# Guide for the Carriage of Alternative Fuelled Vehicle (AFV's) on Board of Ro-Ro Ships

*Effective from 1 February 2023*

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# GENERAL CONDITIONS

**Definitions:**

"*Administration*" means the Government of the State whose flag the Ship is entitled to fly or under whose authority the Ship is authorised to operate in the specific case.

*"IACS"* means the International Association of Classification Societies.

"*Interested Party*" means the party, other than the Society, having an interest in or responsibility for the Ship, product, plant or system subject to classification or certification (such as the owner of the Ship and his representatives, the ship builder, the engine builder or the supplier of parts to be tested) who requests the Services or on whose behalf the Services are requested.

"*Owner*" means the registered owner, the ship owner, the manager or any other party with the responsibility, legally or contractually, to keep the ship seaworthy or in service, having particular regard to the provisions relating to the maintenance of class laid down in Part A, Chapter 2 of the Rules for the Classification of Ships or in the corresponding rules indicated in the specific Rules.

*"Rules"* in these General Conditions means the documents below issued by the Society:

(i) Rules for the Classification of Ships or other special units;
(ii) Complementary Rules containing the requirements for product, plant, system and other certification or containing the requirements for the assignment of additional class notations;
(iii) Rules for the application of statutory rules, containing the rules to perform the duties delegated by Administrations;
(iv) Guides to carry out particular activities connected with Services;
(v) Any other technical document, as for example rule variations or interpretations.

"*Services*" means the activities described in Article 1 below, rendered by the Society upon request made by or on behalf of the Interested Party.

*"Ship"* means ships, boats, craft and other special units, as for example offshore structures, floating units and underwater craft.

"*Society*" or *"TASNEEF"* means Tasneef and/or all the companies in the Tasneef Group which provide the Services.

"*Surveyor*" means technical staff acting on behalf of the Society in performing the Services.

**Article 1**

**1.1.** The purpose of the Society is, among others, the classification and certification of ships and the certification of their parts and components. In particular, the Society:
(i) sets forth and develops Rules;
(ii) publishes the Register of Ships;
(iii) issues certificates, statements and reports based on its survey activities.

**1.2.** The Society also takes part in the implementation of national and international rules and standards as delegated by various G overnments.

**1.3.** The Society carries out technical assistance activities on request and provides special services outside the scope of classification, which are regulated by these general conditions, unless expressly excluded in the particular contract.

**Article 2**

**2.1.** The Rules developed by the Society reflect the level of its technical knowledge at the time they are published. Therefore, the Society, although committed also through its research and development services to continuous updating of the Rules, does not guarantee the Rules meet state-of-the-art science and technology at the time of publication or that they meet the Society's or others' subsequent technical developments.

**2.2.** The Interested Party is required to know the Rules on the basis of which the Services are provided. With particular reference to Classification Services, special attention is to be given to the Rules concerning class suspension, withdrawal and reinstatemen t. In case of doubt or inaccuracy, the Interested Party is to promptly contact the Society for clarification.
The Rules for Classification of Ships are published on the Society's website: www.tasneef.ae.

**2.3.** The Society exercises due care and skill:
(i) in the selection of its Surveyors
(ii) in the performance of its Services, taking into account the level of its technical knowledge at the time the Services are performed.

**2.4.** Surveys conducted by the Society include, but are not limited to, visual inspection and non-destructive testing. Unless otherwise required, surveys are conducted through sampling techniques and do not consist of comprehensive verification or monitoring of the Ship or of the items subject to certification. The surveys and checks made by the Society on board ship do not necessarily require the constant and continuous presence of the Surveyor. The Society may also commission laboratory testing, underwater inspection and other checks carried out by and under the responsibility of qualified service suppliers. Survey practices and procedures are selected by the Society based on its experience and knowledge and according to generally accepted technical standards in the sector.

**Article 3**

**3.1.** The class assigned to a Ship, like the reports, statements, certificates or any other document or information issued by the Society, reflects the opinion of the Society concerning compliance, at the time the Service is provided, of the Ship or product subject to certification, with the applicable Rules (given the intended use and within the relevant time frame).
The Society is under no obligation to make statements or provide information about elements or facts which are not part of th e specific scope of the Service requested by the Interested Party or on its behalf.

**3.2.** No report, statement, notation on a plan, review, Certificate of Classification, document or information issued or given as p art of the Services provided by the Society shall have any legal effect or implication other than a representation that, on the basis of the checks made by the Society, the Ship, structure, materials, equipment, machinery or any other item covered by such document or information meet the Rules. Any such document is issued solely for the use of the Society, its committees and clients or other duly authorised bodies and for no other purpose. Therefore, the Society cannot be held liable for any act made or document issued by other parties on the basis of the statements or information given by the Society. The validity, application, meaning and interpretation of a Certificate of Classification, or any other document or information issued by the Society in connection with its Services, is governed by the Rules of the Society, which is the sole subject entitled to make such interpretation. Any disagreement on technical matters between the Interested Party and the Surveyor in the carrying out of his functions shall be raised in writing as soon as possible with the Society, which will settle any divergence of opinion or dispute.

**3.3.** The classification of a Ship, or the issuance of a certificate or other document connected with classification or certificati on and in general with the performance of Services by the Society shall have the validity conferred upon it by the Rules of the Society at the time of the assignment of class or issuance of the certificate; in no case shall it amount to a statement or warranty of seaw orthiness,

structural integrity, quality or fitness for a particular purpose or service of any Ship, structur e, material, equipment or machinery inspected or tested by the Society.

**3.4.** Any document issued by the Society in relation to its activities reflects the condition of the Ship or the subject of certifi cation or other activity at the time of the check.

**3.5.** The Rules, surveys and activities performed by the Society, reports, certificates and other documents issued by the Society are in no way intended to replace the duties and responsibilities of other parties such as Governments, designers, ship builders, manufacturers, repairers, suppliers, contractors or sub-contractors, Owners, operators, charterers, underwriters, sellers or intended buyers of a Ship or other product or system surveyed.

These documents and activities do not relieve such parties from any fulfilment, warranty, responsibility, duty or obligation (also of a contractual nature) expressed or implied or in any case incumbent on them, nor do they confer on such parties any right, claim or cause of action against the Society. With particular regard to the duties of the ship Owner, the Services undertaken by the Society do not relieve the Owner of his duty to ensure proper maintenance of the Ship and ensure seaworthiness at all times. Likewise, t he Rules, surveys performed, reports, certificates and other documents issued by the Society are intended neither to guarantee the buyers of the Ship, its components or any other surveyed or certified item, nor to relieve the seller of the duties arising out of the law or the contract, regarding the quality, commercial value or characteristics of the item which is the subject of transaction.

