

ELECTRIC VEHICLES TRANSPORTED ON BOARD ROPAX, RORO AND PCTC VESSELS: FIRE RISKS AND ESSENTIAL GUIDELINES

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INTRODUCTION

Electric Vehicles (EVs) currently dominate the Alternative Fuel Vehicle (AFV) market and their numbers are rising rapidly. For EVs transported on board RoPax, RoRo and Pure Car Truck Carrier (PCTC) vessels the question is whether EV lithium-ion batteries present risks and necessitate precautions exceeding those presented by pre-existing Internal Combustion Engine (ICE) Vehicles? This Risk Bulletin responds to that question.

FEATURES OF VESSELS IMPACTED

There are three main types of vessels that carry wheeled vehicles, inclusive of cars, trucks, trailers and other wheeled machinery. Many of them also carry passengers. Their common feature is that vehicles are loaded and unloaded by being driven on or off utilising a ship to terminal ramp. Hence the term 'Roll-On Roll-Off'.

The three types impacted are as below:

- **RoPax (Passenger/Vehicle) vessels** – are defined by SOLAS as being “a passenger ship with Ro-Ro cargo spaces or special category spaces”. RoPax vessels are certified by SOLAS or similar NCVS regulation to carry wheeled vehicles and more than 12 passengers up to a SOLAS or equivalent NCVS designated passenger number.

NOTE: RoPax vessels are usually engaged in short sea routes in either the domestic or international trades. Passenger limits may be set at up to 500 passengers or more. As RoPax vessels carry more than 12 passengers, they are designated as 'passenger ships' for SOLAS/NCVS regulation and IMO recommendation purposes.

- **RoRo (Cargo) vessels** – are certified by SOLAS or similar NCVS regulation to carry wheeled vehicles and up to 12 passengers who, at owner's option, consist of truck/lorry drivers only.

NOTE: RoRo vessels are usually engaged in short sea routes in either the domestic or international trades. Their 12 passenger limit means RoRo vessels are designated as 'cargo ships' for SOLAS/NCVS regulation purposes.

- **PCTC (Pure Car & Truck Carrier) vessels** – are certified by SOLAS regulation to carry wheeled vehicles and up to 12 passengers who, at owner's option, may consist of paying passengers.

NOTE: PCTC vessels may only be designated as such if they are engaged in long haul international voyages. The 12 passenger limit means PCTC vessels are designated as 'cargo ships' for SOLAS regulation purposes.

BACKGROUND

The history of fires in EV's powered by re-chargeable lithium-ion batteries dates to their introduction in 2010. As EVs were unique at that time, such incidents were always newsworthy as media alarms of 'disasters to come'. The actuality is that many of these EV fire incidents were the result of road crashes between EVs and ICE vehicles. Others were traced back to charging cable faults and battery overcharging.

NOTE: Land based EV fire incidents in the US were investigated by the National Highway Traffic Safety Administration (NHTSA). Their findings were that "*EVs pose no more threat than other cars*". Independent and similar findings have been made by governmental agencies in Sweden, Norway and Denmark, where EV usage is approaching prevalence.

With reference to EV fires during transport by sea, the UK's [Royal Institute of Naval Architects \(RINA\) report](#) advises that the first reported EV fire at sea occurred on the RoPax PEARL OF SCANDANAVIA in 2010. It was traced to a fault during battery charging.

NOTE: The EV involved was in fact an experimental conversion of an ICE vehicle to EV power. It seems unlikely its battery control system was as sophisticated or reliable as the units now fitted to purpose built EVs.

The Denmark flag state authorities subsequently banned EV charging while on board. Subsequent EV charging incidents on other RoPax vessels then led to on board charging bans by several major ferry/RoPax operators. Some of these bans continue today while other operators support on board charging as an additional service and revenue stream.

As to PCTCs, RINA reports that several fires occurred during 2022/23 on such vessels while transporting both EV and ICE vehicles. They included fires on board the PCTCs FREMANTLE HIGHWAY and FELICITY ACE. Crew lives were lost, cargoes destroyed and both vessels became constructive total losses. Allegations were made that the causes of the fires emanated from EV battery faults. However, this has not yet been proved conclusively.

In summary, the evidence appears to be that although EV lithium-ion battery fires have occurred at sea, the probability of such an event – especially if on board charging is prohibited – is no more likely than an electrical system fault initiated fire in an ICE vehicle.

