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List of abbreviations

AD&A	Alternative Design and Arrangement
CEN	European Committee for Standardization
CESNI	European Committee for drawing up Standards in the field of Inland Navigation
ES-TRIN	European Standard laying down Technical Requirements for Inland Navigation vessels
IGF Code	International Code of Safety for Ship Using Gases or Other Low-flashpoint Fuels
ILO	International Labour Organization
IMO	International Maritime Organization
ISO	International Organization for Standardization
MSC	Maritime Safety Committee
RBD	Risk Based Design
SOLAS	International Convention for the Safety of Life at Sea

1 EXECUTIVE SUMMARY

The FASTWATER (FAST Track to Clean and Carbon-Neutral WATERborne Transport through Gradual Introduction of Methanol Fuel) project aims to start a fast transitionary path to move waterborne transport away from fossil fuels, and reduce its pollutant emissions to zero impact, through the use of methanol fuel. FASTWATER will develop and demonstrate a path for marine methanol technology, both for retrofit and next generation systems. Specifically, the project will demonstrate feasibility on three vessels running on methanol fuel: a harbour tug, a pilot boat, and a coast guard vessel. A conversion concept for a river cruise ship using methanol-driven propulsion will also be developed and a universal, scalable retrofit kit for converting diesel fuelled ships to methanol use for a wide power range (200 kW-4 MW) will be validated. Part of the work within the FASTWATER project includes an assessment of the existing rules, regulations, and guidelines for use of methanol as a marine fuel. Recommendations regarding the regulations to be applied to smaller methanol fuelled vessels and those operating in inland waterways are to be made, specifically in support of the project demo vessels.

1.1 Purpose

The purpose of this document is to provide a summary of the current knowledge on safety and regulations relevant to the use of methanol as a fuel for ocean-going and inland waterway vessels. The report is meant to provide guidance on the available rules to be considered when assessing the safety of the FASTWATER project demonstration vessels, and to highlight on an overview level any gaps and areas for further development.

1.2 Technical approach

Rules, regulations, and guidelines pertaining to methanol as a marine fuel, either in place or under development at the International Maritime Organization (IMO), at the European inland waterways regulatory level, and at the ship classification society level were summarised and described in this report. Although many classification societies, including the American Bureau of Shipping, Bureau Veritas, China Classification Society, DNV GL, Lloyd's Register, and Registro Italiano Navale have methanol rules in place, in this report only Lloyd's Register Rules and Regulations are discussed in detail.

1.3 Results

The following high level regulations applicable to ships using methanol as fuel were identified:

- Lloyd's Register, Rules and Regulations for the Classification of Ships
- Lloyd's Register, Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels
- Lloyd's Register, Rules and Regulations for the Classification of Methanol Fuelled Ships
- Lloyd's Register, Ship Right, Design and Construction, Additional Design Procedures, Risk Based Designs (RBD)
- IMO, MSC.1/Circ. 1621, INTERIM GUIDELINES FOR THE SAFETY OF SHIPS USING METHYL/ETHYL ALCOHOL AS FUEL

- European Committee for drawing up Standards in the field of Inland Navigation (CESNI), European Standard laying down Technical Requirements for Inland Navigation vessels (ES-TRIN), Edition 2021/1
- European Committee for drawing up Standards in the field of Inland Navigation (CESNI), LEAFLET ON DELIBERATION ON DEROGATIONS AND EQUIVALENCES OF TECHNICAL REQUIREMENTS OF THE ES-TRIN FOR SPECIFIC CRAFT, March 2019
- BS EN 60079-10-1:2015, Explosive atmospheres, Part 10-1: Classification of areas – Explosive gas atmospheres

1.4 Conclusions and recommendations

In the maritime transportation sector for ocean going vessels significant development has taken place with regards to regulations and guidelines for methanol as fuel. Goals and functional requirements were specified for low-flashpoint fuels, and specific rules are now available from ship classification societies, such as Lloyd's Register, Rules and Regulations for the Classification of Methanol Fuelled Ships. Interim guidelines have been released by IMO - MSC.1/Circ. 1621, INTERIM GUIDELINES FOR THE SAFETY OF SHIPS USING METHYL/ETHYL ALCOHOL AS FUEL was approved in November 2020.

For non-SOLAS vessels regulations and guidance are limited to the traditional fuels and LNG. It is recommended that development has to take place in this sector in order to provide rules and regulations for methanol as fuel. Due to the different ship types, concepts, size and purpose to be found in this specific sector the knowledge about methanol as fuel compared to traditional fuels and low flashpoint fuels will be of great importance. It is recommended that specific technical knowledge on methanol as fuel will be made available in order to allow the design, construction and safe operation of the various ship types to be found in this sector.