In no case, therefore, shall the Society assume the obligations incumbent upon the above-mentioned parties, even when it is consulted in connection with matters not covered by its Rules or other documents.

In consideration of the above, the Interested Party undertakes to relieve and hold harmless the Society from any third party claim, as well as from any liability in relation to the latter concerning the Services rendered.

Insofar as they are not expressly provided for in these General Conditions, the duties and responsibilities of the Owner and Interested Parties with respect to the services rendered by the Society are described in the Rules applicable to the specific Service rendered.

**Article 4**

**4.1.** Any request for the Society's Services shall be submitted in writing and signed by or on behalf of the Interested Party. Such a request will be considered irrevocable as soon as received by the Society and shall entail acceptance by the applicant of all relevant requirements of the Rules, including these General Conditions. Upon acceptance of the written request by the Society, a contract between the Society and the Interested Party is entered into, which is regulated by the present General Conditions.

**4.2.** In consideration of the Services rendered by the Society, the Interested Party and the person requesting the service shall be jointly liable for the payment of the relevant fees, even if the service is not concluded for any cause not pertaining to the Society. In the latter case, the Society shall not be held liable for non-fulfilment or partial fulfilment of the Services requested. In the event of late payment, interest at the legal current rate increased by 1.5% may be demanded.

**4.3.** The contract for the classification of a Ship or for other Services may be terminated and any certificates revoked at the request of one of the parties, subject to at least 30 days' notice to be given in writing. Failure to pay, even in part, the fees due for Services carried out by the Society will entitle the Society to immediately terminate the contract and suspend the Services.

For every termination of the contract, the fees for the activities performed until the time of the termination shall be owed to the Society as well as the expenses incurred in view of activities already programmed; this is without prejudice to the right to compensation due to the Society as a consequence of the termination.

With particular reference to Ship classification and certification, unless decided otherwise by the Society, termination of the contract implies that the assignment of class to a Ship is withheld or, if already assigned, that it is suspended or withdrawn; any st atutory certificates issued by the Society will be withdrawn in those cases where provided for by agreements between the Society and the flag State.

**Article 5**

**5.1.** In providing the Services, as well as other correlated information or advice, the Society, its Surveyors, servants or agents operate with due diligence for the proper execution of the activity. However, considering the nature of the activities performed (see art. 2.4), it is not possible to guarantee absolute accuracy, correctness and completeness of any information or advice supplied. Express and implied warranties are specifically disclaimed.

Therefore, except as provided for in paragraph 5.2 below, and also in the case of activities carried out by delegation of Governments, neither the Society nor any of its Surveyors will be liable for any loss, damage or expense of whatever nature sustained by any person, in tort or in contract, derived from carrying out the Services.

**5.2.** Notwithstanding the provisions in paragraph 5.1 above, should any user of the Society's Services prove that he has suffered a loss or damage due to any negligent act or omission of the Society, its Surveyors, servants or agents, then the Society will pay compensation to such person for his proved loss, up to, but not exceeding, five times the amount of the fees charged for the specific services, information or opinions from which the loss or damage derives or, if no fee has been charged, a maximum of AED5,000 (Arab Emirates Dirhams Five Thousand only). Where the fees charged are related to a number of Services, the amount of the fees will be apportioned for the purpose of the calculation of the maximum compensation, by reference to the estimated time involved in the performance of the Service from which the damage or loss derives. Any liability for indirect or consequential loss, damage or expense is specifically excluded. In any case, irrespective of the amount of the fees charged, the maximum damages payable by the Society will not be more than AED5,000,000 (Arab Emirates Dirhams Five Millions only). Payment of compensation under this paragraph will not entail any admission of responsibility and/or liability by the Society and will be made without prejudice to the disclaimer clause contained in paragraph 5.1 above.

**5.3.** Any claim for loss or damage of whatever nature by virtue of the provisions set forth herein shall be made to the Society in writing, within the shorter of the following periods: (i) THREE (3) MONTHS from the date on which the Services were performed, or (ii) THREE (3) MONTHS from the date on which the damage was discovered. Failure to comply with the above deadline will constitute an absolute bar to the pursuit of such a claim against the Society.

**Article 6**

**6.1.** These General Conditions shall be governed by and construed in accordance with United Arab Emirates (UAE) law, and any dispute arising from or in connection with the Rules or with the Services of the Society, including any issues concerning responsibility, liability or limitations of liability of the Society, shall be determined in accordance with UAE law. The courts of the Dubai International Financial Centre (DIFC) shall have exclusive jurisdiction in relation to any claim or dispute which may arise out of or in connection with the Rules or with the Services of the Society.

**6.2.** However,

(i) In cases where neither the claim nor any counterclaim exceeds the sum of AED300,000 (Arab Emirates Dirhams Three Hundred Thousand) the dispute shall be referred to the jurisdiction of the DIFC Small Claims Tribunal; and

(ii) for disputes concerning non-payment of the fees and/or expenses due to the Society for services, the Society shall have the

right to submit any claim to the jurisdiction of the Courts of the place where the registered or operating office of the Interested Party or of the applicant who requested the Service is located.

In the case of actions taken against the Society by a third party before a public Court, the Society shall also have the right to summon the Interested Party or the subject who requested the Service before that Court, in order to be relieved and held harmless according to art. 3.5 above.

**Article 7**

**7.1.** All plans, specifications, documents and information provided by, issued by, or made known to the Society, in connection with the performance of its Services, will be treated as confidential and will not be made available to any other party other than the Owner without authorisation of the Interested Party, except as provided for or required by any applicable international, European or domestic legislation, Charter or other IACS resolutions, or order from a competent authority. Information about the status and validity of class and statutory certificates, including transfers, changes, suspensions, withdrawals of class, recommendations/conditions of class, operating conditions or restrictions issued against classed ships and other related information, as may be required, may be published on the website or released by other means, without the prior consent of the Interested Party.

Information about the status and validity of other certificates and statements may also be published on the website or released by other means, without the prior consent of the Interested Party.

**7.2.** Notwithstanding the general duty of confidentiality owed by the Society to its clients in clause 7.1 above, the Society's clients hereby accept that the Society may participate in the IACS Early Warning System which requires each Classification Society to provide other involved Classification Societies with relevant technical information on serious hull structural and engineering systems failures, as defined in the IACS Early Warning System (but not including any drawings relating to the ship which may be the specific property of another party), to enable such useful information to be shared and used to facilitate the proper working of the IACS Early Warning System. The Society will provide its clients with written details of such information sent to the involved Classification Societies.

**7.3.** In the event of transfer of class, addition of a second class or withdrawal from a double/dual class, the Interested Party undertakes to provide or to permit the Society to provide the other Classification Society with all building plans and drawings, certificates, documents and information relevant to the classed unit, including its history file, as the other Classification Society may require for the purpose of classification in compliance with the applicable legislation and relative IACS Procedure. It is the Owner's duty to ensure that, whenever required, the consent of the builder is obtained with regard to the provision of plans and drawings to the new Society, either by way of appropriate stipulation in the building contract or by other agreement.

