European Maritime Safety Agency

GUIDANCE ON THE CARRIAGE OF AFVs IN RO-RO SPACES

GUIDANCE FOR THE SAFE CARRIAGE OF ALTERNATIVE FUEL VEHICLES (AFVs) IN RO-RO SPACES OF CARGO AND PASSENGER SHIPS

Rev.1.2

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EMSA

Document History

Version	Date	Changes	Prepared
1.0	23/05/2022	Initial version	EMSA
1.1	23/05/2022	Minor editorial in Annex I, LNG/CNG/Hydrogen gas vehicles diagram	EMSA
1.2	01/04/2025	Introduced clarifications to 2.2.7 Charging onboard in relation to the earthing system, the use of adapters and the integrated protection features of the charging station.	EMSA

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Introduction

The main reasons behind the topic of alternative fuel vehicles (AFVs) becoming a serious safety concern are the enormous growth of the AFVs fleet, the potential fire risks of these vehicles and a high uncertainty on the associated fire characteristics. EMSA has collected passenger car registration data in the EU per fuel type as can be seen in Figure 1.

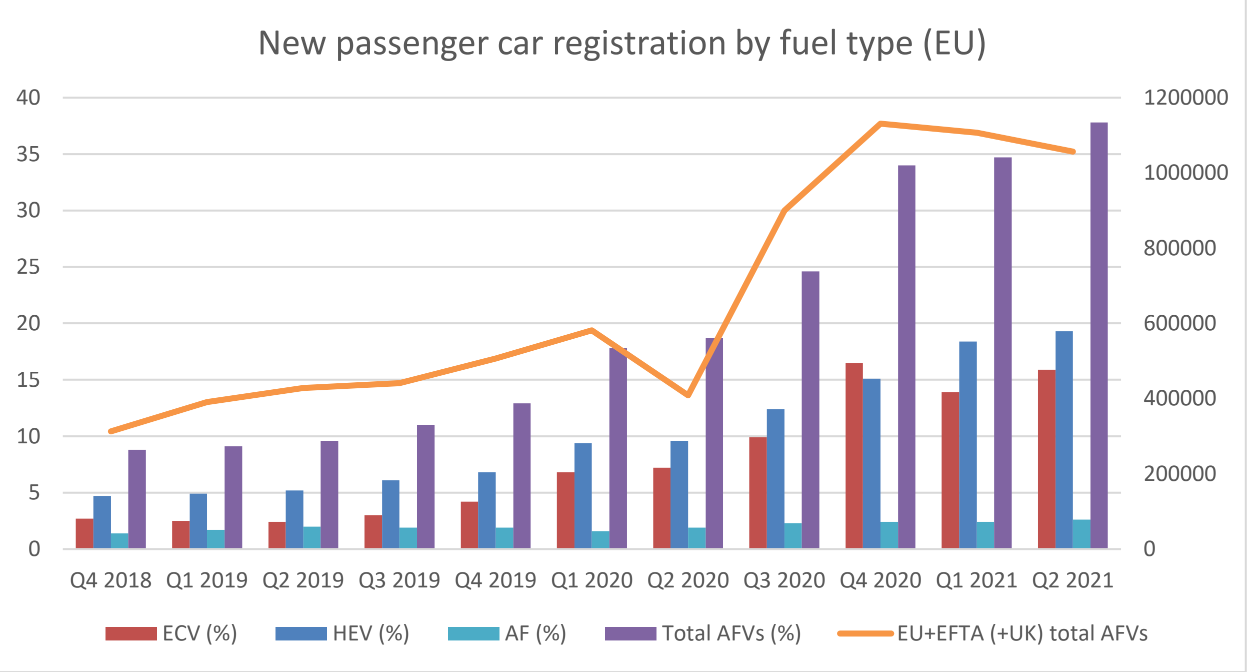


Figure 1 - New passenger car registration by fuel type in the EU, Q4/2018 - Q2/2021. (Data source: European Automobile Manufacturers' Association (ACEA))

The fuel types in the Figure are Electrically Charged Vehicles (ECV) which include both battery electric and plug in hybrids, Hybrid Electric Vehicles (HEV) and other Alternative Fuels (AF). As can be observed, there has been a staggering increase in the EU of the new AFVs registered within a range of 2.5 years from almost 9% to almost 38%. It is also interesting to observe that the percentage increase in new AFVs persisted through the car sales drop that occurred in Q2 of 2020 due to the COVID-19 pandemic.

This means that at a steadily increasing rate both passenger and cargo ships will need to transport AFVs onboard. This Guidance tackles the carriage of AFVs for both ship types under different chapters since they have inherently different operational and design characteristics:

- Chapter 2 tackles ro-ro passenger ships; and
- Chapter 3 tackles ro-ro cargo ships and vehicle carriers.

This document draws knowledge and experience from up-to-date research projects and scientific papers (ALBERO, RISE). However, it is acknowledged that there is significant ongoing research on relevant topics, e.g. in the LASH FIRE project. It is foreseen that this Guidance will be updated accordingly once these studies have been finalised (2023) and relevant experience from the implementation of the document is gathered.

EMSA would like to express its sincere gratitude to the following organisations who have participated actively during the preparations of this guidance and have contributed to this document:

- European Commission (DG MOVE);
- Swedish Maritime Administration (STA);
- Danish Maritime Administration (DMA);
- Italian Maritime Administration (ITCG);
- Finnish Maritime Administration (TRAFI);
- RISE Research Institutes of Sweden AB;
- Stena Line;
- Volkswagen Konzernlogistik as appointed representative of VDA;
- ECG (The Association of European Vehicle Logistics);
- RelyonNutec;
- IACS (International Association of Classification Societies: Bureau Veritas, RINA, Lloyds Register);
- Interferry;
- Neptune Lines;
- Wasaline;
- Attica Group;
- Marine Charging Point;
- Leclanché;
- GNV (Grandi Navi Veloci);
- UECC (United European Car Carriers).

1. General requirements

1.1 Purpose

This Guidance has been developed to assist relevant authorities and stakeholders with ensuring that the carriage of AFVs onboard ships is conducted safely and with due regard for protection of the environment.

1.2 Application

The document provides guidance to:

.1 relevant authorities:

.1 flag State;

.2 port State; and

.2 relevant stakeholders such as shipowners/authorised representatives, operators and other involved parties.

The Guidance is intended to be applied to new and existing ships for the carriage of all AFVs unless specified otherwise. Section 2 applies to ro-ro passenger ships while Section 3 to ro-ro cargo ships and vehicle carriers (PCTCs/PCCs). The Annexes include generic operational guidance providing practical information and suggesting appropriate firefighting procedures in relation to AFVs.

1.3 Glossary

AFVs	Alternative Fuel Vehicles
BEV	Battery Electric Vehicle
BLEVE	Boiling Liquid Expanding Vapor Explosion
CBG	Compressed Bio Gas
CNG	Compressed Natural Gas
DME	Dimethyl Ether
ECV	Electrically Charged Vehicles
EV	Electric Vehicle
HEV	Hybrid Electric Vehicle
HF	Hydrogen Fluoride
ICE	Internal Combustion Engine
IMDG	International Maritime Dangerous Goods
IR	Infrared
ISM	International Safety Management
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MED	Marine Equipment Directive
OEM	Original Equipment Manufacturer
PCC	Pure Car Carrier
PCTC	Pure Car Truck Carrier
PRV	Pressure Relief Valve
PRD	Pressure Relief Device
SoC	State of Charge
TPRV/TPRD	Temperature Pressure Relief Valve/Device
TR	Thermal Runaway

1.4 Basic principles

1.4.1 Risk evaluation

A risk assessment should be conducted for each ship to ensure that risks arising from the carriage of the AFVs that might affect persons onboard, the environment, the safety of the ship are addressed. These risks should be managed within the framework of existing requirements in the ISM code. Consideration should be given to the hazards arising from transporting AFVs and all related operations should be risk evaluated. The result of the risk assessment should be a ship specific procedure to be carried onboard for the prevention and mitigation of fire incidents involving AFVs.

1.4.2 New risks identified in relation to AFVs

The following list contains simplified information on energy carrier specific events and hazards.[1] For more detailed information please refer to this report[2].