2 Safety and regulations relevant to methanol as fuel

In the following chapter safety and regulations relevant to methanol as fuel in the marine environment will be addressed. Overall, the maritime transportation sector is well regulated through international bodies such as IMO and further, individual vessels are to comply with ship classification society rules. Fuels with flashpoints below 60° degrees, with a few special exceptions, were not permitted under the IMO's SOLAS convention, and the recent interest in using low-flashpoint alternative fuels such as LNG and methanol required development of new regulations and guidelines. Detailed regulations for gases or other low-flashpoint fuels are in development by the "International Maritime Organization" (IMO) and "European Committee for drawing up Standards in the field of Inland Navigation" (CESNI). Low-flashpoint fuels and gases are also covered in classification society requirements such as "Lloyd's Register, Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels". Although different low-flashpoint fuels are well known from the regulatory perspective LNG is currently the only fuel covered by some of the specific rule publications such as the "Rules for Low-flashpoint Fuels" and the "European Standard laying down Technical Requirements for Inland Navigation vessels" (ES-TRIN). Regulations covering other low-flashpoint fuels, for example methanol or hydrogen are currently being developed in the IMO and CESNI. For methanol reference is made to the IMO, MSC.1/Circ. 1621, INTERIM GUIDELINES FOR THE SAFETY OF SHIPS USING METHYL/ETHYL ALCOHOL AS FUEL. Specific rules and technical references for methanol fuelled ships were published by Lloyd's Register with the "Rules for the Classification of Methanol Fuelled Ships" already in advance of the MSC.1 Circular 1621 and with the technical reference "Introduction to Methanol Bunkering" in July 2020.

A number of low-flashpoint fuels related industrial standards and publications by national and international organisations are available. At the ISO and CEN level, development will take place relating to Specification of Methanol as a Fuel for Marine Applications and Methanol Bunkering Standards. Although most relate to LNG some are referenced in the following chapters for potential guidance. Furthermore, goals and functional requirements are introduced in the IMO regulations addressing low-flashpoint fuels. A risk assessment is required by the applicable rules in order to eliminate or mitigate any adverse effect to the persons on board, the environment or the ship.

For arrangements and systems which are considered as either deviating from those set out in the applicable ship rules or be designed for a fuel not specifically addressed in this code the Alternative Design and Arrangement process and/or Requirements for Machinery and Engineering Systems of Unconventional Design must be considered. Specific rule arrangements are referenced in the chapter for low-flashpoint fuels.

Classification Societies including American Bureau of Shipping, Bureau Veritas, China Classification Society, DNV GL, Lloyd's Register, and Registro Italiano Navale have their individual rules for low-flashpoint fuels in place. For this specific deliverable on safety and regulations relevant to methanol fuel reference is made to the Rules and Regulations of Lloyd's Register.

The following procedures, guidelines and regulations relevant to methanol as fuel in the maritime transportation sector are addressed in this report:

- Lloyd's Register, Rules and Regulations for the Classification of Ships
- Lloyd's Register, Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels

- Lloyd's Register, Rules and Regulations for the Classification of Methanol Fuelled Ships
- Lloyd's Register, Ship Right, Design and Construction, Additional Design Procedures, Risk Based Designs (RBD)
- IMO, MSC.1/Circ. 1621, INTERIM GUIDELINES FOR THE SAFETY OF SHIPS USING METHYL/ETHYL ALCOHOL AS FUEL
- European Committee for drawing up Standards in the field of Inland Navigation (CESNI), European Standard laying down Technical Requirements for Inland Navigation vessels (ES-TRIN), Edition 2021/1
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- BS EN 60079-10-1:2015, Explosive atmospheres, Part 10-1: Classification of areas – Explosive gas atmospheres

Further standards or guidelines can be identified as applicable to natural gas and liquefied natural gas or to methanol. As development of standards for other low-flashpoint fuels or gases might take time these standards might be considered as providing guidance based on the fuel as referenced in e.g. CWA 17540: 2020 Ships and marine technology - Specification for bunkering of methanol fuelled vessels and EMSA, Guidance on LNG Bunkering to Port Authorities and Administrations, 2018. It shall be highlighted that the physical properties of methanol are rather different compared to natural gas or especially liquefied natural gas. Standards and guidelines not specifically referring to methanol shall be considered with good engineering judgement.