In the event that the ownership of the ship, product or system subject to certification is transferred to a new subject, the latter shall have the right to access all pertinent drawings, specifications, documents or information issued by the Society or which has come to the knowledge of the Society while carrying out its Services, even if related to a period prior to transfer of ownership.

**Article 8**

**8.1.** Should any part of these General Conditions be declared invalid, this will not affect the validity of the remaining provisions.

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# 1 GENERAL

## 1.1 FIELD OF APPLICATION

**1.1.1**

The aim of this guide is to provide a technical instrument to support owners, shipyards, and designers in the risk analysis process for the safe carriage of alternative fuelled vehicles (AFV's) on board of ro-ro ships.

**1.1.2**

The guide applies to:

- ro-ro passenger ships, as defined in SOLAS Reg.II-2/3.42, certified to carry a number of passengers either "up to" or "more than" 36;
- ro-ro cargo ships or vehicle carriers, as defined in SOLAS Reg.II-2/3.56, including:
  a) pure car carriers (PCC ships);
  b) pure car truck carrier (PCTC ships).

**1.1.3**

The guide applies to new and existing ships. On existing ships, the feasibility of the guide application will be evaluated by Tasneef on a "*case-by-case*" basis.

**1.1.4**

The application of the guide is to be considered in addition to other statutory requirements and class regulations for the ships mentioned in [1.1.2].

**1.1.5**

Although the guide refers to AFV's, the case of voyages where AFV's are carried together with traditionally fuelled vehicles has been considered. Therefore, vehicles fuelled by Hydrocarbon fuels and Biofuels are mentioned where deemed necessary.

## 1.2 DEFINITIONS

**1.2.1**

In the application of the present guide, the following definitions apply:

*a) Alternative Fueled Vehicle* (hereinafter AFV's)**:** a vehicle using for its own propulsion fuels different from those traditionally used in internal combustion engines (e.g. gasoline, gasoil and biofuels).

*b) Battery Electric Vehicle*: an AFV driven by means of one or more electric motors powered by a set of batteries.

*c) Compressed Gas*: a gas stored in cylinders, either liquefied or compressed, used as fuel in AFV's driven by internal combustion engines. It can be either a Petroleum or a Natural gas.

*d) Fuel Cell Vehicle*: an AFV powered by a set of electrochemical cells, where the chemical energy of a fuel (e.g., Hydrogen), is converted into electric power used by electric motors.

*e) Hybrid Electric Vehicle*: an AFV capable of being driven by either a set of batteries or an internal combustion engine; in the phase when internal combustion engine is operating it also provides to re-charge the set of batteries.

*f) IMDG Code*: the International Maritime Dangerous Goods code issued by the IMO.

*g) Infrared*: an electromagnetic radiation, invisible to the human eye, used in the thermal imaging technology to detect heated surfaces or fires in concealed or unexposed locations.

*h) Liquified Petroleum Gas* (hereinafter LPG): a by-product of natural gas and crude oil production and refining, mainly composed by Butane and Propane in different fractions.

*i) Liquified Natural Gas* (hereinafter LNG): a natural gas, mainly Methane with some mixture of Ethane, cooled down to liquid form for non-pressurized storage and transport.

*j) Ro-ro space*: a space not normally subdivided in any way, normally extended to either a substantial length or the whole length of the ship, used for the carriage of AFV's that are loaded/unloaded with their own propulsion. In accordance with definitions given in SOLAS Regulation II-2/3, there are different types of ro-ro spaces:

- *vehicle space*: the ro-ro space on board of cargo ships;
- *open vehicle space*: the ro-ro space on board of cargo ships, either open at both ends or having one end opened and permanent openings, with a total area of at least 10% of the total area of the space sides, distributed in the side plating or deckhead or from above;
- *open ro-ro space*: a ro-ro space provided with openings as open vehicle spaces;
- *special category space*: a vehicle space accessible to passengers and where passengers are allowed to provide loading/unloading of their vehicles.

*k) State of Charge* (hereinafter SoC): is the level of charge of an electric battery, relative to its capacity measured in percentage points.

*l) Thermal Runaway*: a phenomenon in which a Lithium-ion cell enters an uncontrollable self-heating state, resulting in:
- extremely high temperatures,
- ejection of gas, shrapnel and particulates;
- smoke;
- fire.

## 2 BASIC PRINCIPLES

### 2.1 RISK ASSESSMENT

An evaluation of risks related to the carriage of AFV's on board of a ship should be carried out by a risk assessment; in the risk assessment the different hazards arising in the various operations involved in the carriage of AFV's are to be analyzed. A summary of the specific events and hazards in case of carriage of AFV's is available in Tab. A.

The risk assessment should be conducted for each ship to ensure that risks arising from the carriage of AFV's and all related operations that might affect persons on board, the environment and the safety of the ship are addressed. These risks should be managed within the framework of existing requirements in the ISM code.

The result of the risk assessment should be a ship specific procedure, to be kept on board, for the prevention and mitigation of fire incidents involving AFV's.

### 2.2 IMDG Code

#### 2.2.1 General

This paragraph illustrates the application of the IMDG Code in the carriage of vehicles and the conditions required to allow their transport.

The IMDG Code regulates vehicles for their sea transport since the 35$^{th}$ amendments: starting from 1 January 2018 (38$^{th}$ amendment), an UN Number is provided for engines and vehicles, depending on fuel contained or capacity of fuel tank.

In accordance with paragraph 2.9.2 of the Code, vehicles are assigned to class 9 and to be mentioned in the carriage certificate as:
- UN 3166, if Fuel Cell, Flammable Gas or Flammable Liquid powered,
- UN 3171, if Battery powered.

#### 2.2.2 Special provisions

The carriage of vehicles has also to consider the Special Provisions SP 961 and SP 962 of the Code, the text of which is quoted in Tab. B, attached to the present guide for a prompt reference.

The Special Provisions provides specific conditions of the vehicles, in order to consent their transport with the exemption from the full application of the Code or not. For instance, in accordance with Special Provision 961, the IMDG Code is not applicable when the AFV's are carried in a special category, vehicle and ro-ro spaces, or on the weather deck of a ro-ro ship, as long as:
- there are no signs of leakage from the battery, engine, fuel cell, compressed gas cylinder or accumulator, or fuel tank when applicable, or
- if liquid fuel tank is empty or gas powered is having its tank empty or positive pressure in the tank does not exceed 2 bar.

In case vehicles are carried within a cargo transport unit stowed in the container cargo spaces of a ro-ro ship, the exception from the application of the Code is not applicable.