- Liquid fuels (diesel, gasoline or ethanol):
  - Fuel tank integrity loss
    - increase in fire size
    - Pool fires (consider alcohol and other than gasoline/diesel)
- Liquefied fuels (LPG, LNG, liquefied DME):
  - Venting of boil-off gas (for LNG only)
  - Jet flames from PRV activations
  - Gas tank integrity loss
    - Increase fire size and fire propagation
    - BLEVE
    - Pressure vessel explosion
    - Fire ball
  - Gas leak
    - Gas explosion under the following conditions
      - There are thermal effects (flash fire) if there is ignition of flammable gas cloud in unconfined and non-congested space; or
      - There are pressure effects (VCE = Vapour Cloud Explosion) if there is ignition of flammable gas cloud in confined and congested space
- Compressed gas:
  - CNG/CBG
    - Jet flames from PRD activations
    - Gas tank integrity loss

[1] Fire-fighting of alternative fuel vehicles in ro-ro spaces, RISE (2019)
[2] Risks associated with alternative fuels in road tunnels and underground garages, SP (2017)

            - Severe increase in fire size and propagation
            - Pressure vessel explosion
            - Fire ball
        - Gas leak
            - Gas explosion (if gas can be accumulated for a while before being ignited)
    - Hydrogen (compressed or in fuel cells)
        - Much higher tank pressure than CNG which may lead to leaks, which could lead to accumulation of flammable or even explosive hydrogen air mixtures for a short period
        - Rupture of pressure tank can cause very high concentrations of hydrogen in the vicinity of the car. In open spaces, this will cause a combustible mix to form for a short period. Enclosed spaces could accumulate enough hydrogen-air mixture for a large explosion[3]
        - More ignitable, higher flammability and explosivity than conventional fuels and natural gas[4]
- Batteries:
    - Increase in fire size and propagation
    - Small jet flames
    - Toxic gases
    - Gas explosion (if the released gas can be accumulated for a while before being ignited)
    - Long lasting re-ignition risk (can ignite or re-ignite weeks, or maybe months after the provoking incident)
    - Difficult to stop/extinguish

It should be noted that the presented risks form a list of possible events without ranking their severity or probability of occurrence. It is expected that incidents related to new risks of AFVs will have a significantly low probability of occurrence due to the built-in safety barriers of these vehicles.

1.4.3 IMDG Code

This section provides an overview of the currently applicable provisions from the IMDG Code in relation to AFVs. It is acknowledged that some of these provisions may be challenging in relation to their implementation.

According to the IMDG Code, 2.9.2, Electric vehicles shall be classified as “UN3171 BATTERY-POWERED VEHICLE”. Similarly, the remaining AFVs shall be typically classified as 3166 VEHICLE, FUEL CELL, FLAMMABLE GAS POWERED or 3166 VEHICLE, FUEL CELL, FLAMMABLE LIQUID POWERED.

Special provision 961 of Chapter 3.3. of the IMDG Code states that the Code shall not be generally applicable for AFVs carried in a special category, vehicle and ro-ro spaces or on the weather deck of a ro-

[3] The International Consortium for fire safety, health & the environment, Safety issues regarding fuel cell vehicles and hydrogen fuelled vehicles
[4] DNV Handbook for hydrogen-fuelled vessels, section 4.1.1

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. When stowed in a cargo transport unit the exception does not apply to container cargo spaces of a ro-ro ship.

1.4.3.1 Electric Vehicles

For EVs (both HEVs and BEVs) the lithium batteries shall meet the provisions of 2.9.4 of the IMDG Code.

Where a lithium battery installed in a vehicle is damaged or defective, the battery shall be removed. If the battery is not removed, the vehicle should not be accepted for transport. A removed damaged battery should be transported in accordance with the provisions of SP376 of Chapter 3.3 of the IMDG Code.

If an electric vehicle is found damaged but it is unclear if the battery is damaged the recommendation is to apply this provision and not accepting it for transport.

1.4.3.2 Gas Vehicles

Section 1.1.3.1 of the IMDG code states that any article (in this case the vehicle) which, as presented for transport, is liable to produce flammable gases or vapours under normal conditions of transport is forbidden for transport.

Vehicles powered by a flammable gas (liquefied or compressed) shall not be subject to the provision of the IMDG Code only if the vehicles are stowed on the vehicle, special category and ro-ro spaces or on the weather deck of a ro-ro ship or a cargo space designated by the Administration (flag State) in accordance with SOLAS 74, chapter II-2, regulation 20 as specifically designed and approved for the carriage of vehicles, and there are no signs of leakage from the compressed gas cylinder or accumulator, or the fuel tank(s) are empty and the positive pressure in the tank does not exceed 2 bar, the fuel shut-off or isolation valve is closed and secured, and installed batteries are protected from short circuit.

With sufficient holding time (the time it will take before the pressure release valve will open) the LNG-vehicle is not liable produce flammable gases or vapours and therefore should be accepted for transport. The holding time can be determined by using a chart available from the car manufacturer after taking readings of fuel tank level and pressure from the vehicle. It can also be considered if this can be simplified by a method established using only tank pressure.

For transport of CNG vehicles in vehicle carriers, see MSC.1/Circ.1471 RECOMMENDATION ON SAFETY MEASURES FOR EXISTING VEHICLE CARRIERS CARRYING MOTOR VEHICLES WITH COMPRESSED HYDROGEN OR NATURAL GAS IN THEIR TANKS FOR THEIR OWN PROPULSION AS CARGO.

1.4.3.3 Small electric vehicles

According to the provisions of the IMDG code small electric vehicles such as electric bicycles and kick bikes shall be classified as UN 3171 BATTERY-POWERED VEHICLE or BATTERY-POWERED EQUIPMENT. Special provision 388 specifies that battery powered vehicles are self-propelled apparatus designed to carry one or more persons or goods, for example bicycles (pedal cycles with a motor) and self-balancing vehicles.

Special provision 961 states that those vehicles are not subject to the provisions of the IMDG code if they are stowed on the vehicle-, special category and ro-ro spaces or on the weather deck of a ro-ro ship or a cargo space fulfilling the requirements of SOLAS II-2/20. If these conditions are not met the vehicles shall be assigned to class 9 and fulfil the provisions of the IMDG code.

2. Application to ro-ro passenger ships

2.1 Stability checks and loading limitations

EVs are expected to be on average 25% heavier than conventional vehicles. Appropriate considerations should be made in relation to loading limitations and stability calculations.

2.2 Precaution against ignition

2.2.1 Identification of vehicles

The information on the type of fuel or energy supply should be provided during booking and confirmed at the check-in if possible. The ship's Operator should update in the most appropriate manner its website/booking system.

The crew should be able to quickly identify the type of AFV based on the information provided.

2.2.2 Conditions for carriage

AFVs should only be allowed onboard if they comply with the provisions of the IMDG Code as also described in1.4.3. Particular attention should be paid to the following:

1. If there is suspicion that the battery of EVs is damaged or their battery is defective, they should only be allowed if their battery is removed

2. are free from any leakages of fuel/gases

2.2.3 Stowage

AFVs should be stowed in a way that will allow patrols direct access to all such vehicles.

In addition, when AFVs are stowed in ro-ro spaces or special category spaces any repair works in such spaces should not be carried out, with particular attention to those activities implying the use of naked flames or fire ignition sources, as also implied by SOLAS Reg.II-2/20.3.4. These risks should be managed through existing requirements in SOLAS II-2/15.2.3 *Training manuals*, II-2/16.2 *Fire Safety operational booklets* and the ISM code.

2.2.4 Requirements for vehicles with compressed hydrogen or natural gas in their tanks for their own propulsion as cargo (reg. 20-1)

The ventilation and electrical equipment installed in the ro-ro spaces and special category spaces intended for carriage of AFVs should be compliant with requirements set out in the SOLAS Reg.II-2/20-1.3 and 20-1.4, as amended. In addition, at least two portable gas detectors should be provided as in SOLAS Reg.II-2/20-1.5. Such detectors should be suitable for the detection of the gas fuel and be of a certified safe type for use in the explosive gas and air mixture.

Alternatively, vehicles with compressed hydrogen or natural gas could be carried on the weather decks or in open ro-ro spaces.

2.2.5 Electrical connections

In relation to electrical connections the provisions under prevention/ignition in the Annex of the Interim Guidelines, MSC.1/Circ.1615 paragraphs 1.1 to 1.6 should be applied.

2.2.6 Small electric vehicles

According to the provisions of the IMDG Code mentioned in 1.4.3.3, small electric vehicles (e.g. electric bicycles and self-balancing vehicles), including their batteries which are considered to be part of the vehicle, should be stowed on a cargo deck fulfilling the requirements of SOLAS II-2/20.

2.2.7 Charging onboard

Charging onboard ro-ro passenger ships should not be allowed unless the ship operator conducts a comprehensive risk assessment and approves and implements the relevant risk control measures. Reference is made to the ALBERO project and its relevant deliverable on requirements of charging stations onboard[5].

The risk assessment should include but not be limited to the following topics:

- Electrical protection class: In addition to current requirements on IP protection, resistance to salty environments should be considered and tested, especially if installed in a non-enclosed deck. A lockable cover on the charging station's connector/plug to prevent unauthorized use should be considered for charging stations with a detachable cable.

- Explosion protection: The installation of a charging station including the charging cable should be considered at a height of more than 45 cm from the deck.

- Vibrations: The charging station should be designed to have at least the same resistance as required for all other electrical installations onboard.

- Electromagnetic compatibility: The electrical installation must not be disturbed by electrical devices within the environment.

- Voltage and frequency deviations: All electrical equipment on board must be designed to operate without interference coming from voltage and frequency deviations during normal operation.

