the minimum required isolation resistance (Ω/V) multiplied by the working voltage (V) of the vehicle plus/minus 20 per cent. R_o is not required to be precisely this value since the equations are valid for any R_o; however, a R_o value in this range should provide a good resolution for the voltage measurements.	
Chapter 5: Specifications	Subchapter 5.2: Specifications, Paragraph 5.2.8	5.2.8.1.4 Isolation resistance,	*If the AC high voltage buses and the DC high voltage buses are conductively connected, they shall meet one of the following requirements:* *(a) Isolation resistance between the high voltage bus and the electrical chassis shall have a minimum value of 500 Ω/V of the working voltage;*	Vehicle integration Test protocols Integrator or FCM supplier

Conditions	Item	Documentation	Additional Description	Information
	Subparagraph 5.2.8.1: Protection against electrical shock	5.2.8.1.4.2: Electrical Power train consisting of combined DC- or AC- buses	*(b) Isolation resistance between the high voltage bus and the electrical chassis shall have a minimum value of 100 Ω/V of the working voltage and the AC bus meets the physical protection as described in paragraph 5.2.8.1.3;* (c) Isolation resistance between the high voltage bus and the electrical chassis shall have a minimum value of 100 Ω/V of the working voltage and the AC bus meets the absence of high voltage as described in paragraph 5.2.8.1.1."	Electrical design requirements

REGULATION N°153 (UN/ECE)

A. IDENTITY CARD OF REGULATION N°153 (UN/ECE)

RCS	N°	Title	Statutory
Regulation	R153	Uniform provisions concerning the approval of vehicles with regard to fuel system integrity and safety of electric power train in the event of a rear-end collision	Y



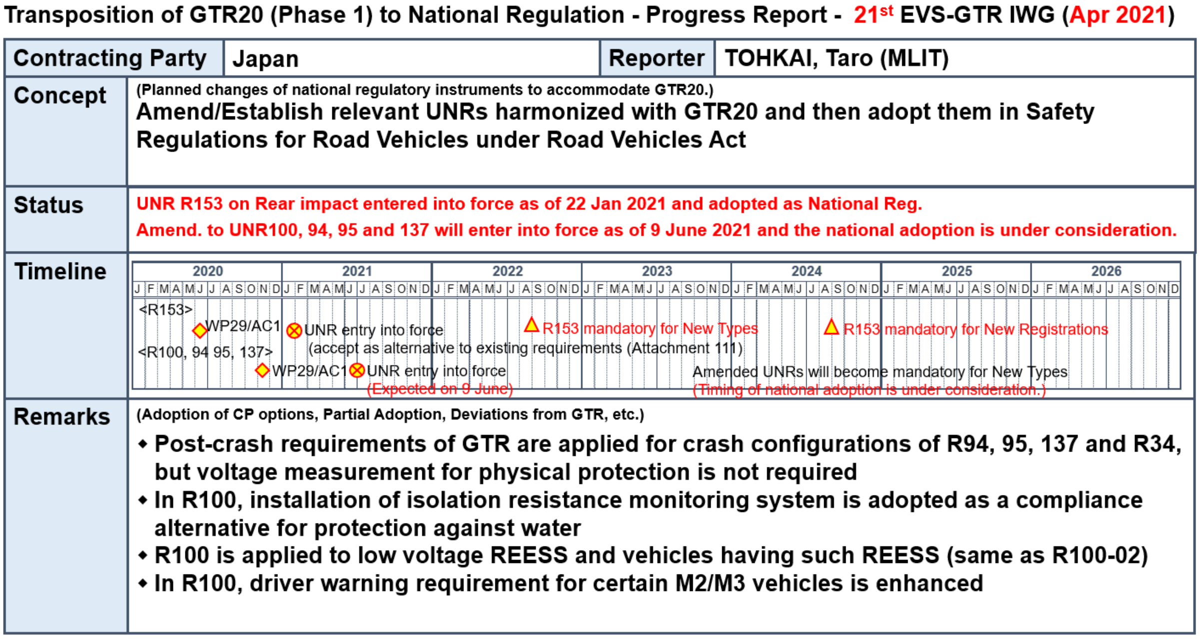
Scope: This Regulation applies to vehicles of category M1 with a total permissible mass not exceeding 3,500 kg and to vehicles of category N1 with regard to fuel system integrity and safety of electric power train operating on high voltage in the event of a rear-end collision.

Domain/category: M1, N1

Specified exclusion: N/A

Reference included in this RCS: See the appendix entitled “list of documents cited in R??? (UN/ECE).

Additionnal informations:



Transposition of GTR20 (Phase 1) to National Regulation - Progress Report - 21st EVS-GTR IWG (Apr 2021)

Contracting Party	**Japan**	**Reporter**	**TOHKAI, Taro (MLIT)**
Concept	(Planned changes of national regulatory instruments to accommodate GTR20.) **Amend/Establish relevant UNRs harmonized with GTR20 and then adopt them in Safety Regulations for Road Vehicles under Road Vehicles Act**		
Status	**UNR R153 on Rear impact entered into force as of 22 Jan 2021 and adopted as National Reg.** **Amend. to UNR100, 94, 95 and 137 will enter into force as of 9 June 2021 and the national adoption is under consideration.**		
Timeline	2020 2021 2022 2023 2024 2025 2026 J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D <R153> ◇WP29/AC1 ⊗UNR entry into force (accept as alternative to existing requirements (Attachment 111) △R153 mandatory for New Types △R153 mandatory for New Registrations <R100, 94 95, 137> ◇WP29/AC1 ⊗UNR entry into force (Expected on 9 June) Amended UNRs will become mandatory for New Types (Timing of national adoption is under consideration.)		
Remarks	(Adoption of CP options, Partial Adoption, Deviations from GTR, etc.) ◆ **Post-crash requirements of GTR are applied for crash configurations of R94, 95, 137 and R34, but voltage measurement for physical protection is not required** ◆ **In R100, installation of isolation resistance monitoring system is adopted as a compliance alternative for protection against water** ◆ **R100 is applied to low voltage REESS and vehicles having such REESS (same as R100-02)** ◆ **In R100, driver warning requirement for certain M2/M3 vehicles is enhanced**		

B. RELEVANT PARTS FOR STASHH PROJECT

The part of this regulation that is relevant to the StasHH project concerns the test preparation, calculation methods and expected performance for verifying the hydrogen leak rate. The test protocol is described in Annex 4.

Conditions	Item	Documentation	Additional Description	Information
Chapter 5 requirements	Paragraph 5.2	Subparagraph 5.2.1.3	*The hydrogen leakage rate (VH2) determined in accordance with either, paragraph 4. of Annex 4 for hydrogen, or paragraph 5. of Annex 4 for helium, shall not exceed an average of 118 NL per minute for the time interval, Δt minutes, after the crash.*	Vehicle integration Test protocols
Chapter 5 requirements	Paragraph 5.2	Subparagraph 5.2.1.4	*The gas (hydrogen or helium as applicable) concentration by volume in air values determined for the passenger and luggage compartments in accordance with paragraph 6. of Annex 4, shall not exceed 4.0 per cent for hydrogen or 3.0 per cent for helium, at any time throughout the 60 minute post-crash measurement period. This requirement is satisfied if it is confirmed that the shut-off valve of each hydrogen storage system has closed within 5 seconds of first vehicle contact with the impactor and there is no leakage from the hydrogen storage system(s).*	Vehicle integration Test protocols
Annexe 4 Test conditions and procedures for the assessment of post-crash hydrogen fuel system integrity	Chapter 3 Preparation, instrumentation and test conditions	subchapter 3.1: Compressed hydrogen ~~storage systems~~ and downstream piping paragraph 3.1.1	*Prior to conducting the crash test, instrumentation is installed in the hydrogen storage system to perform the required pressure and temperature measurements if the standard vehicle does not already possess instrumentation with the required accuracy.*	Vehicle integration Test protocols
Annexe 4	Chapter 3	subchapter 3.1: Compressed	*The hydrogen storage system is then purged, if necessary, following manufacturer directions to remove impurities from the container before*	Vehicle integration Test protocols

Conditions	Item	Documentation	Additional Description	Information
Test conditions and procedures for the assessment of post-crash hydrogen fuel system integrity	Preparation, instrumentation and test conditions	hydrogen ~~storage systems~~ and downstream piping paragraph 3.1.2	*filling the storage system with compressed hydrogen or helium gas. Since the storage system pressure varies with temperature, the targeted fill pressure is a function of the temperature. The target pressure shall be determined from the following equation:* $P_{target} = NWP \times (273 + T_o) / 288$ *where NWP is the nominal working pressure (MPa), To is the ambient temperature to which the storage system is expected to settle, and Ptarget is the targeted fill pressure after the temperature settles*	
Annexe 4 Test conditions and procedures for the assessment of post-crash hydrogen fuel system integrity	Chapter 3 Preparation, instrumentation and test conditions	subchapter 3.1: Compressed hydrogen storage systems and downstream piping paragraph 3.1.3	*The container is filled to a minimum of 95 per cent of the targeted fill pressure and allowed to settle (stabilize) prior to conducting the crash test.*	Vehicle integration Test protocols
Annexe 4 Test conditions and procedures for the assessment of post-crash hydrogen fuel	Chapter 3 Preparation, instrumentation and test conditions	subchapter 3.1: Compressed hydrogen storage systems and downstream piping paragraph 3.1.4	*The main stop valve and shut-off valves for hydrogen gas, located in the downstream hydrogen gas piping, are in normal driving condition immediately prior to the impact.*	Vehicle integration Test protocols

Conditions	Item	Documentation	Additional Description	Information
system integrity				
Annexe 4 Test conditions and procedures for the assessment of post-crash hydrogen fuel system integrity	Chapter 3 Preparation, instrumentation and test conditions	Subchapter 3.2: Enclosed spaces Paragraph 3.2.1	*Sensors are selected to measure either the build-up of the hydrogen or helium gas or the reduction in oxygen (due to displacement of air by leaking hydrogen/helium)*	Vehicle integration Test protocols
Annexe 4 Test conditions and procedures for the assessment of post-crash hydrogen fuel system integrity	Chapter 3 Preparation, instrumentation and test conditions	Subchapter 3.2: Enclosed spaces Paragraph 3.2.2	*Sensors are calibrated to traceable references to ensure an accuracy of ±5 per cent at the targeted criteria of 4 per cent hydrogen or 3 per cent helium by volume in air, and a full scale measurement capability of at least 25 per cent above the target criteria. The sensor shall be capable of a 90 per cent response to a full scale change in concentration within 10 seconds.*	Vehicle integration Test protocols
Annexe 4 Test conditions and procedures for the assessment	Chapter 3 Preparation, instrumentation and test conditions	Subchapter 3.2: Enclosed spaces Paragraph 3.2.3	*Prior to the crash impact, the sensors are located in the passenger and luggage compartments of the vehicle as follows:* *(a) At a distance within 250 mm of the headliner above the driver's seat or near the top centre of the passenger compartment* *(b) At a distance within 250 mm of the floor in front of the rear (or rear most) seat in the passenger compartment*	Vehicle integration Test protocols

Conditions	Item	Documentation	Additional Description	Information
of post-crash hydrogen fuel system integrity			*(c) At a distance within 100 mm of the top of luggage compartments inside the vehicle that are not directly affected by the particular crash impact to be conducted.*	
Annexe 4 Test conditions and procedures for the assessment of post-crash hydrogen fuel system integrity	Chapter 3 Preparation, instrumentation and test conditions	Subchapter 3.2: Enclosed spaces Paragraph 3.2.4	*The sensors are securely mounted on the vehicle structure or seats and protected for the planned crash test from debris, air bag exhaust gas and projectiles. The measurements following the crash are recorded by instruments located in the vehicle or by remote transmission.*	Vehicle integration Test protocols
Annexe 4 Test conditions and procedures for the assessment of post-crash hydrogen fuel system integrity	Chapter 3 Preparation, instrumentation and test conditions	Subchapter 3.2: Enclosed spaces Paragraph 3.2.4	*The test may be conducted either outdoors in an area protected from the wind and possible solar effects, or indoors in a space that is large enough or ventilated to prevent the build-up of hydrogen to more than 10 per cent of the targeted criteria in the passenger and luggage compartments.*	Vehicle integration Test protocols
Annexe 4 Test conditions and procedures	Chapter 4 Post-crash leak test measurement for a	Subchapter 4.1	*The hydrogen gas pressure, P_0 (MPa), and temperature, T_0 (°C), are measured immediately before the impact and then at a time interval, Δt (min), after the impact.*	Vehicle integration Test protocols

Conditions	Item	Documentation	Additional Description	Information
for the assessment of post-crash hydrogen fuel system integrity	compressed hydrogen storage system filled with compressed hydrogen			
Annexe 4 Test conditions and procedures for the assessment of post-crash hydrogen fuel system integrity	Chapter 4 Post-crash leak test measurement for a compressed hydrogen storage system filled with compressed hydrogen	Subchapter 4.1 Paragraph 4.1.1	*The time interval, Δt, starts when the vehicle comes to rest after the impact and continues for at least 60 minutes.*	Vehicle integration Test protocols
Annexe 4 Test conditions and procedures for the assessment of post-crash hydrogen fuel system integrity	Chapter 4 Post-crash leak test measurement for a compressed hydrogen storage system filled with compressed hydrogen	Subchapter 4.1 Paragraph 4.1.2	*The time interval, Δt shall be increased if necessary in order to accommodate measurement accuracy for a storage system with a large volume operating up to 70 MPa; in that case, Δt can be calculated from the following formula:* $\Delta t = V_{CHSS} \times NWP / 1\,000 \times ((-0{,}027 \times NWP + 4) \times R_s - 0{,}21) - 1{,}7 \times R_s$ *where* $R_s = P_s / NWP$*, Ps is the pressure range of the pressure sensor (MPa), NWP is the Nominal Working Pressure (MPa),* V_{CHSS} *is the volume of the compressed hydrogen storage system (L), and Δt is the time interval (min).*	Vehicle integration Test protocols
Annexe 4 Test conditions	Chapter 4 Post-crash leak test	Subchapter 4.1 Paragraph 4.1.3	If *the* calculated value of Δt is less than 60 minutes, Δt is set to 60 minutes.	Vehicle integration Test protocols

Conditions	Item	Documentation	Additional Description	Information
and procedures for the assessment of post-crash hydrogen fuel system integrity	measurement for a compressed hydrogen storage system filled with compressed hydrogen			
Annexe 4 Test conditions and procedures for the assessment of post-crash hydrogen fuel system integrity	Chapter 4 Post-crash leak test measurement for a compressed hydrogen storage system filled with compressed hydrogen	Subchapter 4.2	*The initial mass of hydrogen in the storage system can be calculated as follows:* $P_o' = P_o \times 288 / (273 + T_0)$ $\rho_o' = -0{,}0027 \times (P_0')2 + 0{,}75 \times P_0' + 0{,}5789$ $M_o = \rho_o' \times V_{CHSS}$	Vehicle integration Test protocols
Annexe 4 Test conditions and procedures for the assessment of post-crash hydrogen fuel system integrity	Chapter 4 Post-crash leak test measurement for a compressed hydrogen storage system filled with compressed hydrogen	Subchapter 4.3	*Correspondingly, the final mass of hydrogen in the storage system, Mf, at the end of the time interval, Δt, can be calculated as follows:* $P_f' = P_f \times 288 / (273 + T_f)$ $\rho_f' = -0{,}0027 \times (P_f')2 + 0{,}75 \times P_f' + 0{,}5789$ $M_f = \rho_f' \times V_{CHSS}$ *where* P_f *is the measured final pressure (MPa) at the end of the time interval, and* T_f *is the measured final temperature (°C).*	Vehicle integration Test protocols
Annexe 4	Chapter 4	Subchapter 4.4	*The average hydrogen flow rate over the time interval is therefore:*	Vehicle integration

Conditions	Item	Documentation	Additional Description	Information
Test conditions and procedures for the assessment of post-crash hydrogen fuel system integrity	Post-crash leak test measurement for a compressed hydrogen storage system filled with compressed hydrogen		$V_{H2} = (M_f - M_o) / \Delta t \times 22{,}41 / 2{,}016 \times (P_{target} / P_o)$ *where* V_{H2} *is the average volumetric flow rate (NL/min) over the time interval and the term* (P_{target}/P_o) *is used to compensate for differences between the measured initial pressure* (P_o) *and the targeted fill pressure* (P_{target})*.*	Test protocols
Annexe 4 Test conditions and procedures for the assessment of post-crash hydrogen fuel system integrity	Chapter 5 Post-crash leak test measurement for a compressed hydrogen storage system filled with compressed helium	Subchapter 5.1	*The helium gas pressure,* P_0 *(MPa), and temperature* T_0 *(°C), are measured immediately before the impact and then at a predetermined time interval after the impact.*	Vehicle integration Test protocols
Annexe 4 Test conditions and procedures for the assessment of post-crash hydrogen fuel	Chapter 5 Post-crash leak test measurement for a compressed hydrogen storage system filled with	Subchapter 5.1 Paragraph 5.1.1	*The time interval,* Δt*, starts when the vehicle comes to rest after the impact and continues for at least 60 minutes.*	Vehicle integration Test protocols

Conditions	Item	Documentation	Additional Description	Information
system integrity	compressed helium			
Annexe 4 Test conditions and procedures for the assessment of post-crash hydrogen fuel system integrity	Chapter 5 Post-crash leak test measurement for a compressed hydrogen storage system filled with compressed helium	Subchapter 5.1 Paragraph 5.1.2	*The time interval, Δt, shall be increased, if necessary, in order to accommodate measurement accuracy for a storage system with a large volume operating up to 70 MPa; in that case, Δt can be calculated from the following equation:* $\Delta t = V_{CHSS} \times NWP / 1\,000 \times ((-0{,}028 \times NWP + 5{,}5) \times R_s - 0{,}3) - 2{,}6 \times R_s$ *where* $R_s = P_s / NWP$, P_s *is the pressure range of the pressure sensor (MPa), NWP is the Nominal Working Pressure (MPa),* V_{CHSS} *is the volume of the compressed hydrogen storage system (L), and Δt is the time interval (min).*	Vehicle integration Test protocols
Annexe 4 Test conditions and procedures for the assessment of post-crash hydrogen fuel system integrity	Chapter 5 Post-crash leak test measurement for a compressed hydrogen storage system filled with compressed helium	Subchapter 5.1 Paragraph 5.1.3	*If the value of Δt is less than 60 minutes, Δt is set to 60 minutes.*	Vehicle integration Test protocols
Annexe 4 Test conditions and procedures for the assessment	Chapter 5 Post-crash leak test measurement for a compressed hydrogen	Subchapter 5.2	*The initial mass of helium in the storage system is calculated as follows:* $P_o' = P_o \times 288 / (273 + T_0)$ $\rho_o' = -0{,}0043 \times (P_0')2 + 1{,}53 \times P_0' + 1{,}49$ $M_o = \rho_o' \times V_{CHSS}$	Vehicle integration Test protocols

Conditions	Item	Documentation	Additional Description	Information
of post-crash hydrogen fuel system integrity	storage system filled with compressed helium			
Annexe 4 Test conditions and procedures for the assessment of post-crash hydrogen fuel system integrity	Chapter 5 Post-crash leak test measurement for a compressed hydrogen storage system filled with compressed helium	Subchapter 5.3	*The final mass of helium in the storage system at the end of the time interval, Δt, is calculated as follows:* $P_f' = P_f \times 288 / (273 + T_f)$ $\rho_f' = -0{,}0043 \times (P_f')2 + 1{,}53 \times P_f' + 1{,}49$ $M_f = \rho_f' \times V_{CHSS}$ *where* P_f *is the measured final pressure (MPa) at the end of the time interval, and* T_f *is the measured final temperature (°C).*	Vehicle integration Test protocols
Annexe 4 Test conditions and procedures for the assessment of post-crash hydrogen fuel system integrity	Chapter 5 Post-crash leak test measurement for a compressed hydrogen storage system filled with compressed helium	Annex 4, Chapter 5, Subchapter 5.4	*The average helium flow rate over the time interval is therefore:* $V_{He} = (M_f - M_o) / \Delta t \times 22{,}41 / 4{,}003 \times (P_{target}/ P_o)$ *where* V_{He} *is the average volumetric flow rate (NL/min) over the time interval and the term* (P_{target}/P_o) *is used to compensate for differences between the measured initial pressure* (P_o) *and the targeted fill pressure* (P_{target})*.*	Vehicle integration Test protocols
Annexe 4 Test conditions and procedures	Chapter 5 Post-crash leak test measurement for a	Annex 4, Chapter 5, Subchapter 5.5	*Conversion of the average volumetric flow of helium to the average hydrogen flow is calculated with the following formula:* $V_{H2} = V_{He} / 0{,}75$ *where* V_{H2} *is the corresponding average volumetric flow of hydrogen.*	Vehicle integration Test protocols

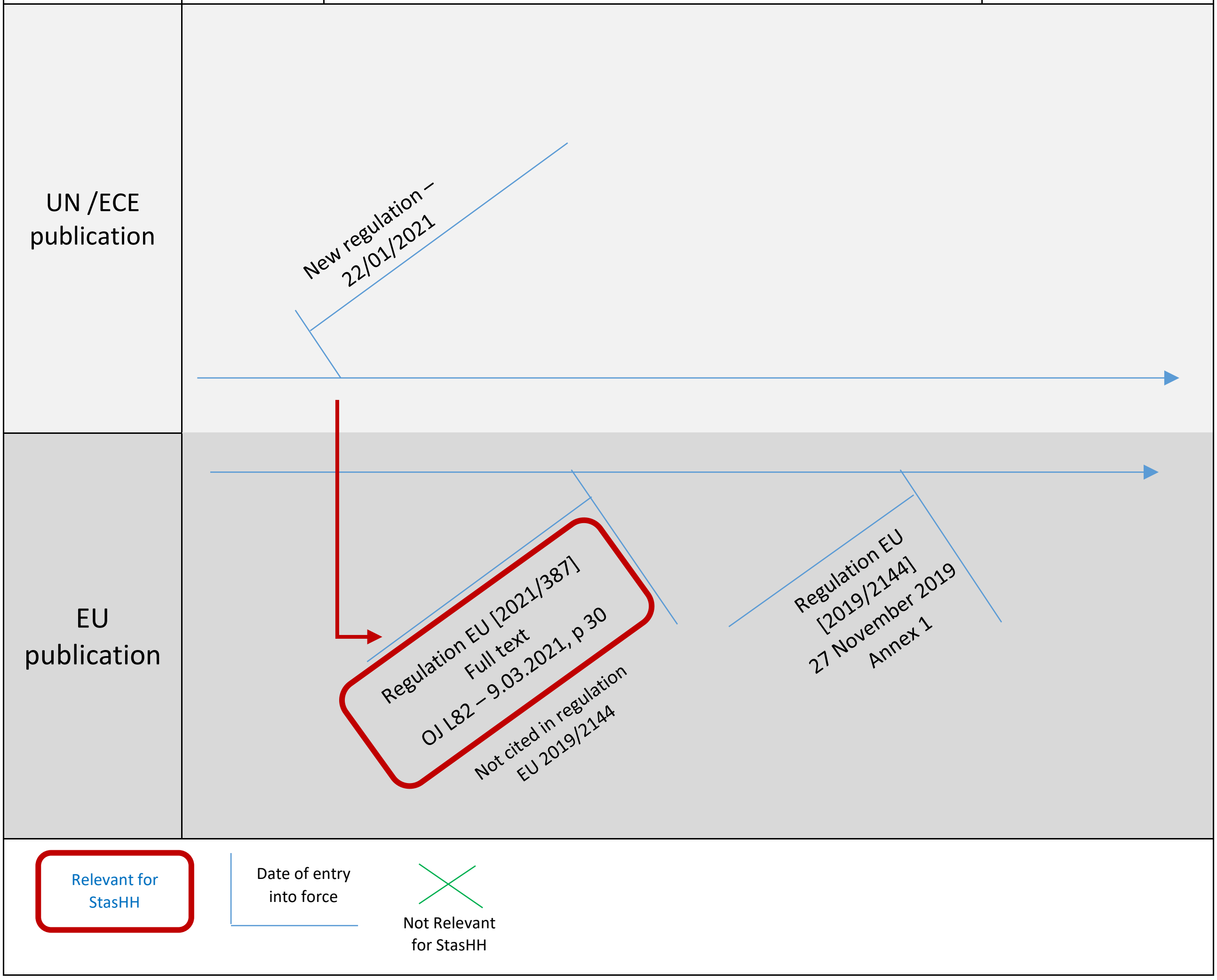
Conditions	Item	Documentation	Additional Description	Information
for the assessment of post-crash hydrogen fuel system integrity	compressed hydrogen storage system filled with compressed helium			
Annexe 4 Test conditions and procedures for the assessment of post-crash hydrogen fuel system integrity	Chapter 6 Post-crash concentration measurement for enclosed spaces	Subchapter 6.1	*Post-crash data collection in enclosed spaces commences when the vehicle comes to a rest. Data from the sensors installed in accordance with paragraph 3.2 of this annex are collected at least every 5 seconds and continue for a period of 60 minutes after the test. A first-order lag (time constant) up to a maximum of 5 seconds may be applied to the measurements to provide 'smoothing' and filter the effects of spurious data points.*	Vehicle integration Test protocols

Annex 21: REGULATION N° 155 (UN/ECE)

REGULATION N° 155 (UN/ECE)

A. IDENTITY CARD OF REGULATION N° 155 (UN/ECE)

RCS	N°	Title	Statutory
Regulation	R155	Uniform provisions concerning the approval of vehicles with regards to cybersecurity and cybersecurity management system	Y



Scope: This Regulation applies to vehicles, with regard to cybersecurity (including the CyberSecurity

This regulation only concerns the vehicle manufacturer, however it is important to take these elements into account in the design of the various systems.

Note:

> This Regulation is without prejudice to other UN Regulations, regional or national legislations governing the access by authorized parties to the vehicle, its data, functions and resources, and conditions of such access. It is also without prejudice to the application of national and regional legislation on privacy and the protection of natural persons with regard to the processing of their personal data.
>
> This Regulation is without prejudice to other UN Regulations, national or regional legislation governing the development and installation/system integration of replacement parts and components, physical and digital, with regards to cybersecurity.
>
> The requirements of this Regulation shall not restrict provisions or requirements of other UN Regulations.

Domain/category:

- Vehicle M,N,
- Vehicle O (only for the vehicle with at least one electronic control unit)
- Vehicle L6/L7 if equipped with automated driving functionalities from level 3 onwards, as defined in the "Reference document with definitions of Automated Driving under WP.29 and the General Principles for developing a UN Regulation on automated vehicles" (ECE/ TRANS/WP.29/1140).

Specifed exclusion: No exclusion specified in this regulation.

Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

This regulation is relevant to StasHH project. It mainly deals with management processes with regard to cybersecurity and these considerations are of high-level.

Its annex 5: it describes a list of vulnerability or attack method related to the treats, mitigations to the threats which are intended for vehicle types and mitigations to the threats which are intended for areas outside of vehicles, e.g. on IT back-ends.

The threat analysis shall also consider possible attack impacts. These may help ascertain the severity of a risk and identify additional risks. Possible attack impacts may include:

(a) Safe operation of vehicle affected;

(b) Vehicle functions stop working;

(c) Software modified, performance altered;

(d) Software altered but no operational effects

(e) Data integrity breach;

(f) Data confidentiality breach;

(g) Loss of data availability;

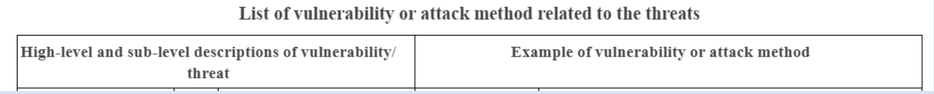
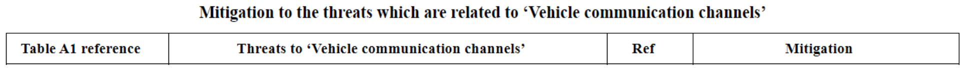
(h) Other, including criminality.

Conditions	Item	Documentation	Additional Description	Information
Chapter 5: Approval	Document	Chapter 5, Paragraph 5.1.1	*The Approval Authority or the Technical Service shall verify by means of document checks that the vehicle manufacturer has taken the necessary measures relevant for the vehicle type to:* *(a) Collect and verify the information required under this Regulation through the supply chain so as to demonstrate that supplier-related risks are identified and are managed;*	Cyber Security Safety Datas from Integrator or FCM supplier

Conditions	Item	Documentation	Additional Description	Information
			(b) Document risks assessment (conducted during development phase or retrospectively), test results and mitigations applied to the vehicle type, including design information supporting the risk assessment; *(c) Implement appropriate cyber security measures in the design of the vehicle type;* *(d) Detect and respond to possible cyber security attacks;* *(e) Log data to support the detection of cyber-attacks and provide data forensic capability to enable analysis of attempted or successful cyber-attacks.*	
Chapter 5: Approval	Document	Chapter 5, Paragraph 5.1.3	*The Approval Authority or Technical Service shall refuse to grant the type approval with regard to cyber security where the vehicle manufacturer has not fulfilled one or more of the requirements referred to in paragraph 7.3., notably:* *(a) The vehicle manufacturer did not perform the exhaustive risk assessment referred to in paragraph 7.3.3.; including where the manufacturer did not consider all the risks related to threats referred to in Annex 5, Part A;* *(b) The vehicle manufacturer did not protect the vehicle type against risks identified in the vehicle manufacturer's risk assessment or proportionate mitigations were not implemented as required by paragraph 7.* *(c) The vehicle manufacturer did not put in place appropriate and proportionate measures to secure dedicated environments on the vehicle type (if provided) for the storage and execution of aftermarket software, services, applications or data;* *(d) The vehicle manufacturer did not perform, prior to the approval, appropriate and sufficient testing to verify the effectiveness of the security measures implemented.* Part A: Follow this link ➔ Table A1 from Part A of annex 5: List of vulnerability or attack method related to the threats	Cyber Security Safety Datas from Integrator or FCM supplier
Chapter 7: Specifications	Sub-chapter 7.2. Requirements for the Cybersecurity Management System	Chapter 7, Sub-chapter 7.2, Sub-paragraph 7.2.2.2	*The vehicle manufacturer shall demonstrate that the processes used within their Cybersecurity Management System ensure security is adequately considered, including risks and mitigations listed in Annex 5. This shall include:* *(a) The processes used within the manufacturer's organization to manage cybersecurity*	Cyber Security Safety Datas from Integrator or FCM supplier

Conditions	Item	Documentation	Additional Description	Information
			(b) The processes used for the identification of risks to vehicle types. Within these processes, the threats in Annex 5, Part A, and other relevant threats shall be considered *(c) The processes used for the assessment, categorization and treatment of the risks identified* *(d) The processes in place to verify that the risks identified are appropriately managed* *(e) The processes used for testing the cybersecurity of a vehicle type* *(f) The processes used for ensuring that the risk assessment is kept current* *(g) The processes used to monitor for, detect and respond to cyberattacks, cyber threats and vulnerabilities on vehicle types and the processes used to assess whether the cybersecurity measures implemented are still effective in the light of new cyber threats and vulnerabilities that have been identified* Part A: Follow this link ➔ Table A1 from Part A of annex 5: List of vulnerability or attack method related to the threats	
Chapter 7: Specifications	Sub-chapter 7.3: Requirements for vehicle types	Chapter 7, Sub-chapter 7.3, paragraph 7.3.3	*The vehicle manufacturer shall identify the critical elements of the vehicle type and perform an exhaustive risk assessment for the vehicle type and shall treat/manage the identified risks appropriately. The risk assessment shall consider the individual elements of the vehicle type and their interactions. The risk assessment shall further consider interactions with any external systems. While assessing the risks, the vehicle manufacturer shall consider the risks related to all the threats referred to in Annex 5, Part A, as well as any other relevant risk.* Part A: Follow this link ➔ Table A1 from Part A of annex 5: List of vulnerability or attack method related to the threats	Cyber Security Safety Datas from Integrator or FCM supplier
Chapter 7: Specifications	Sub-chapter 7.3: Requirements for vehicle types	Chapter 7, Sub-chapter 7.3, paragraph 7.3.4	*The vehicle manufacturer shall protect the vehicle type against risks identified in the vehicle manufacturer's risk assessment. Proportionate mitigations shall be implemented to protect the vehicle type. The mitigations implemented shall include all mitigations referred to in Annex 5, Part B and C which are relevant for the risks identified. However, if a mitigation referred to in Annex 5, Part B or C, is not relevant or*	Cyber Security Safety Datas from Integrator or FCM supplier

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td><i>not sufficient for the risk identified, the vehicle manufacturer shall ensure that another appropriate mitigation is implemented.</i>
<i>In particular, for type approvals prior to 1 July 2024, the vehicle manufacturer shall ensure that another appropriate mitigation is implemented if a mitigation measure referred to in Annex 5, Part B or C is technically not feasible. The respective assessment of the technical feasibility shall be provided by the manufacturer to the approval authority.</i>

Part B and part C: Follow these links ➔
Table B1 from Part B of annex 5: Mitigation to the threats which are related to 'Vehicle communication channels'to the end of this sheet.</td><td></td></tr>
<tr><td></td><td></td><td>7.3.8</td><td><i>Cryptographic modules used for the purpose of this Regulation shall be in line with consensus standards. If the cryptographic modules used are not in line with consensus standards, then the vehicle manufacturer shall justify their use.</i></td><td>Cyber Security Safety
Datas from Integrator or FCM supplier</td></tr>
<tr><td>Annex 5:
List of threats and corresponding mitigations</td><td>Part A:
Vulnerability or attack method related to the threats</td><td>Annex 5,
Part A,
Table A1</td><td>High-level descriptions of threats and relating vulnerability or attack method are listed in Table A1:

<table><tr><th colspan="2">List of vulnerability or attack method related to the threats</th></tr><tr><th>High-level and sub-level descriptions of vulnerability/ threat</th><th>Example of vulnerability or attack method</th></tr></table>
Follow this link ➔ Table A1 from Part A of annex 5: List of vulnerability or attack method related to the threats</td><td>Cyber Security Safety
Datas from Integrator or FCM supplier</td></tr>
<tr><td>Annex 5: List of threats and corresponding mitigations</td><td>Part B:
Mitigations to the threats intended for vehicles</td><td>Annex 5,
Part B,
Table B1</td><td>Mitigations for 'Vehicle communication channels'
Mitigations to the threats which are related to 'Vehicle communication channels' are listed in Table B1:

<table><tr><th colspan="4">Mitigation to the threats which are related to 'Vehicle communication channels'</th></tr><tr><th>Table A1 reference</th><th>Threats to 'Vehicle communication channels'</th><th>Ref</th><th>Mitigation</th></tr></table>
Follow these links ➔</td><td>Cyber Security Safety
Datas from Integrator or FCM supplier</td></tr>
</table>

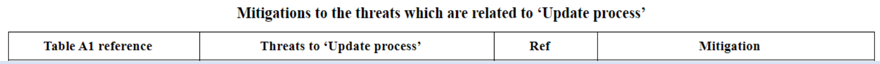
<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td>Table B1 from Part B of annex 5: Mitigation to the threats which are related to ‘Vehicle communication channels’
And
Table B2 from Part B of annex 5: Mitigations to the threats which are related to ‘Update process’</td><td></td></tr>
<tr><td>Annex 5: List of threats and corresponding mitigations</td><td>Part B: Mitigations to the threats intended for vehicles</td><td>Annex 5, Part B, Table B2</td><td>Mitigations for ‘Update process’
Mitigations to the threats which are related to ‘Update process’ are listed in Table B2: Mitigations to the threats which are related to ‘Update process’

Mitigations to the threats which are related to ‘Update process’<table><tr><th>Table A1 reference</th><th>Threats to ‘Update process’</th><th>Ref</th><th>Mitigation</th></tr></table>
Follow these links ➔

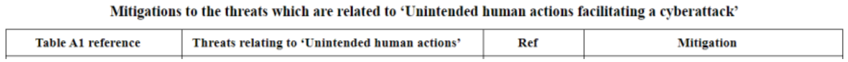
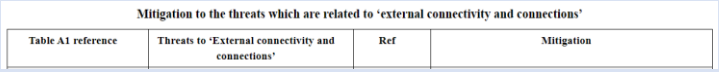
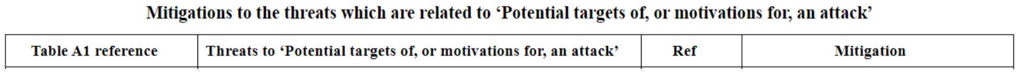
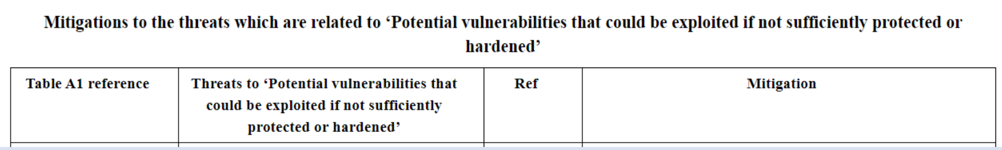
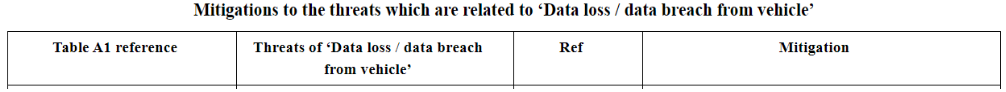
Table B1 from Part B of annex 5: Mitigation to the threats which are related to ‘Vehicle communication channels’
and
Table B3 from Part B of annex 5: Mitigations to the threats which are related to ‘Unintended human actions facilitating a cyberattack’</td><td>Cyber Security Safety
Datas from Integrator or FCM supplier</td></tr>
<tr><td>Annex 5: List of threats and corresponding mitigations</td><td>Part B: Mitigations to the threats intended for vehicles</td><td>Annex 5, Part B, Table B3</td><td>Mitigations for ‘Unintended human actions facilitating a cyberattack’
Mitigations to the threats which are related to ‘Unintended human actions facilitating a cyberattack’ are listed in Table B3:

Mitigations to the threats which are related to ‘Unintended human actions facilitating a cyberattack’<table><tr><th>Table A1 reference</th><th>Threats relating to ‘Unintended human actions’</th><th>Ref</th><th>Mitigation</th></tr></table>
Follow these links ➔

Table B1 from Part B of annex 5: Mitigation to the threats which are related to ‘Vehicle communication channels’
and
Table B4 from Part B of annex 5: Mitigation to the threats which are related to ‘external connectivity and connections’</td><td>Cyber Security Safety
Datas from Integrator or FCM supplier</td></tr>
</table>

Conditions	Item	Documentation	Additional Description	Information
Annex 5: List of threats and corresponding mitigations	Part B: Mitigations to the threats intended for vehicles	Annex 5, Part B, Table B4	Mitigations for ‘External connectivity and connections’ Mitigations to the threats which are related to ‘external connectivity and connections’ are listed in Table B4:  Mitigation to the threats which are related to ‘external connectivity and connections’ Table A1 reference | Threats to ‘External connectivity and connections’ | Ref | Mitigation Follow these links ➔ Table B3 from Part B of annex 5: Mitigations to the threats which are related to ‘Unintended human actions facilitating a cyberattack’ and Table B5 from Part B of annex 5: Mitigations to the threats which are related to ‘Potential targets of, or motivations for, an attack’	Cyber Security Safety Datas from Integrator or FCM supplier
Annex 5: List of threats and corresponding mitigations	Part B: Mitigations to the threats intended for vehicles	Annex 5, Part B, Table B5	Mitigations for ‘Potential targets of, or motivations for, an attack’ Mitigations to the threats which are related to ‘Potential targets of, or motivations for, an attack’ are listed in Table B5:  Mitigations to the threats which are related to ‘Potential targets of, or motivations for, an attack’ Table A1 reference | Threats to ‘Potential targets of, or motivations for, an attack’ | Ref | Mitigation Follow these links ➔ Table B1 from Part B of annex 5: Mitigation to the threats which are related to ‘Vehicle communication channels’ and Table B6 from Part B of annex 5: Mitigations to the threats which are related to ‘Potential vulnerabilities that could be exploited if not sufficiently protected or hardened’	Cyber Security Safety Datas from Integrator or FCM supplier
Annex 5: List of threats and	Part B: Mitigations to the threats	Annex 5, Part B, Table B6	Mitigations for ‘Potential vulnerabilities that could be exploited if not sufficiently protected or hardened’	Cyber Security Safety

Conditions	Item	Documentation	Additional Description	Information
corresponding mitigations	intended for vehicles		Mitigations to the threats which are related to 'Potential vulnerabilities that could be exploited if not sufficiently protected or hardened' are listed in Table B6:  **Mitigations to the threats which are related to 'Potential vulnerabilities that could be exploited if not sufficiently protected or hardened'** **Table A1 reference** **Threats to 'Potential vulnerabilities that could be exploited if not sufficiently protected or hardened'** **Ref** **Mitigation** Follow these links ➔ Table B1 from Part B of annex 5: Mitigation to the threats which are related to 'Vehicle communication channels' and Table B6 from Part B of annex 5: Mitigations to the threats which are related to 'Potential vulnerabilities that could be exploited if not sufficiently protected or hardened'	Datas from Integrator or FCM supplier
Annex 5: List of threats and corresponding mitigations	Part B: Mitigations to the threats intended for vehicles	Annex 5, Part B, Table B7	Mitigations for 'Data loss / data breach from vehicle' Mitigations to the threats which are related to 'Data loss / data breach from vehicle' are listed in Table B7:  **Mitigations to the threats which are related to 'Data loss / data breach from vehicle'** **Table A1 reference** **Threats of 'Data loss / data breach from vehicle'** **Ref** **Mitigation** Follow these links ➔ Table B1 from Part B of annex 5: Mitigation to the threats which are related to 'Vehicle communication channels' and Table B8 from Part B of annex 5: Mitigations to the threats which are related to 'Physical manipulation of systems to enable an attack'	Cyber Security Safety Datas from Integrator or FCM supplier

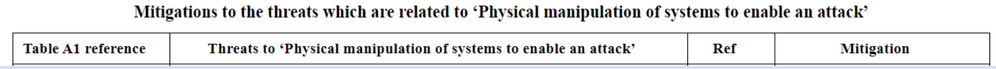
<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr>
<td>Annex 5: List of threats and corresponding mitigations</td>
<td>Part B: Mitigations to the threats intended for vehicles</td>
<td>Annex 5,
Part B,
Table B8</td>
<td>Mitigations for ‘Physical manipulation of systems to enable an attack’
Mitigation to the threats which are related to ‘Physical manipulation of systems to enable an attack’ are listed in Table B8:

Mitigations to the threats which are related to ‘Physical manipulation of systems to enable an attack’
<table><tr><th>Table A1 reference</th><th>Threats to ‘Physical manipulation of systems to enable an attack’</th><th>Ref</th><th>Mitigation</th></tr></table>
Follow these links ➔

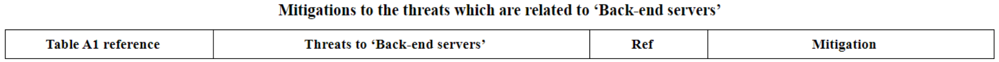
Table B1 from Part B of annex 5: Mitigation to the threats which are related to ‘Vehicle communication channels’0
and
Table B8 from Part B of annex 5: Mitigations to the threats which are related to ‘Physical manipulation of systems to enable an attack’</td>
<td>Cyber Security
Safety
Datas from Integrator or FCM supplier</td>
</tr>
<tr>
<td>Annex 5: List of threats and corresponding mitigations</td>
<td>Part C: Mitigations to the threats outside of vehicles</td>
<td>Annex 5,
Part C,
Table C1</td>
<td>Mitigations for ‘Back-end servers’
Mitigations to the threats which are related to ‘Back-end servers’ are listed in Table C1:

Mitigations to the threats which are related to ‘Back-end servers’
<table><tr><th>Table A1 reference</th><th>Threats to ‘Back-end servers’</th><th>Ref</th><th>Mitigation</th></tr></table>
Follow these links ➔

Table B1 from Part B of annex 5: Mitigation to the threats which are related to ‘Vehicle communication channels’
and
Table C1 from Part C of annex 5: Mitigations to the threats which are related to ‘Back-end servers’</td>
<td>Cyber Security
Safety
Datas from Integrator or FCM supplier</td>
</tr>
<tr>
<td>Annex 5: List of threats and corresponding mitigations</td>
<td>Part C: Mitigations to the threats</td>
<td>Annex 5,
Part C,
Table C2</td>
<td>Mitigations for ‘Unintended human actions’
Mitigations to the threats which are related to ‘Unintended human actions’ are listed in Table C2:</td>
<td>Cyber Security
Safety</td>
</tr>
</table>

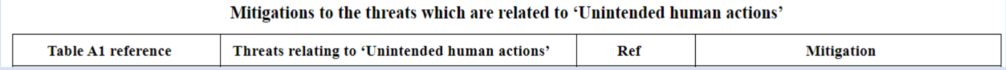
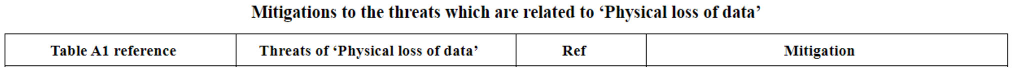
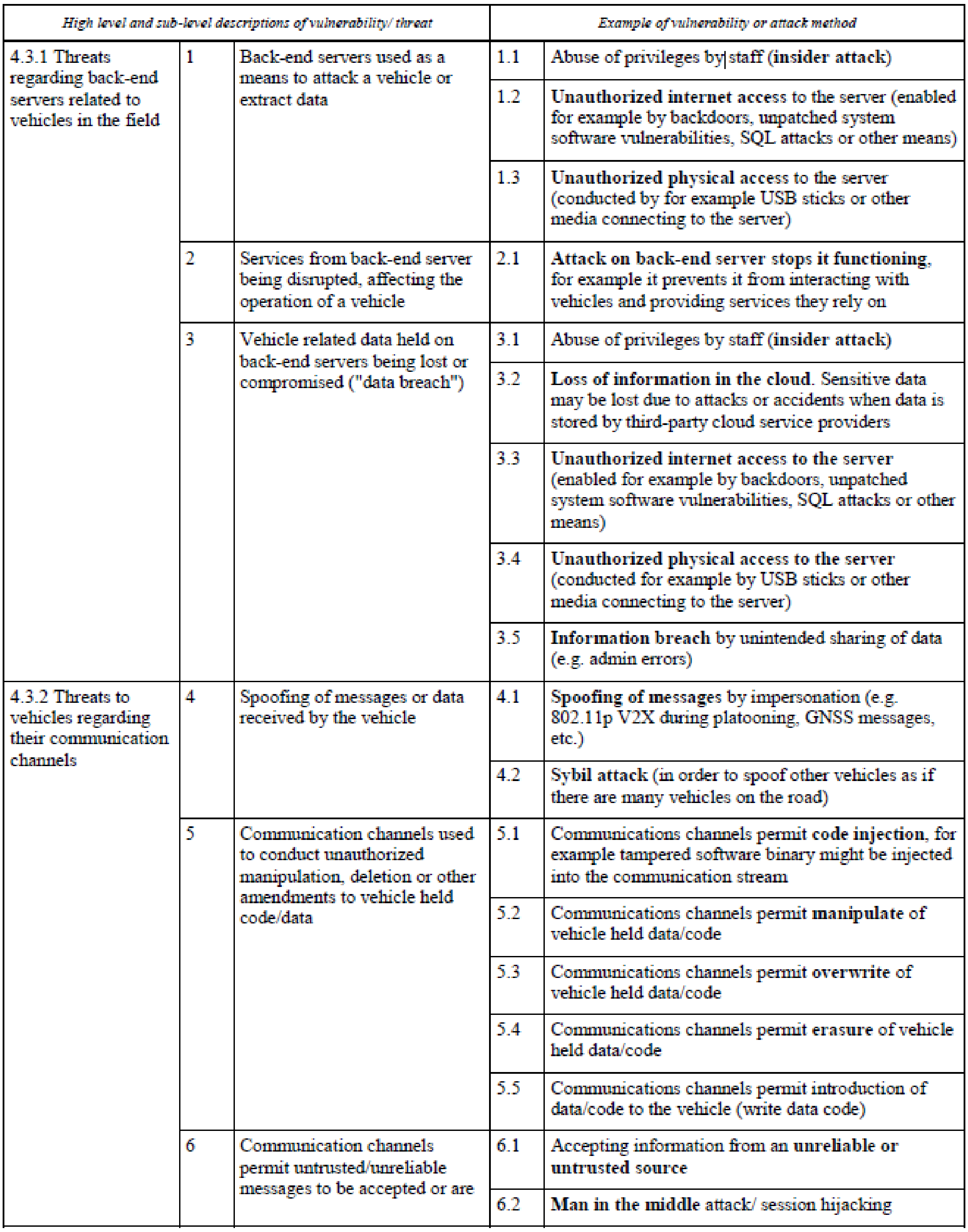
Conditions	Item	Documentation	Additional Description	Information
	outside of vehicles		 Mitigations to the threats which are related to ‘Unintended human actions’ Table A1 reference Threats relating to ‘Unintended human actions’ Ref Mitigation Follow these links ➔ Table B1 from Part B of annex 5: Mitigation to the threats which are related to ‘Vehicle communication channels’ and Table C2 from Part C of annex 5: Mitigations to the threats which are related to ‘Unintended human actions’	Datas from Integrator or FCM supplier
Annex 5: List of threats and corresponding mitigations	Part C: Mitigations to the threats outside of vehicles	Annex 5, Part C, Table C3	Mitigations for ‘Physical loss of data’ Mitigations to the threats which are related to ‘Physical loss of data’ are listed in Table C3:  Mitigations to the threats which are related to ‘Physical loss of data’ Table A1 reference Threats of ‘Physical loss of data’ Ref Mitigation Follow these links ➔ Table B1 from Part B of annex 5: Mitigation to the threats which are related to ‘Vehicle communication channels’ and Table C3 from Part C of annex 5: Mitigations to the threats which are related to ‘Physical loss of data’	Cyber Security Safety Datas from Integrator or FCM supplier

Table A1 from Part A of annex 5: List of vulnerability or attack method related to the threats



High level and sub-level descriptions of vulnerability/ threat			*Example of vulnerability or attack method*	
4.3.1 Threats regarding back-end servers related to vehicles in the field	1	Back-end servers used as a means to attack a vehicle or extract data	1.1	Abuse of privileges by staff (**insider attack**)
			1.2	**Unauthorized internet access** to the server (enabled for example by backdoors, unpatched system software vulnerabilities, SQL attacks or other means)
			1.3	**Unauthorized physical access** to the server (conducted by for example USB sticks or other media connecting to the server)
	2	Services from back-end server being disrupted, affecting the operation of a vehicle	2.1	**Attack on back-end server stops it functioning**, for example it prevents it from interacting with vehicles and providing services they rely on
	3	Vehicle related data held on back-end servers being lost or compromised ("data breach")	3.1	Abuse of privileges by staff (**insider attack**)
			3.2	**Loss of information in the cloud**. Sensitive data may be lost due to attacks or accidents when data is stored by third-party cloud service providers
			3.3	**Unauthorized internet access to the server** (enabled for example by backdoors, unpatched system software vulnerabilities, SQL attacks or other means)
			3.4	**Unauthorized physical access to the server** (conducted for example by USB sticks or other media connecting to the server)
			3.5	**Information breach** by unintended sharing of data (e.g. admin errors)
4.3.2 Threats to vehicles regarding their communication channels	4	Spoofing of messages or data received by the vehicle	4.1	**Spoofing of messages** by impersonation (e.g. 802.11p V2X during platooning, GNSS messages, etc.)
			4.2	**Sybil attack** (in order to spoof other vehicles as if there are many vehicles on the road)
	5	Communication channels used to conduct unauthorized manipulation, deletion or other amendments to vehicle held code/data	5.1	Communications channels permit **code injection**, for example tampered software binary might be injected into the communication stream
			5.2	Communications channels permit **manipulate** of vehicle held data/code
			5.3	Communications channels permit **overwrite** of vehicle held data/code
			5.4	Communications channels permit **erasure** of vehicle held data/code
			5.5	Communications channels permit **introduction** of data/code to the vehicle (write data code)
	6	Communication channels permit untrusted/unreliable messages to be accepted or are	6.1	Accepting information from an **unreliable or untrusted source**
			6.2	**Man in the middle** attack/ session hijacking

High level and sub-level descriptions of vulnerability/ threat			*Example of vulnerability or attack method*	
		vulnerable to session hijacking/replay attacks	6.3	**Replay attack**, for example an attack against a communication gateway allows the attacker to downgrade software of an ECU or firmware of the gateway
	7	Information can be readily disclosed. For example, through eavesdropping on communications or through allowing unauthorized access to sensitive files or folders	7.1	**Interception of information** / interfering radiations / monitoring communications
			7.2	**Gaining unauthorized** access to files or data
	8	Denial of service attacks via communication channels to disrupt vehicle functions	8.1	**Sending** a large number of garbage data to vehicle information system, so **that it is unable to provide** services in the normal manner
			8.2	**Black hole attack**, in order to disrupt communication between vehicles the attacker is able to block messages between the vehicles
	9	An unprivileged user is able to gain privileged access to vehicle systems	9.1	An unprivileged user is able to **gain privileged** access, for example root access
	10	Viruses embedded in communication media are able to infect vehicle systems	10.1	**Virus** embedded in communication media infects vehicle systems
	11	Messages received by the vehicle (for example X2V or diagnostic messages), or transmitted within it, contain malicious content	11.1	Malicious **internal** (e.g. CAN) messages
			11.2	Malicious **V2X messages**, e.g. infrastructure to vehicle or vehicle-vehicle messages (e.g. CAM, DENM)
			11.3	Malicious diagnostic messages
			11.4	Malicious **proprietary messages** (e.g. those normally sent from OEM or component/system/function supplier)
4.3.3. Threats to vehicles regarding their update procedures	12	Misuse or compromise of update procedures	12.1	Compromise of **over the air software update procedures**. This includes fabricating the system update program or firmware
			12.2	Compromise of **local/physical software update procedures**. This includes fabricating the system update program or firmware
			12.3	The software is **manipulated before the update** process (and is therefore corrupted), although the update process is intact
			12.4	**Compromise** of cryptographic keys of the software provider **to allow invalid update**
	13	It is possible to deny legitimate updates	13.1	Denial of Service attack against update server or network to **prevent rollout of critical software updates** and/or unlock of customer specific features
4.3.4 Threats to vehicles regarding unintended human actions facilitating a cyber attack	15	Legitimate actors are able to take actions that would unwittingly facilitate a cyber-attack	15.1	Innocent victim (e.g. owner, operator or maintenance engineer) being **tricked into taking an action** to unintentionally load malware or enable an attack
			15.2	**Defined security procedures** are not followed

High level and sub-level descriptions of vulnerability/ threat			*Example of vulnerability or attack method*	
4.3.5 Threats to vehicles regarding their external connectivity and connections	16	Manipulation of the connectivity of vehicle functions enables a cyber-attack, this can include telematics; systems that permit remote operations; and systems using short range wireless communications	16.1	Manipulation of functions designed to remotely operate systems, such as remote key, immobilizer, and charging pile
			16.2	Manipulation of vehicle telematics (e.g. manipulate temperature measurement of sensitive goods, remotely unlock cargo doors)
			16.3	Interference with short range wireless systems or sensors
	17	Hosted 3rd party software, e.g. entertainment applications, used as a means to attack vehicle systems	17.1	Corrupted applications, or those with poor software security, used as a method to attack vehicle systems
	18	Devices connected to external interfaces e.g. USB ports, OBD port, used as a means to attack vehicle systems	18.1	External interfaces such as USB or other ports used as a point of attack, for example through code injection
			18.2	Media infected with a virus connected to a vehicle system
			18.3	Diagnostic access (e.g. dongles in OBD port) used to facilitate an attack, e.g. manipulate vehicle parameters (directly or indirectly)
4.3.6 Threats to vehicle data/code	19	Extraction of vehicle data/code	19.1	Extraction of copyright or proprietary software from vehicle systems (product piracy)
			19.2	Unauthorized access to the owner's privacy information such as personal identity, payment account information, address book information, location information, vehicle's electronic ID, etc.
			19.3	Extraction of cryptographic keys
	20	Manipulation of vehicle data/code	20.1	Illegal/unauthorized changes to vehicle's electronic ID
			20.2	Identity fraud. For example, if a user wants to display another identity when communicating with toll systems, manufacturer backend
			20.3	Action to circumvent monitoring systems (e.g. hacking/ tampering/ blocking of messages such as ODR Tracker data, or number of runs)
			20.4	Data manipulation to falsify vehicle's driving data (e.g. mileage, driving speed, driving directions, etc.)
			20.5	Unauthorized changes to system diagnostic data
	21	Erasure of data/code	21.1	Unauthorized deletion/manipulation of system event logs
	22	Introduction of malware	22.2	Introduce malicious software or malicious software activity
	23	Introduction of new software or overwrite existing software	23.1	Fabrication of software of the vehicle control system or information system

High level and sub-level descriptions of vulnerability/ threat			*Example of vulnerability or attack method*	
	24	Disruption of systems or operations	24.1	**Denial of service**, for example this may be triggered on the internal network by flooding a CAN bus, or by provoking faults on an ECU via a high rate of messaging
	25	Manipulation of vehicle parameters	25.1	Unauthorized access of **falsify the configuration parameters** of vehicle's key functions, such as brake data, airbag deployed threshold, etc.
			25.2	Unauthorized access of **falsify the charging parameters**, such as charging voltage, charging power, battery temperature, etc.
4.3.7 Potential vulnerabilities that could be exploited if not sufficiently protected or hardened	26	Cryptographic technologies can be compromised or are insufficiently applied	26.1	Combination of short **encryption** keys and long period of validity enables attacker to break encryption
			26.2	Insufficient use of cryptographic algorithms to protect sensitive systems
			26.3	Using already or soon to be deprecated **cryptographic algorithms**
	27	Parts or supplies could be compromised to permit vehicles to be attacked	27.1	**Hardware or software, engineered to enable an attack or fails to meet design criteria to stop an attack**
	28	Software or hardware development permits vulnerabilities	28.1	Software bugs. The presence of software bugs can be a basis for potential exploitable vulnerabilities. This is particularly true if software has not been tested to verify that known bad code/bugs is not present and reduce the risk of unknown bad code/bugs being present
			28.2	**Using remainders** from development (e.g. debug ports, JTAG ports, microprocessors, development certificates, developer passwords, …) can permit access to ECUs or permit attackers to gain higher privileges
	29	Network design introduces vulnerabilities	29.1	**Superfluous internet ports left open**, providing access to network systems
			29.2	Circumvent **network** separation to gain control. Specific example is the use of unprotected gateways, or access points (such as truck-trailer gateways), to circumvent protections and gain access to other network segments to perform malicious acts, such as sending arbitrary CAN bus messages
	31	Unintended transfer of data can occur	31.1	Information breach. Personal data may be leaked when the car **changes** user (e.g. is sold or is used as hire vehicle with new hirers)
	32	Physical manipulation of systems can enable an attack	32.1	**Manipulation of electronic hardware**, e.g. unauthorized electronic hardware added to a vehicle to enable "man-in-the-middle" attack **Replacement of authorized electronic hardware** (e.g., sensors) with unauthorized electronic hardware **Manipulation of the information** collected by a sensor (for example, using a magnet to tamper with the Hall effect sensor connected to the gearbox)

Reading of those different tables

The reading principle between table A1 and the different tables of part B and part C is the same as the example below:

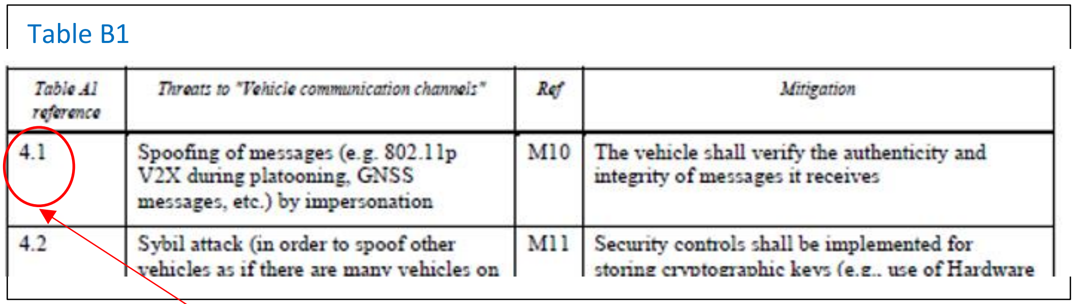


Table B1

Table A1 reference	*Threats to "Vehicle communication channels"*	*Ref*	*Mitigation*
4.1	Spoofing of messages (e.g. 802.11p V2X during platooning, GNSS messages, etc.) by impersonation	M10	The vehicle shall verify the authenticity and integrity of messages it receives
4.2	Sybil attack (in order to spoof other vehicles as if there are many vehicles on	M11	Security controls shall be implemented for storing cryptographic keys (e.g., use of Hardware

This number comes from the columns associated with « example of vulnerability or attack method » from table A1, part A

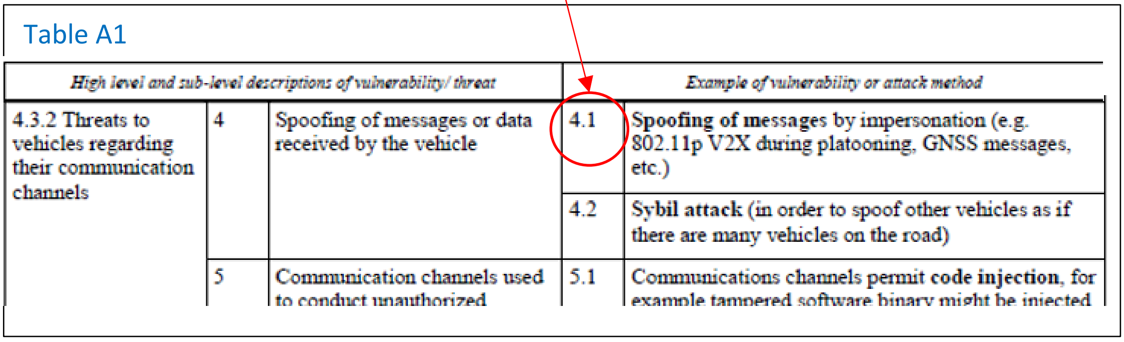


Table A1

High level and sub-level descriptions of vulnerability/ threat			*Example of vulnerability or attack method*	
4.3.2 Threats to vehicles regarding their communication channels	4	Spoofing of messages or data received by the vehicle	4.1	**Spoofing of messages** by impersonation (e.g. 802.11p V2X during platooning, GNSS messages, etc.)
			4.2	**Sybil attack** (in order to spoof other vehicles as if there are many vehicles on the road)
	5	Communication channels used to conduct unauthorized	5.1	Communications channels permit **code injection**, for example tampered software binary might be injected

Table B1 from Part B of annex 5: Mitigation to the threats which are related to 'Vehicle communication channels'

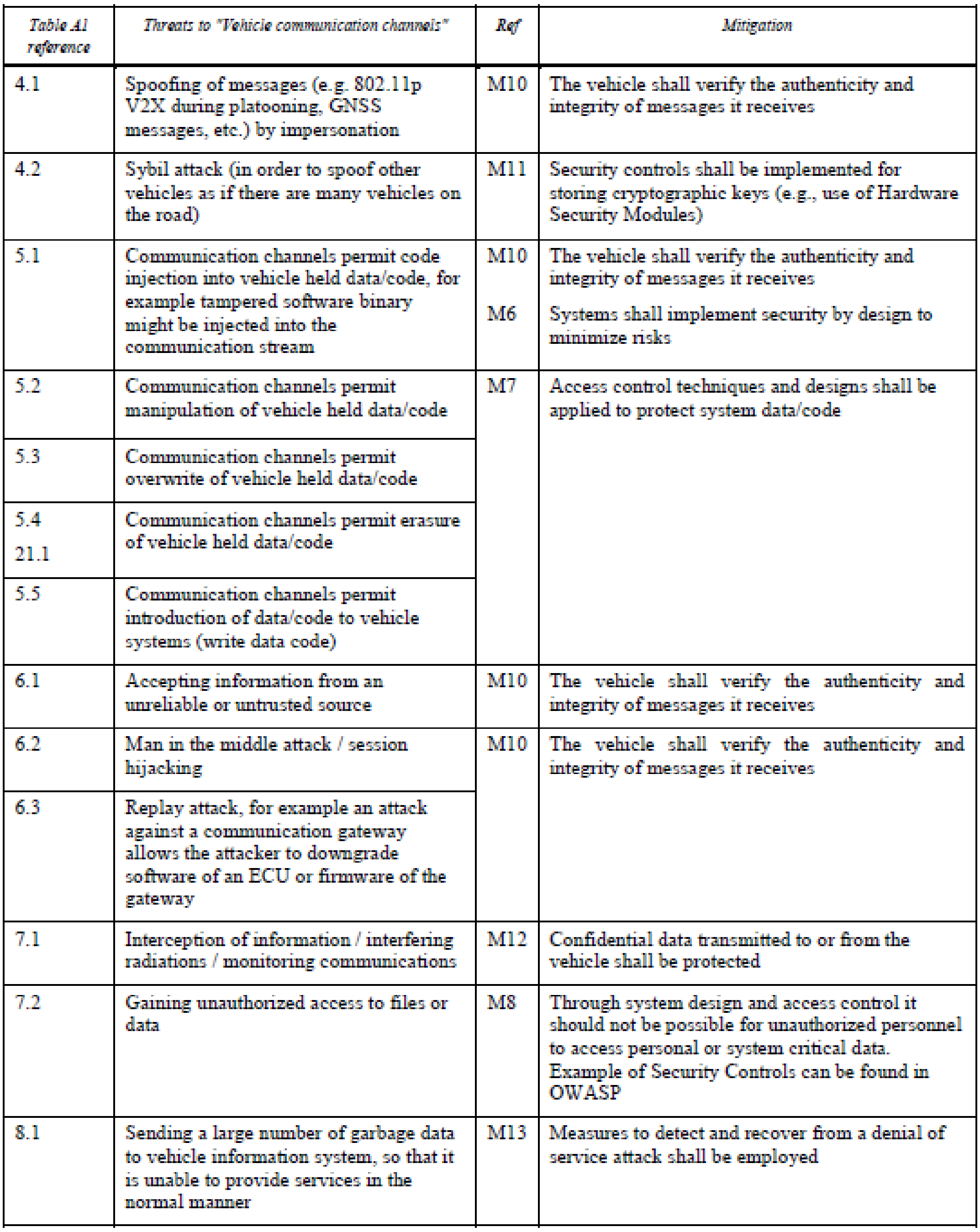


Table A1 reference	*Threats to "Vehicle communication channels"*	*Ref*	*Mitigation*
4.1	Spoofing of messages (e.g. 802.11p V2X during platooning, GNSS messages, etc.) by impersonation	M10	The vehicle shall verify the authenticity and integrity of messages it receives
4.2	Sybil attack (in order to spoof other vehicles as if there are many vehicles on the road)	M11	Security controls shall be implemented for storing cryptographic keys (e.g., use of Hardware Security Modules)
5.1	Communication channels permit code injection into vehicle held data/code, for example tampered software binary might be injected into the communication stream	M10 M6	The vehicle shall verify the authenticity and integrity of messages it receives Systems shall implement security by design to minimize risks
5.2	Communication channels permit manipulation of vehicle held data/code	M7	Access control techniques and designs shall be applied to protect system data/code
5.3	Communication channels permit overwrite of vehicle held data/code		
5.4 21.1	Communication channels permit erasure of vehicle held data/code		
5.5	Communication channels permit introduction of data/code to vehicle systems (write data code)		
6.1	Accepting information from an unreliable or untrusted source	M10	The vehicle shall verify the authenticity and integrity of messages it receives
6.2	Man in the middle attack / session hijacking	M10	The vehicle shall verify the authenticity and integrity of messages it receives
6.3	Replay attack, for example an attack against a communication gateway allows the attacker to downgrade software of an ECU or firmware of the gateway		
7.1	Interception of information / interfering radiations / monitoring communications	M12	Confidential data transmitted to or from the vehicle shall be protected
7.2	Gaining unauthorized access to files or data	M8	Through system design and access control it should not be possible for unauthorized personnel to access personal or system critical data. Example of Security Controls can be found in OWASP
8.1	Sending a large number of garbage data to vehicle information system, so that it is unable to provide services in the normal manner	M13	Measures to detect and recover from a denial of service attack shall be employed

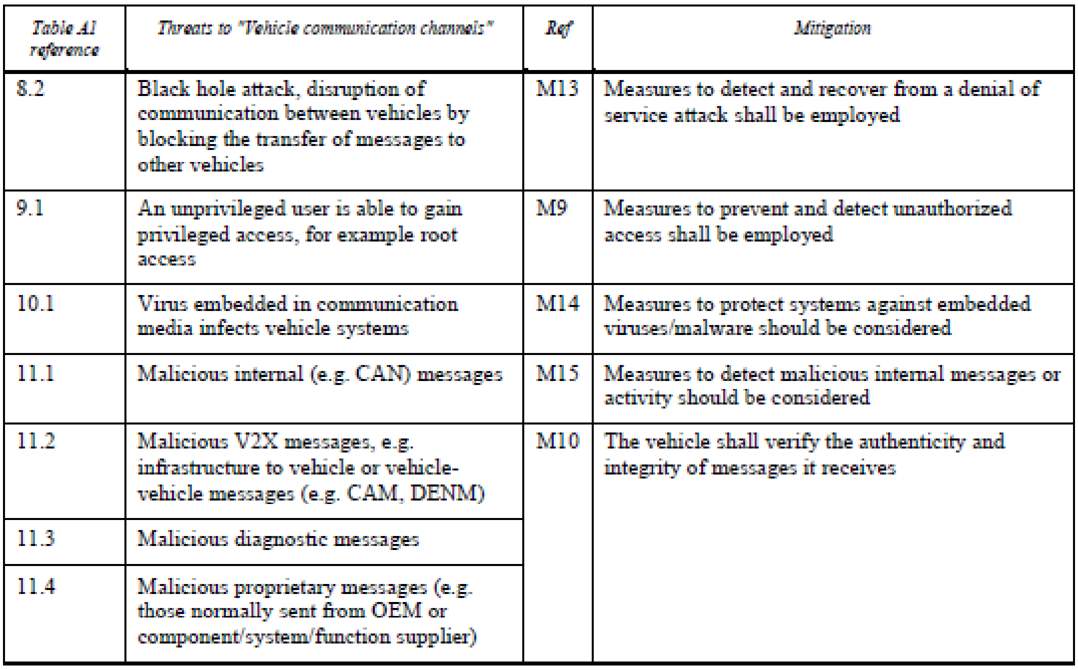


Table A1 reference	*Threats to "Vehicle communication channels"*	*Ref*	*Mitigation*
8.2	Black hole attack, disruption of communication between vehicles by blocking the transfer of messages to other vehicles	M13	Measures to detect and recover from a denial of service attack shall be employed
9.1	An unprivileged user is able to gain privileged access, for example root access	M9	Measures to prevent and detect unauthorized access shall be employed
10.1	Virus embedded in communication media infects vehicle systems	M14	Measures to protect systems against embedded viruses/malware should be considered
11.1	Malicious internal (e.g. CAN) messages	M15	Measures to detect malicious internal messages or activity should be considered
11.2	Malicious V2X messages, e.g. infrastructure to vehicle or vehicle-vehicle messages (e.g. CAM, DENM)	M10	The vehicle shall verify the authenticity and integrity of messages it receives
11.3	Malicious diagnostic messages		
11.4	Malicious proprietary messages (e.g. those normally sent from OEM or component/system/function supplier)		

Table B2 from Part B of annex 5: Mitigations to the threats which are related to 'Update process'

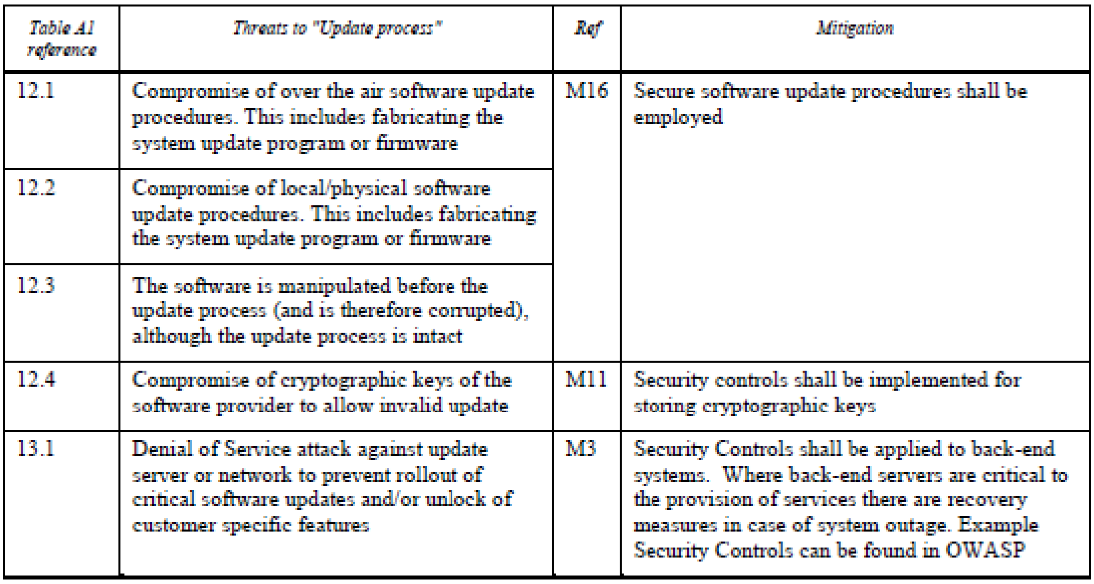


Table A1 reference	*Threats to "Update process"*	*Ref*	*Mitigation*
12.1	Compromise of over the air software update procedures. This includes fabricating the system update program or firmware	M16	Secure software update procedures shall be employed
12.2	Compromise of local/physical software update procedures. This includes fabricating the system update program or firmware		
12.3	The software is manipulated before the update process (and is therefore corrupted), although the update process is intact		
12.4	Compromise of cryptographic keys of the software provider to allow invalid update	M11	Security controls shall be implemented for storing cryptographic keys
13.1	Denial of Service attack against update server or network to prevent rollout of critical software updates and/or unlock of customer specific features	M3	Security Controls shall be applied to back-end systems. Where back-end servers are critical to the provision of services there are recovery measures in case of system outage. Example Security Controls can be found in OWASP

Table B3 from Part B of annex 5: Mitigations to the threats which are related to ‘Unintended human actions facilitating a cyberattack’

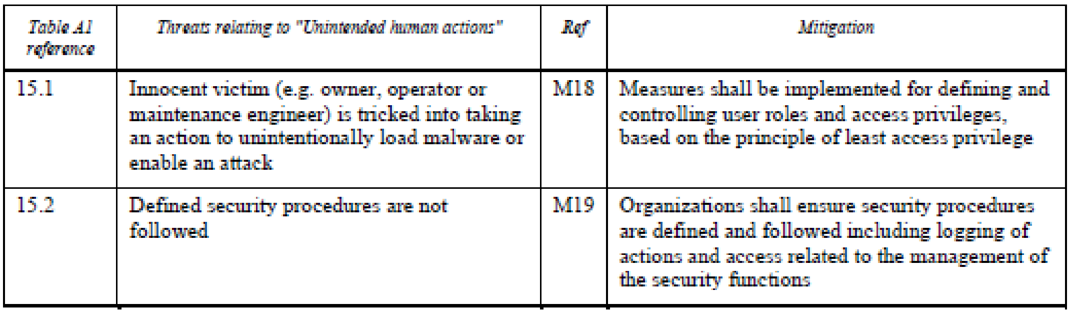


Table A1 reference	*Threats relating to "Unintended human actions"*	*Ref*	*Mitigation*
15.1	Innocent victim (e.g. owner, operator or maintenance engineer) is tricked into taking an action to unintentionally load malware or enable an attack	M18	Measures shall be implemented for defining and controlling user roles and access privileges, based on the principle of least access privilege
15.2	Defined security procedures are not followed	M19	Organizations shall ensure security procedures are defined and followed including logging of actions and access related to the management of the security functions

Table B4 from Part B of annex 5: Mitigation to the threats which are related to ‘external connectivity and connections’

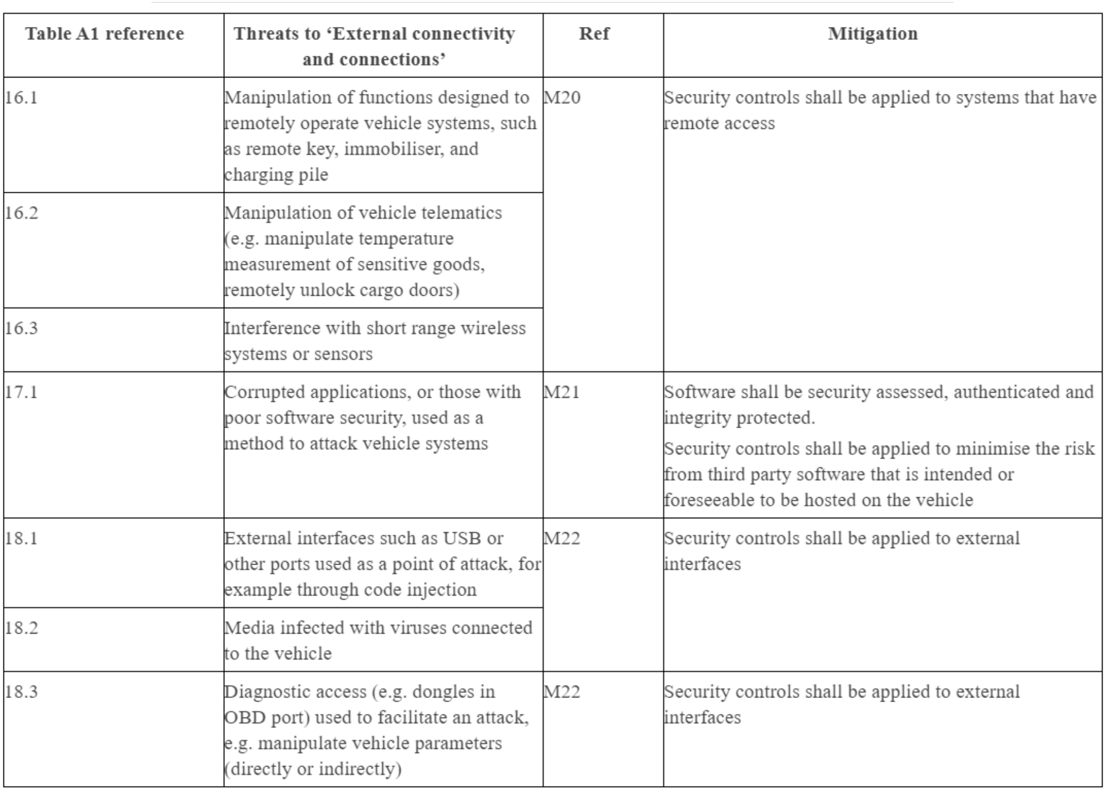


Table A1 reference	Threats to ‘External connectivity and connections’	Ref	Mitigation
16.1	Manipulation of functions designed to remotely operate vehicle systems, such as remote key, immobiliser, and charging pile	M20	Security controls shall be applied to systems that have remote access
16.2	Manipulation of vehicle telematics (e.g. manipulate temperature measurement of sensitive goods, remotely unlock cargo doors)		
16.3	Interference with short range wireless systems or sensors		
17.1	Corrupted applications, or those with poor software security, used as a method to attack vehicle systems	M21	Software shall be security assessed, authenticated and integrity protected. Security controls shall be applied to minimise the risk from third party software that is intended or foreseeable to be hosted on the vehicle
18.1	External interfaces such as USB or other ports used as a point of attack, for example through code injection	M22	Security controls shall be applied to external interfaces
18.2	Media infected with viruses connected to the vehicle		
18.3	Diagnostic access (e.g. dongles in OBD port) used to facilitate an attack, e.g. manipulate vehicle parameters (directly or indirectly)	M22	Security controls shall be applied to external interfaces

Table B5 from Part B of annex 5: Mitigations to the threats which are related to 'Potential targets of, or motivations for, an attack'

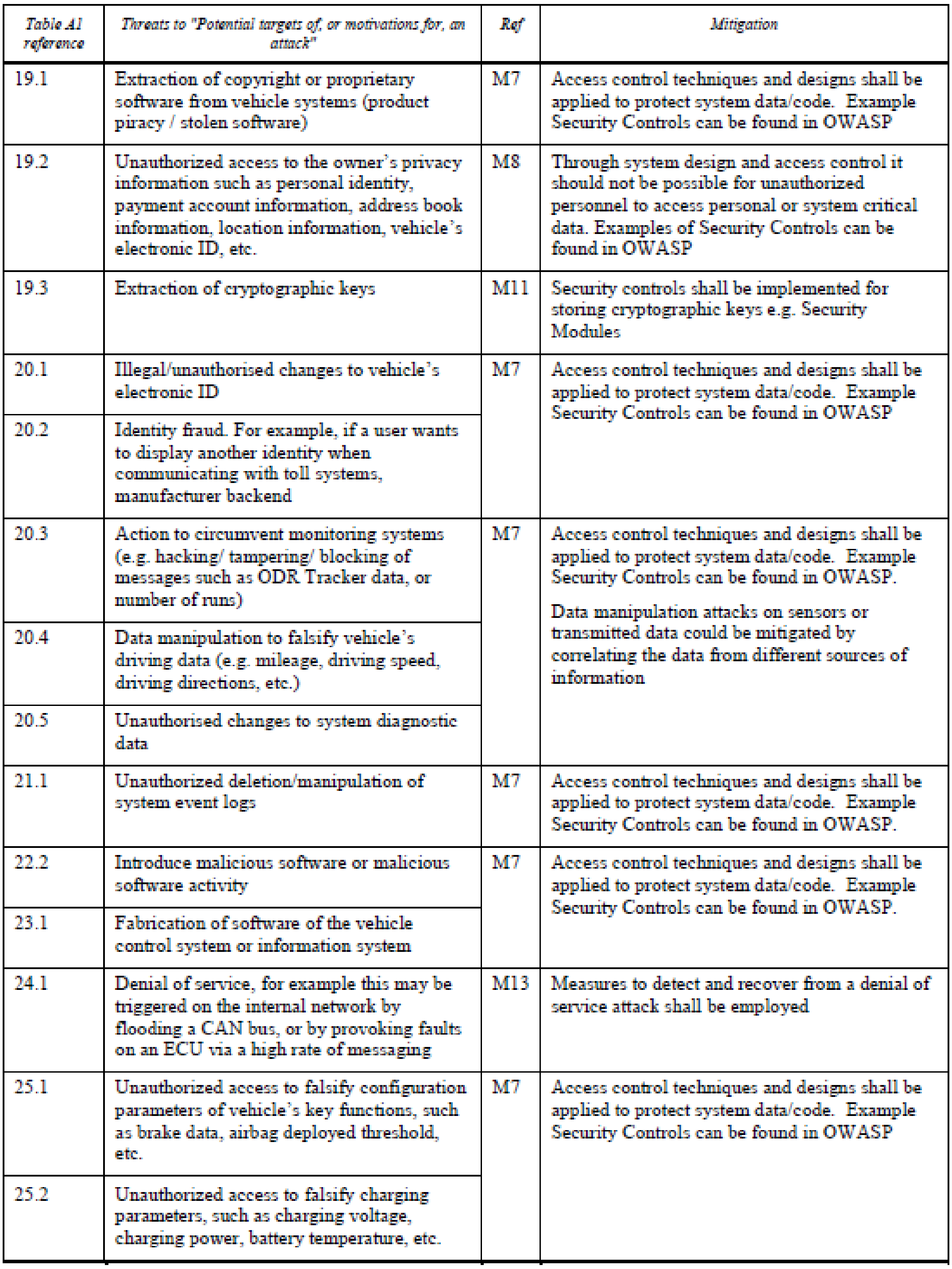


Table A1 reference	*Threats to "Potential targets of, or motivations for, an attack"*	*Ref*	*Mitigation*
19.1	Extraction of copyright or proprietary software from vehicle systems (product piracy / stolen software)	M7	Access control techniques and designs shall be applied to protect system data/code. Example Security Controls can be found in OWASP
19.2	Unauthorized access to the owner's privacy information such as personal identity, payment account information, address book information, location information, vehicle's electronic ID, etc.	M8	Through system design and access control it should not be possible for unauthorized personnel to access personal or system critical data. Examples of Security Controls can be found in OWASP
19.3	Extraction of cryptographic keys	M11	Security controls shall be implemented for storing cryptographic keys e.g. Security Modules
20.1	Illegal/unauthorised changes to vehicle's electronic ID	M7	Access control techniques and designs shall be applied to protect system data/code. Example Security Controls can be found in OWASP
20.2	Identity fraud. For example, if a user wants to display another identity when communicating with toll systems, manufacturer backend		
20.3	Action to circumvent monitoring systems (e.g. hacking/ tampering/ blocking of messages such as ODR Tracker data, or number of runs)	M7	Access control techniques and designs shall be applied to protect system data/code. Example Security Controls can be found in OWASP. Data manipulation attacks on sensors or transmitted data could be mitigated by correlating the data from different sources of information
20.4	Data manipulation to falsify vehicle's driving data (e.g. mileage, driving speed, driving directions, etc.)		
20.5	Unauthorised changes to system diagnostic data		
21.1	Unauthorized deletion/manipulation of system event logs	M7	Access control techniques and designs shall be applied to protect system data/code. Example Security Controls can be found in OWASP.
22.2	Introduce malicious software or malicious software activity	M7	Access control techniques and designs shall be applied to protect system data/code. Example Security Controls can be found in OWASP.
23.1	Fabrication of software of the vehicle control system or information system		
24.1	Denial of service, for example this may be triggered on the internal network by flooding a CAN bus, or by provoking faults on an ECU via a high rate of messaging	M13	Measures to detect and recover from a denial of service attack shall be employed
25.1	Unauthorized access to falsify configuration parameters of vehicle's key functions, such as brake data, airbag deployed threshold, etc.	M7	Access control techniques and designs shall be applied to protect system data/code. Example Security Controls can be found in OWASP
25.2	Unauthorized access to falsify charging parameters, such as charging voltage, charging power, battery temperature, etc.		