#### 2.2.3 Electric Vehicles

In accordance with paragraph 2.9.4 of the Code, in electric vehicles (both Battery Electric and Hybrid Electric) particular attention is to be given to the conditions of the battery.

In case of a Lithium-ion battery installed in a vehicle that is found damaged or defective, it should be removed, or the vehicle not accepted for transport. Similarly, if an electric vehicle is found damaged but it is unclear if the battery is damaged or not, the recommendation is to apply the same provision as above.

#### 2.2.4 Gas vehicles

In accordance with paragraph 1.1.3.1 of the Code, vehicles ("articles" in the Code) presented for transport which are liable to produce flammable gases or vapors under normal condition of transport are forbidden unless:

a) stowed in a space as per [1.2.1 j]

b) the conditions mentioned in [2.2.2] are met and, in addition
c) the fuel shut-off or isolation valve is closed and secured, and installed batteries, excluded those for the engine starting, are protected from short circuit.

It is also known that with a sufficient holding time before the opening of pressure release valves, an LNG vehicle does not produce flammable gases or vapors and can be accepted for transport. The data for the evaluation of the holding time are made available by car's manufacturer, considering the fuel tank level and the pressure, that are to be readable from the vehicle.

#### 2.2.5 Small Electric Vehicles

This type of vehicles, included in the code number UN 3171, refers to vehicles such as electric bicycles and kick bikes. In accordance with Special Provision 388, as "*small battery powered vehicle*" it is intended a self-propelled apparatus designed to carry one or more persons or goods, for instance a bicycle (electric) or a self-balancing vehicle.
The requirements of Special Provision 961 are also applicable to this case.

### 2.3 IDENTIFICATION OF RISKS

#### 2.3.1 General

In case of AFV's, the assessment of risks concerned with their carriage begins from the analysis of vehicles main characteristics (see Tab.A):

1. type of propulsion:
   a. internal combustion engine,
   b. electric motor(s) or hybrid system,
   c. fuel cells;

and

2. type of fuel:
   a. Hydrocarbons or liquid petroleum product fuels (gasoline, gasoil) and biofuels in general,
   b. gases, either liquified (LNG, LPG) or compressed (LPG, $H_2$),
   c. batteries, particularly of the Lithium-ion type.

#### 2.3.2 Risks identification

In Tab. A, the events and hazards due to the type of fuel used in the different type of vehicles are listed: the hazard of each fuel type has a relationship with one or more dangerous gases or vapours with their physical and chemical properties (see Tab.C).
The table data should be used to evaluate the risk of ignition, the ventilation for the control of the atmosphere of the space where vehicles are carried and, in general, to identify the risk-mitigating measures that should be implemented as result of the risk assessment mentioned in [2.1].

## 3 DESIGN REQUIREMENTS

### 3.1 IDENTIFICATION OF SUITABLE ONBOARD PARKING SPACES AND AREAS

#### 3.1.1 General

Parking areas for AFV's assigned on the basis of the type of fuel should be defined at an initial design stage.
To determine these specific parking areas, several factors need to be considered including:

1) the structure of the ship: number and position of the closed decks, extension of partially open decks, weather exposed areas, etc.,
2) volume and type of traffic: designated quantity of a type of AFV's, transport of AFV's contemporary to dangerous goods in cargo units or trailers, etc.,
3) size of the AFV's and occupied space: cars, coaches, trucks, etc.,
4) stowage conditions: possibility of tow vehicles to a safer position away from a fire, safety distances for the operation of fire-fighting equipment, etc.

Suitable indications on board to indicate the parking areas, the extension of stowage points for vehicles on deck floor and the type(s) of AFV's for which the parking area is available, should be provided on board in order to help the crew members for fire control, suppression and extinguishing operations.
In addition to the above, a set of dedicated requirements on parking areas additional to those of SOLAS Regulation II-2/20 and depending from the type of fuel, is provided in [3.1.2] to [3.1.4], considering that different specific requirements may be applied to a ship depending of her design and the vehicle types carried in different voyages.

### 3.1.2 Gas Fueled Vehicles

In the carriage of this type of AFV's, in evaluating the stowage position on board during voyage, first of all the dissipation and discharge outboard of any gas leak or venting that may occur is to be considered in order to avoid any possible creation of explosive atmosphere.

In addition to those on ventilation in [3.2], the following requirements should be applied:

- in case the open deck areas are unavailable, or used for different carriage purposes, vehicles are to be positioned in a well-ventilated space, with air flow continuously maintained and capable to avoid gas pockets;
- in enclosed spaces, the number of air changes per hour suitable to maintain a concentration not greater than 25% of LFL should be provided: to provide flexibility in the use of the cargo spaces for different types of AFV's, the use of double-speed or variable speed ventilation fans is possible;
- the positioning of supply and exhaust openings is to be provided taking into consideration the gases and vapours density, lighter or heavier than air (see Tab.C);
- the positioning of external inlet and discharge grilles or louvers, is to comply with the provisions for safe/hazardous areas given in Standard IEC 60092-502, or equivalent.

### 3.1.3 Electric Powered Vehicles

In the carriage of electric and hybrid vehicles, the main risk is due to the use of batteries for their propulsion, particularly when the vehicles use Lithium-ion batteries:

- these AFV's should be carried preferably on weather decks or on open or partially open decks;
- parking areas of this type of vehicles should be located decks above the waterline to consent the fast and effective discharge of the copious quantities of water needed for fire-suppression purposes;
- in case parking areas are positioned below the waterline, the drainage of water should be provided by means of suitable mechanical bilge drainage systems considering the simultaneous discharge of water from the fixed spray-water fire extinguishing system and the portable fire-fighting equipment necessary in these cases, therefore:
  a) the jets of water required in SOLAS Regulation II-2/19.3.1.2, and
  b) the sprayed water provided by the portable equipment used for the "*bottom cooling*" of the electric vehicles;
- in addition to those of [3.2], the previous [3.1.2] should be applied about ventilation;
- in case of Lithium-ion batteries, the presence of Hydrogen released in case of a thermal runaway should be taken into account, therefore suitable gas sensors should be provided (for instance, in the exhaust ventilation ducts) to grant a continuous monitoring of the atmosphere in enclosed spaces. The fixed gas detection system should comply with Pt C, Ch 4, Sec 1, [5.2.4 b] of Tasneef Rules for the Classification of Ships – "*Arrangement for gas measurement in double hull and double bottom spaces*";
- electric vehicles should be stowed:
  a) at a distance from the adjacent vehicles greater than usual, not less than 0.6 m, to consent the access for manual fire-fighting operations, and
  b) where possible, in areas with a reduced number of vehicles is surrounding them (e.g., at the beginning, at the end, at the sides of the ship) or, in any case, where arrangement to reduce the spread of fire to the adjacent vehicles are present or can be adopted.