2.1 Lloyd's Register, Rules and Regulations for the Classification of Ships

The "Lloyd's Register, Rules and Regulations for the Classification of Ships" are covering the applicable provisions for the classification of ships. Ships built in accordance with Lloyd's Register Group Limited's Rules and Regulations, or in accordance with requirements equivalent thereto, will be assigned a class in the Register Book and will continue to be classed as long as they are found, upon examination at the prescribed surveys, to be maintained in accordance with the requirements of the Rules.

Compliance is required with all applicable mandatory international IMO and ILO conventions and codes e.g. International Convention on Load Lines, International Convention for the Safety of Life at Sea, International Convention for the Prevention of Pollution from Ships, International Convention on the Control of Harmful Anti-Fouling Systems on Ships, International Convention on Tonnage Measurement of Ships, etc., and with requirements of the National Administration.

The "Lloyd's Register, Rules and Regulations for the Classification of Ships" are addressing the following provisions:

- Manufacture, Testing and Certification of Materials
- Ship Structures
- Main and Auxiliary Machinery
- Control, Electrical, Refrigeration and Fire
- Other Ship Types and Systems
- Rules for Ice and Cold Operations

Materials used for the construction, conversion, modification or repair of ships, other marine structures and associated machinery which are classed or are intended for classification by Lloyd's Register, are to be manufactured, tested and inspected in

accordance with these requirements. Details are provided for material testing procedures, the specific tests and test specimen types required for each material type, grade and product type. Requirements are provided for steel plates and bars, castings, forgings, pipes, castings and specific alloys. Furthermore, equipment for mooring and anchoring, welding consumables, welding qualification, welded constructions, plastic and non-metallic materials and corrosion prevention are covered.

Requirements for ship structures are addressing materials, the structural design and strength aspects, machinery spaces, specific structure details and arrangements for e.g. shell, deck and bulkheads. Provisions are provided e.g. ventilator, air, and sounding pipes, overboard discharge, ship control systems, e.g. rudders, steering gear, stern thrust units, stabilizer, mooring equipment and securing of cargo. Main and auxiliary machinery requirements are addressing provisions for e.g. combustion engines, turbines, gearing and propulsion shafting, propellers, podded units, pressure vessels and piping, piping systems, propulsion systems and steering systems.

Control, Electrical, Refrigeration and Fire requirements are addressing requirements for control engineering systems, electrical engineering, refrigerated cargo installations and fire protection, detection and extinction. Further types and systems are addressed, and requirements are provided for e.g. controlled atmosphere systems process plants for chemicals of liquefied gases, dynamic positioning, for unconventional design, refrigeration systems, for ice and cold environment.

For the sake of completeness, it should be noted that in addition to the Lloyd's Rules referenced in this report further Lloyd's Rules and Regulation might be applicable e.g. Rules for Naval Ships, Special Service Crafts, Ships for the Carriage of Liquefied Gases in Bulk, Liquid Chemicals in Bulk, LNG Ships and Barges Equipped, Ships with Regasification Systems, etc.

2.2 Lloyd's Register, Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels

This Lloyd's Register, Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels is providing mandatory provisions for the arrangement, installation, control and monitoring of machinery, equipment as systems using low-flashpoint fuel to minimize the risk to the ship, it's crew and the environment, having regard to the nature of the fuels involved. The basic philosophy of the code considers the goal-based approach (see MSC.1/Circ.1394). Goals and functional requirements were specified for each code section forming the basis for the design, construction and operation.

The current version of these rules includes specific requirements for ships using natural gas as fuel only. As previously stated, regulations for other low-flashpoint fuels are in development on IMO and CESNI level and will be added to the individual low-flashpoint fuels accordingly when they have been ratified. The IMO, MSC.1/Circ. 1621, INTERIM GUIDELINES FOR THE SAFETY OF SHIPS USING METHYL/ETHYL ALCOHOL AS FUEL was released in December 2020.

It shall be noted that for other low-flashpoint fuels compliance with the functional requirements must be demonstrated through the alternative design route. The Lloyd's Register, Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels include the following requirements:

- Goal and Functional Requirements

- General Requirements
- Ship Design and Arrangement
- Fuel Containment System
- Material and General Pipe Design
- Bunkering
- Fuel Supply to Consumers
- Power Generation Including Propulsion and Other Gas Consumers
- Fire Safety
- Explosion Prevention
- Ventilation
- Electrical Installations
- Control, Monitoring and Safety Systems
- Manufacture, Workmanship and Testing
- Drills and Emergency Exercises
- Operation

As already addressed the basic philosophy of the code considers a goal-based approach. The goal is to provide for safe and environmentally friendly design, construction and operation of ships and their installation of systems for propulsion machinery, auxiliary power generation machinery and/or other purpose machinery. The following requirements are addressed in Part A Ch. 3 Goal and Functional Requirements:

- 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.
- 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.
- 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.
- 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.
- Equipment installed in hazardous areas shall be minimized to that required for operational purposes and shall be suitably and appropriately certified.
- Unintended accumulation of explosive, flammable or toxic gas concentrations shall be prevented.
- System components shall be protected against external damages.
- Sources of ignition in hazardous areas shall be minimized to reduce the probability of explosions.
- 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.
- Piping systems, containment and over-pressure relief arrangements that are of suitable design, construction and installation for their intended application shall be provided.
- Machinery, systems and components shall be designed, constructed, installed, operated, maintained and protected to ensure safe and reliable operation.