Table B6 from Part B of annex 5: Mitigations to the threats which are related to 'Potential vulnerabilities that could be exploited if not sufficiently protected or hardened'

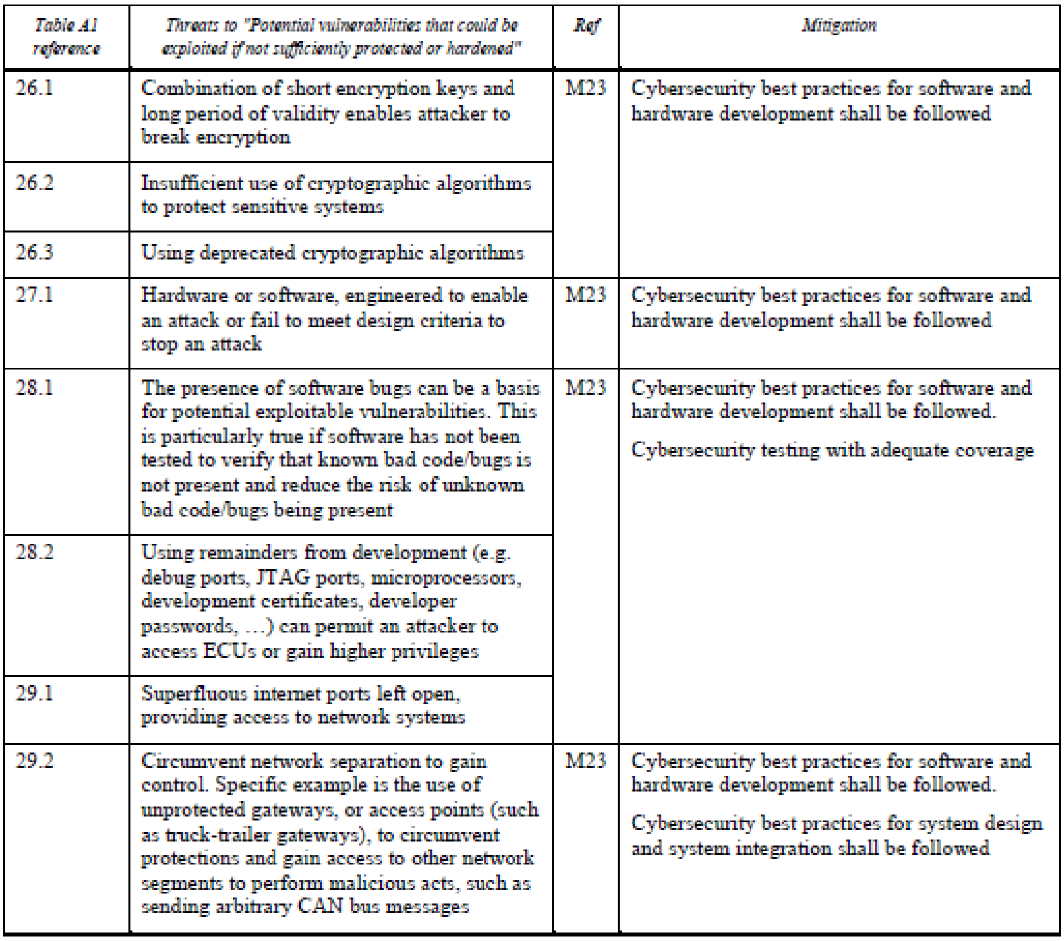


Table A1 reference	*Threats to "Potential vulnerabilities that could be exploited if not sufficiently protected or hardened"*	*Ref*	*Mitigation*
26.1	Combination of short encryption keys and long period of validity enables attacker to break encryption	M23	Cybersecurity best practices for software and hardware development shall be followed
26.2	Insufficient use of cryptographic algorithms to protect sensitive systems		
26.3	Using deprecated cryptographic algorithms		
27.1	Hardware or software, engineered to enable an attack or fail to meet design criteria to stop an attack	M23	Cybersecurity best practices for software and hardware development shall be followed
28.1	The presence of software bugs can be a basis for potential exploitable vulnerabilities. This is particularly true if software has not been tested to verify that known bad code/bugs is not present and reduce the risk of unknown bad code/bugs being present	M23	Cybersecurity best practices for software and hardware development shall be followed. Cybersecurity testing with adequate coverage
28.2	Using remainders from development (e.g. debug ports, JTAG ports, microprocessors, development certificates, developer passwords, …) can permit an attacker to access ECUs or gain higher privileges		
29.1	Superfluous internet ports left open, providing access to network systems		
29.2	Circumvent network separation to gain control. Specific example is the use of unprotected gateways, or access points (such as truck-trailer gateways), to circumvent protections and gain access to other network segments to perform malicious acts, such as sending arbitrary CAN bus messages	M23	Cybersecurity best practices for software and hardware development shall be followed. Cybersecurity best practices for system design and system integration shall be followed

Table B7 from Part B of annex 5: Mitigations to the threats which are related to 'Data loss / data breach from vehicle'

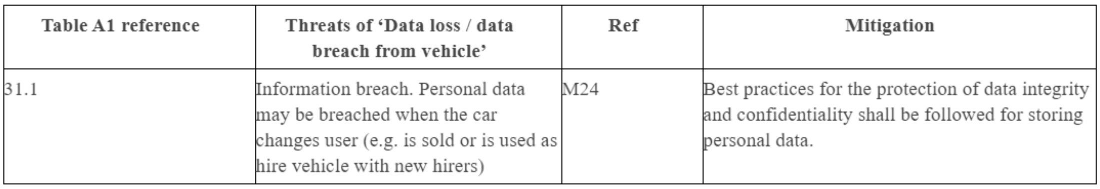


Table A1 reference	**Threats of 'Data loss / data breach from vehicle'**	**Ref**	**Mitigation**
31.1	Information breach. Personal data may be breached when the car changes user (e.g. is sold or is used as hire vehicle with new hirers)	M24	Best practices for the protection of data integrity and confidentiality shall be followed for storing personal data.

Table B8 from Part B of annex 5: Mitigations to the threats which are related to 'Physical manipulation of systems to enable an attack'

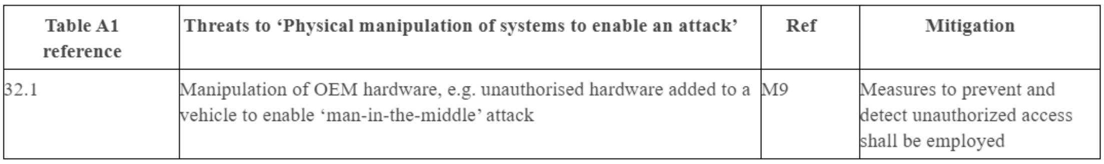


Table A1 reference	**Threats to 'Physical manipulation of systems to enable an attack'**	**Ref**	**Mitigation**
32.1	Manipulation of OEM hardware, e.g. unauthorised hardware added to a vehicle to enable 'man-in-the-middle' attack	M9	Measures to prevent and detect unauthorized access shall be employed

Table C1 from Part C of annex 5: Mitigations to the threats which are related to ‘Back-end servers’

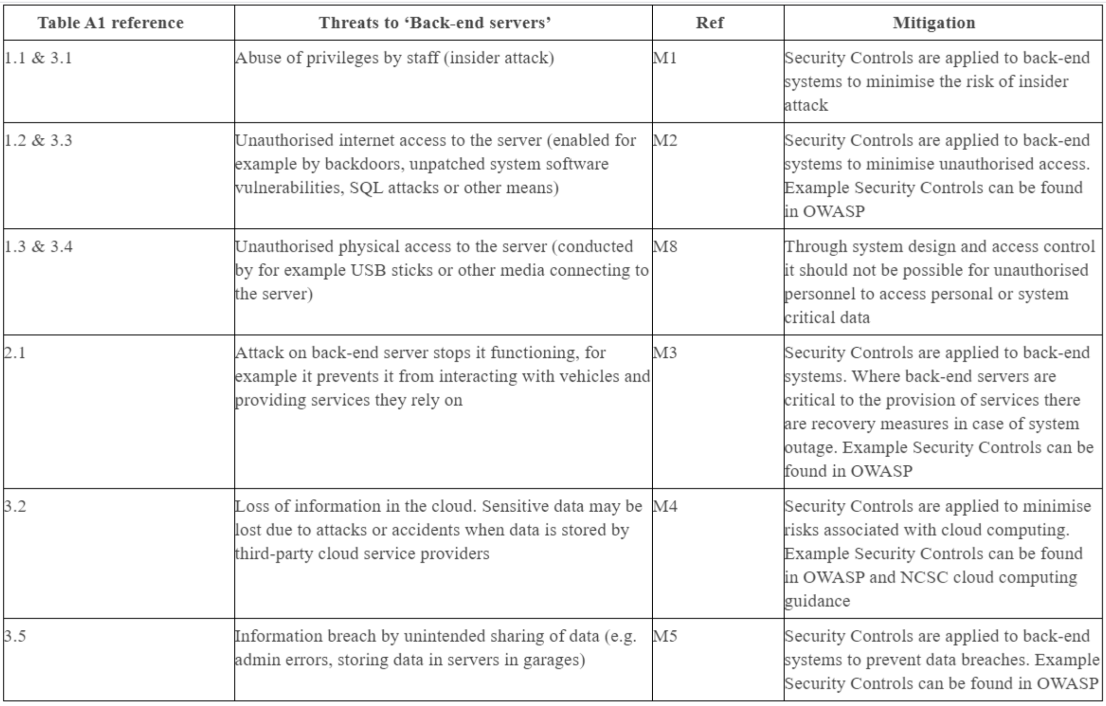


Table A1 reference	Threats to ‘Back-end servers’	Ref	Mitigation
1.1 & 3.1	Abuse of privileges by staff (insider attack)	M1	Security Controls are applied to back-end systems to minimise the risk of insider attack
1.2 & 3.3	Unauthorised internet access to the server (enabled for example by backdoors, unpatched system software vulnerabilities, SQL attacks or other means)	M2	Security Controls are applied to back-end systems to minimise unauthorised access. Example Security Controls can be found in OWASP
1.3 & 3.4	Unauthorised physical access to the server (conducted by for example USB sticks or other media connecting to the server)	M8	Through system design and access control it should not be possible for unauthorised personnel to access personal or system critical data
2.1	Attack on back-end server stops it functioning, for example it prevents it from interacting with vehicles and providing services they rely on	M3	Security Controls are applied to back-end systems. Where back-end servers are critical to the provision of services there are recovery measures in case of system outage. Example Security Controls can be found in OWASP
3.2	Loss of information in the cloud. Sensitive data may be lost due to attacks or accidents when data is stored by third-party cloud service providers	M4	Security Controls are applied to minimise risks associated with cloud computing. Example Security Controls can be found in OWASP and NCSC cloud computing guidance
3.5	Information breach by unintended sharing of data (e.g. admin errors, storing data in servers in garages)	M5	Security Controls are applied to back-end systems to prevent data breaches. Example Security Controls can be found in OWASP

Table C2 from Part C of annex 5: Mitigations to the threats which are related to ‘Unintended human actions’

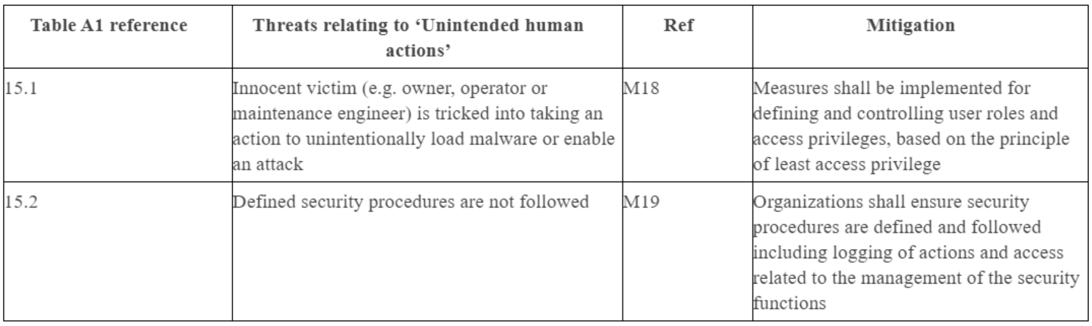


Table A1 reference	Threats relating to ‘Unintended human actions’	Ref	Mitigation
15.1	Innocent victim (e.g. owner, operator or maintenance engineer) is tricked into taking an action to unintentionally load malware or enable an attack	M18	Measures shall be implemented for defining and controlling user roles and access privileges, based on the principle of least access privilege
15.2	Defined security procedures are not followed	M19	Organizations shall ensure security procedures are defined and followed including logging of actions and access related to the management of the security functions

Table C3 from Part C of annex 5: Mitigations to the threats which are related to ‘Physical loss of data’

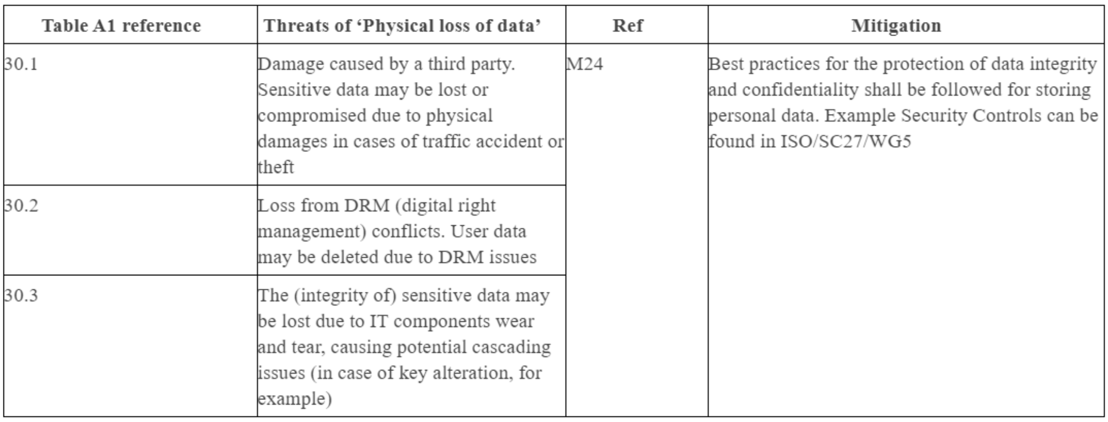


Table A1 reference	Threats of ‘Physical loss of data’	Ref	Mitigation
30.1	Damage caused by a third party. Sensitive data may be lost or compromised due to physical damages in cases of traffic accident or theft	M24	Best practices for the protection of data integrity and confidentiality shall be followed for storing personal data. Example Security Controls can be found in ISO/SC27/WG5
30.2	Loss from DRM (digital right management) conflicts. User data may be deleted due to DRM issues		
30.3	The (integrity of) sensitive data may be lost due to IT components wear and tear, causing potential cascading issues (in case of key alteration, for example)		

Annex 22: REGULATION RID-2021 (COTIF)

REGULATION RID-2021 (COTIF)

A. IDENTITY CARD OF REGULATION RID-2021 (COTIF)

RCS	Number of RCS	Title	Date	Stability date	Statutory
Regulation	RID-2021 (COTIF)	RID Regulations concerning the International Carriage of Dangerous Goods by Rail	06/07/2021	01/01/2021	Y

COTIF: Convention concerning International Carriage by Rail

RID: The Regulation concerning the International Carriage of Dangerous Goods by Rail (RID) forms Appendix C to COTIF, and has an annex. This Regulation applies to international traffic.

Scope: Carriage of dangerous goods by rail

In sub-chapter 1.1.3.2 *"Exemptions related to the carriage of gases"*, it is stated that this RID agreement does not apply to substances used for the propulsion of railway vehicles, ...
It is written in this chapter: *"gases contained in fuel tanks or cylinders of railway vehicles performing a transport operation and destineted for their propulsion or for the operation of any of their equipment used or intended for use during carriage"*.
And
In sub-chapter 1.1.3.7: *"Exemptions related to the carriage of electric energy storage and production systems"*:
"The provisions laid down in RID do not apply to electric enegy storage and production systems (e.g. ....and fuel cell:

(c) installed in railway vehicle, performing a transport operation and destined for its propulsion or for the operation of its equipment"

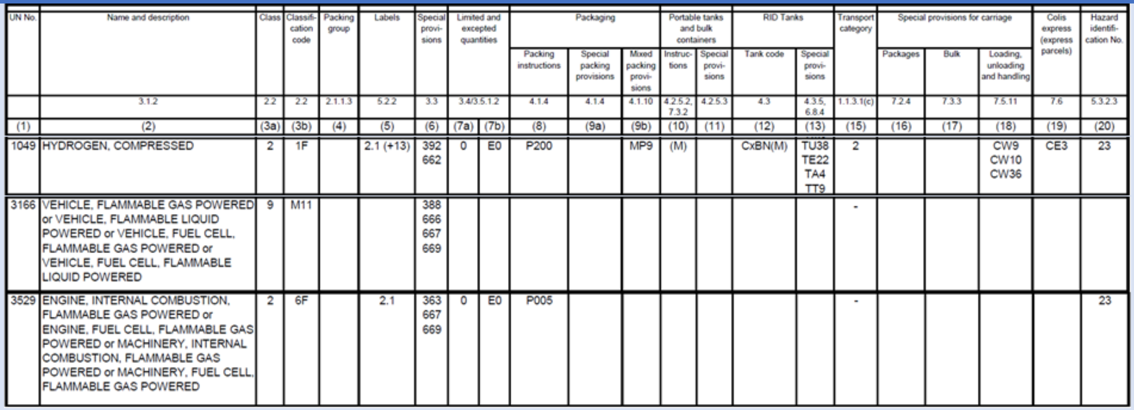
However, for the StasHH project, the requirements and regulations associated with compressed gas tanks may be, in part, relevant to the StasHH project. This sheet has been analyzed in this sense.

Domain/category: carriage of gases in railway vehicle

Specifed exclusion: see above concerning the main exemptions related to the carriage of gases (Interesting about the StasHH project).

Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td>Part 3: Dangerous goods list, special provisions and exemptions related to limited and excepted quantities</td><td>Chapter 3.2 Dangerous goods list</td><td>Table A: List of dangerous goods in numerical order</td><td>
<table>
<tr><th>UN No.</th><th>Name and description</th><th>Class</th><th>Classification code</th><th>Packing group</th><th>Labels</th><th>Special provisions</th><th colspan="2">Limited and excepted quantities</th><th colspan="3">Packaging</th><th colspan="2">Portable tanks and bulk containers</th><th colspan="2">RID Tanks</th><th>Transport category</th><th colspan="3">Special provisions for carriage</th><th>Colis express (express parcels)</th><th>Hazard identification No.</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Packing instructions</td><td>Special packing provisions</td><td>Mixed packing provisions</td><td>Instructions</td><td>Special provisions</td><td>Tank code</td><td>Special provisions</td><td></td><td>Packages</td><td>Bulk</td><td>Loading, unloading and handling</td><td></td><td></td></tr>
<tr><td></td><td>3.1.2</td><td>2.2</td><td>2.2</td><td>2.1.1.3</td><td>5.2.2</td><td>3.3</td><td colspan="2">3.4/3.5.1.2</td><td>4.1.4</td><td>4.1.4</td><td>4.1.10</td><td>4.2.5.2, 7.3.2</td><td>4.2.5.3</td><td>4.3</td><td>4.3.5, 6.8.4</td><td>1.1.3.1(c)</td><td>7.2.4</td><td>7.3.3</td><td>7.5.11</td><td>7.6</td><td>5.3.2.3</td></tr>
<tr><td>(1)</td><td>(2)</td><td>(3a)</td><td>(3b)</td><td>(4)</td><td>(5)</td><td>(6)</td><td>(7a)</td><td>(7b)</td><td>(8)</td><td>(9a)</td><td>(9b)</td><td>(10)</td><td>(11)</td><td>(12)</td><td>(13)</td><td>(15)</td><td>(16)</td><td>(17)</td><td>(18)</td><td>(19)</td><td>(20)</td></tr>
<tr><td>1049</td><td>HYDROGEN, COMPRESSED</td><td>2</td><td>1F</td><td></td><td>2.1 (+13)</td><td>392
662</td><td>0</td><td>E0</td><td>P200</td><td></td><td>MP9</td><td>(M)</td><td></td><td>CxBN(M)</td><td>TU38
TE22
TA4
TT9</td><td>2</td><td></td><td></td><td>CW9
CW10
CW36</td><td>CE3</td><td>23</td></tr>
<tr><td>3166</td><td>VEHICLE, FLAMMABLE GAS POWERED or VEHICLE, FLAMMABLE LIQUID POWERED or VEHICLE, FUEL CELL, FLAMMABLE GAS POWERED or VEHICLE, FUEL CELL, FLAMMABLE LIQUID POWERED</td><td>9</td><td>M11</td><td></td><td></td><td>388
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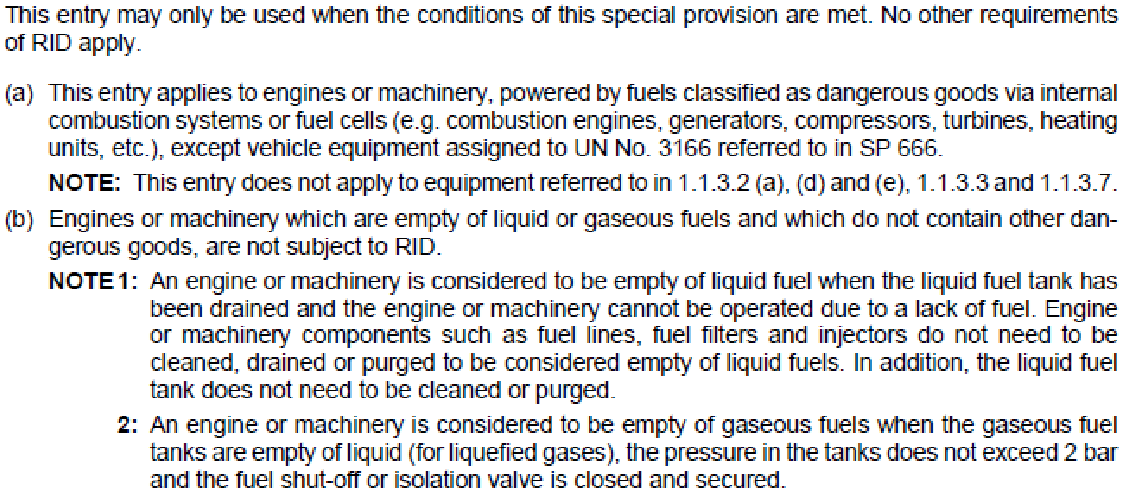
669</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>-</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>3529</td><td>ENGINE, INTERNAL COMBUSTION, FLAMMABLE GAS POWERED or ENGINE, FUEL CELL, FLAMMABLE GAS POWERED or MACHINERY, INTERNAL COMBUSTION, FLAMMABLE GAS POWERED or MACHINERY, FUEL CELL, FLAMMABLE GAS POWERED</td><td>2</td><td>6F</td><td></td><td>2.1</td><td>363
667
669</td><td>0</td><td>E0</td><td>P005</td><td></td><td></td><td></td><td></td><td></td><td></td><td>-</td><td></td><td></td><td></td><td></td><td>23</td></tr>
</table>
The explanations concerning Table A: see page 861 onwards.</td><td></td></tr>
<tr><td>Part 3: Dangerous goods list, special provisions and exemptions related to limited and excepted quantities</td><td>Chapter 3.3 Special provisions applicable to certain articles or substances</td><td>Special provisions number: 363</td><td>
This entry may only be used when the conditions of this special provision are met. No other requirements of RID apply.
(a) This entry applies to engines or machinery, powered by fuels classified as dangerous goods via internal combustion systems or fuel cells (e.g. combustion engines, generators, compressors, turbines, heating units, etc.), except vehicle equipment assigned to UN No. 3166 referred to in SP 666.
NOTE: This entry does not apply to equipment referred to in 1.1.3.2 (a), (d) and (e), 1.1.3.3 and 1.1.3.7.
(b) Engines or machinery which are empty of liquid or gaseous fuels and which do not contain other dangerous goods, are not subject to RID.
NOTE 1: An engine or machinery is considered to be empty of liquid fuel when the liquid fuel tank has been drained and the engine or machinery cannot be operated due to a lack of fuel. Engine or machinery components such as fuel lines, fuel filters and injectors do not need to be cleaned, drained or purged to be considered empty of liquid fuels. In addition, the liquid fuel tank does not need to be cleaned or purged.
2: An engine or machinery is considered to be empty of gaseous fuels when the gaseous fuel tanks are empty of liquid (for liquefied gases), the pressure in the tanks does not exceed 2 bar and the fuel shut-off or isolation valve is closed and secured.</td><td></td></tr>
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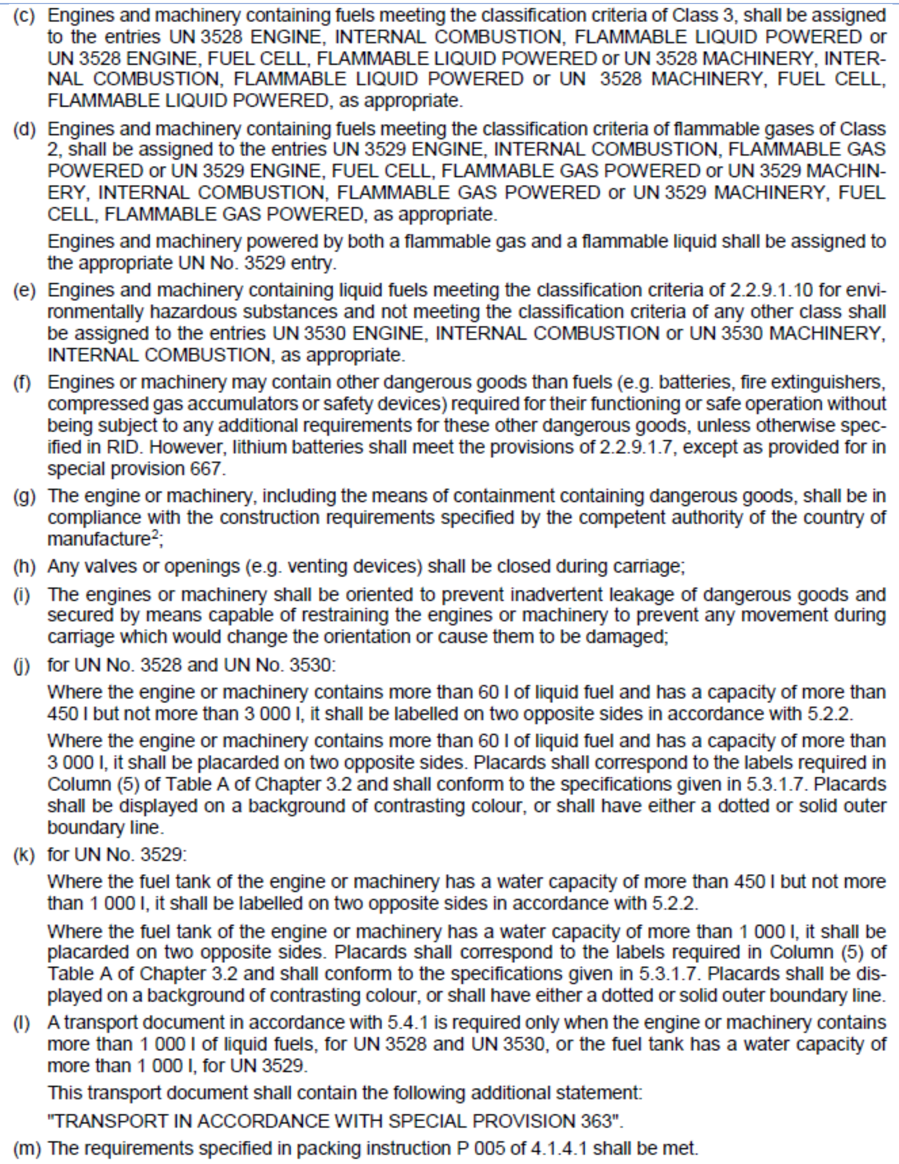


(c) Engines and machinery containing fuels meeting the classification criteria of Class 3, shall be assigned to the entries UN 3528 ENGINE, INTERNAL COMBUSTION, FLAMMABLE LIQUID POWERED or UN 3528 ENGINE, FUEL CELL, FLAMMABLE LIQUID POWERED or UN 3528 MACHINERY, INTERNAL COMBUSTION, FLAMMABLE LIQUID POWERED or UN 3528 MACHINERY, FUEL CELL, FLAMMABLE LIQUID POWERED, as appropriate.

(d) Engines and machinery containing fuels meeting the classification criteria of flammable gases of Class 2, shall be assigned to the entries UN 3529 ENGINE, INTERNAL COMBUSTION, FLAMMABLE GAS POWERED or UN 3529 ENGINE, FUEL CELL, FLAMMABLE GAS POWERED or UN 3529 MACHINERY, INTERNAL COMBUSTION, FLAMMABLE GAS POWERED or UN 3529 MACHINERY, FUEL CELL, FLAMMABLE GAS POWERED, as appropriate.

Engines and machinery powered by both a flammable gas and a flammable liquid shall be assigned to the appropriate UN No. 3529 entry.

(e) Engines and machinery containing liquid fuels meeting the classification criteria of 2.2.9.1.10 for environmentally hazardous substances and not meeting the classification criteria of any other class shall be assigned to the entries UN 3530 ENGINE, INTERNAL COMBUSTION or UN 3530 MACHINERY, INTERNAL COMBUSTION, as appropriate.

(f) Engines or machinery may contain other dangerous goods than fuels (e.g. batteries, fire extinguishers, compressed gas accumulators or safety devices) required for their functioning or safe operation without being subject to any additional requirements for these other dangerous goods, unless otherwise specified in RID. However, lithium batteries shall meet the provisions of 2.2.9.1.7, except as provided for in special provision 667.

(g) The engine or machinery, including the means of containment containing dangerous goods, shall be in compliance with the construction requirements specified by the competent authority of the country of manufacture[2];

(h) Any valves or openings (e.g. venting devices) shall be closed during carriage;

(i) The engines or machinery shall be oriented to prevent inadvertent leakage of dangerous goods and secured by means capable of restraining the engines or machinery to prevent any movement during carriage which would change the orientation or cause them to be damaged;

(j) for UN No. 3528 and UN No. 3530:

Where the engine or machinery contains more than 60 l of liquid fuel and has a capacity of more than 450 l but not more than 3 000 l, it shall be labelled on two opposite sides in accordance with 5.2.2.

Where the engine or machinery contains more than 60 l of liquid fuel and has a capacity of more than 3 000 l, it shall be placarded on two opposite sides. Placards shall correspond to the labels required in Column (5) of Table A of Chapter 3.2 and shall conform to the specifications given in 5.3.1.7. Placards shall be displayed on a background of contrasting colour, or shall have either a dotted or solid outer boundary line.

(k) for UN No. 3529:

Where the fuel tank of the engine or machinery has a water capacity of more than 450 l but not more than 1 000 l, it shall be labelled on two opposite sides in accordance with 5.2.2.

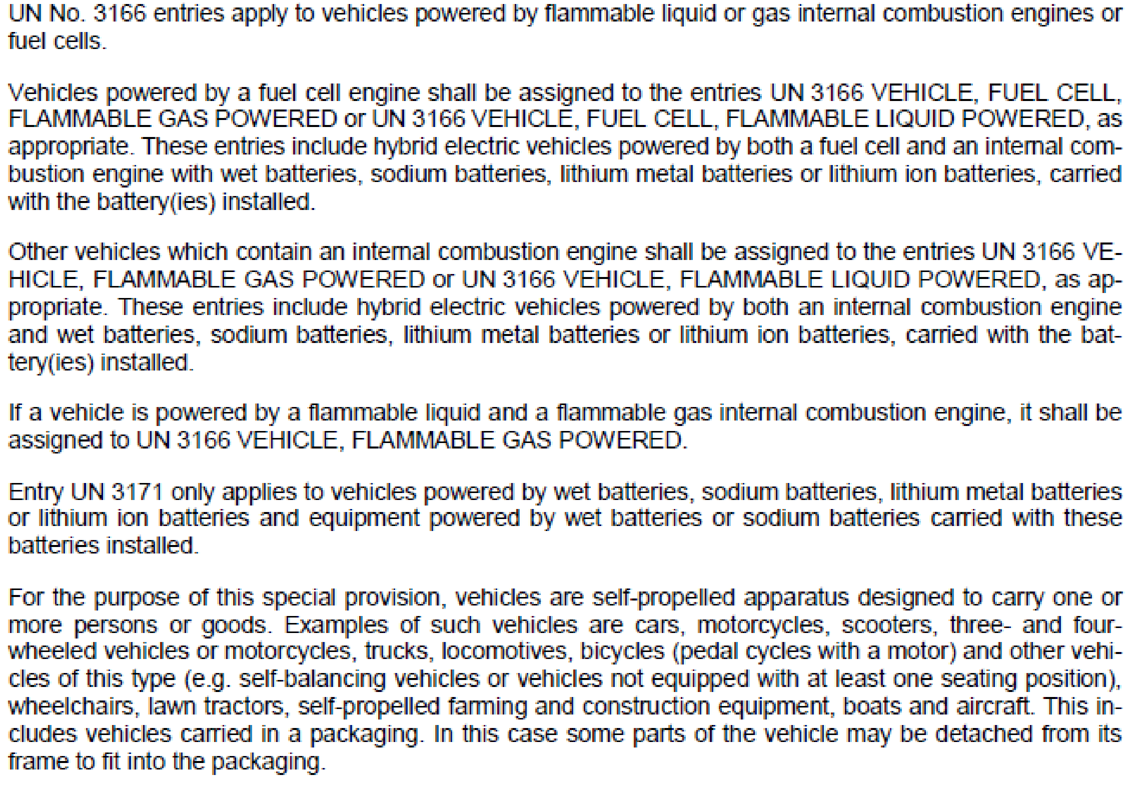
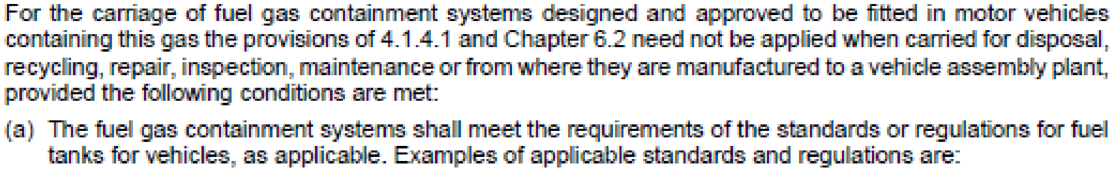
Where the fuel tank of the engine or machinery has a water capacity of more than 1 000 l, it shall be placarded on two opposite sides. Placards shall correspond to the labels required in Column (5) of Table A of Chapter 3.2 and shall conform to the specifications given in 5.3.1.7. Placards shall be displayed on a background of contrasting colour, or shall have either a dotted or solid outer boundary line.

(l) A transport document in accordance with 5.4.1 is required only when the engine or machinery contains more than 1 000 l of liquid fuels, for UN 3528 and UN 3530, or the fuel tank has a water capacity of more than 1 000 l, for UN 3529.

This transport document shall contain the following additional statement:

"TRANSPORT IN ACCORDANCE WITH SPECIAL PROVISION 363".

(m) The requirements specified in packing instruction P 005 of 4.1.4.1 shall be met.

Conditions	Item	Documentation	Additional Description	Information
Part 3: Dangerous goods list, special provisions and exemptions related to limited and excepted quantities	Chapter 3.3 Special provisions applicable to certain articles or substances	Special provisions number: 388	 UN No. 3166 entries apply to vehicles powered by flammable liquid or gas internal combustion engines or fuel cells. Vehicles powered by a fuel cell engine shall be assigned to the entries UN 3166 VEHICLE, FUEL CELL, FLAMMABLE GAS POWERED or UN 3166 VEHICLE, FUEL CELL, FLAMMABLE LIQUID POWERED, as appropriate. These entries include hybrid electric vehicles powered by both a fuel cell and an internal combustion engine with wet batteries, sodium batteries, lithium metal batteries or lithium ion batteries, carried with the battery(ies) installed. Other vehicles which contain an internal combustion engine shall be assigned to the entries UN 3166 VEHICLE, FLAMMABLE GAS POWERED or UN 3166 VEHICLE, FLAMMABLE LIQUID POWERED, as appropriate. These entries include hybrid electric vehicles powered by both an internal combustion engine and wet batteries, sodium batteries, lithium metal batteries or lithium ion batteries, carried with the battery(ies) installed. If a vehicle is powered by a flammable liquid and a flammable gas internal combustion engine, it shall be assigned to UN 3166 VEHICLE, FLAMMABLE GAS POWERED. Entry UN 3171 only applies to vehicles powered by wet batteries, sodium batteries, lithium metal batteries or lithium ion batteries and equipment powered by wet batteries or sodium batteries carried with these batteries installed. For the purpose of this special provision, vehicles are self-propelled apparatus designed to carry one or more persons or goods. Examples of such vehicles are cars, motorcycles, scooters, three- and four-wheeled vehicles or motorcycles, trucks, locomotives, bicycles (pedal cycles with a motor) and other vehicles of this type (e.g. self-balancing vehicles or vehicles not equipped with at least one seating position), wheelchairs, lawn tractors, self-propelled farming and construction equipment, boats and aircraft. This includes vehicles carried in a packaging. In this case some parts of the vehicle may be detached from its frame to fit into the packaging.	
Part 3: Dangerous goods list, special provisions and exemptions related to	Chapter 3.3 Special provisions applicable to certain articles or substances	Special provisions number: 392	 For the carriage of fuel gas containment systems designed and approved to be fitted in motor vehicles containing this gas the provisions of 4.1.4.1 and Chapter 6.2 need not be applied when carried for disposal, recycling, repair, inspection, maintenance or from where they are manufactured to a vehicle assembly plant, provided the following conditions are met: (a) The fuel gas containment systems shall meet the requirements of the standards or regulations for fuel tanks for vehicles, as applicable. Examples of applicable standards and regulations are:	Regulations (EC) 2010/410 and (EC) 2009/79 will be repealed in july 2022

<table>
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<tr>
<td>limited and excepted quantities</td>
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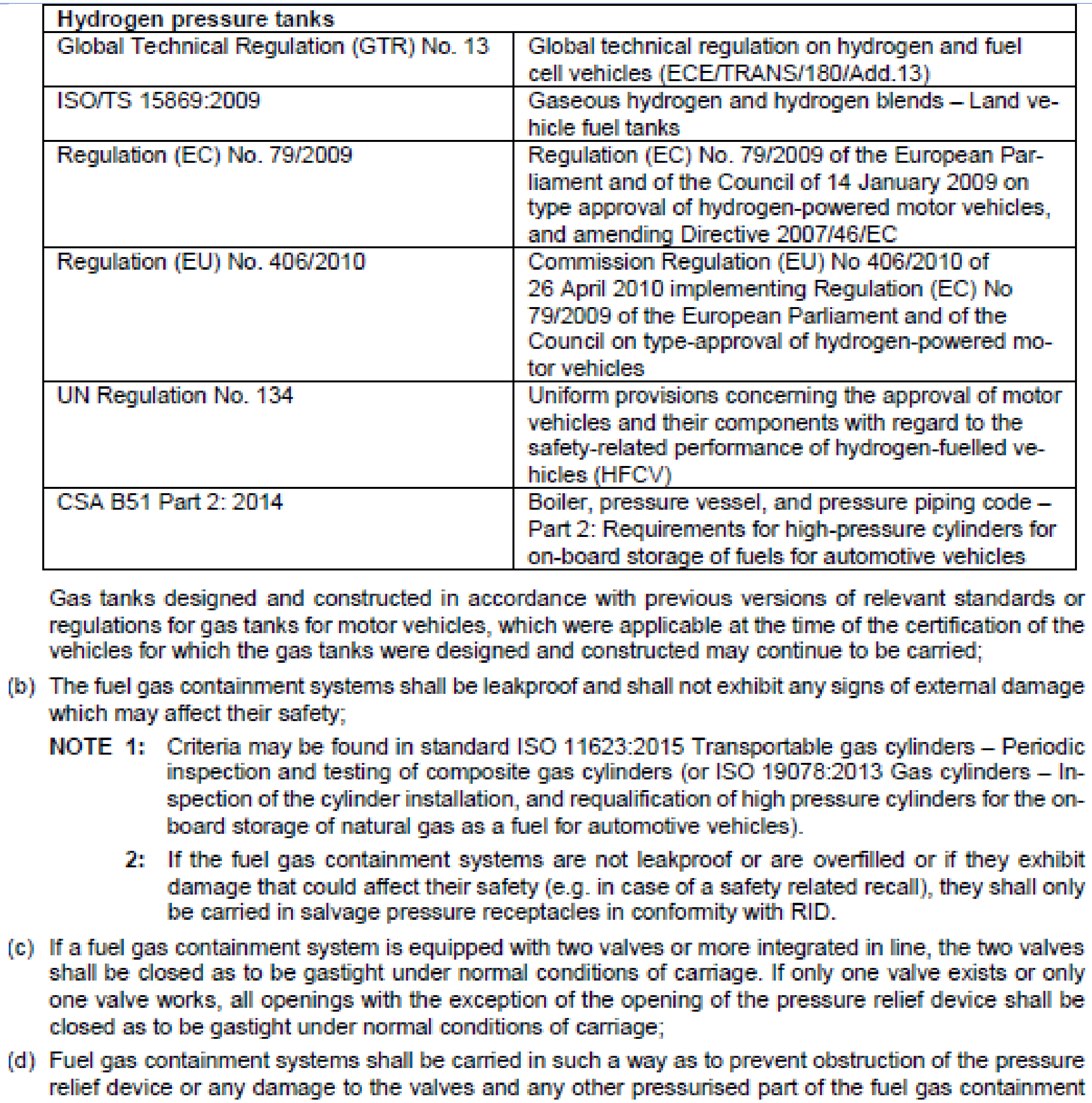

<table>
<tr><th colspan="2">Hydrogen pressure tanks</th></tr>
<tr><td>Global Technical Regulation (GTR) No. 13</td><td>Global technical regulation on hydrogen and fuel cell vehicles (ECE/TRANS/180/Add.13)</td></tr>
<tr><td>ISO/TS 15869:2009</td><td>Gaseous hydrogen and hydrogen blends – Land vehicle fuel tanks</td></tr>
<tr><td>Regulation (EC) No. 79/2009</td><td>Regulation (EC) No. 79/2009 of the European Parliament and of the Council of 14 January 2009 on type approval of hydrogen-powered motor vehicles, and amending Directive 2007/46/EC</td></tr>
<tr><td>Regulation (EU) No. 406/2010</td><td>Commission Regulation (EU) No 406/2010 of 26 April 2010 implementing Regulation (EC) No 79/2009 of the European Parliament and of the Council on type-approval of hydrogen-powered motor vehicles</td></tr>
<tr><td>UN Regulation No. 134</td><td>Uniform provisions concerning the approval of motor vehicles and their components with regard to the safety-related performance of hydrogen-fuelled vehicles (HFCV)</td></tr>
<tr><td>CSA B51 Part 2: 2014</td><td>Boiler, pressure vessel, and pressure piping code – Part 2: Requirements for high-pressure cylinders for on-board storage of fuels for automotive vehicles</td></tr>
</table>

Gas tanks designed and constructed in accordance with previous versions of relevant standards or regulations for gas tanks for motor vehicles, which were applicable at the time of the certification of the vehicles for which the gas tanks were designed and constructed may continue to be carried;

(b) The fuel gas containment systems shall be leakproof and shall not exhibit any signs of external damage which may affect their safety;

NOTE 1: Criteria may be found in standard ISO 11623:2015 Transportable gas cylinders – Periodic inspection and testing of composite gas cylinders (or ISO 19078:2013 Gas cylinders – Inspection of the cylinder installation, and requalification of high pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles).

2: If the fuel gas containment systems are not leakproof or are overfilled or if they exhibit damage that could affect their safety (e.g. in case of a safety related recall), they shall only be carried in salvage pressure receptacles in conformity with RID.

(c) If a fuel gas containment system is equipped with two valves or more integrated in line, the two valves shall be closed as to be gastight under normal conditions of carriage. If only one valve exists or only one valve works, all openings with the exception of the opening of the pressure relief device shall be closed as to be gastight under normal conditions of carriage;

(d) Fuel gas containment systems shall be carried in such a way as to prevent obstruction of the pressure relief device or any damage to the valves and any other pressurised part of the fuel gas containment
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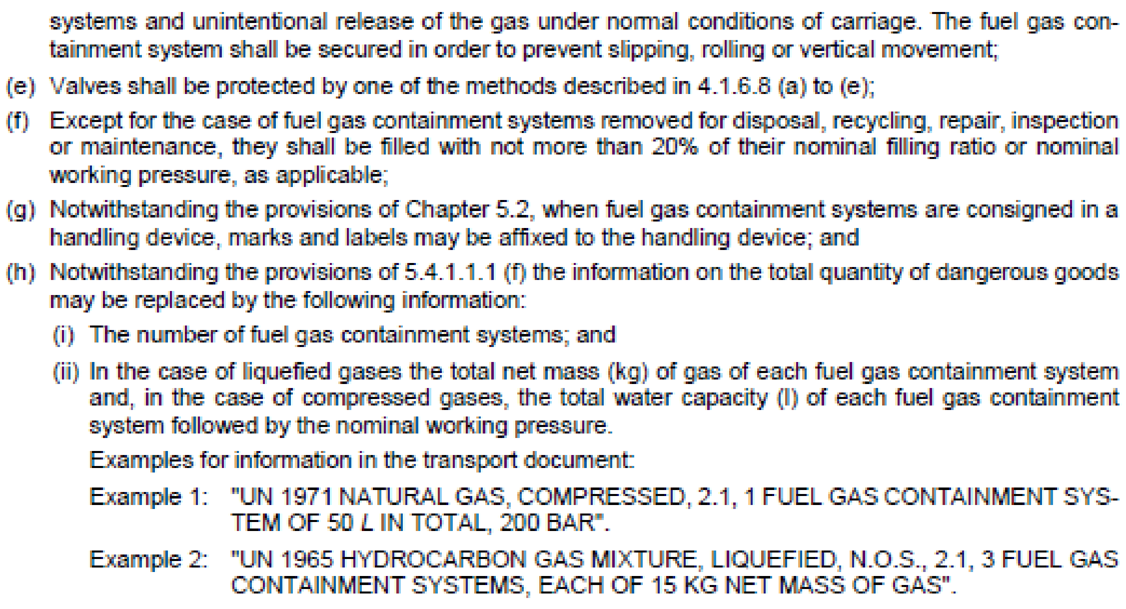
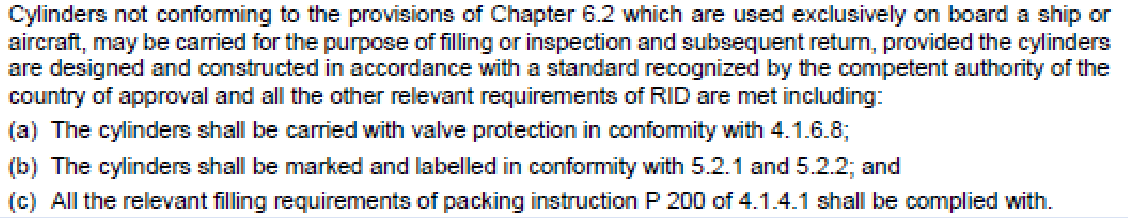
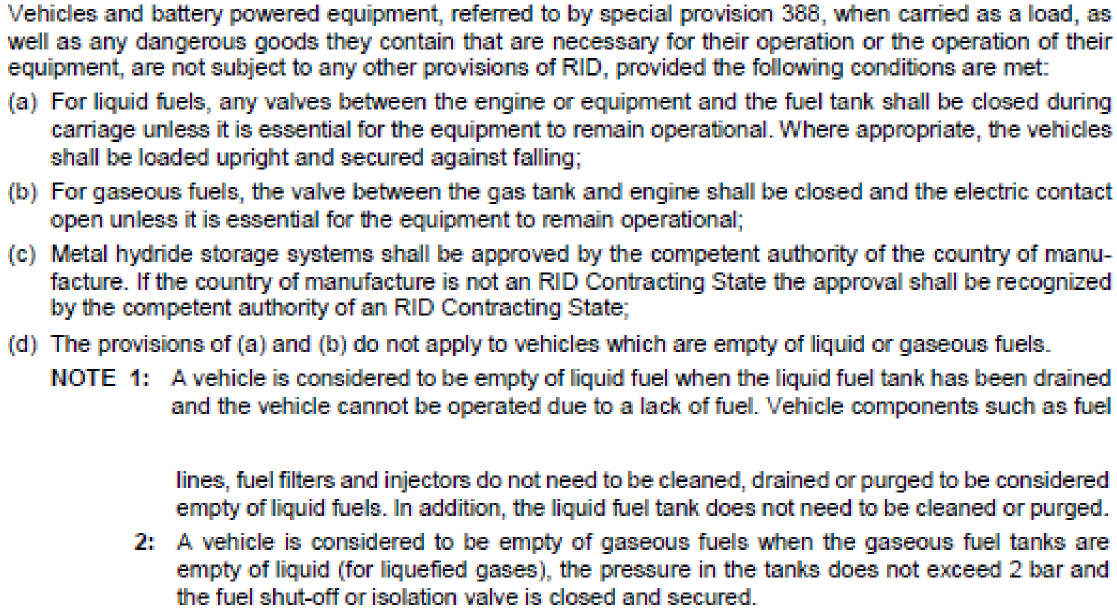
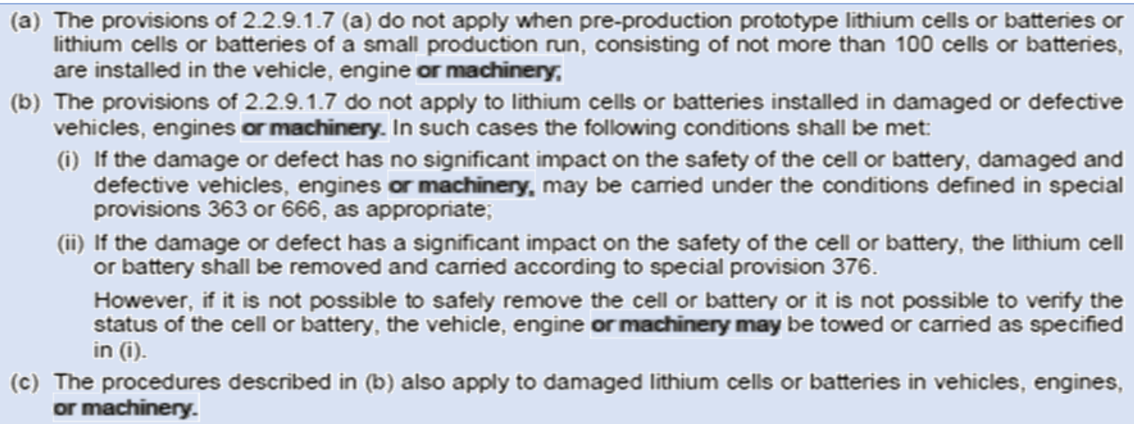
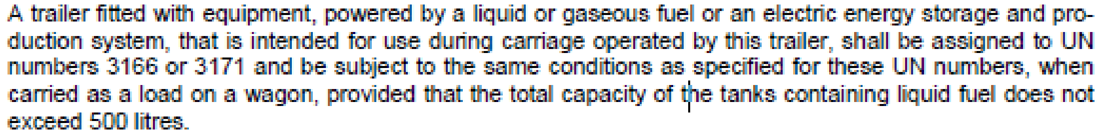
Conditions	Item	Documentation	Additional Description	Information
			 systems and unintentional release of the gas under normal conditions of carriage. The fuel gas containment system shall be secured in order to prevent slipping, rolling or vertical movement; (e) Valves shall be protected by one of the methods described in 4.1.6.8 (a) to (e); (f) Except for the case of fuel gas containment systems removed for disposal, recycling, repair, inspection or maintenance, they shall be filled with not more than 20% of their nominal filling ratio or nominal working pressure, as applicable; (g) Notwithstanding the provisions of Chapter 5.2, when fuel gas containment systems are consigned in a handling device, marks and labels may be affixed to the handling device; and (h) Notwithstanding the provisions of 5.4.1.1.1 (f) the information on the total quantity of dangerous goods may be replaced by the following information: (i) The number of fuel gas containment systems; and (ii) In the case of liquefied gases the total net mass (kg) of gas of each fuel gas containment system and, in the case of compressed gases, the total water capacity (l) of each fuel gas containment system followed by the nominal working pressure. Examples for information in the transport document: Example 1: "UN 1971 NATURAL GAS, COMPRESSED, 2.1, 1 FUEL GAS CONTAINMENT SYSTEM OF 50 *L* IN TOTAL, 200 BAR". Example 2: "UN 1965 HYDROCARBON GAS MIXTURE, LIQUEFIED, N.O.S., 2.1, 3 FUEL GAS CONTAINMENT SYSTEMS, EACH OF 15 KG NET MASS OF GAS".	
Part 3: Dangerous goods list, special provisions and exemptions related to limited and excepted quantities	Chapter 3.3 Special provisions applicable to certain articles or substances	Special provisions number: 662	 Cylinders not conforming to the provisions of Chapter 6.2 which are used exclusively on board a ship or aircraft, may be carried for the purpose of filling or inspection and subsequent return, provided the cylinders are designed and constructed in accordance with a standard recognized by the competent authority of the country of approval and all the other relevant requirements of RID are met including: (a) The cylinders shall be carried with valve protection in conformity with 4.1.6.8; (b) The cylinders shall be marked and labelled in conformity with 5.2.1 and 5.2.2; and (c) All the relevant filling requirements of packing instruction P 200 of 4.1.4.1 shall be complied with.	

Conditions	Item	Documentation	Additional Description	Information
Part 3: Dangerous goods list, special provisions and exemptions related to limited and excepted quantities	Chapter 3.3 Special provisions applicable to certain articles or substances	Special provisions number: 666	 Vehicles and battery powered equipment, referred to by special provision 388, when carried as a load, as well as any dangerous goods they contain that are necessary for their operation or the operation of their equipment, are not subject to any other provisions of RID, provided the following conditions are met: (a) For liquid fuels, any valves between the engine or equipment and the fuel tank shall be closed during carriage unless it is essential for the equipment to remain operational. Where appropriate, the vehicles shall be loaded upright and secured against falling; (b) For gaseous fuels, the valve between the gas tank and engine shall be closed and the electric contact open unless it is essential for the equipment to remain operational; (c) Metal hydride storage systems shall be approved by the competent authority of the country of manufacture. If the country of manufacture is not an RID Contracting State the approval shall be recognized by the competent authority of an RID Contracting State; (d) The provisions of (a) and (b) do not apply to vehicles which are empty of liquid or gaseous fuels. NOTE 1: A vehicle is considered to be empty of liquid fuel when the liquid fuel tank has been drained and the vehicle cannot be operated due to a lack of fuel. Vehicle components such as fuel lines, fuel filters and injectors do not need to be cleaned, drained or purged to be considered empty of liquid fuels. In addition, the liquid fuel tank does not need to be cleaned or purged. 2: A vehicle is considered to be empty of gaseous fuels when the gaseous fuel tanks are empty of liquid (for liquefied gases), the pressure in the tanks does not exceed 2 bar and the fuel shut-off or isolation valve is closed and secured.	
Part 3: Dangerous goods list, special provisions and exemptions related to limited and excepted quantities	Chapter 3.3 Special provisions applicable to certain articles or substances	Special provisions number: 667	 (a) The provisions of 2.2.9.1.7 (a) do not apply when pre-production prototype lithium cells or batteries or lithium cells or batteries of a small production run, consisting of not more than 100 cells or batteries, are installed in the vehicle, engine **or machinery**; (b) The provisions of 2.2.9.1.7 do not apply to lithium cells or batteries installed in damaged or defective vehicles, engines **or machinery**. In such cases the following conditions shall be met: (i) If the damage or defect has no significant impact on the safety of the cell or battery, damaged and defective vehicles, engines **or machinery**, may be carried under the conditions defined in special provisions 363 or 666, as appropriate; (ii) If the damage or defect has a significant impact on the safety of the cell or battery, the lithium cell or battery shall be removed and carried according to special provision 376. However, if it is not possible to safely remove the cell or battery or it is not possible to verify the status of the cell or battery, the vehicle, engine **or machinery may** be towed or carried as specified in (i). (c) The procedures described in (b) also apply to damaged lithium cells or batteries in vehicles, engines, **or machinery**.	

Conditions	Item	Documentation	Additional Description	Information
Part 3: Dangerous goods list, special provisions and exemptions related to limited and excepted quantities	Chapter 3.3 Special provisions applicable to certain articles or substances	Special provisions number: 669	 A trailer fitted with equipment, powered by a liquid or gaseous fuel or an electric energy storage and production system, that is intended for use during carriage operated by this trailer, shall be assigned to UN numbers 3166 or 3171 and be subject to the same conditions as specified for these UN numbers, when carried as a load on a wagon, provided that the total capacity of the tanks containing liquid fuel does not exceed 500 litres.	

REPORT CCC6/14 (IMO)

A. IDENTITY CARD OF REPORT CCC6/14 (IMO)

RCS	Number of RCS	Title	Date	Stability date	Statutory
Report IMO	6th session agenda item 14: CCC 6/14	Report to the maritime safety committee and the marine environment protection committee	21.09.2019	Draft	

Foreword: *Disclaimer* **-** *As at its date of issue, this document, in whole or in part, is subject to consideration by the IMO organ to which it has been submitted. Accordingly, its contents are subject to approval and amendment of a substantive and drafting nature, which may be agreed after that date*

Scope: amendments to the IGF code and development of guidelines for low-flashpoint fuels. Work on the draft interim guidelines on fuel cells and the consideration on low-flashpoint oil fuels

Domain/category: maritime

Specifed exclusion: /

Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

Conditions	Item	Documentation	Additional Description	Information
Chapter 3: Amendments to the igf code and development of guidelines for low-flashpoint fuels	Subchapter 3.3: Draft interim guidelines on fuel cells	3.3	*With regard to the draft interim guidelines for fuel cells, the Sub-Committee noted the Group's discussion and had for its consideration the following documents:* *1. CCC 6/3/6 (CESA), providing comments on the document CCC 6/3 and proposals regarding the references to IEC standards within the draft interim guidelines for the safety of ships using fuel cell power installations,; in particular it recommends making better use of the detailed calculation methodology provided in IEC 60079-10-1:2015 in order to address the hazards associated with the large variety of fuel cell designs in a generic manner; it also states that novel technology has to be assessed with flexible and scientifically sound methods in order to fully utilize innovation for achieving GHG goals; and* *2. CCC 6/INF.17 (CESA), providing complementing information on the application of the standard IEC 60079-10-1:2015 for assigning hazardous zones, with the methodology being illustrated by a sample application on a containerized fuel cell power installation designed for providing onboard electrical energy.*	IEC 60079-10-1:2015
Chapter 3: Amendments to the igf code and development of guidelines for low-flashpoint fuels	Subchapter 3.3: Draft interim guidelines on fuel cells	3.4	*Having noted the Group's view that fuel cell spaces should be considered as hazardous zone 1 and that the fixed zone designation could be verified by calculation according to IEC 60079-10, the Sub-Committee noted the following comments:* *1. the classification of hazardous areas might be different from the conventional methodologies and it should be finalized by the Working Group* *2. the inconsistencies within the existing draft guidelines with regard to area classification, e.g. paragraph 4.2.2.5 and 4.2.3, should be resolved and fuel cell spaces designated as hazardous zone 1 in the draft guidelines should be carefully considered*	

Conditions	Item	Documentation	Additional Description	Information
			3. *paragraph 4.2.1 of the draft should be aligned with paragraph 12.4.2 of the draft interim guidelines for the safety of ships using methyl/ethyl alcohol as fuel* 4. *IEC 60079-10 could serve as an alternative to the prescriptive area classification and the draft guidelines should be finalized by taking into account documents CCC 6/3/6 and CCC 6/INF.17the focus of the requirements should be to ensure that any minor leakage of the vapour under normal conditions would not accumulate to form a flammable explosive atmosphere and related mitigations were in place to address the associated risks, and that ESD concept could be taken into account when developing related regulations* 5. *there were concerns on the use of combustible materials inside the fuel cell power system and paragraph 2.4.4 of the guidelines should be further considered* 6. *the prescriptive area classification was a well-established maritime standard and the IEC 60079-10 was not appropriate to be referenced in the draft guidelines, as the result of the calculation would largely depend on the information provided by the manufacturer on durations and frequency related to leakages, etc., and it would be a major task for the Administration to properly assess the information* 7. *IEC 60079-10-1:2015 was widely used for shore-based applications and the detailed calculation methodology provided would provide a higher level of safety; and* 8. *the term "deemed to be inappropriate" in paragraph 4.2.5 was too vague and the application of "in consultation with the Administration" could lead to differences for implementation*	
Chapter 3: Amendments to the igf code and development	Subchapter 3.3: Draft interim guidelines on fuel cells	3.5	*Taking into account the views expressed above, the Sub-Committee decided to instruct the Working Group to further develop the interim guidelines for fuel cells, based on annex 1 to document CCC 6/3, and taking into account documents CCC 6/3/6 and CCC 6/INF.17*	Annex 1 to document CCC 6/3

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td>of guidelines for low-flashpoint fuels</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Chapter 3: Amendments to the igf code and development of guidelines for low-flashpoint fuels</td><td>Interim guidelines for the safety of ships using fuel cell power installations</td><td>3.30</td><td><i>The Sub-Committee noted the progress made in the development of the Interim guidelines for the safety of ships using fuel cell power installations (CCC 6/WP.3, paragraphs 11 to 32, and annex 2).</i></td><td>Annex 2 CCC6/14</td></tr>
<tr><td>Annex 2: Work plan for the next phase of the development of the igf code</td><td></td><td></td><td>
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<tr><td><i>CCC 7</i></td><td><i>-Finalize Interim Guidelines ❼ fuel cells</i>
<i>-Finalize IGF Code amendments ❼ low-flashpoint oil fuels</i>
<i>-Prepare amendments to the IGF Code ❼ LNG</i>
<i>-Further develop guidelines ❼ LPG CG planned to be established</i></td><td><i>September 2020</i></td></tr>
<tr><td><i>MSC 104</i></td><td><i>-Approve Interim Guidelines ❼ fuel cells</i>
<i>-Approve draft IGF Code amendments ❼ low-flashpoint oil fuels</i></td><td><i>2021</i></td></tr>
<tr><td><i>CCC10</i></td><td><i>-- Discuss the development of mandatory instruments regarding fuel cells</i></td><td><i>2023</i></td></tr>
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IGF CODE (IMO)

A. IDENTITY CARD OF RCS NAME AND ITS NUM

RCS	Number of RCS	Title	Date	Stability date	Statutory
Code	IGF	Annex 1 RESOLUTION MSC.391(95) adoption of the international code of safety for ships using gases or other low-flashpoint fuels (IGF code)	adopted on 11 june 2015		Y

Scope: The purpose of the International Code of Safety for Ship Using Gases or Other Low-flashpoint Fuels is to provide an international standard for ships, other than vessels covered by the IGC Code, operating with gas or low-flashpoint liquids as fuel.

The basic philosophy of the Code is to provide mandatory criteria for the arrangement and installation of machinery, equipment and systems for vessels operating with gas or low-flashpoint liquids as fuel to minimize the risk to the ship, its crew and the environment, having regard to the nature of the fuels involved.

The current version of this Code includes regulations to meet the functional requirements for natural gas fuel. Regulations for other low-flashpoint fuels will be added to this Code as, and when, they are developed by the Organization

In the meantime, for other low-flashpoint fuels, compliance with the functional requirements of this Code must be demonstrated through alternative design.

Domain/category: safety, ships and low-flashpoint fuels.

Specifed exclusion:

Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

Since the current version of this code includes regulations to meet the functional requirements for natural gas fuel and for other low flash point fuels, compliance with the functional requirements of this code must be demonstrated by an alternative design, only the following chapters are relevant in the StasHH project

- Chapter associated with the alternative design
- Chapters associated with the general functional requirements.

The others Parts into IGF Code (part A-1, part B-1, part C-1) deal with natural gas, whether liquefied or gaseous. Part D deals with "training". Therefore, not all of these parts are relevant to StasHH project. Parts A-2, etc. are being developed for low flashpoint fuels other than natural gas.