### 3.1.4 Hydrocarbons or liquid petroleum-type fuels and biofuels powered vehicles

These vehicles are not covered by this guide; however it is reminded that their carriage has to comply with provisions of SOLAS Regulation II-2/20.

## 3.2 VENTILATION

### 3.2.1 General

In general, requirements for ventilation systems provided in SOLAS Regulation II-2/20.3.1 are applicable with the additional provisions given in this guide based on the characteristics of the different type of dangerous gases and vapours (see [3.1]).

The characteristics of the dangerous gases and vapours that need to be evacuated from the space (see Tab. C) can be used to suitably design the positioning of air suction points within the spaces for vehicles.

### 3.2.2 Ventilators

The construction of ventilation equipment used for vehicle spaces, is to comply with Pt C, Ch 4, Sec 1, [5.3] of Tasneef Rules for the Classification of Ships.

When Hydrogen fuelled vehicles are carried and Hydrogen may be released within the space, the use of Aluminium in the construction of spark-proof ventilation equipment should be avoided.

### 3.2.3 Assessment of ventilation systems

The use of Standards or other suitable technical literature for the design and sizing of ventilation systems (for instance, HSE EI15 "*Technical input on ventilation effectiveness for area classification guidance*", IMO Circular MSC.1/1515 "*Revised design guideline and operational recommendations for ventilation systems in ro-ro cargo spaces*", etc.) based on the type of dangerous gases or vapours that need to be evacuated, may be allowed provided that it is part of the risk assessment mentioned in [2.1].

## 3.3 ELECTRICAL SYSTEM AND SOURCES OF IGNITION

### 3.3.1 General

Any ship's electrical system fitted within spaces where vehicles are carried is to be arranged in such a way to avoid any risk of ignition. Attention is to be given at the different types of fuels used by the AFV's carried on board to select the electrical equipment and wiring more suitable for their use in the possible explosive atmospheres that may be present.

The use of different degrees and types of protection to determine different parking areas, each dedicated to one or more category of AFV's within the vehicle spaces on board (see Tab. C) is allowed when the adequate level of safety against ignition is granted.

### 3.3.2 Hazardous areas in passenger ships

The following definitions of hazardous areas, depending on the type of vehicle concerned, its type of fuel and relevant dangerous gases and vapours that may be developed should be applied.

#### 3.3.2.1 Liquid Petroleum-type (Hydrocarbon) fuels and biofuels fueled vehicles

The hazardous areas are to comply with Pt E, Ch 12, Sec 5, [3.1.1], [3.1.2] and [3.1.3] of Tasneef Rules for the Classification of Ships, as reminded here below for a quick reference.

For the purposes of the present paragraph and previous [3.2] on ventilation system, it is pointed out that the petroleum products gases and mixtures of gases and air are heavier than the ambient air itself.

1) Spaces used for the carriage of vehicles above the bulkhead deck:
   a. Zone 1:
      i. areas less than 450 mm above the deck or platforms without openings capable to permit the diffusion of petrol gases downward,
      ii. exhaust ventilation ducts,
      iii. supply ventilation ducts in case of use of reversible-type ventilation equipment.
   b. Zone 2:
      i. areas 450 mm or more above the deck or platforms without openings capable to permit the diffusion of petrol gases downward.
2) Spaces used for the carriage of vehicles below the bulkhead deck:
   a. Zone 1:
      i. the whole space used for the carriage of vehicles,
      ii. exhaust ventilation ducts,
      iii. supply ventilation ducts in case of use of reversible-type ventilation equipment.
   b. Zone 2: not applicable.

#### 3.3.2.2 Liquified Petroleum gas (LPG) fueled vehicles

The definitions of hazardous areas given in [3.2.2.1] about Liquid Petroleum-type (Hydrocarbon) fuels and biofuels vehicles, should be applied.

For the purposes of the present paragraph and previous [3.2] on ventilation system, it is pointed out that LPG gases are heavier than air.

#### 3.3.2.3 Liquified Natural gas (LNG) fuelled vehicles

In the definition of hazardous areas, it should be considered that LNG and mixtures with air are lighter than the ambient air, therefore:

a. Zone 1:
   i. the whole space used for the carriage of vehicles,
   ii. exhaust ventilation ducts,
   iii. supply ventilation ducts in case of use of reversible-type ventilation equipment.
b. Zone 2: not applicable.

#### 3.3.2.4 Hydrogen fueled vehicles

Requirements set out for LNG fueled vehicles in previous [3.3.2.3] should be applied.

#### 3.3.2.5 Electric powered vehicles (EV's) and State of Charge (SoC)

The definition of hazardous areas is based on the likelihood that the presence of a potential explosive atmosphere may occur (e.g. due to the release of flammable or explosive gases or vapours within a space). In case of electric powered vehicles, these gases may be generated by the batteries used for propulsion and, in case of Lithium-ion type, when the battery goes into a thermal runaway: during the thermal runaway a different number of gases is released from the battery, including Hydrogen.
Therefore, definitions of hazardous areas given in [3.3.2.4] about Hydrogen fueled vehicles should be applied.
When analyzing the risks relevant to the carriage of last generation electric vehicles, an important factor to be considered and kept under control from an operational point of view is the State of Charge (SoC).
Accident reports and tests on batteries confirmed that the SoC is related to the occurrence of a thermal runaway: lower values of SoC decrease the likelihood of thermal runaway significantly, particularly it was noted that an SoC ≤ 30% implies a thermal runaway to be very unlikely. From the point of view of fire phenomena, it is important to note that the SoC has not influence in the fire total energy released while it has on the fire peak heat release: it means that the highest is the SoC, the highest (and faster) is the heat peak during a fire, making also faster its spread to the other parts of a vehicle or to other vehicles parked nearby.

### 3.3.3 Hazardous areas in cargo ships

#### 3.3.3.1 Liquid Petroleum-type (hydrocarbon) fuels and biofuels powered vehicles

Hazardous areas given in [3.3.2.1] 2) a) for vehicle spaces below the bulkhead deck in passenger ships, should be applied.

#### 3.3.3.2 Liquified Petroleum gas (LPG) fueled vehicles

Hazardous areas given in [3.3.2.2] should be applied.

#### 3.3.3.3 Liquified Natural gas (LNG) fuelled vehicles

Hazardous areas given in [3.3.2.3] should be applied.

#### 3.3.3.4 Hydrogen fueled vehicles

See [3.3.2.4].

#### 3.3.3.5 Electric powered vehicles (EV's)

Reference should be made to [3.3.2.5] on battery fire and SoC.