- 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.
- Suitable control, alarm, monitoring and shutdown systems shall be provided to ensure safe and reliable operation.
- Fixed gas detection suitable for all spaces and areas concerned shall be arranged.
- Fire detection, protection and extinction measures appropriate to the hazards concerned shall be provided.
- Commissioning, trials and maintenance of fuel systems and gas utilization machinery shall satisfy the goal in terms of safety, availability and reliability.
- 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.
- A single failure in a technical system or component shall not lead to an unsafe or unreliable situation.

For the elimination or mitigation of any adverse effects to the persons on board, the environment or the ship a risk assessment is to be carried out. Where risks cannot be eliminated, an inherently safer design is to be sought in preference to operational or procedural controls. The risk assessment is to be carried out and to be documented in accordance with the Lloyds's Register, Ship Right, Design and Construction, Additional Design Procedures, Risk Based Designs (RBD). All risks shall be analysed based on recognised risk assessment techniques. Except for LNG fuelled ships loss of function, component damage, fire, explosion and electric shock shall be examined as a minimum. Consequences of an explosion shall be limited and shall not:

- cause damage to or disrupt the proper functioning of equipment/systems located in any space other than that in which the incident occurs;
- damage the ship in such a way that flooding of water below the main deck or any progressive flooding occur;
- damage work areas or accommodation in such a way that persons who stay in such areas under normal operating conditions are injured;
- disrupt the proper functioning of control stations and switchboard rooms necessary for power distribution;
- damage life-saving equipment or associated launching arrangements;
- disrupt the proper functioning of firefighting equipment located outside the explosion-damaged space;
- affect other areas of the ship in such a way that chain reactions involving, inter alia, cargo, gas and bunker oil may arise; or
- prevent persons access to life-saving appliances or impede escape routes.

In case the low-flashpoint fuel, appliances, arrangement and systems either deviate from those set out in the code or be designed for a fuel not specifically addressed in this code the alternative design and arrangement process must be considered. Evidence is to be provided that fuel, appliances and arrangement are meeting the intent of the goal and functional requirements and provide an equivalent level of safety demonstrated as specified in SOLAS reg. II-/55. Approval of this Alternative Design and Arrangement is in case for sea going vessels the responsible Flag state. Specific requirements for inland water way vessels are provided in the chapter "European Committee for drawing up Standards in the field of Inland Navigation (CESNI), LEAFLET ON DELIBERATION ON

DEROGATIONS AND EQUIVALENCES OF TECHNICAL REQUIREMENTS OF THE ES-TRIN FOR SPECIFIC CRAFT".

For machinery and engineering systems of unconventional design reference is made in this chapter to the "Lloyd's Register, Rules and Regulations for the Classification of Ships" Part7, Chapter 14 Requirements for machinery and engineering systems of unconventional design.

The requirements of this chapter aim to ensure that risks to maritime safety and the environment, stemming from the introduction of machinery or engineering systems of unconventional design, are addressed insofar as they affect the objectives of classification. The requirements of this section are to be satisfied where:

- machinery is required to be constructed, installed and tested in accordance with Lloyds Register's (hereinafter referred to as LR) Rules and Regulations and for which the corresponding machinery class notation is to be assigned and,
- the machinery and engineering systems are considered by LR to be of an unconventional design and which, as a result, are not directly addressed by LR's extant Rules and Regulations.

While requirements for information to be submitted is provided in the applicable chapters further detailed requirements are provided on quality assurance, design definition, risk management, configuration management integration and validation. A risk management procedure is to be established in order to ensure that any risks stemming from the introduction of the machinery or engineering system are addressed, in particular risks affecting:

- The structural strength and integrity of the ship's hull.
- The safety of shipboard machinery and engineering systems.
- The safety of shipboard personnel.
- The reliability of essential and emergency machinery and engineering systems.
- The environment.