Conditions	Item	Documentation	Additional Description	Information
Part A Chapter 2: General	Sub-chapter 2.3: Alternative design	Paragraph 2.3.1	*This Code contains functional requirements for all appliances and arrangements related to the usage of low-flashpoint fuels.*	
Part A Chapter 2: General	Sub-chapter 2.3: Alternative design	Paragraph 2.3.2	*Fuels, appliances and arrangements of low-flashpoint fuel systems may either:* *1. deviate from those set out in this Code, or* *2. be designed for use of a fuel not specifically addressed in this Code.* *Such fuels, appliances and arrangements can be used provided that these meet the intent of the goal and functional requirements concerned and provide an equivalent level of safety of the relevant chapters.*	
Part A Chapter 2: General	Sub-chapter 2.3: Alternative design	Paragraph 2.3.3	*The equivalence of the alternative design shall be demonstrated as specified in SOLAS regulation II-1/55 and approved by the Administration. However, the Administration shall not allow operational methods or procedures to be applied as an alternative to a particular fitting, material, appliance, apparatus, item of equipment, or type thereof which is prescribed by this Code.*	
Part A Chapter 3:	Sub-chapter 3.1: Goal		*The goal of this Code is to provide for safe and environmentally-friendly design, construction and operation of ships and in particular their installations of systems for propulsion machinery, auxiliary power generation machinery and/or other purpose machinery using gas or low-flashpoint fuel as fuel.*	

Conditions	Item	Documentation	Additional Description	Information
Goal and functional requirements				
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.1	*The safety, reliability and dependability of the systems shall be equivalent to that achieved with new and comparable conventional oil-fuelled main and auxiliary machinery.*	
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.2	*The probability and consequences of fuel-related hazards shall be limited to a minimum through arrangement and system design, such as ventilation, detection and safety actions. In the event of gas leakage or failure of the risk reducing measures, necessary safety actions shall be initiated.*	
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.3	*The design philosophy shall ensure that risk reducing measures and safety actions for the gas fuel installation do not lead to an unacceptable loss of power.*	
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.4	*Hazardous areas shall be restricted, as far as practicable, to minimize the potential risks that might affect the safety of the ship, persons on board, and equipment.*	
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.5	*Equipment installed in hazardous areas shall be minimized to that required for operational purposes and shall be suitably and appropriately certified.*	
Part A Chapter 3:	Sub-chapter 3.2:	Paragraph 3.2.6	*Unintended accumulation of explosive, flammable or toxic gas concentrations shall be prevented.*	

Conditions	Item	Documentation	Additional Description	Information
Goal and functional requirements	Functional requirements			
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.7	*System components shall be protected against external damages.*	
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.8	*Sources of ignition in hazardous areas shall be minimized to reduce the probability of explosions.*	
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.9	*It shall be arranged for safe and suitable fuel supply, storage and bunkering arrangements capable of receiving and containing the fuel in the required state without leakage. Other than when necessary for safety reasons, the system shall be designed to prevent venting under all normal operating conditions including idle periods.*	
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.10	*Piping systems, containment and over-pressure relief arrangements that are of suitable design, construction and installation for their intended application shall be provided.*	
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.11	*Machinery, systems and components shall be designed, constructed, installed, operated, maintained and protected to ensure safe and reliable operation.*	
Part A Chapter 3:	Sub-chapter 3.2:	Paragraph 3.2.12	*Fuel containment system and machinery spaces containing source that might release gas into the space shall be arranged and located such that a fire or*	

Conditions	Item	Documentation	Additional Description	Information
Goal and functional requirements	Functional requirements		*explosion in either will not lead to an unacceptable loss of power or render equipment in other compartments inoperable.*	
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.13	*Suitable control, alarm, monitoring and shutdown systems shall be provided to ensure safe and reliable operation.*	
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.14	*Fixed gas detection suitable for all spaces and areas concerned shall be arranged.*	
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.15	*Fire detection, protection and extinction measures appropriate to the hazards concerned shall be provided.*	
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.16	*Commissioning, trials and maintenance of fuel systems and gas utilization machinery shall satisfy the goal in terms of safety, availability and reliability.*	
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.17	*The technical documentation shall permit an assessment of the compliance of the system and its components with the applicable rules, guidelines, design standards used and the principles related to safety, availability, maintainability and reliability.*	
Part A Chapter 3:	Sub-chapter 3.2:	Paragraph 3.2.18	*A single failure in a technical system or component shall not lead to an unsafe or unreliable situation.*	

Conditions	Item	Documentation	Additional Description	Information
Goal and functional requirements	Functional requirements			
Part A Chapter 4: General requirements	Sub-chapter 4.1: Goal		*The goal of this chapter is to ensure that the necessary assessments of the risks involved are carried out in order to eliminate or mitigate any adverse effect to the persons on board, the environment or the ship.*	
Part A Chapter 4: General requirements	Sub-chapter 4.2: Risk assessment	Paragraph 4.2.1	*A risk assessment shall be conducted to ensure that risks arising from the use of low-flashpoint fuels affecting persons on board, the environment, the structural strength or the integrity of the ship are addressed. Consideration shall be given to the hazards associated with physical layout, operation and maintenance, following any reasonably foreseeable failure.*	
Part A Chapter 4: General requirements	Sub-chapter 4.2: Risk assessment	Paragraph 4.2.3	*The risks shall be analysed using acceptable and recognized risk analysis techniques, and loss of function, component damage, fire, explosion and electric shock shall as a minimum be considered. The analysis shall ensure that risks are eliminated wherever possible. Risks which cannot be eliminated shall be mitigated as necessary. Details of risks, and the means by which they are mitigated, shall be documented to the satisfaction of the Administration.*	
Part A Chapter 4: General requirements	Sub-chapter 4.3: Limitation of explosion consequences		*An explosion in any space containing any potential sources of release (Double wall fuel pipes are not considered as potential sources of release) and potential ignition sources shall not:* *1. cause damage to or disrupt the proper functioning of equipment/systems located in any space other than that in which the incident occurs* *2. damage the ship in such a way that flooding of water below the main deck or any progressive flooding occur* *3. damage work areas or accommodation in such a way that persons who stay in such areas under normal operating conditions are injured* *4. disrupt the proper functioning of control stations and switchboard rooms necessary for power distribution* *5. damage life-saving equipment or associated launching arrangements*	

Conditions	Item	Documentation	Additional Description	Information
			6. disrupt the proper functioning of firefighting equipment located outside the explosion-damaged space *7. affect other areas of the ship in such a way that chain reactions involving, inter alia, cargo, gas and bunker oil may arise; or* *8. prevent persons access to life-saving appliances or impede escape routes.*	

Annex 25: GUIDELINE MSC.1/CIRC.1212 ALTERNATIVE DESIGN (IMO)

GUIDELINE MSC.1/CIRC.1212 ALTERNATIVE DESIGN (IMO)

A. IDENTITY CARD OF GUIDELINE MSC.1/CIRC.1212 ALTERNATIVE DESIGN (IMO)

RCS	Number of RCS	Title	Date	Stability date	Statutory
Guideline	MSC.1/Circ.1212	1212 Alternative design and arrangements for SOLAS Chapters II-1 and III	15.12.2006		

Scope: These Guidelines are intended for application of safe engineering design to provide technical justification for alternative design and arrangements to SOLAS chapters II-1 (parts C, D and E) and III. The Guidelines serve to outline the methodology for the engineering analysis required by Part F of SOLAS regulation II-1 and Part C of SOLAS chapter III "Alternative design and arrangements", applying to a specific safety system, design or arrangements for which the approval of an alternative design deviating from the prescriptive requirements of SOLAS chapters II-1 and III is sought.

Domain/category: safety method for alternative design in ship.

Specifed exclusion: These Guidelines are not intended to:

- be applied to the type approval of individual materials, components or portable equipment.
- serve as a stand-alone document, but should be used in conjunction with the appropriate engineering design guides and other literature.

Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

To support the application of SOLAS Reg. II-1/55, the IMO has issued guidelines published in MSC.1/Circular.1212 Guidelines on Alternative Design and Arrangements for SOLAS Chapters II-1 and III. The alternative design method is applicable to the StasHH Project.

The alternative design method is based in a **RISK BASED DESIGN** in order to determine whether the design has an equivalent level of safety.

No appendix are recalled here because they concern the formalism of the documentation to be transmitted.

Conditions	Item	Documentation	Additional Description	Information
Chapter 03: Engineering analysis		Paragraph 3.1	*The engineering analysis used to show that the alternative design and arrangements provide the equivalent level of safety to the prescriptive requirements of SOLAS chapters II-1 and III should follow an established approach to safety design. This approach should be based on sound science and engineering practice incorporating widely accepted methods, empirical data, calculations, correlations and computer models as contained in engineering textbooks and technical literature.* **SOLAS chapters II-1:** Construction – Subdivision and stability, machinery and electrical installations: This chapter of SOLAS deals with watertight integrity of the ship, including the passenger's vessel and comprises of 7 parts, explaining the requirement for structural, machinery, electrical, stability and other criteria for a safe ship. Part A contains 3 regulations which explain the "Application" of this chapter on ships as per their keel laying. The regulations explain the "Definition" of different terminology which is used in the chapter. **SOLAS chapter III:** Life-saving appliances and arrangements: All the lifesaving appliances and there use in different situations according to the ship type is described in this chapter. This chapter comprises of 3 Parts.	

Conditions	Item	Documentation	Additional Description	Information
			Part A contains 5 regulation which explains the "Application" of this chapter in different types of the ship along with the "Definition" of different terminology which is used in the chapter. The regulation may not be applicable to all types of a ship; hence a separate section of "Exceptions" and "Exemptions" is also provided. Further, onboard testing and production testing procedures are also explained. Part C of this chapter gives the details about the alternative design and arrangement for ship's lifesaving appliances under regulation 38.	
Chapter 03: Engineering analysis		Paragraph 3.2	*Other safety engineering approaches recognized by the Administration may be used.*	
Chapter 05: Preliminary analysis in qualitative terms	Sub-chapter 5.1: definitions of scope	Paragraph 5.1.1	*The ship, ship system(s), component(s), space(s) and/or equipment subject to the analysis should be thoroughly defined. This includes the ship or system(s) representing both the alternative design and arrangements and the regulatory prescribed design. Depending on the extent of the desired deviation from prescriptive requirements, some of the information that may be required includes: detailed ship plans, drawings, equipment information and drawings, test data and analysis results, ship operating characteristics and conditions of operation, operating and maintenance procedures, material properties, etc.*	
Chapter 05: Preliminary analysis in qualitative terms	Sub-chapter 5.1: definitions of scope	Paragraph 5.1.2	*The regulations affecting the proposed alternative design and arrangements, along with their functional requirements, should be clearly understood and documented in the preliminary analysis report ~~(see paragraph 5.5)~~. This should form the basis for the evaluation referred to in paragraph 6.4.*	
Chapter 05: Preliminary analysis in qualitative terms	Sub-chapter 5.2: Development of casualty or operational scenarios		*Casualty or operational scenarios should provide the basis for analysis and trial alternative design evaluation and, therefore, are the backbone of the alternative design process. Proper casualty or operational scenario development is essential and, depending on the extent of deviation from the prescribed design, may require a significant amount of time and resources. This phase should outline why an alternative design may be beneficial. For life-saving arrangements, this may focus on casualty scenarios where an*	

Conditions	Item	Documentation	Additional Description	Information
			alternative design or arrangement will provide an equivalent (or greater) level of safety. Mechanical or electrical arrangements may focus on an operational scenario that will provide an equivalent level of safety, but may increase efficiencies or reduce cost to the operator.	
Chapter 05: Preliminary analysis in qualitative terms	Sub-chapter 5.3: Casualty scenario development	Paragrah 5.3.1: General	*Casualty scenario development can be broken down into four areas:* *1. identification of hazards;* *2. enumeration of hazards;* *3. selection of hazards; and* *4. specification of design casualty scenarios.*	
Chapter 05: Preliminary analysis in qualitative terms	Sub-chapter 5.3: Casualty scenario development	Paragraph 5.3.2: Identification of hazards	*This step is crucial in the casualty scenario development process as well as in the entire alternative design methodology. If a particular hazard or incident is omitted, then it will not be considered in the analysis and the resulting final design may be inadequate. Hazards may be identified using historical and statistical data, expert opinion and experience and hazard evaluation procedures. There are many hazard evaluation procedures available to help identify the hazards including Hazard and Operability Study (HAZOP), Process Hazard Analysis (PHA), Failure Mode and Effects Analysis (FMEA), "what-if", etc. As a minimum, the following conditions and characteristics should be identified and considered:* *1. pre-casualty situation: ship, platform, compartment, available potential and kinetic energy, environmental conditions;* *2. potential initiating events, causes;* *3. detailed technical information and properties of potential hazards;* *4. secondary hazards that might be subject to effects of initial hazard;* *5. extension potential: beyond compartment, structure, area (if in open);* *6. target locations: note target items or areas associated with the performance parameters;* *7. critical factors relevant to the hazard: ventilation, environment, operational, time of day, etc.; and* *8. relevant statistical data: past casualty history, probability of failure, frequency and severity rates, etc.*	

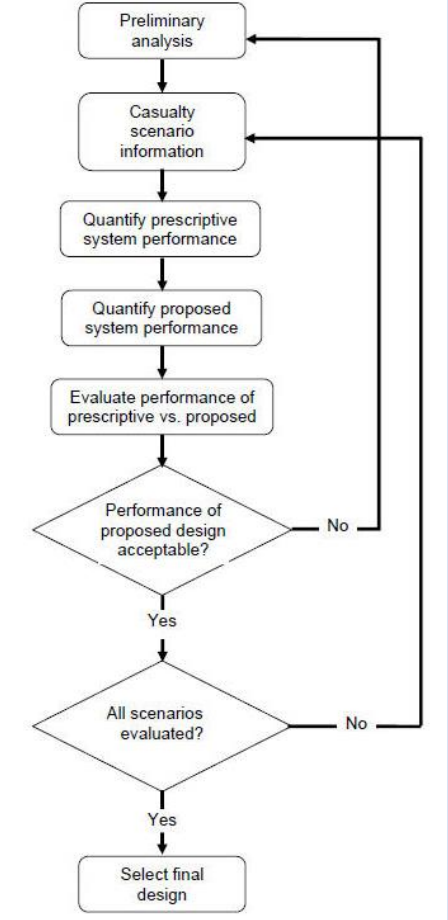
Conditions	Item	Documentation	Additional Description	Information
Chapter 05: Preliminary analysis in qualitative terms	Sub-chapter 5.3: Casualty scenario development	Paragraph 5.3.3: Enumeration of hazards	*All of the hazards identified above should be grouped into one of three incident classes: localized, major or catastrophic. A localized incident consists of a casualty with a localized effect zone, limited to a specific area. A major incident consists of a casualty with a medium effect zone, limited to the boundaries of the ship. A catastrophic incident consists of a casualty with a large affect zone, beyond the ship and affecting surrounding ships or communities. In the majority of cases, only localized and/or major incidents need to be considered. Examples where the catastrophic incident class may be considered would include transport and/or offshore production of petroleum products or other hazardous materials where the incident effect zone is very likely to be beyond the ship vicinity. The hazards should be tabulated for future selection of a certain number of each of the incident classes.*	
Chapter 05: Preliminary analysis in qualitative terms	Sub-chapter 5.3: Casualty scenario development	Paragraph 5.3.4: Selection of hazards	*The number and type of hazards that should be selected for the quantitative analysis is dependent on the complexity of the trial alternative design and arrangements. All of the hazards identified should be reviewed for selection of a range of incidents. In determining the selection, frequency of occurrence does not need to be fully quantified, but it can be utilized in a qualitative sense. The selection process should identify a range of incidents which cover the largest and most probable range of enumerated hazards. Because the engineering evaluation relies on a comparison of the proposed alternative design and arrangements with prescriptive designs, demonstration of equivalent performance during the major incidents should adequately demonstrate the design's equivalence for all lesser incidents and provide the commensurate level of safety. In selecting the hazards it is possible to lose perspective and to begin selecting highly unlikely or inconsequential hazards. Care should be taken to select the most appropriate incidents for inclusion in the selected range of incidents.*	
Chapter 05: Preliminary analysis in	Sub-chapter 5.3: Casualty	Paragraph 5.3.5:	*Based on the hazards selected, the casualty scenarios to be used in the quantitative analysis should be clearly documented. The specification should include a qualitative description of the design casualty (e.g., initiating and*	

Conditions	Item	Documentation	Additional Description	Information
qualitative terms	scenario development	Specification of design casualty scenarios	*subsequent chain of events, location, etc.), description of the vessel, compartment or system of origin, safeguard systems installed, number of occupants, physical and mental status of occupants and available means of escape. The casualty scenarios should consider possible future changes to the hazards (increased or decreased) in the affected areas. The design casualty or casualties will be characterized in more detail during the quantitative analysis for each trial alternative design. Operational scenario development for a mechanical or electrical alternative design or arrangement should include the operating scenarios under which the alternative will be utilized.*	
Chapter 05: Preliminary analysis in qualitative terms	Sub-chapter 5.4: Development of trial alternative designs		*At this point in the analysis, one or more trial alternative designs should be developed so that they can be compared against the developed performance criteria. The trial alternative design should also take into consideration the importance of human factors, operations and management. It should be recognized that well defined operations and management procedures may play a big part in increasing the overall level of safety.*	
Chapter 6: Quantitative analysis	Sub-chapter 6.1: General	Pragraph 6.1.1	*The quantitative analysis is the most labour intensive from an engineering standpoint. It consists of quantifying the design casualty scenarios, developing the performance criteria, verifying the acceptability of the selected safety margins and evaluating the performance of trial alternative designs against the prescriptive performance criteria.*	
Chapter 6: Quantitative analysis	Sub-chapter 6.1: General	Pragraph 6.1.2	*The quantification of the design casualty scenarios may include calculating the effects of casualty detection systems, alarm and mitigation methods, generating timelines from initiation of the casualty until control of the casualty or evacuation, and estimating consequences in terms of damage to the vessel, and the risk of harm to passengers and crew. This information should then be utilized to evaluate the trial alternative designs selected during the preliminary analysis.*	
Chapter 6: Quantitative analysis	Sub-chapter 6.1: General	Pragraph 6.1.3	*Risk assessment may play an important role in this process. It should be recognized that risk cannot ever be completely eliminated. Throughout the entire performance based design process, this fact should be kept in mind. The purpose of performance design is not to build a fail safe design, but to*	

Conditions	Item	Documentation	Additional Description	Information
			specify a design with reasonable confidence that it will perform its intended function(s) when necessary and in a manner equivalent to or better than the prescriptive requirements of SOLAS chapters II-1 and III.	
Chapter 6: Quantitative analysis	Sub-chapter 6.2: quantification of design casualty scenarios	Paragraph 6.2.1	*After choosing an appropriate range of incidents, quantification of the casualties should be carried out for each of the incidents. Quantification will require specification of all factors that may affect the type and extent of the hazard. The casualty scenarios should consider possible future changes to the affected systems and areas. This may include calculation of specific casualty parameters, ship damage, passenger exposure to harm, time-lines, etc. It should be noted that, when using any specific tools, the limitations and assumptions of these models should be well understood and documented. This becomes very important when deciding on and applying safety margins. Documentation of the alternative design should explicitly identify the models used in the analysis and their applicability. Reference to the literature alone should not be considered as adequate documentation. The general procedure for specifying design casualties includes casualty scenario development completed during the preliminary analysis, timeline analysis and consequence estimation which is detailed below.*	
Chapter 6: Quantitative analysis	Sub-chapter 6.2: quantification of design casualty scenarios	Paragraph 6.2.2	*For each of the identified hazards, a range of casualty scenarios should be developed. Because the alternative design approach is based on a comparison against the regulatory prescribed design, the quantification can often be simplified. In many cases, it may only be necessary to analyse one or two scenarios if this provides enough information to evaluate the level of safety of the alternative design and arrangements against the required prescriptive design.*	
Chapter 6: Quantitative analysis	Sub-chapter 6.2: quantification of design casualty scenarios	Paragraph 6.2.3	*A timeline should be developed for each of the casualty scenarios beginning with initiation. Timelines should include the entire chain of relevant events up to and including escape times (to assembly stations, evacuation stations and lifeboats, as appropriate). This timeline should include personnel response, activation of damage control systems or active damage control measures, untenable conditions, etc. The timeline should include a description of the*	

Conditions	Item	Documentation	Additional Description	Information
			extent of the casualty throughout the scenario, as determined by using the various correlations, models and data from the literature or actual tests.	
Chapter 6: Quantitative analysis	Sub-chapter 6.2: quantification of design casualty scenarios	Paragraph 6.2.4	*Consequences of various casualty scenarios should be quantified in relevant engineering terms. This can be accomplished by using existing correlations and calculation procedures for determining the characteristics of a casualty. In certain cases, full scale testing and experimentation may be necessary to properly predict the casualty characteristics. Regardless of the calculation procedures utilized, a sensitivity analysis should be conducted to determine the effects of the uncertainties and limitations of the input parameters.*	
Chapter 6: Quantitative analysis	Sub-chapter 6.3: Development performance criteria	Paragraph 6.3.1	*Performance criteria are quantitative expressions of the intent of the requirements of the relevant SOLAS regulations. The required performance of the trial alternative designs are specified numerically in the form of performance criteria. Performance criteria may include tenability limits or other criteria necessary to ensure successful alternative design and arrangements.*	
Chapter 6: Quantitative analysis	Sub-chapter 6.3: Development performance criteria	Paragraph 6.3.2	*Compliance with the prescriptive regulations is one way to meet the stated functional requirements. The performance criteria for the alternative design and arrangements should be determined, taking into consideration the intent of the regulations.*	
Chapter 6: Quantitative analysis	Sub-chapter 6.3: Development performance criteria	Paragraph 6.3.3	*If the performance criteria for the alternative design and arrangements cannot be determined directly from the prescriptive regulations because of novel or unique features, they may be developed from an evaluation of the intended performance of a commonly used acceptable prescriptive design, provided that an equivalent level of safety is maintained.*	
Chapter 6: Quantitative analysis	Sub-chapter 6.3: Development performance criteria	Paragraph 6.3.4	*Before evaluating the prescriptive design, the design team should agree on what specific performance criteria and safety margins should be established. Depending on the prescriptive requirements to which the approval of alternative design or arrangements is sought, these performance criteria could fall within one or more of the following areas:*	

Conditions	Item	Documentation	Additional Description	Information
			1. Life safety criteria - These criteria address the survivability of passengers and crew and may represent the effects of flooding, fire, etc. *2. Criteria for damage to ship structure and related systems - These criteria address the impact that casualty might have on the ship structure, mechanical systems, electrical systems, fire protection systems, evacuation systems, propulsion and manoeuvrability, etc. These criteria may represent physical effects of the casualty.* *3. Criteria for damage to the environment ¿ These criteria address the impact of the casualty on the atmosphere and marine environment.*	
Chapter 6: Quantitative analysis	Sub-chapter 6.3: Development performance criteria	Paragraph 6.3.5	*The design team should consider the impact that one particular performance criterion might have on other areas that might not be specifically part of the alternative design. For example, the failure of a particular safeguard may not only affect the life safety of passengers and crew in the adjacent space, but it may result in the failure of some system affecting the overall safety of the ship.*	
Chapter 6: Quantitative analysis	Sub-chapter 6.3: Development performance criteria	Paragraph 6.3.6	*Once all of the performance criteria have been established, the design team can then proceed with the evaluation of the trial alternative designs (see section 6.4).*	
Chapter 6: Quantitative analysis	Sub-chapter 6.4: Evaluation of trial alternative designs	Paragraph 6.4.1	*All of the data and information generated during the preliminary analysis and specification of design casualty should serve as input to the evaluation process. The evaluation process may differ depending on the level of evaluation necessary (based on the scope defined during the preliminary analysis), but should generally follow the process illustrated in figure 6.4.1.*	

Conditions	Item	Documentation	Additional Description	Information
			 *Figure 6.4.1 Alternative design and arrangements process flowchart*	
Chapter 6: Quantitative analysis	Sub-chapter 6.4:	Paragraph 6.4.2	*Each selected trial alternative design should be analysed against the selected design casualty scenarios to demonstrate that it meets the performance criteria with the agreed safety margin, which in turn demonstrates equivalence to the prescriptive design.*	

Conditions	Item	Documentation	Additional Description	Information
	Evaluation of trial alternative designs			
Chapter 6: Quantitative analysis	Sub-chapter 6.4: Evaluation of trial alternative designs	Paragraph 6.4.3	*The level of engineering rigor required in any particular analysis will depend on the level of analysis required to demonstrate equivalency of the proposed alternative design and arrangements to the prescriptive requirements. Obviously, the more components, systems, operations and parts of the ship that are affected by a particular alternative design, the larger the scope of the analysis.*	
Chapter 6: Quantitative analysis	Sub-chapter 6.4: Evaluation of trial alternative designs	Paragraph 6.4.4	*The final alternative design and arrangements should be selected from the trial alternative designs that meet the selected performance criteria and safety margins.*	

GUIDELINE MSC.1/CIRC.1455 APPROVAL ALTERNATIVE AND:OR EQUIVALENCY DESIGNS (IMO)

A. IDENTITY CARD OF GUIDELINE MSC.1/CIRC.1455 APPROVAL ALTERNATIVE AND:OR EQUIVALENCY DESIGNS (IMO)

RCS	Number of RCS	Title	Date	Stability date	Statutory
Guideline	MSC.1/Circ.1455	1455 Guidelines for the approval of alternatives and equivalents as provided for in various IMO instruments	24.06.2013		

Scope:

These Guidelines are intended for application when approving alternative and/or equivalency designs in general and specifically according to the provisions given for alternative design and arrangements in applicable statutory IMO instruments.

The Guidelines serve to outline the methodology for the analysis and approval process for which the approval of an alternative and/or equivalent design is sought.

Domain/category: Some designs may deviate from the normative requirements for certain components, systems or functions or for the whole vessel. An alternative and/or equivalent design and its approval shall be carried out only for those ship functions, systems or components that directly or indirectly provide alternative means of compliance with the applicable regulations.

Specifed exclusion:

Reference included in this RCS:

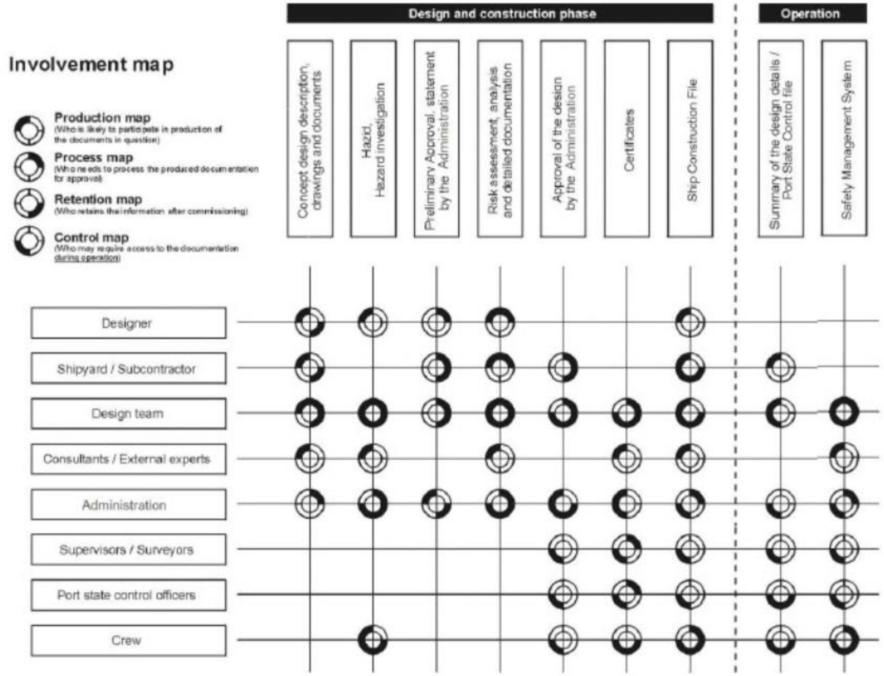
B. RELEVANT PARTS FOR STASHH PROJECT

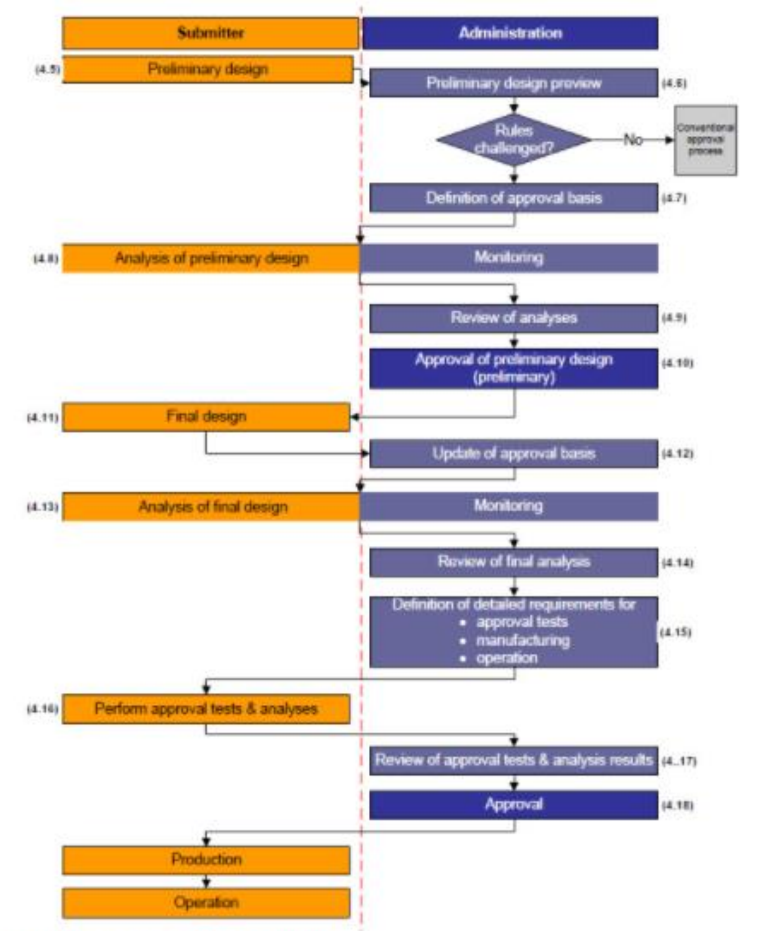
To support the application of SOLAS Reg. II-1/55, the IMO has issued guidelines published in MSC.1/Circular.1455 Guidelines for the Approval of Alternatives and Equivalents as Provided for in Various IMO Instruments.

One approach to the approval of an alternative and/or equivalent design is to compare the innovative design to existing designs to demonstrate that the design has an equivalent level of safety. In order to demonstrate an equivalent level of safety, functional requirements and performance criteria should be established for essential ship functions, which should be met by the alternative and/or equivalent design. An alternative approach could be to carry out a risk analysis of the alternative and/or equivalent design and compare it to overall risk evaluation criteria.

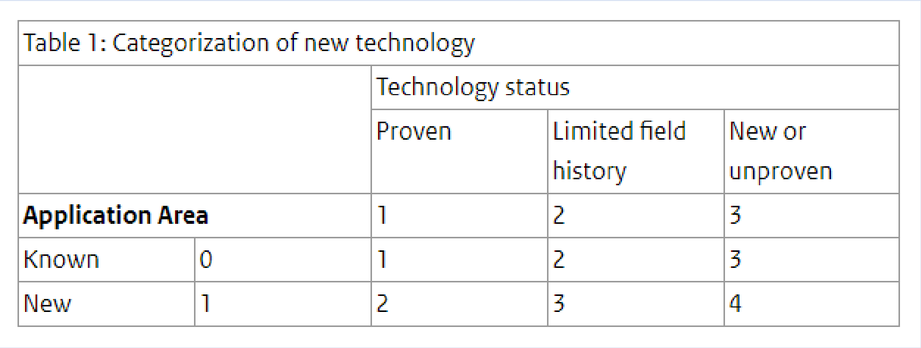
Guidelines for the approval of alternatives and equivalents as provided for in various IMO instruments is applicable to the StasHH Project. These guidelines address the responsibility of stakeholders in the preparation of dossiers for the approval of alternative or equivalent designs. In the following table, only the requirements or process associated with this assembly are briefly recalled. The formalism of the various expected documents is not mentioned in this table.

Conditions	Item	Documentation	Additional Description	Information
Chapter 3: Qualification requirements			*This section of the Guidelines addresses requirements for key personnel involved in the different stages of the alternative and/or equivalent design approval process.*	
Chapter 3: Qualification requirements	Sub-chapter 3.1: Stakeholders and target groups		*The various main stakeholders and their involvement are indicated in the involvement map in figure 1. In this section, the anticipated need for qualifications of stakeholders, in order to accommodate risk-based approaches in ship design, construction, operation and approval, are based on the involvement of the different target groups.*	

Conditions	Item	Documentation	Additional Description	Information
			 **Figure 1: Combined involvement map**	
Chapter 4: Process	Sub-chapter 4.1: the following process		*The following process, illustrated in figure 2, is intended to describe the procedure for obtaining and maintaining approval of an alternative and/or equivalency taking into account the Submitter and the Administration. Even though the diagram in figure 2 may suggest a strictly linear or sequential process, this is not the intention, and it is important to note that each phase may be a series of iterations in a loop. As seen from figure 2, the process, which covers concept development through operation, includes the following milestones:* *1. development of a preliminary design;*	

Conditions	Item	Documentation	Additional Description	Information
			2. approval of preliminary design; *3. development of final design;* *4. final design testing and analyses; and* *5. approval.*  Figure 2: Design and Approval Process	

Conditions	Item	Documentation	Additional Description	Information
Chapter 4: Process	Sub-chapter 4.5: Preliminary design development phase	Paragraph 4.5.1	*In the first phase of the alternative and/or equivalency process the Preliminary design is carried out by the Submitter. A draft of the alternative and/or equivalent under consideration is developed, taking into account among other things general arrangement, components as well as the boundary conditions of the system, including physical boundaries and system interfaces.*	
Chapter 4: Process	Sub-chapter 4.5: Preliminary design development phase	Paragraph 4.5.2	*The objective of this phase is to develop a common level of understanding of the proposed alternative and/or equivalent design to enable the subsequent tasks of the submission and approval process to be properly defined and carried out. Those rules, standards and/or regulations that are being challenged should be identified and thoroughly explained by the Submitter. Furthermore, prior to the start of the project, a selection may be made of the appropriate terminology and semantics. The definition of the terminology and semantics used in the approval process avoids misinterpretation and thus increases the efficiency of the process.*	
Chapter 4: Process	Sub-chapter 4.6: Preliminary design preview phase	Paragraph 4.6.3	*The aim of the Preliminary preview phase is also to decide whether the alternative and/or equivalency challenge any prescriptive rules, regulations or standards to such an extent that a risk analysis is required. The safety and environmental aspects of the alternative and/or equivalency design are crucial for this decision. If the Administration comes to the conclusion that there is no need of a risk analysis, the Submitter can follow a conventional approval process, to be determined by the Administration.*	
Chapter 4: Process	Sub-chapter 4.6: Preliminary design preview phase	Paragraph 4.6.4	*The decision whether the alternative and/or equivalency requires a risk-based analysis demonstrating that an equivalent level of safety may be reached by using table 1 to determine the degree of novelty. This decision needs to be transparently documented by the Administration (for the purpose of objectivity). Technology in category 1 is proven technology where proven methods for classification, tests, calculations and analyses may be used. Technology in categories 2-4 is defined as new technology and may follow the procedure described in this report. The distinction between categories 2, 3 and 4 makes it easier to focus on the areas of concern. The objective of using*	

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td>the categorization is to establish whether or not the alternative and/or equivalency design qualifies as a novel design and to gain a general understanding of the variation from proven designs. The categorization will also assist in defining the level of detail of the different analyses that will be required in the following phase.

<table>
<tr><th colspan="5">Table 1: Categorization of new technology</th></tr>
<tr><td colspan="2" rowspan="2"></td><td colspan="3">Technology status</td></tr>
<tr><td>Proven</td><td>Limited field history</td><td>New or unproven</td></tr>
<tr><td colspan="2">Application Area</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>Known</td><td>0</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>New</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
</table></td><td></td></tr>
<tr><td>Chapter 4: Process</td><td>Sub-chapter 4.7: Definition of approval basis phase</td><td>Paragraph 4.7.1</td><td>Following the Preliminary design preview phase, the next phase is for the Administration to define the approval basis with respect to scope of analysis and evaluation criteria. In order to accomplish this, the Administration and the Submitter may have to meet one or several times to discuss the alternative and/or equivalency, its purpose and objectives, deviations from conventional approaches, relevant rules and regulations, possible deviations from or lack of rules and regulations, requirements that may not be covered by the rules, proposed operations and potential impact on other systems, components, etc. During this time, the alternative and/or equivalency will have to be well understood.</td><td></td></tr>
<tr><td>Chapter 4: Process</td><td>Sub-chapter 4.7:</td><td>Paragraph 4.7.3</td><td>A risk assessment plan should be developed to identify appropriate types of assessment techniques by Submitter. The plan should clearly state the proposed evaluation criteria and the basis for the criteria.</td><td></td></tr>
</table>

Conditions	Item	Documentation	Additional Description	Information
	Definition of approval basis phase			
Chapter 4: Process	Sub-chapter 4.7: Definition of approval basis phase	Paragraph 4.7.4	*A testing and analysis plan should be developed to identify appropriate types of test and engineering analyses by Submitter. This plan is only a preliminary plan, as it will most likely be revised following the results of the analysis for the preliminary design phase.*	
Chapter 4: Process	Sub-chapter 4.8: Analysis of preliminary Design Phase	Paragraph 4.8.1	*The scope of this phase is to conduct an analysis of the Preliminary design that has been specified in the previous phases of the process. The Submitter is responsible for facilitating all analyses agreed with the Administration. It is highly recommended to invite Administration representatives to attend the meetings to provide a close dialogue between the Administration and the Submitter in order to ensure that all relevant issues are taken into consideration. However, careful consideration should be given to ensuring that their independence from the design team is maintained. The analysis of the preliminary design is a stepwise process monitored by the Administration that may be terminated in case so-called showstoppers are identified.*	
Chapter 4: Process	Sub-chapter 4.8: Analysis of preliminary Design Phase	Paragraph 4.8.2	*At a minimum, a HazId should be required in order to request for preliminary approval of the preliminary design. The Submitter will be required to arrange a HazId workshop, which is a structured brainstorming with the purpose of identifying all relevant hazards and their consequences and mitigating measures already included in the design. The HazId provides a unique meeting place for designers, engineers, operational and safety personnel as well as Administration representatives to discuss the alternative and/or equivalency and its associated hazards.*	
Chapter 4: Process	Sub-chapter 4.8:	Paragraph 4.8.5	*The results of the HazId should be documented (HazId Report) by the Submitter and submitted to the Administration. A list of the participants in the HazId and their expertise and experience should be submitted to the Administration as well.*	

Conditions	Item	Documentation	Additional Description	Information
	Analysis of preliminary Design Phase			
Chapter 4: Process	Sub-chapter 4.8: Analysis of preliminary Design Phase	Paragraph 4.8.6	*Depending on the scope defined by the Submitter and the Administration, the Preliminary design analysis may include a risk assessment. If so, a coarse risk model should be developed based on the HazId. The scope of the evaluation of risk control options depends on the outcome of the risk evaluation.*	
Chapter 4: Process	Sub-chapter 4.8: Analysis of preliminary Design Phase	Paragraph 4.8.7	*The scope related to the risk assessments at this phase will depend on the degree of novelty of the alternative and/or equivalency and the risk assessment plans defined during the Definition of Approval Basis Phase (see paragraph 4.1.3). Typically, the risk assessments will include the following (which is also documented and submitted to the Administration):* *1. ranking of hazards (identification of frequencies and consequences) and selection of hazards for risk model;* *2. development of a coarse risk model in order to perform quantitative analyses;* *3. description of data analysis, assumptions, uncertainties and sensitivities;* *4. assessment of the alternative and/or equivalency design by means of reference design;* *5. identification of issues, such as design casualty scenarios, that may require further analyses and testing; and* *6. identification of issues that may require special attention with respect to operations, accessibility and inspections.*	
Chapter 4: Process	Sub-chapter 4.8: Analysis of preliminary Design Phase	Paragraph 4.8.8	*The risk model may be developed using one of the well-established methods such as fault tree analyses, event tree analyses, Markov models, Bayesian networks, structural reliability analyses, etc. Description of the proposed qualitative and quantitative methods as well as the objectives, scope and basis of the assessments may be included in the risk assessment plan*	

Conditions	Item	Documentation	Additional Description	Information
			submitted at the time of Definition of Approval Basis Phase ~~(see paragraph 4.1.3)~~. This paragraph doesn't exist, may be, it's the paragraph 4.7.3	
Chapter 4: Process	Sub-chapter 4.11: Final design phase	Paragraph 4.11.2	*The objective of this phase is to elaborate the preliminary design to a corresponding Final design. This Final design complies with the results of the preliminary analysis with respect to risk control options already identified and the requirements of the Administration. The final design is developed on the basis of the statement by the Administration.*	
Chapter 4: Process	Sub-chapter 4.13: Analysis of final design phase	Paragraph 4.13.1	*The tasks to be performed in this phase are similar to the analysis of the Preliminary design. In a first sub-phase, a review of the analysis of the preliminary design is performed to determine the difference between Preliminary design and Final design in order to specify the scope of the analyses that have to be considered in this phase. Thus, this analysis phase may contain an update of the HazId, a quantitative risk analysis and risk evaluation.*	
Chapter 4: Process	Sub-chapter 4.13: Analysis of final design phase	Paragraph 4.13.2	*The requirements related to the risk assessment of the final design will be based on the novelty of the design, the risk assessment plans defined for the previous phase and the differences between the preliminary and the final design. Typically, the risk assessment will address the following:* *1. identified hazards associated with the alternative and/or equivalency (update of preliminary analysis);* *2. identified potential safeguards already considered in the design;* *3. identification of frequencies and consequences associated with the hazards, and the resulting risks;* *4. a precise risk model in order to perform quantitative analyses;* *5. description of data references, assumptions, uncertainties and sensitivities;* *6. comparison of risk levels with evaluation criteria;* *7. identification of potential risk reducing measures;* *8. cost-benefit assessments in order to select the most appropriate risk reducing measures;*	

Conditions	Item	Documentation	Additional Description	Information
			9. description of selected risk reducing measures; *10. re-evaluation of risk taking into account the additional risk reducing measures and comparison with evaluation criteria;* *11. identification of issues that may require further analyses and testing; and* *12. identification of issues that may require special attention with respect to operations, accessibility and inspections.*	
Chapter 4: Process	Sub-chapter 4.15: Defintion of details requirements phase		*Detailed requirements will be defined for the alternative and/or equivalency design by the Administration and the Submitter jointly on the basis of the results of the quantitative risk analyses in order to achieve approval. These requirements address the following topics:* *1. approval tests: testing and analysis methods required to confirm assumptions used for the quantitative risk analysis;* *2. approval numerical calculations/simulations: numerical results required to demonstrate quantitative performance;* *3. manufacturing: level of quality control during manufacturing and installation; and* *4. operation: operational limits and maintenance, including definition of operation and maintenance procedures, as well as data acquisition and assessment during operation.*	
Chapter 4: Process	Sub-chapter 4.16: Perform approval tests and analyses phase	Paragraph 4.16.1	*If required, further engineering analyses are used to verify that the design is feasible with respect to intentions and overall safety in all phases of operation. That is, the analyses and tests will ensure that the alternative and/or equivalency will meet expectations from a functional and safety point of view, including environmental protection. The engineering analyses are performed by the Submitter. Models used for the analyses, input data and results are documented and submitted to the Administration for review.*	
Chapter 4: Process	Sub-chapter 4.16:	Paragraph 4.16.2	*The types and extent of the analyses and tests required depend on the level of novelty, confidence in analyses and the extent of experience with similar concepts. While the objectives of the analyses are primarily to verify function*	

Conditions	Item	Documentation	Additional Description	Information
	Perform approval tests and analyses phase		*and reliability, additional objectives of the tests are also to obtain data for analyses and verify the results obtained from analytical methods. The analyses and tests are meant to demonstrate additional safety margins compared to target limits defined in the design basis. The tests are performed in accordance with the requirements. The Administration should oversee these tests with experts in relevant areas.*	
Chapter 4: Process	Sub-chapter 4.18: Final approval	Paragraph 4.18.2	*At the time of approval, all potential hazards and failure modes for the alternative and/or equivalency will have been assessed versus evaluation criteria, to a level of confidence necessary to grant final approval.*	
Chapter 4: Process	Sub-chapter 4.18: Final approval	Paragraph 4.18.3	*In most cases, approval of the alternative and/or equivalency will involve conditions related to in-service surveys, inspections, monitoring, and possibly testing. In most cases, the conditions will be fixed already during the design phase. As experience accumulates and confidence in the alternative and/or equivalency is gained, these additional conditions and requirements may be relaxed.*	
Chapter 5: Evaluation criteria	Sub-chapter 5.1: General	Paragraph 5.1.1	*The expected safety performance of the alternative and/or equivalent design should be quantitatively specified in the form of the evaluation criteria. As stated in section 4, the approval of alternatives and/or equivalencies requires the development, review, and selection of appropriate evaluation criteria. Before evaluation the alternative and/or equivalent design, the Submitter and the Administration need to agree on established evaluation criteria.*	
Chapter 5: Evaluation criteria	Sub-chapter 5.1: General	Paragraph 5.1.3	*Safety objectives and functional requirements available in IMO instruments should be taken into consideration when developing the evaluation criteria.*	
Chapter 5: Evaluation criteria	Sub-chapter 5.2: Evaluation criteria	Paragraph 5.2.1	*The basic principle for the evaluation criterion should be "safety equivalence". This means that the alternative and/or equivalent will be designed so that it will perform its intended safety related function(s) in a manner that is equivalent to or better than the prescriptive requirement it is deviating from. The evaluation criterion used for the evaluation of the alternative/equivalent design shall be specified either on basis of prescriptive requirements or an equivalent, regulations compliant design. Therefore, the safety level of the*	

Conditions	Item	Documentation	Additional Description	Information
			prescriptive requirement should be made explicit to enable a comparison with the safety level of the alternative and/or equivalent design.	
Chapter 5: Evaluation criteria	Sub-chapter 5.2: Evaluation criteria	Paragraph 5.2.2	*Depending on the area to which the approval of the alternative and or equivalent design is being sought, the evaluation criteria could fall into one or more of the following categories:* *1. life safety criteria – These criteria address the survivability of passengers and crew and may represent the effects or flooding, fire, etc.* *2. damage to ship structure and related systems – These criteria address the impact that a casualty might have on a ship structure, mechanical systems, electrical systems, fire protection systems, etc. These criteria may represent physical effects of an accident.* *3. damage to the environment – These criteria address the impact of an accident on the atmosphere and the marine environment.*	
Chapter 5: Evaluation criteria	Sub-chapter 5.2: Evaluation criteria	Paragraph 5.2.3	*The evaluation criterion can be also specified by means of performance criteria characterizing the safety level of IMO regulations. In that case the performance criterion should be developed, taking into consideration the intent of the regulations and related mandatory instruments (e.g. mandatory codes and standards), if any.*	
Chapter 5: Evaluation criteria	Sub-chapter 5.2: Evaluation criteria	Paragraph 5.2.4	*The purpose of the analyses is to verify that a design with reasonable confidence will perform its intended safety related function(s) when necessary and in a manner equivalent to or better than the prescriptive IMO requirements.*	
Chapter 5: Evaluation criteria	Sub-chapter 5.2: Evaluation criteria	Paragraph 5.2.5	*The analysis used to show that the alternative design and arrangements provide the equivalent level of safety to the prescriptive IMO requirements should follow an established approach to safety design. This approach should be based on sound science and engineering practice incorporating widely accepted methods, empirical data, calculations, correlations and computer models as contained in engineering textbooks and technical literature. The general process of analysis is outlined in section 4 of these Guidelines.*	

Conditions	Item	Documentation	Additional Description	Information
Chapter 5: Evaluation criteria	Sub-chapter 5.2: Evaluation criteria	Paragraph 5.2.6	*For alternative design falling into areas where no appropriate IMO regulations or other relevant industry standard exist the evaluation criteria may be specified by means of risk acceptance and agreed with Administration.*	
Chapter 5: Evaluation criteria	Sub-chapter 5.2: Evaluation criteria	Paragraph 5.2.7	*Risk analysis is the calculation of probabilities and consequences for the event examined and the conversion of these into a risk metric (i.e. a measurable value, risk acceptance criterion, evaluation criterion, safety level, etc.) based on which decisions may be taken.*	
Chapter 5: Evaluation criteria	Sub-chapter 5.2: Evaluation criteria	Paragraph 5.2.8	*This approach may address the risk to human life, including injuries and ill health, and the risk to the environment. Other types of risk could also be covered, as appropriate to the design of the alternative and/or equivalency in question.*	
Chapter 5: Evaluation criteria	Sub-chapter 5.2: Evaluation criteria	Paragraph 5.2.9	*Different risk metrics for each type of risks can be employed and typically the following types of evaluation criteria are used:* *1. individual and societal risk; and* *2. risk to crew, passengers and people ashore, as appropriate.*	
Chapter 5: Evaluation criteria	Sub-chapter 5.2: Evaluation criteria	Paragraph 5.2.10	*The above are criteria for total risk (e.g. fatalities from fire, collision, structural damage, etc.) as opposed to criteria for individual hazards or individual risks. For the risk assessment of structural issues of ships, among others, it may be necessary to develop acceptance criteria for individual failure modes (limit states) of ships (e.g. failure due to fatigue of steel plates). This may also be necessary when examining the satisfaction or not of acceptance criteria for individual functional requirements relating to the structure of ships, its global and local strength, etc. Such risk evaluation criteria for individual hazards of ship structures and individual failure modes have not been developed nor established to date.*	
Chapter 5: Evaluation criteria	Sub-chapter 5.2: Evaluation criteria	Paragraph 5.2.11	*The risk acceptance criteria should be preferably specified by IMO or by the Administration otherwise.*	

Conditions	Item	Documentation	Additional Description	Information
Chapter 5: Evaluation criteria	Sub-chapter 5.3: Special considerations	Paragraph 5.3.1	*In those cases where it may not be possible to define the evaluation criteria during the Preliminary Design phase, the Submitter and Administration should agree on the strategy for defining such criteria.*	
Chapter 5: Evaluation criteria	Sub-chapter 5.3: Special considerations	Paragraph 5.3.2	*If the evaluation criteria cannot be fulfilled the approval process should be either terminated or restarted with a modified design.*	
Chapter 5: Evaluation criteria	Sub-chapter 5.3: Special considerations	Paragraph 5.3.3	*Submitter and Administration should consider the impact that one particular evaluation criterion might have on other areas that might not be specifically part of the alternative design. For example, the failure of a particular safeguard may not only affect the life safety of passengers and crew in the adjacent space, but it may result in the failure of some system affecting the overall safety of the ship.*	
Chapter 5: Evaluation criteria	Sub-chapter 5.3: Special considerations	Paragraph 5.3.4	*The Revised Guidelines for Formal Safety Assessment (FSA) for use in the IMO rule-making process (MSC-MEPC.2/Circ.12) contains information on risk acceptance evaluation criteria.*	
Chapter 6: Documentation	Sub-chapter 6.3: General considerations	Paragraph 6.3.1	*Table 2: The approval matrix ➔ see the table at the end of this sheet*	
Chapter 6: Documentation	Sub-chapter 6.3: General considerations	Paragraph 6.3.4: Requirements for risk control measures	***6.3.4.1** For alternative designs the acceptable risk level will typically be set by a regulation compliant reference design (see sections 4 and 5).* ***6.3.4.2** In the absence of a regulation compliant reference design to compare with, the evaluation criteria may be specified by means of risk analysis. Identified risk levels will usually be categorized to belong to three categories: intolerable risks which should be reduced, negligible risks which do not require any action, and risks in the ALARP area which should be reduced to as low as reasonably practicable.*	

Conditions	Item	Documentation	Additional Description	Information
			6.3.4.3 *If several possible options can efficiently reduce the same risk, the passive options, which are usually more verifiable and reliable, should be chosen. As a majority of incidents are strongly influenced by human error and operational faults, the team may seek solutions that minimize potential human error, if at all viable and efficient.* ***6.3.4.4*** *If risk control measures are operational, then their implementation into management systems should be documented, to ensure that the crew is fully informed and familiar of such special measures.*	
Chapter 6: Documentation	Sub-chapter 6.3: General considerations	Paragraph 6.3.6: Calculation/analysis requirements	***6.3.6.1*** *When making decisions based on analysis techniques, care should be taken to evaluate their adequacy. This requires expertise on various types of risk assessment methods to ensure that the most suitable will be selected for the application in question. As is deductible from prior elaborations, the level of novelty/regulation challenge is variable and, depending hereon, the most suitable methodologies may also vary.* ***6.3.6.2*** *Below are nine reminders when performing in-depth risk analyses:* *1. apply best industry practice and be consistent with IMO FSA Guidelines when selecting risk assessment techniques;* *2. perform a high-level assessment of the design type for which approval is sought;* *3. ensure that the specific risk assessment (based on the generic high-level assessment) meets the requirements for methodology and depth level acceptable by the Approval Authority;* *4. ensure that the applied model reflects the as built and operated ship or system as accurately as possible. If necessary, the process should be conducted iteratively, as the design process progresses, to ensure all safety critical aspects are covered;* *5. apply assumptions on a sound basis and perform frequency and consequence analyses based on relevant and consistent data;* *6. check for consistency between the level of detail in the assessment and the assumed risk control measures and the system safety testing and -management program (programmed maintenance, safety*	

Conditions	Item	Documentation	Additional Description	Information
			management systems), especially if such assumed control- or mitigating measures are of an operational character; 7. *include internal and external events in the analysis;* 8. *include normal operational modes as well as states of emergency in the analysis; and* 9. *include sensitivity analysis, uncertainty analysis and importance measures.*	
Chapter 6: Documentation	Sub-chapter 6.3: General considerations	Paragraph 6.3.7: Errors and uncertainties	***6.3.7.1*** *To be able to compute or determine the different parameters which are to be applied in the risk analysis or which are found in any form of design equation, it is necessary to have access to various types of data.* ***6.3.7.2*** *Uncertainty reflects either lack of knowledge about the actual value of a variable (epistemic uncertainty) or variability intrinsic to the parameter (aleatory uncertainty). In standard risk assessment methods, however, uncertainties involved can be accounted for within the method (e.g. conservative assumptions).* ***6.3.7.3*** *Although uncertainty on variables may be considerable, expected values can be estimated. Therefore, it may be sensible to choose a reasonable estimate reference. Choosing values implying the worst conceivable case could result in an exaggerated picture of the risks involved.* ***6.3.7.4*** *To examine the impact of specific variables on the final results, a sensitivity analysis should be carried out, where the effect of for example doubling the value of a variable may be examined to decide whether the originally selected values are conservative enough or if they deserve a more precise/detailed analysis or not.* ***6.3.7.5*** *Hence the following issues which may require investigation at any given stage require consideration:* 1. *variation in the input data;* 2. *the impact of simplifications/assumptions of problems;* 3. *the effects of various characteristics of the scenarios; and* 4. *the reliability of systems.*	

Conditions	Item	Documentation	Additional Description	Information
			6.3.7.6 *Variables which are found to have a major impact in the sensitivity analysis may justify a more conservative or precise approach than variables of lesser importance. The sensitivity analysis may indicate the variables of major impact and how uncertainties of such variables are handled.*	

Table 2: The approval matrix:

Project Category		Known application of proven technology (conventional process)	Known application of a technology with a limited field history/New application of proven technology	New application of a technology with a limited field history/Known application of a new or unproven technology	New application of novel or unproven technology	Activity performed by:
Requirements		(1)	(2)	(3)	(4)	
A)	Basic risk assessment	Not required	Required (unless rule challenge deemed insignificant or of negligible impact on safety and environment)	Required	Required	Submitter (yard, supplier)
B)	Further analysis requirements	Not required	Depending on basic risk assessment outcome. Hazards medium or high, if any, may be examined further, at least by semi-quantified analysis	Semi-quantified assessment. All hazards medium and high may be examined by means of quantified analysis	Quantified risk assessment to all risk contributions (due to the novelty of the design, it may not be possible to rank such hazards credibly. Hence, all may be examined in depth)	Submitter in cooperation with the Administration
C)	Qualifications of analysts	N/A	Operational experience General knowledge	Operational experience. In-depth experience with risk assessment. Some	Operational experience Risk assessment	N/A

Project Category		Known application of proven technology (conventional process)	Known application of a technology with a limited field history/New application of proven technology	New application of a technology with a limited field history/Known application of a new or unproven technology	New application of novel or unproven technology	Activity performed by:
			of risk assessment techniques	knowledge of analysis techniques	and analysis experts	
D)	Applied rules and guidance	Existing prescriptive rules (SOLAS, MARPOL, relevant codes, national, regional and international legislation, prescriptive class rules)	Existing prescriptive rules where no rule challenge prevails (SOLAS, MARPOL, relevant codes, national, regional and international legislation, prescriptive class rules) applicable standards if available from other industrial sectors, class guidance on risk-based approval as applicable	IMO circulars on alternative arrangements, class guidance on risk-based approval, other relevant industry standards	IMO circulars on alternative arrangements, class guidance on risk-based approval	N/A
E)	Potential additional tests, surveys and compliance control (after commissioning)	As per Safety Management System (SMS) and existing regulation	Internal surveying. Additional review at safety related events subject to recording and corrective action	Internal/external surveying, recording and additional intermediate surveys of risk-based	Continuous monitoring and review subject to reporting to the Administration until a sufficient	Submitter (operator)

Project Category		**Known application of proven technology (conventional process)**	**Known application of a technology with a limited field history/New application of proven technology**	**New application of a technology with a limited field history/Known application of a new or unproven technology**	**New application of novel or unproven technology**	**Activity performed by:**
				features, if deemed necessary	level of experience is gained	
F)	Review by third party	Considered	Considered	Considered	Recommended	N/A

Annex 27: GUIDE FUEL CELL POWER SYSTEM FOR MARITIME AND OFFSHORE APPLICATIONS (ABS)

GUIDE FUEL CELL POWER SYSTEM FOR MARITIME AND OFFSHORE APPLICATIONS (ABS)

A. IDENTITY CARD OF GUIDE FUEL CELL POWER SYSTEM FOR MARITIME AND OFFSHORE APPLICATIONS (ABS)

RCS	Number of RCS	Title	Date	Stability date	Statutory
Guide	ABS[42] guide	ABS – Guide for fuel cell power systems for marine and offshore applications	Edition November 2019	Publication november 2019	Yes

Foreword: *The requirements in this Guide have been developed considering the IMO Draft Interim Guideline to the IGF Code pertaining to fuel cells. It is recognized that when the Draft Interim Guidelines are finalized, the Guide will be updated.*

Scope: This Guide is applicable to marine and offshore assets designed, constructed, or retrofitted with a fuel cell using a gaseous fuel as well as liquid fuels. Where a fuel cell power system is to be installed, it is to comply with the requirements in this Guide and is to be verified by ABS (in order to obtain the certification).

Alternative design accepted: Annex to MSC.1/Circ.1455 (Guidelines for the Approval of Alternatives and Equivalents as Provided for in Various IMO Instruments)

The corresponding sheet in document MSC.1/Circ.1455 is included in this deliverable.

Domain/category: fuel cell power systems used for auxiliary and main electric power systems onboard vessels, offshore, floating production installations (FPIs), etc.

- Fuel cells
- Fuel stacks
- Modules
- Fuel systems
- Safety systems
- Monitoring control
- Testing certification
- Etc.

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[42] ABS: American Bureau of Shipping. https://ww2.eagle.org/en.html
The American Bureau of Shipping (ABS) is an American maritime classification society established in 1862.[1] Its stated mission to promote the security of life, property and the natural environment, primarily through the development and verification of standards for the design, construction and operational maintenance of marine and offshore assets.

Specifed exclusion:

1. Where a vessel is arranged to use the fuel cell power system for essential services (primary and secondary) or emergency services, the system is designed, constructed and tested in accordance with this Guide. See also 2/5.2 of this Guide.

2. Where a vessel is arranged to use the fuel cell power system for non-essential services, the system is designed, constructed and tested in accordance with this Guide except with the requirements as per 2/5.2 of this Guide.

Reference included in this RCS: In this paragraph, only potentially relevant references are mentionned here.

- MSC.1/Circ.1455 (Guidelines for the Approval of Alternatives and Equivalents as Provided for in Various IMO Instruments). Fuel cell power systems may comply with the requirements of alternative design, in lieu of the specific requirements in ABS Guide, subject to such a design being determined to ABS as not less effective or safe.
- IMO Draft Interim Guideline to the IGF Code

The others references potentially relevant in StasHH project are cited in following chapter.

B. RELEVANT PARTS FOR STASHH PROJECT

Below are the sections relevant to the StasHH project:

Fuels for use in Fuel Cell	*~~Fuel Containment System~~*	*Material and General Piping System*	*Fire Safety Systems*	*Electrical System*	*Control, Monitoring and Safety Systems*
Hydrogen	~~Section 3 of this Guide~~	2/2.2.2 and 3/4 of this Guide	Section 4 of this Guide	Section 5 of this Guide	Section 6 of this Guide

Conditions	Item	Documentation	Additional Description	Information
Section 1: General	Chapter 6: Environmental conditions		*The fuel cell power systems are to be suitable for inclinations and environmental conditions found in marine and offshore installations such as those mentioned in 4-1-1/Table 7 and 4-1-1/Table 8 of the Marine Vessel Rules.*	4-1-1/Table 7 and 4-1-1/Table 8 of the *Marine Vessel Rules* Sections 4-9-1 and 4-9-2, as appropriate, of the Marine Vessel Rules

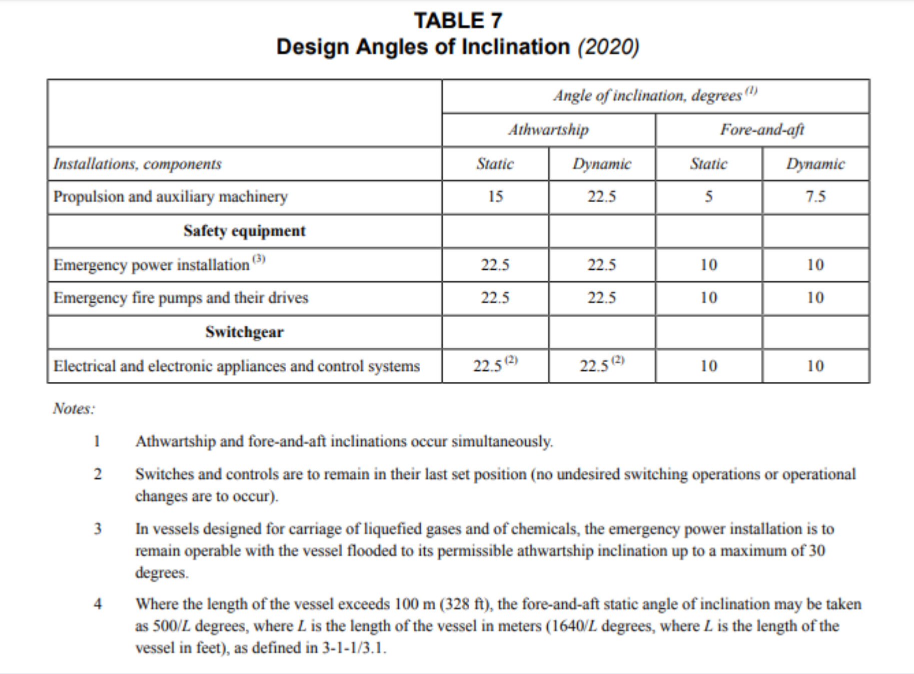
Conditions	Item	Documentation	Additional Description	Information
				

TABLE 7
Design Angles of Inclination *(2020)*

	Angle of inclination, degrees (1)			
	Athwartship		*Fore-and-aft*	
Installations, components	*Static*	*Dynamic*	*Static*	*Dynamic*
Propulsion and auxiliary machinery	15	22.5	5	7.5
Safety equipment				
Emergency power installation (3)	22.5	22.5	10	10
Emergency fire pumps and their drives	22.5	22.5	10	10
Switchgear				
Electrical and electronic appliances and control systems	22.5 (2)	22.5 (2)	10	10

Notes:

1 Athwartship and fore-and-aft inclinations occur simultaneously.

2 Switches and controls are to remain in their last set position (no undesired switching operations or operational changes are to occur).

3 In vessels designed for carriage of liquefied gases and of chemicals, the emergency power installation is to remain operable with the vessel flooded to its permissible athwartship inclination up to a maximum of 30 degrees.

4 Where the length of the vessel exceeds 100 m (328 ft), the fore-and-aft static angle of inclination may be taken as 500/*L* degrees, where *L* is the length of the vessel in meters (1640/*L* degrees, where *L* is the length of the vessel in feet), as defined in 3-1-1/3.1.

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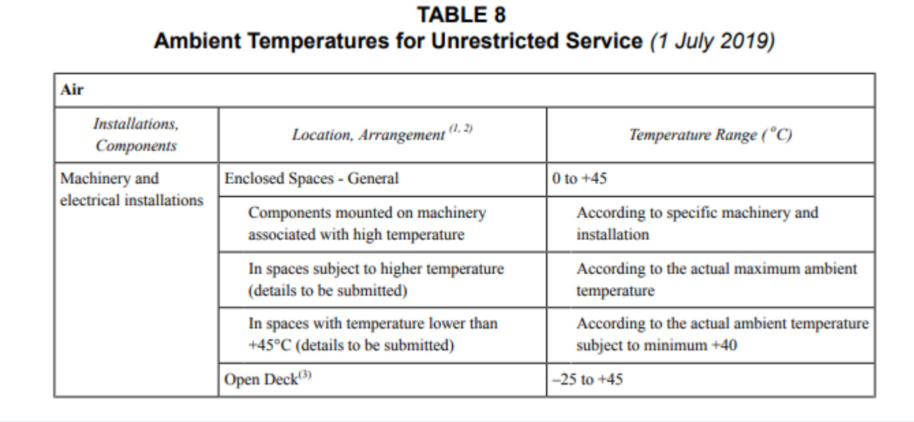
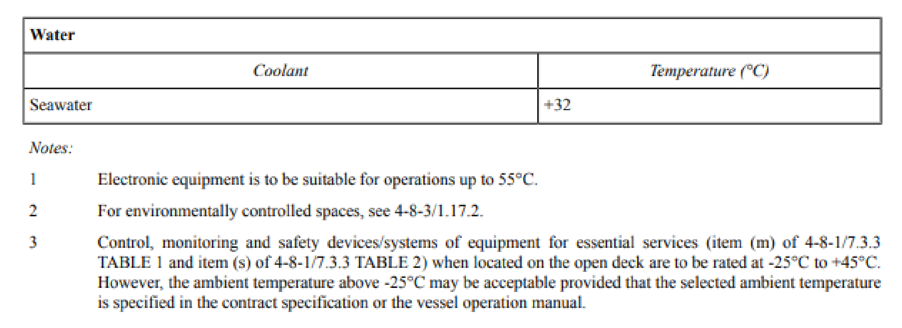


TABLE 8
Ambient Temperatures for Unrestricted Service <i>(1 July 2019)</i>
<table>
<tr><th colspan="3">Air</th></tr>
<tr><th><i>Installations, Components</i></th><th><i>Location, Arrangement</i> (1, 2)</th><th><i>Temperature Range (°C)</i></th></tr>
<tr><td>Machinery and electrical installations</td><td>Enclosed Spaces - General</td><td>0 to +45</td></tr>
<tr><td></td><td>Components mounted on machinery associated with high temperature</td><td>According to specific machinery and installation</td></tr>
<tr><td></td><td>In spaces subject to higher temperature (details to be submitted)</td><td>According to the actual maximum ambient temperature</td></tr>
<tr><td></td><td>In spaces with temperature lower than +45°C (details to be submitted)</td><td>According to the actual ambient temperature subject to minimum +40</td></tr>
<tr><td></td><td>Open Deck(3)</td><td>–25 to +45</td></tr>
</table>

<table>
<tr><th colspan="2">Water</th></tr>
<tr><th><i>Coolant</i></th><th><i>Temperature (°C)</i></th></tr>
<tr><td>Seawater</td><td>+32</td></tr>
</table>
<i>Notes:</i>
1 Electronic equipment is to be suitable for operations up to 55°C.
2 For environmentally controlled spaces, see 4-8-3/1.17.2.
3 Control, monitoring and safety devices/systems of equipment for essential services (item (m) of 4-8-1/7.3.3 TABLE 1 and item (s) of 4-8-1/7.3.3 TABLE 2) when located on the open deck are to be rated at -25°C to +45°C. However, the ambient temperature above -25°C may be acceptable provided that the selected ambient temperature is specified in the contract specification or the vessel operation manual.