### 3.3.4 Open decks and partially open decks

There are no limitations in case the AFV's are carried on open deck areas.
In case the AFV's are carried in decks of the partially open type, the definition and location of hazardous areas should consider the different types of dangerous gases and vapours that may be involved and should be made on a "*case-by-case*" basis, taking into consideration the following aspects:

a) height and vertical distance above decks level of the permanent openings provided on the ship's side;
b) longitudinal extension of the openings mentioned in a) above;
c) efficiency of the natural ventilation and characteristics of mechanical ventilation and ventilation equipment, if any.

The details on openings and ventilation are to be examined in the risk analysis mentioned in [2.1]; the efficiency and effective action of the ventilation as per c) above should be evaluated on board after installation by means of a practical operational test. The test may be carried out in accordance with IMO Circular MSC.1/Circ.1515, Appendix 2.

### 3.3.5 Safety characteristics of electrical equipment

Explosion protection groups and classes of temperature for electrical equipment certified of safe type can be found in Tab. D.

### 3.3.6 Cables

Electrical cables should be as per Pt C, Ch 2, Sec 3, [10.2.2] of Tasneef Rules for the Classification of Ships.

## 3.4 DETECTION AND ALARM

### 3.4.1 General

The requirements of SOLAS Regulation II-2/20.4.1 apply and the requirements for electrical equipment and the type of fuel used by the AFV's given in [3.3] above should also be taken into consideration.
In addition, the provisions stated in paragraphs 2.1.2 and 2.1.3 of IMO Circular MSC.1/Circ.1615 should also be applied. On weather decks, reference should be made to paragraph 2.4 of the same IMO Circular.

### 3.4.2 Video monitoring

A continuous video surveillance of the areas where vehicles are stowed should be provided in accordance with paragraphs 2.2.1 and 2.2.2 of IMO Circular MSC.1/Circ.1615.

The effectiveness of the video surveillance should be ensured considering the system layout, cameras location and coverage, and suitable operational instructions on embarkation and storage (see also [3.1] on identification of parking areas).

To increase fire recognition and notification capabilities, the system should be implemented with thermal imaging capability: as an alternative the use of portable thermal imaging equipment may be considered (see [5.3] on fire patrol).

### 3.4.3 Gas measurement

As an alternative to the provision of a continuous monitoring as per [3.1.3], the use of portable gas detection equipment may be provided in accordance with the following considerations:

1) type and characteristic of the developed dangerous gases and vapours;
2) type of AFV's and most suitable points where readings with the portable equipment should be taken;
3) frequency of readings to ensure an efficient evaluation of possible gas leaks or releases with regards to the ship's safety.

## 4 FIRE SUPPRESSION AND FIRE-FIGHTING

### 4.1 Fixed fire-extinguishing systems

#### 4.1.1 General

In general, the spaces where vehicles are stowed are to be protected by any of the fixed fire-fighting systems required in SOLAS Regulation II-2/20.6.1. It is reminded that the Convention stipulates the type of fire-extinguishing system with regards to:

1) type of ship: cargo ship (where vehicle spaces may be sealed, etc.) or passenger ships (on which the entrance of passengers into special category spaces is prohibited during navigation and in any case the use of $CO_2$ is not allowed, etc.), and
2) type of space to be protected: partially open deck, enclosed deck capable of being sealed or not, etc.

In accordance with 1) and 2) above, fixed fire-extinguishing systems currently used are summoned here below together with their most important characteristics, either effective or not:

a) gas-based systems:
   - they use large quantities of gas-based extinguishing agent, mainly $CO_2$,
   - they are effective only when the protected space can be sealed, thus largely used on board of cargo ships in closed spaces, either above or below the bulkhead deck,
   - they are not allowed in passenger ships because the gas agent has hazards for persons.
   - although suitable for almost all dangerous goods classes, the $CO_2$ is recognized ineffective in cases where the oxidizing agent is released by the same object on fire (e.g., batteries).

b) high-expansion foam systems:
   - these systems are suitable for extinguishing pool fires of combustible liquids such as petroleum-based fuels or biofuels (class B fires) only,
   - they are ineffective when fire involves solid combustible materials (class A fires) or jet fires (e.g. LPG/CNG/H2 fueled vehicles), and fires from batteries, since affected by the effect described at last bulleted item of a) above.

c) spray water-based systems:
   - a type of system found suitable to act for in the presence of a wide range of combustibles and fire classes, proved by practical tests as the most effective system for the protection of spaces where vehicles are carried, therefore recommended as the fixed fire-extinguishing system adopted also in case of AFV's too,
   - however, in case of fires involving batteries (particularly the Lithium-ion types) for the automotive, the spray water remains ineffective for extinguishing and should be used for suppression purposes only,
   - the seat of a fire in case of vehicles could be severely shielded from the direct application of water, either because of the vehicle's body or because the batteries are always installed in a well concealed and inaccessible position inside the vehicle's chassis.

Following the facts described above, in the carriage of vehicles the following fixed fire-extinguishing systems should be considered:

1) gas-based systems:
   a. as total flooding for the protection of vehicle spaces on board of cargo ships only, arranged in compliance with Chapter 5 of the IMO Code on Fire Safety Systems (FSS), as amended by IMO Resolution MSC.206(81),

b. as supplementary to the total flooding gas-based system above, because of its limitations (for instance, gas agent is available for a single discharge only), a fire protection of the water-based type should be added, at least for the protection of stowage areas dedicated to those AFV's for which the positive effects of water are recognized to avoiding explosion in case of gas release from tanks and the subsequent spread of fire: CNG, LPG and Hydrogen fueled vehicles,
c. the supplementary water system should be preferably activated automatically, at an early stage of the fire, to limits its extension and to grant the availability of more time for the gas-based system activation and manual fire-suppression and fire-fighting actions.

2) spray water-based systems:
   a. for systems installed on board of ships before 21 May 2012, IMO Resolution A.123(V) and Circular MSC.1/Circ.1272 are applicable,
   b. for systems installed on board of ships on or after the 21 May 2012, IMO Circular MSC.1/Circ.1430 is applicable,
   c. the systems should be automatically activated, if possible.

The use of high-expansion foam fire-extinguishing systems should be avoided in any case.

#### 4.1.2 Electric powered vehicles (EV's)

In case of carriage of electric powered vehicles, the use of Lithium-ion type batteries has a strong influence in the design of vehicle spaces fire protection. The choice of a system, as well as the related fire-extinguishing agent, should consider the following factors:

a) the traditional fire-extinguishing agents (water, $CO_2$) are known of being ineffective to extinguish battery fires and the extinguishing agents known suitable for battery fires need to be discharged within the battery case, acting at the "cell level",
b) the seat of a fire could be severely shielded from direct application of water, as mentioned in third bulleted item of [4.1.1], c),
c) it is known that fire in Lithium-ion batteries of electric vehicles is self-sufficient and continue to burn without access to additional Oxygen, they may also continue to generate high amounts of heat following fire-extinction and are at risk of re-ignition. In addition, in hybrid vehicles the risks from both battery and hydrocarbon fires exist simultaneously,
d) whether a burning EV battery is unattended or under offensive fire-fighting attack, it will almost certainly burn for longer than traditional internal combustion engine (ICE) vehicles; incident reports commonly found then EV's fires took anywhere between three and five hours to extinguish, whereas an ICE fire may take less than an hour to make safe.