2.3 Lloyd's Register, Rules and Regulations for the Classification of Methanol Fuelled Ships

The Lloyd's Register, Rules and Regulations for the Classification of Methanol Fuelled Ships are providing requirements for machinery using methanol as fuel. These rules were developed by Lloyd´s Register in advance to the IMO MSC Guidelines. The objective of this regulation is as well to provide a level of safety that is commensurate with conventional oil-fuelled propulsion and auxiliary machinery. These requirements are in addition to the applicable requirements of the Rules and Regulations for the Classification of Ships. The following areas are addressed in this classification rule:

- General
- Submission Requirements
- Risk-Based Studies
- Materials, Components and Equipment
- Location and Arrangement of Spaces
- System Design
- Piping
- Control, Alert and Safety Systems
- Electrical

- Fire Safety
- Testing and Trials

In order to evaluate the specific applied safety considerations, the dependability of essential service and specially considered arrangements which may deviate from these rule requirements risk-based studies have to be carried out. These are e.g. safety risk assessments, system dependability assessments, failure modes and effects analysis, hazardous area classification studies, system hazard and operability studies, bunkering studies and other risk-based studies identified by the risk assessment.

Materials used in methanol fuelled ships shall comply with the requirements of the Lloyd's Rules for the Carriage of Liquid Chemicals in Bulk. Further requirements are provided for tank coatings, stainless steel and different alloys. Electrical equipment and components for use in hazardous areas are required to be of a certified safe type. Specific location and arrangements are demanded for the bunkering station, fuel storage tanks, fuel supply equipment, methanol-fuelled consumer equipment, access to a hazardous space, ventilation and pressurisation and hazardous areas.

Specific requirements are provided for the system design relating methanol bunkering system, the fuel storage tanks, associated coffer dams, the methanol supply system, potential used methanol-fuelled combustion engines and turbines, boilers and, the inert gas system. For the design and construction of piping reference is made to the Loyd's Rules for Ships as well specific requirements are provided and details are requested for the control, alert and safety systems, electrical installation and fire safety and to testing of consumers and trials.

2.4 Lloyd's Register, Ship Right, Design and Construction, Additional Design Procedures, Risk Based Designs (RBD)

The Lloyd's Register, Ship Right, Design and Construction, Additional Design Procedures, Risk Based Designs (RBD) is providing additional guidance and support in satisfying the requirements for risk-based designs. The following sections are included in this procedure:

- Introduction
- Process overview
- Process application
- Process description
- Reference rules, regulations, standards and guidance
- Information requirements
- Acceptable risk criteria
- System integration

A risk-based analysis and demonstrating equivalence with the regulation under consideration is required in the application of the rules for low-flashpoint fuels and the AD&A process. Furthermore, an RBD process is typically applied for designs which deviate from the existing rules or for novel or complex designs for which prescriptive rules and regulations do currently not exists. The scope of this process is depending on the degree of novelty, degree of deviation, design complexity, and safety consideration. The RBD process comprises the following stages and is shown in the following figure:

Stage 1 – Design and Safety Statement.

Stage 2 – Risk Assessment.

Stage 3 – Revision and Supporting Studies.

Stage 4 – Final Design Assessment.

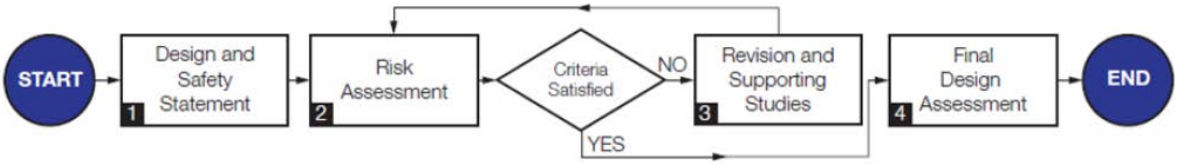

Figure. 1 Generic Process for Risk Based Design (RBD), taken from [4]

In Stage 1 "Design and Safety Statement" responsibilities are shown, potential relevant regulations and items to be considered are referenced for, e.g. for the development team, definition of novel or alternative design, scope of novel or alternative design, classification and statutory requirements not complied with, safety objectives to be met, functional requirements to be met, integration requirements to meet safety objectives and functional requirements and the preparation of Stage 1 Appraisal Report.

The Stage 2 "Risk Assessment" items to be considered are provided e.g. for the assessment team, method, acceptance criteria, hazard identification, consequences, likelihood, risk categorization, acceptance criteria, additional measures, justification and the preparation of Stage 2 Appraisal Report.

The Stage 3 "Revision and Supporting Studies" is providing items to be considered in case criteria are not satisfied and supporting studies, assessments and revisions are requested. Responsibilities are given, potentially relevant regulations are addressed with items to be considered e.g. objective and scope of assessment, acceptance criteria, assessment team, method and techniques and justification of appropriate safety with a Stage 3 Appraisal Report.