- Network parameters: While the transmission voltage ashore is usually at 400 V and 50 Hz most vessels are operating at 440 V and 60 Hz. A charging station should be able to function according to these input values. This is especially pertinent if the conversion of voltage and frequency is done within the charging station and not by the car (DC charging). In the case of AC charging, a charging station voltage inlet may differ depending on vessel's operating voltage and if 1 or 3 phase charging is used.

- Power grid, grounding, distribution: An earthed network should be created by using an isolating transformer in the case of terra neutral (TN) network or ship's hull in the case of isolation terre (IT) network. The transformer must be adapted to the performance parameters of the charging station. Potential hazards linked with galvanic isolation should be considered.

- Cable: The cable should be firmly connected to the charging station in a way that no driver can use his own cables. If the cable is getting tight (e.g. movement of vehicles in heavy weather) the connection should be disconnected (emergency disconnection).

  It is generally understood that the alternatives for AC charging are to use 1) detachable charging cables or 2) tethered charging cables, while DC charging implies only tethered cables.

- Adapters: The use of unauthorised or "home-made[6]" charging adapters should be prevented and measures should be taken to ensure that authorised adapters are not used in an unsafe manner.

- Integration into the onboard Power Management System: The charging station should be integrated into the ship's Power Management System. An integration into a group of "unimportant consumers" would be recommendable. In case of high-power demands, the charging station can be automatically disconnected from the grid until sufficient power is available again.

- Manual switch-off: It should be possible to disconnect the entire charging station easily from the grid to stop further use, e.g. by a manual switch-off (access only for crew). This may become necessary, for example, if dangerous goods are transported at nearby parking spaces or if heavy weather is expected. The switch-off device (to disconnect charging station from power supply)

[5] WP 5.4 Catalogue of requirements for the design of charging stations to ensure safe onboard operation, *Lloyds Register, Institute for Safety Technology/Ship Safety i.a.*, 2021 (*download here*)
[6] It refers to adapters that are not recommended in the instructions' manual of the EV and/or are not built against an international standard (such as ISO, IEC, CENELEC, UN).

should always be located in a non-explosive area/room. This can also be realized by integration into the Power Management System, if necessary.

- Integrated protection features: The charging station must include all safety measures that are also required ashore. Among other things the functionality of communication between the charging station and the battery management system of the vehicle is required, e.g.
    - short circuit protection,
    - insulation monitoring and fault detection devices,
    - overcharging protection – shut down if an overcharging of the battery occurs,
    - internal cooling of the charging station or the charging cable, if necessary (depending on power),
    - temperature monitoring of the charging station, the cable and the plug - switch-off in case of damage and overheating, and
    - shutdown at a hazard alert of vehicle's battery management system
- Integration into ship´s Alarm and Monitoring System: The charging station should give an alert in case of internal as well as external malfunctions. The alert should be transferred to the bridge or to a permanently manned control centre (e.g. engine control room).
- Ventilation: Appropriate use of the ventilation system of the ship and its tactical use in case of emergency should be considered.
- Remote emergency shutdown: In case of an accident, e.g. a fire nearby, it should be possible to remotely switch off the charging station.
- Alarm: Each charging station should trigger an audible alarm, distinct from other alarms in the ro-ro space in case of dangerous situations (e.g. problem within the charging station, with the connection or with the car battery).
- Monitoring: A video monitoring system that fully covers the charging station and its surroundings should be provided. Preference should be given to thermal imaging. The footage should be made available and grouped together with other fire safety related controls and systems in a continuously manned control station or the safety centre, if provided.
- Mechanical protection of components and cables: An IK10 rating should be considered. Furthermore, any components of the charging station that can be installed outside the ro-ro space should be installed at other locations.
- Procedures for storage of cables, connection and disconnection:
    - The cables should be long enough to reach the car’s charge port without being connected in an unsafe way for passengers to move on the car deck or putting unnecessary physical strain on the cable itself.
    - Before disconnecting a charging cable, it’s usually required to push a unlock or release button in the car/on the car key in order to physically unlock the charging cable from the car’s charging connector. This ensures that there is no electric current in the car-cable-charging station connection when disconnecting the cable. So in general, the car’s driver/owner must be present when disconnecting the charging cable.
    - The crew members should recognize common light indicators of different vehicles’ charging procedures, which means that they should be trained to fully understand the properties of the charging station.

- Training of fire teams: Training of fire teams should take into consideration the specific design parameters of the charging stations.

- Signage and marking at location of charging: Clearly visible signs and painting of dedicated charging spaces on the ship's car deck floor should be provided including a sign next to every charging station, that urges passengers not to start/stop any charging activity.

- Information to passengers: Appropriate information should be provided to passengers intending to charge their vehicles.

- Special considerations with respect to carriage of dangerous goods/condition of battery: "Home made" electric vehicles should not be allowed to be charged.

2.3 Detection

2.3.1 Fixed fire detection

Ro-ro spaces or special category spaces intended for the carriage of AFVs should have appropriate detectors installed. While technology is still under development in this field for fixed detection systems (carbon monoxide, hydrogen), paragraph 2.2.4 should be followed.

2.3.2 Video monitoring

It is assumed that effective television surveillance systems are provided as described in 2.2.2 of the Annex of Circ.1615. AFVs should be stowed in a position where the images from such systems are not obstructed from other vehicles or ship's structures.

2.3.3 Fire patrol routines

1. Crew members on fire patrol duties should be familiarised in the basic characteristics and safety aspects of AFVs. Fire patrol to be skilled in routines for emergency disconnection of charging EVs.

2. Fire patrol routes should be arranged in such way that cargo spaces with a high content of AFVs, such as, but not limited to, spaces designated to EV charging, are well covered.

3. A portable IR camera should be carried at all times and should be used regularly. The portable gas detectors described in 2.2.4 should be available for use on suspicion of gas leak during the fire patrols.

4. In addition to general signs of fire or elevated risk of ignition, Fire patrols should be especially alert to AFV related signs of instability such as:

   - Smoke/heat emitted from parts of vehicle where a battery is normally located

   - Popping sounds from battery cells caused by a thermal runaway

   - Sounds related to opening of over pressure valves on CNG or LNG tanks

   - Any observation of tank pressure manometer values indicating tank pressure close to pressure relief limit

   - Gas smell

   - Suspected unauthorized connection to ship electric system for charging of batteries

5. On suspicion of unstable behaviour of an AFV, in terms of fire safety, the fire patrol should take safety precautions such as keeping a safe distance and avoidance of potentially hazardous gases.

2.3.4 Exchange of information provided to the driver by the vehicle

The ship should ensure that the driver of a AFV is aware that the crew should be informed if the driver/owner becomes aware of anything unusual about their vehicle. In that case, the driver/owner should inform the crew immediately.

2.4 Fire suppression and extinguishment

2.4.1 AFVs emergency response procedure

2.4.1.1 Emergency response procedures and contingency plan

In general, the activation of the fixed fire-extinguishing system should be the preferred response for a fully developed fire. However, under specific circumstances, a first response through manual means may be effective. As also mentioned in 1.2, additional content is included in the Annexes.

The procedure determined in 1.4.1 should also include an emergency response part which should be incorporated in the Decision Support System required by SOLAS Reg.III/29.

The response procedures should include, but not be limited to, the following:

1. mitigation actions for all specific foreseeable hazards caused by a fire involving AFVs;
2. the number, the type and capacity of fixed and portable equipment (local water cooling etc) of the fire-fighting team;
3. the appropriate smoke strategy to ensure the operation of the fire-fighting team and avoiding a fire growth, also taking into account the type of ro-ro space;
4. a strategy to contain the fire;
5. fire-fighting team strategy, taking into consideration the possibility of entering a space with toxic gases (e.g. HF in the case of EVs), procedures for decontamination of firefighters and handling of contaminated clothes and equipment after the operation;
6. post fire routine, to prevent reignition;
7. the activation and operation of fixed fire-fighting system, in combination with appropriate ventilation system operation.

2.4.1.2 Drills (specific for AFVs)

A fire drill using a scenario involving AFVs should be carried out at least every two months. Such a fire drill should follow the requirements under SOLAS Reg.III/19.3 and III/30.

2.4.2 Fire suits and specifications

Compared to conventional vehicles, AFVs do not, to today’s knowledge, introduce any additional specifications of the fire suits. The suit should be certified according to EN 469:2020 and fulfil level 2 for heat protection, water penetration and water vapor resistance (indicated with X2, Y2 and Z2). Note that MED also allows level 1, which has a lower level of protection and should not be used. Furthermore, the firefighter should wear a hood (balaclava), to protect exposed areas of the head and neck. Such hoods are not (yet) included in MED and can instead be approved according to EN 13911:2017. Full-coverage clothing 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 ensured that the firefighter can work with both hands free and does not have to hold, for example, a flashlight or radio in their hand. Additionally, it is recommended that each smoke diver has access to a personal communication device, which can be easily operated while wearing the full equipment.