Therefore, suitable means should be provided to ensure that any fire is limited and controlled efficiently in such a way to avoid the spread to the adjacent vehicles and spaces, as well as structural damages to the ship.
At this purposes, suitable portable fire-fighting equipment should be provided on board to grant an effective fire-suppression action dedicated to the electric vehicles (see [4.2.2], [4.2.3] and [4.2.4]), in addition to the effects of fire control and suppression that are made possible by the presence of the fixed fire-extinguishing system.

#### 4.1.3 Open decks

Open deck areas should be protected by means of water monitors arranged in accordance with the following requirements:

1) mounted on opposing sides of the weather deck, either 90° or 180° of each other, giving them opposing suppression angles,
2) positioned such as capable of covering all areas of weather deck where the carried vehicles are stowed by the streams of water discharged from at least two individual monitors,
3) installed at a vertical distance from the deck flooring at least 25% of the width of the weather deck, but not less than 7 meters,
4) water supply from a single monitor not lower than 1,200 l/min,
5) capable of being remotely activated to reduce the reaction time between the fire detection/behaviour and the fire-fighting operation.

### 4.2 Portable fire-fighting equipment

#### 4.2.1 General

As mentioned in [4.1.1] the usual fixed fire-extinguishing systems may be not capable to grant the necessary and efficient cooling effect on the underside of the vehicles, particularly in case of electric powered AFV's, and batteries may need the extinguishing agent is discharged inside the battery case making impossible their use directly on vehicles. Therefore, manual fire-fighting equipment should be provided making possible the external attack to fires.

#### 4.2.2 Underbody cooling

Suitable devices capable of being coupled to the hoses of the ship's fire main and of being positioned below the underside of a vehicle to discharge water, should be available on board in addition to the standard fire-fighters' equipment: a minimum number of at least 4 devices should be considered.
The devices should be stowed at an easily accessible position in case a fire affects electric vehicles or any of the vehicles parked nearby.

#### 4.2.3 Under carriage "single axis" nozzles

This type of device consists of portable "small-scale" monitors, or high-capacity nozzles, that can be coupled to the hoses of the ship's fire main: once they are posed on the deck, they discharge in a single direction directly under vehicles a jet of either water only or water and foam if necessary.
Their main purpose is to help in the containment of pool fires under vehicles, particularly when of large dimensions (trucks, buses, trailers), and limit the spread of fire in other areas of the space or to other vehicles.
A set of "single axis" nozzles, but not less than two, should be available on board to consent the attack of pool fires under vehicles from at least two different directions. About their stowage, reference to [4.2.2] should be made.

#### 4.2.4 Fire blankets and protective covers

Fire blankets and protective covers are flexible devices easily portable by the teams of fire-fighters; however two important disadvantages may condition their use:

a) after their application, the fire appears to be well contained but when the blanket is removed a re-ignition may occur immediately, and
b) it is necessary that the emergency personnel move relatively close to the damaged vehicle in order to cover it.

For what in the above, unlikely their expected use (e.g., covering a car on fire), they can be used to protect all cars parked nearby against the spread of spark, hot debris, etc. from the vehicle under fire: at this purpose a suitable number of them should be available on board, in general not less than 8.
It is important to note that these types of devices may have a reduced effect in the presence of elevated temperatures with the subsequent transmission of heat, therefore the cooling effect by jet(s) or sprayed water may need to be provided in any case.

#### 4.2.5 Fire suits

Fire involving gas fuelled vehicles are capable of an elevated heat release and transmission: for this reason the fire-fighters' suits should be capable to grant the maximum possible degree of protection against heat, for instance they should be of Level 2 type if certified in accordance with Standard ISO 15538:2001.
A protective clothing against heat should be worn under the suit and it is recommended that the fire station is equipped with undergarments for any firefighter arriving without wearing long sleeves.
It should be also considered:

1) the provision of accessories, such as flashlights and radio equipment, of a type capable of leaving free the hands of the fire-fighters,
2) arrangement and procedures for a prompt availability of Self-Contained Breathing Apparatus (SCBA's) or protective masks, because of the hazardous gases that are usually released, mainly in case of battery fires.

## 5 OPERATIONAL PROVISIONS

### 5.1 Identification of the AFV's

A system to consent the fast identification of the AFV's and the relevant type of fuel used by them should be provided and described in the ship's operation instructions.
The identification system may use colour codes, labels, etc. and may be arranged in accordance with a Standard, such as ISO 17840 Part 1, Euro NCAP 2020, etc. or any other internal procedure developed by the Owner/Operator.

### 5.2 Conditions for carriage

Before their embarkation on the ship, the AFV's should be checked to verify the compliance with the provisions of the IMDG Code referred to in [2.2].
Particular attention should be given to the following:

1) if there is suspicion that any battery of EV's is damaged or defective, the vehicle should only be allowed on board if the battery is removed,
2) there is to be no sign of any leakages of fuel or gases: the use of portable gas detection devices, particularly where a leak of Hydrogen may happen, is recommended,
3) in case of EV's capable of being controlled from remote (e.g. telephone apps, wi-fi communication, etc.), the communications within the vehicle spaces should be inhibited, particularly on board of ro-ro passenger ships.

### 5.3 Fire patrols

Spaces where AFV's are carried should be regularly patrolled by trained members of the crew, maintaining an appropriate surveillance to integrate fire detection and video monitoring of the spaces themselves.
The following provisions should be carefully considered:

1) crew members part of the fire patrol should be trained appropriately:
   - on the arrangement of the ship and of parking areas assigned to the different types of AFV's,
   - on the characteristics and safety aspects of the different types of AFV's; at this purpose, the safety instructions or emergency response guide for the different maker and type of EV's should be available on board of the ship and be part of the training for the crew;
   - on positioning and operational details of any fire-fighting equipment designed for special operations, for instance those for underbody cooling of electric vehicles,
   - on emergency disconnection of charging equipment for electric vehicles, if present.
2) The routes of fire patrol should be arranged in such a way that any vehicle space where AFV's are stowed, is well covered, with particular attention to areas dedicated for the charging of EV's, if present.
3) Every team of the fire patrol should be equipped with:
   - a portable IR camera for thermal imaging control, better if of a type capable to also detect a gas cloud generated by a possible leak, and
   - a portable gas detector device, suitable to detect the dangerous gases and vapours that may be released in the environment by the AFV's.