<i>In addition to Section 6 of this Guide, the requirements of Sections 4-9-1 and 4-9-2, as appropriate, of the Marine Vessel Rules are also applicable to all vessels with equipment for control, monitoring and safety systems associated to the fuel cell power system.</i>

<i>Where vessels request special notations (such as ACC, ACCU, and ABCU in Marine Vessel Rules), this equipment is to be designed to successfully withstand the test conditions stipulated in 4-9-9/Table 1 of the Marine Vessel Rules, as applicable.</i>
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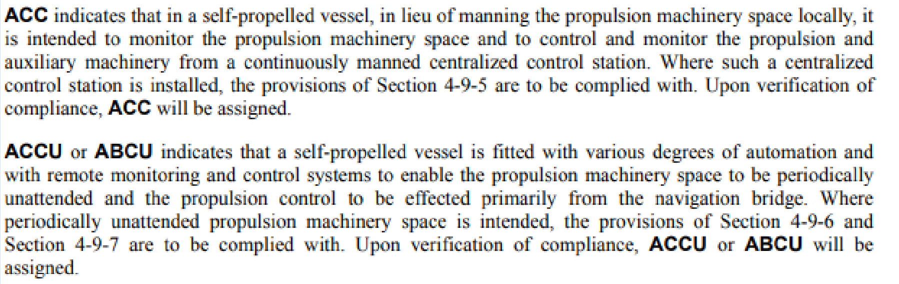
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td>
ACC indicates that in a self-propelled vessel, in lieu of manning the propulsion machinery space locally, it is intended to monitor the propulsion machinery space and to control and monitor the propulsion and auxiliary machinery from a continuously manned centralized control station. Where such a centralized control station is installed, the provisions of Section 4-9-5 are to be complied with. Upon verification of compliance, ACC will be assigned.
ACCU or ABCU indicates that a self-propelled vessel is fitted with various degrees of automation and with remote monitoring and control systems to enable the propulsion machinery space to be periodically unattended and the propulsion control to be effected primarily from the navigation bridge. Where periodically unattended propulsion machinery space is intended, the provisions of Section 4-9-6 and Section 4-9-7 are to be complied with. Upon verification of compliance, ACCU or ABCU will be assigned.</td><td></td></tr>
<tr><td>Section 1: General</td><td>Chapter 10: Certification</td><td></td><td><i>Fuel cell power systems are to be certified at the manufacturer’s facility in accordance with Section 1, Table 3 below. This table also provides the applicability of the certification requirements for certain equipment and components as referred to in Part 4, Part 5C and their applicable Chapters and Sections of the Marine Vessel Rules. See also notes under this Table.</i>
<table>
<tr><th><i>System, Equipment, Component</i></th><th><i>ABS Certification(4)</i></th><th><i>ABS Type Approval Tier (See Appendix 1-1-A4 of ABS Rules for Conditions of Classification)</i></th><th><i>Standards</i></th><th><i>Rule Reference (Marine Vessel Rules)</i></th><th><i>Section of this Guide</i></th></tr>
<tr><td><i>Fuel Cell Modules</i></td><td><i>Required</i></td><td><i>4/5</i></td><td><i>IEC 62282-2</i></td><td></td><td><i>2/4</i></td></tr>
<tr><td><i>Fuel cell power system</i></td><td><i>Required(1)</i></td><td><i>4/5</i></td><td><i>IEC 62282-3 Series</i></td><td></td><td><i>2/5</i></td></tr>
<tr><td><i>Pipe, Valves and Fitting</i></td><td><i>Required(2)</i></td><td><i>4/5</i></td><td></td><td><i>4-6-1, 4-1-1/Table 6, 5C-13-16</i></td><td><i>3/4</i></td></tr>
<tr><td><i>Pressure Vessels</i></td><td><i>Required</i></td><td><i>4/5</i></td><td></td><td><i>4-4-1, 4-1-1/Table 5</i></td><td><i>2/2.2.1</i></td></tr>
<tr><td><i><s>Hydrogen Storage Tank</s></i></td><td><i><s>Required</s></i></td><td><i><s>4/5</s></i></td><td></td><td><i><s>4-4-1, 4-1-1/Table 5</s></i></td><td><i><s>3/8.3</s></i></td></tr>
</table></td><td>Part 4, Part 5C and their applicable Chapters and Sections of the Marine Vessel Rules.
Out of scope:
<i>-5C-13-11</i>
<i>-5C-13-15</i></td></tr>
</table>

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<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td>
<table>
<tr><td>Fuel Cell Control and monitoring system</td><td>Required</td><td>4/5</td><td>IEC 62282-3 Series</td><td></td><td>Section 6</td></tr>
<tr><td>Electrical Equipment</td><td>Required</td><td>4/5</td><td></td><td>4-8-3, 4-1-1/Table 3</td><td>Section 5</td></tr>
<tr><td>~~Rotating Machines~~</td><td>~~Required~~</td><td>~~4/5~~</td><td></td><td>~~4-8-3, 4-1-1/Table 3~~</td><td>~~3/10~~</td></tr>
<tr><td>~~Fixed Fire and Gas detection system~~</td><td>~~Required~~</td><td>~~4/5~~</td><td></td><td>~~4-7-3, 4-1-1/Table 4, 5C-13-11, 5C-13-15~~</td><td>~~Section 4~~</td></tr>
<tr><td>~~Ships Bunker Hoses~~</td><td>~~Required(3)~~</td><td>~~4/5~~</td><td></td><td>~~5C-13-8/3.2~~</td><td>~~3/9.3~~</td></tr>
</table>
<p>Notes:</p>
<p>(1) Fuel cell power systems having a net electrical output of 100 kW or greater are required to be certified by ABS. (See Note 4). For fuel cell power systems having a net electrical output of less than 100 kW, the manufacturer is to certify the standard to which it is designed, fabricated and tested to, and to report the results of the tests conducted.</p>
<p>(2) Where indicated as ‘required’ in 4-6-1/Table 2 of the Marine Vessel Rules, the piping component is to be certified by ABS. This involves design approval of the component, as applicable, and testing in accordance with the standard of compliance at the manufacturer’s plant. Such components may also be accepted under the Type Approval Program</p>
<p>(4) ABS Certification means plan review, and surveys' attendance during construction and after installation to verify to itself that a vessel, structure, item of material, equipment or machinery is in compliance with the Rules, Guides, standards or other criteria of ABS and to the satisfaction of the attending Surveyor.</p>
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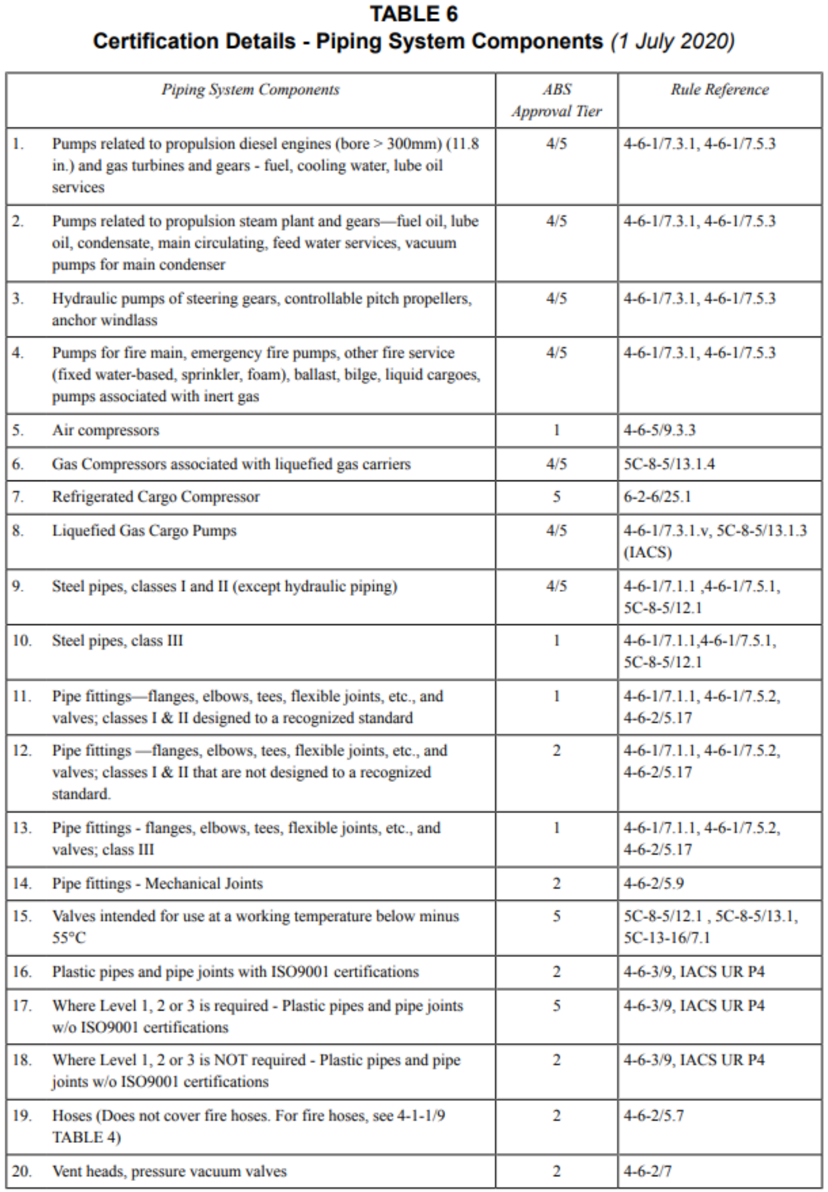


TABLE 6

Certification Details - Piping System Components *(1 July 2020)*

Piping System Components	*ABS Approval Tier*	*Rule Reference*
1. Pumps related to propulsion diesel engines (bore > 300mm) (11.8 in.) and gas turbines and gears - fuel, cooling water, lube oil services	4/5	4-6-1/7.3.1, 4-6-1/7.5.3
2. Pumps related to propulsion steam plant and gears—fuel oil, lube oil, condensate, main circulating, feed water services, vacuum pumps for main condenser	4/5	4-6-1/7.3.1, 4-6-1/7.5.3
3. Hydraulic pumps of steering gears, controllable pitch propellers, anchor windlass	4/5	4-6-1/7.3.1, 4-6-1/7.5.3
4. Pumps for fire main, emergency fire pumps, other fire service (fixed water-based, sprinkler, foam), ballast, bilge, liquid cargoes, pumps associated with inert gas	4/5	4-6-1/7.3.1, 4-6-1/7.5.3
5. Air compressors	1	4-6-5/9.3.3
6. Gas Compressors associated with liquefied gas carriers	4/5	5C-8-5/13.1.4
7. Refrigerated Cargo Compressor	5	6-2-6/25.1
8. Liquefied Gas Cargo Pumps	4/5	4-6-1/7.3.1.v, 5C-8-5/13.1.3 (IACS)
9. Steel pipes, classes I and II (except hydraulic piping)	4/5	4-6-1/7.1.1 ,4-6-1/7.5.1, 5C-8-5/12.1
10. Steel pipes, class III	1	4-6-1/7.1.1,4-6-1/7.5.1, 5C-8-5/12.1
11. Pipe fittings—flanges, elbows, tees, flexible joints, etc., and valves; classes I & II designed to a recognized standard	1	4-6-1/7.1.1, 4-6-1/7.5.2, 4-6-2/5.17
12. Pipe fittings —flanges, elbows, tees, flexible joints, etc., and valves; classes I & II that are not designed to a recognized standard.	2	4-6-1/7.1.1, 4-6-1/7.5.2, 4-6-2/5.17
13. Pipe fittings - flanges, elbows, tees, flexible joints, etc., and valves; class III	1	4-6-1/7.1.1, 4-6-1/7.5.2, 4-6-2/5.17
14. Pipe fittings - Mechanical Joints	2	4-6-2/5.9
15. Valves intended for use at a working temperature below minus 55°C	5	5C-8-5/12.1 , 5C-8-5/13.1, 5C-13-16/7.1
16. Plastic pipes and pipe joints with ISO9001 certifications	2	4-6-3/9, IACS UR P4
17. Where Level 1, 2 or 3 is required - Plastic pipes and pipe joints w/o ISO9001 certifications	5	4-6-3/9, IACS UR P4
18. Where Level 1, 2 or 3 is NOT required - Plastic pipes and pipe joints w/o ISO9001 certifications	2	4-6-3/9, IACS UR P4
19. Hoses (Does not cover fire hoses. For fire hoses, see 4-1-1/9 TABLE 4)	2	4-6-2/5.7
20. Vent heads, pressure vacuum valves	2	4-6-2/7

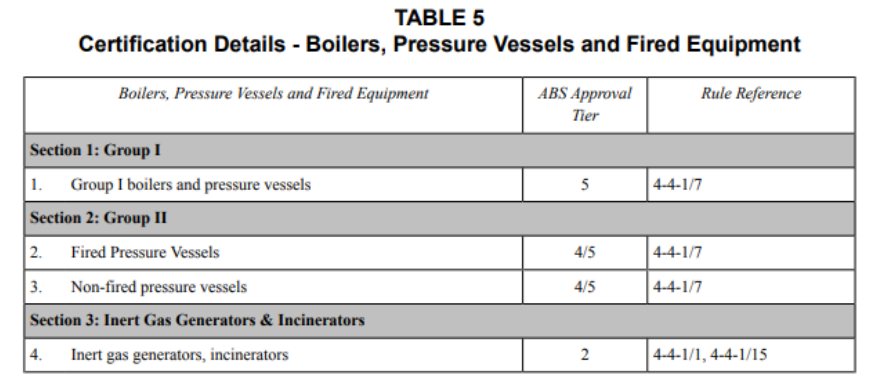
Conditions	Item	Documentation	Additional Description	Information
				

TABLE 5
Certification Details - Boilers, Pressure Vessels and Fired Equipment

Boilers, Pressure Vessels and Fired Equipment	*ABS Approval Tier*	*Rule Reference*
Section 1: Group I		
1. Group I boilers and pressure vessels	5	4-4-1/7
Section 2: Group II		
2. Fired Pressure Vessels	4/5	4-4-1/7
3. Non-fired pressure vessels	4/5	4-4-1/7
Section 3: Inert Gas Generators & Incinerators		
4. Inert gas generators, incinerators	2	4-4-1/1, 4-4-1/15

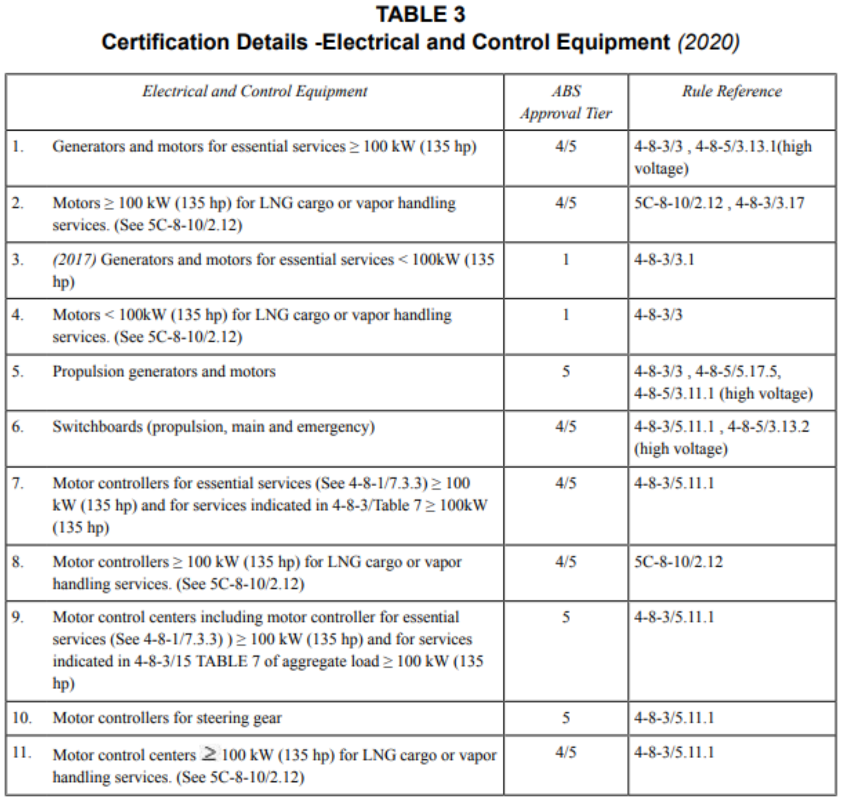
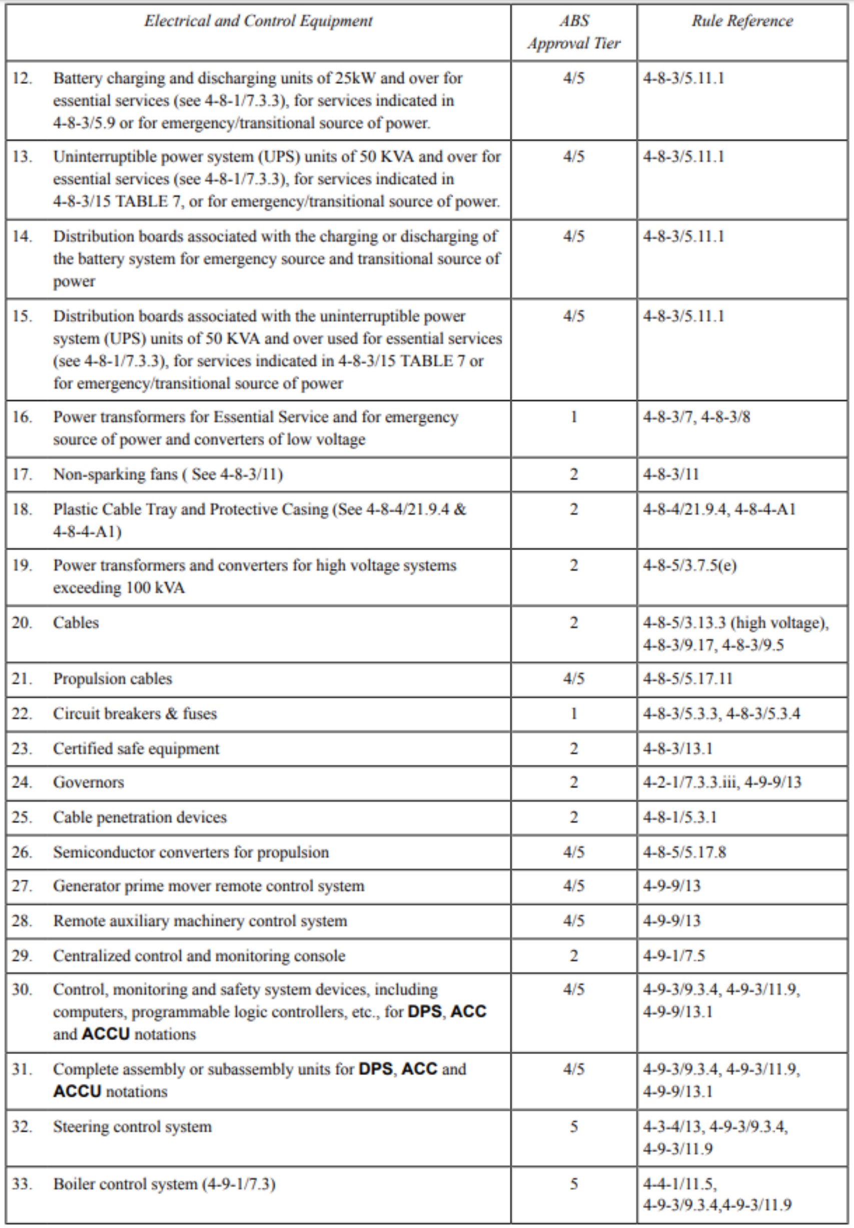
Conditions	Item	Documentation	Additional Description	Information
				

TABLE 3
Certification Details -Electrical and Control Equipment *(2020)*

Electrical and Control Equipment	*ABS Approval Tier*	*Rule Reference*
1. Generators and motors for essential services ≥ 100 kW (135 hp)	4/5	4-8-3/3 , 4-8-5/3.13.1(high voltage)
2. Motors ≥ 100 kW (135 hp) for LNG cargo or vapor handling services. (See 5C-8-10/2.12)	4/5	5C-8-10/2.12 , 4-8-3/3.17
3. *(2017)* Generators and motors for essential services < 100kW (135 hp)	1	4-8-3/3.1
4. Motors < 100kW (135 hp) for LNG cargo or vapor handling services. (See 5C-8-10/2.12)	1	4-8-3/3
5. Propulsion generators and motors	5	4-8-3/3 , 4-8-5/5.17.5, 4-8-5/3.11.1 (high voltage)
6. Switchboards (propulsion, main and emergency)	4/5	4-8-3/5.11.1 , 4-8-5/3.13.2 (high voltage)
7. Motor controllers for essential services (See 4-8-1/7.3.3) ≥ 100 kW (135 hp) and for services indicated in 4-8-3/Table 7 ≥ 100kW (135 hp)	4/5	4-8-3/5.11.1
8. Motor controllers ≥ 100 kW (135 hp) for LNG cargo or vapor handling services. (See 5C-8-10/2.12)	4/5	5C-8-10/2.12
9. Motor control centers including motor controller for essential services (See 4-8-1/7.3.3)) ≥ 100 kW (135 hp) and for services indicated in 4-8-3/15 TABLE 7 of aggregate load ≥ 100 kW (135 hp)	5	4-8-3/5.11.1
10. Motor controllers for steering gear	5	4-8-3/5.11.1
11. Motor control centers ≥ 100 kW (135 hp) for LNG cargo or vapor handling services. (See 5C-8-10/2.12)	4/5	4-8-3/5.11.1



Electrical and Control Equipment	*ABS Approval Tier*	*Rule Reference*
12. Battery charging and discharging units of 25kW and over for essential services (see 4-8-1/7.3.3), for services indicated in 4-8-3/5.9 or for emergency/transitional source of power.	4/5	4-8-3/5.11.1
13. Uninterruptible power system (UPS) units of 50 KVA and over for essential services (see 4-8-1/7.3.3), for services indicated in 4-8-3/15 TABLE 7, or for emergency/transitional source of power.	4/5	4-8-3/5.11.1
14. Distribution boards associated with the charging or discharging of the battery system for emergency source and transitional source of power	4/5	4-8-3/5.11.1
15. Distribution boards associated with the uninterruptible power system (UPS) units of 50 KVA and over used for essential services (see 4-8-1/7.3.3), for services indicated in 4-8-3/15 TABLE 7 or for emergency/transitional source of power	4/5	4-8-3/5.11.1
16. Power transformers for Essential Service and for emergency source of power and converters of low voltage	1	4-8-3/7, 4-8-3/8
17. Non-sparking fans (See 4-8-3/11)	2	4-8-3/11
18. Plastic Cable Tray and Protective Casing (See 4-8-4/21.9.4 & 4-8-4-A1)	2	4-8-4/21.9.4, 4-8-4-A1
19. Power transformers and converters for high voltage systems exceeding 100 kVA	2	4-8-5/3.7.5(e)
20. Cables	2	4-8-5/3.13.3 (high voltage), 4-8-3/9.17, 4-8-3/9.5
21. Propulsion cables	4/5	4-8-5/5.17.11
22. Circuit breakers & fuses	1	4-8-3/5.3.3, 4-8-3/5.3.4
23. Certified safe equipment	2	4-8-3/13.1
24. Governors	2	4-2-1/7.3.3.iii, 4-9-9/13
25. Cable penetration devices	2	4-8-1/5.3.1
26. Semiconductor converters for propulsion	4/5	4-8-5/5.17.8
27. Generator prime mover remote control system	4/5	4-9-9/13
28. Remote auxiliary machinery control system	4/5	4-9-9/13
29. Centralized control and monitoring console	2	4-9-1/7.5
30. Control, monitoring and safety system devices, including computers, programmable logic controllers, etc., for **DPS**, **ACC** and **ACCU** notations	4/5	4-9-3/9.3.4, 4-9-3/11.9, 4-9-9/13.1
31. Complete assembly or subassembly units for **DPS**, **ACC** and **ACCU** notations	4/5	4-9-3/9.3.4, 4-9-3/11.9, 4-9-9/13.1
32. Steering control system	5	4-3-4/13, 4-9-3/9.3.4, 4-9-3/11.9
33. Boiler control system (4-9-1/7.3)	5	4-4-1/11.5, 4-9-3/9.3.4,4-9-3/11.9

Conditions	Item	Documentation	Additional Description	Information
Section 2: Fuel cell design requirements	Chapter 1: Design principles	Sub-chapter 1.1: General	*The fuel cell space is to be regarded as a machinery space of Category A and categorized according to SOLAS Chapter II-2 for fire protection purposes. The fire extinguishing system is to be compatible with the specific fuel and fuel cell technology proposed.* “'A' Class Divisions" are those divisions formed by bulkheads and decks which com ply with the following: (i) They shall be constructed of steel or other equivalent material; (ii) They shall be suitably stiffened; *(iii)* They shall be so constructed as to be capable of preventing the passage of smoke and flame to the end of the one-hour standard fire test” *The fuel cell space is to be designed to mitigate hazards to lower hazardous levels under all operational conditions. Due to the possibility of hydrogen leaks within the fuel cell stacks, the fuel cell space is to be classified as a hazardous area Zone 1 (refer to 5/3.2 i) of this Guide).* “Hazardous Area Zone 1 includes: *i)* Fuel cell space. *ii)* Areas on the open deck or semi- enclosed spaces on deck, within 3 m of any reformed fuel or purge gas outlets, or fuel cell space ventilation outlets. *iii)* Fuel cell exhaust air and exhaust gas outlets. *iv)* Areas on open deck or semi-enclosed spaces on deck, within 1.5 m of fuel cell space entrances, fuel cell space ventilation inlets and other openings into Zone 1 spaces. *v)* Areas on open deck or semi-enclosed spaces within 3 m in which other sources of release of reformed fuel are located.”	SOLAS Chapter II-2 IACS Rec. 146 4-8-2/3.11.2 or 4-8-2/3.11.3 of the Marine Vessel Rules

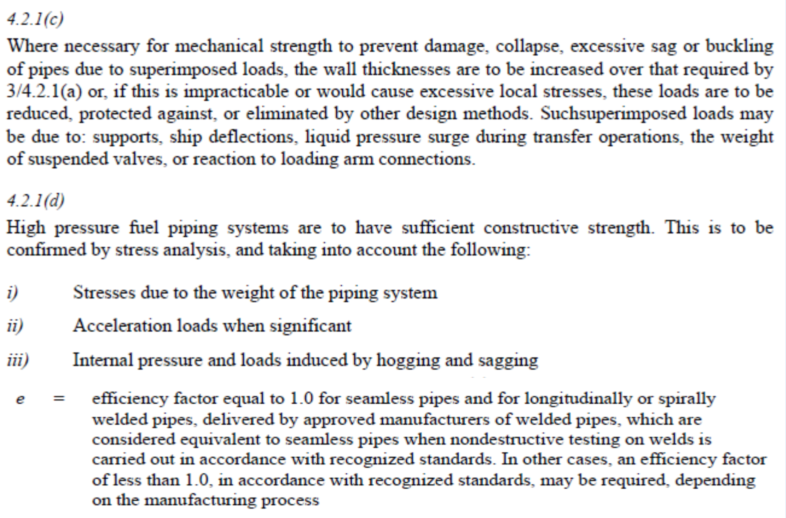
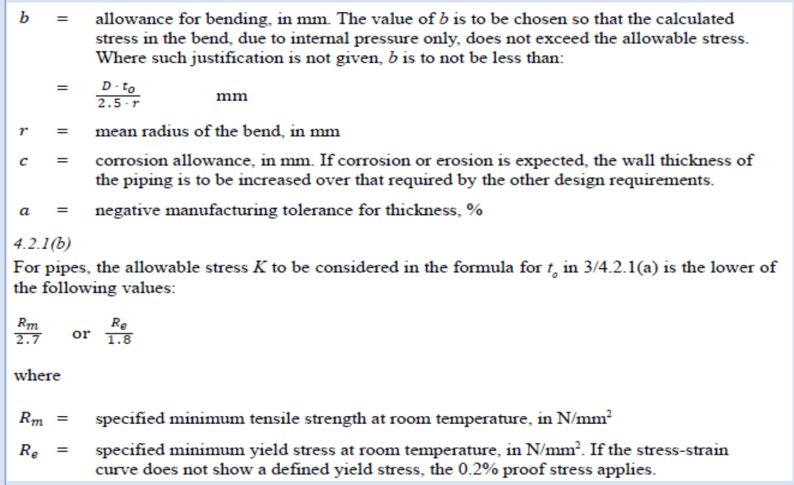
Conditions	Item	Documentation	Additional Description	Information
			Therefore, equipment or components installed in this space are to be of a certified safe type in order to minimize the probability of a gas explosion in such a fuel cell space. *When an alternative design is proposed, the equivalence of such an alternative design is to be demonstrated in accordance with 1/8 of this Guide.* *The Fuel cell power system is to be designed such that failure of any of the system's components will not cause unsafe operation of the process or its control systems, emergency control systems or safety systems.* *Risk Assessment (i.e., HAZID, HAZOP, FMEA, see 2/3) is to be used to determine that any component failure will not result in the complete loss of control, the unsafe shutdown of the process or equipment, or other undesirable consequences. IACS Rec. 146 may be referred to for the application of acceptable and recognized techniques and means to document the risk assessment.* *The vessel electrical system is to be so arranged that, in the event of the loss of the fuel cell(s) power system(s) in service, the electrical supply to equipment necessary for propulsion and steering and for the safety of the vessel will be maintained or restored in accordance with the provision in 4-8-2/3.11.2 or 4-8-2/3.11.3 of the Marine Vessel Rules. See also 2/5.2i) and 2/5.2ii) of this Guide.*	
Section 2: Fuel cell design requirements	Chapter 2: Materials	Sub-chapter 2.2: Material requirements for specific fuels Paragraph 2.2.2: hydrogen gas	*Materials used in all components in contact with hydrogen are to be resistant to hydrogen embrittlement and hydrogen attack. A material is not to be used unless data is available showing that it is suitable for the planned service conditions. In case of any doubt the material can be subjected to hydrogen embrittlement susceptibility testing (as per ISO 11114-4) to evaluate material suitability before use.*	ISO 11114-4

Conditions	Item	Documentation	Additional Description	Information
Section 2: Fuel cell design requirements	Chapter 3: fuel Cell power system risk assessment	Sub-chapter 3.2: Risk assessment	*i) The primary objective of the risk assessment is to identify risks and uncertainties associated with the proposed fuel cell power system design and its installation on a vessel. The risk assessment is to be conducted to evaluate the design as a whole, encompassing the general arrangement of where and how the fuel cell is integrated into the vessel design.* *ii) The use of risk assessment techniques should be discussed with ABS prior to performing the risk assessment. The risk assessment is to be carried out in accordance with the ABS Guidance Notes on Risk Assessment Application for the Marine and Offshore Oil and Gas Industries, ABS Guidance Notes on Failure Mode and Effects Analysis (FMEA) for Classification or other ABS recognized industry standards (such as IEC 60812).* *iii) Several risk assessment techniques may be applied. At the early design stages, a Hazard Identification (HAZID) technique may be conducted to identify potential hazards that could result in consequences to personnel, the environment, and assets. The Hazard and Operability (HAZOP) study may also be conducted in order to identify and evaluate hazards that may represents risks to personnel or equipment. A Failure Mode and Effects Analysis (FMEA) may also be used to demonstrate that any single failure will not lead to an undesirable event.* *All foreseeable hazards, their causes, consequences (local and global effects), and associated risk control measures are to be documented. The fuel cell power system risk assessment report is to be submitted for review, and at a minimum is to address the following issues, as applicable:* ●*Internal leakage in Fuel Cell Module* ●*Leakage of hydrogen gases, any fuels gases* ●*Failure of fuel pressure reduction* ●*Failure of the electrical power output conditioning system* ●*Thermal runaway of onboard energy buffer* ●*Loss of inert gas system*	IEC 60812

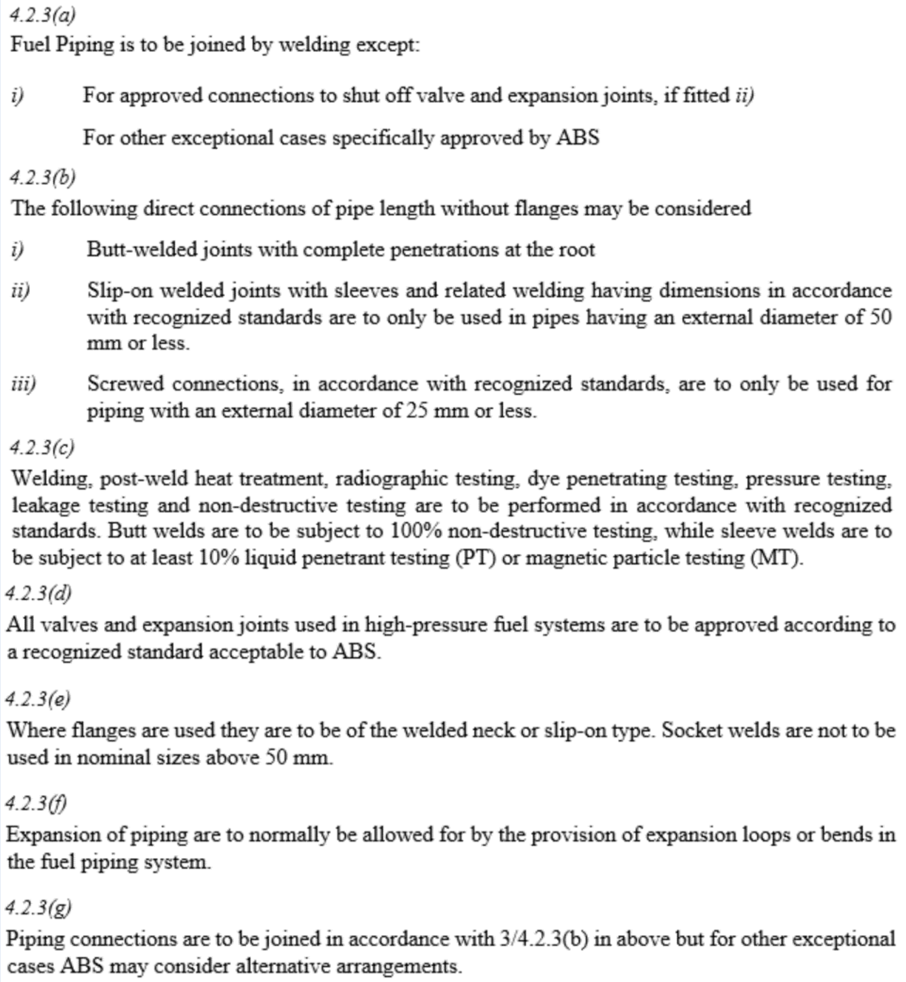
Conditions	Item	Documentation	Additional Description	Information
			●Toxicity potential and risk of oxygen deficiency or other negative impacts on crew health due to fuels (i.e., methyl/ethyl alcohol, ammonia, etc.) and inert gases *●Safe handling, stowage, marking and carriage of flammable, toxic, and other dangerous substances* *●The causes and consequences of release of fuel. The consequences of any release of fuel are to be minimized, while providing safe access for operation and inspection* *●Safe handling and containment arrangement for excess fuel (e.g. in the fuel cell stack) where there is no recirculation to the fuel processing system* *●Arrangement of any fixed and/or portable fire extinguishing systems* *●Permanently installed gas detectors at ventilation inlets to accommodation and machinery spaces*	
Section 2: Fuel cell design requirements	Chapter 4: Fuel cell module	Paragraph 4.1: general	*The fuel cell module is to be designed, type and/or routine tested, and certified for compliance with IEC 62282-2 or other recognized standards by ABS or a competent, independent testing laboratory.* *In addition, the module is to comply with appropriate requirements for installation in a marine environment as documented in 1/6.*	IEC 62282-2
Section 2: Fuel cell design requirements	Chapter 5: Fuel cell power system	Paragraph 5.1: general requirements	*i) Accessible parts of the fuel cell power system are to have no sharp edges, sharp angles or rough surfaces likely to cause injury.* *ii) The easily accessed parts of the fuel cell power system are to be designed and constructed to prevent slipping, tripping or falling hazards* *iii) The fuel cell power system, components and fittings are to be designed and constructed so that they are stable enough, under the foreseen operating conditions for use without risk of overturning, falling or unexpected movement. Otherwise, appropriate means of anchorage are to be incorporated and indicated in the instructions.*	

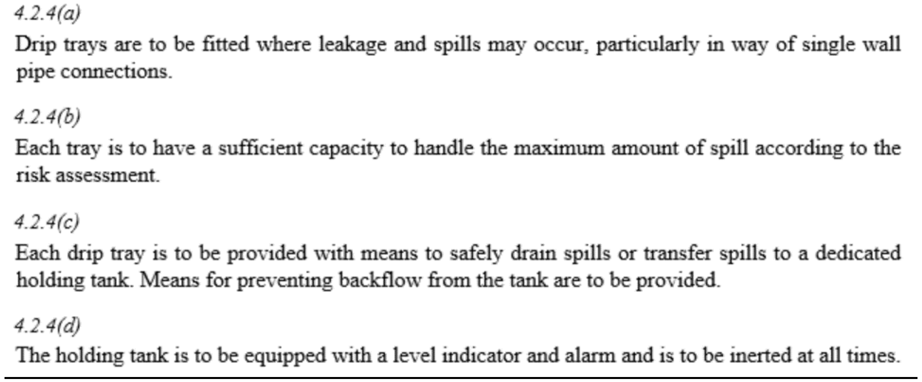
Conditions	Item	Documentation	Additional Description	Information
			iv) The moving parts of the fuel cell power system are to be designed, built and arranged to avoid hazards or, where hazards persist, fixed with guards or protective devices in such a way to prevent all risk of contact. *v) The various parts of the fuel cell power system and their linkages are to be so constructed that, when used normally, no instability, distortion, breakage or wear can occur that is likely to impair safety.* *vi) The fuel cell power system is to be designed, constructed and/or equipped so that risks due to gases, liquids, dust or vapors released during the operation or maintenance of a fuel cell power system are avoided.* *vii) All parts are to be securely mounted or attached and rigidly supported. The use of shock-mounts is permitted when suitable for the application.* *viii) All safety shutdown system components, whose failure may result in a hazardous event, as identified by the risk analysis noted in 2/3, are to be recognized, certified or separately tested for their intended usage.* *ix) The manufacturer is to take steps to eliminate any risk of injury caused by contact with, or proximity to, external surfaces of the fuel cell power system enclosure, handle, grips or knobs at high temperatures.*	
Section 2: Fuel cell design requirements	Chapter 5: Fuel cell power system	Paragraph 5.3: standards	*For functional safety, the required installation level, performance level or the class of test and control function are to be determined and designed in accordance with following standards:* • *IEC 62282-3-100, applicable to marine power safety systems* • *IEC 62282-3-200 for operational and environmental aspects of stationary fuel cell power systems performance*	IEC 62282-3-100 IEC 62282-3-200
Section 3: Ship arrangements and installation requirements	Chapter 4: Piping design	Sub-chapter 4.1 General	*i)* The design pressure is not to be less than 1 MPa, except for open-ended pipes where it is not to be less than 0.5 MPa. The design pressure *P* in the formula for t_o in 3/4.2 below is the maximum gauge pressure to which the system may be subjected in service, taking into account the highest set pressure on any relief valve on the system.	

Conditions	Item	Documentation	Additional Description	Information
			ii) For pipes made of materials other than steel, the allowable stress is to be considered by ABS on a case-by-case basis provided that a recognized standard has been used. *iii)* Fuel pipes and all the other piping needed for a safe and reliable operation and maintenance are to be color marked in accordance with a standard. *iv)* All fuel piping and independent fuel tanks are to be electrically bonded to the ship's hull. Electrical conductivity is to be maintained across all joints and fittings. Electrical resistance between piping and the hull are to be a maximum of 10^6 Ohm. *v)* Piping other than fuel supply piping and cabling may be arranged in the double wall piping or duct provided that they do not create a source of ignition, or compromise the integrity of the double pipe or duct. The double wall piping or duct is to only contain the piping or cabling necessary for operational purposes. *vi)* Filling lines to fuel tanks are to be arranged to minimize static electricity by minimizing the free fall distance into the fuel tank.	
Section 3: Ship arrangements and installation requirements	Chapter 4: Piping design	Sub-chapter 4.2: piping system component requirements	The following requirements are applicable to piping system components. ABS may consider other approaches based on a case-by-case basis provided that a recognized standard has been used.	

Conditions	Item	Documentation	Additional Description	Information
Section 3: Ship arrangements and installation requirements	Chapter 4: Piping design	Sub-chapter 4.2: Piping system component requirements Paragraph 4.2.1: Piping scrantlings	 *4.2.1(c)* Where necessary for mechanical strength to prevent damage, collapse, excessive sag or buckling of pipes due to superimposed loads, the wall thicknesses are to be increased over that required by 3/4.2.1(a) or, if this is impracticable or would cause excessive local stresses, these loads are to be reduced, protected against, or eliminated by other design methods. Suchsuperimposed loads may be due to: supports, ship deflections, liquid pressure surge during transfer operations, the weight of suspended valves, or reaction to loading arm connections. *4.2.1(d)* High pressure fuel piping systems are to have sufficient constructive strength. This is to be confirmed by stress analysis, and taking into account the following: *i)* Stresses due to the weight of the piping system *ii)* Acceleration loads when significant *iii)* Internal pressure and loads induced by hogging and sagging e = efficiency factor equal to 1.0 for seamless pipes and for longitudinally or spirally welded pipes, delivered by approved manufacturers of welded pipes, which are considered equivalent to seamless pipes when nondestructive testing on welds is carried out in accordance with recognized standards. In other cases, an efficiency factor of less than 1.0, in accordance with recognized standards, may be required, depending on the manufacturing process  b = allowance for bending, in mm. The value of b is to be chosen so that the calculated stress in the bend, due to internal pressure only, does not exceed the allowable stress. Where such justification is not given, b is to not be less than: = $\frac{D \cdot t_o}{2.5 \cdot r}$ mm r = mean radius of the bend, in mm c = corrosion allowance, in mm. If corrosion or erosion is expected, the wall thickness of the piping is to be increased over that required by the other design requirements. a = negative manufacturing tolerance for thickness, % *4.2.1(b)* For pipes, the allowable stress K to be considered in the formula for t_o in 3/4.2.1(a) is the lower of the following values: $\frac{R_m}{2.7}$ or $\frac{R_e}{1.8}$ where R_m = specified minimum tensile strength at room temperature, in N/mm^2 R_e = specified minimum yield stress at room temperature, in N/mm^2. If the stress-strain curve does not show a defined yield stress, the 0.2% proof stress applies.	

Conditions	Item	Documentation	Additional Description	Information
Section 3: Ship arrangements and installation requirements	Chapter 4: Piping design	Sub-chapter 4.2: Piping system component requirements Paragraph 4.2.2: Flexibility of piping	*The arrangement and installation of fuel piping is to provide the necessary flexibility to maintain the integrity of the piping system in actual service situations, taking potential for fatigue into account.*	

Conditions	Item	Documentation	Additional Description	Information
Section 3: Ship arrangements and installation requirements	Chapter 4: Piping design	Sub-chapter 4.2: Piping system component requirements Paragraph 4.2.3: Joining Details for Flanges, Valves and Fittings	 *4.2.3(a)* Fuel Piping is to be joined by welding except: *i)* For approved connections to shut off valve and expansion joints, if fitted *ii)* For other exceptional cases specifically approved by ABS *4.2.3(b)* The following direct connections of pipe length without flanges may be considered *i)* Butt-welded joints with complete penetrations at the root *ii)* Slip-on welded joints with sleeves and related welding having dimensions in accordance with recognized standards are to only be used in pipes having an external diameter of 50 mm or less. *iii)* Screwed connections, in accordance with recognized standards, are to only be used for piping with an external diameter of 25 mm or less. *4.2.3(c)* Welding, post-weld heat treatment, radiographic testing, dye penetrating testing, pressure testing, leakage testing and non-destructive testing are to be performed in accordance with recognized standards. Butt welds are to be subject to 100% non-destructive testing, while sleeve welds are to be subject to at least 10% liquid penetrant testing (PT) or magnetic particle testing (MT). *4.2.3(d)* All valves and expansion joints used in high-pressure fuel systems are to be approved according to a recognized standard acceptable to ABS. *4.2.3(e)* Where flanges are used they are to be of the welded neck or slip-on type. Socket welds are not to be used in nominal sizes above 50 mm. *4.2.3(f)* Expansion of piping are to normally be allowed for by the provision of expansion loops or bends in the fuel piping system. *4.2.3(g)* Piping connections are to be joined in accordance with 3/4.2.3(b) in above but for other exceptional cases ABS may consider alternative arrangements.	

Conditions	Item	Documentation	Additional Description	Information
~~Section 3: Ship arrangements and installation requirements~~	~~Chapter 4: Piping design~~	~~Sub-chapter 4.2: Piping sytsem component requirements~~ ~~Paragraph 4.2.4: Drip trays~~	 *4.2.4(a)* Drip trays are to be fitted where leakage and spills may occur, particularly in way of single wall pipe connections. *4.2.4(b)* Each tray is to have a sufficient capacity to handle the maximum amount of spill according to the risk assessment. *4.2.4(c)* Each drip tray is to be provided with means to safely drain spills or transfer spills to a dedicated holding tank. Means for preventing backflow from the tank are to be provided. *4.2.4(d)* The holding tank is to be equipped with a level indicator and alarm and is to be inerted at all times.	
Section 3: Ship arrangements and installation requirements	Chapter 4: Piping design	Sub-chapter 4.3: Hydrogen piping requirements	*Hydrogen piping systems are to be designed in accordance with recognized standards. The fabrication, assembly, erection, inspection, examination and testing of hydrogen piping systems are to be performed in accordance with a recognized standard (i.e. ASME B31-12, Hydrogen Piping and Pipelines) acceptable to ABS. To minimize the potential for leaks and allow for their easy detection are to be defined in the Risk Assessment.*	*ASME B31-12*
Section 3: Ship arrangements and installation requirements	Chapter 10: ventillation system	Sub-chapter 10.2: Fuel cell space	*i) Fuel cell spaces are to be equipped with a mechanical ventilation system of the extraction type providing effective ventilation of the complete space, also taking into consideration the density of potentially leaking fuel gases.* *ii) The ventilation rate in fuel cell spaces are to be sufficient to dilute the gas/vapor concentration to below the flammable range in all leakage scenarios, including the fuel released upon pipe rupture with consideration for automatic detection and line shutoff processes that limit the release duration.* *iii) Any ducting used for the ventilation of fuel cell spaces is not to serve any other space.* *iv) Ventilation ducts from spaces containing reformed fuel piping or release sources are to be vertical or steadily ascending and without sharp bends to avoid any opportunity for gas to accumulate.*	

Conditions	Item	Documentation	Additional Description	Information
			v) *Two fans are to be installed for the ventilation of the fuel cell space with 100% capacity each. Both fans are to be supplied from separate circuits. In case of loss of ventilation or loss of negative pressure in the fuel cell space the fuel cell power system is to carry out an automatic, controlled shutdown of the fuel cell and isolation of the fuel supply.*	
Section 3: Ship arrangements and installation requirements	Chapter 11: Fuel leakage	Sub-chapter 11.1: General	i) The *propulsion and fuel supply system are to be designed so that safety actions after any fuel leakage do not lead to an unacceptable loss of power.* ii) *Fuel cell spaces are to be designed to safely contain and exhaust fuel leakages and are to be provided with suitable leakage detection systems.* iii) *If fuel leakage is detected in the ducting enclosure or the annular spaces of the double walled bunkering lines, an audible and visual alarm and emergency shutdown of the bunkering valve is to automatically be activated.* iv) *If a leak leading to a fuel supply shutdown occurs, the fuel supply is not to be operated until the leak has been found and addressed. Instructions to this effect are to be placed in a prominent position in the fuel cell space.* v) *Fixed fuel vapor and/or leakage detection suitable for all spaces and areas concerned, arranged to automatically shutdown the fuel supply, and disconnect all electrical equipment or installations not of a certified safe type, is to be provided.* vi) *Drip trays are to be provided where leakage and spills may occur in accordance with 3/4.2.4 of this Guide.* "4 Drip Trays 4.2.4(a) Drip trays are to be fitted where leakage and spills may occur, particularly in way of single wall pipe connections. 4.2.4(b) Each tray is to have a sufficient capacity to handle the maximum amount of spill according to the risk assessment. 4.2.4(c) Each drip tray is to be provided with means to safely drain spills or transfer spills to a dedicated holding tank. Means for preventing backflow from the tank are to be provided.	

Conditions	Item	Documentation	Additional Description	Information
			4.2.4(d) The holding tank is to be equipped with a level indicator and alarm and is to be inerted at all Times” *vii) The fuel cell space is to have an independent deck drain or no deck drain at all.*	
Section 3: Ship arrangements and installation requirements	Chapter 12: Fuel cell exhaust system	Sub-chapter 12.1: General	*i) Exhaust gases from the fuel cell power systems are not to be combined with any ventilation systems and are to be led to the open air.* *ii) Fuel cell exhaust air and exhaust gas outlets are to be regarded as Zone 1 hazardous areas.*	
Section 4: Fire safety	Chapter 1: General	Sub-chapter 1.1: Application	*i) The fire safety system is to be suitable for use with the specific fuel and fuel cell technology proposed. ABS may allow any alternative fire safety measures if equivalence is demonstrated by a risk assessment considering the fuels used.* *ii) Fuel cell spaces are to be designed to provide a geometrical shape that minimizes the accumulation of gases or formation of gas pockets.*	
Section 4: Fire safety	Chapter 3: Fire extinguishing	Sub-chapter 3.1: General	The fire-extinguishing system is to be suitable for use with the specific fuel and fuel cell technology proposed and included in the Risk Assessment. Spaces such as fuel cell are to be fitted with a suitable Fixed Fire Extinguishing System (FFES) recommended by the vendor and appropriate to the fuel chemistry used in those spaces. The FFES is to adequately consider the potential fire loads involved. Technical validation of the system is to be carried out in accordance with the procedures outlined in the ABS *Guidance Notes on Alternative Design and Arrangements for Fire Safety* and sufficient documentation to verify the same is to be submitted along with arrangements and details of the system for review.	
Section 4: Fire safety	Chapter 4: Fire detection and alarm systems	Sub-chapter 4. Fire Detection and Alarm Systems	*i) A fixed fire detection and fire alarm system complying with the Chapter 9 of International Code for Fire Safety Systems is to be provided for all compartments containing the fuel system.*	Chapter 9 of International Code for Fire Safety Systems

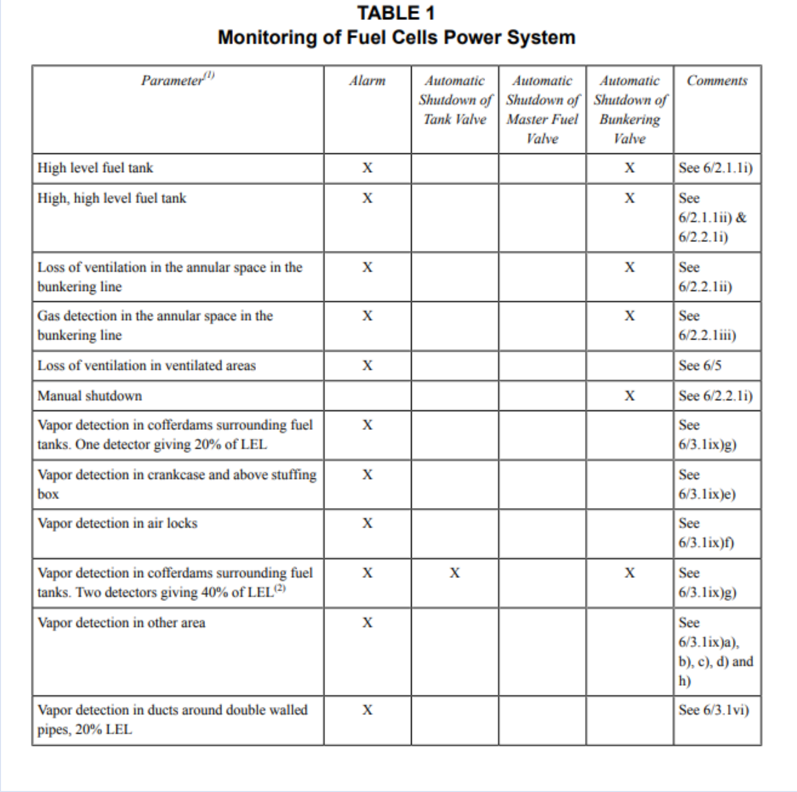
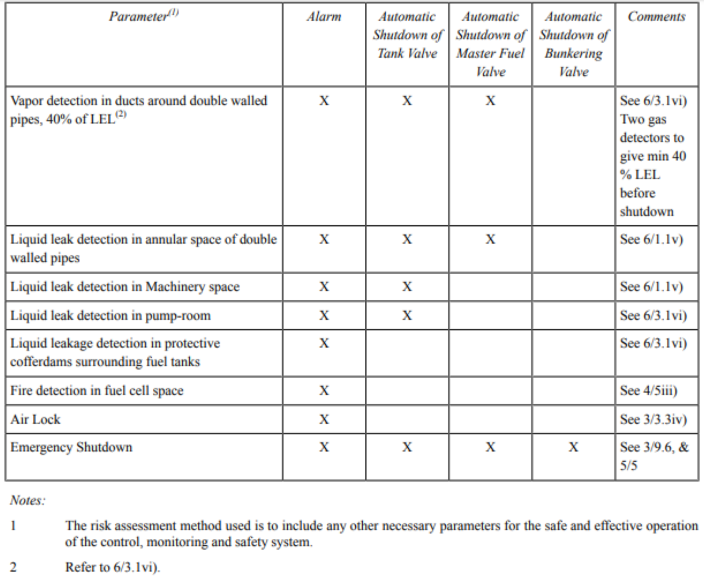
Conditions	Item	Documentation	Additional Description	Information
			ii) Suitable detectors are to be selected based on the fire characteristics of the fuel. Smoke detectors are to be used in combination with detectors which can detect fire. *iii) Required safety actions at the fire detection in the fuel cell spaces are given in Section 6, Table 1* 	

TABLE 1
Monitoring of Fuel Cells Power System

Parameter[1]	*Alarm*	*Automatic Shutdown of Tank Valve*	*Automatic Shutdown of Master Fuel Valve*	*Automatic Shutdown of Bunkering Valve*	*Comments*
High level fuel tank	X			X	See 6/2.1.1i)
High, high level fuel tank	X			X	See 6/2.1.1ii) & 6/2.2.1i)
Loss of ventilation in the annular space in the bunkering line	X			X	See 6/2.2.1ii)
Gas detection in the annular space in the bunkering line	X			X	See 6/2.2.1iii)
Loss of ventilation in ventilated areas	X				See 6/5
Manual shutdown				X	See 6/2.2.1i)
Vapor detection in cofferdams surrounding fuel tanks. One detector giving 20% of LEL	X				See 6/3.1ix)g)
Vapor detection in crankcase and above stuffing box	X				See 6/3.1ix)e)
Vapor detection in air locks	X				See 6/3.1ix)f)
Vapor detection in cofferdams surrounding fuel tanks. Two detectors giving 40% of LEL[2]	X	X		X	See 6/3.1ix)g)
Vapor detection in other area	X				See 6/3.1ix)a), b), c), d) and h)
Vapor detection in ducts around double walled pipes, 20% LEL	X				See 6/3.1vi)

Conditions	Item	Documentation	Additional Description	Information
				
Section 5: Electrical systems	Chapter 1: General	Sub-chapter 1.1: Application	*i) The electrical requirements in this Section supplement the requirements of Part D of SOLAS Chapter II-1 and Part 4, Section 8 of the Marine Vessel Rules.* *ii) Electrical equipment is not to be installed in hazardous areas unless essential for operational purposes or safety enhancement.* *iii) Where electrical equipment is installed in hazardous areas it is to be selected, installed and maintained in accordance with standards at least equivalent to those acceptable to the Organization (i.e., IEC 60079 series and IEC 60092-502, as applicable).* *iv) Cable penetrations are to satisfy the requirements regulating the dispersion of gas.* *v) The lighting system in hazardous areas is to be divided between at least two branch circuits. All switches and protective devices are to interrupt all poles or phases and are to be located in a nonhazardous area.*	requirements of Part D of SOLAS Chapter II-1 and Part 4, Section 8 of the *Marine Vessel* Rules This two reference does not exist IEC 60079 series IEC 60092-502

Parameter[(1)]	*Alarm*	*Automatic Shutdown of Tank Valve*	*Automatic Shutdown of Master Fuel Valve*	*Automatic Shutdown of Bunkering Valve*	*Comments*
Vapor detection in ducts around double walled pipes, 40% of LEL[(2)]	X	X	X		See 6/3.1vi) Two gas detectors to give min 40 % LEL before shutdown
Liquid leak detection in annular space of double walled pipes	X	X	X		See 6/1.1v)
Liquid leak detection in Machinery space	X	X			See 6/1.1v)
Liquid leak detection in pump-room	X	X			See 6/3.1vi)
Liquid leakage detection in protective cofferdams surrounding fuel tanks	X				See 6/3.1vi)
Fire detection in fuel cell space	X				See 4/5iii)
Air Lock	X				See 3/3.3iv)
Emergency Shutdown	X	X	X	X	See 3/9.6, & 5/5

Notes:

1 The risk assessment method used is to include any other necessary parameters for the safe and effective operation of the control, monitoring and safety system.

2 Refer to 6/3.1vi).

Conditions	Item	Documentation	Additional Description	Information
			vi) The installation of the electrical equipment units is to provide the safe bonding to the hull of the units themselves. *vii) Hoses, transfer arms, piping and fittings provided by the delivering facility used for bunkering are to be electrically continuous, suitably insulated and are to provide a level of safety compliant with recognized standards*	
Section 5: Electrical systems	Chapter 3: Hazardous area zones	Sub-chapter 3.2: Hazardous area zone 1	Hazardous Area Zone 1 includes: i) Fuel cell space. ii) Fuel cell exhaust air and exhaust gas outlets.	
Section 5: Electrical systems	Chapter 5: Emergency shutdown	Sub-chapter 5.1: General	*In general, arrangements are to be provided for the disconnection or shutdown, either selectively or simultaneously, of all electrical equipment and devices, including the emergency generator, except for the services listed in accordance with the applicable sections of the Marine Vessel Rules (MVR) and the Mobile Offshore Units (MOU) Rules, from the emergency control stations (see 5/5.2 below). Initiation of the above shut-downs may vary according to the nature of the emergency. A recommended shut down sequence is to be provided in the vessel's operating manual.* *To address risks associated with technical faults and inadvertent operations of the emergency shutdown, each vessel is to develop a detailed plan for recovery and restoration of operation after operation of each level of ESD.* *If limit values determined for the control process, e.g. temperature, pressure, or voltage, which may lead to hazardous situations, the fuel cell power system are to be automatically shut down and interlocked by an independent protective device.* *For emergency shutdown arrangement submissions please see:* *1/9.8 ii)* "9.8 Fuel Cell Control Monitoring and Safety System Submissions ii)Arrangement of emergency shutdown system (ESD)", *1/9.11 "9.11 Emergency Shutdown Systems (ESD) Submissions*	

Conditions	Item	Documentation	Additional Description	Information
			i) Details of disconnection arrangement (such as ESD, stop buttons, etc.) *ii) Emergency shutdown arrangement of bunkering system* *iii) Emergency shutdown arrangement of fuel supply system"* *3/9.6.* "9.6 Emergency Shutdown System The ship is to be fitted with a bunkering Emergency Shutdown (ESD) system operable from both the ship and the bunker supply facility. This is to allow a rapid and safe shutdown of the bunker supply system without the release of liquid or vapor."	
Section 5: Electrical systems	Chapter 5: Emergency shutdown	Sub-chapter 5.2: Manual emergency shutdown	*The means of manual emergency shutdown of fuel cell power system is to be provided the following locations as fitted:* *-Inside the Fuel Cell Space*	
Section 6: Control, monitoring and safety systems	Chapter 1: General	Sub-chapter 1.1: Application	*i) The control system for the fuel cell power system may be connected to an integrated control system or be a stand-alone system. See Section 6, Table 1 for list of fuel cell monitoring requirements.* *ii) The overall system design is to be based on single-fault criteria. The system is to be designed such that a single fault of a component will not lead to serious consequences.* *iii) Suitable instrumentation devices are to be fitted to allow a local and a remote reading of essential parameters to provide safe management of the whole fuel-gas system including bunkering.* *iv) At least one bilge well with a level indicator is to be provided for each enclosed space where an independent storage tank without a protective cofferdam or secondary barrier is located. Alarms are to be given at a high level in the bilge well. The leakage detection system is to trigger an alarm and safety functions in accordance with Section 6, Table 1.* *v) For tanks not permanently installed in the ship, a monitoring system is to be provided that is equivalent for the permanently installed tanks. Liquid leakage detection is to be installed in the protective cofferdams or secondary barrier space surrounding the fuel tanks, in all ducts around fuel pipes, in fuel*	

Conditions	Item	Documentation	Additional Description	Information
			preparation rooms, and in other enclosed spaces containing single walled fuel piping or other fuel equipment. vi) *Chemical reactions, such as those that occur during fuel reforming or within the fuel cell, are to be monitored (e.g., by means of temperature, pressure or voltage monitoring).* vii) *If limit values determined for the process (e.g., temperature, pressure, voltage) which may lead to hazardous situations are exceeded, the fuel cell power system is to be automatically shut down and interlocked by an independent protective device* viii) *Computer based systems where used for control, monitoring and safety systems are to comply with the applicable provisions of Section 4-9-3 of the Marine Vessel Rules.*	
Section 6: Control, monitoring and safety systems	Chapter 2: Control and monitoring system	Sub-chapter 2.4: Fuel cell condition monitoring	i) *All operating conditions are to be monitored to verify they are within the acceptable design range specified by the manufacturer.* ii) *A failure mode and effect analysis examining all possible faults affecting the fuel cell operation and safety are to be carried out. Based on the outcome of the analysis, the extent of the monitoring and control are to be decided. As a minimum the following items are to typically be monitored, as applicable:* a) *Cell voltage* b) *Cell voltage deviations* c) *Exhaust gas temperature* d) *Fuel Cell temperature* e) *Electric current* *Other typical monitoring that should be considered:* a) *Air flow* b) *Air pressure* c) *Cooling medium flow, pressure, temperature (if applicable)* d) *Fuel flow* e) *Fuel temperature* f) *Fuel pressure* g) *Gas detection based on the risk assessment*	

Conditions	Item	Documentation	Additional Description	Information
			h) Water system level *i) Water system pressure* *j) Water system purity* *k) Parameters necessary to monitor lifetime/ deterioration.* *iii) The fuel cell power system is to be arranged for manual remote emergency stop from the following locations:* a) *Cargo control room (relevant for cargo ships only)* b) *Navigation bridge* c) *Engine control room* d) *Fire control station* *iv) The fuel cell operation condition indicators (see above ii)) are to be fitted on the navigation bridge, the engine control room and the maneuvering platform, as appropriate.*	
Section 6: Control, monitoring and safety systems	Chapter 3: Gas detection system	Sub-chapter 3.1: Location	*i) Generally, gas detectors are not required in spaces where fuel piping is completely ducted.* *ii) The number of detectors in each space are to be considered taking into account the size, layout and ventilation of the space.* *iii) Independent gas detector systems are to be fitted for each required fuel supply system.* *iv) The detection equipment is to be located where vapor may accumulate and/or in the ventilation outlets.* *v) Fuel vapor detection equipment is to be designed, installed and tested in accordance with a recognized standard.* *vi) An audible and visible alarm is to be activated at a fuel vapor concentration of 20% of the lower explosion limit (LEL). The safety system is to be activated at 40% of LEL at two detectors. Please refer to Section 6, Table 1 for identification of locations calling for a minimum of two gas detectors.* *vii) The gas detection system is to initiate audible and visual alarms distinct in both respects from the alarms of any other system not indicating gas,*	

Conditions	Item	Documentation	Additional Description	Information
			so that the alarms are heard and observed at the following locations as fitted: *a. Navigating bridge* *b. Continuously manned central control station* *c. Fire control station* *d. Control location for bunkering* *e. Locally* *When the navigating bridge is unmanned the alarm is to sound in a place where a responsible member of the crew is on duty.* *viii) Fuel vapor detection required by this Section is to be continuous and without delay.* *ix) Permanently installed gas detectors are to be fitted in:* *a) All ventilated annular spaces of the double walled fuel pipes* *b) Machinery spaces (i.e., fuel cell space, etc.) containing fuel piping, fuel equipment or consumers* *c) Other enclosed spaces containing fuel piping or other fuel equipment without ducting*	
Section 6: Control, monitoring and safety systems	Chapter 4: Fire detection system	Sub-chapter 4.1: General	*Fire detection in machinery spaces containing the fuel and rooms containing independent tanks for fuel storage are to be give audible and visual alarms*	
Section 6: Control, monitoring and safety systems	Chapter 5: Ventilation system	Sub-chapter 5.1: General	*Any loss of the required ventilating capacity (see ventilation system, 3/10 of this Guide for specific spaces) is to be give an audible and visual alarm on the navigation bridge, in a continuously manned central control station or fire control station, as well as locally.*	

RULES FOR CLASSIFICATION – DNV – PART 6 – CHAPTER 2 – SECTION 3

A. IDENTITY CARD OF RULES FOR CLASSIFICATION – DNV – PART 6 – CHAPTER 2 – SECTION 3

RCS	Number of RCS	Title	Date	Stability date	Statutory
Rules	DNV-RU-SHIP Pt.6 Ch.2.	Rules For Classification - Ships Part 6: Additional Class Notations Chapter 2: Propulsion, Power Generation And Auxiliary Systems Section 3: Fuel Cell Installations - FC	July 2021		

Foreword: DNV is a classification society, member of IACS association which cooperates with the work of the IMO.

IACS: International Association for Classification Societies and IMO: International Maritime Organization

Scope: The objective of this section is to provide requirements for fuel cell power installations with respect to safe operation and availability.

The scope includes requirements for the design and arrangement of fuel cell power installations and the fuel cell space. It covers all aspects of the installation from primary fuel supply up to, and including, the exhaust gas system. Further the following is covered:

- control, monitoring and safety systems
- manufacture, workmanship and testing.

The use of fuel cells is currently not covered by international conventions, hence such installations will require additional acceptance by the flag authorities.

The requirements for fuel cell installation rooms will be considered on a case-by-case basis.

Vessels complying with the requirements given in this section will be assigned the additional class notation **FC**, as specified in **Erreur ! Source du renvoi introuvable.**

Class notation	*qualifer*	*purpose*	*Application*
FC *Mandatory: Yes* *Design requirements: Sec.3* *FIS requirements: part 7, chapter 1, Section 2* *And*	*Power*	*Fuel cell power installations intended for electrical propulsion.*	- *all-electric vessel, i.e. all main sources of power are based on fuel cells* - *hybrid vessel where one of the main sources of power is based on fuel cells* - *hybrid vessel having an operational mode where the vesse lis operating on fuek cell*

Class notation	qualifer	purpose	Application
Part 7, Chapter 1, Section 3			*only, with other main source of power in standby*
	safety	*Fuel cell power installations where the main source of power is based on other energy converters than fuel cells or on electrical energy storage (ESS).*	- *hybride vessels not using the fuel cell as a main source of power* - *hybrid vessels using fuel cell solely when moored*

Domain/category: All vessels with fuel cell power installations on board.

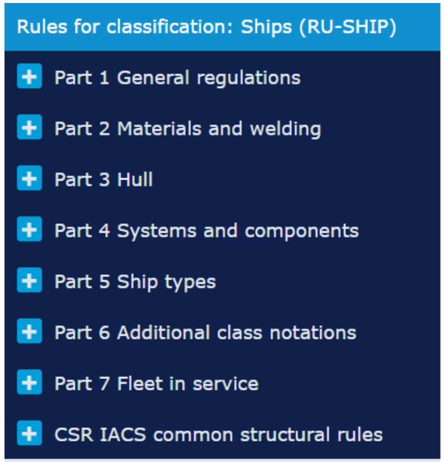
Specifed exclusion:

Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

The following requirements apply only to the datas from: **Part 6-Additional class notations - Chapter 2-Propulsion, power generation and auxiliary systems - Section 3-Fuel cell installations – FC**

The DNV references mentioned in this table can be consulted from this link: [Rules for classification: General (RU-SHIP)]()



Rules for classification: Ships (RU-SHIP)

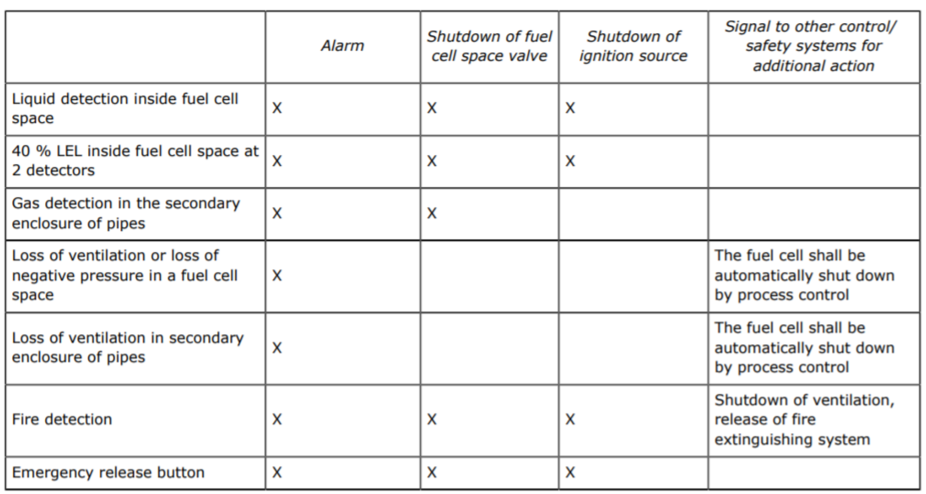
- Part 1 General regulations
- Part 2 Materials and welding
- Part 3 Hull
- Part 4 Systems and components
- Part 5 Ship types
- Part 6 Additional class notations
- Part 7 Fleet in service
- CSR IACS common structural rules

Conditions	Item	Documentation	Additional Description	Information
Section 2	2: Materials	Paragraph 2.1.1: Material requirements	*2.1.1.1 Materials shall be accordance with the requirements in Pt.2 of the rules.* *Pt.2 of the rules* ➔ • Part 2: Materials and welding – Chapter 1: General requirements for materials and fabrication • Part 2: Materials and welding – Chapter 2: Metallic materials	
Section 2	2: Materials	Paragraph 2.1.1: Material requirements	*2.1.1.2 The materials shall be suitable for the intended application and shall comply with recognised standards.*	

Conditions	Item	Documentation	Additional Description	Information
Section 2	2: Materials	Paragraph 2.1.1: Material requirements	*2.1.1.3 Use of flammable materials shall be minimized as far as practicable and requires the approval of the Society.*	
Section 2	2: Materials	Paragraph 2.1.2: Requirements for piping systems	*2.1.2.1 ~~Austenitic stainless steel (e.g. 304, 316, 304L and 316L) shall be used for materials in contact with reformed fuel.~~ Other materials may be approved after special consideration.*	
Section 2	2: Materials	Paragraph 2.1.2: Requirements for piping systems	*2.1.2.2 The materials used for auxiliary piping shall meet the requirements of Pt.4 Ch.6.* Access to the file Pt.4 Ch.6. ➔ Part 4: Systems and components, chapter 6: Piping systems	
Section 2	2: Materials	Paragraph 2.1.2: Requirements for piping systems	*2.1.2.3 The materials used for primary fuel piping shall meet the requirements of Sec.5, Sec.6 or Pt.4 Ch.6 as applicable.* Sec.5, Sec.6: see below in this sheet. Access to the file Pt.4 Ch.6. ➔ Part 4: Systems and components, chapter 6: Piping systems	
Section 2	2: Materials	Paragraph 2.1.2: Requirements for piping systems	*2.1.2.4 The certification of materials used for primary ~~or reformed~~ fuel piping shall be in accordance with Sec.5, Sec.6 or Pt.4 Ch.6 as applicable.* Sec.5, Sec.6: see below in this sheet. Access to the file Pt.4 Ch.6. ➔ Part 4: Systems and components, chapter 6: Piping systems	
Section 2	3: Design principles for FC(power) notation	3.1: General	*3.1.1 The design shall ensure that a single failure in the FC power installation shall not lead to an unacceptable loss of power.*	
Section 2	3: Design principles for FC(power) notation	3.1: General	*3.1.2 The fuel cell power installation shall be so designed that safety actions required by the rules shall not lead to an unacceptable loss of power.*	

Conditions	Item	Documentation	Additional Description	Information
Section 2	3: Design principles for FC(power) notation	3.1: General	*3.1.3 If the power from the fuel cell is needed for restoration of power in a black out or dead ship situation, the recovery arrangements shall be documented and approved in each case.*	
Section 2	4: requirements for fuel cell power system	4.1: Piping arrangement for fuel cell power system	*4.1.1 All pipes containing primary for fuel cell power systems, where fitted, shall:* *1) not be led through enclosed spaces outside of fuel cell spaces* *2) be fully welded as far as practicable* *3) be arranged to minimise the number of connections.* *Guidance note: When piping for primary or reformed fuel need to pass enclosed spaces, the rules of the relevant fuels are valid*	
Section 2	4: requirements for fuel cell power system	4.2: exhaust gas and exhaust air oulets	*4.2.1 Exhaust air and exhaust gases from the fuel cell power systems shall be led to the open air and shall not be combined with ventilation systems.*	
Section 2	4: requirements for fuel cell power system	4.2: exhaust gas and exhaust air oulets	*4.2.2 If the presence of explosive gases cannot be excluded, the exhaust air and/or exhaust gas shall be arranged as an outlet from a hazardous zone.*	
Section 2	4: requirements for fuel cell power system	4.3: Purge gas oulets	*4.3.1 Purge piping from the fuel cell power systems shall be led separately to the open air and shall be arranged as an outlet from a hazardous zone.*	
Section 2	6: Safety	6.1 General Parargraph 6.1.1 General	*6.1.1.1 The requirements in this section are additional to those given in SOLAS Ch.II-2.*	

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td>Section 2</td><td>6:
Safety</td><td>6.4
Fire extinguishing Parargraph 6.4.1 General</td><td>6.4.1.2 The fire extinguishing system shall be suitable for use with the specific primary fuel cell tech nology used.</td><td></td></tr>
<tr><td>Section 2</td><td>6:
Safety</td><td>6.4
Fire extinguishing Parargraph 6.4.1 General</td><td>6.4.1.3 Required safety actions at fire detection in the FC space are given in Table 7.

Table 7 ➔

<table>
<tr><th></th><th>Alarm</th><th>Shutdown of fuel cell space valve</th><th>Shutdown of ignition source</th><th>Signal to other control/ safety systems for additional action</th></tr>
<tr><td>Liquid detection inside fuel cell space</td><td>X</td><td>X</td><td>X</td><td></td></tr>
<tr><td>40 % LEL inside fuel cell space at 2 detectors</td><td>X</td><td>X</td><td>X</td><td></td></tr>
<tr><td>Gas detection in the secondary enclosure of pipes</td><td>X</td><td>X</td><td></td><td></td></tr>
<tr><td>Loss of ventilation or loss of negative pressure in a fuel cell space</td><td>X</td><td></td><td></td><td>The fuel cell shall be automatically shut down by process control</td></tr>
<tr><td>Loss of ventilation in secondary enclosure of pipes</td><td>X</td><td></td><td></td><td>The fuel cell shall be automatically shut down by process control</td></tr>
<tr><td>Fire detection</td><td>X</td><td>X</td><td>X</td><td>Shutdown of ventilation, release of fire extinguishing system</td></tr>
<tr><td>Emergency release button</td><td>X</td><td>X</td><td>X</td><td></td></tr>
</table></td><td></td></tr>
<tr><td>Section 2</td><td>7:
Electrical system</td><td>7.1 General Paragraph 7.1.1: General</td><td>7.1.1.1 The requirements in this section are additional to those given in Pt.4 Ch.8.

Pt.4 Ch.8. ➔
Part 4: Systems and components – Chapter 8: Electrical installation</td><td></td></tr>
<tr><td>Section 2</td><td>7:
Electrical system</td><td>7.1 General Paragraph 7.1.1: General</td><td>7.1.1.3 It shall be ensured that the fuel cell can be disconnected from the electrical load at any load condition.</td><td></td></tr>
</table>

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td>Section 2</td><td>7: Electrical system</td><td>7.1 General Paragraph 7.1.1: General</td><td>*7.1.1.5 The outgoing circuits on a fuel cell arrangement shall be provided with a switch disconnector for isolating purposes so that isolating for maintenance is possible. Contactors are not accepted as isolating devices.*

Guidance note: For definition of switch disconnector, see IEC 60947-3.</td><td></td></tr>
<tr><td>Section 2</td><td>7: Electrical system</td><td>7.1 General Paragraph 7.1.1: General</td><td>*7.1.1.6 With reference to IEC 60079-20, the following temperature class and equipment groups may be used for potential ship fuels:*
<table>
<tr><th></th><th>*Temperature class*</th><th>*Equipment group*</th></tr>
<tr><td>*Natural gas*</td><td>*T1*</td><td>*IIA*</td></tr>
<tr><td>*LPG (propane, butane)*</td><td>*T2*</td><td>*IIA*</td></tr>
<tr><td>*Hydrogen*</td><td>*T1*</td><td>*IIC*</td></tr>
<tr><td>*Methyl alcohol*</td><td>*T2*</td><td>*IIA*</td></tr>
<tr><td>*Ethyl alcohol*</td><td>*T2*</td><td>*IIB*</td></tr>
</table>
</td><td></td></tr>
<tr><td>Section 2</td><td>7: Electrical system</td><td>7.2 Area classification Paragraph 7.2.1: General</td><td>*7.2.1.1 In order to facilitate the selection of appropriate electrical apparatus and the design of suitable electrical installations, hazardous areas are divided into zones 0, 1 and 2 according to the principles of the standards IEC 60079-10 and guidance and informative examples given in IEC 60092-502 for tankers. Main features of the guidance are given in [7.2.2].*</td><td></td></tr>
<tr><td>Section 2</td><td>7: Electrical system</td><td>7.2 Area classification Paragraph 7.2.1: General</td><td>*7.2.1.2 Areas and spaces other than those mentioned in [7.2.2] shall be subject to special consideration. The principles of the IEC standards shall be applied.*</td><td></td></tr>
<tr><td>Section 2</td><td>7: Electrical system</td><td>7.2 Area classification Paragraph 7.2.2: Definition of zones</td><td>*Hazardous areas zone 0*
7.2.2.1 The interiors of buffer tanks, reformers, pipes and equipment containing low flashpoint fuel or reformed fuel, any pipework of pressure-relief or other venting.