3. Application to ro-ro cargo ships and vehicle carriers (PCTCs)

3.1 Stability checks and loading limitations

EVs are expected to be on average 25% heavier than conventional vehicles. Appropriate considerations should be made in relation to loading limitations and stability calculations.

3.2 Precaution against ignition

3.2.1 Identification of vehicles

The charterer should provide information on the type of fuel or the energy supply of the vehicles transported to the ship's Operator before loading commences.

The crew should be aware of the location and type of AFVs onboard (as indicated in the stowplan) and be able to quickly identify the type of AFV based on the information provided.

3.2.2 Conditions for carriage (Min holding time, origin, no damage etc)

AFVs should only be allowed onboard if they comply with the provisions of the IMDG Code as also described in 1.4.3. Particular attention should be paid to the following:

1. If EVs are damaged or their battery is defective, they should only be allowed if their battery is removed

2. are free from any leakages of fuel/gases.

3.2.3 Max SoC requirement

While the SoC does not influence the total energy released from a battery fire, it directly influences the growth and peak heat release rate, meaning that it is expected that batteries with higher SoC levels will tend to release heat in higher heat peaks and much faster than batteries with lower SoC levels.

Furthermore, SoC is also related to the occurrence of a Thermal Runaway (TR), meaning that lower values decrease the likelihood of TR significantly. It should be noted that a SoC<30% implies TR to be very unlikely. This refers to the actual SoC of the battery, which is seldom the same as the SoC displayed in a vehicle.

Taking the above points into consideration, particular attention should be given to the maximum SoC values recommended by car manufacturers when loading EVs. It is noted that these may vary among car manufacturer, car model and length of route to end destination.

In general, EVs should have displayed SoC values within the respective 20%-50% charge range. Vehicles showing only a Full to Empty measurement gauge should have a level indicating within the 20%-50% charge range. Vehicles which can be set in to a ‘transport mode’, which run on a ‘power down’ modus throughout the logistics chain, must have sufficient battery power to safely operate the basic functions of the vehicle. All hybrids with possibility to drive on the ‘ICE’ with the electric mode disengaged, should do so.

The lower end SoC 20% limitation is recommended to ensure minimum basic driving and operation of the vehicle, covering dwell time at port, vessel load and discharge operations, to First Point of Rest. The higher end SoC 50% limitation is recommended to accommodate vehicles with smaller powered battery packs to facilitate driving requirements factory distribution line to final port of discharge, including without guarantee, a +/-driving distance of 20km to dealership and/or to an available localized recharging point. The higher end SoC is also recommended to avoid unnecessary carriage of charge and power during marine carriage.[7]

[7] UECC Electric Vehicle Guideline, v1, download link

3.2.4 Repair works

When AFVs are stowed in ro-ro spaces or special category spaces any repair works in such spaces should not be carried out, with particular attention to those activities implying the use of naked flames or fire ignition sources, as also implied by SOLAS Reg.II-2/20.3.4.

3.2.5 Low ground clearance[6]

EV batteries are commonly positioned under the vehicle between the 2 axles. Vehicles with low ground clearance should be clearly labelled by OEMs to draw attention to low ground clearance batteries which could lead to challenges with cresting and break-over angles on vessel ramps and inner slopes.

Ship operators may request pre-notice of low ground clearance units with information detailing the cresting and break over angles of such EVs. OEMs should consider the use of spring blocks or other methods to control suspension movement on vehicles with low ground clearance, or under battery plate protection covers as a prevention measure against damage to vehicles with low ground clearance.

Ship operators may take any damage preventable measures to avoid any ground contact and damage to batteries.

3.2.6 Charging onboard

Charging of electric vehicles onboard should not be allowed. Charging onboard should only be allowed if an EV with a flat battery needs to be moved to allow the unloading of other vehicles. In such case, charging should be performed by the stevedores, following the approval of the Chief Officer.

Electric plugs, charging devices and cables should be carefully examined prior to their use. Only approved equipment should be used.

3.3 Detection

3.3.1 Fixed fire detection

Ro-ro spaces or special category spaces intended for the carriage of AFVs should have appropriate detectors installed. While technology is still under development in this field for fixed detection systems (carbon monoxide, hydrogen), paragraph SOLAS Reg.II-2/20-1.5 should be followed.

3.4 Fire suppression and extinguishment

3.4.1 AFVs emergency response procedure

3.4.1.1 Emergency response procedures and contingency plan

In general, the activation of the fixed fire-extinguishing system should be the preferred response for a developed fire. As also mentioned in 1.2, additional content is included in the Annexes.

The procedure determined in 1.4.1 should also include an emergency response part which should be incorporated in the Decision Support System required by SOLAS Reg.III/29.

The response procedures should include, but not be limited to the following:

1. mitigation actions for all specific foreseeable hazards caused by a fire involving AFVs;
2. the number, the type and capacity of fixed and portable equipment (local water cooling etc) of the fire-fighting team;
3. the appropriate smoke strategy to ensure the operation of the fire-fighting team and preventing fire from spreading, also taking into account the type of ro-ro space;
4. a strategy to contain the fire;

5. fire-fighting team strategy, taking into consideration the possibility of entering a space with toxic gases (e.g. HF in the case of EVs), procedures for decontamination of firefighters and handling of contaminated clothes and equipment after the operation;

6. post fire routine, to prevent reigniting;

7. the activation and operation of the fixed fire-fighting system.

3.4.1.2 Drills (specific for AFVs)

A fire drill using a scenario involving AFVs should be carried out at least every two months. Such a fire drill should follow the requirements under SOLAS Reg.III/19.3.

3.4.2 Fire suits and specifications

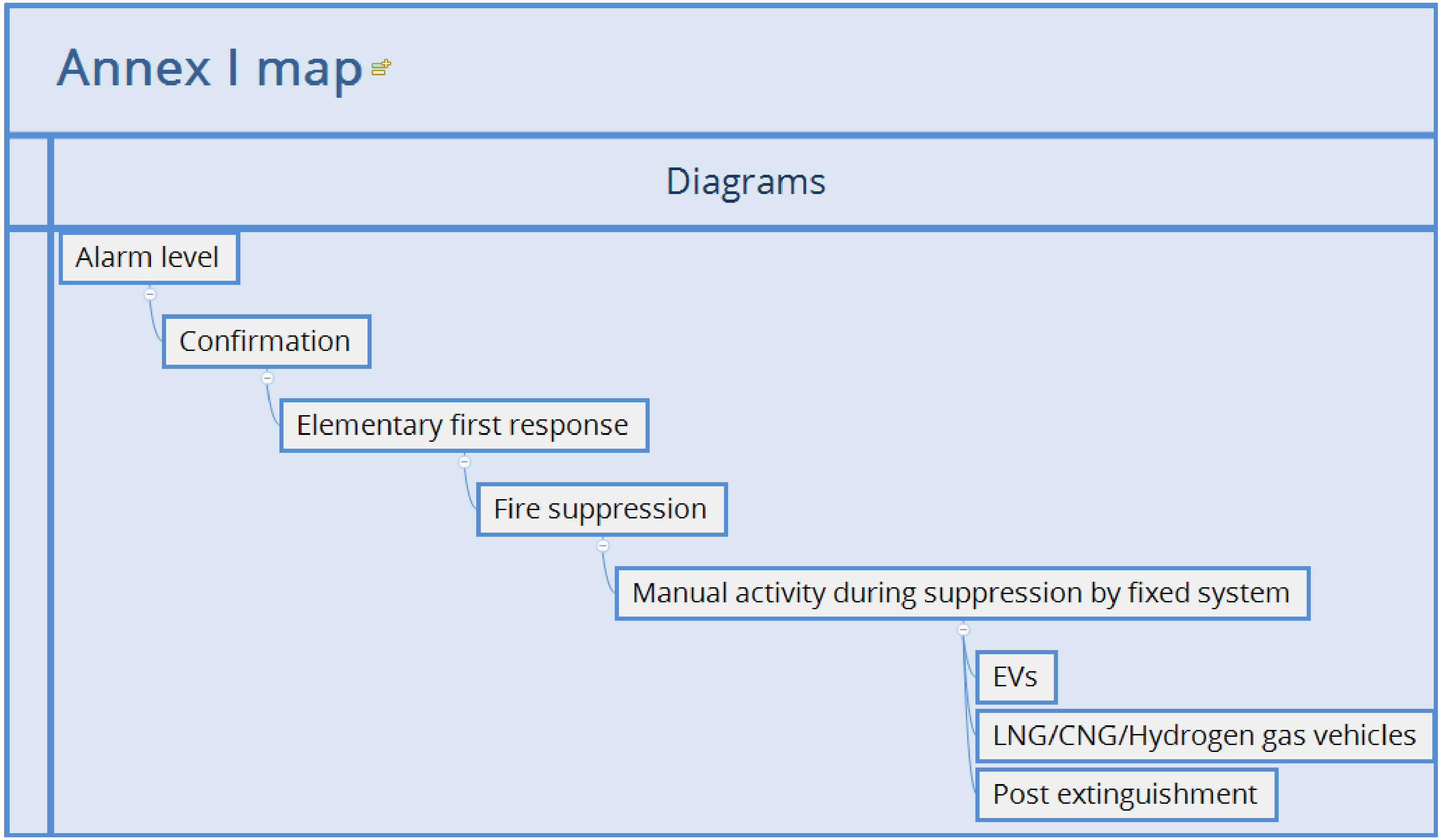
Compared to conventional vehicles, AFVs do not, to today's knowledge, introduce any additional specifications of the fire suits. The suit should be certified according to EN 469:2020 and fulfil level 2 for heat protection, water penetration and water vapor resistance (indicated with X2, Y2 and Z2). Note that MED also allows level 1, which has a lower level of protection and should not be used. Furthermore, the firefighter should wear a hood (balaclava), to protect exposed areas of the head and neck. Such hoods are not (yet) included in MED and can instead be approved according to EN 13911:2017. Full-coverage clothing 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.