The equipment indicated in 3) above should be checked regularly by responsible members of the crew and carried at any times by the patrol's teams.

### 5.4 Crew training

In addition to that mentioned in [5.3], 1), a comprehensive system of training and drills on responding to a fire incident, based on well-defined procedures, should be provided to ensure that the crew is able to operate the fixed fire-extinguishing system as swiftly as possible.
An estimated acceptable time of operation is evaluated in 3 minutes for water deluge systems and 15 minutes for gas-based ($CO_2$) systems.

### 5.5 Emergency response procedures

In general, the activation of the fixed fire-extinguishing system should be the preferred response in case of a fully developed fire.
However, under specific circumstances, a first response through manual equipment may be effective. The procedure determined by the risk assessment should also include an "emergency response" part included in the "Decision Support System" required by SOLAS Regulation III/29. The response procedures should include, but not be limited to:

1) mitigation actions for all specific foreseeable hazards caused by a fire involving AFV's, for instance:
   - evidence of smoke and heat,
   - popping sounds (hissing, whistling, etc.),
   - chemical smell, then black "smoke" (actually nanoparticles of heavy metals, not smoke) then white vapour,
2) number, type, capacity and positioning/distribution on board of portable equipment (underbody water cooling, etc.) for the fire-fighting teams, as well as the fixed fire-extinguishing systems connections and controls,
3) application of suitable smoke strategies depending on the different locations and extension of fire, to protect and help the operation of the fire-fighting teams avoiding a fire growth, also taking into consideration the type of vehicle space involved,
4) strategy provided for fire containment,
5) activation and operation of fixed fire-fighting system in combination with appropriate ventilation system operation,
6) fire-fighting team strategies that consider the necessity of entering a space where toxic gases may be present (e.g., HF or $H_2$, in case of EV's),
7) procedures necessary to decontaminate fire-fighters and handling of contaminated clothes and equipment after the operation,
8) post fire routine, to prevent re-ignition.

### 5.6 Operational guidance

In developing operational procedures to be adopted for fires in vehicle spaces in case of carriage of AFV's and conventional vehicles, reference could be made at the set of tables published in the Annex to the "Guidance for AFVs carriage in ro-ro spaces", published by the European Maritime Safety Agency (EMSA), as amended.

## 6 CHARGING ONBOARD

### 6.1 General

Charging onboard of either passenger or cargo ro-ro ships should be allowed only when the Owner/Operator has conducted a comprehensive and approved risk assessment and implements the relevant risk control measures.

The risk control measures identified should be implemented and the charging on board authorized by the ship's Flag Authority.

### 6.2 Risk assessment

In the risk assessment the following topics should be considered:

a) Protection: in addition to the requirements about IP protection, it is to be considered the resistance of the equipment to the marine environment (water fog test), particularly for those expected to be installed on open or partially open deck types. A lockable cover on the charging station's connector/plug to prevent unauthorized use should be present for all charging stations.

b) Explosion proof:
   1. enclosed vehicle spaces: the installation of a charging station including the charging cable should be considered at a height more than 450 mm above the deck, provided that the ventilation of the space has been proved capable of diluting and discharging overboard any type of dangerous vapours and gases that may be present in the space. Provisions should be considered for gas detection and subsequent automatic stop of charging system in case of dangerous levels of gases and vapours within the space;
   2. open/partially open vehicle spaces: the installation of charging station including the charging cable at a height more than 450 mm above the deck should be deemed sufficient without any further consideration.

c) Vibrations: the charging station should be designed to have at least the same resistance as required for any electrical installations onboard.

d) Electromagnetic compatibility: the electrical installation should be capable of not being disturbed by any of the electrical devices within the environment and vice versa.

e) Voltage/Frequency: the electrical equipment should be designed to operate without interference coming from voltage and frequency deviations during normal operation. Moreover, charging stations should be able to operate in accordance with the voltage/frequency on board the ship, either if capable of the conversion of voltage and frequency, or not.

f) Power grid: earthed network should be provided by means of isolating transformer(s), suitable for the performance parameters of the charging stations.

g) Charging cable: the charging cables should be connected to the charging station in a way that cables provided by drivers cannot be used. If the cable is tightened due to any movement of vehicle, for instance in case of heavy weather condition, the connection should be interrupted (emergency disconnection).

h) PMS Integration: the charging stations should be integrated into the ship's Power Management System (PMS) and in case of a too elevated power request, the charging stations system be automatically disconnected from the grid until there will be enough power available again.

i) Manual switch-off: the manual disconnection of the charging station, either whole or in sections, by the crew should be possible when necessary (simultaneous carriage of dangerous goods, navigation in heavy weather, etc.). Switch or switches should be located at an easily accessible position outside the vehicle spaces and by the crew only. An integrated system into the PMS may be allowed.

j) Integrated protection features: all safety measures necessary to protect the charging stations system should be provided with particular attention to the communication capability with the vehicle's battery management system. Parameters that should be considered among the others:
   1. short-circuit,
   2. overcharging,
   3. monitoring of temperature of charging station, cable and plug with shut down in case of damage and overheating,
   4. shutdown at any alarm from the vehicle's battery management system

k) AMS Integration: the charging stations should be integrated into the ship's Alarm Management System (AMS) with the capacity of alarm activation in case of a malfunction either internal or external. The alarm

should be available at a continuously manned control station, or safety centre if provided, and in the vehicle space, distinct from other alarms.

l) Ventilation: reference should be made at [6.2], as well as [2 b)].

m) Monitoring: video monitoring of the vehicle spaces should cover the charging station and surrounding areas. It should be capable to provide thermal imaging too. The footage should be made available and grouped together with other fire safety related controls and systems at the continuously manned control station, or safety centre if provided.

n) Mechanical protection of components and cables: suitable protection against physical damage should be provided. Any part of the charging system that does not need to be installed within the vehicle spaces should be installed at different locations.

o) Storage of cables, connection and disconnection:
   1. the length of the cables should be sufficient to reach cars' charging port without additional connection, in a safe way for persons moving on the car deck or giving physical strain on the cable itself,
   2. before connection/disconnection the presence of any control on the car should be ascertained and, if necessary, the car's driver/owner present when connecting/disconnecting the charging cable,
   3. the crew members should be trained in recognizing the different indicators of different vehicles' charging procedures or, if necessary, suitable technical documentation available as per [5.3.1].

p) Training of fire teams: in addition to [5.4], training of fire teams should take into consideration the specific design parameters of the charging stations.

q) Signage and marking: clear visible signs and painting of dedicated charging spaces should be provided on the car deck floor. In addition, a sign next to every charging station to forbid passengers of start/stop charging, should be provided.

r) Information to passengers: appropriate information should be provided to passengers intending to charge their vehicles, particularly about safety instructions and that only ship's equipment and cables are used for charging.