Guidance note: Instrumentation and electrical apparatus in contact with the gas or liquid should be of a type suitable for zone 0. Temperature sensors installed in thermo wells, and pressure sensors without additional separating chamber should be suitable for installation in zone 0.</td><td></td></tr>
<tr><td>Section 2</td><td>7:</td><td>7.2 Area classification</td><td>*7.2.2.2 Hazardous areas zone 1*
1) Fuel cell spaces.</td><td></td></tr>
</table>

Conditions	Item	Documentation	Additional Description	Information
	Electrical system	Paragraph 7.2.2: Definition of zones	*2) Fuel cell exhaust air and exhaust gas outlets.*	
Section 2	7: Electrical system	7.2 Area classification Paragraph 7.2.2: Definition of zones	*7.2.2.3 Hazardous areas zone 2* *1) Areas within 1.5 m surrounding open or semi-enclosed spaces of zone 1 as specified in [7.2.2.2], if not otherwise specified in this standard.* *2) Air locks.* *Guidance note: Where requirements of [7.2.2] is deemed to be impracticable, the Society may accept classification according to IEC-60079-10. This requires an acceptance by the flag administration.*	
Section 2	7: Electrical system	7.2 Area classification Paragraph 7.2.2: Definition of zones	*7.2.2.4 Ventilation ducts shall have the same area classification as the ventilated space.*	
Section 2	7: Electrical system	7.2 Area classification Paragraph 7.2.2: Definition of zones	*7.2.2.5 Fuel cells not certified for zone 1 shall be deenergized in case of gas detection.*	
Section 2	8: Control, monitoring and safety systems	8.1: General Paragraph 8.1.1: Functional requirements	*8.1.1.1 The control, monitoring and safety systems applied to a fuel cell power installation shall be arranged to fulfil the functional requirements stated below:* • *Leakages of gaseous fuel / vapour shall be detected and alarmed.* • *A fuel safety system shall be arranged to automatically close down the fuel supply system and isolate ignition sources, upon fault conditions which may develop too fast for manual intervention and upon system failures in accordance with these rules and the installations safety philosophy.* • *Control, monitoring and safety systems shall be arranged to avoid spurious shutdowns of the fuel supply system.* • *Information and means for manual intervention shall be available for the operator.*	

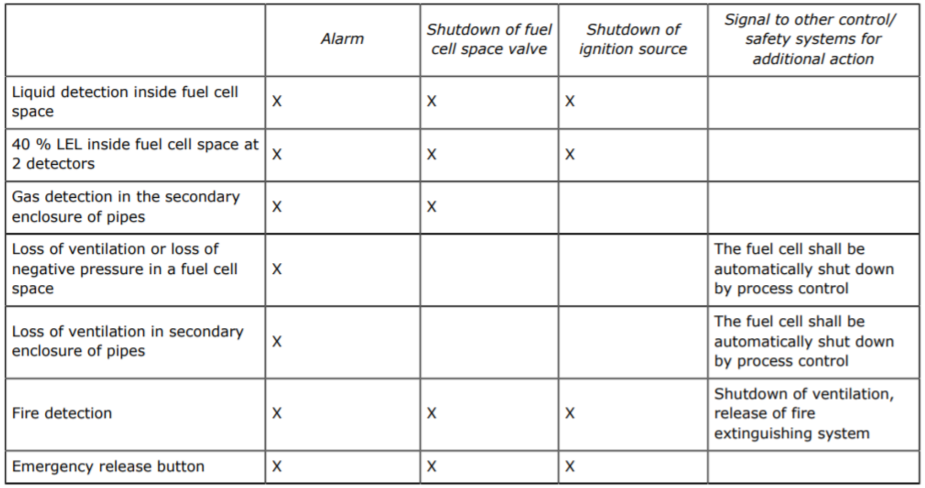
Conditions	Item	Documentation	Additional Description	Information
Section 2	8: Control, monitoring and safety systems	8.1: General Paragraph 8.1.2: Arrangement of gas control, monitoring and safety systems	*8.1.2.1 Each fuel cell power installation shall be fitted with dedicated systems for gas/vapour detection, fuel safety functions and fuel control and monitoring functions. Gas detection system and fuel safety system are considered to be protective safety systems, see Pt.4 Ch.9 Sec.3 [1.4].* *Guidance note: The controllers may be part of the same redundant network if arranged in accordance with Pt.4 Ch.9 Sec.3. Note that the protective safety systems shall, if part of an integrated network, be arranged in a separate network segment in accordance with Pt.4 Ch.9 Sec.2 [1.4.2] and Pt.4 Ch.9 Sec.4 [3].*	
Section 2	8: Control, monitoring and safety systems	8.1: General Paragraph 8.1.2: Arrangement of gas control, monitoring and safety systems	*8.1.2.2 Monitoring requirements for the fuel cell power installation are given in Table 5 and Table 6. Table 6 gives alarm requirements for gas detection and other conditions, Table 7 give requirements to protective safety functions with alarm to be handled by the fuel safety system. For alarm conditions found in Table 7, separate sensors shall be arranged for the gas control and monitoring system and for the fuel safety system.*	
Section 2	8: Control, monitoring and safety systems	8.1: General Paragraph 8.1.2: Arrangement of gas control, monitoring and safety systems	*8.1.2.5 Gas detection functionality and fuel safety functionality for a fuel supply system inside fuel cell space can be implemented in a common system unit if the system is redundant.*	
Section 2	8: Control, monitoring and safety systems	8.1: General Paragraph 8.1.2: Arrangement of gas control, monitoring and safety systems	*8.1.2.6 The signals required to support the safety functions given in Table 7 shall be hardwired, and arranged with loop monitoring unless they are inherently fail safe.* *Guidance note: The requirement for hardwired signals is not applicable for signals sent to other systems for additional safety actions as specified in Table 7.*	
Section 2	8:	8.1: General	*8.1.2.7 The output signals required to perform the safety actions specified in Table 7 shall be electrically independent of the fuel control system.*	

Conditions	Item	Documentation	Additional Description	Information
	Control, monitoring and safety systems	Paragraph 8.1.2: Arrangement of gas control, monitoring and safety systems	*Guidance note: This implies that the output signal should be separate from any control loop, and connected to e.g. separate solenoids and breaker terminals/coils.*	
Section 2	8: Control, monitoring and safety systems	8.1: General Paragraph 8.1.2: Arrangement of gas control, monitoring and safety systems	*8.1.2.8 Where gas/vapour detection shall cause shutdown in accordance with Table 7, detector voting shall be applied. A failed detector shall be considered as an active detection.* *Guidance note: A common voting principle is 2oo2 (meaning two out of two) where both units should detect gas to activate shutdown.*	
Section 2	8: Control, monitoring and safety systems	8.1: General Paragraph 8.1.3: Emergency stop	*8.1.3.1 Fuel cell power installations shall be arranged for manual remote emergency stop from the following locations as applicable:* • *navigation bridge;* • *onboard safety centre;* • *engine control room;* • *fire control station; and* • *adjacent to the exit and inside of fuel cell space.*	
Section 2	8: Control, monitoring and safety systems	8.1: General Paragraph 8.1.4: Risk analysis	*8.1.4.1 A risk analysis examining all possible faults affecting the fuel cell operation and safety shall be carried out.* *Based on the outcome of the analysis the extent of the monitoring and control shall be decided.* *Guidance note: Typical monitoring that should be considered:* *— cell voltage* *— cell voltage deviations* *— temperature exhaust gas* *— temperature in FC stack* *— electric current* *— process air flow* *— process air pressure*	

Conditions	Item	Documentation	Additional Description	Information
			— cooling medium flow, level, pressure, temperature *— fuel flow* *— fuel temperature* *— fuel pressure* *— gas detection in exhaust gas* *— process water system level, pressure, purity* *— parameters necessary to monitor lifetime/ deterioration*	
Section 2	8: Control, monitoring and safety systems	8.2: fuel cell power installation – control and monitoring Paragraph 8.2.1: Gas or vapour detection	*8.2.1.1 A permanently installed gas/vapour detection system shall be provided for: — fuel cell spaces — air locks — expansion tanks/degassing vessels in — heating/cooling circuits in contact with fuel — other enclosed spaces where primary/reformed fuel may accumulate.*	
Section 2	8: Control, monitoring and safety systems	8.2: fuel cell power installation – control and monitoring Paragraph 8.2.1: Gas or vapour detection	*8.2.1.2 The detection systems shall continuously monitor for gas/vapour.*	
Section 2	8: Control, monitoring and safety systems	8.2: fuel cell power installation – control and monitoring Paragraph 8.2.1: Gas or vapour detection	*8.2.1.3 Detection systems for flammable products capable of measuring gas/vapour concentrations in the range 0-100% LEL are acceptable.*	

Conditions	Item	Documentation	Additional Description	Information
Section 2	8: Control, monitoring and safety systems	8.2: fuel cell power installation – control and monitoring Paragraph 8.2.1: Gas or vapour detection	*8.2.1.4 The number of detectors in each space shall be considered taking size, layout and ventilation of the space into account, and each space shall be covered by sufficient number of detectors to allow for voting in accordance with Table 6.*	
Section 2	8: Control, monitoring and safety systems	8.2: fuel cell power installation – control and monitoring Paragraph 8.2.1: Gas or vapour detection	*8.2.1.5 The detectors shall be located where gas/vapour may accumulate and/or in the ventilation outlets. Gas dispersal analysis or a physical smoke test shall be used to find the best arrangement.*	
Section 2	8: Control, monitoring and safety systems	8.3: fuel cell power installation – safety Paragraph 8.3.1: safety upon gas, vapour or liquid detection	*8.3.1.2 Gas/vapour detection in a fuel cell space when two self-monitored detectors indicate a gas or vapour concentration of 40% LEL shall shut-down the affected fuel cell power system and disconnect ignition sources and shall result in automatic closing of all valves required to isolate the leakage. This will require that valves in the primary fuel system supplying liquid or gaseous fuel to the fuel cell space shall close automatically.*	
Section 2	8: Control, monitoring and safety systems	8.3: fuel cell power installation – safety Paragraph 8.3.1:	*8.3.1.3 Gas detection in the secondary enclosure of pipes for gaseous fuel shall be d esigned in accordance with Sec.5 [9.3.2].*	

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td>safety upon gas, vapour or liquid detection</td><td></td><td></td></tr>
<tr><td>Section 2</td><td>8:
Control, monitoring and safety systems</td><td>8.3:
fuel cell power installation – safety
Paragraph 8.3.3: Manual shutdown push button</td><td><i>8.3.3.1 Means of manual emergency shutdown of fuel supply to the fuel cell space a nd de-energizing the ignition sources shall be provided inside a fuel cell space, in the engine control room and from the navigation bridge. The activation device shall be arranged as a physical button, duly marked and protected against inadvertent operation. The manual shutdown shall be handled by the safety system and be arranged with loop monitoring.</i></td><td></td></tr>
<tr><td>Section 2</td><td>8:
Control, monitoring and safety systems</td><td>8.3:
fuel cell power installation – safety
Paragraph 8.3.4: Safety action</td><td><i>8.3.4.1 The requirements above and Table 7 below specify fuel cell power installations safety actions required to limit the consequences of system failures.</i>
<i>8.3.4.2 Safety actions additional to the ones required by Table 7 may be required for unconventional or complex fuel cell power installations.</i>

Table 7 ➔

<table>
<tr><th></th><th><i>Alarm</i></th><th><i>Shutdown of fuel cell space valve</i></th><th><i>Shutdown of ignition source</i></th><th><i>Signal to other control/ safety systems for additional action</i></th></tr>
<tr><td>Liquid detection inside fuel cell space</td><td>X</td><td>X</td><td>X</td><td></td></tr>
<tr><td>40 % LEL inside fuel cell space at 2 detectors</td><td>X</td><td>X</td><td>X</td><td></td></tr>
<tr><td>Gas detection in the secondary enclosure of pipes</td><td>X</td><td>X</td><td></td><td></td></tr>
<tr><td>Loss of ventilation or loss of negative pressure in a fuel cell space</td><td>X</td><td></td><td></td><td>The fuel cell shall be automatically shut down by process control</td></tr>
<tr><td>Loss of ventilation in secondary enclosure of pipes</td><td>X</td><td></td><td></td><td>The fuel cell shall be automatically shut down by process control</td></tr>
<tr><td>Fire detection</td><td>X</td><td>X</td><td>X</td><td>Shutdown of ventilation, release of fire extinguishing system</td></tr>
<tr><td>Emergency release button</td><td>X</td><td>X</td><td>X</td><td></td></tr>
</table>
</td><td></td></tr>
</table>

Conditions	Item	Documentation	Additional Description	Information
Section 2	9: Manufacture workmanship and testing	9.1: Fuel cell piping systems Paragraph 9.1.1: Fuel cell pipes and ducting	*9.1.1.2 Valves in the FC piping system shall be leakage tested for the FC fuel used.*	
Section 2	9: Manufacture workmanship and testing	9.1: Fuel cell piping systems Paragraph 9.1.1: Fuel cell pipes and ducting	*9.1.1.4 Expansion bellows intended for use in FC fuel systems shall be prototype tested as given in Pt.5 Ch.7 Sec.5 [13.2].*	
Section 2	9: Manufacture workmanship and testing	9.2: On board testing of FC plant Paragraph 9.2.1: General	*9.2.1.1 Testing after installation on board of the whole system shall be performed in different relevant load conditions (typically: 'start up'; 'normal running';' full load'; 'load changes up/down').*	
Section 2	9: Manufacture workmanship and testing	9.2: On board testing of FC plant Paragraph 9.2.1: General	*9.2.1.2 It shall be verified for the following events that the FC power installation triggers an alarm and / or is automatically transferred into a safe condition:* *— fire detection* *— gas detection* *— loss of ventilation flow* *— loss of negative pressure in fuel cell space* *— failure of the power supply* *— failure of the programmable logic controllers (PLCs)* *— triggering of the protective devices* *— failure in the protective system.* *Further tests may be required based on the approved risk analysis and related test programs.*	

Conditions	Item	Documentation	Additional Description	Information
Section 2	9: Manufacture workmanship and testing	9.2: On board testing of FC plant Paragraph 9.2.1: General	*9.2.1.3 The interaction of the FC power installation with the ship systems shall be tested as applicable:* *— power generation by the FC power installation system alone* *— FC power installation together with conventional shipboard generation of electrical power* *— FC power installation together with batteries* *— change-over to the emergency source of electrical power* *— switching the FC power installation online or offline* *— testing of sudden load variations and load rejection.*	
Section 2	9: Manufacture workmanship and testing	9.2: On board testing of FC plant Paragraph 9.2.1: General	*9.2.1.4 If the FC power installation constitutes the main propulsion system of the ship, it shall be verified that the ship has adequate propulsion power in all maneuvering situations.*	
Section 2	9: Manufacture workmanship and testing	9.2: On board testing of FC plant Paragraph 9.2.1: General	*9.2.1.5 For fuel cell spaces and ventilated ducts it shall be examined and tested that underpressure and ventilation can be fully accomplished. Ventilation rate at minimum flow shall be documented. Required shutdowns and / or alarms upon ventilation falling below prescribed values shall be tested.*	
Section 2	9: Manufacture workmanship and testing	9.3: Survey and testing of electrical equipment in hazardous area	*9.3.1 For equipment for which safety in hazardous areas depends upon correct operation of protective devices (for example overload protection relays) and / or operation of an alarm (for example loss of pressurization for an Ex(p) control panel) it shall be verified that the devices have correct settings and/or correct operation of alarms.*	

Annex 29: GUIDELINE OF BUREAU VERITAS FOR FUEL CELL SYSTEMS ONBOARD COMMERCIAL SHIPS

GUIDELINE OF BUREAU VERITAS FOR FUEL CELL SYSTEMS ONBOARD COMMERCIAL SHIPS

A. IDENTITY CARD OF GUIDELINE OF BUREAU VERITAS FOR FUEL CELL SYSTEMS ONBOARD COMMERCIAL SHIPS

RCS	Number of RCS	Title	Date	Stability date	Statutory
Guideline	NI 547 DR R00 E	Guideline for Fuel cell systems onboard commercial ships – Bureau Veritas	04/2009		Yes

Scope: These Guidelines apply to fuel cell systems installations in ships. These Guidelines address the hazards related to the arrangements for the storage, distribution and use of a gas fuel with a fuel cell system.

Domain/category: This Guideline is applicable to new ships.

Specifed exclusion: /

Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

Conditions	Item	Documentation	Additional Description	Information
Chapter 1 - General	1.5 Installation trials		*1.5.1 Prior to servicing, a complete set of trials should be performed.* *1.5.2 The programme of trials should be documented and presented for approval to the Societyb (Table 2, item 6). It should at least cover tests of the following items:* *.1 Tests to be performed onboard as specified in Chapter 7 -* *.2 All control, monitoring and safety systems as described in Chapter 5 -* *.3 All procedures as described in Table 2.* *.4 Protective measures which have been installed for items representing significant risks, according to the risk analysis performed as per 2.1.2, 6.1.2 and Appendix 1* *1.5.3 Relevant provisions of [16], Sec 15 related to regulatory machinery tests onboard should also be considered for defining the test plan.*	
Chapter 2 - Ship Arrangements and System Design	2.1 General		2.1.8 Access to all components of the fuel cell installation should be possible for survey.	
Chapter 2 - Ship Arrangements and System Design	2.2 Material requirements		2.2.2 Materials used in gas tanks, gas piping, process pressure vessels and other components in contact with gas should be in accordance with IGC Code Chapter 6. For compressed gas tanks, the use of materials not covered by the IGC Code may be specially considered by the Society. 2.2.3 Materials for piping system for liquefied gases should comply with the requirements of IGC Code Chapter 6.2. Some relaxation may, however, be permitted in the quality of the material of open ended vent piping, provided the temperature of the gas at atmospheric pressure is -55°C or higher and	

Conditions	Item	Documentation	Additional Description	Information
			provided no liquid discharge to the vent piping can occur. Materials should be in general in accordance with recognised standards. 2.2.4 Materials having a melting point below 925°C, should not be used for piping outside the gas tanks except for short lengths of pipes attached to the gas tanks, in which case the low melting point materials should be wrapped in class A-60 insulation. 2.2.5 The materials used for the gas piping systems should be certified as class 1 pipes, in accordance with the requirements of [16], Sec 10. 2.2.6 All components in contact with hydrogen should be made of material compatible with this element, in particular with respect to embrittlement and hydrogen attack phenomena. Information on material compatibility with hydrogen can be found in [3], [5] and [13]. Tests for checking the compatibility of metals with hydrogen are specified in [4]. The demonstration of the suitability of materials should be performed by tests according to specifications given in [5], [15] Annexes 7 and 8, [13], [14] or to any other equivalent recognised standard. 2.2.7 In the case of compressed gaseous hydrogen, the normal operating temperature range for materials used in hydrogen components should be -40°C to +85°C .The gas temperature should be between -40°C to +85°C in normal operating conditions including filling or discharging. 2.2.8 Materials for piping of the fuel cell installation containing other fluids than the hydrogen or natural gas should be in accordance with [16], Sec 10.	
Chapter 2 - Ship Arrangements	2.3 Location and separation of spaces		2.3.2 The fuel cell installation components should be located in spaces separated from other machinery spaces. Tank rooms should be separated from the spaces containing the fuel cell power system components. Fuel-fired	

Conditions	Item	Documentation	Additional Description	Information
and System Design			boilers or heating devices should also be located in spaces separated from the spaces containing the other fuel cell power system components.	
Chapter 2 - Ship Arrangements and System Design	2.3 Location and separation of spaces	2.3.3 Gas compressor rooms	2.3.4 The spaces containing fuel cell power systems components should be considered as machinery spaces. Spaces containing a fuel-fired boiler or heating device belonging to the fuel cell installation should be considered as machinery spaces of category A (see 1.3.29 & 1.3.30).	
Chapter 2 - Ship Arrangements and System Design	2.3 Location and separation of spaces	2.3.5 Machinery spaces containing fuel cell power system components	.1 When more than one machinery space is required for fuel cell power system components and these spaces are separated by a single bulkhead, the arrangements should be such that the effects of a gas explosion in either space, in conditions to be determined as described in 2.1.6, can be contained or vented without affecting the integrity of the adjacent space and equipment within the space.	
Chapter 2 - Ship Arrangements and System Design	2.5 General pipe design and arrangement		2.5.1 The recommendations of this section apply to gas piping. The Society may accept relaxation from these recommendations for gas piping inside gas tanks and open ended piping after special consideration, such as risk assessment. Piping of the fuel cell installation containing other fluids than the hydrogen or natural gas should be designed in accordance with [16], Sec 10. 2.5.2 Gas piping should be protected against mechanical damage (e.g. due to handling of equipment in the vicinity of the piping) and the piping should be capable of assimilating thermal expansion without developing substantial tension. 2.5.3 The piping system should be joined by welding with a minimum of flange connections. Gaskets should be protected against blow-out. 2.5.4 The wall thickness of pipes should not be less than:	

Conditions	Item	Documentation	Additional Description	Information
			$t = \dfrac{t_0 + b + c}{1 - \dfrac{a}{100}}$ (mm) where: t0 = theoretical thickness t0 = pD/(20Ke + p) with: p = design pressure (bar), refer to 2.5.5 D = outside diameter (mm) K = allowable stress (N/mm2), refer to 2.5.6 e = efficiency factor equal to 1.0 for seamless pipes and for longitudinally or spirally welded pipes, delivered by approved manufacturers of welded pipes, which are considered equivalent to seamless pipes when non-destructive testing on welds is carried out in accordance with recognised standards. In other cases an efficiency factor value depending on the manufacturing process may be determined by the Society. b = allowance for bending (mm). The value of b should be chosen so that the calculated stress in the bend, due to internal pressure only, does not exceed the allowable stress. Where such justification is not given, b should be: $b = \dfrac{Dt_0}{2.5r}$ (mm) with: r = mean radius of the bend (mm) c = corrosion allowance (mm). If corrosion allowance or erosion is expected, the wall thickness of the piping should be increased over that required by other design requirements. This allowance should be consistent with the expected life of the piping. a = negative manufacturing tolerance for thickness (%)	

Conditions	Item	Documentation	Additional Description	Information
			The minimum wall thickness should be in accordance with Recognised Standards. 2.5.6 For pipes made of steel including stainless steel, the permissible stress to be considered in the formula of the strength thickness in 2.5.4 is the lower of the following values: $\frac{Rm}{2.7}$ or $\frac{Re}{1.8}$ with: Rm: specified minimum tensile strength at room temperature, in N/mm² Re: specified lower minimum yield stress or 0.2% proof stress at room temperature, in N/mm² For pipes made of materials other than steel, the allowable stress should be considered by the Society. 2.5.7 Where necessary for mechanical strength to prevent damage, collapse, excessive sag or buckling of pipe due to superimposed loads from supports, ship deflection or other causes, the wall thickness should be increased over that required by 2.5.4 or, if this is impractical or would cause excessive local stresses, these loads should be reduced, protected against or eliminated by other design methods. 2.5.11 The following types of connections may be considered for direct connection of pipe lengths (without flanges): 1) Butt welded joints with complete penetration at the root may be used in all applications. For design temperature below -10°C, butt welds should be either double welded or equivalent to a double welded butt joint. This may be accomplished by use of a backing ring, consumable insert or inert gas back-up on the first pass. For design pressures in excess of 10 bar and design temperatures above -10°C, backing rings should be removed.	

Conditions	Item	Documentation	Additional Description	Information
			2) Slip-on welded joints with sleeves and related welding, having dimensions satisfactory to the Society, should only be used for open-ended lines with external diameter of 50 mm or less and design temperatures not lower than -55°C. 3) The use of screwed couplings should be subject to special examination by the Society. 2.5.12 Flanges should be of the welding neck, slip-on or socket welding type. For all piping (except open ended lines), the following restrictions apply: 1) For design temperatures < -55°C only welding neck flanges should be used. 2) For design temperatures < -10°C slip-on flanges should not be used in nominal sizes above 100 mm and socket welding flanges should not be used in nominal sizes above 50 mm. 2.5.20 Gas pipes should be colour marked based on a recognised standard (e.g. [6]).	
Chapter 2 - Ship Arrangements and System Design	2.7 Gas supply system in gas machinery spaces	2.7.1 Gas supply system for gas safe machinery spaces	2) The connecting of gas piping and ducting to the fuel cell system gas inlet should be so as to provide complete coverage by the ducting. The arrangement should facilitate the fuel cell system maintenance. The double ducting should be required also for gas pipes on the fuel cell system itself. 3) For high-pressure piping the design pressure of the ducting should be taken as the higher of the following: a. the maximum built up pressure: static pressure in way of the rupture resulting from the gas flowing in the annular space; b. local instantaneous peak pressure in way of the rupture: this pressure should be taken as the critical pressure and is given by the following expression:	

Conditions	Item	Documentation	Additional Description	Information
			$p^{*} = p_0 \left(\frac{2}{k+1} \right)^{\frac{k}{k+1}}$ where: p_0 = maximum working pressure of the inner pipe k = C_p/C_v constant pressure specific heat divided by the constant volume specific heat (1.31 for CH_4, 1.41 for H_2) The tangential membrane stress of a straight pipe should not exceed the tensile strength divided by 1.5 (Rm/1.5) when subjected to the above pressure. The pressure ratings of all other piping components should reflect the same level of strength as straight pipes. As an alternative to using the peak pressure from the above formula, the peak pressure found from representative tests can be used. Test reports should then be submitted. 4) For low pressure piping the duct should be dimensioned for a design pressure not less than the maximum working pressure of the gas pipes. The duct should also be pressure tested to show that it can withstand the expected maximum pressure at gas pipe rupture.	
Chapter 2 - Ship Arrangements and System Design	2.10 Ventilation system	2.10.3 Machinery spaces containing gas utilisation equipment	1) The ventilation system for machinery spaces containing gas utilisation equipment should be independent of all other ventilation systems. 2) ESD protected machinery spaces should have ventilation with a capacity of at least 30 air changes per hour. The ventilation system should ensure a good air circulation in all spaces, and in particular ensure that any formation of gas pockets in the room are detected. As an alternative, arrangements whereby under normal operation the machinery space is ventilated with at least 15 air changes an hour is acceptable provided that, if gas is detected in the machinery space, the number of air changes will automatically be increased to at least 30 an hour. 3) The number and power of the ventilation fans should be such that the capacity is not reduced by more than 50% of the total ventilation capacity, if a fan with a separate circuit from the main switchboard or emergency	

Conditions	Item	Documentation	Additional Description	Information
			switchboard or a group of fans with common circuit from the main switchboard or emergency switchboard, is out of action.	
Chapter 2 - Ship Arrangements and System Design	2.11 Fuel filters		If filters are used for reducing hazards associated with contamination, especially from solid particles, and, in liquid hydrogen systems, from solid particles that could include oxygen, the following recommendations should be accounted for: 1) Filters should be accessible and capable of being isolated for cleaning. 2) Filters should not be cleaned by back-flushing through the system. 3) Filters should be cleaned or replaced periodically or whenever the pressure drop across the filter reaches a specified value. 4) The quantity and location of filters should be determined as required to minimize impurities in a system (refill or re-supply lines are primary locations for filters). The use of non-metallic filter to trap particles can increase build-up of electric charge and can produce from 10 to 200 more charge than a system with no filter. The large surface area of filters allows static charge to accumulate more readily. Grounding should be designed accordingly.	
Chapter 4 - Electrical Systems	4.2 Area classification	4.2.1 General	1) Area classification is a method of analyzing and classifying the areas where explosive gas atmospheres may occur. The object of the classification is to allow the selection of electrical apparatus able to be operated safely in these areas. 2) In order to facilitate the selection of appropriate electrical apparatus and the design of suitable electrical installations, hazardous areas are divided into zones 0, 1 and 2 according to the principles of the standard [8] and guidance and informative examples given in [7]. Main features of the guidance are given in 4.3. The definition of each zone is given in 1.3.22. 3) Area classification of a space may be dependent on ventilation as specified in [7], Table 1.	

Conditions	Item	Documentation	Additional Description	Information
			4) A space with opening to an adjacent hazardous area on open deck, may be made into a less hazardous or non-hazardous space, by means of overpressure. Specifications for such pressurization are given in 2.10. 5) Ventilation ducts should have the same area classification as the ventilated space.	
Chapter 4 - Electrical Systems	4.3 Definition of hazardous area zones	4.3.1 Hazardous area zone 0	This zone includes: The interiors of gas tanks, any pipe work of pressure-relief or other venting systems for gas tanks, pipes and equipment containing gas.	
Chapter 4 - Electrical Systems	4.3 Definition of hazardous area zones	4.3.2 Hazardous area zone 1	This zone includes: 1) tank room; 2) compressor room arranged with ventilation according to .3; 3) areas on open deck, or semi- enclosed spaces on deck, within 3 m of any gas tank outlet, gas or vapour outlet, bunker manifold valve, other gas valve, gas pipe flange, gas pump-room ventilation outlets and gas tank openings for pressure release provided to permit the flow of small volumes of gas or vapour mixtures caused by thermal variation; 4) areas on open deck or semi-enclosed spaces on deck, within 1.5 m of gas compressor entrances, gas pump and compressor room ventilation inlets and other openings into zone 1 spaces; 5) areas on the open deck within spillage coamings surrounding gas bunker manifold valves and 3 m beyond these, up to a height of 2.4 m above the deck; 6) compartments for gas bunkering hoses; 7) enclosed or semi-enclosed spaces in which pipes containing gas are located, e.g. ducts around gas pipes, gas valve unit enclosures, semi-enclosed bunkering stations; and 8) the ESD protected machinery space is considered as non-hazardous area during normal operation, but changes to zone 1 in the event of gas leakage.	
Chapter 4 - Electrical Systems	4.3 Definition of hazardous area zones	4.3.3 Hazardous area zone 2	This zone includes:	

Conditions	Item	Documentation	Additional Description	Information
			Areas within 1.5 m surrounding open or semi-enclosed spaces of zone 1 as specified in [7] or [8], as applicable, if not otherwise specified in this standard.	
Chapter 5: Control, Monitoring and Safety Systems	5.4 Fuel cell power system monitoring		5.4.1 Additional to the instrumentation provided in accordance with [16], Sec 3 §5.2 and with [18], indicators should be fitted on the navigation bridge, the engine control room and the manoeuvring platform, for operation of the fuel cell power system. 5.4.2 Auxiliary systems where gas may leak directly into the system medium (lubricating oil, cooling water) should be equipped with appropriate gas extraction measures fitted directly after the medium outlet from the system in order to prevent gas dispersion. The gas extracted from auxiliary systems media should be vented to a safe location in the open air (see also 2.10.1.2 and 2.8.1.5). 5.4.3 The fuel processing unit(s) should be fitted with audible and visual alarms both on the bridge and in the engine room. The parameters to be monitored and the levels for raising alarms should be defined according to the risk analysis performed on this system (see 6.1.2). 5.4.4 Monitoring of fuel-fired boiler and/or oxidation reactors proper ignition and operation should be provided when applicable. 5.4.6 The following are faults associated with the fuel cell module components that may require monitoring to address potentially hazardous conditions: 1) Cell Stack or Process fault: out-of-limit thermal, pressure, flow or composition conditions within cell stacks or other reactors in the fuel cell system which could lead to internal or external component failures and subsequently expose personnel to hazards. 2) Ground Fault: electrical isolation below the limit defined for high voltage isolation in operation represents a hazard to service personnel. 3) Low Voltage Fault: the fuel cell stack or individual cells may experience low voltage that could lead to internal or external component failures and subsequently expose personnel to hazards.	

Conditions	Item	Documentation	Additional Description	Information
			4) Overcurrent Fault: currents greater than the rated values could lead to internal or external component failures and subsequently expose personnel to hazards. Items which can encounter such exceedance of limits for safe operations should be designed according to the fail-safe principle. If such exceedance occur, immediate actions should be taken by means of fail-safe procedures.	
Chapter 5: Control, Monitoring and Safety Systems	5.5 Gas detection		5.5.4 An audible and visible alarm should be activated before the vapour concentration reaches 20% LFL. For ventilated ducts around gas pipes in the machinery spaces containing gas utilisation equipment, the alarm limit can be set to 30% LFL. The protective system should be activated at a LFL of 40 %.	
Chapter 5: Control, Monitoring and Safety Systems	5.7 Safety functions of the fuel cell power system		5.7.1 In case of exceeding limits for safe operations of items which are monitored as recommended in 5.4, immediate actions should be taken by means of fail-safe procedures. 5.7.2 These procedures should include recommendations on protection against fire and explosion hazards, on shutdowns and on protective components as given in 6.4, 6.6.6 and 6.6.11 respectively. 5.7.3 These procedures should be verified and completed when necessary according to the risk analysis performed on the fuel cell power system (see 6.1.2)	

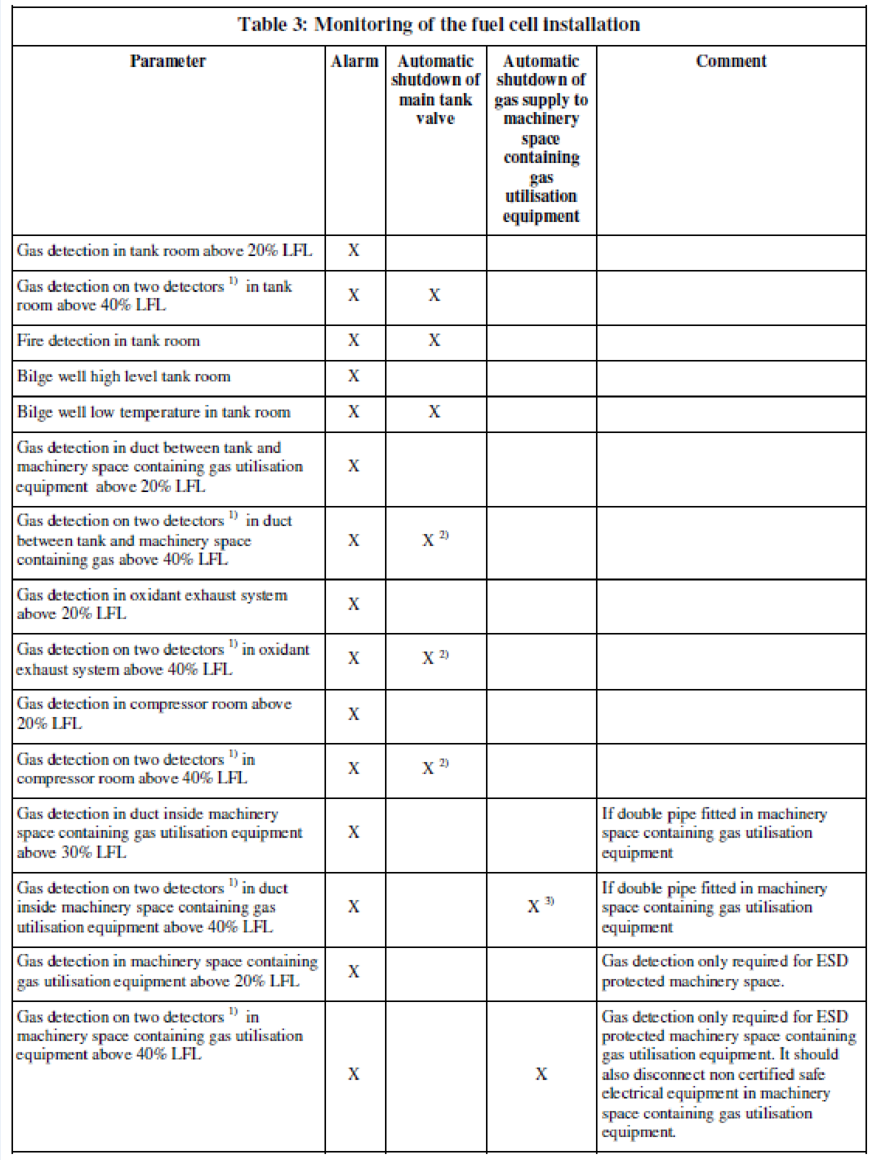


Table 3: Monitoring of the fuel cell installation

Parameter	Alarm	Automatic shutdown of main tank valve	Automatic shutdown of gas supply to machinery space containing gas utilisation equipment	Comment
Gas detection in tank room above 20% LFL	X			
Gas detection on two detectors 1) in tank room above 40% LFL	X	X		
Fire detection in tank room	X	X		
Bilge well high level tank room	X			
Bilge well low temperature in tank room	X	X		
Gas detection in duct between tank and machinery space containing gas utilisation equipment above 20% LFL	X			
Gas detection on two detectors 1) in duct between tank and machinery space containing gas above 40% LFL	X	X 2)		
Gas detection in oxidant exhaust system above 20% LFL	X			
Gas detection on two detectors 1) in oxidant exhaust system above 40% LFL	X	X 2)		
Gas detection in compressor room above 20% LFL	X			
Gas detection on two detectors 1) in compressor room above 40% LFL	X	X 2)		
Gas detection in duct inside machinery space containing gas utilisation equipment above 30% LFL	X			If double pipe fitted in machinery space containing gas utilisation equipment
Gas detection on two detectors 1) in duct inside machinery space containing gas utilisation equipment above 40% LFL	X		X 3)	If double pipe fitted in machinery space containing gas utilisation equipment
Gas detection in machinery space containing gas utilisation equipment above 20% LFL	X			Gas detection only required for ESD protected machinery space.
Gas detection on two detectors 1) in machinery space containing gas utilisation equipment above 40% LFL	X		X	Gas detection only required for ESD protected machinery space containing gas utilisation equipment. It should also disconnect non certified safe electrical equipment in machinery space containing gas utilisation equipment.

<table>
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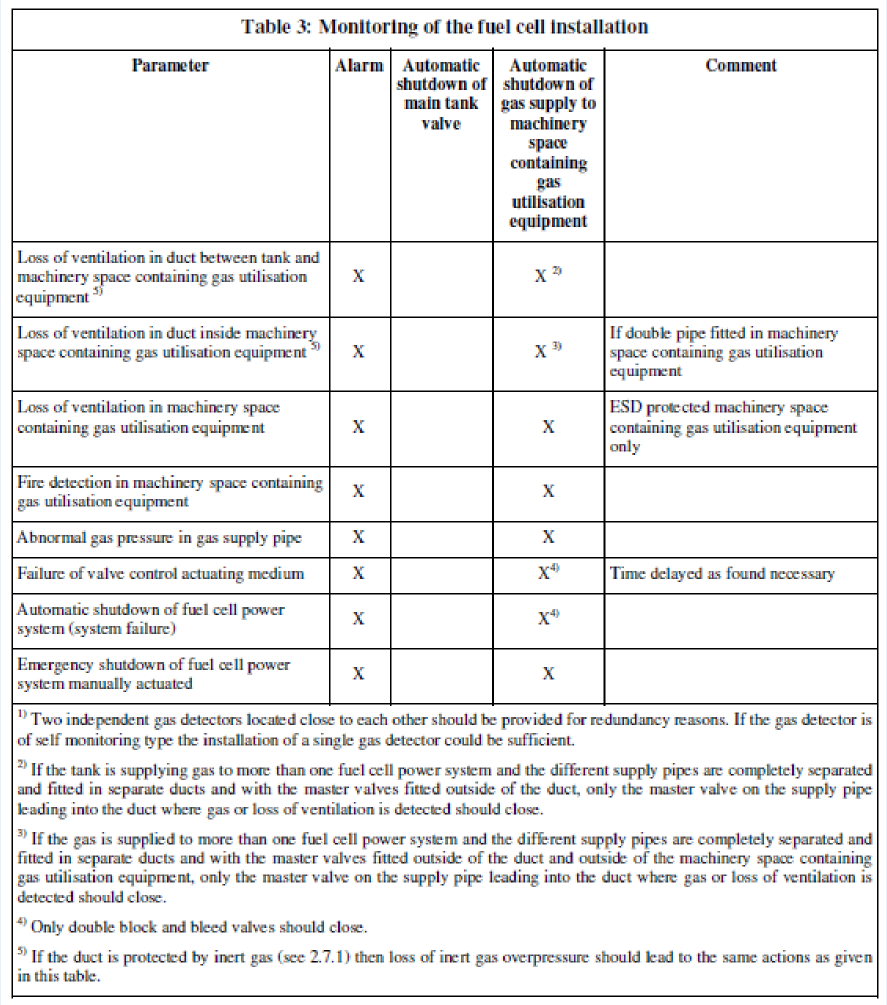


<table>
<tr><th colspan="5">Table 3: Monitoring of the fuel cell installation</th></tr>
<tr><th>Parameter</th><th>Alarm</th><th>Automatic shutdown of main tank valve</th><th>Automatic shutdown of gas supply to machinery space containing gas utilisation equipment</th><th>Comment</th></tr>
<tr><td>Loss of ventilation in duct between tank and machinery space containing gas utilisation equipment [5]</td><td>X</td><td></td><td>X [2]</td><td></td></tr>
<tr><td>Loss of ventilation in duct inside machinery space containing gas utilisation equipment [5]</td><td>X</td><td></td><td>X [3]</td><td>If double pipe fitted in machinery space containing gas utilisation equipment</td></tr>
<tr><td>Loss of ventilation in machinery space containing gas utilisation equipment</td><td>X</td><td></td><td>X</td><td>ESD protected machinery space containing gas utilisation equipment only</td></tr>
<tr><td>Fire detection in machinery space containing gas utilisation equipment</td><td>X</td><td></td><td>X</td><td></td></tr>
<tr><td>Abnormal gas pressure in gas supply pipe</td><td>X</td><td></td><td>X</td><td></td></tr>
<tr><td>Failure of valve control actuating medium</td><td>X</td><td></td><td>X[4]</td><td>Time delayed as found necessary</td></tr>
<tr><td>Automatic shutdown of fuel cell power system (system failure)</td><td>X</td><td></td><td>X[4]</td><td></td></tr>
<tr><td>Emergency shutdown of fuel cell power system manually actuated</td><td>X</td><td></td><td>X</td><td></td></tr>
<tr><td colspan="5">[1] Two independent gas detectors located close to each other should be provided for redundancy reasons. If the gas detector is of self monitoring type the installation of a single gas detector could be sufficient.
[2] If the tank is supplying gas to more than one fuel cell power system and the different supply pipes are completely separated and fitted in separate ducts and with the master valves fitted outside of the duct, only the master valve on the supply pipe leading into the duct where gas or loss of ventilation is detected should close.
[3] If the gas is supplied to more than one fuel cell power system and the different supply pipes are completely separated and fitted in separate ducts and with the master valves fitted outside of the duct and outside of the machinery space containing gas utilisation equipment, only the master valve on the supply pipe leading into the duct where gas or loss of ventilation is detected should close.
[4] Only double block and bleed valves should close.
[5] If the duct is protected by inert gas (see 2.7.1) then loss of inert gas overpressure should lead to the same actions as given in this table.</td></tr>
</table>
</td><td></td></tr>
<tr><td>Chapter 6 - Fuel cell power system</td><td>6.1 General</td><td></td><td>6.1.1 The fuel cell power system should comply with recognised standards such as [10] and [11].</td><td></td></tr>
</table>

Conditions	Item	Documentation	Additional Description	Information
			6.1.3 In so far as their purpose allows, accessible parts of the fuel cell power system should have no sharp edges, no sharp angles, and no rough surfaces likely to cause injury. 6.1.6 The fuel cell power system components and fittings supports and fixation should be designed and constructing accounting for loads related to ship motions, hull deformation, vibration in normal operation as well as acceleration due to collision. The same type of analysis as requested for storage tanks supports and fixation (see 2.8.5) should be performed. 6.1.8 The various parts of the fuel cell power system and their linkages should be so constructed that, when used normally, no instability, distortion, breakage or wear likely to impair their safety can occur. 6.1.12 The fuel cell power system should be so designed and constructed that the emission of airborne noise is reduced to a level suited for the intended use or location in compliance with applicable regional or national airborne noise codes and standards or in compliance with relevant class notation (e.g. BV COMF notation, [20]) if applicable. 6.1.13 The fuel cell power system exhaust to atmosphere, under normal steady-state operating conditions, should not contain concentrations of carbon monoxide in excess of 300 ppm in an air-free sample of the effluents, which is a sample that has its effluent CO concentration mathematically corrected as though there was zero per cent excess air.	
Chapter 6 - Fuel cell power system	6.2 Pressure equipment and piping		6.2.1 Fuel cell power system containing high pressure fluid should comply with recognised standards such as [10] and [11], with relevant recommendations of 2.5 and 2.8 and with relevant BV rules ([16], Sec 3).	
Chapter 6 - Fuel cell power system	6.3 Effluents venting system		6.3.1 The fuel cell power system should be provided with a vent system to convey products of combustion from fuel utilisation equipment to the outside atmosphere. The vent pipe parts should be so designed and	

Conditions	Item	Documentation	Additional Description	Information
			constructed, in particular relative to mechanical strength, corrosion, temperature limitation, strength and resistance to the action of condensate, that they do not become damaged to the extent that they permit unsafe fuel cell power system operation. Requirements of [16], Sec 2 §3.4 and Sec 10 should be accounted for. 6.3.2 The outlets of the effluent gas venting system should be located outdoors in a safe location, away from user areas, ignition sources, air intakes, building openings and overhangs (see also 2.8.1.5). They should be considered as hazardous zones representing possible sources of ignition for explosive gaseous mixtures for defining their location with respect to other ventilation inlet/outlet and vents outlet. 6.3.3 The exhaust pipes of gas utilisation equipment should not be connected to the exhaust pipes of other gas utilisation equipment or systems. The presence of external air flow (e.g. resulting from ship relative wind speed) at the gas effluent venting system outlets should not lead to a fuel cell power system shutdown or unsafe operation. 6.3.9 In case of effluent venting systems which may contain gas (e.g. exhaust of the air supply to the fuel cell system which may contain hydrogen in case of internal fuel cell stack leakage or membrane leakage), a gas detector should be installed at the venting outlet and actions taken in case of gas detection as indicated in Table 3.	
Chapter 6 - Fuel cell power system	6.4 Protection against fire or explosion hazards		6.4.1 All gas fuel cell power system components, systems and subsystems should be designed to: 1) exclude any explosion at all possible situations; or 2) to allow explosions without detrimental effect and to discharge to a safe location. The explosion event should not interrupt the safe operation of the	

Conditions	Item	Documentation	Additional Description	Information
			fuel cell power system unless other safety measures allow the shutdown of the affected components.	
Chapter 6 - Fuel cell power system	6.5 Electrical safety		6.5.1 Applicable requirements of [17] should be considered. 6.5.2 In addition to 6.5.1, relevant specifications for electrical safety of recognised standards for fuel cell power systems (e.g. [10], §4.7) should be used. The following aspects should be particularly addressed: .1 Protection against electric shock and energy hazards. a. Attention should be paid to the need and means of limiting Operator access to energized parts. b. The fuel cell generator should be provided with an integral single emergency switching device, or terminals, for connection of a remote emergency switching device, which prevents further supply to the load in any mode of operation. Plug-connected fuel cell generators should not require an emergency switching device if the plug can perform the same function. .2 Electrical components .3 Input current .4 Insulation .5 Limited current circuits and limited power circuits .6 Protective earthing .7 AC and DC power isolation .8 Over-current and earth fault protection 6.5.3 The fuel cell module should be protected from unintended back-feed of power from energy.	
Chapter 6 - Fuel cell power system	6.6 Control systems and protective components		6.6.1 The protection parameters of the safety circuit should be set on the basis of the safety and reliability analysis as specified in 6.1.2.	

Conditions	Item	Documentation	Additional Description	Information
			6.6.2 The fuel cell power system should be designed in such a way that the single failure of a component does not cascade into a hazardous condition. Means to prevent cascade failures can be found in [10], §4.9.1.2. 6.6.3 Automatic electrical and electronic controls of fuel cell power systems should be designed and constructed so that they are safe and reliable. Standards for automatic electrical heating devices (burners) control systems and for automatic electrical control systems for catalytic oxidation reactors are given in [10], §4.9.2. 6.6.4 Manual controls should be clearly marked and designed to prevent inadvertent adjustment and activation.	
Chapter 6 - Fuel cell power system	6.6 Control systems and protective components	6.6.5 Start	1) The start of an operation should be possible only when all the safeguards are in place and are functional. 2) Suitable interlocks should be provided to secure correct sequential starting. 3) It should be possible for automated plant functioning in automatic mode to be restarted after a stoppage once the safety conditions have been fulfilled. It should also be possible to restart the fuel cell power system by intentional actuation of a control provided for the purpose, provided such restarting is verifiably non-hazardous. This recommendation should not apply to the restarting of the fuel cell power system resulting from the normal sequence of an automatic cycle. 4) If the start of a gas utilisation equipment has not been detected by the fuel cell power system monitoring system within an equipment specific time after opening of the gas supply valve, the gas supply valve should be automatically shut off and the starting sequence terminated. It should be ensured by any means that any unburned gas mixture is flushed away from the exhaust system.	

Conditions	Item	Documentation	Additional Description	Information
Chapter 6 - Fuel cell power system	6.6 Control systems and protective components	6.6.6 Shutdowns	1) As determined by the reliability assessment indicated in 6.1.2 and the functional requirements of the fuel cell power system, the latter should be provided with safety shutdowns and controlled shutdowns. 2)A safety shutdown is the de-energization of the main fuel flow means and/or the deenergization of both the process air flow and the main fuel flow means, as the result of the action of a limiter, a cut-out or the detection of an internal fault of the system. a. Safety shutdowns should be incorporated as part of the fuel cell power system in order to avert actual or impending danger that cannot be corrected by controls. These functions should: - stop the dangerous condition without creating additional hazards; - trigger or permit the triggering of certain safeguard actions where necessary; - override all other functions and operations in all modes; - prevent reset from initiating a restart; - be fitted with restart lock-outs in such a way that a new start command may take effect on normal operation only after the restart lock-outs have been intentionally reset. b. Emergency stops (i.e. manual safety shutdown), if required by the safety and reliability analysis in 6.1.2, should have clearly identifiable, clearly visible and quickly accessible controls such as buttons, in accordance with recognised standards (e.g. ISO 13850). Emergency stops should stop the fuel and air processing flow, and should electrically isolate both poles of the fuel cell module, and other high voltage sources (if fitted) from external circuitry or components. c. In case of fault in the control system logic or failure of, or damage to, the control system hardware: - the fuel cell power system should not be prevented from stopping once the stop command has been given; - automatic or manual stopping of the moving parts should be unimpeded;	

Conditions	Item	Documentation	Additional Description	Information
			- the protection devices should remain fully effective; - the fuel cell power system should not restart unexpectedly. When a protective device or interlock causes a safety shutdown of the fuel cell power system, that condition should be signalled to the logic of the control system. The reset of the shutdown function should not initiate any hazardous condition. Control/monitoring systems that can operate safely in the hazardous situation may be left energized to provide system information. 3) A controlled shutdown is the de-energization of the main fuel flow means and/or the deenergization of both the process air flow and the main fuel flow means, as the result of the opening of a control loop by a control device such as a thermostat. The system returns to the start position. Upset conditions that can be safely controlled or that do not pose immediate danger may be corrected with a controlled shutdown. A controlled shutdown may remove all power to the equipment, or may leave power available to the fuel cell power system actuators. 6.6.9 Manual controls locations 1) It should be possible to activate manual controls locally (close to the fuel cell power system component to control), from the navigation bridge and from the engine control room. The priority should be given to local activations. 2) It should be possible to activate emergency stops locally, from the navigation bridge, from the engine control room and from the fire control room. 3) When a protective device or interlock causes a safety shutdown of the fuel cell power system, that condition should be signalled in the navigation bridge and in the engine control room.	

Conditions	Item	Documentation	Additional Description	Information
			6.6.11 Protective devices should be provided as required by the safety and reliability analysis in 6.1.2. The following aspects should be considered: 1) Protective devices can consist of adequate monitoring devices such as indicators and/or alarms which enable adequate action to be taken either automatically or manually to keep the fuel cell power system within the allowable limits; 2) Protective devices should be so designed and constructed as to be reliable and suitable for their intended duty and take into account the maintenance and testing requirements of the devices, where applicable; 3) Protective devices should have their protective functions independent of other possible functions; 4) Dangerous overloading of equipment should be prevented at the design stage by means of integrated measurement, regulation and control devices, such as over-current cut-off switches, temperature limiters, differential pressure switches, flow-meters, time-lag relays, over-speed monitors and/or similar types of monitoring devices; 5) Protective devices with a measuring function should be designed and constructed so that they can cope with foreseeable operating requirements and special conditions of use. Where necessary, it should be possible to check the reading accuracy and serviceability of devices. These devices should incorporate a safety factor that ensures that the alarm threshold lies far enough outside the limits to be registered, taking into account, in particular, the operating conditions of the installation and possible aberrations in the measuring system. 6) Sensors used as protective devices should have adequate ranges and response times. They should be calibrated and maintained according to the manufacturer’s specifications. 7) All parts of fuel cell power systems which are set or adjusted at the stage of manufacture, and which should not be manipulated by the user or the installer, should be appropriately protected.	

Conditions	Item	Documentation	Additional Description	Information
			8) Levers and other controlling and setting devices should be clearly marked and given appropriate instructions so as to prevent any error in handling. Their design should be such as to preclude accidental manipulation.	
Chapter 7 - Manufacture, Workmanship and Testing	7.7 Fuel cell power system		7.7.1 The fuel cell system to be installed on the ship, or a representative production sample of this system should be subject to a series of type tests according to recognised standards (e.g. [10], §5 and guidance for measurement and analysis in [11]). The tests should cover, when relevant and applicable, at least the following items: .1 Gas leakage tests .2 Liquid leakage tests .3 Strength tests of gas and liquid sections .4 Ambient condition tests (according to conditions as defined in [17], Sec 2) .5 Normal operation test .6 Electrical overload test .7 Dielectric tests simulating abnormal conditions .8 Shutdown tests .9 Burner operating characteristics tests (applicable to fuel cell power systems equipped with any fuel-fired boiler or heating device, for example, the start burner of the reformer section) .10 Automatic control of burners and catalytic oxidation reactors tests .11 Exhaust gas temperature tests .12 Surface and component temperature tests .13 Wind tests (applicable for fuel cell systems intended for installation on open deck or for units in enclosed spaces having horizontal air inlets and exhaust to the outdoors; wind conditions to be defined with the Society) .14 Rain tests (applicable for fuel cell systems intended for installation on open deck; test conditions should correspond to the IP rating declared by the manufacturer and tests should be performed according to a recognised standard (e.g. IEC 60529, Degrees of protection provided by enclosures (IP Code)) .15 CO emission tests	

Conditions	Item	Documentation	Additional Description	Information
			7.7.2 In case tests listed in 7.7.1 are performed a representative production sample of the fuel cell system, routine tests should be performed on the unit that will be installed onboard. These tests should cover at least (e.g. see [10], §6 and [11] for guidance) the following items: .1 Gas leakage tests .2 Coolant (liquid) leakage tests .3 Normal operation test .4 Dielectric tests simulating abnormal conditions .5 Burner operating characteristics tests .6 CO emission tests	

Annex 30: GUIDANCE NOTES FOR FUEL SYSTEM RISK ASSESSMENT, HAZARD IDENTIFICATION - HYDROGEN (LR)

GUIDANCE NOTES FOR FUEL SYSTEM RISK ASSESSMENT, HAZARD IDENTIFICATION - HYDROGEN (LR)

A. IDENTITY CARD OF GUIDANCE NOTES FOR FUEL SYSTEM RISK ASSESSMENT, HAZARD IDENTIFICATION - HYDROGEN (LR)

RCS	Number of RCS	Title	Date	Stability date	Statutory
Guidance notes LR	/	Guidance Notes for Fuel System Risk Assessment, Hazard identification - Hydrogen	February 2021		yes

The use of gaseous or other low-flashpoint fuels, other than natural gas, on board ships requires an Engineering Analysis to be submitted for review. The basis of the Engineering Analysis is typically a safety risk assessment which would be expected to include early hazard identification.

Scope:

Domain/category: Safety, ships, Low-FlashPoint fuel, hydrogen.

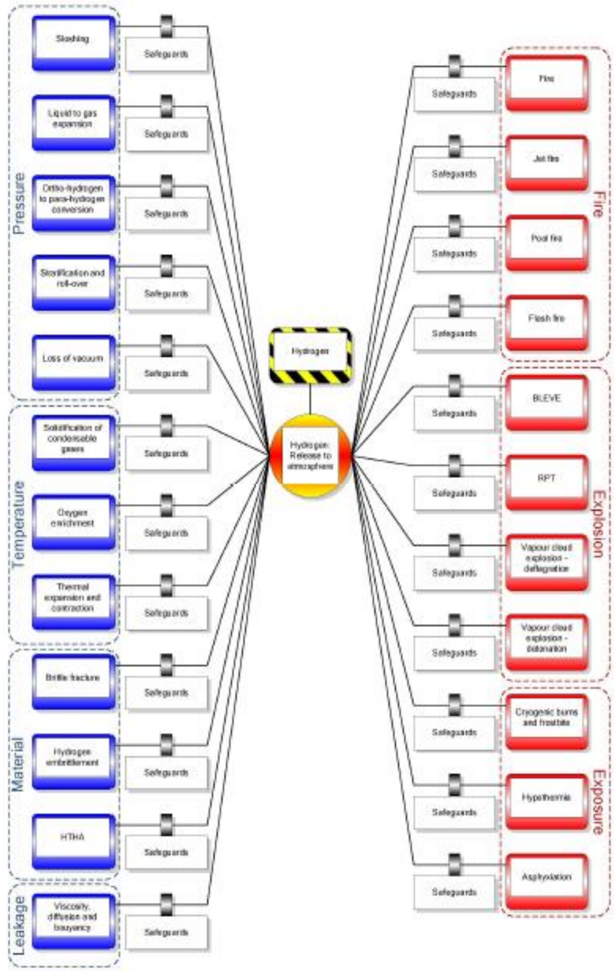
Specifed exclusion: /

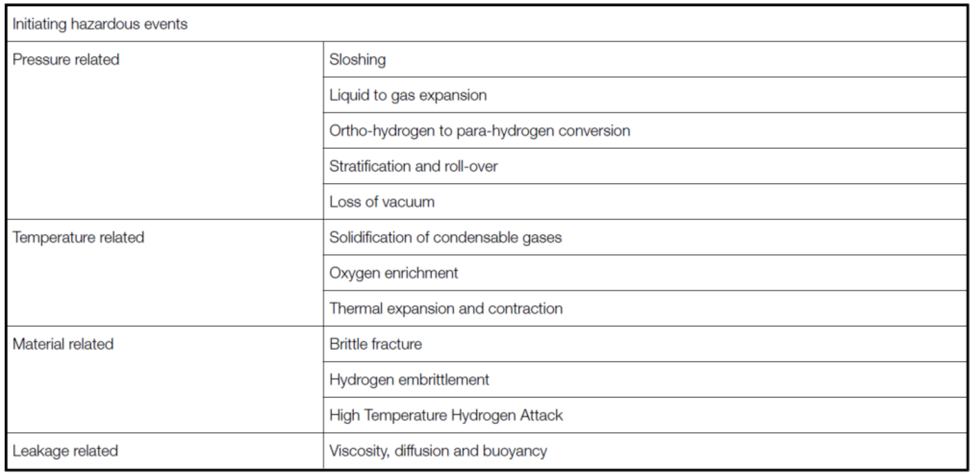
Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

Conditions	Item	Documentation	Additional Description	Information
Chapter 2: Hydrogen Fuel Hazard	Section 1: Hazard identification	Paragraph 1.1: Scope of hazard identification Sub paragraph 1.1.1	*Hazard identification is undertaken during Stage 2 of LR's RBD process.* « RBD: Risk Based design »	
Chapter 2: Hydrogen Fuel Hazard	Section 1: Hazard identification	Paragraph 1.1: Scope of hazard identification Sub paragraph 1.1.2	*In accordance with the aims of Classification, the hazards to be identified are those which may potentially impact on the dependability of services essential to the safe operation of the ship, and those hazards which may potentially impact the safety of personnel, machinery and equipment on board the ship.*	
Chapter 2: Hydrogen Fuel Hazard	Section 1: Hazard identification	Paragraph 1.1: Scope of hazard identification Sub paragraph 1.1.3	*Hazards which may potentially impact upon the dependability of services essential to the safe operation of the ship are predominately related to functional failure of the systems providing those essential services (e.g. loss of output, insufficient output, delayed output etc.). Such functional failures are generally the same irrespective of fuel, consequently, while functional failures must still be considered during the hazard identification, consistent with the scope of this document, those hazards are not explored further.*	
Chapter 2: Hydrogen Fuel Hazard	Section 1: Hazard identification	Paragraph 1.1: Scope of hazard identification Sub paragraph 1.1.4	*In the context of hydrogen fuel systems generally, i.e. irrespective of whether they supply essential services or not, hazards which may potentially impact on the safety of personnel, machinery and equipment are, for the purposes of this document, considered to be those hazards associated with the use of hydrogen for which the consequences would be fire, explosion.*	
Chapter 2: Hydrogen Fuel Hazard	Section 1: Hazard identification	Paragraph 1.1: Scope of hazard identification	*Fire, explosion and exposure consequences are, for the purposes of this document, attributed to a single hazardous event, a hydrogen release to atmosphere. In consideration of such a hazard, only the initiating hazardous events and*	

Conditions	Item	Documentation	Additional Description	Information
		Sub paragraph 1.1.5	*consequences which are considered to pose additional, increased or unknown risk when compared to natural gas are further discussed.*	
Chapter 2: Hydrogen Fuel Hazard	Section 1: Hazard identification	Paragraph 1.1: Scope of hazard identification Sub paragraph 1.1.6	*While initiating hazardous events and consequences which are considered to present similar or reduced risk compared to natural gas release are not discussed further in this document, they would however need to be explored and considered in any risk assessment of a hydrogen fuel system.*	
Chapter 2: Hydrogen Fuel Hazard	Section 2: Hazard and consequences	Paragraph 2.1: Hazardous events Sub paragraph 2.1.1	*The bow-tie diagram for a 'hydrogen release to atmosphere' event is shown in Figure 2.2.1 Hydrogen release to atmosphere – initiating hazardous events and potential consequences requiring additional consideration. As is usual, the initiating hazardous events which may result in a hydrogen release to atmosphere are shown on the left-hand side of the diagram while the potential consequences of a hydrogen release to atmosphere are shown on the right-hand side of the diagram.*	

			 **Figure 2.2.1 Hydrogen release to atmosphere – initiating hazardous events and potential consequences requiring additional consideration**	

Conditions	Item	Documentation	Additional Description	Information
Chapter 2: Hydrogen Fuel Hazard	Section 2: Hazard and consequences	Paragraph 2.1: Hazardous events Sub paragraph 2.1.2	*The initiating hazardous events and the potential consequences of a hydrogen release are also listed in Table 2.2.1 Hydrogen release to atmosphere – initiating hazardous events requiring additional consideration* **Table 2.2.1 Hydrogen release to atmosphere – initiating hazardous events requiring additional consideration**  *and Table 2.2.2 Hydrogen release to atmosphere – potential consequences requiring additional consideration respectively.*	

Initiating hazardous events	
Pressure related	Sloshing
	Liquid to gas expansion
	Ortho-hydrogen to para-hydrogen conversion
	Stratification and roll-over
	Loss of vacuum
Temperature related	Solidification of condensable gases
	Oxygen enrichment
	Thermal expansion and contraction
Material related	Brittle fracture
	Hydrogen embrittlement
	High Temperature Hydrogen Attack
Leakage related	Viscosity, diffusion and buoyancy

<table>
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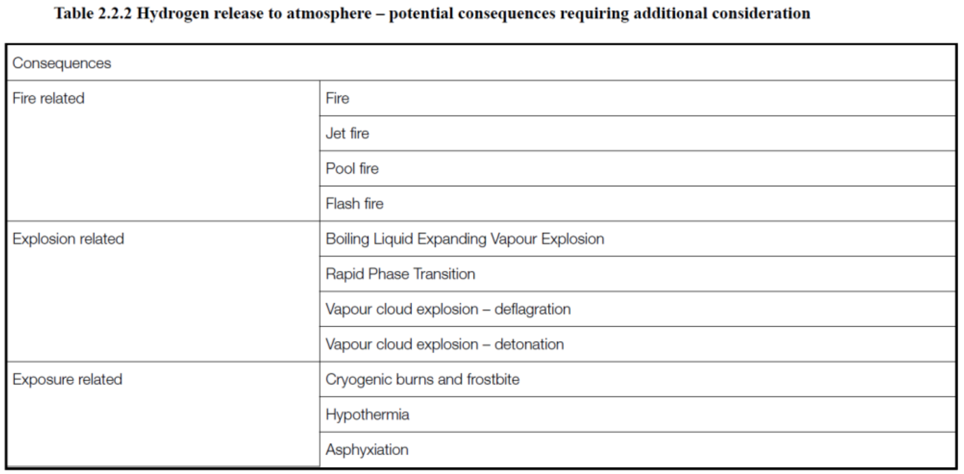
<tr><td></td><td></td><td></td><td>
Table 2.2.2 Hydrogen release to atmosphere – potential consequences requiring additional consideration
<table>
<tr><th colspan="2">Consequences</th></tr>
<tr><td>Fire related</td><td>Fire</td></tr>
<tr><td></td><td>Jet fire</td></tr>
<tr><td></td><td>Pool fire</td></tr>
<tr><td></td><td>Flash fire</td></tr>
<tr><td>Explosion related</td><td>Boiling Liquid Expanding Vapour Explosion</td></tr>
<tr><td></td><td>Rapid Phase Transition</td></tr>
<tr><td></td><td>Vapour cloud explosion – deflagration</td></tr>
<tr><td></td><td>Vapour cloud explosion – detonation</td></tr>
<tr><td>Exposure related</td><td>Cryogenic burns and frostbite</td></tr>
<tr><td></td><td>Hypothermia</td></tr>
<tr><td></td><td>Asphyxiation</td></tr>
</table></td><td></td></tr>
<tr><td>Chapter 2: Hydrogen Fuel Hazard</td><td>Section 2: Hazard and consequences</td><td>Paragraph 2.2: Initiating hazardous events
Sub paragraph 2.2.1</td><td><i>Only those initiating hazardous events which are considered to pose an additional, increased or unknown risk compared to the use of natural gas as fuel are considered further. This is either because they are uniquely associated with the use of hydrogen as fuel, considered more likely to occur, the consequences are considered to be greater compared to those associated with natural gas, or because the actual implications are not well established.</i></td><td></td></tr>
<tr><td>Chapter 2: Hydrogen Fuel Hazard</td><td>Section 2: Hazard and consequences</td><td>Paragraph 2.2: Initiating hazardous events
Sub paragraph 2.2.2</td><td><i>The initiating hazardous events listed are common to compressed hydrogen fuel systems, cryogenic liquid hydrogen fuel systems or to both, and common to individual elements, some elements or all elements of the fuel system (see Figure 1.1.2 Fundamental elements of a fuel system including consumers).</i></td><td></td></tr>
</table>

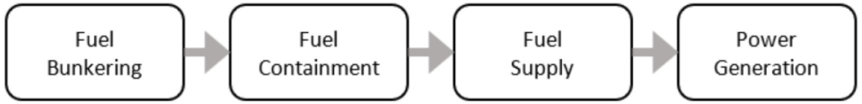
<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td>

Figure 1.1.2 Fundamental elements of a fuel system including consumers</td><td></td></tr>
<tr><td>Chapter 2: Hydrogen Fuel Hazard</td><td>Section 2: Hazard and consequences</td><td>Paragraph 2.2: Initiating hazardous events
Sub paragraph 2.2.3</td><td>The initiating hazardous events are listed in Table 2.2.1 Hydrogen release to atmosphere – initiating hazardous events requiring additional consideration and described in greater detail thereafter.

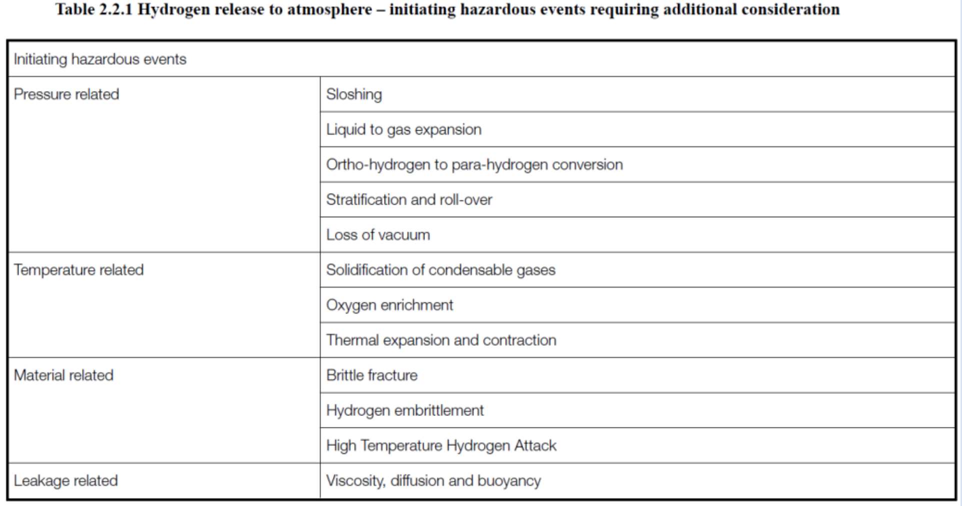



Table 2.2.1 Hydrogen release to atmosphere – initiating hazardous events requiring additional consideration
<table>
<tr><td colspan="2">Initiating hazardous events</td></tr>
<tr><td>Pressure related</td><td>Sloshing</td></tr>
<tr><td></td><td>Liquid to gas expansion</td></tr>
<tr><td></td><td>Ortho-hydrogen to para-hydrogen conversion</td></tr>
<tr><td></td><td>Stratification and roll-over</td></tr>
<tr><td></td><td>Loss of vacuum</td></tr>
<tr><td>Temperature related</td><td>Solidification of condensable gases</td></tr>
<tr><td></td><td>Oxygen enrichment</td></tr>
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<tr><td>Material related</td><td>Brittle fracture</td></tr>
<tr><td></td><td>Hydrogen embrittlement</td></tr>
<tr><td></td><td>High Temperature Hydrogen Attack</td></tr>
<tr><td>Leakage related</td><td>Viscosity, diffusion and buoyancy</td></tr>
</table></td><td></td></tr>
<tr><td></td><td></td><td>2.2.6 Material related initiating events</td><td>Metallic materials exposed to hydrogen may experience loss of ductility due to changes in their microstructure which can result in cracking and catastrophic failure. The potential for premature failure due to hydrogen embrittlement depends upon the susceptibility of the material to hydrogen embrittlement, exposure to a hydrogen environment and the presence of tensile stress.</td><td></td></tr>
</table>

Conditions	Item	Documentation	Additional Description	Information
		b) Hydrogen embrittlement	*• This hazard is not normally relevant to liquefied natural gas. Consideration needs to be given to embrittlement in the design of the compressed or liquid hydrogen fuel bunkering arrangements, the compressed or liquid hydrogen fuel containment system, the hydrogen fuel supply system and the power generation system. The suitability of the materials, particularly high tensile steels and aluminium alloys, intended to be used in fuel system components expected to be exposed to hydrogen needs to be considered, including fuel storage tanks, piping, pumps, heat exchangers, valves, etc.*	
		2.2.6 Material related initiating events c) Hydrogen embrittlement	*• High Temperature Hydrogen Attack (HTHA) occurs in steels with prolonged exposure to hydrogen at elevated temperatures. It is a degradation mechanism that attacks the material structure and is most likely to occur in regions of higher stress, such as welds. It can cause surface or internal decarburisation (reduction of the carbon content of the material), resulting in a softening of the material and with it the potential for fissures and cracking.* *• This hazard is not normally relevant to liquefied natural gas. The design of the power generation system needs to take account of the construction materials to be used for components potentially exposed to hydrogen at elevated temperatures, such as high temperature components e.g. fuel reformation equipment.*	
		2.2.7 Leakage related initiating events a) Viscosity, diffusion and buoyancy	*• The usual sources of gas leaks from containment and piping systems (i.e. connections, couplings, seals, seats, glands, gaskets, welds, etc.) are potential sources of hydrogen leakage. Additionally, diffusion through containment materials is also a potential source of hydrogen leakage which may result in the build-up of hydrogen in confined spaces over prolonged periods.* *• Although common to both, this hazard is expected to be greater for hydrogen compared to natural gas. Unless appropriately mitigated, for a given pressure and hole size, the likelihood of leakage and the rate of leakage would be significantly greater for hydrogen compared to natural gas owing to the smaller size of the hydrogen molecule and its low viscosity compared to that of natural gas.* *• The rate of leakage from pressurised containment systems will be significantly greater – almost three times faster – than that of natural gas. While the high*	

Conditions	Item	Documentation	Additional Description	Information
			diffusivity and high buoyancy of hydrogen in air helps with the dispersal of leaks in unconfined spaces, leaks in confined spaces may result in a rapid accumulation of flammable mixtures high up in those spaces. However, such buoyancy effects are less significant, and should not be relied upon for leaks of liquid hydrogen, owing to their higher density compared to the surrounding air, or for pressurised leaks for which dispersion will generally be determined by the orientation of the leak owing to the momentum of the hydrogen, or for low concentrations of hydrogen in air for which the difference in density compared to the surrounding air will be less significant. *• Materials, components and arrangements proven suitable for natural gas fuel systems may not be suitable for hydrogen fuel systems without specific consideration. Conventional approaches for the pressure testing of natural gas fuel systems are unlikely to identify all potential sources of leakage from hydrogen fuel systems. Particular attention needs to be given to leakage in the design of the compressed or liquid hydrogen fuel bunkering arrangements, the compressed or liquid hydrogen fuel containment system, the hydrogen fuel supply system and the power generation system beyond that normally given in the design of natural gas fuel systems.* *• Consideration needs to be given to connections, couplings, seals, seats, glands, gaskets and welds – in terms of their numbers, their locations, their orientations, their suitability for hydrogen containment and their suitability for the marine environment – and testing on board after installation. Piping systems found to be 'leak tight' when pressure tested with nitrogen may well leak profusely when operating with hydrogen. Attention also needs to be given to the permeability of construction materials to be used for all components containing hydrogen. Owing to the possibility of diffusion, the need for gas detection and ventilation of spaces even without an obvious source of release from components containing or transferring hydrogen also needs to be considered.*	

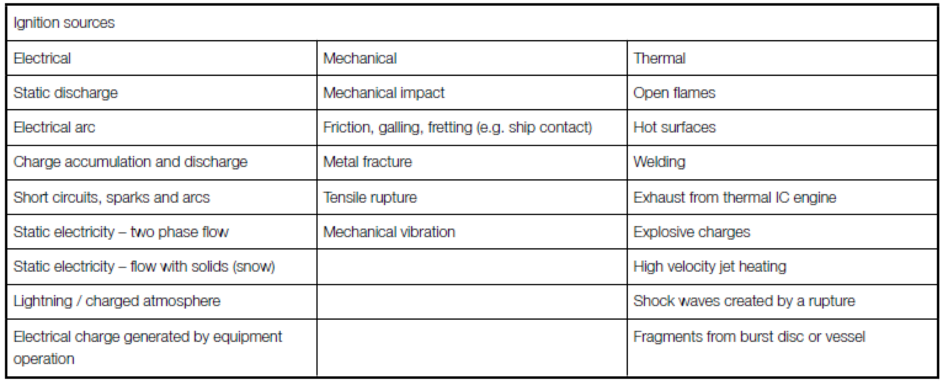
Conditions	Item	Documentation	Additional Description	Information
	2.3 Consequences	2.3.2 Fire related consequences (a) Fire	*Fires resulting from the accidental ignition of unintended hydrogen releases (e.g. leakage) or accidental ignition of deliberate hydrogen releases (e.g. venting) are likely to cause harm or damage as a result of conduction (direct flame impingement), convection or radiant heat transfer. While the ultimate consequences of hydrogen fires may be comparable to those of natural gas fires, unless specifically considered, the likelihood of hydrogen fires may be significantly greater due to the increased likelihood of hydrogen leakage, the much wider flammable range of hydrogen in air, and the much lower ignition energy required to ignite a release of hydrogen compared to natural gas. Hydrogen flames are nearly invisible during daylight, they generally produce a lower radiant heat compared to natural gas flames and their temperature is hotter than natural gas flames.* *• The design and arrangement of the enclosed and semi-enclosed spaces in which compressed or liquid hydrogen fuel bunkering arrangements are located and of the enclosed spaces in which the compressed or liquid hydrogen fuel containment system, the hydrogen fuel supply system and power generators are located needs to take account of the increased potential for hydrogen escape from pipe couplings, pipe joints, equipment seals, etc. within those spaces when compared to natural gas.* *• Hazardous zones need to be defined according to potential points of release and release conditions within those spaces, under both normal and reasonably foreseeable abnormal conditions, in accordance with standards and criteria acceptable to the Flag Administration. Hazardous zones defined on the basis of a natural gas release may not be appropriate for a hydrogen release.* *• Hazardous zones in the vicinity of ventilation and pressure relief outlets in open areas on deck need to be defined according to potential discharge conditions, taking account of relevant environmental influences e.g. humidity, wind velocity and direction etc. Discharges should be avoided in all but emergency situations.* *• In accordance with the definition of hazardous zones, the design and arrangements within those spaces needs to eliminate potential electrical,*	

Conditions	Item	Documentation	Additional Description	Information
			mechanical and thermal sources of ignition. Safe type electrical equipment, certified for hydrogen atmospheres, needs to be installed and the surface temperature of exposed machinery and equipment needs to be sufficiently below the auto-ignition temperature of hydrogen. *• Recognising the much lower ignition energy required to ignite a release of hydrogen compared to natural gas, in addition to the elimination of all potential electrical sources of ignition, equal attention needs to be given to the elimination of potential mechanical and thermal sources of ignition. The installation of safe type electrical equipment, certified for hydrogen atmospheres, alone may not be sufficient to ensure all potential sources of ignition are eliminated from within the space.* *• Owing to the much lower ignition energy compared to natural gas, ignition of hydrogen caused by electrostatic discharge is significantly more likely and particular consideration needs to be given to the control of electrostatic discharges (see Table* *2.3.2 Hydrogen ignition sources [4]). Devices such as flame arrestors and flame traps intended to prevent the passage of natural gas flames are very unlikely to be suitable for preventing the passage of hydrogen flames owing to the smaller quenching gap associated with hydrogen.* *• While it is important to ensure all potential sources of ignition are eliminated, this alone may not ensure that the possibility of ignition is eliminated. It is important to recognise that hydrogen releases can self or spontaneously ignite when released under pressure. This phenomenon is currently not fully understood and therefore preventing the accumulation of hydrogen following release is of paramount importance.* *• Arrangements for the detection of a hydrogen release within the spaces and the dilution and dispersion thereof through appropriate ventilation arrangements need to be provided. The location of hydrogen detectors needs careful consideration and the latency of the hydrogen detection system needs to be minimised, such that any release can be rapidly diluted and dispersed to an appropriately zoned area.*	

Conditions	Item	Documentation	Additional Description	Information
			• Fire detection, fire protection and fire-fighting arrangements within those spaces should be appropriate for hydrogen fires. Water jets, watersprays or water flows should not act directly on pressure relief valves associated with liquid hydrogen containment in order to avoid the possibility of icing and blockage. The isolation of hydrogen leakage before extinguishing a hydrogen fire should be ensured in order to avoid the build-up of unignited hydrogen and the possibility of an ensuing explosion.	
		(b) Jet fire	*• The potential for a jet fire, resulting from the accidental ignition and combustion of a continuous, pressurised hydrogen release, exists wherever containment systems, process equipment or pipe work contain pressurised hydrogen or liquid hydrogen or hydrogen vapour. Under pressure, choked flow generally occurs when the hydrogen, flashing hydrogen or twophase flow reaches sonic velocities. Jet fire flames have high momentum and can have significant reach and erosive force. The potential flame lengths mean that the heat flux to surrounding steel structures can be significant.* *• In addition to the considerations already mentioned related to the prevention of a release of hydrogen resulting in a fire (i.e. the definition of hazardous zones, the elimination of potential sources of ignition, the detection and dispersion of releases and fire-fighting) the design and arrangement of enclosed and semi-enclosed spaces in which the hydrogen bunkering arrangements are located and the enclosed spaces in which the hydrogen containment system, the hydrogen supply system, and power generators are located need to take account of the possibility of pressurised hydrogen escaping with high velocity. Likely sources of leakage included pipe couplings, joints, seals, etc. and sources of intended release from relief valves, bursting discs, fusible plugs, etc. within those spaces. All potential points of release need to be evaluated in terms of likelihood and consequences of a release and implications for other fuel system components located in the immediate vicinity.*	
		(d) Flash fire	*• A flash fire describes the ignition and combustion of a release of hydrogen which exhibits intense heat but no significant increase in pressure. While flash fires are also associated with liquefied natural gas, the likelihood of hydrogen flash fires may*	

Conditions	Item	Documentation	Additional Description	Information
			be significantly greater owing to the increased likelihood of leakage, the much wider flammable range of hydrogen in air, and the much lower ignition energy required to ignite a release compared to natural gas. *• The considerations already mentioned related to the prevention of a release of hydrogen resulting in a fire (i.e. the definition of hazardous zones, the elimination of potential sources of ignition, the detection and dispersion of releases and fire-fighting) need to be considered in the design and arrangement of enclosed and semi-enclosed spaces in which the hydrogen bunkering arrangements are located and the enclosed spaces in which the hydrogen containment system, the hydrogen supply system and the power generators are located.*	
		2.3.3 Explosion related consequences (c) Vapour cloud explosion – deflagration	*• In the event that a flammable mixture of hydrogen ignites, depending upon the release and combustion conditions, deflagration may occur in which the flame front propagates outwards at subsonic speeds. The combustion takes place through thermal conduction (the transfer of heat and combustion products) to the unburned mixture ahead of the flame front. The speed of the flame front may range from a few metres per second to several hundreds of metres per second with overpressures of a few millibar with potentially limited consequences to several bar and with potentially catastrophic consequences in confined spaces. Under certain conditions of turbulence and instability, the flame front may accelerate and transition from deflagration to detonation, with the potential for even more severe consequences in confined spaces.* *• The consequences may be more severe for hydrogen owing to the significantly higher propagation velocity and the higher overpressures when compared to natural gas. Hydrogen properties, such as high diffusivity and high buoyancy, which may serve to reduce the likelihood of deflagration in open air may have the opposite effect in confined spaces. Within enclosed and semi-enclosed spaces in which the hydrogen fuel system components are located, conventional structural arrangements are likely to be severely damaged by significant hydrogen deflagrations and as such the possibility of deflagration needs to be eliminated during all normal and reasonably foreseeable abnormal operating conditions.*	

Conditions	Item	Documentation	Additional Description	Information
			• In addition to the considerations already mentioned related to the prevention of a release of hydrogen resulting in a fire (i.e. the definition of hazardous zones, the elimination of potential sources of ignition, the detection and dispersion of releases and fire-fighting), the design and arrangement of enclosed and semi-enclosed spaces in which the hydrogen bunkering arrangements are located and the enclosed spaces in which the hydrogen containment system, the hydrogen supply system, and power generators are located need to ensure that flammable accumulations of hydrogen and air cannot develop under any circumstances. All potential ignition sources within those spaces – electrical, mechanical and thermal – need to be eliminated in accordance with established engineering best practice recognising the much lower ignition energy required to ignite a release of hydrogen. *• The design of the fuel system needs to ensure that, other than components intended for the combustion of hydrogen (e.g. engine combustion chambers), all fuel system components containing hydrogen including piping, pumps, heat exchangers, etc. do not normally contain flammable mixtures of hydrogen, and that instead, the atmosphere within those components should be either too lean or too rich to support combustion at all times, including the filling and emptying of those components. The potential accumulation of hydrogen within void and fluid spaces of connected components such as heat exchangers, engine scavenge spaces, crankcases, etc. due to leakage of gaskets, seals, rings, etc. needs also to be considered.*	
		(d) Vapour cloud explosion – detonation	*• In the event that an explosive mixture of hydrogen ignites, depending upon the release and combustion conditions, detonation may occur in which the flame front propagates outwards at supersonic speeds typically in the range of one to two thousand metres per second, which drives a high-pressure shock wave ahead of the flame front creating overpressures, significantly higher than those associated with deflagration, with almost certain catastrophic consequences in confined spaces.* *• Generally, the likelihood of a deflagration to detonation transition is related to laminar burning velocity, and accordingly, is significantly greater for hydrogen compared to natural gas owing to the higher laminar burning velocity of hydrogen.*	

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td>Within enclosed and semi-enclosed spaces in which the hydrogen fuel system components are located, conventional structural arrangements will almost certainly not withstand hydrogen detonations and as such the possibility of detonation needs to be eliminated during all normal and reasonably foreseeable abnormal operating conditions. The design of those spaces and the arrangement of the equipment located within those spaces needs to ensure that explosive accumulations of hydrogen and air cannot develop under any circumstances. All potential ignition sources within those spaces – electrical, mechanical and thermal – need to be eliminated in accordance with established engineering best practice recognising the much lower ignition energy required to ignite a release of hydrogen.
• In addition to the prevention of accumulations of explosive mixtures and the elimination of possible ignition sources, congestion due to the presence of machinery, equipment, piping, etc. within those spaces needs to be minimised as far as possible to reduce the potential for turbulence and instability and an increased likelihood of detonation in the event of a hydrogen release.</td><td></td></tr>
<tr><td></td><td>3.2 Hydrogen ignition sources</td><td></td><td>3.2.1 Examples of hydrogen ignition sources are given in the following table:
Table 2.3.2 Hydrogen ignition sources [4]

<table>
<tr><th colspan="3">Ignition sources</th></tr>
<tr><td>Electrical</td><td>Mechanical</td><td>Thermal</td></tr>
<tr><td>Static discharge</td><td>Mechanical impact</td><td>Open flames</td></tr>
<tr><td>Electrical arc</td><td>Friction, galling, fretting (e.g. ship contact)</td><td>Hot surfaces</td></tr>
<tr><td>Charge accumulation and discharge</td><td>Metal fracture</td><td>Welding</td></tr>
<tr><td>Short circuits, sparks and arcs</td><td>Tensile rupture</td><td>Exhaust from thermal IC engine</td></tr>
<tr><td>Static electricity – two phase flow</td><td>Mechanical vibration</td><td>Explosive charges</td></tr>
<tr><td>Static electricity – flow with solids (snow)</td><td></td><td>High velocity jet heating</td></tr>
<tr><td>Lightning / charged atmosphere</td><td></td><td>Shock waves created by a rupture</td></tr>
<tr><td>Electrical charge generated by equipment operation</td><td></td><td>Fragments from burst disc or vessel</td></tr>
</table></td><td></td></tr>
</table>

RULES AND REGULATIONS FOR THE CLASSIFICATION OF SHIPS USING GASES OR OTHER LOW-FLASHPOINT (LR)

A. IDENTITY CARD OF RULES AND REGULATIONS FOR THE CLASSIFICATION OF SHIPS USING GASES OR OTHER LOW-FLASHPOINT (LR)

RCS	Number of RCS	Title	Date	Stability date	Statutory
Rules and Regulations (LR)	/	Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint (Lloyd's Register)	July 2020		

Lloyd's Regsiter (LR) is a Non-Governement Organization who works with IMO. LR is a member of IACS.