EV TECHNICAL ASPECTS AND RELATED RISKS

Reference to the International Union of Marine Insurers ([IUMI](#)) [position paper 'Best Practice and Recommendations for the Safe Carriage of EVs'](#) provides some interesting EV battery facts and fire test findings. A bullet point summary is as below.

- EVs are powered by lithium-ion traction batteries which are specially encapsulated. Impact shielding is also provided by their low/under floor positioning within an EV's crash protected body frame. The downside is these cause firefighting access problems.
- EV battery management safety systems (BMS) automatically shut down the power and isolate the battery pack when a collision, short circuit or other significant fault is detected. This ensures the battery, and its component cells, operate within their designated safe operating parameters inclusive of charge, voltage and temperature.
- Despite EV battery BMS features, thermal runaway/overheating and fire may still occur if a cell or battery is mistreated (e.g. due external heating, mechanical impact damage or overcharging) or if a manufacturing fault occurs. However, government agency statistics indicate that the probability of an EV battery fire is lower than that of an ICE vehicle fire relative to the total number of vehicles in operation.
- EV fires are often claimed to be more intense than ICE vehicle fires. Full scale testing has shown only minor differences between ICE vehicle and EV total heat release. Further, that once established, EV fires are largely fuelled by the EV's body and plastic interior parts. This is similar to ICE fires but without the danger of a fuel tank explosion.
- EV battery thermal runaway fires are often alleged to be impossible to extinguish. Testing and experience has shown this to be untrue. Yes, EV fires may require direct injection of water into the battery to optimise cooling and special equipment is required. Additionally, battery fire re-ignition prevention by water cooling for an extended period will likely be required.
- In summary, objective testing indicates that fires in EVs are not more dangerous than fires in ICE vehicles and, statistically, are not more frequent. However, due to EV fire special characteristics, careful pre-planning, special equipment (inclusive of water lances, foam extinguishers and fire blankets) and additional crew training are essential to ensuring ship, crew and passenger safety.

CURRENT IMO REGULATION (MANDATORY) AND IMO GUIDELINES (RECOMMENDATORY)

The current IMO fire equipment and safety regulations which apply to the above listed vessel types and all vessels over 500 GT engaged in international trade are provided by SOLAS, Chapter II-2. These regulations include special requirements for RoPax, RoRo and PCTC vessels due to their large open and/or closed vehicle deck spaces and the potentially volatile nature of the wheeled vehicles and the cargo (often IMDG Code listed) they may be carrying.

With respect to EVs and associate fire risks, there is currently no IMO mandatory regulation in place. This is because SOLAS Chapter II-2 was created and entered into force before EVs, and other Alternative Fuel Vehicles (AFVs) were considered commercially viable and in public use.

In addition to the aforesaid EV and AFV regulation gap, concerns were being expressed by EU flag states as to the large number of RoPax and RoRo vessel ICE vehicle fires and the apparent inadequacy of the SOLAS Chapter II-2 provisions. This motivated research and extensive testing by the European Maritime Safety Agency (EMSA) and the publication of detailed technical reports published as the [EMSA Firesafe Studies](#).

EMSA then submitted the Firesafe Studies and their recommendations for upgraded regulatory amendment to the IMO. In turn, the IMO created and in 2019 formally adopted [MSC.1/1615 Interim Guidelines for Minimising the Incidence and Consequence of Fires on New and Existing RoRo Passenger Ships](#).

NOTE: It is important to understand that the IMO Interim Guidelines were designed primarily for RoPax vessels and that they are recommendatory and not mandatory. Also of note is that the Interim Guidelines are directed primarily at ICE vehicles and (at para. 1.8.1) provide only general guidance on AFV and EV fire safety planning and training.

The IMO intended the Interim Guidelines to be later finalised based on feedback from IMO member states. It was then planned that SOLAS Chap II-2 mandatory regulation would be amended. Regrettably, the COVID-19 pandemic interrupted the IMO process, and the intended review did not resume until March 2024. Finalisation and SOLAS Chapter II-2 amendments to mandatory regulation are therefore likely to be several years away.

Meantime, RINA's report – based on their Nov. 2023 interviews with leading RoPax operators in Western Europe and the UK – is that the IMO Interim Guidelines are already being applied. This

includes the pre-embarkation identification of EVs, utilisation of thermal image detectors (both fixed and portable) and special EV and AFV firefighting training. Importantly, it also demonstrates industry 'best practice' application of IMO recommendations which exceed current SOLAS Chap II-2 regulatory requirements.