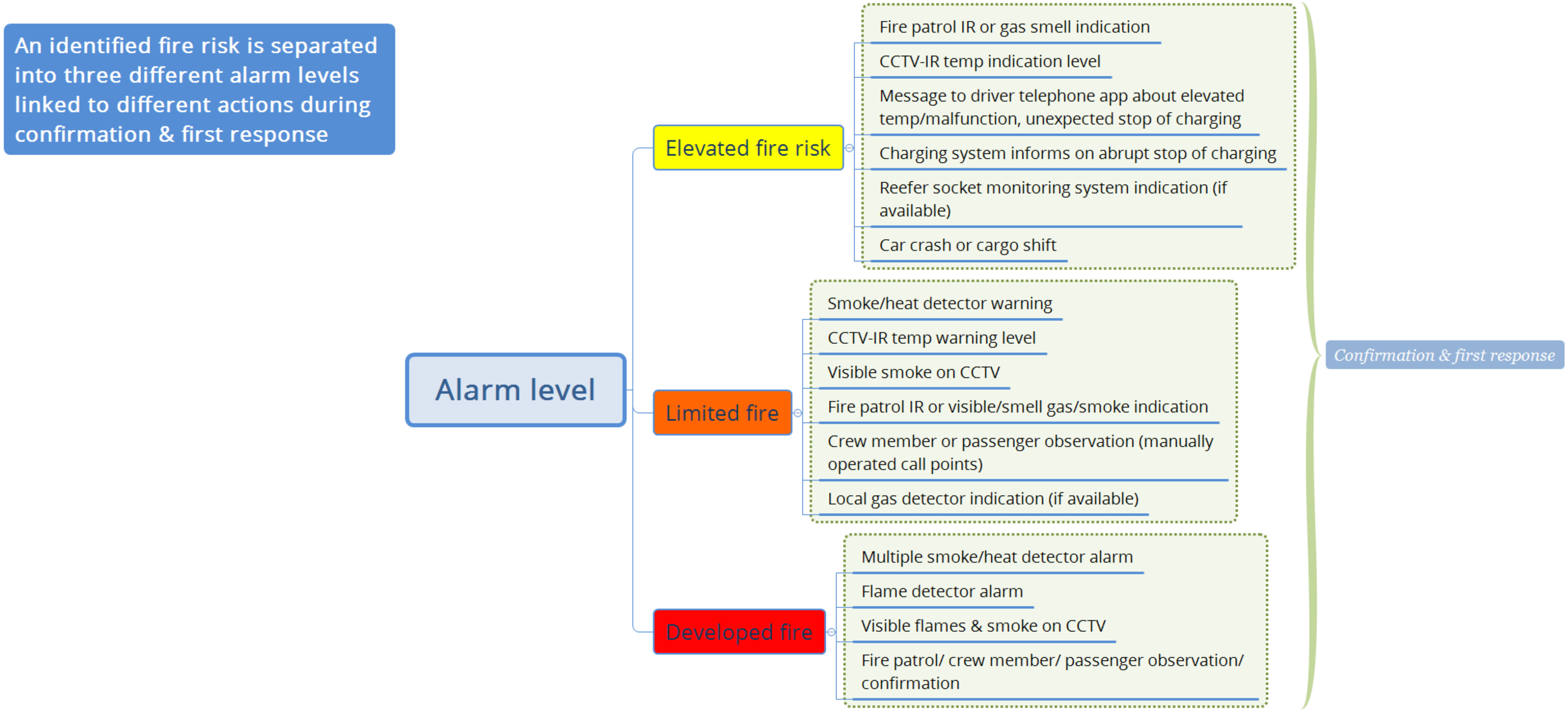
It should be ensured that the firefighter can work with both hands free and does not have to hold, for example, a flashlight or radio in their hand. Additionally, it is recommended that each smoke diver has access to a personal communication device, which can be easily operated while wearing the full equipment.

