Risk Focus: Safe Carriage of Vehicle Cargoes

Car carriers, Ro-Ro and Ro-Pax ship safety
– A guide for shipowners, ship managers and crew

UK P&I CLUB IS MANAGED BY **THOMAS MILLER**

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Introduction

The carriage of vehicles and vehicle cargoes presents distinctive challenges to Pure Car Carriers (PCC), Pure Car and Truck Carriers (PCTC), Roll-on/Roll-off (Ro-Ro) and Ro-Ro Passenger (Ro-Pax) vessels.

The structural design of these vessels, featuring multiple vehicle decks, a high-sided box-shaped superstructure and subdivision characteristics above the freeboard deck, makes them particularly sensitive to stability-related risks. Similarly, any cargo shift can also reduce the available intact stability and the safety of the ship.

In recent years, the increasing demand for the transportation of electric vehicles (EVs) has introduced unique risks, primarily associated with lithium-ion batteries (LiBs), which are still being understood. Compounding the increased use of composite materials, while offering advantages in weight reduction and fuel efficiency, can introduce higher fire loads in the event of a fire in modern vehicles.

Recognising these challenges, the IMO Sub-Committee on Ship Systems and Equipment, during its 11th session (SSE 11) in February 2025, adopted an action plan to evaluate the adequacy of existing fire protection, detection and extinguishing arrangements for EVs (old and new) and other new-energy vehicles. The plan calls for a systematic review of reports, studies and technologies, identification of key hazards and development of goal-based measures to enhance safety.

In parallel, several organisations, including the European Maritime Safety Agency (EMSA)[1] and the Maritime Technologies Forum (MTF)[2], have also conducted detailed studies and issued technical guidance on the safe carriage of Alternative Fuel Vehicles (AFVs) and EVs at sea.

To ensure their safe carriage, it is essential that seafarers are familiar with the characteristics of EVs and other new-energy vehicles and that they are properly trained in their handling, monitoring and emergency response.

Onboard incidents involving EVs can and do occur while a vessel is alongside, where the proximity to port infrastructure, personnel and other cargo can significantly amplify potential consequences. In these situations, a fundamental requirement for effective risk mitigation is close collaboration and a common understanding among all parties – ship operators, terminals, insurers, emergency responders and supply chain stakeholders. Establishing shared expectations, clear procedures and coordinated response capabilities is essential to managing these risks responsibly and safeguarding people, assets and the environment.

This guide outlines these risks and offers practical measures to help seafarers and shipping companies manage them effectively.

A history of casualties

There have been numerous serious incidents involving both vehicle carriers and Ro-Ro vessels over the years.
The most common types of incidents affecting these types of vessels concern a loss of stability or fire originating on the vehicle decks.

Some of these incidents proved to be the catalyst for changes in the way these types of vessels were operated and saw the introduction of new design features to improve stability and safety.

Despite developments and improvements over the years, issues remain, compounded by the emergence of the risks presented by LiBs used in fully electric and hybrid vehicles. Shipowners, operators, managers and crew must remain alive to both the established and evolving hazards to ensure that risks are identified, understood and mitigated.

1 Publications – 'Guidance on the carriage of AFVs in RO-RO spaces' – EMSA – European Maritime Safety Agency
2 2025-mtf-safe-carriage-of-evs-3.pdf

Case studies: Fire incidents

The following is a summary of major fire incidents concerning vessels carrying vehicles since 2014.