In Stage 4 "Final Design Assessment" items to be considered and responsibilities are shown for the final design assessment.

2.5 IMO, MSC.1/Circ. 1621, INTERIM GUIDELINES FOR THE SAFETY OF SHIPS USING METHYL/ETHYL ALCOHOL AS FUEL

IMO had published this interim guideline as a Maritime Safety Committee Circular in December 2020. This interim guideline follows a goal-based approach and includes provisions to meet functional requirements for methyl and ethyl alcohol as fuel. The following provisions are addressed in this interim guideline:

- Goal and functional requirements
- General provisions
- Ship design arrangements
- Fuel containment system
- Material and general pipe design
- Bunkering
- Fuel supply to consumers
- Power generation including propulsion and other energy converters
- Fire safety
- Explosion prevention and area classification
- Ventilation
- Electrical installations
- Control, monitoring and safety systems

- Training, drills and emergency exercise
- Operation

As addressed in the IGF code, arrangements and appliances may deviate from the requirements in the interim guidelines for methyl and ethyl alcohol as fuel, provided the arrangements and appliances meet the intent of the goal and functional requirements and provide an equivalent level of safety.

The equivalence shall be demonstrated as specified by SOLAS regulation II-1/55 – Alternative design and arrangement. Reference is made to the "Lloyd's Register, Ship Right, Design and Construction, Additional Design Procedures, Risk Based Designs (RBD)" and "Lloyd's Register, Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels".

"The goal of these Interim Guidelines 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 methyl/ethyl alcohol as fuel." The functional requirements to be met are provided in the following:

- The safety, reliability and dependability of the systems should be equivalent to that achieved with new and comparable conventional oil-fuelled main and auxiliary machinery.
- The probability and consequences of fuel-related hazards should be limited to a minimum through arrangement and system design, such as ventilation, detection and safety actions. In the event of fuel leakage or failure of the risk reducing measures, necessary safety actions should be initiated.
- The design philosophy should ensure that risk-reducing measures and safety actions for the fuel installation do not lead to an unacceptable loss of power.
- Hazardous areas should be restricted, as far as practicable, to minimize the potential risks that might affect the safety of the ship, persons on board and equipment.
- Equipment installed in hazardous areas should be minimized to that required for operational purposes and should be suitably and appropriately certified.
- Unintended accumulation of explosive, flammable or toxic vapour and liquid concentrations should be prevented.
- System components should be protected against external damage.
- Sources of ignition in hazardous areas should be minimized to reduce the probability of fire and explosions.
- Safe and suitable fuel supply, storage and bunkering arrangements should be provided, capable of receiving and containing the fuel in the required state without leakage.
- Piping systems, containment and overpressure relief arrangements that are of suitable design, material, construction and installation for their intended application should be provided.
- Machinery, systems and components should be designed, constructed, installed, operated, maintained and protected to ensure safe and reliable operation.
- Suitable control, alarm, monitoring and shutdown systems should be provided to ensure safe and reliable operation.
- Fixed fuel vapour and/or leakage detection suitable for all spaces and areas concerned should be arranged.
- Fire detection, protection and extinction measures appropriate to the hazards concerned should be provided.

- Commissioning, trials and maintenance of fuel systems and fuel utilization machinery should satisfy the goal in terms of safety, availability and reliability.
- The technical documentation should 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.
- A single failure in a technical system or component should not lead to an unsafe or unreliable situation.

A risk assessment is required using acceptable and recognized risk analysis techniques by considering loss of function, component damage, fire, explosion, toxicity and electric shock, as a minimum, in the assessment. Reference is made to the "Lloyd's Register, Ship Right, Design and Construction, Additional Design Procedures, Risk Based Designs (RBD)" process. The consequences of explosions are to be limited in that way that any explosion in any space containing a potential source of release and potential ignition should not:

- cause damage to or disrupt the proper functioning of equipment/systems located in any space other than that in which the incident occurs;
- damage the ship in such a way that flooding of water below the main deck or any progressive flooding occur;
- damage work areas or accommodation in such a way that persons who stay in such areas under normal operating conditions are injured;
- disrupt the proper functioning of control stations and switchboard rooms necessary for power distribution;
- damage life-saving equipment or associated launching arrangements;
- disrupt the proper functioning of fire-fighting equipment located outside the explosion-damaged space;
- affect other areas of the vessel in such a way that chain reactions involving, inter alia, cargo, gas and bunker oil may arise; or
- prevent persons' access to life-saving appliances or impede escape routes.