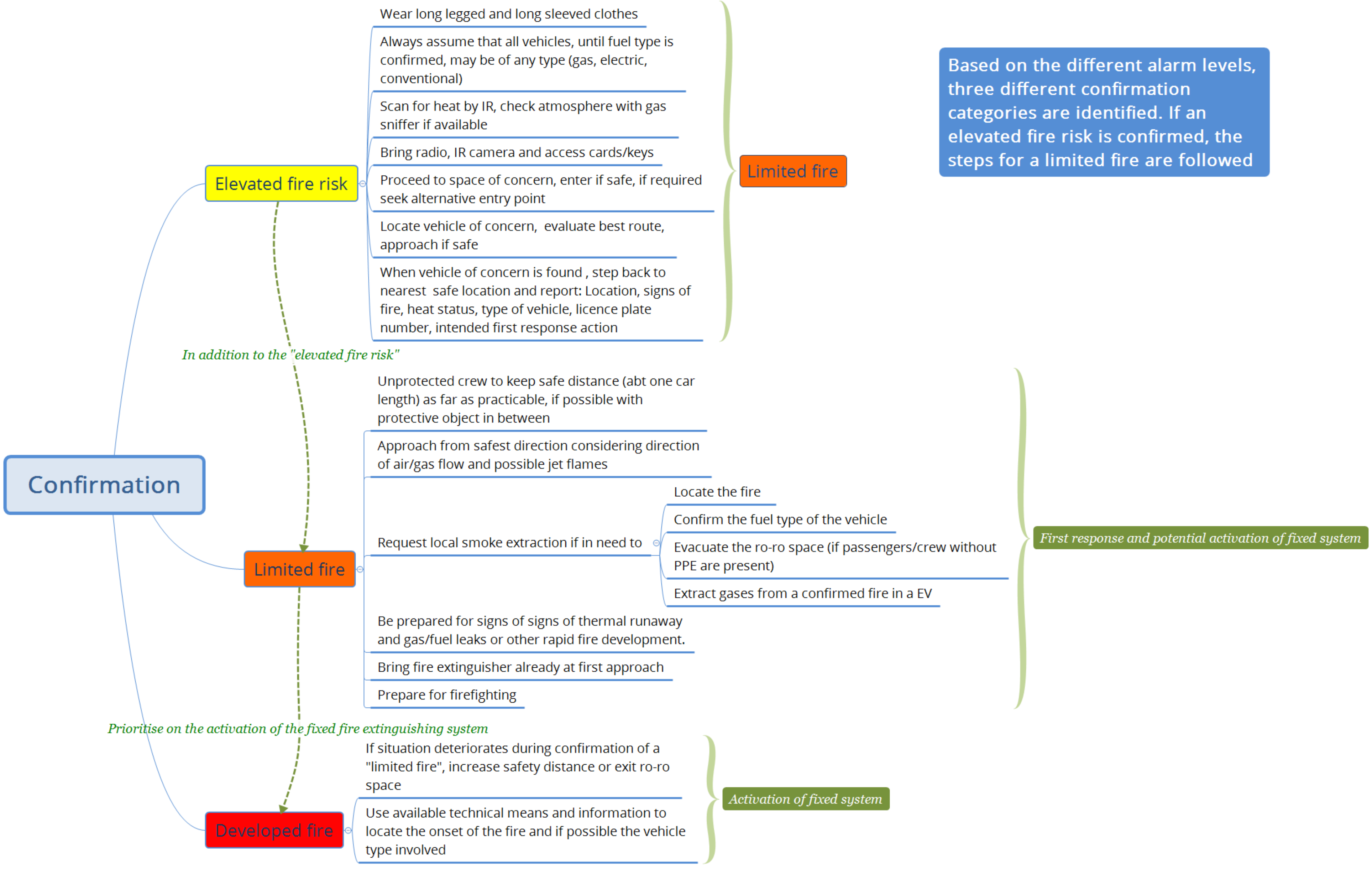
Annexes

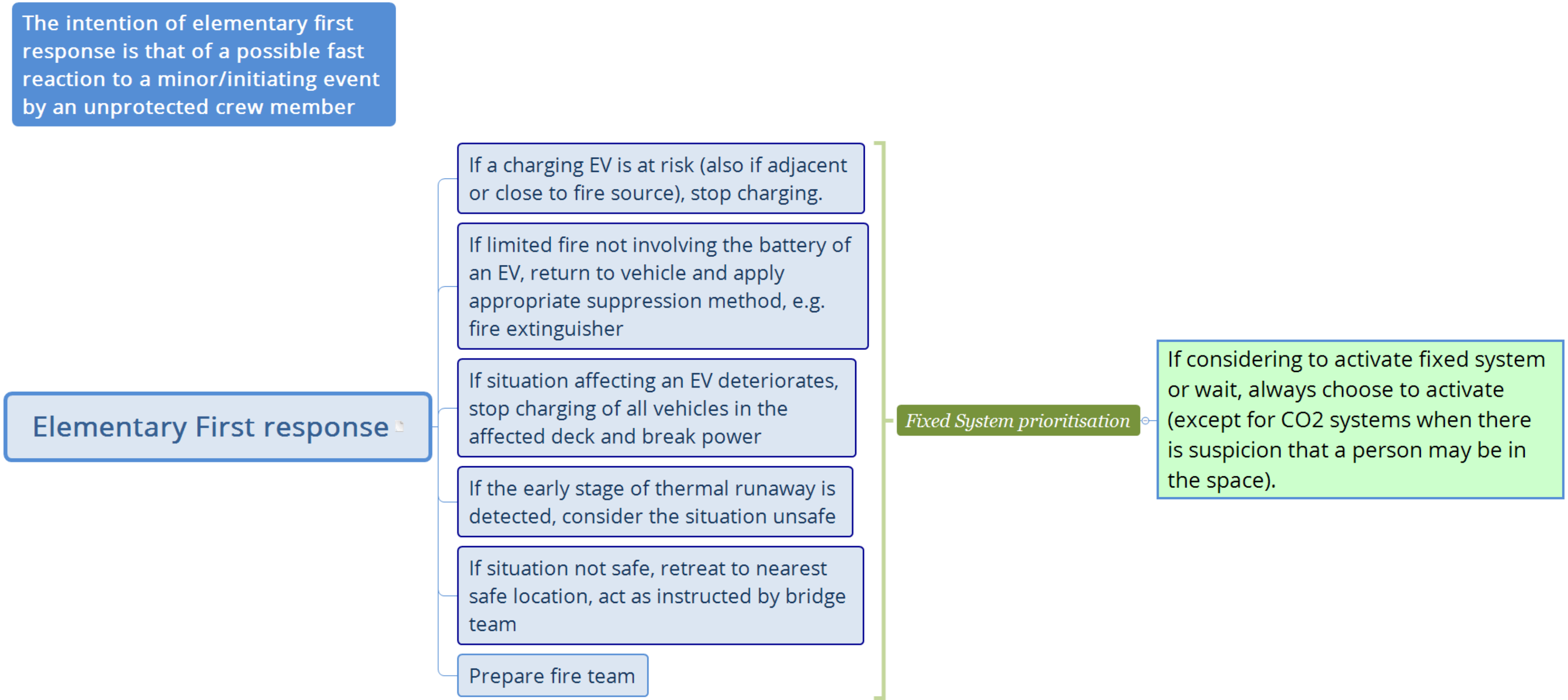
I. Operational guidance in case of AFVs fire incidents

The purpose of this annex is to guide operators and crew on how to act in the risk of fire considering conventional vehicles and AFVs in a safe and effective way.




An identified fire risk is separated into three different alarm levels linked to different actions during confirmation & first response
Alarm level
Elevated fire risk
Fire patrol IR or gas smell indication
CCTV-IR temp indication level
Message to driver telephone app about elevated temp/malfunction, unexpected stop of charging
Charging system informs on abrupt stop of charging
Reefer socket monitoring system indication (if available)
Car crash or cargo shift
Limited fire
Smoke/heat detector warning
CCTV-IR temp warning level
Visible smoke on CCTV
Fire patrol IR or visible/smell gas/smoke indication
Crew member or passenger observation (manually operated call points)
Local gas detector indication (if available)
Developed fire
Multiple smoke/heat detector alarm
Flame detector alarm
Visible flames & smoke on CCTV
Fire patrol/ crew member/ passenger observation/ confirmation
Confirmation & first response

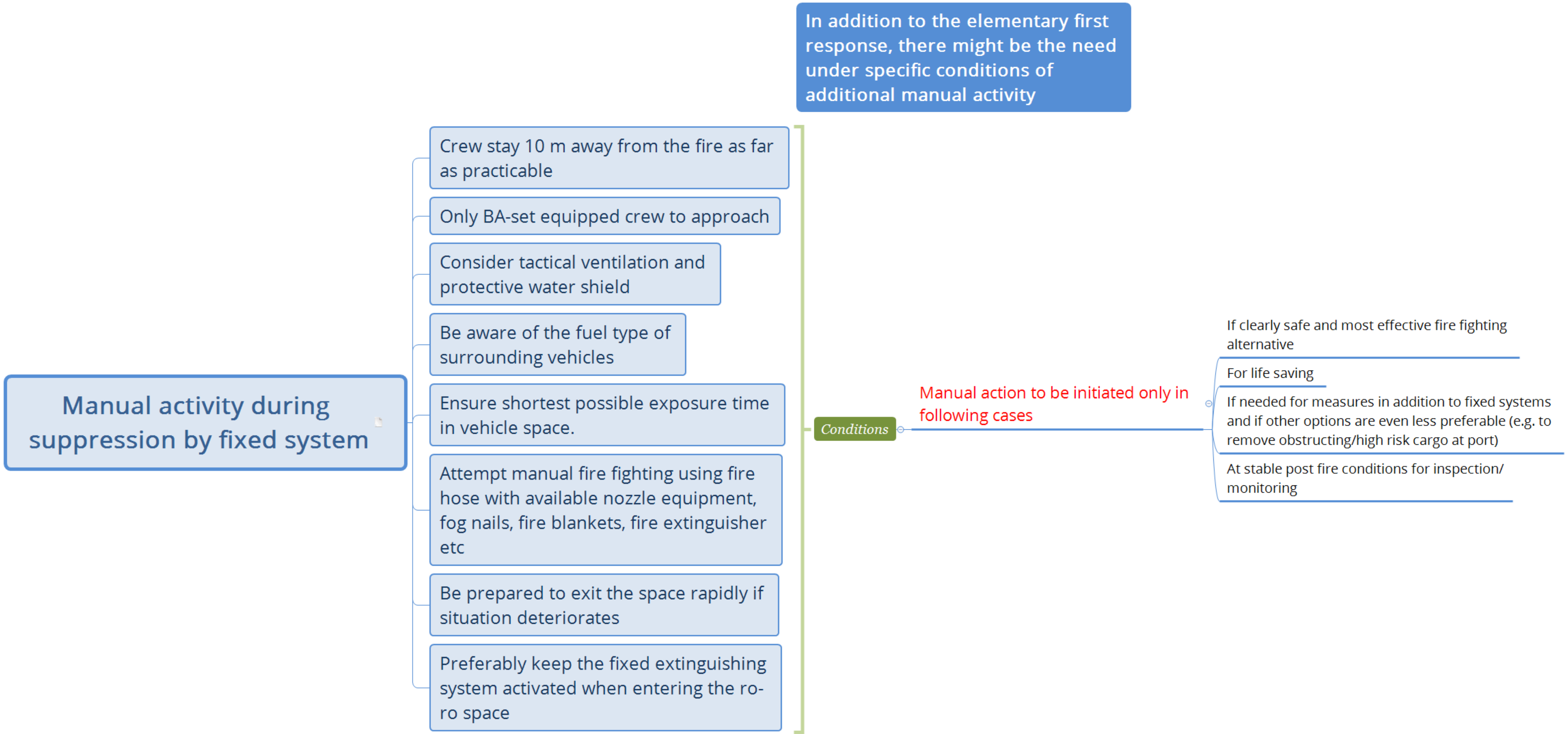

Confirmation
Elevated fire risk
Wear long legged and long sleeved clothes
Always assume that all vehicles, until fuel type is confirmed, may be of any type (gas, electric, conventional)
Scan for heat by IR, check atmosphere with gas sniffer if available
Bring radio, IR camera and access cards/keys
Proceed to space of concern, enter if safe, if required seek alternative entry point
Locate vehicle of concern, evaluate best route, approach if safe
When vehicle of concern is found , step back to nearest safe location and report: Location, signs of fire, heat status, type of vehicle, licence plate number, intended first response action
Limited fire
Based on the different alarm levels, three different confirmation categories are identified. If an elevated fire risk is confirmed, the steps for a limited fire are followed
In addition to the "elevated fire risk"
Limited fire
Unprotected crew to keep safe distance (abt one car length) as far as practicable, if possible with protective object in between
Approach from safest direction considering direction of air/gas flow and possible jet flames
Request local smoke extraction if in need to
Locate the fire
Confirm the fuel type of the vehicle
Evacuate the ro-ro space (if passengers/crew without PPE are present)
Extract gases from a confirmed fire in a EV
Be prepared for signs of signs of thermal runaway and gas/fuel leaks or other rapid fire development.
Bring fire extinguisher already at first approach
Prepare for firefighting
First response and potential activation of fixed system
Prioritise on the activation of the fixed fire extinguishing system
Developed fire
If situation deteriorates during confirmation of a "limited fire", increase safety distance or exit ro-ro space
Use available technical means and information to locate the onset of the fire and if possible the vehicle type involved
Activation of fixed system


The intention of elementary first response is that of a possible fast reaction to a minor/initiating event by an unprotected crew member
Elementary First response
If a charging EV is at risk (also if adjacent or close to fire source), stop charging.
If limited fire not involving the battery of an EV, return to vehicle and apply appropriate suppression method, e.g. fire extinguisher
If situation affecting an EV deteriorates, stop charging of all vehicles in the affected deck and break power
If the early stage of thermal runaway is detected, consider the situation unsafe
If situation not safe, retreat to nearest safe location, act as instructed by bridge team
Prepare fire team
Fixed System prioritisation
If considering to activate fixed system or wait, always choose to activate (except for CO2 systems when there is suspicion that a person may be in the space).