The Lloyd's Register document entitled "Rules and Regulations Regulations for the Classification of Ships using Gases or other Low-flashpoint" follows the structure of the IGF Code, namely:

- Parts A and D cover requirements that are generic to all low flashpoint fuels (unless otherwise stated)
- Parts A-1, B-1 and C-1 cover specific requirements for ships using natural gas as fuel.
- Parts A-2, etc. are being developed for low flashpoint fuels other than natural gas. Until these specific requirements are included in the *IGF Code*, then ships using a low flashpoint fuel other than natural gas need to meet alternative design requirements as noted in Part A, 2.3.

Therefore, the objective of this sheet is to recall the parts relevant to the StasHH project that were defined in the IGF Code sheet (associated with this deliverable) and to complete them with those defined in LR's “Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint”.

Scope:

Domain/category: safety, ships and low-flashpoint fuels.

Specifed exclusion: /

Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

LR document content: "Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint"				Identical or complement to the IGF Code
Conditions	Item	Documentation	Additional Description	
Part A Chapter 2:	sub-chapter 2: General	Parargraph 2.1: Application	*Unless expressly provided otherwise this Code applies to ships to which part G of SOLAS chapter II-1 applies..*	
Part A Chapter 2:	sub-chapter 2: General	Parargraph 2.1: Application	***LR 2.1-01*** *These Rules specify requirements for the use of gases or other low-flashpoint fuels as a fuel for ships other than ships covered by the IGC Code (e.g. LNG carriers).*	
Part A Chapter 2:	sub-chapter 2: General	Parargraph 2.1: Application	***LR 2.1-02*** *The requirements are in addition to the applicable requirements of the Rules and Regulations for the Classification of Ships (hereinafter referred to as the Rules for Ships), Rules and Regulations for the Classification of Naval Ships, Rules and Regulations for the Classification of Inland Waterways Ships, Rules and Regulations for the Classification of Special Service Craft and statutory conventions such as SOLAS.*	
Part A Chapter 2:	sub-chapter 2: General	Parargraph 2.1: Application	***LR 2.1-03*** *Inland Waterways Vessels are to meet the requirements of these Rules. Where it is not possible or it is not appropriate for Inland Waterways Vessels to comply with the specific requirements of these Rules as a result of national or regional requirements, details of the design that deviate from the LR requirements are to be submitted for consideration, see LR 2.1-05*	
Part A Chapter 2:	sub-chapter 2: General	Parargraph 2.1: Application	***LR 2.1-04*** *The Rules do not repeat the general requirements for fire safety as stated in statutory conventions.* ***LR 2.1-05*** *Additional requirements may be imposed by the National Administration with which the ship is registered and/or by the Administration within whose territorial jurisdiction the ship is intended to operate.*	
Part A Chapter 2:	sub-chapter 2: General	Parargraph 2.1: Application	***LR 2.1-06*** *The periodic survey regulations for natural gas fuel installations are located in the Rules and Regulations for the Classification of Ships, Part 1, Chapter 3, Section 24*	
Part A Chapter 2: General	Sub-chapter 2.3:	Paragraph 2.3.1	*This Code contains functional requirements for all appliances and arrangements related to the usage of low-flashpoint fuels.*	Identical

LR document content: “Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint”				Identical or complement to the IGF Code
Conditions	Item	Documentation	Additional Description	
	Alternative design			
Part A Chapter 2: General	Sub-chapter 2.3: Alternative design	Paragraph 2.3.2	*Fuels, appliances and arrangements of low-flashpoint fuel systems may either:* *3. deviate from those set out in this Code, or* *4. be designed for use of a fuel not specifically addressed in this Code.* *Such fuels, appliances and arrangements can be used provided that these meet the intent of the goal and functional requirements concerned and provide an equivalent level of safety of the relevant chapters.*	Identical
Part A Chapter 2: General	Sub-chapter 2.3: Alternative design	Paragraph 2.3.3	*The equivalence of the alternative design shall be demonstrated as specified in SOLAS regulation II-1/55 and approved by the Administration. However, the Administration shall not allow operational methods or procedures to be applied as an alternative to a particular fitting, material, appliance, apparatus, item of equipment, or type thereof which is prescribed by this Code.*	Identical
Part A Chapter 2: General	Sub-chapter 2.3: Alternative design	Paragraph 2.3.3	***LR 2.3-01*** *LR can consider alternative design proposals for approval by the Administration.*	complement
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.1: Goal		*The goal of this Code is to provide for safe and environmentally-friendly design, construction and operation of ships and in particular their installations of systems for propulsion machinery, auxiliary power generation machinery and/or other purpose machinery using gas or low-flashpoint fuel as fuel.*	Identical
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.1	*The safety, reliability and dependability of the systems shall be equivalent to that achieved with new and comparable conventional oil-fuelled main and auxiliary machinery.*	Identical
Part A Chapter 3:	Sub-chapter 3.2:	Paragraph 3.2.2	*The probability and consequences of fuel-related hazards shall be limited to a minimum through arrangement and system design, such as ventilation,*	Identical

LR document content: "Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint"				Identical or complement to the IGF Code
Conditions	Item	Documentation	Additional Description	
Goal and functional requirements	Functional requirements		*detection and safety actions. In the event of gas leakage or failure of the risk reducing measures, necessary safety actions shall be initiated.*	
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.3	*The design philosophy shall ensure that risk reducing measures and safety actions for the gas fuel installation do not lead to an unacceptable loss of power.*	Identical
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.3	***LR 3.2-01*** *The requirement given in 3.2.3 is applicable to gas fuels and to all low flashpoint fuels.*	Complement
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.4	*Hazardous areas shall be restricted, as far as practicable, to minimize the potential risks that might affect the safety of the ship, persons on board, and equipment.*	Identical
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.5	*Equipment installed in hazardous areas shall be minimized to that required for operational purposes and shall be suitably and appropriately certified.*	Identical
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.6	*Unintended accumulation of explosive, flammable or toxic gas concentrations shall be prevented.*	Identical
Part A Chapter 3:	Sub-chapter 3.2:	Paragraph 3.2.7	*System components shall be protected against external damages.*	Identical

LR document content: "Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint"				Identical or complement to the IGF Code
Conditions	Item	Documentation	Additional Description	
Goal and functional requirements	Functional requirements			
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.8	*Sources of ignition in hazardous areas shall be minimized to reduce the probability of explosions.*	Identical
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.9	*It shall be arranged for safe and suitable fuel supply, storage and bunkering arrangements capable of receiving and containing the fuel in the required state without leakage. Other than when necessary for safety reasons, the system shall be designed to prevent venting under all normal operating conditions including idle periods.*	Identical
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.10	*Piping systems, containment and over-pressure relief arrangements that are of suitable design, construction and installation for their intended application shall be provided.*	Identical
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.11	*Machinery, systems and components shall be designed, constructed, installed, operated, maintained and protected to ensure safe and reliable operation.*	Identical
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.12	*Fuel containment system and machinery spaces containing source that might release gas into the space shall be arranged and located such that a fire or explosion in either will not lead to an unacceptable loss of power or render equipment in other compartments inoperable.*	Identical
Part A Chapter 3:	Sub-chapter 3.2:	Paragraph 3.2.13	*Suitable control, alarm, monitoring and shutdown systems shall be provided to ensure safe and reliable operation.*	Identical

LR document content: "Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint"				Identical or complement to the IGF Code
Conditions	Item	Documentation	Additional Description	
Goal and functional requirements	Functional requirements			
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.14	*Fixed gas detection suitable for all spaces and areas concerned shall be arranged.*	Identical
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.15	*Fire detection, protection and extinction measures appropriate to the hazards concerned shall be provided.*	Identical
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.16	*Commissioning, trials and maintenance of fuel systems and gas utilization machinery shall satisfy the goal in terms of safety, availability and reliability.*	Identical
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.17	*The technical documentation shall permit an assessment of the compliance of the system and its components with the applicable rules, guidelines, design standards used and the principles related to safety, availability, maintainability and reliability.*	Identical
Part A Chapter 3: Goal and functional requirements	Sub-chapter 3.2: Functional requirements	Paragraph 3.2.18	*A single failure in a technical system or component shall not lead to an unsafe or unreliable situation.*	Identical

LR document content: "Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint"				Identical or complement to the IGF Code
Conditions	Item	Documentation	Additional Description	
Part A Chapter 4: General requirements	Sub-chapter 4.1: Goal		*The goal of this chapter is to ensure that the necessary assessments of the risks involved are carried out in order to eliminate or mitigate any adverse effect to the persons on board, the environment or the ship.*	Identical
Part A Chapter 4: General requirements	Sub-chapter 4.1: Goal		***LR 4.1-01*** *Where the risks cannot be eliminated, an inherently safer design is to be sought in preference to operational or procedural controls and this is to be consistent with 2.3.3. This is to focus on engineered prevention of failure, that is, a minimised number of connections, increased reliability and redundancy. Where this cannot be achieved or is insufficient, protection of occupants is to focus on:* *(a) firstly, passive means, such as physical barriers, separation and absence of ignition sources; and* *(b) secondly, active means, such as detection, isolation, ventilation and extinguishment.* *Both passive and active means may be required to demonstrate an appropriate level of safety.*	Complement
Part A Chapter 4: General requirements	Sub-chapter 4.2: Risk assessment	Paragraph 4.2.1	*A risk assessment shall be conducted to ensure that risks arising from the use of low-flashpoint fuels affecting persons on board, the environment, the structural strength or the integrity of the ship are addressed. Consideration shall be given to the hazards associated with physical layout, operation and maintenance, following any reasonably foreseeable failure.*	Identical
Part A Chapter 4: General requirements	Sub-chapter 4.2: Risk assessment	Paragraph 4.2.1	***LR 4.2-01*** *The risk assessment is to be undertaken and documented in accordance with LR's ShipRight Procedure for Risk Based Designs (RBD) and associated annexes. Consideration of hazards is to include fuel and inert gas tanks, machinery and equipment, and the specific location of accommodation and cargo.*	Complement
Part A Chapter 4:	Sub-chapter 4.2:	Paragraph 4.2.3	*The risks shall be analysed using acceptable and recognized risk analysis techniques, and loss of function, component damage, fire, explosion and electric shock shall as a minimum be considered. The analysis shall ensure that*	Identical

LR document content: "Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint"				Identical or complement to the IGF Code
Conditions	Item	Documentation	Additional Description	
General requirements	Risk assessment		*risks are eliminated wherever possible. Risks which cannot be eliminated shall be mitigated as necessary. Details of risks, and the means by which they are mitigated, shall be documented to the satisfaction of the Administration.*	
Part A Chapter 4: General requirements	Sub-chapter 4.3: Limitation of explosion consequences		*An explosion in any space containing any potential sources of release (Double wall fuel pipes are not considered as potential sources of release) and potential ignition sources shall not:* *9. cause damage to or disrupt the proper functioning of equipment/systems located in any space other than that in which the incident occurs* *10. damage the ship in such a way that flooding of water below the main deck or any progressive flooding occur* *11. damage work areas or accommodation in such a way that persons who stay in such areas under normal operating conditions are injured* *12. disrupt the proper functioning of control stations and switchboard rooms necessary for power distribution* *13. damage life-saving equipment or associated launching arrangements* *14. disrupt the proper functioning of firefighting equipment located outside the explosion-damaged space* *15. affect other areas of the ship in such a way that chain reactions involving, inter alia, cargo, gas and bunker oil may arise; or* *16. prevent persons access to life-saving appliances or impede escape routes.*	Identical

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SPECIFICATION – TYPE APPROVAL TEST SPECIFICATIONS (LR)

A. IDENTITY CARD OF SPECIFICATION – TYPE APPROVAL TEST SPECIFICATIONS (LR)

RCS	Number of RCS	Title	Date	Stability date	Statutory
Specification	/	Specifications – Type Approval Test Specifications (Lloyd's Register)			Yes

Scope:

Test Specification 1

Performance and Environmental Test Specification for the following Environmentally Tested Products used in Marine Applications:

- Electrical Equipment
- Control and Monitoring Equipment
- Instrumentation and Internal Communication Equipment
- Programmable Electronic Systems

Test Specification 2

Performance and Test Specifications for the following Piping System Components primarily to be used in Marine Applications:

- Expansion pieces - Bellows and sliding types
- Filter units
- Flexible hose assemblies
- Mechanical pipe joints - Fixed connections
- Metallic formed pipe pieces
- Plastics pipes and formed pipe pieces
- Valves
- Air pipes closing devices

Test Specification 3

Performance Test Specification for Equipment to be used in Marine Applications:

- Electric Cables
- Circuit-breakers

- Fuses and Fuse Holders
- Fixed Submerged Electrical Equipment

Test Specification 4
Type testing for reciprocating internal combustion engines and associated ancillary equipment for Marine, Offshore and Industrial applications

Test Specification 5
Type testing for lithium battery systems

Test Specification 6
Canadian Coastguard Plastic Buoy Impact Testing Specification

Test Specification GT04
Type testing for gas turbines for Marine, Offshore and Industrial applications

Test Specification No. 917
Product type approval portlights for Special Service Craft

Test Specification No. 918
Product type approval Deck Hatches for Special Service Craft

Domain/category: Marine applications

Specifed exclusion: /

Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr>
<td>Test specification 1 Performance and Environmental Test Specification for the following Environmentally Tested Products used in Marine Applications:</td>
<td></td>
<td>1.1 General</td>
<td><i>1.1.8 Approval can be given for one or more of the following environmental categories given in Table 1.1.1 Environmental Categories (ENV).</i>

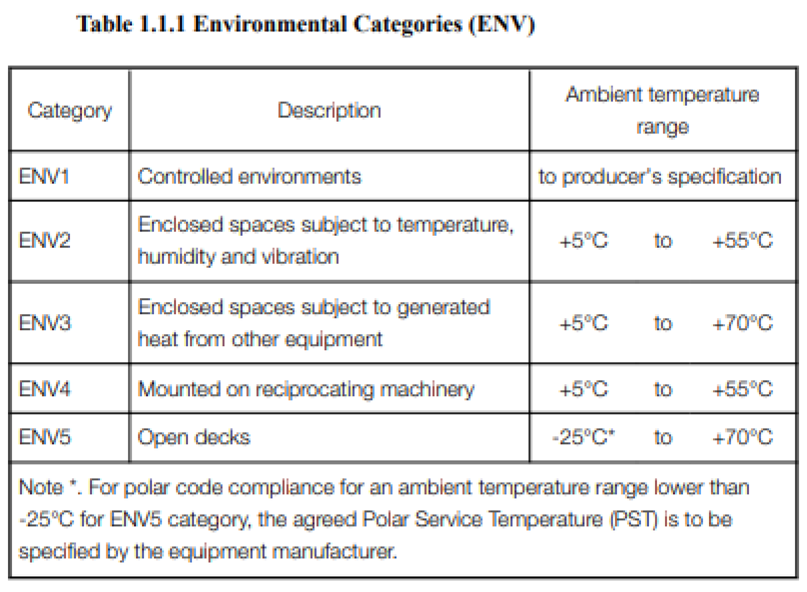



Table 1.1.1 Environmental Categories (ENV)
<table>
<tr><th>Category</th><th>Description</th><th>Ambient temperature range</th></tr>
<tr><td>ENV1</td><td>Controlled environments</td><td>to producer's specification</td></tr>
<tr><td>ENV2</td><td>Enclosed spaces subject to temperature, humidity and vibration</td><td>+5°C to +55°C</td></tr>
<tr><td>ENV3</td><td>Enclosed spaces subject to generated heat from other equipment</td><td>+5°C to +70°C</td></tr>
<tr><td>ENV4</td><td>Mounted on reciprocating machinery</td><td>+5°C to +55°C</td></tr>
<tr><td>ENV5</td><td>Open decks</td><td>-25°C* to +70°C</td></tr>
<tr><td colspan="3">Note *. For polar code compliance for an ambient temperature range lower than -25°C for ENV5 category, the agreed Polar Service Temperature (PST) is to be specified by the equipment manufacturer.</td></tr>
</table>
<i>1.1.9 Basic tests applicable for each environmental category are given in Table 1.1.2 Basic ENV tests.</i>
<i>1.1.10 The severities detailed in this test specification are to be maintained for the environmental categories specified in Table 1.1.2 Basic ENV tests. Where an IEC standard/publication is specified at the end of an individual test requirement, further detailed information on that test procedure may be obtained from that publication. The latest additions and amendments of the standards apply.</i></td>
<td></td>
</tr>
</table>

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td>

1.1.11 Additional tests required for specific products are given in Ch 1, 32 Additional tests

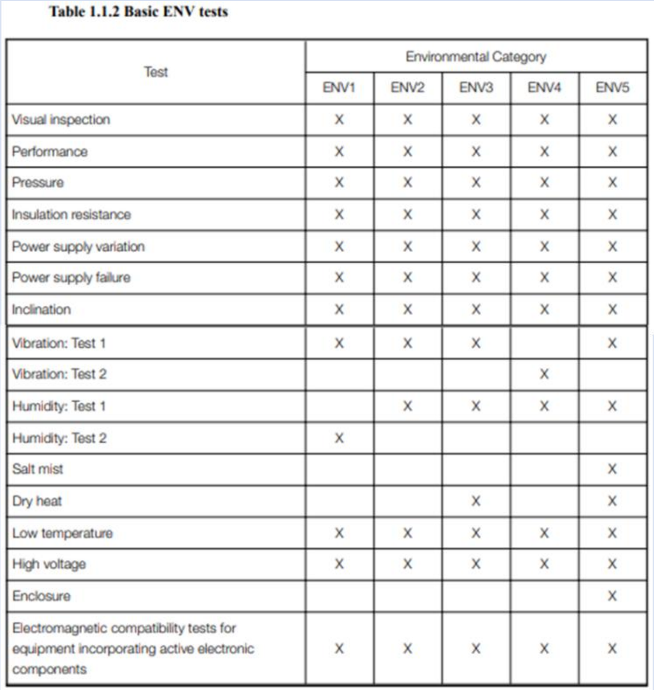
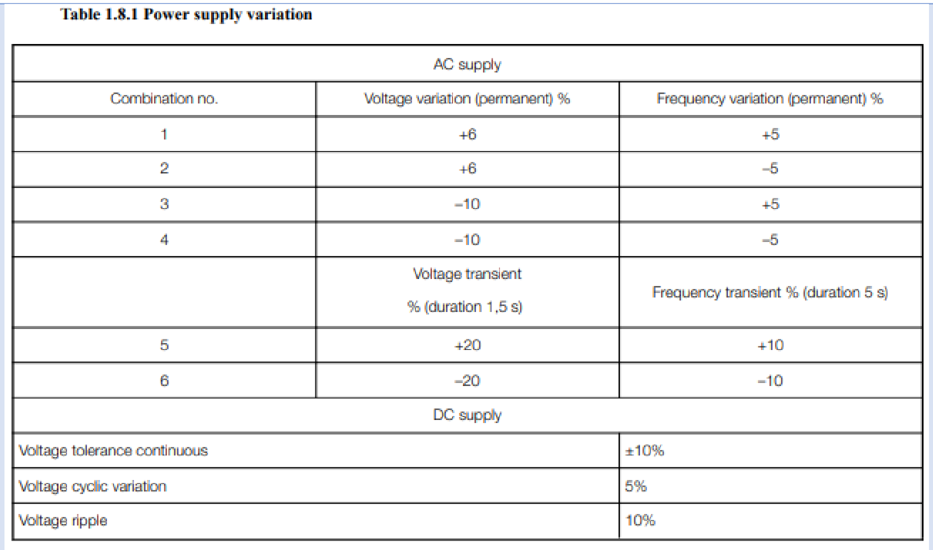


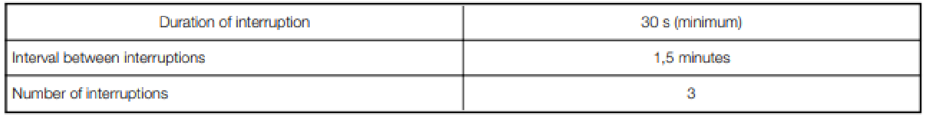
Table 1.1.2 Basic ENV tests

<table>
<tr><th rowspan="2">Test</th><th colspan="5">Environmental Category</th></tr>
<tr><th>ENV1</th><th>ENV2</th><th>ENV3</th><th>ENV4</th><th>ENV5</th></tr>
<tr><td>Visual inspection</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Performance</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Pressure</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Insulation resistance</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Power supply variation</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Power supply failure</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Inclination</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Vibration: Test 1</td><td>X</td><td>X</td><td>X</td><td></td><td>X</td></tr>
<tr><td>Vibration: Test 2</td><td></td><td></td><td></td><td>X</td><td></td></tr>
<tr><td>Humidity: Test 1</td><td></td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Humidity: Test 2</td><td>X</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Salt mist</td><td></td><td></td><td></td><td></td><td>X</td></tr>
<tr><td>Dry heat</td><td></td><td></td><td>X</td><td></td><td>X</td></tr>
<tr><td>Low temperature</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>High voltage</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>Enclosure</td><td></td><td></td><td></td><td></td><td>X</td></tr>
<tr><td>Electromagnetic compatibility tests for equipment incorporating active electronic components</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td></tr>
</table>

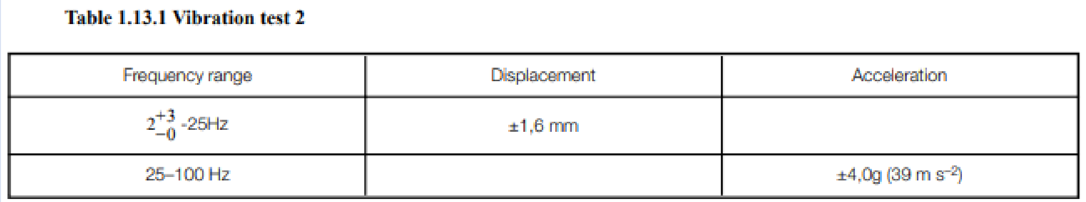
</td><td></td></tr>
<tr><td></td><td>Section 3 General</td><td>3.1 General</td><td>3.1.1 Test area ambient conditions are to be maintained within the standard range of atmospheric conditions as follows:
(a) Temperature: 25°C ± 10°C.
(b) Relative humidity: 60 per cent (allowable deviation during test ±30 per cent).
(c) Air pressure: 90 kPa ± 10 kPa.
3.1.2 All measuring instruments shall be calibrated with respect to traceable secondary standards.
3.1.3 Temperature changes required in the various tests are to be undertaken at approximately 1°C per minute unless specified otherwise.</td><td></td></tr>
</table>

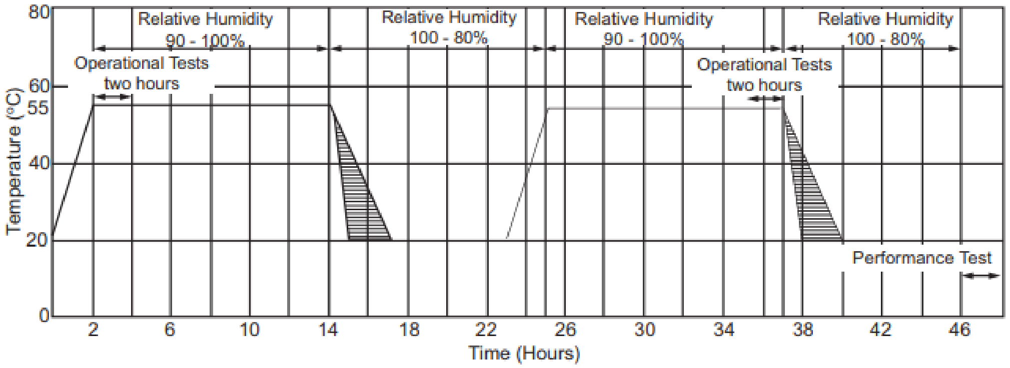
Conditions	Item	Documentation	Additional Description	Information
			3.1.4 During the tests, the EUT (excepting quiescent units) shall be maintained in its normal operative condition with power applied. 3.1.5 Satisfactory operation of the product shall be demonstrated both during and after each test. In all cases, accuracy shall be maintained within specified limits and there shall be no visible deterioration of the product (see also Appendix 1 – General acceptance criteria applicable to LR Test Specification No. 1). 3.1.6 Where accuracy is the essence of performance (e.g. transducers, measurement systems) compliance with the manufacturer's published specification and any specified standards should be demonstrated during the performance test and under the relevant environmental tests. 3.1.7 Testing should follow the sequence as set out in the Sections following unless otherwise agreed.	
	Section 4 Visual inspection		4.1.1 Products shall be examined for workmanship and for conformity with drawings and design data, and LR Rules	
	Section 5 Performance test		5.1.1 Performance tests shall be carried out in accordance with specified standards and the producer's specification. The performance test specification shall be submitted to LR for agreement prior to testing. The performance test is to demonstrate compliance with the relevant LR Rules applicable to the product. 5.1.2 The performance test programme and software are to be suitable for executing all normal functions of the EUT. While the use of special test programs is encouraged they are acceptable only if it can be shown that the EUT is fully operational, see also Ch 1, 3.1 General 3.1.6. 5.1.3 The performance test for products that utilise programmable electronic systems is to demonstrate that the specified functions are provided in a safe, stable and repeatable manner under all operating conditions, including emergency conditions. Response times are to be adequate for all functions, taking into account both normal and abnormal operating conditions. For all aspects of system performance, compliance with the relevant LR Rule requirements is to be demonstrated.	
	Section 6 Pressure test		6.1.1 Sensors, instruments and control devices that are in contact with process fluid shall have their pressure parts tested to twice the maximum working pressure. 6.1.2 For hydraulically or pneumatically operated systems, the following shall apply:	

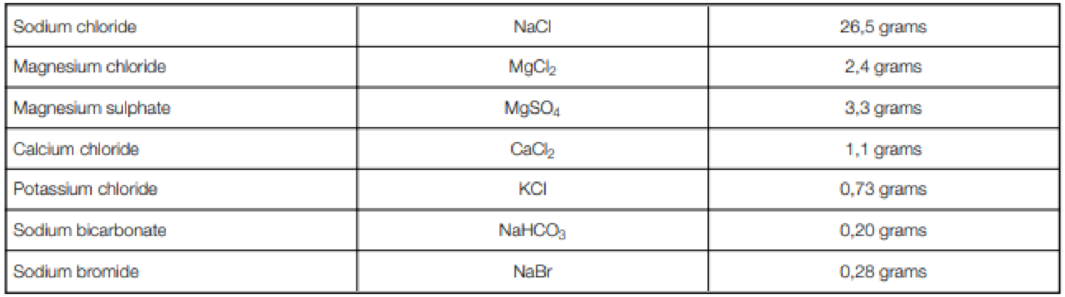
<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td>(a) Design temperature ≤ 300°C internal test pressure 1,5 times product design pressure.
(b) Design temperature > 300°C internal test pressure 2,0 times product design pressure.</td><td></td></tr>
<tr><td></td><td>Section 7 Insulation resistance test</td><td></td><td>7.1.1 Insulation resistance tests shall be carried out on electrical products before and after the high voltage test, humidity test, low temperature test and salt mist test. The test voltage and insulation resistance shall be as given in Table 1.7.1 Insulation resistance test
Table 1.7.1 Insulation resistance test
<table>
<tr><th rowspan="2">Rated supply voltage</th><th rowspan="2">Test voltage (d.c.)</th><th colspan="2">Minimum insulation resistance</th></tr>
<tr><th>Before test</th><th>After test</th></tr>
<tr><td>Up to 65 V</td><td>2 × supply voltage minimum 24 V</td><td>10 MΩ</td><td>1 MΩ</td></tr>
<tr><td>Over 65 V</td><td>500 V</td><td>100 MΩ</td><td>10 MΩ</td></tr>
</table>
7.1.2 The insulation resistance test shall be applied between all circuits and earth and between the supply terminals where appropriate. Certain components, such as filters, surge arrestors, variable resistors, etc., may be required to be disconnected for this test.
7.1.3 Reference standard IEC 60092-504 Section 5.</td><td></td></tr>
<tr><td></td><td>Section 8 Power supply variation test</td><td>8.1 Electrical mains supply</td><td>
Table 1.8.1 Power supply variation
<table>
<tr><th colspan="3">AC supply</th></tr>
<tr><td>Combination no.</td><td>Voltage variation (permanent) %</td><td>Frequency variation (permanent) %</td></tr>
<tr><td>1</td><td>+6</td><td>+5</td></tr>
<tr><td>2</td><td>+6</td><td>−5</td></tr>
<tr><td>3</td><td>−10</td><td>+5</td></tr>
<tr><td>4</td><td>−10</td><td>−5</td></tr>
<tr><td></td><td>Voltage transient
% (duration 1,5 s)</td><td>Frequency transient % (duration 5 s)</td></tr>
<tr><td>5</td><td>+20</td><td>+10</td></tr>
<tr><td>6</td><td>−20</td><td>−10</td></tr>
<tr><td colspan="3">DC supply</td></tr>
<tr><td colspan="2">Voltage tolerance continuous</td><td>±10%</td></tr>
<tr><td colspan="2">Voltage cyclic variation</td><td>5%</td></tr>
<tr><td colspan="2">Voltage ripple</td><td>10%</td></tr>
</table></td><td></td></tr>
</table>

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td>Each combination of voltage and frequency variation is given in Table 1.8.1 Power supply variation.</td><td></td></tr>
<tr><td></td><td></td><td>8.2 Electrical battery supply</td><td>8.2.1 With voltage variation of +30 per cent to –25 per cent of the nominal voltage for equipment connected to charging battery or as determined by the charging/discharging characteristics, including ripple voltage from the charging device.
8.2.2 With voltage variation of +20 per cent to –25 per cent for equipment not connected to the battery during charging.
8.2.3 Reference standards IEC 60092-504 and Pt 6, Ch 2, 1.7 Design and construction 1.7.4 of the Rules and Regulations for the Classification of Ships (hereinafter referred to as the Rules for Ships).</td><td></td></tr>
<tr><td></td><td></td><td>8.3 Hydraulic or pneumatic supplies</td><td>8.3.1 With a supply pressure deviation of ±20 per cent. Each supply pressure deviation is to be applied for 15 minutes to ensure that equilibrium is attained before carrying out the operational test.</td><td></td></tr>
<tr><td></td><td>Section 9 Power supply failure test</td><td></td><td>9.1.1 Products are to be subjected to a power supply failure test as indicated in Table 1.9.1 Power supply failure.
Table 1.9.1 Power supply failure
<table><tr><th>Duration of interruption</th><th>30 s (minimum)</th></tr><tr><td>Interval between interruptions</td><td>1,5 minutes</td></tr><tr><td>Number of interruptions</td><td>3</td></tr></table>9.1.2 The specified response of the equipment is to be confirmed on loss of power and subsequent re-start.
9.1.3 The time of 1,5 minutes may be exceeded if the equipment under test needs a longer time for start-up such as to execute a booting sequence. Where a booting sequence is required, an additional power supply interruption is to be conducted during the booting sequence.
9.1.4 There is to be no corruption of programme or data held in programmable electronic systems.
9.1.5 Reference standard IEC 60092-504 Section 4b and IEC 6100-4-11.</td><td></td></tr>
</table>

Conditions	Item	Documentation	Additional Description	Information
	Section 10 Inclinaison test Static		10.1.1 Tests are only normally required for equipment containing moving parts. 10.1.2 The product shall be: (a) Inclined to the vertical at an angle of at least 22,5°. (b) Inclined to at least 22,5° on the other side of the vertical and in the same plane as in (a). (c) Inclined to the vertical at an angle of at least 22,5° in a plane at right angles to that used in (a). (d) Inclined to be at least 22,5° on the other side of the vertical and in the same plane as in (c). 10.1.3 The period of testing in each position should be sufficient to evaluate fully the behaviour of the equipment. 10.1.4 Reference standard IEC 60092-504 Section 11a.	
	Section 10 Inclinaison test Dynamic		11.1.1 Tests are normally only required for equipment containing moving parts. 11.1.2 Using the directions defined in Ch 1, 10.1 General 10.1.2, the equipment is to be rolled to an angle of 22,5° each side of the vertical with a period of 10 seconds. 11.1.3 The test in each direction is carried out for a minimum of 15 minutes. 11.1.4 On ships for the carriage of liquefied gases and chemicals, the emergency power supply is to remain operational with the ship flooded up to a maximum final athwart ship inclination of 30°.	
	Section 13 Vibration test 2		13.1.1 The product shall be mounted on the vibration table through its normal points of attachment, and in its normal orientation with respect to the vertical. Where the product may be supplied with anti-vibration mountings, these are to be specified and fitted during the tests. 13.1.2 Testing shall be carried out in three mutually perpendicular directions where one of which shall be vertical in respect to the normal orientation of the product. 13.1.3 Testing shall be carried out with varying frequency, displacement and acceleration in accordance with Table 1.13.1 Vibration test 2 at a rate sufficiently low to permit the detection of resonance. In principle, products undergoing this test should not resonate in the specified frequency band.	

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td>
Table 1.13.1 Vibration test 2
<table>
<tr><th>Frequency range</th><th>Displacement</th><th>Acceleration</th></tr>
<tr><td>2^{+3}_{-0} -25Hz</td><td>±1,6 mm</td><td></td></tr>
<tr><td>25–100 Hz</td><td></td><td>±4,0g (39 m s^{-2})</td></tr>
</table>
13.1.4 Should, however, resonance occur, the following is noted:
(a) Amplification factors ‘Q’ are measured and recorded where Q ≥ 2.
(b) The position of the accelerometers shall be indicated diagrammatically within the test report.
(c) Any resonance with amplification greater than 5 is not acceptable.
13.1.5 At each resonant frequency, where an amplification factor 2 or above is recorded, an endurance vibration test shall be carried out for a minimum of 90 minutes in accordance with Table 1.13.1 Vibration test 2 in the direction where resonance occurs. The test equipment shall be controlled to follow any shift of the resonance frequency during the test. An operational test of the equipment under test is to be conducted during each vibration endurance test.
13.1.6 The product shall be endurance tested for a minimum of 90 minutes in each mutually perpendicular direction at the frequency 30 Hz with an acceleration of ±4,0g. This test need not be performed in the directions tested under Ch 1, 13.1 General 13.1.5. An operational test of the equipment under test is to be conducted during each vibration endurance test.
13.1.7 Reference standard IEC 60068-2-6 Test Fc. For equipment intended for use under extreme vibration conditions, see Ch 1, 32.2 Extreme vibration.</td><td></td></tr>
<tr><td></td><td>Section 14 Humidity test 1 cyclic</td><td></td><td>14.1.1 Refer to insulation resistance test, Ch 1, 7 Insulation resistance test.
14.1.2 Where a product is normally supplied with heaters or devices to prevent condensation, they may be used during the test.
14.1.3 The test parameters are to be as follows, configured in accordance with the limits and tolerances as defined in the reference specification:
(a) Temperature: 55°C.
(b) Humidity: 95 per cent.</td><td></td></tr>
</table>

Conditions	Item	Documentation	Additional Description	Information
			(c) Duration: 2 cycles of (12 +12) hours' duration. 14.1.4 Two operational tests shall be carried out during the periods indicated in Figure 1.14.1 Example of a humidity test (2 cycles). 14.1.5 A performance test shall be carried out during the period indicated in Figure 1.14.1 Example of a humidity test (2 cycles). Surface moisture may be removed by hand prior to this test.  **Figure 1.14.1 Example of a humidity test (2 cycles)** 14.1.6 On completion of the performance test there shall be no visible deterioration of the product. 14.1.7 Reference standard IEC 60068-2-30, Test Db.	
	Section 15 Humidity test 2 steady state		15.1.1 Refer to insulation resistance test, Ch 1, 7 Insulation resistance test. 15.1.2 Where a product is normally supplied with heaters or devices to prevent condensation, these may be used during the test. 15.1.3 The test chamber parameters are configured as follows: (a) Temperature raised from an initial 20°C to the specified maximum operating temperature for the product ±2°C within a period of two hours.	

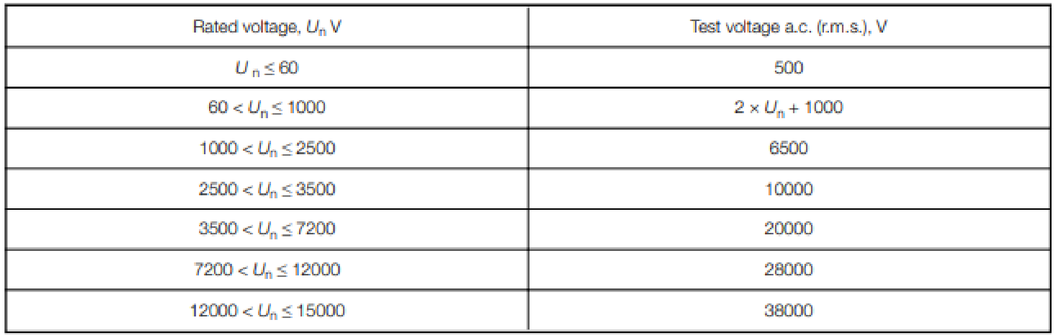
<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td>(b) This temperature shall be maintained at the maximum relative humidity as specified for the product ±5 per cent.
(c) The product shall be kept under these conditions for a period of not less than 96 hours, following which temperature shall be reduced to 20°C within a period of between one and two hours.
(d) The product shall then be exposed to laboratory conditions.
15.1.4 Operational tests shall be carried out during the first hour, at 50 hours ±2 hours, and the last 2 hours at the specified test conditions.
15.1.5 A performance test shall be carried out 4 to 6 hours after exposure to laboratory conditions.
15.1.6 On completion of the performance test there is to be no visible deterioration of the product.
15.1.7 Reference standard IEC 60068-2-78, Test Cab.</td><td></td></tr>
<tr><td></td><td>Section 16 Salt mist test</td><td></td><td>16.1.1 Refer to insulation resistance test, Ch 1, 7 Insulation resistance test.
16.1.2 The salt solution shall be prepared by dissolving the compounds listed below in distilled water and making up the volume of the solution to one litre. The quantities of the salts in the solution are to be within 10 per cent of those shown in Table 1.16.1 Salt mist solution. A solution prepared to the IEC standard would be acceptable as an alternative
Table 1.16.1 Salt mist solution
<table><tr><td>Sodium chloride</td><td>NaCl</td><td>26,5 grams</td></tr><tr><td>Magnesium chloride</td><td>$MgCl_2$</td><td>2,4 grams</td></tr><tr><td>Magnesium sulphate</td><td>$MgSO_4$</td><td>3,3 grams</td></tr><tr><td>Calcium chloride</td><td>$CaCl_2$</td><td>1,1 grams</td></tr><tr><td>Potassium chloride</td><td>KCl</td><td>0,73 grams</td></tr><tr><td>Sodium bicarbonate</td><td>$NaHCO_3$</td><td>0,20 grams</td></tr><tr><td>Sodium bromide</td><td>NaBr</td><td>0,28 grams</td></tr></table>16.1.3 The test chamber parameters are configured as follows:
(a) The salt mist conditions are to be maintained in all parts of the exposure zone in which a clean collecting receptacle with a horizontal collecting area of 80 cm2,</td><td></td></tr>
</table>

Conditions	Item	Documentation	Additional Description	Information
			placed at any point in the exposure zone, shall collect between 1,0 ml and 2,0 ml of solution per hour, averaged over the collecting period. A minimum of two receptacles are to be used, that are to be placed such that they are not shielded by the specimen and so that no condensate from any source shall be collected. When calibrating the spray rate of the chamber, a minimum spray period of 8 hours should be used, for accurate measurement purposes. To avoid contamination, salt solution dripping from the walls and ceiling of the test chamber and from the product shall not be recycled for re-spraying. (b) The spraying shall continue for 2 hours, after which the product is to be maintained as follows: (i) Temperature: 40°C ±2°C. (ii) Relative humidity: 90 per cent to 95 per cent. (iii) Duration: 7 days. (c) This procedure shall be repeated four times in succession, following which the test chamber temperature and humidity shall be reduced to ambient conditions. 16.1.4 On completion of exposure, an insulation resistance test shall be carried out four to six hours after recovery, and the product examined to ensure that any deterioration or corrosion is superficial in nature. 16.1.5 Reference standard IEC 60068-2-52 Test Kb severity 1.	
	Section 17 Dry heat test	17.1 General	17.1.1 The test chamber parameters are configured as follows: (a) Temperature: Raised from the initial ambient temperature to 70°C and maintained within ±2°C (see Ch 1, 3.1 General 3.1.3). (b) Relative humidity: Monitored during heating process not to exceed 50 per cent at 35°C (equivalent to 9 per cent at 70°C). (c) Duration (at 70°C): 16 hours. (d) Temperature is then reduced to ambient temperature. 17.1.2 Satisfactory operation of the product shall be demonstrated during the last hour at test temperature. 17.1.3 Reference standard IEC 60068-2-2 Tests Bb for non-heat-dissipating products and Be for heat-dissipating products	
		17.2 Heat-dissipating	17.2.1 The test chamber should be adequately sized to allow the product to stabilise with the cooling system in operation if provided.	

Conditions	Item	Documentation	Additional Description	Information
		products normally cooled by convection	17.2.2 The test temperature is measured at such a distance from the product that the effect of dissipation is negligible. Note For any specified operating temperature over 55°C other than for ENV3 and ENV5 categories, the dry heat test is to be conducted at the agreed test temperature.	
	Section 18 Low temperature test		18.1.1 Refer to insulation resistance test, Ch 1, 7 Insulation resistance test. 18.1.2 The test chamber parameters are configured as follows: (a) Temperature: Lowered from the initial ambient temperature to +5ºC for environmental categories ENV 1 to 4 inclusive and for environmental category ENV 5 to –25°C and maintained within ±2°C (see Ch 1, 3.1 General 3.1.3). (b) Duration (at +5°C or –25°C): 16 hours. (c) Temperature shall then be raised to ambient temperature. 18.1.3 Satisfactory operation of the product shall be demonstrated during the last hour at test temperature. 18.1.4 Reference standard IEC 60068-2-1 Tests Ab for non heat-dissipating products and Ad for heat-dissipating products. Note: For any specified temperature under 5°C other than for ENV5 category, the low temperature test is to be conducted at the agreed test temperature. For polar code compliance for any specified temperature under -25°C for ENV5 category, the low temperature test is to be conducted at the agreed Polar Service Temperature (PST).	
	Section 19 high voltage test		19.1.1 Refer to insulation resistance test, Ch 1, 7 Insulation resistance test. 19.1.2 A high voltage (dielectric) test shall be carried out at power frequencies (50 or 60 Hz) as appropriate and at a test voltage as given in Table 1.19.1 Test voltage. 19.1.3 Separate circuits shall be tested against each other, and all circuits shall be tested against earth. Contact pieces shall be tested across their open points of contact. 19.1.4 Printed circuits with electronic components which could be subject to damage may be removed prior to the test. The test voltage should be applied between the power supply terminals strapped together and earth (enclosure). 19.1.5 Period of application of test voltage to be 1 minute. 19.1.6 Reference Pt 6, Ch 2, 21.1 Testing of the Rules for Ships.	

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td>

Table 1.19.1 Test voltage



<table>
<tr><th>Rated voltage, U_n V</th><th>Test voltage a.c. (r.m.s.), V</th></tr>
<tr><td>$U_n \leq 60$</td><td>500</td></tr>
<tr><td>$60 < U_n \leq 1000$</td><td>$2 \times U_n + 1000$</td></tr>
<tr><td>$1000 < U_n \leq 2500$</td><td>6500</td></tr>
<tr><td>$2500 < U_n \leq 3500$</td><td>10000</td></tr>
<tr><td>$3500 < U_n \leq 7200$</td><td>20000</td></tr>
<tr><td>$7200 < U_n \leq 12000$</td><td>28000</td></tr>
<tr><td>$12000 < U_n \leq 15000$</td><td>38000</td></tr>
</table>

</td><td></td></tr>
<tr><td></td><td>Section 20
Enclosure test</td><td></td><td>20.1.1 Tests are to be carried out in accordance with IEC 60529 – Degrees of protection provided by enclosures (IP code) or an acceptable National Standard.
20.1.2 For category ENV5, a minimum enclosure notation of IP56 is required to protect against:
(a) Ingress of dust in sufficient quantity to interfere with satisfactory operation of the product.
(b) Water from heavy seas or water projected in powerful jets entering the enclosure in harmful quantities.
20.1.3 Where alternative enclosure notations are specified, see Ch 1, 32.1 Enclosure test</td><td></td></tr>
<tr><td></td><td>Section 21
Electromagnetic immunity tests for equipment incorporating active electronic components</td><td></td><td>21.1.1 Electronic products shall be subjected to the specified electromagnetic interference tests for:
(a) Immunity to conducted low frequency interference.
(b) Immunity to conducted high frequency interference.
(c) Immunity to radiated radio frequency fields.
(d) Immunity to fast, low energy transients-bursts (on power, control and signal lines).
(e) Immunity to slow high energy transients (surges).
(f) Immunity to electrostatic discharge (ESD).
21.1.2 The documentation of the test conditions, test equipment, configuration of the test set-up and test specimens as well as the presentation of the results should be sufficient to</td><td></td></tr>
</table>

Conditions	Item	Documentation	Additional Description	Information
			enable the tests to be repeated at a future date with similar results, should this be required.	
	Section 22 Immunity to conducted low frequency interference	22.2 D.C. powered equipment	22.2.1 A sinusoidal r.m.s voltage is to be superimposed on the power supply lines and configured as follows: (a) Amplitude/frequency range: 10 per cent of the nominal supply voltage over the range 50 Hz to 10 kHz. (b) Applied power: A maximum of 2,0 W to the supply lines, when the impedance is too low to maintain a signal level of 3V r.m.s. 22.2.2 The signal level shall be maintained as the frequency is adjusted through the specified frequency range at a rate sufficiently low to detect any malfunction of the product under test. 22.2.3 Reference standard IEC 60533.	
	Section 23 Immunity to conducted radio interference		23.1.1 The test shall be carried out as described in IEC 61000-4-6 with the test parameters given below and applied to: (a) A.C. power lines. (b) D.C. power lines. (c) Signal/control lines. (d) I/O ports. 23.1.2 The disturbing signal supplied by the specified generator shall be applied by direct injection using the coupling/ decoupling network (CDN) specifications given in the standard referenced in Ch 1, 23.1 General 23.1.1. The test shall be performed by connecting the generator to each CDN in turn while the other CDNs are terminated by 50 Ω load resistors. The test disturbance level shall be set for each CDN with the generator connected and the EUT replaced by a 150 Ω resistor. If the use of CDNs is not possible, alternative clamp injection as described in the standard may be applied. 23.1.3 Test parameters: (a) Frequency range: 150 kHz-80 MHz (b) Amplitude: 3V r.m.s (c) Modulation: 80 per cent ±5 per cent at 1000 Hz ±10 per cent, or 400 Hz ±10 per cent where an input signal at a modulation frequency of 1000 Hz is necessary.	

Conditions	Item	Documentation	Additional Description	Information
			(d) Frequency sweep: Not exceeding 1,5 x 10–3 decades per second, or 1 per cent per second. For bridge and deck mounted equipment only (in accordance with IEC 60945); (e) Amplitude: 10V r.m.s; at (f) Spot frequencies: 2, 3, 4, 6,2, 8,2, 12,6, 16,5, 18,8, 22 and 25 MHz (g) Modulation: 80 per cent ±10 per cent at 1000 Hz ±10 per cent, or 400 Hz ±10 per cent where an input signal at a modulation frequency of 1000 Hz is necessary.	
	Section 24 Immunity to radiated radio frequency fields		24.1.1 The test shall be carried out as described in IEC 61000-4-3, severity level 3, with the test parameters given below. 24.1.2 The EUT shall be tested in a: (a) Suitably shielded test facility. (b) Anechoic chamber. (c) TEM cell appropriate for the size of the EUT. 24.1.3 The uniform test area shall be calibrated prior to placing the EUT in position and the same power output shall be applied during the tests. 24.1.4 The EUT shall be housed in the enclosure shown in the manufacturer's published specification or be tested in open rack configuration. 24.1.5 All modules of the EUT shall be interconnected with the type of cables specified by the manufacturer or if not specified, with parallel unscreened conductors and be left exposed for a distance of 1 m from the EUT. 24.1.6 The configuration of the EUT shall be accurately recorded in the test report. 24.1.7 The test shall be carried out with the generating antenna facing each of the four sides of the EUT in turn. 24.1.8 The equipment shall be continuously operated, including data transfer between each module. 24.1.9 The frequency scan shall be slow enough to detect any malfunctioning. 24.1.10 Sensitive frequencies (e.g. clock frequencies, and harmonics) shall be analysed separately. 24.1.11 Test parameters: (a) Frequency range: 80 MHz – 2 GHz	

Conditions	Item	Documentation	Additional Description	Information
			(b) Modulation: 80 per cent ±10 per cent at 1000 Hz ±10 per cent, or 400 Hz ±10 per cent where an input signal at a modulation frequency of 1000 Hz is necessary. (c) Field strength: 10 V/m (d) Frequency sweep: Not exceeding 1,5 x 10–3 decades per second, or 1 per cent per second.	
	Section 25 Immunity to fast low energy transients (bursts)		24.1.1 The test shall be carried out as described in IEC 61000-4-3, severity level 3, with the test parameters given below. 24.1.2 The EUT shall be tested in a: (a) Suitably shielded test facility. (b) Anechoic chamber. (c) TEM cell appropriate for the size of the EUT. 24.1.3 The uniform test area shall be calibrated prior to placing the EUT in position and the same power output shall be applied during the tests. 24.1.4 The EUT shall be housed in the enclosure shown in the manufacturer's published specification or be tested in open rack configuration. 24.1.5 All modules of the EUT shall be interconnected with the type of cables specified by the manufacturer or if not specified, with parallel unscreened conductors and be left exposed for a distance of 1 m from the EUT. 24.1.6 The configuration of the EUT shall be accurately recorded in the test report. 24.1.7 The test shall be carried out with the generating antenna facing each of the four sides of the EUT in turn. 24.1.8 The equipment shall be continuously operated, including data transfer between each module. 24.1.9 The frequency scan shall be slow enough to detect any malfunctioning. 24.1.10 Sensitive frequencies (e.g. clock frequencies, and harmonics) shall be analysed separately. 24.1.11 Test parameters: (a) Frequency range: 80 MHz – 2 GHz (b) Modulation: 80 per cent ±10 per cent at 1000 Hz ±10 per cent, or 400 Hz ±10 per cent where an input signal at a modulation frequency of 1000 Hz is necessary. (c) Field strength: 10 V/m	

Conditions	Item	Documentation	Additional Description	Information
			(d) Frequency sweep: Not exceeding 1,5 x 10–3 decades per second, or 1 per cent per second.	
	Section 25 Immunity to fast low-energy transients (bursts)		25.1.1 The test shall be carried out as described in standard IEC 61000-4-4, severity level 3, using the specified interference generator, with test parameters as given in Ch 1, 25.1 General 25.1.4. 25.1.2 All input/output lines of the EUT shall be connected to appropriate devices. The type of cabling shall be as specified in the manufacturer's data sheets. 25.1.3 The test signal shall be applied to A.C. & D.C. power and control/signal lines using the following coupling methods: (a) Coupling/decoupling network for a.c./d.c. mains supply port. (b) Capacitive coupling clamp. 25.1.4 Test parameters: (a) Single pulse rise time: 5 ns (between 10 per cent and 90 per cent value). (b) Single pulse width: 50 ns (50 per cent value). (c) Wave shape of the pulse output into 50 Ω amplitude (peak): 2 kV line/earth, power lines 1 kV line/earth, control and signal lines. (d) Pulse repetition rate: 5 kHz at 1 kV and at 2 kV. (e) Application: 15 ms bursts in every 300 ms. (f) Duration/polarity: 5 minutes for positive and negative polarity pulses.	
	Section 26 Immunity to slow high-energy transients (surges)		26.1.1 The test shall be carried out as described in the standard IEC 61000-4-5, severity level 2, using the specified 1,2/5 µs – 8/20 µs combination wave pulse generator with test parameters given below. 26.1.2 All input/output lines of the EUT shall be connected to appropriate devices. The test signal shall be applied to A.C. and D.C. power lines using the coupling method specified in IEC 61000-4-5. 26.1.3 Test parameters: (a) Pulse rise time: 1,2 µs (between 30 per cent and 90 per cent value). (b) Pulse width: 50 µs (50 per cent value). (c) Amplitude (peak): 1 kV line/earth, 0,5 kV line/line.	

Conditions	Item	Documentation	Additional Description	Information
			(d) Repetition rate: ≥ 1 pulse/min. (e) No. of pulses: 5 positive and negative polarity pulses.	
	Section 27 Immunity to electrostatic discharge (ESD)		27.1.1 The test shall be carried out in accordance with IEC 61000-4-2, severity level 3, using the specified ESD generator and test parameters as given in Ch 1, 27.1 General 27.1.7. 27.1.2 The equipment shall be placed on, but insulated from, a metal ground plate extending at least 0,5 m beyond the perimeter of the EUT. Discharges from the ESD generator as described in IEC 61000-4-2 held perpendicular to the surface shall be applied only to points accessible to the operator in normal use. 27.1.3 Preliminary tests may be made: (a) At a rate of 20 discharges per second. (b) At each position tested 10 discharges should be applied, with both +ve and -ve polarity with at least 1 second intervals between discharges. 27.1.4 Contact discharges shall be applied to conducting surfaces, and air discharges only to areas declared insulating by the manufacturer, in order to simulate discharges on objects placed or installed near the EUT. 27.1.5 10 single contact discharges per polarity shall be applied to positions on the ground plane around and at a distance from the EUT. In addition, at least 10 single discharges (in the most sensitive polarity) shall be applied to the centre of one edge of a vertical coupling plane of dimension 0,5 x 0,5 m placed parallel to and at 0,1 m distance from the EUT. 27.1.6 Discharges shall be applied with this coupling plane in sufficient different positions so that all four faces of the EUT are sufficiently illuminated. 27.1.7 Test parameters: (a) Output voltage: Contact discharge 6 kV Air discharge 8 kV (b) Pulse interval: 1 second (c) No. of pulses: 10 for positive and negative polarity pulses.	
	Section 28 Electromagnetic emission tests for		28.1.1 Electronic products intended for use on the bridge, deck and general power distribution zones shall be subjected to the following specified electromagnetic tests for: (a) Radiated emissions.	

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td>equipment incorporating active electronic components</td><td></td><td>(b) Conducted emissions.
28.1.2 The documentation of the test conditions, test equipment, configuration of the test set-up and test specimens as well as the presentation of the results should be sufficient to enable the tests to be repeated at a future date with similar results, should this be required.</td><td></td></tr>
<tr><td></td><td>Section 29 Radiated emissions</td><td></td><td>29.1.1 The test shall generally be carried out as described in CISPR 16-1-4 utilising equipment specified in CISPR 16-1-1 with the test parameters as given in Table 1.29.1 Equipment on the bridge and deck zone and Table 1.29.2 Equipment in general power distribution zones.
29.1.2 To establish the maximum emission levels, the tests should be carried out with the EUT in varying orientations relative to the antenna and the latter’s elevation varied. The same applies to the positioning of cables.
29.1.3 Test parameters:

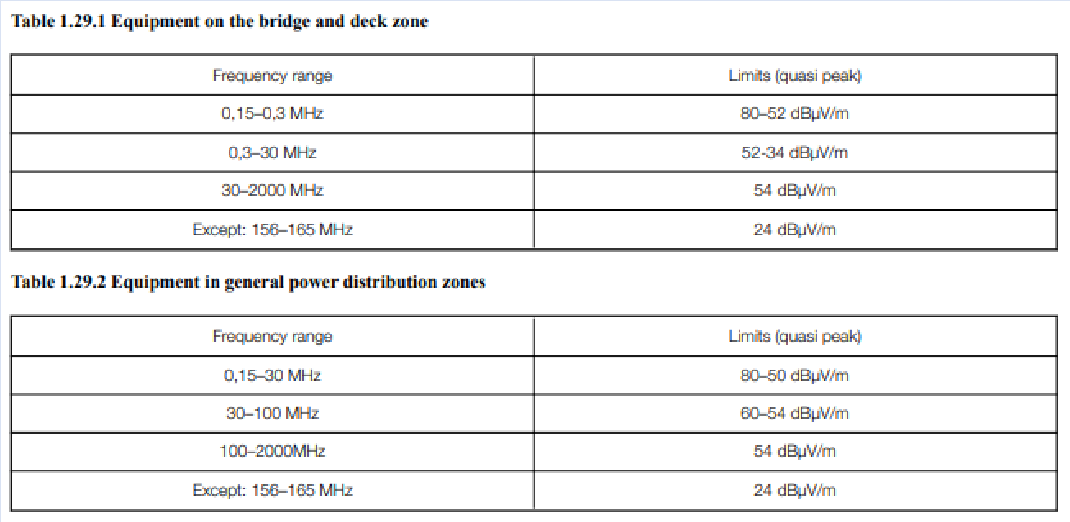
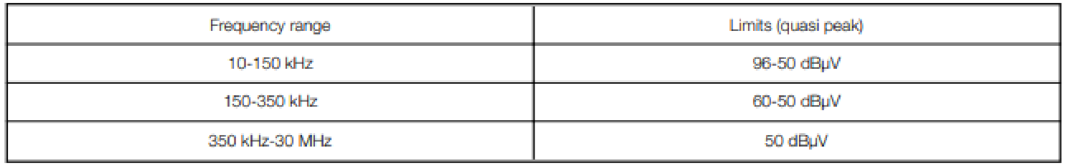
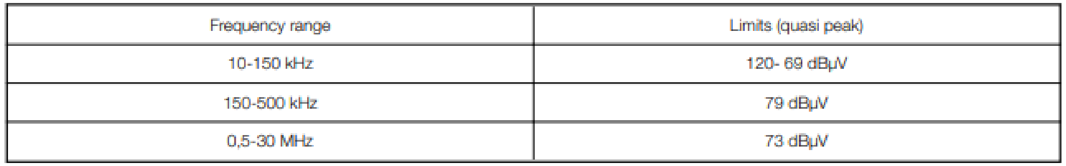



Table 1.29.1 Equipment on the bridge and deck zone
<table>
<tr><th>Frequency range</th><th>Limits (quasi peak)</th></tr>
<tr><td>0,15–0,3 MHz</td><td>80–52 dBμV/m</td></tr>
<tr><td>0,3–30 MHz</td><td>52-34 dBμV/m</td></tr>
<tr><td>30–2000 MHz</td><td>54 dBμV/m</td></tr>
<tr><td>Except: 156–165 MHz</td><td>24 dBμV/m</td></tr>
</table>
Table 1.29.2 Equipment in general power distribution zones
<table>
<tr><th>Frequency range</th><th>Limits (quasi peak)</th></tr>
<tr><td>0,15–30 MHz</td><td>80–50 dBμV/m</td></tr>
<tr><td>30–100 MHz</td><td>60–54 dBμV/m</td></tr>
<tr><td>100–2000MHz</td><td>54 dBμV/m</td></tr>
<tr><td>Except: 156–165 MHz</td><td>24 dBμV/m</td></tr>
</table></td><td></td></tr>
</table>

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td>Section 30 Conducted emissions</td><td></td><td>30.1.1 The test shall generally be carried out as described in CISPR 16-1-2 utilising equipment specified in CISPR 16-1-1 with the test parameters as given in Table 1.30.1 Equipment on the bridge and deck zone and Table 1.30.2 Equipment in general power distribution zones.
Table 1.30.1 Equipment on the bridge and deck zone

<table>
<tr><th>Frequency range</th><th>Limits (quasi peak)</th></tr>
<tr><td>10-150 kHz</td><td>96-50 dBμV</td></tr>
<tr><td>150-350 kHz</td><td>60-50 dBμV</td></tr>
<tr><td>350 kHz-30 MHz</td><td>50 dBμV</td></tr>
</table>
Table 1.30.2 Equipment in general power distribution zones

<table>
<tr><th>Frequency range</th><th>Limits (quasi peak)</th></tr>
<tr><td>10-150 kHz</td><td>120- 69 dBμV</td></tr>
<tr><td>150-500 kHz</td><td>79 dBμV</td></tr>
<tr><td>0,5-30 MHz</td><td>73 dBμV</td></tr>
</table>
</td><td></td></tr>
<tr><td></td><td>Section 32 Additional tests</td><td>32.1 Enclosure test</td><td>32.1.1 Where the manufacturer states a degree of protection from dust and water by means of an enclosure other than IP56 for category ENV5, the appropriate tests shall be carried out in accordance with IEC 60529 or an acceptable National Standard for the specified enclosure notation.</td><td></td></tr>
<tr><td></td><td></td><td>32.2 Extreme vibration</td><td>32.2.1 Where products are intended for use under extreme vibration conditions, in addition to the tests of Ch 1, 12 Vibration test 1 or Ch 1, 13 Vibration test 2 of this specification, the product may be subjected to a vibration test with conditions as follows:
(a) Frequency range: 40 Hz to 2000 Hz
(b) Acceleration: ±10g
(c) Endurance duration: 90 min
(d) Test specification: IEC 60068-2-6.</td><td></td></tr>
</table>

Conditions	Item	Documentation	Additional Description	Information
		32.3 Explosion protection tests	32.3.1 Where the product is specified as suitable for use in potentially hazardous areas, certification for such use by an accredited testing authority is required.	
		32.4 Further tests	32.4.1 Further tests may be required for specific products and these are to be agreed with LR. Such tests will be based on National or International Standards where available. Examples of such tests are: (a) Endurance tests. (b) Free-fall tests for portable equipment. (c) Shock test (e.g. low-level lighting systems). (d) Ultraviolet tests for plastic materials exposed to sunlight. (e) Flame retardance tests (products with significant plastics content combustible material content): IEC 60695-2-11 and IEC 60695-11-5 or equivalent.	
Test specification 2 Performance and Test Specifications for the following Piping System Components primarily to be used in Marine Applications:	Chapter 2 Appendix 1 EXPANSION PIECES – BELLOWS AND SLIDING TYPES	4.2 Testing requirements	4.2.1 Proof testing is to be carried out on typical expansion pieces complete with end connections. Tests are to meet the requirements of the applicable specification, which may include, for example, hydrostatic proof, pneumatic proof, static bend tests, fatigue life tests, yield and burst/squirm/meridional yield-rupture tests, and where necessary, fire and intercrystalline corrosion tests. Longitudinal and/or central restraint may require to be provided during some of the tests, dependent upon the design of the expansion piece and the applicable specification. Examination during the testing may include: (a) Radiographic examination (of welding for example). (b) Liquid penetrant examination. (c) Fluorescent penetrant examination. (d) Magnetic particle examination. (e) Ultrasonic examination. (f) Halogen leak examination. (g) Mass spectrometer examination. 4.2.2 Unless specified otherwise in the applicable standard, the following notes should be used for guidance when carrying out the tests:	

Conditions	Item	Documentation	Additional Description	Information
			(a) Hydrostatic proof test. All test assemblies are required to complete this test. Hydrostatic pressure of 1,5 x maximum design pressures to be applied with assembly set at maximum specified misalignment, for at least one minute. (b) Pneumatic proof test. Pneumatic pressure of 1,1 x maximum design pressure to be applied with assembly set at maximum specified misalignment, for at least one minute. (c) Hydrostatic burst test. (Yield and burst/squirm/meridional yield-rupture.) Representative test assemblies to be tested by hydraulic pressure to at least 4 x maximum design pressure (or 2 x estimated yield pressure) with assembly at maximum specified misalignment or until deformation/rupture takes place. Duration of the test should be not less than 5 minutes. Samples from this test are not to be used for further testing. (d) Repeated assembly test. This test is required for separable assembly expansion pieces only and is to be carried out on at least one representative sample. Sample assembly is to be dismantled and remade a total of 10 times and then tested as per the Hydrostatic Proof Test above. (e) Fatigue life tests. Should be performed with a varying pressure unless a constant pressure is acceptable by the required standard. For the bellows design of an expansion piece, the minimum number of convolutions tested should be three of minimum diameter, and the cyclic movement should be of axial compression from free length. Maximum deflection should be applied at 30 cycles per minute maximum for a minimum of 10 000 cycles unless otherwise specified. Note, however, liquefied gas carriage on ships may require 2 000 000 cycles at not more than 5 cycles per second. 4.2.3 Additional testing, where required, may be requested, including: (a) Vacuum test. Using a suitable pump, a vacuum of 635 mm of Hg shall be drawn and held for a minimum of 15 minutes with assembly at maximum specified misalignment. Loss of vacuum not to exceed 30 mbar in 15 minutes. (b) Extreme displacement test. Assembly to be pressurised to 2 x maximum design pressures at maximum displacement without permanent deformation. This test may require to be carried out at minimum design temperature.	

Conditions	Item	Documentation	Additional Description	Information
			(c) Cyclic test. For liquefied gas carriage, bellows type expansion pieces require a cyclic test to accommodate all conditions of pressure, temperature, axial movement, rotational movement, and transverse movement, as will be expected in actual service. (d) Fire test. Where required, fire tests are to be carried out in accordance with an acceptable recognised Standard such as ISO 15540, ISO 15541 ASTM F 1387 Standard specification for performance of mechanically attached fitting, series S7. Attention is also drawn to the requirements of the Statutory Authorities, the United Kingdom's Maritime and Coastguard Agency, e.g. Survey of Fire Appliances, Appendix D, 'Fire Test Requirements for Fire Mains and Fittings'.	
		4.3 Production testing	4.3.1 Production testing is to be carried out to meet the requirements of the applicable specification. This may include the following: (a) Material testing. (b) Chemical analysis. (c) Non-destructive testing, including any of the forms of examination referenced in Appendix 1, 4.2 Testing requirements 4.2.1. (d) Hydrostatic testing. (e) Air jet leak examination. 4.3.2 Large diameter expansion pieces may require to be tested so far as may be applicable, at the manufacturer's production facility, to a hydrostatic pressure not less than 1,5 times the rated pressure of the pipe. Other test criteria may be accepted. 4.3.3 Additional special testing may be required as part of the approval procedure, depending upon the use and location of the pipe joint.	
	Chapter 3 Appendix 2 - FILTER UNITS	4.2 Test requirements	4.2.1 Proof testing. The filter units require to be prototype tested to ensure that they meet the performance requirements of this Appendix and/or the requirements of the applicable specification, including hydrostatic or pneumatic testing. 4.2.2 Unless testing is to be restricted to specified standards only, consideration should be given to the following tests as appropriate: (a) Proof test to be effected unless specifically not called for by the applicable specification. This hydrostatic test is to be limited to materials with a ratio of	

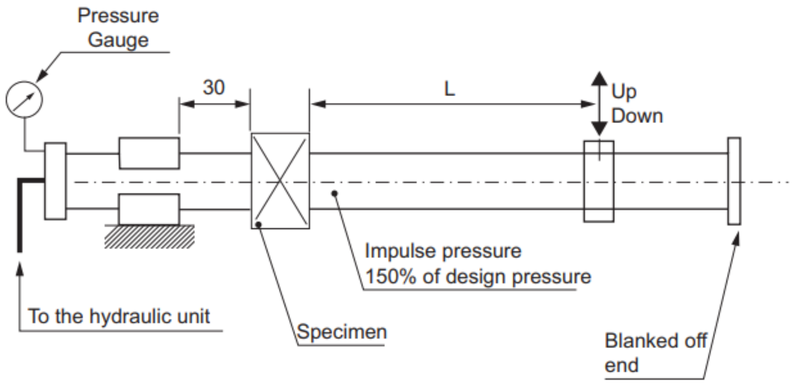
Conditions	Item	Documentation	Additional Description	Information
			minimum specified yield to minimum specified ultimate tensile strength of 0,625 or less and is to be based on yielding of any part of the filter unit. The allowable design pressure will generally be based on 0,2 x the hydrostatic test pressure at which the proof test was stopped, dependent on the materials of manufacture. Tests are to be effected at a temperature of between 7°C and 25°C. Proposals to use other proof testing specifications can be considered. (b) Hydrostatic tests. Each size of filter unit is to be individually subjected to a hydrostatic test of 1,5 x maximum allowable design pressure x the lowest ratio (for the materials from which the filter unit is to be constructed) of the stress value for the test temperature of the filter unit to the stress value for the design temperature or as otherwise called for by the specification. Tests are to be effected at a temperature of between 7°C and 25°C. Liquids other than water may be used subject to agreement. (c) Pneumatic tests may be effected where water or other tests fluids cannot be tolerated or where the filter unit cannot be readily dried. The test pressure is to be limited to 1,25 xmaximum allowable design pressure x the lowest ratio (for the materials of which the filter unit is to be constructed) of the stress value at test temperature to the stress value at design temperature, except where other specification requirements govern. Tests are to be effected at room temperature (at least 17°C) unless otherwise specified. Gases other than air can be considered and full details are to be submitted for consideration. (d) Mountings – Hydrostatic tests are to be effected on applicable mountings at not less than 2 x design pressure. (e) Material tests as may be required by the applicable specification or called for by the intended services. Tests are to be in accordance with recognised Standards. (f) Performance testing with an agreed program of tests to demonstrate the filtration properties of the unit.	

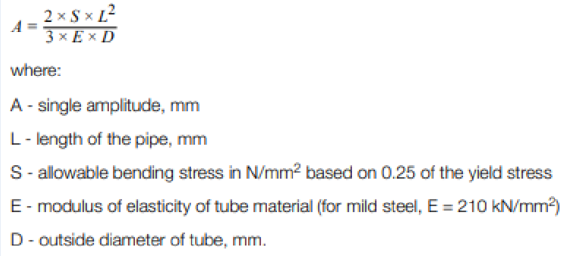
Conditions	Item	Documentation	Additional Description	Information
		4.3 Production testing and inspection	4.3.1 Production testing is to be carried out to meet the requirements of the applicable specification. This may include the following: (a) Material testing. (b) Chemical analysis. (c) Weld procedure tests. (d) Welder qualification tests. (e) Non-destructive testing, including visual, ultrasonic, magnetic particle, dye penetrant and radiographic examination, in way of any welding. (f) Destructive weld inspection tests. (g) Individual hydrostatic testing 1,5 x the design pressure. This test may be effected using air subject to prior agreement. 4.3.2 No welding shall be carried out on the pressurised parts of a filter unit once the pressure testing has been successfully completed. 4.3.3 Production inspection is to be carried out to meet the requirements of the applicable specification. This is likely to include: (a) Material inspection. (b) Welding inspection where applicable. (c) Visual inspection. (d) Dimensional inspection. (e) Assembly inspection.	
		4.4 Additional testing	4.4.1 Additional special testing may be required as part of the approval procedure, depending upon the proposed use and location of the filter units. 4.4.2 Where filters are of a duplex design, the ability for one unit to be cleaned without interrupting the flow must be demonstrated. 4.4.3 A vibration test according to Test Specification Number 1 is to be undertaken if the filters are intended for installation directly on combustion engines or equivalents.	
	CHAPTER 4 APPENDIX 3 - FLEXIBLE HOSE ASSEMBLIES	Section 4 Testing procedures 4.1 General	4.1.1 Generally, the requirements of any suitable recognised Standards can be used for the basis of the test programme. The primary objective of the tests is to determine the following with the hose assembly at the design bend radius:	

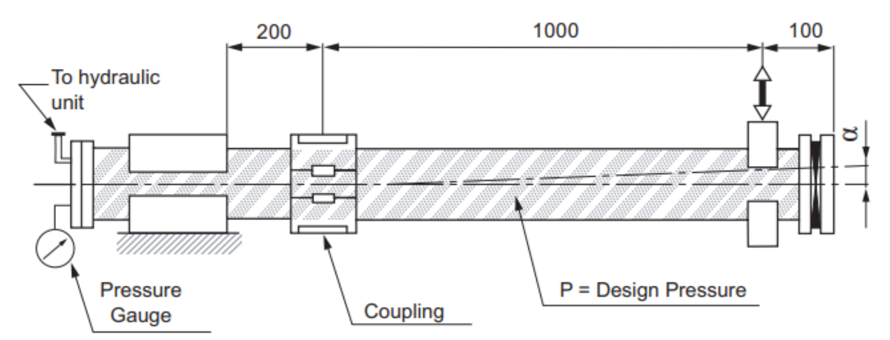
Conditions	Item	Documentation	Additional Description	Information
			(a) Pressure – static and impulse. Impulse testing is particularly important for main/auxiliary engine oil fuel supply and spill systems, and hydraulic oil systems, e.g. steering gears. (b) Temperature conditions – maximum and minimum. (c) Ageing of rubber in operating environment, e.g. at high temperatures. (d) Degradation of flexible materials within operating pressure and temperature conditions, e.g. at low temperatures (bending tests). (e) Endurance testing, including burst testing. (f) Fire testing, e.g. for use in flammable fluid systems and systems which, following failure of a hose assembly, could lead to danger due to possible flooding or loss of integrity of an emergency shut-down or control system. (g) Shore hardness test. (h) Determination of adhesion between components. (i) Assessment of ozone resistance under static/dynamic conditions. 4.1.2 Additional tests to those detailed in Appendix 3, 4.4 Additional testing 4.4.1, which may have to be considered depending upon use and location of the hose assembly, are: (a) Determination of permeability of gas. (b) Determination of transmission of liquids through hose walls. (c) Determination of abrasion resistance of outer cover. (d) Determination of vacuum resistance – static and impulse. (e) Determination of electrical resistance. (f) Determination of ultraviolet resistance under static conditions. (g) Determination of the effects of oil. (h) Determination of crush resistance. (i) Depending upon the field of application of the flexible hose assembly, additional testing may be required. This may include noperating beyond the design ranges stipulated by the client.	
	CHAPTER 5 APPENDIX 4 - MECHANICAL PIPE JOINTS –	4.2 Test methods	4.2.1 The test procedures detailed in Appendix 4, 4.2 Test methods 4.2.2 to Appendix 4, 4.2 Test methods 4.2.9 are applicable for mechanical joints installed on board ships as specified in Table 4.1, the applicability of these tests for joints used in other applications will depend on the specified standard(s).	