Requirements are provided for the fuel tanks, fuel containment system, access or other openings to hazardous areas, fuel piping, propulsion, fuel supply system and minimizing the probability of a fire or explosion. The fuel containment system shall have a at least equivalent level of safety to a conventional oil-fuelled ship. Provisions are addressed for fuel tank venting and the gas freeing system, inerting and atmospheric control within the fuel storage system. Materials and general pipe design and provisions for bunkering is addressed.

A safe and reliable distribution of fuel to consumers is requested by defining requirements and provisions for the fuel supply system, e.g. by an outer pipe or pipe duct, a redundant fuel supply, safety functions of the fuel supply system and fuel preparation spaces and fuel pumps. The safe and reliable delivery of mechanical, electrical or thermal energy is requested by addressing functional requirements and provisions for dual-fuel and single fuel engines.

The goal and functional requirements for providing fire protection, detection and fighting for all systems is given as well as for explosion prevention and area classification. A prescriptive area classification is provided in this chapters and as an alternative area classification according IEC 60079-10:1 is proposed with special consideration by the Administration. Ventilation requirements, provisions for electrical installations and for bunkering, training and operation are given in the last chapters.

2.6 European Committee for drawing up Standards in the field of Inland Navigation (CESNI), European Standard laying down Technical Requirements for Inland Navigation vessels (ES-TRIN), Edition 2019/1

Fuels with a flashpoint equal or lower than 55°C are currently addressed in the Chapter 30 Special Provisions Applicable to Craft Equipped with Propulsion or Auxiliary Systems Operating on Fuels with a Flashpoint equal to or lower than 55°C of the ES-TRIN rules. Propulsion and auxiliary systems operating on these fuels may be installed on craft provided the requirements in this chapter and Annex 8 of ES-TRIN is complied with. Annex 8 of ES-TRIN currently only consists of one section applicable to Liquefied Natural Gas. Regulations for further low-flashpoint fuels methanol and hydrogen, as well as for fuel cells are currently under development.

Chapter 30 provides provisions for:

- Testing
- Safety organization
- Marking
- Independent propulsion
- Technical services

Annex 8 Supplementary Provisions Applicable to Craft Operating on Fuels with a Flashpoint equal to or lower than 55°C provides, in Section 1, requirements for Liquefied Natural Gas. Details are provided for:

- Vessel arrangements and system design
- Fire safety
- Electrical systems
- Control, monitoring and safety systems

A risk assessment is required for all concepts and configurations addressing risks arising from the use of LNG affecting people on board, the environment, the structural strength and the integrity of the craft. By the inspection body recognized risk analysis techniques are to be applied addressing as a minimum Loss of function, component damage, fire, explosion, tank room flooding, vessel sinking and electric overvoltage.

2.7 European Committee for drawing up Standards in the field of Inland Navigation (CESNI), LEAFLET ON DELIBERATION ON DEROGATIONS AND EQUIVALENCES OF TECHNICAL REQUIREMENTS OF THE ES-TRIN FOR SPECIFIC CRAFT, March 2019

Craft operating on the Rhine and in the EU waterways are to be compliant with the technical requirements of the ES-TRIN. A Rhine vessel inspection certificate or a Union certificate for inland navigation vessels issued by the national competent authority confirm this compliance. Derogations to the technical requirements of the ES-TRIN are allowed in justified cases in order to encourage innovation and the use of new technologies in inland navigation and when technical requirements are technically difficult to apply or where their application might entail disproportionate costs. The "Leaflet on deliberation on derogations and equivalence of technical requirements of the ES-TRIN for specific craft" providing support and guidance in this certification process. The following details are provided in this leaflet:

- Inland navigation vessel certificate
- Possibilities for international derogations to the technical requirements

- Advantages of an approval of derogation at CCNR or European Union level
- Derogation approval validity period
- Application for approval of derogations and examination of application documents in practice

Responsible for initiating this derogation process at his national competent authority is the ship owner. This authority is responsible for examination of the application and decides together with the owner whether the vessel should receive a Rhine certificate or a Union certificate. Depending on this certificate decision the member state applies to the Central Commission for the Navigation of the Rhine or CESNI Committee for approval to derogate from ES-TRIN.

The procedure for application and approval consists of three basic steps: preparation of a technical file, technical examination by an international working group (either CESNI/PT or RV/G) and administrative validation by international bodies. A summary of the procedure is provided in the following figure.