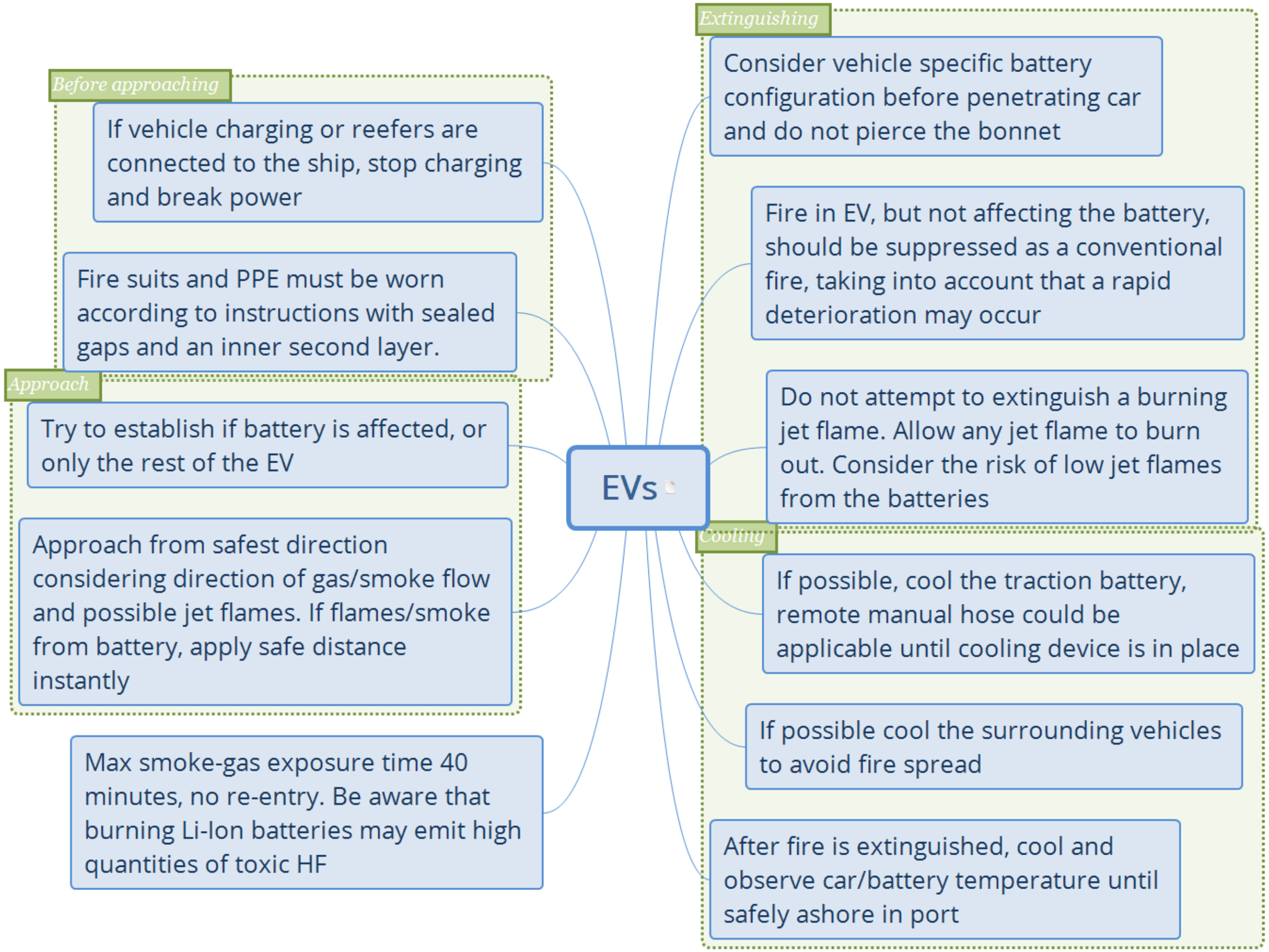
Fire suppression as presented here should be understood as being generic and applicable to all vehicles.

Fire suppression

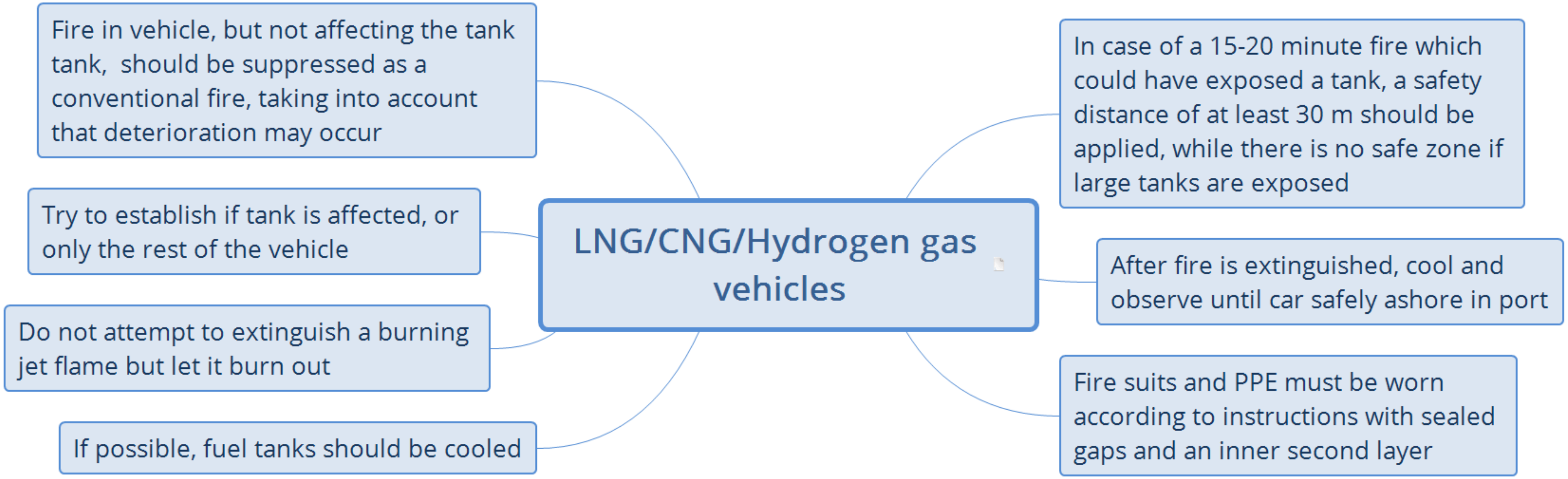
- All vehicles
  - *Main actions*
    - Activate fixed system
    - Mobilize fire team
    - Put ventilation/fire dampers in suitable fire mode
      - Normal operation -> get potential gases out 6/10 ACPH
      - Elevated risk, gas emission, pre fire -> gas evacuation
      - Fire -> Minimize oxygen supply
      - Manual entry -> secure fresh air
    - Apply boundary space cooling as required
    - Monitor fire development taking into account cargo type and location, stability, temperature of boundaries, smoke and gas conditions
    - If significant signs of improvement are observed (significant drop in temperature of boundaries of adjacent spaces for a period of at least 1h) calibrate strategy
    - If significant signs of deterioration and uncontrolled fire growth are observed (e.g. fire spread on a second deck), ship evacuation should be considered taking into account smoke/fire conditions
  - *General principles*
    - Use primarily remotely controlled systems such as (IR-) CCTV, heat detectors, drencher, water monitors
    - Do not enter vehicle space unless for lifesaving or similarly urgent condition
    - Unprotected crew to stay out of ro-ro spaces
  - On weather decks
    - Use fixed system if available
    - If fixed system is unavailable, take appropriate measures to protect crew and accommodation areas from heat/smoke/possible explosions
    - Manual means only to be used as a first response, for cooling or for lifesaving, taking weather conditions into consideration