Conditions	Item	Documentation	Additional Description	Information
	FIXED CONNECTIONS		4.2.2 Tightness test - all mechanical joint types are to be subjected to a tightness test, as follows. (a) The mechanical joint assembly test specimen is to be assembled in accordance with the requirements of Appendix 4, 4.1 General 4.1.10, Appendix 4, 4.1 General 4.1.11 and the manufacturer's instructions, filled with test fluid and de-aerated. Mechanical joints assemblies intended for use in rigid connections of pipe lengths, are not to be longitudinally restrained. (b) The pressure inside the joint assembly is to be slowly increased to 1.5 times the design pressure. This test pressure is to be retained for a minimum period of 5 minutes. (c) In the event of a drop in pressure or visible leakage, the test (including fire test) is to be repeated for two further specimens. If during the repeat test one test piece fails, the coupling is regarded as having failed. An alternative tightness test procedure, such as a pneumatic test, may be accepted. (d) For compression couplings a static gas pressure test is to be carried out to demonstrate the integrity of the mechanical joints assembly for tightness under the influence of gaseous media. The pressure is to be raised to the maximum design pressure or 70 bar whichever is the lesser using an inert gas. The pressure is to be held for not less than 10 minutes. (e) Three test assemblies are to be subjected to a pressure Check for leaks by: (i) Soap solution. (ii) Submersion in water. (iii) Gas detection equipment. (f) Where the tightness test is carried out using gaseous media as permitted in (c) above, then the static pressure test mentioned in (d) and (e) above need not be carried out. 4.2.3 Burst pressure test – all mechanical joint types are to be burst tested. At least three representative mechanical joint test specimens are to be tested as follows:	

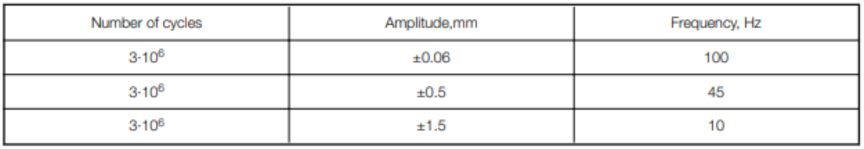
Conditions	Item	Documentation	Additional Description	Information
			(a) The sample joint is to be connected to the pipe or tubing in accordance with the requirements of Appendix 4, 4.1 General 4.1.10 and the manufacturer's instructions, filled with test fluid and de-aerated mechanical joint assembly intended for use in rigid connections of pipe lengths is not to be longitudinally restrained. (b) Pressure inside the test assembly is to be increased to 4 x maximum specified design pressure with an increasing rate of 10% per minute of test pressure. The duration of this test is not to be less than 5 minutes at the maximum pressure. For design pressures above 200 bar the required burst pressure will be specially considered. (c) The specimen may have small deformation whilst under test pressure, but no leakage or visible cracks are permitted. (d) Where considered convenient, the mechanical joint test specimen used in tightness test may be used for the burst test provided it passed the tightness test. Samples from the burst test are not to be used for further testing. 4.2.4 Vibration (fatigue) test – The mechanical joint assembly is to be tested to establish the capability of the mechanical joint assembly to withstand fatigue, which is likely to occur due to vibrations under service conditions. The test method is dependent on the mechanical joint type as follows: (a) Compression couplings and pipe unions intended for use in rigid pipe connections, where rigid connection means no free angular or axial movement, are to be tested as follows: (i) Two lengths of pipe are to be connected by means of the joint to be tested. One end of the pipe is to be rigidly fixed while the other end is to be fitted to the vibration rig. The test rig and the joint assembly specimen being tested are to be arranged as shown in Figure 5.4.1 Arrangement for	

Conditions	Item	Documentation	Additional Description	Information
			Vibration (fatigue) Testing of Compression Couplings and Pipe Unions.  **Figure 5.4.1 Arrangement for Vibration (fatigue) Testing of Compression Couplings and Pipe Unions** (ii) The joint assembly is to be filled with test fluid, de-aerated and pressurised to the design pressure of the joint. (iii) Pressure during the test is to be monitored. In the event of a drop in the pressure and visible leakage the test is to be repeated as described in Appendix 4, 4.1 General 4.1.12. Visual examination of the joint assembly is to be carried out. Re-tightening may be accepted once during the first 1000 cycles. (iv) Vibration amplitude is to be within 5% of the value calculated from the following formula:	

Conditions	Item	Documentation	Additional Description	Information
			The test specimen is to withstand not less than 107 cycles with frequency 20 - 50 Hz without leakage or damage.  $A = \frac{2 \times S \times L^2}{3 \times E \times D}$ where: A - single amplitude, mm L - length of the pipe, mm S - allowable bending stress in N/mm^2 based on 0.25 of the yield stress E - modulus of elasticity of tube material (for mild steel, E = 210 kN/mm^2) D - outside diameter of tube, mm. (b) Grip type joints and other similar joints containing elastic elements are to be tested in accordance with the following method: (i) Two lengths of pipes are to be connected by means of joint assembly specimen to be tested. One end of the pipe is to be rigidly fixed while the other end is to be fitted to the vibrating element on the rig. The length of pipe connected to the fixed end should be kept as short as possible and in no case exceed 200 mm. Mechanical joint assemblies are not to be longitudinally restrained. The test rig and the joint assembly specimen being tested are to be arranged as shown in Figure 5.4.2 Arrangement for Vibration (fatigue) Testing of	

Conditions	Item	Documentation	Additional Description	Information
			Grip Type and Machine Grooved Type Joints.  **Figure 5.4.2 Arrangement for Vibration (fatigue) Testing of Grip Type and Machine Grooved Type Joints** (ii) The joint assembly is to be filled with test fluid, de-aerated and pressurised to the design pressure of the joint. (iii) Preliminary angle of deflection of pipe axis is to be equal to the maximum angle of deflection, recommended by the manufacturer. The amplitude is to be measured at 1m distance from the centre line of the joint assembly at free pipe end connected to the rotating element of the rig. (See Figure 5.4.2 Arrangement for Vibration (fatigue) Testing of Grip Type and Machine Grooved Type Joints) (iv) Pressure during the test is to be monitored. In the event of drop in the pressure and visual signs of leakage the test is to be repeated as described in Appendix 4, 4.1 General 4.1.11. Visual examination of the joint assembly is to be carried out for signs of damage which may eventually lead to joint leakage. (v) Parameters of testing are to be as indicated below and to be carried out on the same assembly:	

Conditions	Item	Documentation	Additional Description	Information



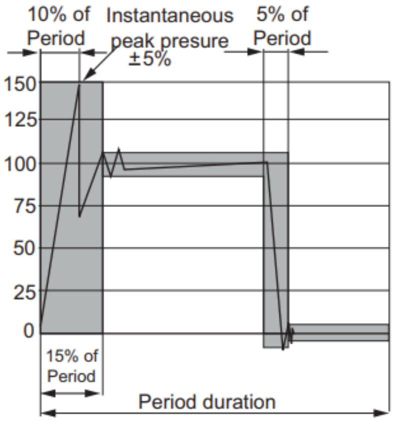
Number of cycles	Amplitude,mm	Frequency, Hz
$3 \cdot 10^6$	±0.06	100
$3 \cdot 10^6$	±0.5	45
$3 \cdot 10^6$	±1.5	10

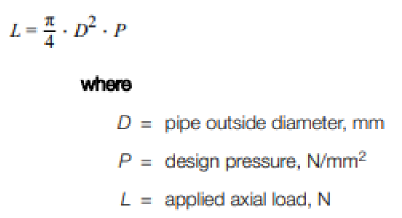
(c) On completion of the tests, all sample joints tested require to be retested as per the tightness test above.

4.2.5 Pressure pulsation test - The mechanical joint assembly is to be tested to establish the capability of mechanical joint assembly to withstand pressure pulsation likely to occur during working conditions. Joint assemblies intended for use in rigid connections of pipe lengths, are to be tested in accordance with the following method.

(a) The mechanical joint test specimen for carrying out this test may be the same as that used in the test in Appendix 4, 4.2 Test methods 4.2.3(a) provided it passed that test. The vibration test in Appendix 4, 4.2 Test methods 4.2.4 and the pressure pulsation test are to be carried out simultaneously for compression couplings and pipe unions.

(b) The mechanical joint test specimen is to be connected to a pressure source capable of generating pressure pulses of magnitude as shown in Figure 5.4.3

Conditions	Item	Documentation	Additional Description	Information
			Impulse pressure diagram.  **Figure 5.4.3 Impulse pressure diagram** (c) Impulse pressure is to be raised from 0 to 1.5 times the design pressure of the joint with a frequency equal to 30-100 cycles per minute. The number of cycles is not to be less than 5 x 105. (d) The mechanical joint is to be examined visually for sign of leakage or damage during the test. On completion of the tests, all sample joints tested require to be retested as per the tightness test above. 4.2.6 Pull-out test - In order to determine the ability of a mechanical joint assembly to withstand the axial loading likely to be encountered in service without the connecting pipe becoming detached, a following pull-out test is to be carried out: (a) Pipes suitable length are to be fitted to each end of the mechanical joint assembly test specimen. (b) The test specimen is to be pressurised to design pressure. When pressure is attained, an external axial load is to be imposed with a value calculated using the following formula:	

Conditions	Item	Documentation	Additional Description	Information
			 $L = \frac{\pi}{4} \cdot D^2 \cdot P$ **where** D = pipe outside diameter, mm P = design pressure, N/mm^2 L = applied axial load, N (c) The pressure and axial load are to be maintained for a period of 5 minutes. During the test, pressure is to be monitored and relative movement between the joint assembly and the pipe measured. (d) The mechanical joint assembly is to be visually examined for drop in pressure and signs of leakage or damage. There is to be no movement between the mechanical joint assembly and the connecting pipes. 4.2.7 Fire endurance test - In order to establish the capability of the mechanical joints to withstand effects of fire which may be encountered in service, mechanical joints are to be subjected to a fire endurance test. The fire endurance test is to be conducted on the selected test specimens in accordance with an acceptable recognised standard such as: (a) ISO 19921: 2005(E): Ships and marine technology – Fire resistance of metallic pipe components with resilient and elastomeric seals – Test methods; or (b) ISO 19922: 2005(E): Ships and marine technology – Fire resistance of metallic pipe components with resilient and elastomeric seals – Requirements imposed on the test bench. Clarifications to the standard requirements: (a) If the fire test is conducted with circulating water at a pressure different from the design pressure of the joint (however of at least 5 bar) the subsequent pressure test is to be carried out to twice the design pressure. (b) A selection of representative nominal bores may be tested in order to evaluate the fire resistance of a series or range of mechanical joints of the same design. When a mechanical joint of a given nominal bore (Dn) is so tested then other mechanical joints falling in the range Dn to 2xDn (both inclusive) are considered accepted.	

Conditions	Item	Documentation	Additional Description	Information
			(c) Alternative test methods and/or test procedures considered to be at least equivalent will be considered by LR in cases where the test pieces are too large for the test bench and cannot be completely enclosed by the flames. (d) Thermal insulation materials applied on couplings are to be non-combustible in dry condition and when subjected to oil spray. A non-combustibility test according to ISO 1182 is to be carried out. 4.2.8 Vacuum Test - In order to establish the capability of the mechanical joint assembly to withstand internal pressures below atmospheric, similar to the conditions likely to be encountered under service conditions, the following vacuum test is to be carried out. (a) Each mechanical joint assembly is to be connected to a vacuum pump and subjected to a pressure of 170 mbar absolute. (b) Once this pressure is stabilized the specimen under test is to be isolated from the vacuum pump and the pressure is to be retained for a period of 5 minutes. (c) No internal pressure rise is permitted. 4.2.9 Repeated assembly test - This test is required for separable assembly joints only and is to be carried out on at least one representative sample of joint. Where impulse and/or flexure fatigue tests are required, the test may be conducted during those tests. The sample joint is to be dismantled and reassembled a total of 10 times and then tested as per the tightness test above.	
	CHAPTER 6 APPENDIX 5 - METALLIC FORMED PIPE PIECES	4.2 Test requirements	4.2.1 Proof testing. Proof testing is to be carried out to meet the requirements of the applicable specification, including hydrostatic testing and where necessary, vacuum and intercrystalline corrosion tests. 4.2.2 Production testing. Production testing is to be carried out to meet the requirements of the applicable specification. This may include the following: (a) Material testing. (b) Chemical analysis. (c) Non-destructive testing, including radiography in way of welding. (d) Hydrostatic testing.	

Conditions	Item	Documentation	Additional Description	Information
			4.2.3 Additional testing. Additional special testing may be required as part of the approval procedure, depending upon the use and location of the piping.	
	CHAPTER 7 APPENDIX 6 - PLASTICS PIPING SYSTEMS, INCLUDING PIPE JOINTS AND FITTINGS MADE PREDOMINANTLY OF OTHER MATERIAL THAN METAL	4.2 Internal pressure	4.2.1 The nominal internal pressure for a pipe is to be determined by dividing the short-term hydrostatic test failure pressure by a safety factor of 4 or the long-term hydrostatic (>100 000 h) test failure pressure by a safety factor of 2,5, whichever is the lesser. The hydrostatic test failure pressure is to be verified experimentally or by a suitable combination of testing and calculation methods.	
		4.3 External pressure	4.3.1 External pressure is to be taken into account in the design of piping for any installation which may be subject to vacuum conditions inside the pipe or a head of liquid acting on the outside of the pipe. 4.3.2 Piping is to be designed for an external pressure not less than the sum of the maximum potential head of liquid outside the pipe, plus full vacuum (1 bar). The nominal external pressure for a pipe is to be determined by dividing the collapse test pressure by a safety factor of 3. The collapse test pressure is to be verified experimentally or by a suitable combination of testing and calculation methods. For Classification marine applications, the collapse pressure is not to be less than 3 bar.	
		4.4 Axial strength	4.4.1 The sum of the longitudinal stresses due to pressure, weight and other dynamic and sustained loads is not to exceed the allowable stress in the longitudinal direction. Forces due to thermal expansion, contraction and external loads, where applicable, are to be considered when determining longitudinal stresses in the system. 4.4.2 In the case of fibre reinforced plastic pipes, the sum of the longitudinal stresses is not to exceed half of the nominal circumferential stress derived from the nominal internal pressure determined according to Appendix 6, 4.2 Internal Pressure unless the minimum	

Conditions	Item	Documentation	Additional Description	Information
			allowable longitudinal stress is verified experimentally or by a suitable combination of testing and calculation methods.	
		4.5 Temperature	4.5.1 Piping is to meet the design requirements of this Appendix over the range of service temperatures it will experience. 4.5.2 High temperature limits and pressure reductions relative to nominal pressures are to be in accordance with the recognised Standard. For compliance with the Classification requirements for marine services, in each case the maximum working temperature is to be at least 20°C lower than the minimum heat distortion temperature (determined according to ISO 75 method A, or equivalent, e.g. ASTM D648)) of the resin or plastic material and the minimum heat distortion temperature is to be not less than 80°C. 4.5.3 Where low temperature services are considered, special attention is to be paid to material properties.	
		4.6 Impact resistance	4.6.1 Piping is to meet the minimum resistance to impact criteria of the applicable specification.	
		4.7 Ageing	4.7.1 Where applicable, before selection of a piping material, the manufacturer may be required to confirm that the environmental effects, including but not limited to, ultraviolet rays, salt-water exposure, oil and grease exposure, temperature, and humidity, will not degrade the mechanical and physical properties of the piping material below the values necessary to meet the criteria of the required specification. The manufacturer may have to establish material ageing characteristics by subjecting samples of piping to a suitable ageing test and then confirming its physical and mechanical properties by the performance criteria required.	
		4.8 Fatigue	4.8.1 In cases where design loadings incorporate a significant cyclic or fluctuating component, fatigue may require to be considered in the material selection process and taken into account in the installation design. 4.8.2 In addressing material fatigue, the designer may rely on experience with similar materials in similar service or on laboratory evaluation of mechanical test specimens. However, the designer is cautioned that small changes in the material composition may significantly affect fatigue behaviour.	
		4.9 Erosion resistance	4.9.1 In the cases where fluid in the system has high flow velocities, abrasive characteristics or where there are flow path discontinuities producing excessive	

Conditions	Item	Documentation	Additional Description	Information
			turbulence, the possible effect of erosion may require to be considered. If erosion cannot be avoided then adequate measures are to be taken, such as increased wall thickness, special liners, change of materials, etc.	
		4.10 Fluid absorption	4.10.1 Absorption of contact fluids by the piping material is not to cause a reduction of mechanical and physical properties of the material below that required. 4.10.2 The fluid being carried or in which the pipe is immersed is not to permeate through the wall of the pipe. Testing for fluid absorption characteristics of the pipe material is to be to a recognised Standard.	
		4.11 Material compatibility	4.11.1 The piping material is to be compatible with the fluid being carried or in which it is immersed, such that its design strength does not degenerate below that required. Where the reaction between the pipe material and the fluid is unknown, the compatibility may require to be demonstrated.	
		4.12 Test requirements	4.12.1 It may also be necessary to consider the test requirements in Appendix 6, 4.13 Fire endurance to Appendix 6, 4.20 Prototype testing which may apply, dependent on the piping system service and/or location.	
		4.13 Fire endurance	4.13.1 General. Pipes and their associated formed pipe pieces whose functions or integrity are essential to the safety of ships are required to meet the minimum fire endurance requirements given below. 4.13.2 Fire endurance requirements. The fire endurance of a piping system is the capability to maintain its strength and integrity (i.e., capable of performing its intended function) for some predetermined period of time, while exposed to fire that reflects anticipated conditions. Three different levels of fire endurance for plastic are given. These levels consider the different severity of consequences resulting from the loss of system integrity for the various applications and locations. The highest fire endurance standard (level 1) will ensure the integrity of the system during a full-scale hydrocarbon fire and is particularly applicable to systems where loss of integrity may cause outflow of flammable liquids and worsen the fire situation. The intermediate fire endurance standard (level 2) is intended to ensure the availability of systems essential to the safe operation of the ship, after a fire of short duration, allowing the system to be restored after the fire has been extinguished. The lowest level (level 3) is considered to provide the fire endurance	

Conditions	Item	Documentation	Additional Description	Information
			necessary for a water-filled piping system to survive a local fire of short duration. The system's function is to be capable of being restored after the fire has been extinguished. 4.13.3 Level 1. Piping systems essential to the safety of the ship and those systems outside machinery spaces where the loss of integrity may cause outflow of flammable fluid and worsen the fire situation are to be designed to endure a fully developed hydrocarbon fire for a long duration without loss of integrity under dry conditions. Piping having passed the fire endurance test specified in Appendix 1 of IMO Res. A.753(18), as amended by IMO Res. MSC. 313(88) and IMO Res. MSC.399(95) for a duration of a minimum of one hour without loss of integrity in the dry condition is considered to meet the level 1 fire endurance standard (L1). Level 1W – Piping systems are similar to Level 1 systems except these systems do not carry flammable fluid or any gas, and a maximum 5 per cent flow loss in the system after exposure is acceptable (L1W). 4.13.4 Level 2. Piping systems essential to the safe operation of the ship are to be designed to endure a fire without loss of the capability to restore the system function after the fire has been extinguished. Piping having passed the fire endurance test specified in Appendix 1 of IMO Res. A.753(18), as amended by IMO Res. MSC. 313(88) and IMO Res. MSC.399(95) for a duration of a minimum of 30 minutes in the dry condition is considered to meet the level 2 fire endurance standard (L2). Level 2W – Piping systems are similar to Level 2 systems except a maximum 5 per cent flow loss in the system after exposure is acceptable (L2W). 4.13.5 Level 3. Piping systems essential to the safe operation of the ship are to be designed to endure a fire without loss of the capability to restore the system function after the fire has been extinguished. Piping having passed the fire endurance test specified in Appendix 2 of IMO Res. A.753 (18) for a duration of a minimum of 30 minutes in the wet condition is considered to meet the level 3 fire endurance standard (L3).	
		4.15 Flame spread	4.15.1 For shipboard applications, IMO Resolution A. 753 (18) as amended by IMO Res. MSC. 313(88) and IMO Res. MSC. 399(95) requires that all pipes, except those fitted on open decks and within tanks, cofferdams, void spaces, pipe tunnels and ducts should have low flame spread characteristics as determined by the test procedures given in IMO Resolution A.653(16) Recommendation on Improved Fire Test Procedures for Surface Flammability of Bulkhead, Ceiling and Deck Finish Materials. Some Classification Societies	

Conditions	Item	Documentation	Additional Description	Information
			including Lloyd's Register recommend other standards, e.g. BS 476 'Fire Tests on Building Materials and Structures' Part 7 'Method of test to determine the classification of the surface spread of flame of products' or ASTM D 635 'Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Self-Supporting Plastics in a Horizontal Position'. 4.15.2 In Resolution A.653(16) the test sample configuration only considers flat surfaces. Procedure modifications to Resolution A.653(16) are necessary due to the curvilinear pipe surfaces. These procedure modifications are listed in Annex 3 of this Appendix. 4.15.3 Piping materials giving average values for all of the surface flammability criteria not exceeding the values listed in IMO Resolution A.653(16) Surface flammability criteria, bulkhead, wall and ceiling linings, are considered to meet the requirements for low flame spread in accommodation, service and control spaces. In other areas or where the quantity of pipe is small, equivalent acceptance criteria may be allowed.	
		4.16 Smoke generation	4.16.1 For shipboard applications, criteria for smoke production need only be applied to pipes within the accommodation, service, and control spaces. SOLAS Regulations II-2/34.7 and 49.2 are applicable to exposed interior surfaces which are interpreted as including the surface finish of piping systems. 4.16.2 Attention is drawn to the IMO Resolution MSC.61(67) (adopted on December 5, 1996) entitled Adoption of the International Code for Application of Fire Test Procedures, Annex 1 Fire Test Procedures, Part 2-Smoke and Toxicity Tests for fire test procedures and smoke obscuration criteria for shipboard applications together with any requirements required by the National Authorities. For industrial purposes, consideration could be given to this hazard in accordance with ISO 5659-2: 1994 'Plastics – Smoke Generation, Part 2: Determination of Optical Density by a Single Chamber Test,' or similar acceptable standard as may be applicable.	
		4.17 Toxicity	4.17.1 Attention is drawn to the IMO Resolution MSC.61(67) and the Annexes thereto (see Appendix 6, 4.16 Smoke generation 4.16.2) for toxicity testing together with any requirements required by the National Authorities.	
		4.18 Electrical conductivity	4.18.1 Electrostatic charges can be generated on the inside and outside of plastic pipes. The resulting sparks can ignite surrounding explosive atmospheres, or can create punctures through pipe walls leading to leakage of pipe contents. Consideration is to be	

Conditions	Item	Documentation	Additional Description	Information
			given to these hazards when seeking approval of plastic piping carrying fluids capable of generating electrostatic charges (static accumulators) inside the pipe, and plastic piping in hazardous areas (i.e., areas that could, either in normal or fault conditions, contain an explosive atmosphere) where there is a possibility of electrostatic charges outside the pipe. 4.18.2 In practice, fluids with conductivity less than 1000 pico siemens per metre (pS/m) are considered to be non- conductive and therefore capable of generating electrostatic charges. Refined products and distillates fall into this category and piping used to convey these liquids are therefore to be electrically conductive. Fluids with conductivity greater than 1000 pS/m are considered to be static non-accumulators and can therefore be conveyed through pipes not having special conductive properties when located in non-hazardous areas. 4.18.3 Regardless of the fluid being conveyed, plastic piping is to be electrically conductive if the piping passes through a hazardous area. 4.18.4 Where conductive piping is required, the resistance per unit length of the pipe, bends, elbows, fabricated branch pieces, etc., is not to exceed 1 x 105 ohm/m and the resistance to earth from any point in the piping system is not to exceed 1 x 106 ohm. It is preferred that pipes and formed pipe pieces be homogeneously conductive. Pipes and such fittings having conductive layers may be accepted subject to the arrangements for minimising the possibility of spark damage to the pipe wall being satisfactory. Satisfactory earthing is to be provided.	
		4.19 Fire protection coatings	4.19.1 Where a fire protective coating of pipes and formed pipe pieces is necessary for achieving the fire endurance standards required, the following requirements apply: (a) Pipes may be delivered from the manufacturer with the protective coating on, in which case on-site application of protection can be limited to what is necessary for installation purposes (e.g. joints). Alternatively, pipes may be coated on site in accordance with an approved procedure for each combination of materials, using approved materials of both pipe and insulation. (b) The liquid absorption properties of the coating and piping are to be considered. The fire protection properties of the coating are not to be diminished when exposed to salt-water, rainwater, oil, bilge slops, etc., so far as may be applicable.	

Conditions	Item	Documentation	Additional Description	Information
			That is, the coating is to be resistant to products likely to come in contact with the piping. (c) Fire protection coatings are not to degrade due to the effects of environmental exposure over time, such as ultraviolet rays, salt-water, rainwater, temperature and humidity. Other areas requiring consideration include thermal expansion, resistance against vibration and elasticity. Resistance to ageing of the fire protection coatings is to be satisfactory, consistent with ageing tests specified for piping. (d) The adhesion qualities of the coating are to be such that the coating does not flake, chip, or powder, when subjected to an acceptable adhesion test. (e) The fire protection coating is to have an impact resistance of acceptable value. 4.19.2 Special testing may be required as part of the approval procedure, depending upon the use and location of the piping.	

Annex 33: RULE PROPOSAL 2021-ENG007 (LR)

RULE PROPOSAL 2021-ENG007 (LR)

A. IDENTITY CARD OF RULE PROPOSAL 2021-ENG007 (LR)

RCS	Number of RCS	Title	Date	Stability date	Statutory
Rule	Lloyd'Register identification: 2021-ENG007	Rule proposal 2021-ENG007 - Rules for fuel cell installations Proposal for amendment to Part 5, Chapter 26 (New)	Effective date: 01 january 2022		

Foreword:

This rule proposal is in link with The "Draft Interim Guidelines for the Safety of Ships Using Fuel Cell Power Installations" published by the IMO, CCC 7/3, Annex 1, Round 5. This latter has informed the document's structure, Sections and sub-Sections, and has provided requirements. LR has elaborated certain Sections, sub-Sections and requirements based on knowledge and experience acquired to date in order to provide a holistic set of requirements.

PLEASE NOTE: This document is a submission and is provided for information only.

For fuel cells specifically, IMO-CCC7 is due to take place between 6th to 10th Sept 2021 where it is expected that the Interim Guidelines for Fuel Cell Installations are accepted. The current draft text from IMO, in addition to the LR (draft) Rules for Fuel Cell Installation due to be published January 2022.

Scope:

This Rule proposal contains requirements for installation of fuel cell power systems and applies to ships constructed in accordance with the *Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels* or the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk*.

The common fuel cell technologies, of which there are a number, generally categorised by their chemistry or by their temperature of operation or both, are specifically:

- Solid Oxide (high temperature);
- Molten Carbonate (high temperature);
- Proton Exchange Membrane, also known as Polymer Electrolyte (low temperature);
- Alkaline (low temperature);
- Phosphoric Acid (intermediate temperature)

In general, this proposal is based on a philosophy of preventing any unintended leakage of flammable or otherwise hazardous gases and substances. However, recognising that certain fuel cell technologies are designed to operate with a continuous leakage of hydrogen in normal service, such designs will be subject to special consideration by LR and the approval process will be based on risk based studies.

Domain/category:

This Rule proposal is intended to address design and arrangement, materials, electrical monitoring, control, alarms and safety systems equipment and components, in addition to the testing and trials.

Specifed exclusion:

Reference included in this RCS: in link with The *Draft Interim Guidelines for the Safety of Ships Using Fuel Cell Power Installations* published by the IMO, CCC 7/3, Annex 1, Round 5 has informed the document's structure, Sections and sub-Sections, and has provided requirements.

B. RELEVANT PARTS FOR STASHH PROJECT

This LR working group rules proposal adresses general requirements for fuel cell power installation on board. Thus the chapters relevant to StasHH project, concern:

- Section 1: General functional requirements for installation of fuel cell power installation. In the rest of this LR proposal, it is about fuel cell modules and for this reason, the general requirements for the installation are retained.
- Section 2: Risk assessments and its requirements for installation of fuel cell power installation. The risk assessment approach should also be considered at the fuel cell module level. Part of this section also deals with alternative design for all appliances and arrangements related to the usage of fuel cell technology.
- Section 4 includidng a paragraph specific to design requirements for fuel cell module.
- Section 5: concerns the requirements about materials, equipment and components (material, mechanical, electrical, piping and pressurised, monitoring control, alarm and safety system).
- Section 6: concerns fire and explosion safety.

All the

Conditions	Item	Documentation	Additional Description	Information
Chapter 26: Fuel cell Power installations	Section 1: General	Paragraph 1.1: Goal	*1.1.1 The goal of these Rules is to provide safe and reliable delivery of electrical and/or thermal energy through the use of fuel cell technology.*	
Chapter 26: Fuel cell Power installations	Section 1: General	Paragraph 1.1: Goal	*1.1.2 These Rules do not substitute or supersede statutory conventions but do include additional fire safety requirements to those stated in the statutory conventions specific to the use of fuel cell power systems.*	
Chapter 26: Fuel cell Power installations	Section 1: General	Paragraph 1.1: Goal	*1.1.3 Additional requirements may be imposed by the Administration with which the ship is registered and/or by the Flag Administration within whose territorial jurisdiction the ship is intended to operate.*	
Chapter 26: Fuel cell	Section 1: General	Paragraph 1.1: Goal	*1.1.4 These Rules specify requirements for fuel cell power installations on board ships that comply with either the Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels or the Rules and Regulations*	

Conditions	Item	Documentation	Additional Description	Information
Power installations			*for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk.* **Note: the following documents come from LR** "Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels" And "Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk"	
Chapter 26: Fuel cell Power installations	Section 1: General	Paragraph 1.1: Goal	*1.1.5 All references to the IMO IGF Code throughout these Rules are to be interpreted as references to the Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels, which are fully consistent with the IGF Code.*	
Chapter 26: Fuel cell Power installations	Section 1: General	Paragraph 1.2: Functional requirements	*1.2.1 The safety, reliability and dependability of the systems shall be equivalent to those achieved with new and comparable conventional oil-fuelled main and auxiliary machinery installations, regardless of the specific fuel cell type and fuel.*	
Chapter 26: Fuel cell Power installations	Section 1: General	Paragraph 1.2: Functional requirements	*1.2.2 The probability and consequences of fuel-related hazards shall be limited to a minimum through arrangement and system design, such as ventilation, detection and safety actions. In the event of gas leakage or failure of the risk reducing measures, necessary safety actions should be initiated.*	
Chapter 26: Fuel cell Power installations	Section 1: General	Paragraph 1.2: Functional requirements	*1.2.3 The design philosophy shall ensure that risk reducing measures and safety actions for the fuel cell power installation do not lead to an unacceptable loss of power.*	
Chapter 26: Fuel cell Power installations	Section 1: General	Paragraph 1.2: Functional requirements	*1.2.4 Hazardous areas shall be restricted, as far as practicable, to minimise the potential risks that might affect the safety of the ship, persons on board and equipment.*	
Chapter 26: Fuel cell	Section 1: General	Paragraph 1.2: Functional requirements	*1.2.5 Equipment installed in hazardous areas shall be minimised to that required for operational purposes and should be suitably and appropriately certified.*	

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td>Power installations</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 1: General</td><td>Paragraph 1.2: Functional requirements</td><td>1.2.7 System components shall be protected against external damages.</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 1: General</td><td>Paragraph 1.2: Functional requirements</td><td>1.2.8 Sources of ignition in hazardous areas shall be minimised to reduce the probability of explosions.</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 1: General</td><td>Paragraph 1.2: Functional requirements</td><td>1.2.9 Piping systems and overpressure relief arrangements that are of suitable design, construction and installation for their intended application shall be provided.</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 1: General</td><td>Paragraph 1.2: Functional requirements</td><td>1.2.10 Machinery, systems and components shall be designed, constructed, installed, operated, maintained and protected to ensure safe and reliable operation.</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 1: General</td><td>Paragraph 1.2: Functional requirements</td><td>1.2.12 Suitable control, alarm, monitoring and shutdown systems shall be provided to ensure safe and reliable operation.</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 1: General</td><td>Paragraph 1.2: Functional requirements</td><td>1.2.13 Fixed leakage detection suitable for all spaces and areas concerned shall be arranged.</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 1: General</td><td>Paragraph 1.2: Functional requirements</td><td>1.2.14 Fire detection, protection and extinction measures appropriate to the hazards concerned shall be provided.
<table>
<tr><th>Item</th><th>Alarm</th><th>Fuel supply isolation</th><th>Fuel cell power</th><th>note</th></tr>
</table></td><td></td></tr>
</table>

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td><table><tr><td></td><td></td><td></td><td>system shutdown</td><td></td></tr><tr><td>Fire detection</td><td>Logical alarm</td><td>X</td><td>X</td><td>Detection at all locations required by the rules</td></tr></table></td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 1: General</td><td>Paragraph 1.2: Functional requirements</td><td>1.2.15 Commissioning, trials and maintenance of fuel systems and gas utilisation machinery shall satisfy the goal in terms of safety, availability and reliability.</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 1: General</td><td>Paragraph 1.2: Functional requirements</td><td>1.2.16 The technical documentation shall permit an assessment of the compliance of the system and its components with the applicable Rules, guidelines, design standards used and the principles related to safety, availability, maintainability and reliability.</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 1: General</td><td>Paragraph 1.2: Functional requirements</td><td>1.2.17 A single failure in a technical system or component shall not lead to an unsafe or unreliable situation.</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 1: General</td><td>Paragraph 1.2: Functional requirements</td><td>1.2.18 Safe access shall be provided for operation, inspection and maintenance.</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 2: Risk based studies</td><td>Paragraph 2.1: Risk assessments</td><td>2.1.1 A risk assessment specific to fuel cell power installations is to be carried out for each installation on board. The risk assessment is to evaluate risks related to the safe operation of the ship and as such is to address the safety of the fuel cell power installation itself and, where the fuel cell installation provides power for propulsion of the ship or other essential services, the dependability of the fuel cell power installation.</td><td></td></tr>
</table>

Conditions	Item	Documentation	Additional Description	Information
Chapter 26: Fuel cell Power installations	Section 2: Risk based studies	Paragraph 2.1: Risk assessments	*2.1.2 The risk assessment may be additional to or included in the risk assessment required elsewhere by the Rules, including as required by Pt A, 4.2 Risk assessment of the Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels and Ch 16, 16.9 Alternative fuels and technologies LR 16.9-02 of the Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk.* **Note: the following documents come from LR** Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels And Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk	
Chapter 26: Fuel cell Power installations	Section 2: Risk based studies	Paragraph 2.1: Risk assessments	*2.1.3 For any new or altered concept or configuration of a fuel cell power installation a risk analysis shall be conducted in order to ensure that any risks arising from the use of fuel cells affecting the integrity of the ship are addressed. Consideration shall be given to the hazards associated with installation, operation, and maintenance, following any reasonably foreseeable failure.* .	
Chapter 26: Fuel cell Power installations	Section 2: Risk based studies	Paragraph 2.1: Risk assessments	*2.1.4 The risks shall be analysed using acceptable and recognised risk assessment techniques, and mechanical damage to components, operational and weather-related influences, electrical faults, unwanted chemical reactions, toxicity, auto-ignition of fuels, fire, explosion, and short-term power failure (blackout) shall as a minimum be considered. The assessment shall ensure that risks are eliminated wherever possible. Risks which cannot be eliminated shall be mitigated as necessary.*	
Chapter 26: Fuel cell	Section 2: Risk based studies	Paragraph 2.1: Risk assessments	*2.1.5 System safe states are to be considered with regards to the behaviour and characteristics of the fuel and fuel cell power installation.*	

Conditions	Item	Documentation	Additional Description	Information
Power installations				
Chapter 26: Fuel cell Power installations	Section 2: Risk based studies	Paragraph 2.1: Risk assessments	*2.1.6 Where fuel cell modules are intended to be supplied with oxidant in the form of oxygen gas or oxygen enriched compounds, this is to be specifically addressed in the engineering and safety justification. Such proposals are subject to special consideration.*	
Chapter 26: Fuel cell Power installations	Section 2: Risk based studies	Paragraph 2.1: Risk assessments	*2.1.7 Where any part of the fuel cell power installation is intended to operate with a continuous leakage of flammable gas, this is to be specifically addressed in the engineering and safety justification. Such proposals are subject to special consideration. The leakage rate is to be calculated in accordance with a recognised International or National Standard such as IEC 62282-3-100 – Fuel Cell Technologies Part 3-100: Stationary fuel cell systems – Safety.*	
Chapter 26: Fuel cell Power installations	Section 2: Risk based studies	Paragraph 2.1: Risk assessments	*2.1.8 Where fuel cell modules incorporate catalytic oxidation or controlled combustion units in order to prevent the accumulation of flammable gases or vapours, this is to be specifically addressed in the engineering and safety justification. Such proposals are subject to special consideration*	
Chapter 26: Fuel cell Power installations	Section 2: Risk based studies	Paragraph 2.2: Alternative design	*2.2.1 These Rules contain functional requirements for all appliances and arrangements related to the usage of fuel cell technology.*	
Chapter 26: Fuel cell Power installations	Section 2: Risk based studies	Paragraph 2.2: Alternative design	*2.2.2 Appliances and arrangements of fuel cell power systems may deviate from those set out in these Rules, provided such appliances and arrangements meet the intent of the goal and functional requirements concerned and provide an equivalent level of safety of the relevant sections.*	
Chapter 26: Fuel cell Power installations	Section 2: Risk based studies	Paragraph 2.2: Alternative design	*2.2.3 The equivalence of the alternative design shall be demonstrated as specified in SOLAS Chapter II-1, Regulation 55 and approved by the Administration. However, the Administration should not allow operational methods or procedures to be applied as an alternative to a particular fitting, material, appliance, apparatus or item of equipment or type there of which is prescribed by these Rules.*	

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 2: Risk based studies</td><td>Paragraph 2.3: System dependability assessment</td><td><i>2.3.1 Where fuel cell power installations are used to supply power for propulsion of the ship or other essential services then a system dependability assessment is to be undertaken. The fuel cell power installation is to demonstrate that the dependability of power is commensurate with that provided by conventional oil-fuelled reciprocating or rotating machinery. The assessment is to include consideration of reliability, availability and maintainability of the fuel cell power installation, taking account of any potential single-point failures and common mode failures and of the need for redundancy of components and equipment.</i></td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 2: Risk based studies</td><td>Paragraph 2.3: System dependability assessment</td><td><i>2.3.2 The system dependability assessment is to be undertaken to a recognised International or National Standard such as IEC 60300-3-1 Dependability management Part 3-1: Application guide – Analysis techniques for dependability – Guide on methodology.</i></td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 4: Design principles for Fuel cell installations</td><td>Paragraph 4.2: Fuel cell power installation – Fuel cell power system</td><td><i>4.2.1 A single failure of any part of the fuel cell power system is not to result in a hazardous release into a non-hazardous area.</i>
<i>4.2.2 The fuel cell power system shutdown and fuel supply isolation are to be capable of being performed locally and from a position outside the fuel cell space which will always be easily accessible even in the event of fire occurring in that space.</i>
<table>
<tr><td><i>Item</i></td><td><i>Alarm</i></td><td><i>Fuel supply isolation</i></td><td><i>Fuel cell power system shutdown</i></td><td><i>note</i></td></tr>
<tr><td><i>Emergency release button</i></td><td><i>Logical alarm</i></td><td><i>X</i></td><td><i>X</i></td><td></td></tr>
</table>
<i>4.2.3 Exhaust gases and exhaust air from the fuel cell power systems shall not be combined with any ventilation except ventilation serving fuel cell spaces and shall be led to a safe location in the open air.</i></td><td></td></tr>
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<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td>4.2.4 Filters which could cause a failure of the fuel cell power system if blocked are to be provided with differential pressure monitoring and a stand-by filter unit. High differential pressure is to initiate an alarm.
<table>
<tr><td>Item</td><td>Alarm</td><td>Fuel supply isolation</td><td>Fuel cell power system shutdown</td><td>note</td></tr>
<tr><td>Differential cell pressure</td><td>First stage high</td><td></td><td></td><td>All filters which if blocked could cause failure of the fuel cell power system</td></tr>
<tr><td>Flammable gas in auxiliary system</td><td>Logical alarm</td><td></td><td></td><td></td></tr>
</table>

4.2.5 Where any part of the fuel cell power system is susceptible to attack or degradation from airborne contaminants typical of the marine environment then arrangements for filtering and drying or closed air circulation are provided to ensure that the required air quality is in accordance with the fuel cell module manufacturer’s requirements. Any parts of the system sensitive to air quality are to be sealed.
4.2.6 Where any exposed part of the fuel cell power system exceeds 220°C in normal operation or under reasonably foreseeable abnormal conditions the exposed surfaces are to be cooled or efficiently lagged so as to minimise the risk of fire or harm.</td><td></td></tr>
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<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td><i>4.2.7 Means to safely remove the primary and reformed fuel from the fuel cell power system shall be provided.
4.2.8 Means shall be provided to set a fuel cell power installation into a safe state for maintenance and shutdown.
4.2.9 All pipes containing reformed fuel for fuel cell power systems, where fitted, are to be provided with fixed hydrogen detectors being capable of detecting a hydrogen leak for places where leakage of hydrogen may occur, such as valves, flanges and seals.</i>
<table>
<tr><td><i>Item</i></td><td><i>Alarm</i></td><td><i>Fuel supply isolation</i></td><td><i>Fuel cell power system shutdown</i></td><td><i>note</i></td></tr>
<tr><td><i>Hydrogen leakage at valves, flanges, seals</i></td><td><i>Logical alarm</i></td><td></td><td></td><td></td></tr>
</table>
<i>4.2.10 For the auxiliary systems of the fuel cell power system where primary fuel or reformed fuel may leak directly into a system medium (e.g. cooling water), such auxiliary systems shall be equipped with appropriate extraction and detection means fitted as close as possible after the media outlet from the system in order to prevent gas dispersion. Gas extracted from the auxiliary system media shall be vented to a safe location on the open deck.</i></td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 4: Design principles for Fuel cell installations</td><td>Paragraph 4.3: Fuel cell power installation – Fuel cell modules</td><td><i>4.3.1 Fuel cell modules are to satisfy the testing requirements of a recognised international or national type testing standard as agreed by LR.</i></td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 4: Design principles for</td><td>Paragraph 4.3: Fuel cell power installation –</td><td><i>4.3.2 Fuel cell modules are to be protected against overpressure, and over- and under-temperature.</i></td><td></td></tr>
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<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td>Fuel cell installations</td><td>Fuel cell modules</td><td><table>
<tr><td><i>Item</i></td><td><i>Alarm</i></td><td><i>Fuel supply isolation</i></td><td><i>Fuel cell power system shutdown</i></td><td><i>note</i></td></tr>
<tr><td><i>Fuel cell module pressure</i></td><td><i>First stage high</i></td><td></td><td></td><td></td></tr>
<tr><td><i>Fuel cell module pressure</i></td><td><i>2nd stage high</i></td><td></td><td></td><td></td></tr>
<tr><td><i>Fuel cell module temperature</i></td><td><i>First stage low</i>
<i>First stage high</i></td><td></td><td></td><td><i>Low temperature may be omitted if agreed to by LR</i></td></tr>
<tr><td><i>Fuel cell module temperature</i></td><td><i>2nd stage low</i>
<i>2nd stage high</i></td><td></td><td><i>X</i></td><td><i>Low temperature may be omitted if agreed to by LR</i></td></tr>
</table></td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 4: Design principles for Fuel cell installations</td><td>Paragraph 4.3: Fuel cell power installation – Fuel cell modules</td><td><i>4.3.3 Arrangements are to allow purging of flammable gases or vapours and inerting of the fuel cell modules.</i></td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 4: Design principles for Fuel cell installations</td><td>Paragraph 4.3: Fuel cell power installation – Fuel cell modules</td><td><i>4.3.4 Fuel and oxidant supplies to the fuel cell modules are to be in accordance with the fuel cell module manufacturer’s requirements and are to be provided with a means of monitoring the flow, temperature and pressure of the fuel and oxidant supplied.</i></td><td></td></tr>
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<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td>
<table>
<tr><td>Item</td><td>Alarm</td><td>Fuel supply isolation</td><td>Fuel cell power system shutdown</td><td>note</td></tr>
<tr><td>Fuel and oxidant supply flow, temperature, pressure</td><td>1st stage low
1st stage high</td><td></td><td></td><td></td></tr>
<tr><td>Fuel and oxidant supply flow, temperature, pressure</td><td>2nd stage low
2nd stage high</td><td>X</td><td>X</td><td></td></tr>
</table>
</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 4: Design principles for Fuel cell installations</td><td>Paragraph 4.3: Fuel cell power installation – Fuel cell modules</td><td>4.3.5 Arrangements are to prevent reverse flow of fuel and oxidant from the fuel cell modules back to the supply.</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 4: Design principles for Fuel cell installations</td><td>Paragraph 4.3: Fuel cell power installation – Fuel cell modules</td><td>4.3.6 Fuel cell modules which utilise electrolytic fluids that are corrosive, flammable or otherwise harmful at high temperatures are to be provided with a means of monitoring the temperature of the electrolyte.
<table>
<tr><td>Item</td><td>Alarm</td><td>Fuel supply isolation</td><td>Fuel cell power system shutdown</td><td>note</td></tr>
<tr><td>Fuel cell module electrolyte temperature</td><td>1st stage high</td><td></td><td></td><td>For electrolytic fluids which are corrosive, flammable</td></tr>
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<tr><td></td><td></td><td></td><td></td><td>*or harmful at high temperature*</td></tr>
<tr><td>*Fuel cell module electrolyte temperature*</td><td>*2nd stage high*</td><td></td><td>*X*</td><td>*For electrolytic fluids which are corrosive, flammable or harmful at high temperature*</td></tr>
</table></td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 4: Design principles for Fuel cell installations</td><td>Paragraph 4.3: Fuel cell power installation – Fuel cell modules</td><td>*4.3.7 Exhaust arrangements are to convey exhaust gas from the fuel cell modules to a safe location on deck.*</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 4: Design principles for Fuel cell installations</td><td>Paragraph 4.3: Fuel cell power installation – Fuel cell modules</td><td>*4.3.8 Arrangements are to prevent cross flow of exhaust gases between fuel cell modules.*</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 4: Design principles for Fuel cell installations</td><td>Paragraph 4.3: Fuel cell power installation – Fuel cell modules</td><td>*4.3.9 Exhaust arrangements are to prevent water entering the fuel cell module and, where the possibility of condensate accumulating exists, the arrangements are to prevent the backflow of condensate to the fuel cell module and provide for condensate removal.*</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 4: Design principles for</td><td>Paragraph 4.3: Fuel cell power installation –</td><td>*4.3.10 Exhaust temperature and flammable gas detection is to be provided for the fuel cell modules. An alarm is to be given at a gas concentration of 20 per cent LEL and the fuel cell module is to be shut down at a concentration of 40 per cent LEL.*</td><td></td></tr>
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<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td>Fuel cell installations</td><td>Fuel cell modules</td><td>
<table>
<tr><td>Item</td><td>Alarm</td><td>Fuel supply isolation</td><td>Fuel cell power system shutdown</td><td>note</td></tr>
<tr><td>Fuel cell module gas detection 20% LEL</td><td>1st stage high</td><td></td><td></td><td></td></tr>
<tr><td>Fuel cell module gas detection 40% LEL</td><td>1st stage high</td><td>X</td><td>X</td><td></td></tr>
<tr><td>Fuel cell exhaust temperature</td><td>1st stage high</td><td></td><td></td><td></td></tr>
</table>
</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 4: Design principles for Fuel cell installations</td><td>Paragraph 4.6: Fuel cell power installation – Thermal managment system</td><td>4.6.1 A thermal management system which provides cooling, heating, humidity management and condensate removal where required by the fuel cell modules is to be provided.</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 4: Design principles for Fuel cell installations</td><td>Paragraph 4.6: Fuel cell power installation – Thermal managment system</td><td>4.6.2 Thermal conditioning equipment utilising services from the ship's supply such as cooling water, compressed air, etc. is to be compatible with expected variations in the ship's supply and is to include arrangements to prevent reverse flow back to the supply.</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 4: Design principles for Fuel cell installations</td><td>Paragraph 4.6: Fuel cell power installation – Thermal</td><td>4.6.3 Loss of fuel cell coolant shall result in an automatic shutdown of the fuel cell by the process control within a limited period of time.</td><td></td></tr>
</table>

Conditions	Item	Documentation	Additional Description	Information
		managment system		
Chapter 26: Fuel cell Power installations	Section 4: Design principles for Fuel cell installations	Paragraph 4.6: Fuel cell power installation – Thermal managment system	*4.6.4 Where thermal conditioning equipment is fitted to the fuel cell power system exhaust, the resulting back pressure is to remain within the allowable limit of the fuel cell module.*	
Chapter 26: Fuel cell Power installations	Section 4: Design principles for Fuel cell installations	Paragraph 4.6: Fuel cell power installation – Thermal managment system	*4.6.5 A means of collecting and storing any condensate produced by the fuel cell power system is to be provided. Substances which react if mixed are to be provided with separate and distinct condensate drainage arrangements.*	
Chapter 26: Fuel cell Power installations	Section 4: Design principles for Fuel cell installations	Paragraph 4.6: Fuel cell power installation – Thermal managment system	*4.6.6 Condensate collection piping, collection tank and transfer arrangement are to be suitable for the composition of condensate.*	
Chapter 26: Fuel cell Power installations	Section 4: Design principles for Fuel cell installations	Paragraph 4.6: Fuel cell power installation – Thermal managment system	*4.6.7 Where the condensate collection tank is arranged such that more than one fuel cell module delivers condensate to the tank then each fuel cell module is to have a separate feed to the collection tank or, alternatively, the condensate collection piping is to incorporate a means of preventing the cross flow of condensate between fuel cell modules.*	
Chapter 26: Fuel cell Power installations	Section 4: Design principles for Fuel cell installations	Paragraph 4.6: Fuel cell power installation – Thermal	*4.6.8 Where primary fuel ~~or reformed fuel~~ may leak directly into the thermal conditioning equipment, the equipment is to be provided with appropriate extraction and detection means fitted as close as possible after the media outlet from the equipment. Gas extracted is to be vented to a safe location on the open deck.*	

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<tr><td></td><td></td><td>managment system</td><td>
<table>
<tr><td>Item</td><td>Alarm</td><td>Fuel supply isolation</td><td>Fuel cell power system shutdown</td><td>note</td></tr>
<tr><td>Fuel cell coolant level, pressure</td><td>1st stage low</td><td></td><td>X</td><td>Shutdown within a limited period of time

Cooling water may be monitored at a single point on the supply circuit to fuel cell power system components where supllied by a common system</td></tr>
</table>
</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 4: Design principles for Fuel cell installations</td><td>Paragraph 4.8: Fuel cell power installation – control system</td><td>4.8.1 Safety related parts of the fuel cell control systems shall be designed to be independent from any other control and monitoring systems or shall comply with the process as described in industry standards acceptable to LR for the performance level or equivalent.</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 4: Design principles for Fuel cell installations</td><td>Paragraph 4.8: Fuel cell power installation – control system</td><td>4.8.2 Alarm, control and safety systems are to be designed as far as practicable to function independently from each other.</td><td></td></tr>
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<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 4: Design principles for Fuel cell installations</td><td>Paragraph 4.8: Fuel cell power installation – control system</td><td><i>4.8.3 Fuel cell power installations shall be designed for automatic operation and equipped with all the monitoring and control facilities required for safe operation of the system. These facilities may be provided at the ship’s main control station or, alternatively, at subsidiary control stations. In the latter case, a master alarm display is to be provided at the main control station showing which of the subsidiary control stations is indicating a fault condition.</i></td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 4: Design principles for Fuel cell installations</td><td>Paragraph 4.8: Fuel cell power installation – control system</td><td><i>4.8.4 Chemical reactions, such as those taking place during fuel reforming, if fitted, or within the fuel cell modules, are to be monitored at the control station, e.g. by means of temperature, pressure or voltage monitoring.</i>
<table>
<tr><th><i>Item</i></th><th><i>Alarm</i></th><th><i>Fuel supply isolation</i></th><th><i>Fuel cell power system shutdown</i></th><th><i>note</i></th></tr>
<tr><td><i>Fuel cell module pressure</i></td><td><i>First stage high</i></td><td></td><td></td><td></td></tr>
<tr><td><i>Fuel cell module pressure</i></td><td><i>2nd stage high</i></td><td></td><td></td><td></td></tr>
<tr><td><i>Fuel cell module temperature</i></td><td><i>First stage low</i>
<i>First stage high</i></td><td></td><td></td><td><i>Low temperaturemay be omitted if agreed to by LR</i></td></tr>
<tr><td><i>Fuel cell module temperature</i></td><td><i>2nd stage low</i></td><td></td><td><i>X</i></td><td><i>Low temperature may be omitted if agreed to by LR</i></td></tr>
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<table>
<tr><td></td><td><i>2nd stage high</i></td><td></td><td></td><td></td></tr>
<tr><td><i>Fuel cell module voltage, current</i></td><td><i>Out of Range</i></td><td></td><td></td><td></td></tr>
</table>
</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 4: Design principles for Fuel cell installations</td><td>Paragraph 4.8: Fuel cell power installation – control system</td><td>
<i>4.8.5 Alarms are to be provided to notify of abnormal conditions and faults.</i>
<table>
<tr><td><i>Item</i></td><td><i>Alarm</i></td><td><i>Fuel supply isolation</i></td><td><i>Fuel cell power system shutdown</i></td><td><i>note</i></td></tr>
<tr><td><i>Fuel cell module pressure</i></td><td><i>First stage high</i></td><td></td><td></td><td></td></tr>
<tr><td><i>Fuel cell module pressure</i></td><td><i>2nd stage high</i></td><td></td><td></td><td></td></tr>
<tr><td><i>Fuel cell module temperature</i></td><td><i>First stage low
First stage high</i></td><td><i>2nd stage low
2nd stage high</i></td><td><i>X</i></td><td><i>Low temperaturemay be omitted if agreed to by LR</i></td></tr>
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2nd stage high</i></td><td></td><td><i>X</i></td><td><i>Low temperaturemay be omitted if agreed to by LR</i></td></tr>
<tr><td><i>Fuel cell module voltage, current</i></td><td><i>Out of range</i></td><td></td><td></td><td></td></tr>
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Conditions	Item	Documentation	Additional Description	Information
Chapter 26: Fuel cell Power installations	Section 4: Design principles for Fuel cell installations	Paragraph 4.8: Fuel cell power installation – control system	*4.8.6 As a minimum, alarms are to be provided in accordance with Table 26.4.1 Fuel cell power installation alarms and safeguards. A justification is to be provided for any items considered not applicable to the fuel cell installation.*	
Chapter 26: Fuel cell Power installations	Section 4: Design principles for Fuel cell installations	Paragraph 4.8: Fuel cell power installation – control system	*4.8.7 Alarms additional to the ones required by Table 26.4.1 Fuel cell power installation alarms and safeguards may be recommended for unconventional or complex fuel cell power installations.*	
Chapter 26: Fuel cell Power installations	Section 4: Design principles for Fuel cell installations	Paragraph 4.8: Fuel cell power installation – control system	*4.8.8 If limit values determined for the control process, e.g. temperature, pressure, voltage, gas concentrations, which may lead to hazardous situations are exceeded, the fuel cell power system is to be automatically shut down and interlocked by an independent protective device.*	
Chapter 26: Fuel cell Power installations	Section 4: Design principles for Fuel cell installations	Paragraph 4.8: Fuel cell power installation – control system	*4.8.9 Safeguards, including shutdowns, to be provided are to take account of any related requirements or recommendations from the engineering and safety justification. As a minimum, safeguards are to be provided in accordance with Table 26.4.1 Fuel cell power installation alarms and safeguards. A justification is to be provided for any items considered not applicable to the fuel cell installation.*	
Chapter 26: Fuel cell Power installations	Section 4: Design principles for Fuel cell installations	Paragraph 4.8: Fuel cell power installation – control system	*4.8.10 Safeguards additional to the ones required by Table 26.4.1 Fuel cell power installation alarms and safeguards may be recommended for unconventional or complex fuel cell power installations.*	
Chapter 26: Fuel cell Power installations	Section 4: Design principles for Fuel cell installations	Paragraph 4.8: Fuel cell power installation – control system	*4.8.11 It shall be possible to shut down the fuel cell power system from an easily accessible location outside the fuel cell spaces.*	

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 4: Design principles for Fuel cell installations</td><td>Paragraph 4.8: Fuel cell power installation – control system</td><td><i>4.8.12 The output voltage, current and frequency (where applicable) of the fuel cell power installation are to be displayed at the control station for the fuel cell power installation.</i>
<table>
<tr><td><i>Item</i></td><td><i>Alarm</i></td><td><i>Fuel supply isolation</i></td><td><i>Fuel cell power system shutdown</i></td><td><i>note</i></td></tr>
<tr><td><i>Power conditioning output voltage, current and frequency</i></td><td><i>Out of range</i></td><td></td><td></td><td></td></tr>
</table></td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 4: Design principles for Fuel cell installations</td><td>Paragraph 4.8: Fuel cell power installation – control system</td><td><i>4.8.13 The output voltage and current of each fuel cell module and the output voltage and current at the outlet of power conditioning equipment are to be displayed at the control station for the fuel cell power installation.</i>
<table>
<tr><td><i>Item</i></td><td><i>Alarm</i></td><td><i>Fuel supply isolation</i></td><td><i>Fuel cell power system shutdown</i></td><td><i>note</i></td></tr>
<tr><td><i>Fuel cell module voltage, current</i></td><td><i>Out of range</i></td><td></td><td></td><td></td></tr>
<tr><td><i>Power conditioning output voltage, current and frequency</i></td><td><i>Out of range</i></td><td></td><td></td><td></td></tr>
<tr><td><i>Emergency release button</i></td><td><i>Logical alarm</i></td><td><i>X</i></td><td><i>X</i></td><td></td></tr>
</table></td><td></td></tr>
<tr><td>Chapter 26: Fuel cell</td><td>Section 5:</td><td>Paragrah 5.1 Materials</td><td><i>5.1.1 In addition to the fuel cell specific requirements within these Rules, where fuel cell installations incorporate materials included in the Rules for the</i></td><td></td></tr>
</table>

Conditions	Item	Documentation	Additional Description	Information
Power installations	Materials, equipment and components		*Manufacture, Testing and Certification of Materials, they are to satisfy the corresponding requirements therein.*	
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.1 Materials	*5.1.2 The materials within the fuel cell power installation shall be suitable for the intended application and are to comply with recognised International or National Standards.*	
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.1 Materials	*5.1.3 The use of combustible materials within the fuel cell power system shall be kept to a minimum.*	
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.1 Materials	*5.1.4 Pipes, valves and other components for the containment of hydrogen or hydrogen rich gas are to be constructed of austenitic stainless steel. Other materials are subject to special consideration where they can be demonstrated to:* *(a) be resistant to the chemical and physical action of hydrogen at the operating conditions, including consideration of hydrogen embrittlement and hydrogen attack;* *(b) be suitable for the intended application, including consideration of hydrogen permeability, static accumulation and sparking;* *(c) have hydrogen compatibility in accordance with a recognised International or National Standard (e.g. ASME B31.12 Hydrogen Piping and Pipelines); and* *(d) comply with any specifications and test procedures considered necessary by LR.*	
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.2: Piping and pressurised equipment and components	*5.2.1 In addition to the fuel cell specific requirements within these Rules, where fuel cell power installations incorporate piping components included in Pt 5 Main and Auxiliary Machinery, they are to satisfy the corresponding requirements therein.*	

Conditions	Item	Documentation	Additional Description	Information
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.2: Piping and pressurised equipment and components	*5.2.2 All pipes containing reformed fuel for fuel cell power systems, where fitted, shall:* *(a) not be led through enclosed spaces outside of fuel cell spaces;* *(b) be fully welded as far as practicable;* *(c) be arranged to minimise the number of connections; and* *(d) use fixed hydrogen detectors being capable of detecting a hydrogen leak in places where leakage of hydrogen may occur, such as valves, flanges and seals.*	
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.2: Piping and pressurised equipment and components	*5.2.3 Piping sections which can be isolated containing fuel and are not open-ended are to be provided with relief valves. Alternative arrangements may be considered where an equivalent level of safety can be demonstrated.*	
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.2: Piping and pressurised equipment and components	*5.2.4 The design pressure is the maximum permissible working pressure and is to be not less than the highest set pressure of the safety valve or relief valve. In no case is the design pressure to be less than 10 barg except for open-ended piping where the minimum design pressure is to be 5 barg.*	
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.2: Piping and pressurised equipment and components	*5.2.5 The design pressure of feed piping and other piping on the discharge from pumps is to be taken as the pump pressure at full rated speed against a shut valve. Where a safety valve or other protective device is fitted to restrict the pressure to a lower value than the shut valve load, the design pressure is to be the highest set pressure of the device.*	
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.2: Piping and pressurised	*5.2.6 Low temperature piping is to be thermally isolated from the adjacent hull structure, where the piping temperature can be lower than the design temperature of the hull.*	

Conditions	Item	Documentation	Additional Description	Information
		equipment and components		
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.2: Piping and pressurised equipment and components	*5.2.7 Piping is to demonstrate electrical continuity and be earth bonded to the hull.*	
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.2: Piping and pressurised equipment and components	*5.2.8 Heat exchangers and evaporators are to be designed to prevent cross-contamination between the primary and secondary sides of the heat exchanger and are to incorporate an alarm and fuel supply shutdown in the event of cross-contamination.*	
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.2: Piping and pressurised equipment and components	*5.2.10 Where connections and non-welded joints for piping are required, they are to be of an approved type and are to:* *(a) be resistant to the chemical and physical action of hydrogen at the operating conditions, including consideration of hydrogen embrittlement and hydrogen attack;* *(b) be suitable for the intended application, including consideration of hydrogen permeability, static accumulation and sparking;* *(c) demonstrate hydrogen compatibility in accordance with a recognised International or National Standard (e.g. ASME B31.12 Hydrogen Piping and Pipelines); and* *(d) comply with any specifications and test procedures considered necessary by LR.*	
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.3: Mechanical equipment and components	*5.3.1 In addition to the fuel cell specific requirements within these Rules, where fuel cell power installations incorporate mechanical equipment and components included in Pt 5 Main and Auxiliary Machinery, they are to satisfy the corresponding requirements therein.*	

Conditions	Item	Documentation	Additional Description	Information
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.3: Mechanical equipment and components	*5.3.2 Mechanical equipment is not to be installed in hazardous areas unless essential for operational purposes or safety enhancement.*	
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.3: Mechanical equipment and components	*5.3.3 The design, arrangements and selection of mechanical equipment and components for use in hazardous areas are to minimise sources of ignition.*	
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.3: Mechanical equipment and components	*5.3.4 Mechanical equipment and components intended for use in a hazardous area are to be designed, constructed and installed to ensure that they are:* *(a) capable of safe operation in normal and all reasonably foreseeable hazardous conditions;* *(b) capable of preventing the formation of a hazardous and toxic atmosphere that may be produced or released by the components or equipment;* *(c) capable of preventing the ignition of hazardous atmospheres, taking into account the nature of every electrical and non-electrical source of ignition; and,* *(d) appropriate for use in a hazardous area in accordance with a recognised International or National Standard, such as BS EN 13463-1 Non-electrical equipment for use in potentially explosive atmospheres.*	
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.4: Electrical equipment and components	*5.4.1 In addition to the fuel cell specific requirements within these Rules, where fuel cell power installations incorporate electrical equipment and components included in Pt 6, Ch 2 Electrical Engineering, they are to satisfy the corresponding requirements therein.*	
Chapter 26: Fuel cell	Section 5:	Paragrah 5.4:	*5.4.2 Electrical equipment shall not be installed in hazardous areas unless essential for operational purposes or safety enhancement.*	

Conditions	Item	Documentation	Additional Description	Information
Power installations	Materials, equipment and components	Electrical equipment and components		
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.4: Electrical equipment and components	*5.4.3 Where electrical equipment including components of fuel cell power systems is installed in hazardous areas, it is be selected, installed and maintained in accordance with recognised International or National Standards such as IEC 60079-10 Explosive atmospheres Part 10-1: Classification of areas – Explosive gas atmospheres.*	
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.4: Electrical equipment and components	*5.4.4 In order to facilitate the selection of appropriate electrical apparatus and the design of suitable electrical installations, hazardous areas are divided into Zones 0, 1 and 2, according to Pt 5, Ch 26, 5.4 Electrical equipment and components 5.4.5. In cases where the prescriptive provisions in Pt 5, Ch 26, 5.4 Electrical equipment and components 5.4.5 are deemed to be inappropriate, area classification according to IEC 60079-10 Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres shall be applied with special consideration by LR and the Administration.*	
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.4: Electrical equipment and components	*5.4.5 Definition of zones* *(a) Hazardous areas Zone 0* *The interiors of buffer tanks, reformers, pipes and equipment containing low-flashpoint fuel or reformed fuel, any pipework of pressure-relief or other venting.* *(b) Hazardous areas Zone 1* *(i) areas on open deck or semi-enclosed spaces on deck within 3 m of any reformed fuel or purge gas outlets or fuel cell space ventilation outlets;* *(ii) fuel cell exhaust air and exhaust gas outlets;* *(iii) areas on open deck or semi-enclosed spaces on deck within 1,5 m of fuel cell space entrances, fuel cell space ventilation inlets and other openings into Zone 1 spaces;*	

Conditions	Item	Documentation	Additional Description	Information
			(iv) areas on open deck or semi-enclosed spaces within 3 m of areas in which other sources of release of reformed fuel are located; and *(v) fuel cell spaces.* *(c) Hazardous areas Zone 2* *(i) areas within 1,5 m surrounding open or semi-enclosed spaces of Zone 1 as specified above, if not otherwise specified; and* *(ii) airlocks.*	
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.4: Electrical equipment and components	*5.4.6 Ventilation ducts are to have the same area classification as the ventilated space.*	
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.5: Monitoring, control, alarm and safety system equipment and components	*5.5.1 In addition to the fuel cell specific requirements within these Rules, where fuel cell power installations incorporate monitoring control, alarm and safety systems, equipment and components included in Pt 6, Ch 1 Control Engineering Systems, they are to satisfy the corresponding requirements therein.*	
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.5: Monitoring, control, alarm and safety system equipment and components	*5.5.2 For gas detection, requirements of the IGF Code section 15.8 are to be satisfied as appropriate as given in the Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels.*	
Chapter 26: Fuel cell Power installations	Section 5: Materials, equipment and components	Paragrah 5.5: Monitoring, control, alarm and safety	*5.5.3 The fuel cell shall be monitored appropriately to avoid any loss or degradation of its safety.*	

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td>system equipment and components</td><td></td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 5: Materials, equipment and components</td><td>Paragrah 5.5: Monitoring, control, alarm and safety system equipment and components</td><td><i>5.5.4 All operating conditions are to be monitored to verify they are within the acceptable design range.</i></td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 5: Materials, equipment and components</td><td>Paragrah 5.5: Monitoring, control, alarm and safety system equipment and components</td><td><i>5.5.5 A Failure Mode and Effects Analysis (FMEA) shall be used to analyse and determine the extent of monitoring and control of the fuel cell power systems. The following shall be included as a minimum:</i>
<i>(a) voltage of fuel cells;</i>
<i>(b) temperature of exhaust gas and exhaust air;</i>
<i>(c) the internal temperature of the fuel cell. When the internal temperature reaches 80 per cent of the self-ignition temperature for the reformed fuel used, the load of the fuel cell shall be disconnected or reduced, or other cooling measures shall be taken;</i>
<i>(d) purity of the reformed fuel;</i>
<i>(e) output current;</i>
<i>(f) contamination of air into fuel cell fuel lines, or of fuel cell fuel into air pipes.</i>
<table>
<tr><th><i>Item</i></th><th><i>Alarm</i></th><th><i>Fuel supply isolation</i></th><th><i>Fuel cell power system shutdown</i></th><th><i>note</i></th></tr>
<tr><td><i>Fuel cell module temperature</i></td><td><i>First stage low</i></td><td></td><td></td><td><i>Low temperaturemay be omitted if agreed to by LR</i></td></tr>
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<tr><td></td><td><i>First stage high</i></td><td></td><td></td><td></td></tr>
<tr><td><i>Fuel cell module temperature</i></td><td><i>2nd stage low</i>
<i>2nd stage high</i></td><td></td><td><i>X</i></td><td><i>Low temperaturemay be omitted if agreed to by LR</i></td></tr>
<tr><td><i>Fuel cell module exhaust temperature</i></td><td><i>1st stage high</i></td><td></td><td></td><td></td></tr>
<tr><td><i>Fuel cell module exhaust temperature</i></td><td><i>2nd stage high</i></td><td></td><td><i>X</i></td><td></td></tr>
<tr><td><i>Fuel cell module voltage, current</i></td><td><i>Out of range</i></td><td></td><td></td><td></td></tr>
<tr><td><i>Power conditioning output voltage, current and frequency</i></td><td><i>Out of range</i></td><td></td><td></td><td></td></tr>
<tr><td><i>Emergency release button</i></td><td><i>A</i></td><td><i>X</i></td><td><i>X</i></td><td></td></tr>
</table>
</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 5: Materials, equipment and components</td><td>Paragrah 5.5: Monitoring, control, alarm and safety system equipment and components</td><td><i>5.5.6 The following monitoring contents shall be considered according to the type and working condition of fuel cell:</i>
<i>(a) air flow;</i>
<i>(b) air pressure;</i>
<i>(c) flow rate, pressure and temperature of cooling medium;</i>
<i>(d) fuel flow;</i>
<i>(e) fuel temperature;</i></td><td></td></tr>
</table>

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<tr><td></td><td></td><td></td><td><i>(f) fuel pressure;</i>
<i>(g) gas detection of exhaust fuel and exhaust air;</i>
<i>(h) liquid level of water system;</i>
<i>(i) pressure of water system;</i>
<i>(j) purity of water system;</i>
<i>(k) parameters necessary to monitor life time/deterioration of fuel cell.</i>
<i>(l) balancing the air-to-fuel ratio in operation.</i></td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 5: Materials, equipment and components</td><td>Paragrah 5.5: Monitoring, control, alarm and safety system equipment and components</td><td><i>5.5.7 The fuel cell shall be provided with fault monitoring sensors to maintain the reaction process within the design limits.</i></td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 5: Materials, equipment and components</td><td>Paragrah 5.5: Monitoring, control, alarm and safety system equipment and components</td><td><i>5.5.10 Gas/vapour detection shall be provided in the fuel cell’s coolant supply/header tank, and this should cause an alarm.</i></td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 5: Materials, equipment and components</td><td>Paragrah 5.5: Monitoring, control, alarm and safety system equipment and components</td><td><i>5.5.11 Gas/vapour detection shall be provided at the process air outlet exhaust, and this should cause an alarm.</i>
<table>
<tr><td><i>Item</i></td><td><i>Alarm</i></td><td><i>Fuel supply isolation</i></td><td><i>Fuel cell power system shutdown</i></td><td><i>note</i></td></tr>
<tr><td><i>Fuel cell module gas detection 20% LEL</i></td><td><i>1st stage high</i></td><td></td><td></td><td></td></tr>
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<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 5: Materials, equipment and components</td><td>Paragrah 5.5: Monitoring, control, alarm and safety system equipment and components</td><td><i>5.5.12 Gas/vapour detection shall be provided in the inter-barrier spaces, and this should cause an alarm.</i></td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 5: Materials, equipment and components</td><td>Paragrah 5.5: Monitoring, control, alarm and safety system equipment and components</td><td><i>5.5.13 Two independent gas detectors located close to each other are required for redundancy reasons (1oo2). If the gas detector is of the self-monitoring type, the installation of a single gas detector can be permitted.</i></td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 5: Materials, equipment and components</td><td>Paragrah 5.5: Monitoring, control, alarm and safety system equipment and components</td><td><i>5.5.14 Manual activation of emergency shutdown shall be arranged in the following locations as applicable:</i>
<i>(a) navigation bridge;</i>
<i>(b) onboard safety centre;</i>
<i>(c) engine control room;</i>
<i>(d) fire control station; and</i>
<i>(e) adjacent to the exit of the fuel cell space.</i></td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 6: Fire and explosion safety</td><td>Paragrah 6.1: Fire protection</td><td><i>6.1.3 The fire-extinguishing system is to be suitable for use with the specific fuel and fuel cell technology. LR and the Administration may allow any alternative fire safety measures if the equivalence of the measure is demonstrated by a risk assessment considering the characteristics of fuels for use.</i></td><td></td></tr>
</table>

Conditions	Item	Documentation	Additional Description	Information
Chapter 26: Fuel cell Power installations	Section 6: Fire and explosion safety	Paragrah 6.1: Fire protection	*6.1.4 Where any part of the fuel cell power system is intended to operate with a continuous leakage of hydrogen rich gas, the fire and safety provisions are to be derived from the engineering and safety justification.*	
Chapter 26: Fuel cell Power installations	Section 6: Fire and explosion safety	Paragrah 6.2: Explosion protection	*6.2.2 Failures leading to dangerous overpressure, e.g. gas pipe ruptures or blow out of gaskets, shall be mitigated by suitable explosion pressure relief devices and ESD arrangements.*	
Chapter 26: Fuel cell Power installations	Section 6: Fire and explosion safety	Paragrah 6.2: Explosion protection	*6.2.3 The probability of a gas accumulation and explosion in fuel cell spaces shall be minimised by one or more of the following strategies:* *(a) purging the fuel cell power system before initiating the reaction;* *(b) purging the system as necessary after shutdown;* *(c) providing failure monitoring in the fuel cell fuel containment systems;* *(d) monitoring potential contamination of air into fuel cell fuel lines, or of fuel cell fuel into air pipes;* *(e) monitoring pressures and temperatures;* *(f) implementing a pre-programmed sequence to contain or manage the propagation of the reaction to other sections of the fuel cell system or to the surrounding space; and* *(g) any other strategy proposed by the manufacturer to the satisfaction of LR.*	
Chapter 26: Fuel cell Power installations	Section 6: Fire and explosion safety	Paragrah 6.3: Fire detection	*6.3.1 A fixed fire detection and fire alarm system complying with the Fire Safety Systems Code shall be provided.*	
Chapter 26: Fuel cell Power installations	Section 6: Fire and explosion safety	Paragrah 6.3: Fire detection	*6.3.5 Fire detection shall initiate automatic shutdown and isolation of the hydrogen supply within the fuel cell space.* *Item* | *Alarm* | *Fuel supply isolation* | *Fuel cell power system shutdown* | *note*	

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td><table><tr><td>Fire detection</td><td>Logical alarm</td><td>X</td><td>X</td><td>Detection at all locations required by the rules</td></tr></table></td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 6: Fire and explosion safety</td><td>Paragrah 6.3: Fire detection</td><td>6.3.6 Fire detection is to be arranged such that the activation of any fire detectors in, or adjacent to, hazardous areas or spaces containing gaseous, cryogenic liquid, toxic, corrosive or liquid fuels with a flash point below 60°C will automatically shut down any part of the fuel cell power system within or adjacent to such spaces.<table><tr><td>Item</td><td>Alarm</td><td>Fuel supply isolation</td><td>Fuel cell power system shutdown</td><td>note</td></tr><tr><td>Fire detection</td><td>Logical alarm</td><td>X</td><td>X</td><td>Detection at all locations required by the rules</td></tr></table></td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 6: Fire and explosion safety</td><td>Paragrah 6.4: Fire extinguishing</td><td>6.4.2 The fire-extinguishing system shall be suitable for use with the specific primary and reformed fuel and fuel cell technology proposed.</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell Power installations</td><td>Section 6: Fire and explosion safety</td><td>Paragrah 6.5: Fire dampers</td><td>6.5.1 Air inlet and outlet openings shall be provided with fail safe automatic closing fire dampers which shall be operable from outside the fuel cell space.</td><td></td></tr>
<tr><td>Chapter 26: Fuel cell</td><td>Section 6:</td><td>Paragrah 6.5: Fire dampers</td><td>6.5.2 Before actuation of the fire-extinguishing system the fire dampers shall be closed.</td><td></td></tr>
</table>

Conditions	Item	Documentation	Additional Description	Information
Power installations	Fire and explosion safety			
Chapter 26: Fuel cell Power installations	Section 7: Testing and trails	Paragrah 7.1: Testing	*7.1.1 The fuel cell models are to be factory tested in accordance with a recognised National or International Standard acceptable to LR.*	
Chapter 26: Fuel cell Power installations	Section 7: Testing and trails	Paragrah 7.1: Testing	*7.1.2 The fuel cell power system is to be factory tested in accordance with an approved test schedule.*	
Chapter 26: Fuel cell Power installations	Section 7: Testing and trails	Paragrah 7.2: Trials	*7.2.1 Commissioning tests and trials of the fuel cell power system are to be carried out in accordance with a testing programme which is to be agreed by LR, and all tests are to be carried out in the presence of a Surveyor.*	
Chapter 26: Fuel cell Power installations	Section 7: Testing and trails	Paragrah 7.2: Trials	*7.2.2 Trials are to include the testing of all alarms and safeguards associated with the fuel cell power installation for all modes of operation as defined in the service profile*	

Annex 34: GUIDE RISK BASED DESIGN (LR)

GUIDE RISK BASED DESIGN (LR)

A. IDENTITY CARD OF GUIDE RISK BASED DESIGN (LR)

RCS	Number of RCS	Title	Date	Stability date	Statutory
Guidance	RBD	Risk based design	2018	2018	yes

Scope: This procedure provides additional guidance in satisfying the requirements of Classification Rules and Statutory Conventions when using risk based techniques. This requirement may be for designs which deviate from existing specific Rule and Regulation requirements, or for novel or complex designs where prescriptive Rules and Regulations do not currently apply. The use of risk based techniques will involve the production of documents detailing the technical outcome of the risk assessment. Such documents should be considered as supporting evidence and be marked accordingly. Where risk based techniques are used in design, the generic description is Risk Based Designs (RBD).