NOTE: Members who operate RoPax vessels should refer to [MM Risk Bulletin No. 51, Ferries and RoPax Vessels: Hazards and Precautions](#). This RB provides fire safety information and detailed recommendations for RoPax vessels engaged in both SOLAS regulated international trades and NCVS regulated domestic trades.

OTHER GOVERNMENTAL AND INDUSTRY GUIDELINES

Bearing in mind the limited AFV and EV fire safety content of the IMO's Interim Guidelines, Members should also review other reliable and detailed Guidance on this subject for incorporation into their ISM Code/NCVS equivalent SMS manuals and procedures. Links are provided as below together with a brief description of content.

- [EMSA Guidance on the Safe Carriage of AFVs in RoRo Spaces](#)

The 30 page EMSA Guidance content is based on the findings of the EMSA Fire Safe Studies and the experience of leading ferry operators. It is designed for RoPax (Passenger) vessels (Chapters 1 and 2) and for RoRo (Cargo) vessels and PCTC vessels (Chapter 1 and 3). These chapters cover stability and loading limitations, protection against ignition, fire detection and fire suppression and extinguishment for AFVs with a special focus on EVs. It also provides practical advice on AFV/EV fires and the general fire properties of all vehicles inclusive of ICE vehicles.

- [UK Maritime Coast Guard Agency \(MCA\) MGN 653 \(M\), Amendment 1, Electric Vehicles on Board Passenger RoRo \[RoPax\] Ferries](#)

The MCA Guidance supplements the IMO Interim Guidelines MSC.1/1615 by providing, *"...a framework for the safe carriage of electric vehicles, and for charging operations onboard, should operators choose to offer this. Operators should perform a thorough risk-assessment in conjunction with these guidelines, regulations and operational aspects."*

NOTE: Both the EMSA Guidance and the UK MCA MGN 653 are detailed and well explained. Their contents – in conjunction with IMO Interim Guidelines MSC.1/1615 – should be considered as essential to preparing adequate AFV and EV fire control planning, training and implementation on board RoPax vessels. RoRo (Cargo) and PCTC vessel operators should also consider and apply the MCA advice provided.

- [ICS, Common Guidance on the Presentation and Loading of Vehicles](#)

This ICS Guidance publication contains guidelines prepared by industry organizations and companies engaged in the shipment of new and second hand vehicles on board RoRo (Cargo) and PCTC vessels. It includes a detailed checklist to assist management of vehicle shipment risks, including electric and hybrid vehicles, and the support of terminal, personnel and vessel safety.

CONCLUSION AND TAKEAWAY

The objective investigation and related testing of EV battery fire incidents during transport by sea indicates that the hazards presented are evidently not greater than those presented by ICE vehicles. Furthermore, statistics show that the likelihood of EV battery fires is not greater than for fires in ICE vehicles.

However, EV battery fires present special characteristics in terms of potential intense heating in their battery areas which – due to their encapsulation and under vehicle position – are difficult to access for cooling, fire extinguishment and re-ignition prevention purposes. These special fire risk characteristics require special fire control processes. At present, these special processes exceed the current minimum requirements of SOLAS Chapter II -1 or equivalent NCVS regulation.

MM's recommendations are therefore as follows:

- Members operating RoPax vessels should ensure the priority adoption and implementation of the IMO MSC.1/1615 Interim Guidelines, the EMSA Guidance (Chapters 1, 2 and Annexes) and MCA MGN 653 (M).
- Members operating RoRo (Cargo) and PCTC vessels should ensure the priority adoption and implementation of the EMSA Guidance (Chapters 1, 3 and Annexes), the ICS Common Guidance on the Presentation and Loading of Vehicles and MCA MGN 653 (M).

NOTE: MCA MGN 653 (M) is directed at EV fire safety on board RoPax vessels. However, much of the advice it contains is applicable to RoRo (Cargo) and PCTC vessels as well.

MM's assessment is that the above referenced IMO, EMSA, MCS and ICS guidelines – when applied together with the applicable SOLAS/NCVS regulation – provide the current 'industry best practice' benchmark for fire training, detection, containment and extinguishment on board RoPax as well as RoRo (Cargo) and PCTC vessels. Members should review their ISM Code or equivalent NCVS SMS manuals and procedures and then ensure the guidelines and recommendations referred to in this Risk Bulletin No. 84 and Risk Bulletin No. 51 are incorporated as appropriate to vessel type and trade. Effective adherence should then be monitored and reinforced by way of ISM Code or equivalent NCVS audit procedures.