In addition to the elementary first response, there might be the need under specific conditions of additional manual activity
Manual activity during suppression by fixed system
Crew stay 10 m away from the fire as far as practicable
Only BA-set equipped crew to approach
Consider tactical ventilation and protective water shield
Be aware of the fuel type of surrounding vehicles
Ensure shortest possible exposure time in vehicle space.
Attempt manual fire fighting using fire hose with available nozzle equipment, fog nails, fire blankets, fire extinguisher etc
Be prepared to exit the space rapidly if situation deteriorates
Preferably keep the fixed extinguishing system activated when entering the ro-ro space
Conditions
Manual action to be initiated only in following cases
If clearly safe and most effective fire fighting alternative
For life saving
If needed for measures in addition to fixed systems and if other options are even less preferable (e.g. to remove obstructing/high risk cargo at port)
At stable post fire conditions for inspection/ monitoring

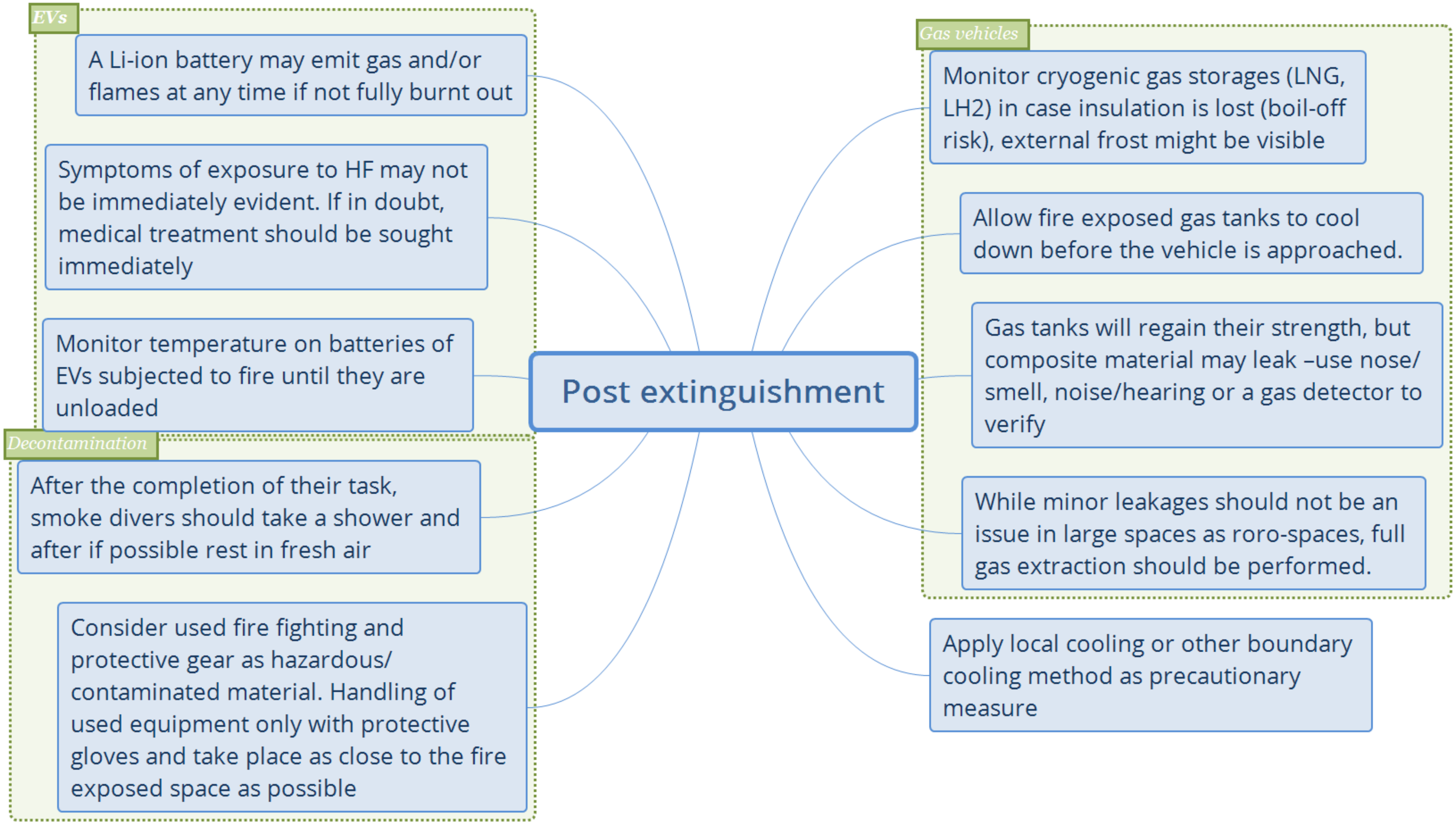
Additional considerations related to manual activity during fire suppression



Additional considerations related to manual activity during fire suppression



Generic post extinguisment measures



II. General fire properties of vehicles

The purpose of this annex is to provide some basic characteristics and properties of different types of AFVs in an overview format, in order to be able to rapidly communicate differences between different types of vehicle fires.

Parameter	**Cab fire**	**ICE**	**HEV**	**EV**	**LNG/LPG/CNG**	**Hydrogen**	**Small electric units**
Energy carrier	Plastic material, rubber, textile etc	Petrol, Diesel	NiCd/Li-Ion battery & Petrol	Li-Ion battery	Liquified CH_4/ Liquified Butane & Propane/ Compressed CH4	Compressed H_2	Li-Ion battery
Gas form density relative air	N/A	N/A	N/A	Heavier apart from H_2	Lighter/ Heavier/ Lighter	Lighter	Heavier apart from H_2
Toxicity (pre-fire)	N/A	N/A	N/A	Yes	Asphyxiant	Asphyxiant	Yes
Stowage advice	No preference	No preference	No preference	No preference	Preferably weather and, alternatively, open decks	Preferably weather and, alternatively, open decks	Designated area on vehicle deck, if possible, with natural ventilation
Pre-ignition signs of increased fire risk	Smoke, heat	Fuel leak	Fuel leak	Heavy smoke & heat from battery. Popping sounds from battery cells	Noise from Pressure Relief Device.	Noise from Thermally activated Pressure Relief Device	Heavy smoke & heat from battery. Popping sounds from battery cells
Ignition	Heat/ spark and external fire	Heat/ spark and external fire	Heat/ spark and external fire	Battery heat, external heat/spark	Heat/ spark and external fire	Heat/ spark and external fire	Battery heat, external heat/spark

Modes of fire spread	Heat	Fuel pool	Fuel pool	Short lived jet flames, flame length up to several metres	Jet flame, flame length up to several metres resulting to quick fire spread	Jet flame, extensive flame length up to several metres resulting to very quick fire spread	Short lived jet flames Scatter of hot objects, mainly for cylindrical cells
Main hazards - Worse case scenario	Fire Haz smoke/gases Exploding tyres, airbags, gas springs	Fuel pool Haz smoke/gases	Fuel pool Haz smoke/gases	Thermal runaway haz gas release, explosion/ignition risk. Unpredictable battery contribution 50% extra HF gas from fire compared to ICE	Gas boil off (for LNG only) Tank explosion Explosion/ BLEVE - only in case of pressure relief valve failure LNG: Cryogenic hazards	Extensive jet flame (7-9 metres directed downward and rearward) Tank explosion (TPRD failure) Gas release: In enclosed deck: gas pocketing from high explosive GH2 under ceiling	Thermal run-away gas release, explosion/ignition risk
Distance considerations	If risk of tyre explosion safety distance 20 m with ear protection			Jet flames max 7-10 m, duration 1-2 min. Do not approach directly from the rear or the front of the vehicle, as it might move due to short circuit	Jet flames from PRV or TPRV 7-10 m, fading rapidly. At risk of explosion safety distance 25 m with ear protection for personal car tank. For large tank (heavy vehicle), stay outside the space	10m jet flames during TPRV release. If risk of explosion 30 meters safety distance with ear protection	

Suppression/ manual fire fighting (first response only)	Water/Powder/ Foam Water on burning vehicle components cool tank	Water/Powder / Foam Water on burning vehicle components cool tank	Water/Foam Water on burning vehicle components cool tank	Water on burning vehicle components	Water on burning vehicle components Take into account the danger of BLEVE (in case of prolonged thermal radiation)	Water on tank Water on burning vehicle components	Water on battery Water on burning vehicle components
Containment	Drencher/ Hose	Drencher/Foam	Drencher/Foam	Drencher/extra water	Drencher	Drencher	Submerge battery in water/ Hose
Post fire	Cool until temp is low	Cool until temp is low	Cool until temp is low	Monitor, risk of spontaneous re-ignition. Cool with water	Cool until temp is low. Maintain safe distance to tank. Blow off by PRV's. Prevent freezing of the blow-off safety device (through contact with water). Control Ventilation / wind direction to prevent accumulation explosive gasses	Cool until temp is low	Ensure cooling Monitor

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