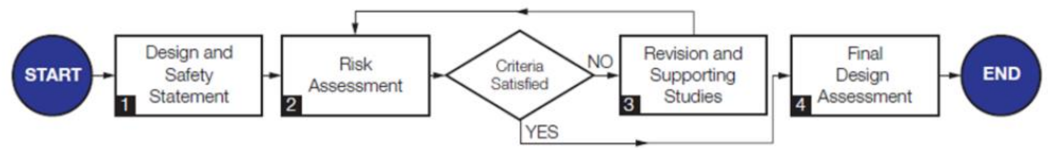
Domain/category: Ships

Specifed exclusion: /

Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

This guide is relevant to StasHH to explain the process to be used for risk analysis, particularly in the case of alternative designs/processes for ships.

Conditions	Item	Documentation	Additional Description	Information
Section3: Process Application	3.1: Process application		 **Figure 1.3.1 Generic Process for Risk Based Designs (RBD)**	
Section 4: Process description	4.1: Process description	4.1.1	The following figures provide a description of the process steps within each stage of the appraisal of Risk Based Designs (RBD) together with an example of assigned responsibilities	
Section 4: Process description	4.2 RBD – Stage 1 Appraisal, Design and Safety Statement	4.2.1	A checklist of items to be considered at each stage is also given in Table 1.4.1 Stage 1 Appraisal, Design and Safety Statement	

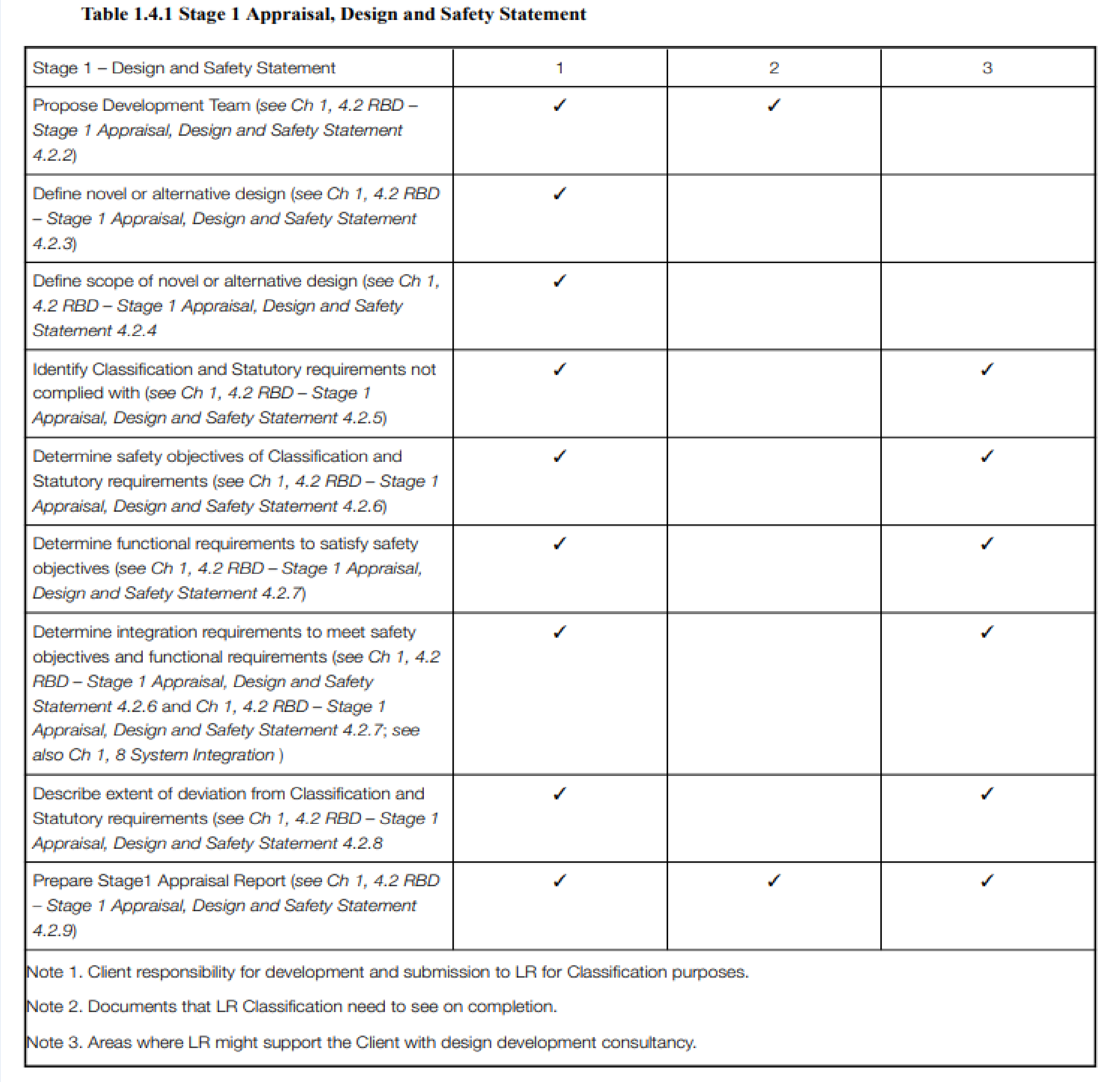
Conditions	Item	Documentation	Additional Description	Information
				

Table 1.4.1 Stage 1 Appraisal, Design and Safety Statement

Stage 1 – Design and Safety Statement	1	2	3
Propose Development Team (see *Ch 1, 4.2 RBD – Stage 1 Appraisal, Design and Safety Statement 4.2.2*)	✓	✓	
Define novel or alternative design (see *Ch 1, 4.2 RBD – Stage 1 Appraisal, Design and Safety Statement 4.2.3*)	✓		
Define scope of novel or alternative design (see *Ch 1, 4.2 RBD – Stage 1 Appraisal, Design and Safety Statement 4.2.4*	✓		
Identify Classification and Statutory requirements not complied with (see *Ch 1, 4.2 RBD – Stage 1 Appraisal, Design and Safety Statement 4.2.5*)	✓		✓
Determine safety objectives of Classification and Statutory requirements (see *Ch 1, 4.2 RBD – Stage 1 Appraisal, Design and Safety Statement 4.2.6*)	✓		✓
Determine functional requirements to satisfy safety objectives (see *Ch 1, 4.2 RBD – Stage 1 Appraisal, Design and Safety Statement 4.2.7*)	✓		✓
Determine integration requirements to meet safety objectives and functional requirements (see *Ch 1, 4.2 RBD – Stage 1 Appraisal, Design and Safety Statement 4.2.6* and *Ch 1, 4.2 RBD – Stage 1 Appraisal, Design and Safety Statement 4.2.7*; see also *Ch 1, 8 System Integration*)	✓		✓
Describe extent of deviation from Classification and Statutory requirements (see *Ch 1, 4.2 RBD – Stage 1 Appraisal, Design and Safety Statement 4.2.8*	✓		✓
Prepare Stage1 Appraisal Report (see *Ch 1, 4.2 RBD – Stage 1 Appraisal, Design and Safety Statement 4.2.9*)	✓	✓	✓

Note 1. Client responsibility for development and submission to LR for Classification purposes.

Note 2. Documents that LR Classification need to see on completion.

Note 3. Areas where LR might support the Client with design development consultancy.

Conditions	Item	Documentation	Additional Description	Information
Section 4: Process description	4.2 RBD – Stage 1 Appraisal, Design and Safety Statement	4.2.2 Propose Development Team	Relevant requirements: • IMO MSC Circ.1002, 4.1-4.3. • IMO MSC Circ.1212, 4.1-4.3. • Pt 7, Ch 14, 1.7.3 Risk management of LR's Rules for Ships. • MSC-MEPC.2/Circ12/Rev.1 IMO FSA • Guidelines 18th June 2015, Table 1 page 46. • IACS Rec 46 Risk Assessment as required by the IGF Code. Ch 1, 7 Acceptable Risk Criteria .	

Section 4: Process description	4.2 RBD – Stage 1 Appraisal, Design and Safety Statement	4.2.3	Define novel or alternative design:
			• Functional requirements including underway, manoeuvring, berthing and alongside and other operational modes as required by the operational profile of the vessel.
			• System design:
			  • Requirements.
			  • Description.
			  • Block diagram.
			  • Rules, Regulations, Codes and Standards applied.
			• Operational modes:
			  • Start-up.
			  • Shutdown.
			  • Normal operation.
			  • Abnormal operation.
			  • Emergency shutdown*.
			• Relevant requirements:
			  • IMO MSC Circ.1002, 4.3 and 5.1.1.
			  • IMO MSC Circ.1212, 4.3 and 5.1.1.
			  • Pt 7, Ch 14, 1.4.3 of LR's Rules for Ships.
			*Where emergency is any situation which presents an immediate threat to life or the vessel. Abnormal operation is any other degraded state outside of Normal or Emergency	

Section 4: Process description	4.2 RBD – Stage 1 Appraisal,	4.2.4	Define scope of novel or alternative design :• Systems and arrangements. • Spaces, separation, containment, ventilation.	

Conditions	Item	Documentation	Additional Description	Information
	Design and Safety Statement		• Consumers (e.g. Main engines, boilers). • Control, alarm and safety systems (e.g. gas detection). • Fire protection. • Fire detection. • Fire-extinguishing. • Relevant requirements.	
Section 4: Process description	4.2 RBD – Stage 1 Appraisal, Design and Safety Statement	4.2.5	Identify Classification and Statutory requirements not complied with: • Fire Safety. • Mechanical. • Structural. • Electrical. • Control, Alarm and Safety System	
Section 4: Process description	4.2 RBD – Stage 1 Appraisal, Design and Safety Statement	4.2.6	Determine safety objectives of Classification and Statutory requirements: • Fire Safety. • Mechanical. • Structural. • Electrical. • Control, Alarm and Safety Systems. • Systems integration – see Ch 1, 8 System Integration .	
Section 4: Process description	4.2 RBD – Stage 1 Appraisal, Design and Safety Statement	4.2.7	Determine functional requirements to satisfy safety objectives • Fire Safety. • Mechanical. • Structural. • Electrical. • Control, Alarm and Safety Systems. • Systems integration – see Ch 1, 8 System Integration	
Section 4: Process description	4.2 RBD – Stage 1 Appraisal, Design and	4.2.8 Classification and Statutory requirements	Describe overall extent of deviation from • Extent of deviation from functional requirements. • Extent of deviation from prescriptive requirements.	

Conditions	Item	Documentation	Additional Description	Information
	Safety Statement			
Section 4: Process description	4.2 RBD – Stage 1 Appraisal, Design and Safety Statement	4.2.9	Prepare Stage 1 Appraisal Report: • Above information to be included. • Further Risk Assessment Stages anticipated with justification. • Relevant requirements: IMO MSC Circ. 1002, Annex, 7.1.1-7.1.3.3. IMO MSC Circ. 1212, Annex, 7.1.1-7.1.3.3.	
Section 4: Process description	4.3 RBD – Stage 2 Appraisal, Risk Assessment	4.3.1	A checklist of items to be considered at each stage is also given in Table 1.4.2 RBD – Stage 2 Appraisal, Risk Assessment.	

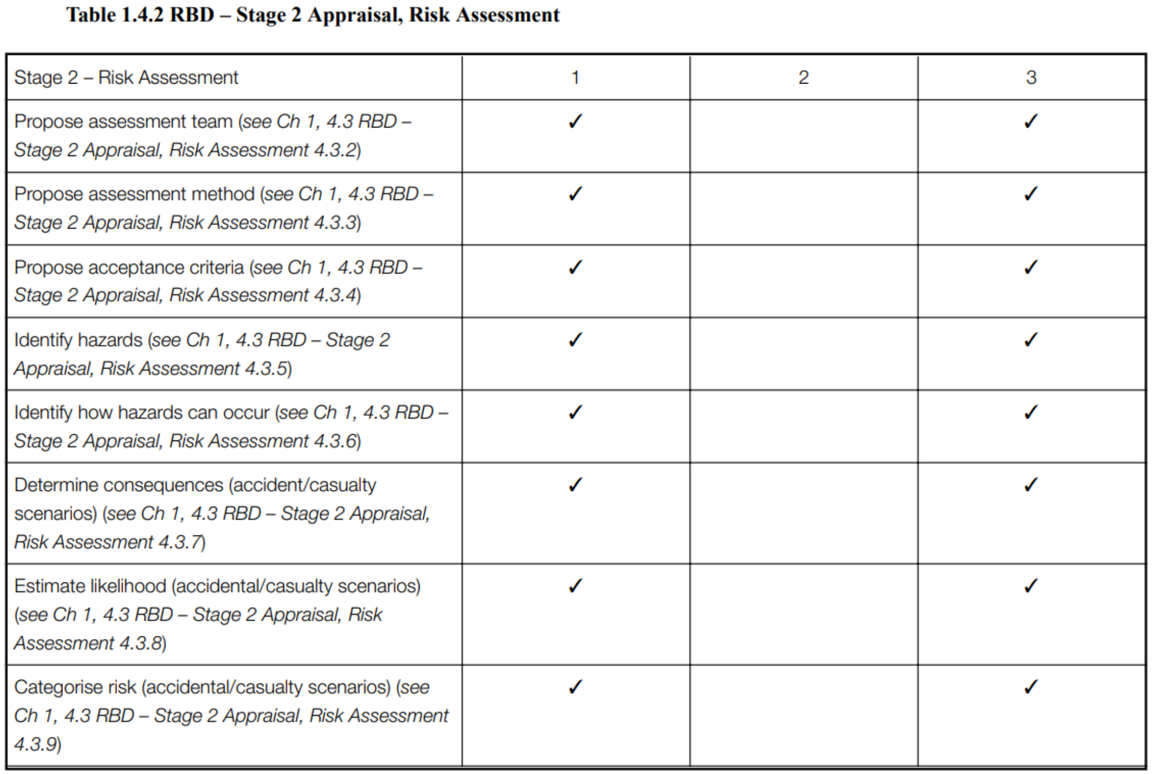
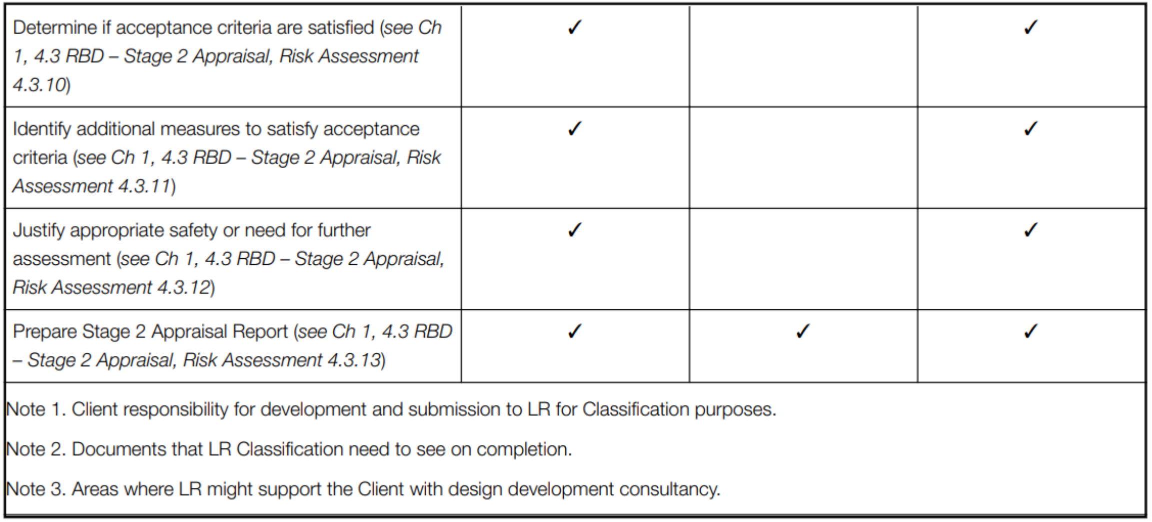
Conditions	Item	Documentation	Additional Description	Information
				

Table 1.4.2 RBD – Stage 2 Appraisal, Risk Assessment

Stage 2 – Risk Assessment	1	2	3
Propose assessment team (*see Ch 1, 4.3 RBD – Stage 2 Appraisal, Risk Assessment 4.3.2*)	✓		✓
Propose assessment method (*see Ch 1, 4.3 RBD – Stage 2 Appraisal, Risk Assessment 4.3.3*)	✓		✓
Propose acceptance criteria (*see Ch 1, 4.3 RBD – Stage 2 Appraisal, Risk Assessment 4.3.4*)	✓		✓
Identify hazards (*see Ch 1, 4.3 RBD – Stage 2 Appraisal, Risk Assessment 4.3.5*)	✓		✓
Identify how hazards can occur (*see Ch 1, 4.3 RBD – Stage 2 Appraisal, Risk Assessment 4.3.6*)	✓		✓
Determine consequences (accident/casualty scenarios) (*see Ch 1, 4.3 RBD – Stage 2 Appraisal, Risk Assessment 4.3.7*)	✓		✓
Estimate likelihood (accidental/casualty scenarios) (*see Ch 1, 4.3 RBD – Stage 2 Appraisal, Risk Assessment 4.3.8*)	✓		✓
Categorise risk (accidental/casualty scenarios) (*see Ch 1, 4.3 RBD – Stage 2 Appraisal, Risk Assessment 4.3.9*)	✓		✓

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td></td><td></td><td>
<table>
<tr><td>Determine if acceptance criteria are satisfied (see Ch 1, 4.3 RBD – Stage 2 Appraisal, Risk Assessment 4.3.10)</td><td>✓</td><td></td><td>✓</td></tr>
<tr><td>Identify additional measures to satisfy acceptance criteria (see Ch 1, 4.3 RBD – Stage 2 Appraisal, Risk Assessment 4.3.11)</td><td>✓</td><td></td><td>✓</td></tr>
<tr><td>Justify appropriate safety or need for further assessment (see Ch 1, 4.3 RBD – Stage 2 Appraisal, Risk Assessment 4.3.12)</td><td>✓</td><td></td><td>✓</td></tr>
<tr><td>Prepare Stage 2 Appraisal Report (see Ch 1, 4.3 RBD – Stage 2 Appraisal, Risk Assessment 4.3.13)</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td colspan="4">Note 1. Client responsibility for development and submission to LR for Classification purposes.
Note 2. Documents that LR Classification need to see on completion.
Note 3. Areas where LR might support the Client with design development consultancy.</td></tr>
</table></td><td></td></tr>
<tr><td>Section 4: Process description</td><td>4.3 RBD – Stage 2 Appraisal, Risk Assessment</td><td>4.3.4 Propose acceptance criteria:</td><td>• Acceptance criteria based on either:
Equivalence with current arrangements.
Risk being As Low As Reasonably Practicable (ALARP).
• Acceptance criteria to account for likelihood and consequence.
• Acceptance criteria to take account of Stage 1 Appraisal Report.
• Acceptance criteria to distinguish risk by a minimum of three groupings:
Unacceptable or intolerable;
Tolerable if ALARP; and
Acceptable, tolerable or negligible.
• Acceptance criteria to ensure appropriate safety margin.
• For Classification items the risk criteria detailed in Ch 1, 7 Acceptable Risk Criteria or criteria as agreed with LR are to be
used. For statutory items, e.g. AD&A, Flag will need to agree to the criteria proposed.
The default criteria should be those
given in Ch 1, 7 Acceptable Risk Criteria .
• Relevant requirements:</td><td></td></tr>
</table>

Conditions	Item	Documentation	Additional Description	Information
			IMO MSC Circ.1002, 5.4.2 and 6.3. IMO MSC Circ.1212, 5.3.1.4 and 6.3. MSC-MEPC.2/Circ12/Rev.1 IMO FSA Guidelines 18th June 2015, Table 1 page 46. IACS Rec 46 Risk Assessment as required by the IGF Code. Ch 1, 7 Acceptable Risk Criteria .	
Section 4: Process description	4.3 RBD – Stage 2 Appraisal, Risk Assessment	4.3.5 Identify hazards:	Hazards are system, design and application specific. Examples include: • Cryogenic burns. • Rapid Phase Transition. • Low temperature embrittlement. • Fire. • Explosion. • Asphyxiation. • Burns. • Pressure release. • Electric shock. • Structural failure. • Flooding. • Loss of essential functionality, e.g., propulsion, auxiliary power. • Integration of the system and sub-systems into the ship must be considered in each case, see Ch 1, 8 System Integration . • Relevant requirements: LR Rules IMO MSC Circ.1002, 5.2.1.1. IMO MSC Circ.1212, 5.3.2.	
Section 4: Process description	4.3 RBD – Stage 2 Appraisal, Risk Assessment	4.3.6 Identify how hazards can occur:	• Normal ship conditions Ship motions (e.g.,inclination, shock, vibration). Equipment degradation. Equipment failure. Control system failure/error. Operational error. Maintenance error.	

Conditions	Item	Documentation	Additional Description	Information
			Fuel characteristics. • Abnormal/emergency ship conditions: Fire outside of the space. Flooding of the space. Ship collision. Grounding. • Operational modes: Start-up. Shutdown. Normal operation. Abnormal operation. Emergency shutdown. • System Integration needs to be considered for normal and abnormal/emergency ship conditions and operational modes. See Ch 1, 8 System Integration . • Relevant requirements: LR Rules IMO MSC Circ.1002, 5.2.1.1. IMO MSC Circ.1212, 5.3.2. MSC-MEPC.2/Circ12/Rev.1 IMO FSA Guidelines 18th June 2015, Table 1 page 46. IACS Rec 46 Risk Assessment as required by the IGF Code. Ch 1, 7 Acceptable Risk Criteria .	
Section 4: Process description	4.3 RBD – Stage 2 Appraisal, Risk Assessment	4.3.7 Determine consequences (accident/casualty scenarios):	• Safety of: Ship. Ship's occupants. Ship's machinery and equipment. Environment. • Severity category: Localised hazards (localised). Major hazards (ship wide). Catastrophic hazards (beyond ship). • Relevant requirements: IMO MSC Circ.1002, 5.2.1.2.	

Conditions	Item	Documentation	Additional Description	Information
			IMO MSC Circ.1212, 5.3.3.	
Section 4: Process description	4.3 RBD – Stage 2 Appraisal, Risk Assessment	4.3.8 Estimate likelihood (accident/casualty scenarios):	• Incident/Accident history: Owner. Ship type. Ship routes (e.g., Europe, Asia, North America). • Other factors: Complexity of equipment and layout. Competency of crew. • Relevant requirements: IMO MSC Circ.1002, 5.2.1.3. IMO MSC Circ.1212, 5.3.4.	
Section 4: Process description	4.3 RBD – Stage 2 Appraisal, Risk Assessment	4.3.9 Categorise risk (accident/casualty scenarios):	• The sensitivity of risk categorisation to small changes in consequence and likelihood judgements (see Ch 1, 4.3 RBD – Stage 2 Appraisal, Risk Assessment 4.3.7 and Ch 1, 4.3 RBD – Stage 2 Appraisal, Risk Assessment 4.3.8). • Relevant requirements: IMO MSC Circ.1002, 5.2.1.3. IMO MSC Circ.1212, 5.3.5.	
Section 4: Process description	4.4 RBD – Stage 3 Appraisal, Revision and Supporting Studies	4.4.1	4.4.1 A checklist of items to be considered at each stage is also given in Table 1.4.3 RBD – Stage 3 Appraisal, Revision and Supporting Studies	

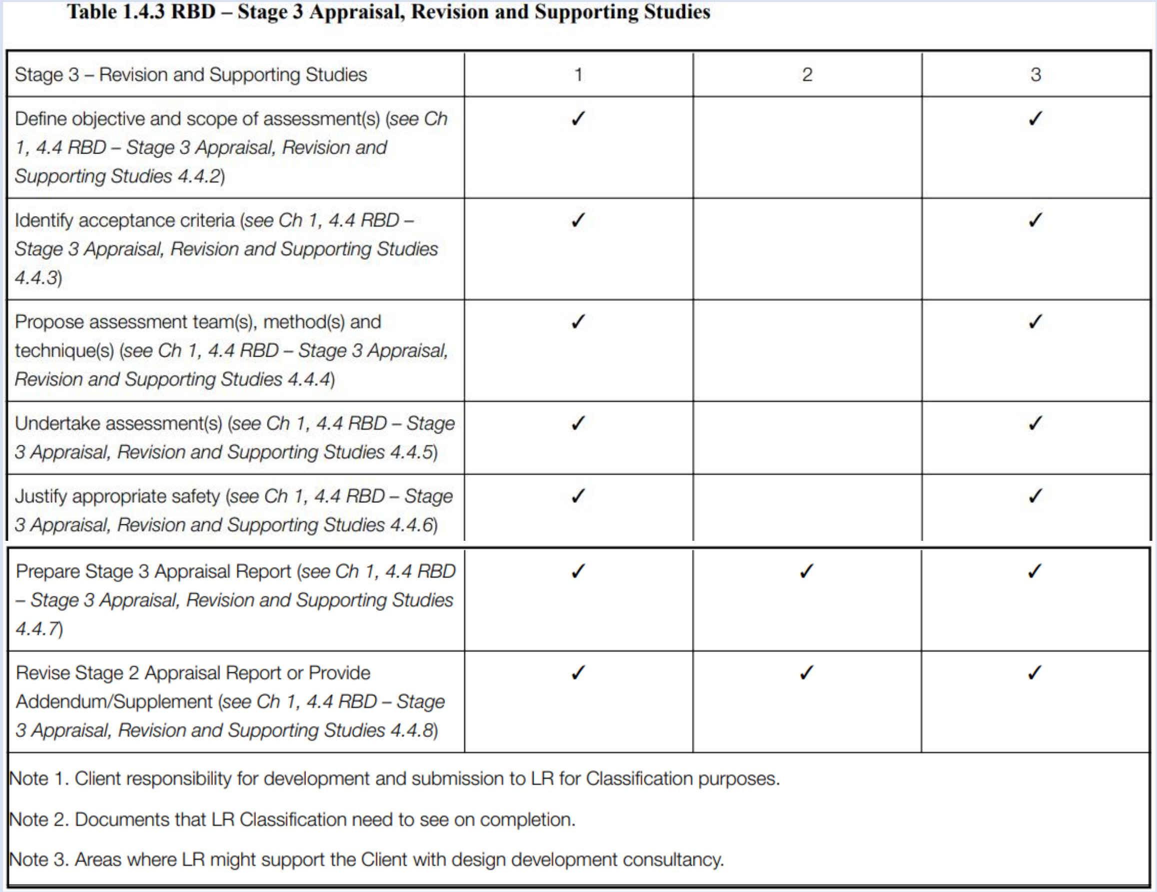
Conditions	Item	Documentation	Additional Description	Information
				

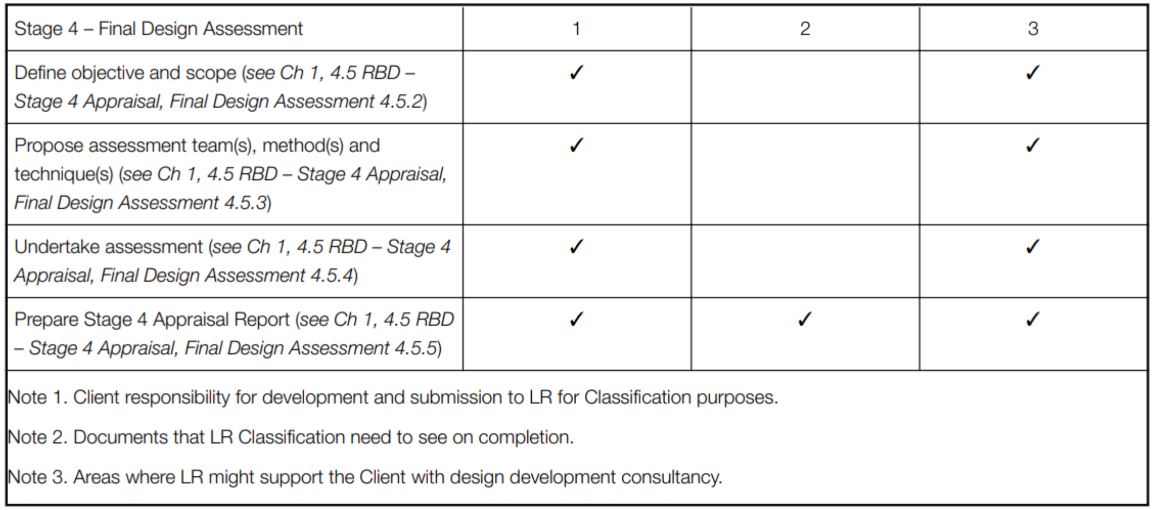
Table 1.4.3 RBD – Stage 3 Appraisal, Revision and Supporting Studies

Stage 3 – Revision and Supporting Studies	1	2	3
Define objective and scope of assessment(s) *(see Ch 1, 4.4 RBD – Stage 3 Appraisal, Revision and Supporting Studies 4.4.2)*	✓		✓
Identify acceptance criteria *(see Ch 1, 4.4 RBD – Stage 3 Appraisal, Revision and Supporting Studies 4.4.3)*	✓		✓
Propose assessment team(s), method(s) and technique(s) *(see Ch 1, 4.4 RBD – Stage 3 Appraisal, Revision and Supporting Studies 4.4.4)*	✓		✓
Undertake assessment(s) *(see Ch 1, 4.4 RBD – Stage 3 Appraisal, Revision and Supporting Studies 4.4.5)*	✓		✓
Justify appropriate safety *(see Ch 1, 4.4 RBD – Stage 3 Appraisal, Revision and Supporting Studies 4.4.6)*	✓		✓
Prepare Stage 3 Appraisal Report *(see Ch 1, 4.4 RBD – Stage 3 Appraisal, Revision and Supporting Studies 4.4.7)*	✓	✓	✓
Revise Stage 2 Appraisal Report or Provide Addendum/Supplement *(see Ch 1, 4.4 RBD – Stage 3 Appraisal, Revision and Supporting Studies 4.4.8)*	✓	✓	✓

Note 1. Client responsibility for development and submission to LR for Classification purposes.

Note 2. Documents that LR Classification need to see on completion.

Note 3. Areas where LR might support the Client with design development consultancy.

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td></td><td>4.5 RBD – Stage 4 Appraisal, Final Design Assessment</td><td>4.5.1 A checklist of items to be considered at each stage is also given in Table 1.4.4 RBD – Stage 4 Appraisal, Final Design Assessment.</td><td>
Table 1.4.4 RBD – Stage 4 Appraisal, Final Design Assessment

<table>
<tr><th>Stage 4 – Final Design Assessment</th><th>1</th><th>2</th><th>3</th></tr>
<tr><td>Define objective and scope (<i>see Ch 1, 4.5 RBD – Stage 4 Appraisal, Final Design Assessment 4.5.2</i>)</td><td>✓</td><td></td><td>✓</td></tr>
<tr><td>Propose assessment team(s), method(s) and technique(s) (<i>see Ch 1, 4.5 RBD – Stage 4 Appraisal, Final Design Assessment 4.5.3</i>)</td><td>✓</td><td></td><td>✓</td></tr>
<tr><td>Undertake assessment (<i>see Ch 1, 4.5 RBD – Stage 4 Appraisal, Final Design Assessment 4.5.4</i>)</td><td>✓</td><td></td><td>✓</td></tr>
<tr><td>Prepare Stage 4 Appraisal Report (<i>see Ch 1, 4.5 RBD – Stage 4 Appraisal, Final Design Assessment 4.5.5</i>)</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td colspan="4">Note 1. Client responsibility for development and submission to LR for Classification purposes.
Note 2. Documents that LR Classification need to see on completion.
Note 3. Areas where LR might support the Client with design development consultancy.</td></tr>
</table>
</td><td></td></tr>
<tr><td>Section 5: Reference Rules, Regulations, Standards and Guidance</td><td>5.1 Reference Rules, Regulations, Standards and Guidance</td><td></td><td>Pt 7, Ch 14, 1 of the Rules and Regulations for the Classification of Ships.
SOLAS Chapter II-1, Part F, Reg. 55.
SOLAS Chapter II-2, Part F, Reg. 17.
MSC Circ.1002 Guidelines on Alternative Design and Arrangements for Fire Safety.
MSC Circ.1212 Guidelines on Alternative Design and Arrangements for SOLAS Chapters II-1 and III.
IMO Circ.1455 Guidelines for the Approval of Alternative and Equivalents as Provided for in Various IMO Instruments.
ISO 31010 Risk Assessment Techniques.
SOLAS Chapter III, Part C, Reg 38.
MSC-MEPC.2/Circ12/Rev.1 IMO FSA Guidelines 18th June 2015.
IACS Rec 146 Risk assessment as required by the IGF Code Aug 2016</td><td></td></tr>
</table>

<table>
<tr><th>Conditions</th><th>Item</th><th>Documentation</th><th>Additional Description</th><th>Information</th></tr>
<tr><td>Section 7: Acceptable risk criteria</td><td>7.1 Acceptable risk criteria</td><td></td><td></td><td></td></tr>
<tr><td>Section 7: Acceptable risk criteria</td><td>7.1 Acceptable risk criteria</td><td></td><td>Table 1.7.1 Useful measures for evaluating likelihoods illustrates examples of useful measures for evaluating likelihoods. When likelihood bands are measuring very infrequent periods, it is quite difficult for people to be able to effectively judge the time period being considered. Table 1.7.1 Useful measures for evaluating likelihoods gives four different ways of expressing the same likelihood, supported by definitions to help visualise likelihood using practical measures. As the likelihood reduces, using the likelihood measures towards the right of the table become easier to visualise and understand. For instance judging whether an incident will happen within a time span of (1E-5 to 1E-6) one hundred thousand years to one million ship years is quite difficult. In this case it’s easier to think of the likelihood dimension in terms of world ship years. It is easier, for instance, to judge that an incident would happen once, during a period of total world ship operation during 1.67 years to 16.67 years.

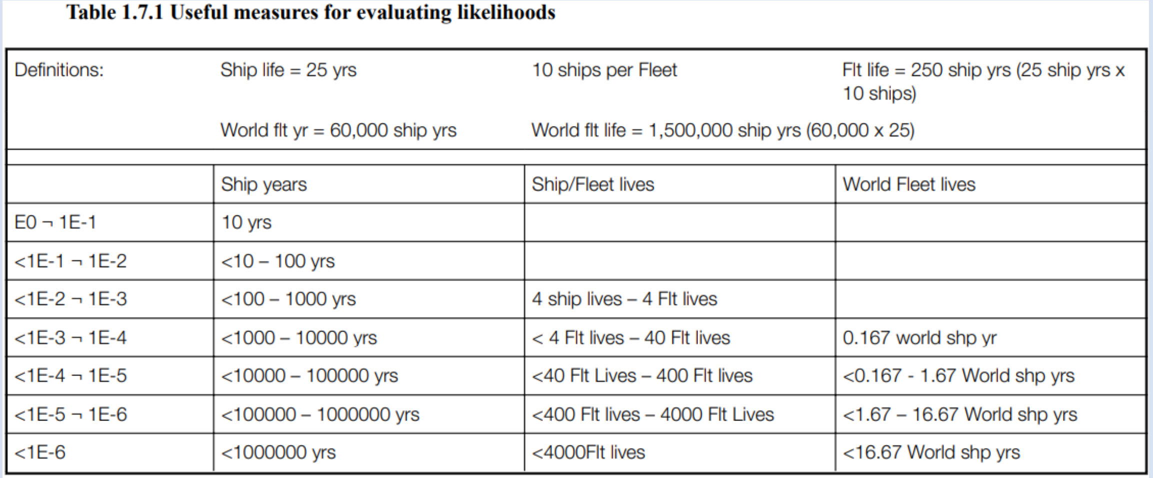
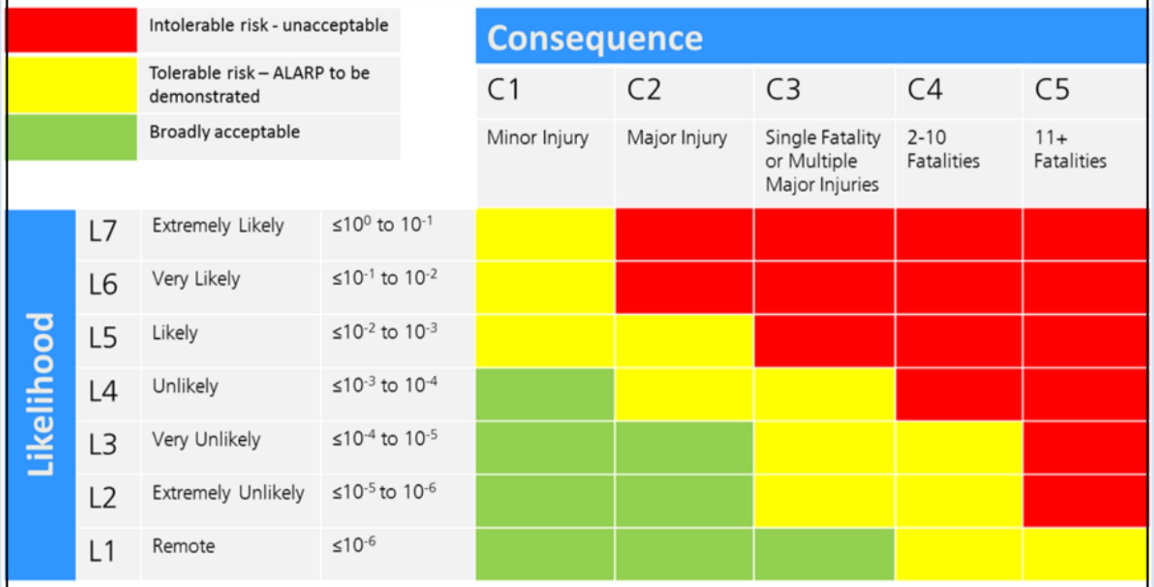



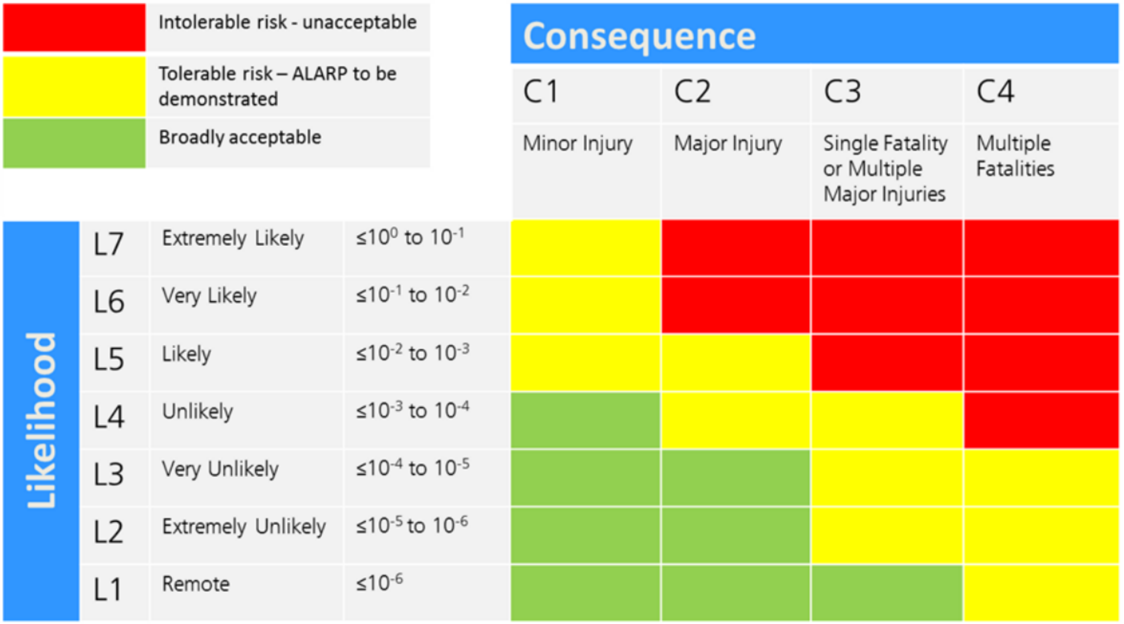
Table 1.7.1 Useful measures for evaluating likelihoods
<table>
<tr><td>Definitions:</td><td>Ship life = 25 yrs</td><td>10 ships per Fleet</td><td>Flt life = 250 ship yrs (25 ship yrs x 10 ships)</td></tr>
<tr><td></td><td>World flt yr = 60,000 ship yrs</td><td>World flt life = 1,500,000 ship yrs (60,000 x 25)</td><td></td></tr>
<tr><td></td><td>Ship years</td><td>Ship/Fleet lives</td><td>World Fleet lives</td></tr>
<tr><td>E0 ¬ 1E-1</td><td>10 yrs</td><td></td><td></td></tr>
<tr><td><1E-1 ¬ 1E-2</td><td><10 – 100 yrs</td><td></td><td></td></tr>
<tr><td><1E-2 ¬ 1E-3</td><td><100 – 1000 yrs</td><td>4 ship lives – 4 Flt lives</td><td></td></tr>
<tr><td><1E-3 ¬ 1E-4</td><td><1000 – 10000 yrs</td><td>< 4 Flt lives – 40 Flt lives</td><td>0.167 world shp yr</td></tr>
<tr><td><1E-4 ¬ 1E-5</td><td><10000 – 100000 yrs</td><td><40 Flt Lives – 400 Flt lives</td><td><0.167 - 1.67 World shp yrs</td></tr>
<tr><td><1E-5 ¬ 1E-6</td><td><100000 – 1000000 yrs</td><td><400 Flt lives – 4000 Flt Lives</td><td><1.67 – 16.67 World shp yrs</td></tr>
<tr><td><1E-6</td><td><1000000 yrs</td><td><4000Flt lives</td><td><16.67 World shp yrs</td></tr>
</table>
</td><td></td></tr>
</table>

Conditions	Item	Documentation	Additional Description	Information
			Figure 1.7.1 Acceptable Risk Criteria, reflecting aversion to escalating fatalities & Figure 1.7.2 Acceptable Risk Criteria, with a simple approach to escalating fatalities are two examples of acceptable risk criteria. It is important to note that the risk acceptance criteria for single fatality are the same in both cases, as are the risk acceptance criteria for minor and major injuries. For escalating consequences of two or more fatalities there are a number of items to consider 	

🟥	Intolerable risk - unacceptable
🟨	Tolerable risk – ALARP to be demonstrated
🟩	Broadly acceptable

				Consequence				
				C1	C2	C3	C4	C5
				Minor Injury	Major Injury	Single Fatality or Multiple Major Injuries	2-10 Fatalities	11+ Fatalities
Likelihood	L7	Extremely Likely	≤10^{0} to 10^{-1}	🟨	🟥	🟥	🟥	🟥
	L6	Very Likely	≤10^{-1} to 10^{-2}	🟨	🟥	🟥	🟥	🟥
	L5	Likely	≤10^{-2} to 10^{-3}	🟨	🟨	🟥	🟥	🟥
	L4	Unlikely	≤10^{-3} to 10^{-4}	🟩	🟨	🟨	🟥	🟥
	L3	Very Unlikely	≤10^{-4} to 10^{-5}	🟩	🟩	🟨	🟨	🟥
	L2	Extremely Unlikely	≤10^{-5} to 10^{-6}	🟩	🟩	🟨	🟨	🟥
	L1	Remote	≤10^{-6}	🟩	🟩	🟩	🟨	🟨

Figure 1.7.1 Acceptable Risk Criteria, reflecting aversion to escalating fatalities

Conditions	Item	Documentation	Additional Description	Information
Section 7: Acceptable risk criteria	7.1 Acceptable risk criteria		 **Figure 1.7.2 Acceptable Risk Criteria, with a simple approach to escalating fatalities**	

🟥	Intolerable risk - unacceptable
🟨	Tolerable risk – ALARP to be demonstrated
🟩	Broadly acceptable

			Consequence			
			C1	C2	C3	C4
Likelihood			Minor Injury	Major Injury	Single Fatality or Multiple Major Injuries	Multiple Fatalities
L7	Extremely Likely	≤10^{0} to 10^{-1}	🟨	🟥	🟥	🟥
L6	Very Likely	≤10^{-1} to 10^{-2}	🟨	🟥	🟥	🟥
L5	Likely	≤10^{-2} to 10^{-3}	🟨	🟨	🟥	🟥
L4	Unlikely	≤10^{-3} to 10^{-4}	🟩	🟨	🟨	🟥
L3	Very Unlikely	≤10^{-4} to 10^{-5}	🟩	🟩	🟨	🟨
L2	Extremely Unlikely	≤10^{-5} to 10^{-6}	🟩	🟩	🟨	🟨
L1	Remote	≤10^{-6}	🟩	🟩	🟩	🟨

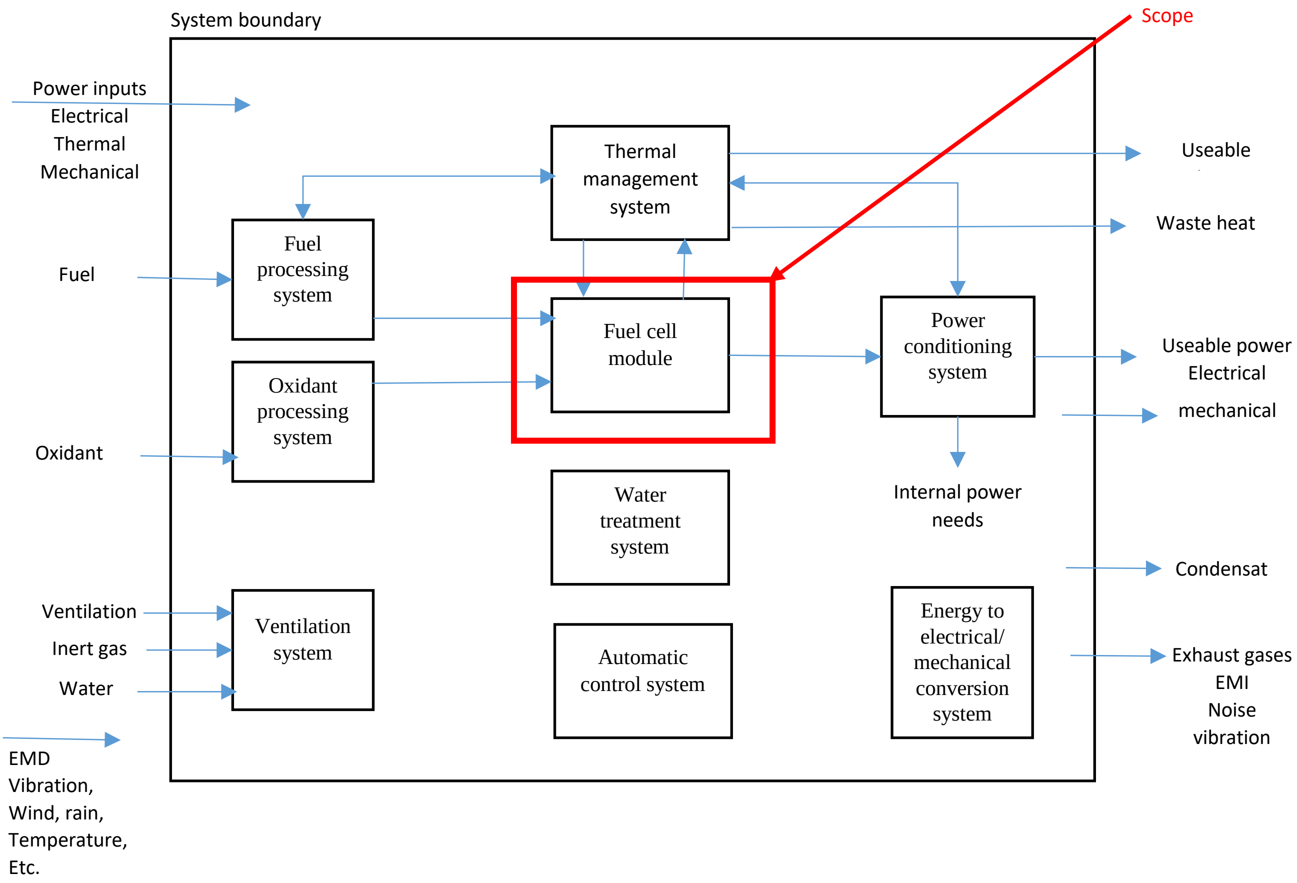
Annex 35: STANDARD IEC 26282-2-100

STANDARD IEC 26282-2-100

A. IDENTITY CARD OF SANDARD N° IEC 26282-2-100

RCS	Number of RCS	Title	Date	Stability date	Statutory
Standard	IEC 62282-2-100	Fuel cell technologies – Part 2-100: Fuel cell modules - Safety	05.2020	2020	Y

Scope: provides safety related requirements for construction, operation under normal and abnormal conditions and the testing of fuel cell modules. This standard covers only up to the DC output of the fuel cell module.



Fuel cell power system component

Domain/category: Genset, off-road, railway and water application

Specifed exclusion: Fuel cell road vehicles. This standard does not cover the storage and delivery of fuel and oxidant to the fuel cell module. Protection against damage inside the fuel cell modules is not addressed in this document, provided it does not lead to hazards outside the module.

Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

Some sub-chapters of chapter 4 (requirements) and chapter 5 (type tests) are relevant to the project.

See the current version of IEC 26282-2-100.

Annex 36: STANDARD NF EN IEC 60079-10-1 (AFNOR)

STANDARD NF EN IEC 60079-10-1 (AFNOR)

A. IDENTITY CARD OF STANDARD NF EN 60079-10-1 (AFNOR)

RCS	Number of RCS	Title	Date	Stability date	Statutory
NF EN	IEC 60079-10-1	Explosive atmospheres Part 10-1: Classification of area - Gaseous explosive atmospheres	27/05/2016	13/07/2016	Yes

This standard is a point-by-point transcription of the standard IEC 60079-10-1:2015

Scope: This part of IEC 60079 sets out the essential criteria against which ignition hazards can be assessed and gives guidance on design and operational parameters that can be used to reduce these hazards.

Domain/category: It is intended to be applied where there may be a danger of ignition due to the presence of flammable gases or vapors, mixed with air.

Specifed exclusion: It does not apply:

a) gassy mines;
b) the processing and manufacture of explosives;
c) catastrophic failures or rare malfunctions, which go beyond the concept of abnormality dealt with in this standard (see 3.7.3 and 3.7.4);
d) premises used for medical purposes;
e) commercial and industrial applications in which only low pressure fuel gas is used, for example, for cooking, water heating, etc., the installation satisfying the corresponding gas codes;
f) premises for domestic use;
g) when a hazard may arise due to the presence of combustible dust or combustible particles suspended in the air, but the principles defined may however be applied in the assessment of a hybrid mixture.

Reference included in this RCS:

- IEC 60079-0, Explosive atmospheres - Part 0: Equipment - General requirements

IEC 60079-14, Explosive atmospheres - Part 14: Design, selection and construction of electrical installations

B. RELEVANT PARTS FOR STASHH PROJECT

The relevant clauses to StasHH project are:

- Clause 4 about the generality on Security principles, Objectives of site classification, Assessment of the risk of explosion,

- Clause 5: Methodology for ranking locations,
- Clause 6: Release of flammable substance (Sources of release, Forms of release, Ventilation (or air movement) and dilution)
- Clause 7: type zone Influence of dilution, influence of the availability of ventilation, Influence of the degree of the release source.

See IEC 60079-10-1.

Annex 37: STANDARD IEC 62282-3-100

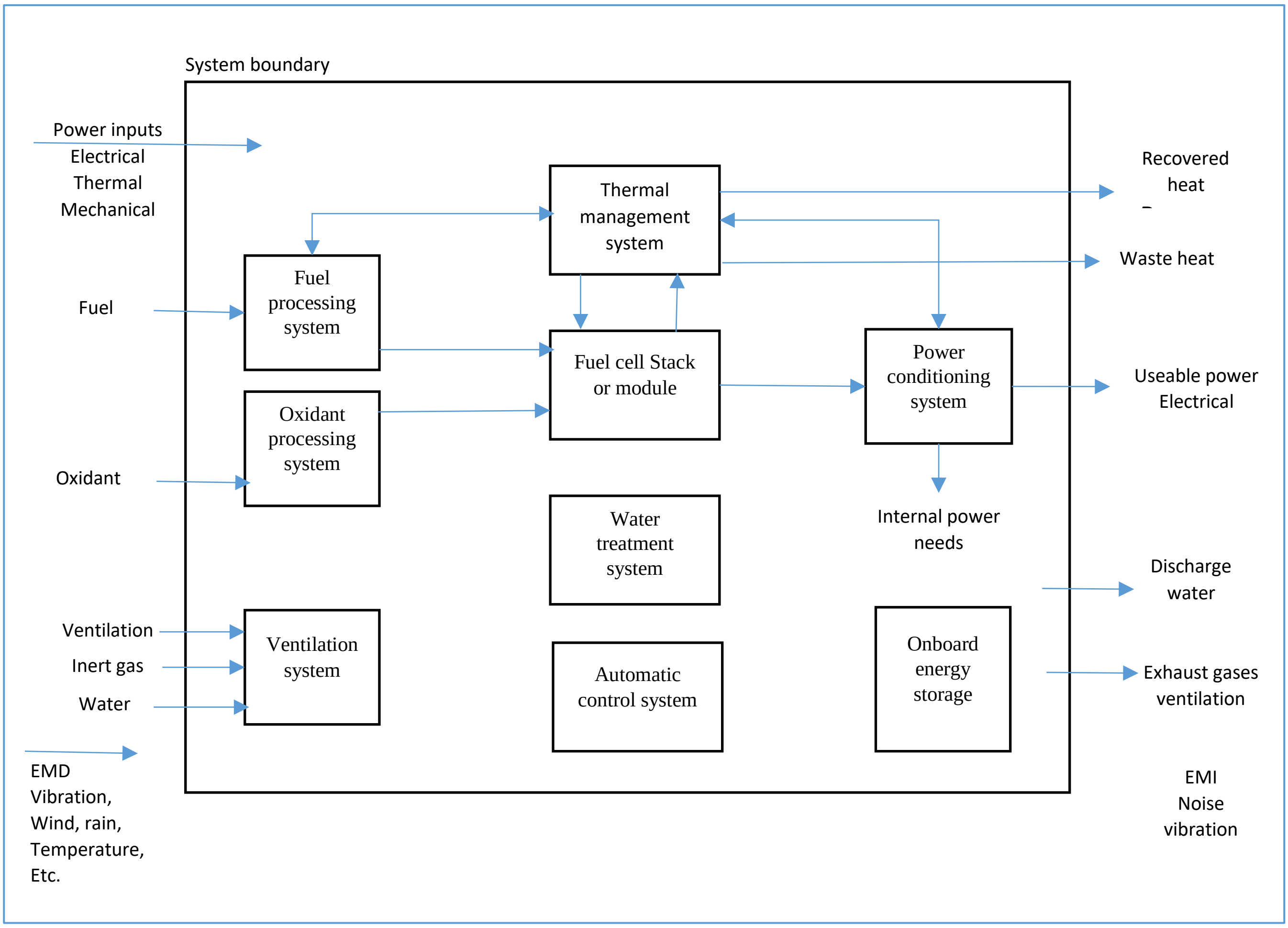
STANDARD IEC 62282-3-100

A. IDENTITY CARD OF STANDARD IEC 62282-3-100

RCS	Number of RCS	Title	Date	Stability date	Statutory
Standard	IEC 62282-3-100	Fuel cell technologies – Part 3-100: Stationary fuel cell power systems - Safety	01.02.2019	01.02.2019	Yes

Scope: This part of IEC 262282 applies to stationary packaged, self-contained fuel cell power systems or fuel cell power systems comprised of factory matched packages of integrated systems which generate electricity through electochemical reactions.

A typical stationary fuel cell power system is shown below:



Domain/category: Stationary fuel cell power systems

a) Intended for electrical connection to main direct, or with a transfert switch, or to a stand-alone power distribution system
b) Intended to provide AC or DC power
c) With or without the ability to recover useful heat
d) Intended for operation on the following input fuels:
    1) Natural gas and methane rich gases derived from renewable (biomass) or fossile fuel sources, for example, landfill gas, digester gas, coal mine gas
    2) Fuel derived from oil refining, for example, diesel, gasoline, kerosene, liquified petroleum gases such as propane or butane
    3) Alcohols, esters, ethers, aldehyedes, ketones, fischer-tropsch liquids and other suitable hydrogen-rich organic compounds derived from renewable (biomass) or fossil fuel sources, for example, methanol, ethanol, di-methyl ether, biodiesel
    4) Hydrogen, gaseous mixtures containing hydrogen gas, for example, synthesis gas, town gas

This document is applicable to stationary fuel cell power system intended dor indoor and outdoor commercial, industrial and residential use in non-hazardous areas.

This document contemplates all signicant hazards, hazardous situations and events, with the exception of those associated with environmental compatibility (installation conditions), relevant to fuel cell power systems, when they are used as intended and under the conditions foreseen by the manufacturer.

This document deals with conditions that can yield hazards on the one hand to persons, and on the other o damage outside the fuel power system only.protections against damage to the fuel cell power system internals is not addressed in this document, provided it does not lead to hazards outside the fuel cell power system.

Specifed exclusion:

- micro fuel cell power systems
- portable fuel cell power systems
- propulsion fuel cell power systems

Reference included in this RCS: *Only those RCSs that will potentially be analyzed as part of the project*

B. RELEVANT PARTS FOR STASHH PROJECT

Some sub-chapters of chapter 4 are relevant to the project.

See IEC 62282-3-100.

Annex 38: STANDARD IEC 62282-4-101

STANDARD IEC 62282-4-101

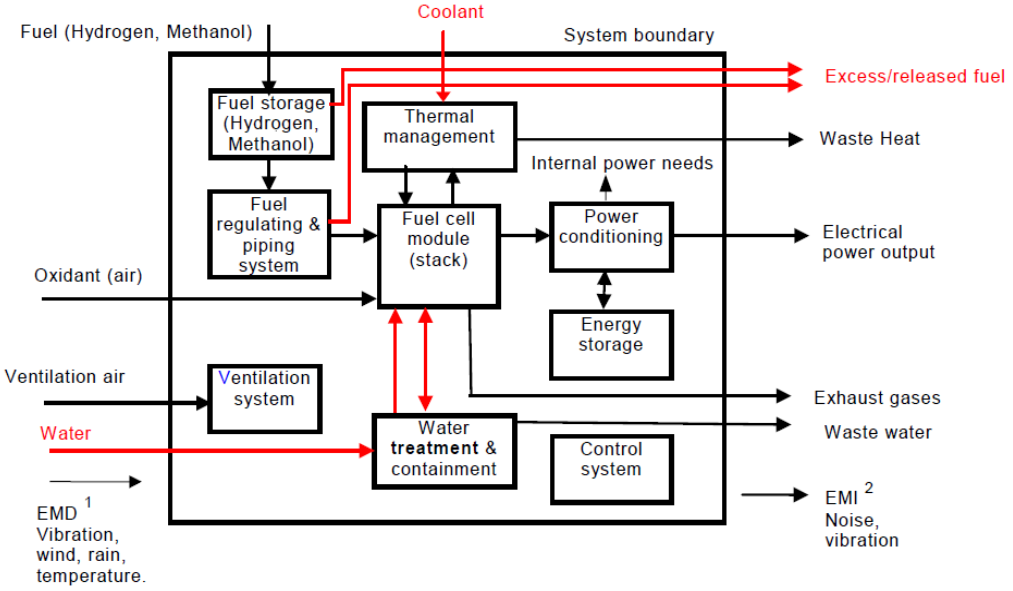
A. IDENTITY CARD OF STANDARD IEC 62282-4-101

RCS	Number of RCS	Title	Date	Stability date	Statutory
Standard	IEC 62282-4-101	Fuel cell technologies – Part 4-101: Fuel cell power systems for propulsion other than road vehicles and auxiliary power units (APU) – Safety of electrically powered industrial trucks	01/08/2014	01/08/2014	Yes

Scope: This standard covers safety requirements of fuel cell power systems intended to be used for electrical powered industrial trucks. This standard is limited to electrically powered industrial trucks and is applicable to material-handling equipment, e.g. forklifts. It applies to gaseous hydrogen-fuelled fuel cell power systems and direct methanol fuel cell power systems for electrically powered industrial trucks.

The following fuels are considered within the scope of this standard:

- methanol.
- gaseous hydrogen



Key

[1] EMD: Electromagnetic disturbance

[2] EMI: Electromagnetic interference

NOTE: A fuel cell power system may contain all or some of the above components

Figure 1 – Fuel cell power systems for industrial forklift trucks

Domain/category: Off road - industrial truck

Specifed exclusion:

The following are not included in the scope of this standard:

- detachable type fuel source containers;
- hybrid trucks that include an internal combustion engine;
- reformer-equipped fuel cell power systems;
- fuel cell power systems intended for operation in potentially explosive atmospheres;
- fuel storage systems using liquid hydrogen.

Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

Although this standard is applicable for trucks, it is also cited in IEC 63341, which concerns fuel cell railways. See standard IEC 62282-4-101.

Annex 39: STANDARD IEC 63341-1

STANDARD IEC 63341-1

A. IDENTITY CARD OF STANDARD IEC 63341

RCS	Number of RCS	Title	Date	Stability date	Statutory
IEC	63341-1	Railway applications – Rolling stock – Fuel cell systems for propulsion – Part 1: Fuel Cell Power System	2020-07-03	Draft (New work Item Proposal)	/

Scope: This document applies to Fuel Cell System for traction and auxiliaries purpose used on rolling stock. This document focuses on:

- the scope of supply and the description of the interfaces (fluidic, electrical and mechanical),
- the description of environmental conditions,
- the design requirements and the functional requirements to ensure the fuel cell system compliancy with a railway application
- the definition of the standardization process to validate the fuel cell system capacity required for a specific mission profile,
- the safety and protection requirement to design and install a fuel cell system for railway application,
- the protection of persons and the environment inside and outside the vehicle against hydrogen related hazards
- the marking and labelling requirements
- the requirements related to storage, transportation, installation and maintenance
- the tests (type and routine) to validate the fuel cell system

Domain/category: This document applies to any rolling stock types (e.g. light rail vehicles, tramways, streetcars, metros, commuter trains, regional trains, high speed trains, locomotives, etc).

Specifed exclusion: The storage of H2 is not inclued in this document

Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

The clauses relevant to StasHH project are the environmental conditions (Clause 5), the fluidic interfaces (clause 6), performances requirements (clause 7), design requirements (clause 8),Safety, reliability and protection requirements (clause 9) and testing (clause 13).

This Standard n° IEC 63341-1 is under review by the technical committee.

Annex 40: STANDARD ISO 6469-2

STANDARD ISO 6469-2

A. IDENTITY CARD OF STANDARD ISO 6469-2

RCS	Number of RCS	Title	Date	Stability date	Statutory
Standard	ISO 6469-2	Electrically propelled road vehicles - safety specifications Part 2:Vehicle operational safety	02/2018	02/2018	yes

Scope: *This document specifies requirements for operational safety specific to electrically propelled road vehicles, for the protection of persons inside and outside the vehicle.*

Domain/category: Electrical propelled road vehicles (safety)

Specifed exclusion:

- Requirements are not relevant for motorcycles and mopeds (categories L1 to L7)
- This document does not provide comprehensive safety information for manufacturing, maintenance and repair personnel.
- This document does not consider specific aspects of driving automation features. *(For definition of the term "driving automation features", see SAE J3016)*

Reference included in this RCS:

- ISO 11451 (all parts), *Road vehicles — Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy*

B. RELEVANT PARTS FOR STASHH PROJECT

The points relevant to the StasHH project mainly concern the requirements of operating safety, environmental conditions and compatibility electromagnetic.

See ISO 6469-2.

Annex 41: STANDARD ISO 6469-3

STANDARD ISO 6469-3

A. IDENTITY CARD OF STANDARD ISO 6469-3

RCS	Number of RCS	Title	Date	Stability date	Statutory
Standard	ISO 6469-3	Electrically propelled road vehicles — Safety specifications Part 2: Electrical safety	February 2018	2018	Yes
	ISO 6469-3:2018 /Amd.1:2020	Electrically propelled road vehicles — Safety specifications Part 3: Electrical safety AMENDMENT 1: Withstand voltage test for electric power sources	March 2020	2020	Yes

Scope: This document specifies electrical safety requirements for voltage class B electric circuits of electric propulsion systems and conductively connected auxiliary electric systems of electrically propelled road vehicles.

It specifies electrical safety requirements for protection of persons against electric shock and thermal incidents.

For the StasHH project, the maximum operating voltage class selected is Class B2.

Voltage class	Maximum working voltage	
	DC in V	AC in V (rms value)
B2	$75 < U \leq 1\,500$	$50 < U \leq 1\,000$

Different requirements are specified for voltage class B2, for which the requirements are more stringent.

In cases where voltage class B is referenced by another standard, the requirements of voltage class B2 apply.

Domain/category: safety for voltage class B electric circuits (main and auxillary electric systems)

Specifed exclusion:

- It does not provide comprehensive safety information for manufacturing, maintenance and repair personnel.

Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

The points relevant to the StasHH project mainly concern:

- Chapter 5: General requirements about environmental and operating requirements
- Chapter 6: Requirements for protection of persons against electric shock
- Chapter 7:Protection against thermal incidents
- Chapter 8: Requirements for vehicle power supply circuit
- Chapter 10:Test procedures

See the standard n°ISO 6469-3.

Annex 42: STANDARD ISO 6469-4

STANDARD ISO 6469-4

A. IDENTITY CARD OF STANDARD ISO 6469-4

RCS	Number of RCS	Title	Date	Stability date	Statutory
Standard	ISO 6469-4	Electrically propelled road vehicles — Safety specifications Part 4: Post crash electrical safety	01/09/2015	01/09/2015	Yes

Scope: This part of ISO 6469 specifies safety requirements for the electric propulsion systems and conductively connected auxiliary electric systems of electrically propelled road vehicles for the protection of persons inside and outside the vehicle. It specifies electrical safety requirements for vehicle post-crash conditions. It applies to electrically propelled road vehicles with voltage class B electric circuits.

The safety requirements of this part of ISO 6469 apply to applicable vehicles in accordance with published crash test procedures of each country or region.

Applicable vehicles are those vehicles which are explicitly specified in these crash test procedures.

Domain/category: Electrically propelled road vehicles with voltage class B electric circuits

Specifed exclusion:

- It does not apply to motorcycles and mopeds.
- It does not specify any crash test procedure.
- It does not provide comprehensive safety information for first responders, emergency services, maintenance, and repair personnel.

Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

The main relevant parts are the requirements of electric safety (clause 5) and the tests (clause 7) after crash-tests.

See the standard n° 6469-4.

Annex 43: STANDARD ISO 12619-1

STANDARD ISO 12619-1

A. IDENTITY CARD OF STANDARD ISO 12619-1

RCS	Number of RCS	Title	Date	Stability date	Statutory
Standard	ISO 12619-1	Road vehicles — Compressed gaseous hydrogen (CGH2) and hydrogen/ natural gas blend fuel system components — Part 1: General requirements and definitions	15/06/2014	15/06/2014	Yes

Scope: This part of ISO 12619 specifies general requirements and definitions of compressed gaseous hydrogen (CGH2) and hydrogen/natural gas blends fuel system components, intended for use on the types of motor vehicles defined in ISO 3833. It also provides general design principles and specifies requirements for instructions and markings.
This part of ISO 12619 is applicable to vehicles using CGH2 and hydrogen/natural gas blends using natural gas.

Domain/category: hydrogen components for road vehicles

Specifed exclusion:

- Liquefied hydrogen (LH2) fuel system components;
- Fuel containers;
- Stationary gas engines;
- Container mounting hardware;
- Electronic fuel management;
- Refuelling receptacles.

NOTE 3: This part of ISO 12619 may not apply to fuel cell vehicles in compliance with international regulations.

Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

The relevant sub-clauses of this standard part are the general requirements on the mechanical strength of materials in contact with hydrogen and on the electrical equipement and wiring.

See Standard n° ISO 12619-1.

Annex 44: STANDARD ISO 12619-2

STANDARD ISO 12619-2

A. IDENTITY CARD OF STANDARD ISO 12619-2

RCS	Number of RCS	Title	Date	Stability date	Statutory
Standard	ISO 12619-2	Road vehicles — Compressed gaseous hydrogen (CGH2) and hydrogen/ natural gas blend fuel system components — Part 2: Performance and general test methods	15/06/2014 *(First edition)*	15/06/2014	Yes
			15/05/2016 Amendment 1	15/06/2016	Yes

Scope: This part of ISO 12619 specifies performance and general test methods for compressed gaseous hydrogen (CGH2) and hydrogen/natural gas blends fuel system components, intended for use on the types of motor vehicles defined in ISO 3833.

This part of ISO 12619 is applicable to vehicles using CGH2 and hydrogen/natural gas blends using natural gas.

Domain/category: hydrogen components for road vehicles (tests)

Vehicle category: all road vehicle

Specifed exclusion:

- Liquefied hydrogen (LH2) fuel system components;
- Fuel containers;
- Stationary gas engines;
- Container mounting hardware;
- Electronic fuel management;
- Refuelling receptacles.

NOTE 3: This part of ISO 12619 may not apply to fuel cell vehicles in compliance with international regulations.

Reference included in this RCS:

B. RELEVANT PARTS FOR STASHH PROJECT

This part of ISO 12619 defines the tests and performances associated with components for compressed hydrogen supply. For the StasHH project, this concerns the components carrying compressed hydrogen upstream or even in the fuel cell module. See ISO 12619-2.

Annex 45: STANDARD ISO 12619-3

STANDARD ISO 12619-3

A. IDENTITY CARD OF STANDARD ISO 12619-3

RCS	Number of RCS	Title	Date	Stability date	Statutory
Standard	ISO 12619-3	Road vehicles — Compressed gaseous hydrogen (CGH2) and hydrogen/ natural gas blend fuel system components — Part 3: Pressure regulator	15/06/2014 *(First edition)*	15/06/2014	Yes

Scope: This part of ISO 12619 specifies test and requirements for the pressure regulator, a compressed gaseous hydrogen (CGH2) and hydrogen/natural gas blends fuel system components, intended for use on the types of motor vehicles defined in ISO 3833.

This part of ISO 12619 is applicable to vehicles using CGH2 and hydrogen/natural gas blends using natural gas.

Domain/category: component regulator for road vehicles (tests and requirements)

Specifed exclusion:

- Liquefied hydrogen (LH2) fuel system components;
- Fuel containers;
- Stationary gas engines;
- Container mounting hardware;
- Electronic fuel management;
- Refuelling receptacles.

NOTE 3: This part of ISO 12619 may not apply to fuel cell vehicles in compliance with international regulations.

Reference included in this RCS: /

B. RELEVANT PARTS FOR STASHH PROJECT

This part of ISO 12619 defines the tests and requirements for the pressure regulator component for compressed hydrogen supply.

For the StasHH project, if the pressure regulator is a component in the fuel cell module or upstream of this, this part of this standard is relevant. See standard ISO 12619-3.

Annex 46: STANDARD ISO 23273

STANDARD ISO 23273

A. IDENTITY CARD OF STANDARD ISO 23273

RCS	Number of RCS	Title	Date	Stability date	Statutory
Standards	ISO 23273	Fuel cell road vehicles — Safety specifications — Protection against hydrogen hazards for vehicles fuelled with compressed hydrogen	2013-06-15	2013-06	Yes

Scope: This International Standard specifies the essential requirements for fuel cell vehicles (FCV) with respect to the protection of persons and the environment inside and outside the vehicle against hydrogen related hazards.

Domain/category: It applies only to such FCV where compressed hydrogen is used as fuel for the fuel cell system.

Applicable to road vehicles

Specifed exclusion: This International Standard does not apply to manufacturing, maintenance, and repair

Reference included in this RCS:

B. RELEVANT PARTS FOR STASHH PROJECT

The clauses relevant to StasHH project are:

- Environmental and operational conditions (clause 4),
- Design and performance requirements of the fuel system (clause 5),
- Complementary or alternative approach to verify hydrogen-related safety requirements (clause 7).

See ISO 23273.

Annex 47: STANDARD ESTRIN-2021 (CESNI)

STANDARD ESTRIN-2021 (CESNI)

A. IDENTITY CARD OF STANDARD ESTRIN-2021 (CESNI)

RCS	Number of RCS	Title	Date	Stability date	Statutory
Standard	CESNI[43] ES-TRIN	European Standard laying down Technical Requirements for Inland Navigation vessels	01/2021	01/2021	Yes

Scope: Requirements for Inland navigation vessels.

Domain/category: Inland vessels

Specifed exclusion: /

Reference included in this RCS: /

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[43] CESNI: European Committee for drawing up Standards in the field of Inland Navigation. https://www.cesni.eu/en/

B. RELEVANT PARTS FOR STASHH PROJECT

The most relevant part is chapter 11 dedicated to the electric propulsion of ships.

Conditions	Item	Documentation	Additional Description	Information
Chapter 11 Special provisions applicable to electric vessel propulsion	Article 11.01 General provisions for electric vessel propulsion	paragraph 1	*Craft's electric main propulsion must consist of at least* *a) two electrical power source, irrespective of the number of main propulsion,* *b) an electric propulsion motor,* *c) depending on the design of the electric main propulsion, the corresponding power electronics.*	
Chapter 11 Special provisions applicable to electric vessel propulsion	Article 11.01 General provisions for electric vessel propulsion	Paragraph 4	*If the electric propulsion motors are fed by batteries or accumulators, their capacity must be monitored and displayed.* *It must be ensured that the capacity of batteries or accumulators shall enable the safe reaching of a berth under the craft's own power at all times and under all conditions.* *In the event of a drop of the capacity of batteries or accumulators to the minimum residual capacity required pursuant second sentence, an optical and acoustic alarm is to be triggered and displayed in the wheelhouse.*	
Chapter 11 Special provisions applicable to electric vessel propulsion	Article 11.02 Generators, transformers and switchgear for electric vessel propulsion	Paragraph 1	*The generators, transformers and switchgear must be designed for* *a) temporary overloads and* *b) the effects of manoeuvres* *according to their application and operating conditions.*	
Chapter 11 Special provisions applicable to electric	Article 11.02 Generators, transformers and switchgear for electric	Paragraph 3	*The electrical power sources according to Article 11.01(1)(a) of the generators must be designed so that they can record the reverse power occurring during reversing manoeuvres when considering the propulsion concept.*	

Conditions	Item	Documentation	Additional Description	Information
vessel propulsion	vessel propulsion			