Steps	Type of certificate	
	Rhine vessel inspection certificate (request for derogation according to RVIR)	**Union certificate for inland navigation vessels** (request for derogation according to Directive (EU) 2016/1629)
I **File preparation**	Project initiators and national authority (3-12 months)	
II **Submission of the application**	via the CCNR Secretariat in the case of the RV/G working group (max. 3 months, i.e. in good time prior to a meeting)	via the CCNR Secretariat in the case of the CESNI/PT Working Group (max. 3 months, i.e. in good time prior to a meeting)
III **Technical examination**	Working group RV/G (6-9 months)	Working Group CESNI/PT (6-9 months)
IV **Approval process**	CCNR (publication) (2 weeks)	Communication from the MS to the EC - adoption of the implementing act[3] (roughly 12 months)

Table. 1 Application and Examination, taken from [11]

2.8 BS EN 60079-10-1, Explosive atmospheres Part 10-1: Classification of areas – Explosive gas atmospheres

In the rules for low-flashpoint fuels and gases requirements are provided for preventing the explosion and for the limitation of effects from the explosion. Typically, the probability of an explosion shall be reduced to a minimum by reducing the number of sources of ignition and reducing the probability of formation of ignitable mixtures. A hazardous classification study is required to be undertaken. The scope of this study might comprise normal operation, start-up, normal down, non-use, emergency shut down and venting systems. A prescriptive area classification is typically provided in the relevant rules and as an alternative an area classification according IEC 60079-10:1 is proposed.

The standard BS EN 60079-10-1:2015, Explosive atmospheres, Part 10-1: Classification of areas – Explosive gas atmospheres is concerned with the classification of areas where gas or vapour hazards may arise. This standard may be used as a basis for the selection and installation of equipment for use in hazardous areas. It shall be pointed out that this standard does not apply to catastrophic failures or rare malfunctions. Catastrophic failures might be the rupture of a process vessel, total breakdown of a flange or seal. In

addition, equipment will not be considered as a source of release if it can not release a flammable substance per definition, e.g. a fully welded pipe. The following contents are provided in this standard:

- Area classification methodology
- Release of flammable substances
- Type of zone
- Extent of zone
- Documentation

The area classification can be carried out based on the "classification by sources of release method", by the "use of industry codes and national standards" or by "simplified methods". The formal process follows the investigation of the release of flammable substances, the ventilation and the dilution, the definition of the type of the zone determined by the grade of release and extent of the zone.

A risk assessment is proposed in this standard to be carried out after area classification. The consequences of ignition of an explosive atmosphere shall be analysed in order to assess whether a higher equipment protection level is required, or a lower equipment protection level might be justified. Zones of negligible extend might be identified which will be considered as non-hazardous. Such zones are understood as areas where a potential explosion will have negligible consequences.

3 REFERENCES

[1] Lloyd's Register, Rules and Regulations for the Classification of Ships, July 2020

[2] Lloyd's Register, Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels, July 2020

[3] Lloyd's Register, Rules and Regulations for the Classification of Methanol Fuelled Ships, July 2020

[4] Lloyd's Register, Ship Right, Design and Construction, Additional Design Procedures, Risk Based Designs (RBD), January 2018

[5] IMO, MSC.1/Circ. 1621, INTERIM GUIDELINES FOR THE SAFETY OF SHIPS USING METHYL/ETHYL ALCOHOL AS FUEL, 7 December 2020

[6] SOLAS Regulations Chapter II-1, Part F, Reg. 55 – Alternative Design and Arrangements

[7] BS EN 60079-10-1:2015, Incorporating corrigendum December 2016, Explosive atmospheres, Part 10-1: Classification of areas – Explosive gas atmospheres

[8] HyMethShip, D6.1, Review of Existing Design & Testing Standards and Regulations on HyMethShip Technologies for Maritime Applications

[9] HyMethShip, D6.3, Gap Analysis of Existing Standards and Regulations on HyMethShip Technologie for Maritime Applications

[10] European Committee for drawing up Standards in the field of Inland Navigation (CESNI), European Standard laying down Technical Requirements for Inland Navigation vessels (ES-TRIN), Edition 2021/1

[11] European Committee for drawing up Standards in the field of Inland Navigation (CESNI), LEAFLET ON DELIBERATION ON DEROGATIONS AND EQUIVALENCES OF TECHNICAL REQUIREMENTS OF THE ES-TRIN FOR SPECIFIC CRAFT, March 2019

[12] EMSA, SSPA, J. Ellis, K. Tanneberger, Study on the use of ethyl and methyl alcohol as alternative fuels in shipping, Final Report Version 20151204.5

[13] EMSA, Guidance on LNG Bunkering to Port Authorities and Administrations, 2018

[14] Lloyd's Register, Introduction to Methanol Bunkering, July 2020