Ship name	Ship type	Date	Location	Brief details
NORMAN ATLANTIC	Ro-Pax ferry	28 Dec 2014	Adriatic Sea	• Fire on vehicle deck. • 31 fatalities with another 64 people injured. • Two crew members of the tug also died during salvage operations.
COURAGE	Ro-Ro	2 Jun 2015	North Sea	• Fire on vehicle deck while on passage from Bremerhaven to Southampton. • Fire contained by crew but caused extensive damage to vessel's hold and its cargo (vehicles and household goods).
SILVER SKY	PCTC	20 Oct 2016	Antwerp, Belgium	• Fire on vehicle deck while in port. • Fire was suppressed after almost three days. • Fire originated from second-hand vehicle.
HONOR	Ro-Ro	24 Feb 2017	English Channel	• Fire on upper vehicle deck while the vessel was on a voyage from Southampton to Baltimore. • Fire extinguished by using the vessel's fixed CO_2 firefighting system. • Injuries sustained during the firefighting efforts. • Extensive damage to vessel's hold and roughly 5,000 vehicles.
SINCERITY ACE	PCTC	30 Dec 2018	Pacific Ocean	• Fire mid-Pacific Ocean. • Fire out of control and crew abandoned ship. • Five crew lost their lives in this incident. • The fire continued to burn for five days, and the ship was towed to Japan.
GRANDE AMERICA	Con-Ro	10 Mar 2019	Bay of Biscay	• Fire broke out on a voyage from Hamburg to Casablanca. • Vessel was carrying 365 containers (some of which were IMDG) and 2,184 vehicles. • The chief mate informed sparks could be seen coming out of one of the trucks on Deck 2. • Reported presence of a lot of smoke without flames. • Fire initially contained with powder, then CO_2 released. • Further fire reported in container stack on deck. • Crew abandoned ship and were rescued by a UK Royal Navy vessel. • Vessel sank the following day.

GRANDE EUROPA	PCTC	15 May 2019	Mediterranean Sea	• Vessel caught fire near Mallorca while on passage from Salerno, Italy, to Valencia, Spain. • Initial fire started on Deck 3 but was initially extinguished by the ship's crew. • However, a few hours later, a second fire ignited on Deck 8 and subsequently spread to Deck 9. • Fifteen crew were safely evacuated. • Fire was extinguished by firefighting tugs.
DIAMOND HIGHWAY	PCTC	15 Jun 2019	South China Sea	• Fire while on passage from Singapore to Philippines. • Crew abandoned ship and were subsequently rescued by a nearby bulk carrier.
FELICITY ACE	PCTC	16 Feb 2022	Atlantic Ocean (off Azores)	• Vessel caught fire in the North Atlantic while carrying about 4,000 cars, including 574 EVs. • Smoke was detected on Deck 1, prompting the crew to investigate. • Due to the severe conditions, fire teams had to withdraw. • All 22 crew members abandoned ship safely. • The fire continued to burn until the ship sank about two weeks later.
AH SHIN	PCTC	3 Feb 2023	South China Sea	• Fire broke out while the vessel was off the coast of Vietnam, en route from South Korea to Singapore. • Decks 8, 9 and 10 were reported to be affected. • Adverse sea conditions and inclement weather hindered immediate assistance from shore-based resources.
GRANDE COSTA D'AVORIO	Con-Ro	8 Jul 2023	Port Newark, USA	• Fire started while loading used vehicles. • At the time of the fire, the ship was carrying 1,200 vehicles and 157 containers. No EVs or hazardous cargo was reported to be on board. • The fire continued to burn for about six days before it was extinguished.
FREMANTLE HIGHWAY	PCTC	26 Jul 2023	North Sea	• Vessel, carrying 3,783 vehicles, including nearly 500 EVs, caught fire near Ameland, Netherlands. • The fire began on a vehicle deck and quickly spread to other decks. • After the fire burnt out, the vessel was towed to Eemshaven. • The ship was sent to China for repairs.
DELPHINE	Ro-Ro	16 Apr 2025	Zeebrugge, Belgium	• Fire broke out on one of the vehicle decks while the vessel was alongside in port. • Amongst the vehicle cargo, the vessel was carrying 260 EVs. • Firefighting tugs responded to the scene, and the fire was brought under control following the deployment of the CO_2 system.
MORNING MIDAS	PCTC	3 Jun 2025	Pacific Ocean	• Vessel caught fire about 300 miles south of Adak, Alaska, during its voyage from China to Mexico. • Vessel was carrying 3,048 vehicles, including around 70 EVs and 681 hybrids. • All 22 crew members were rescued by a passing vessel. • The vessel sank on 23 June 2025.

Case studies: Loss of stability incidents

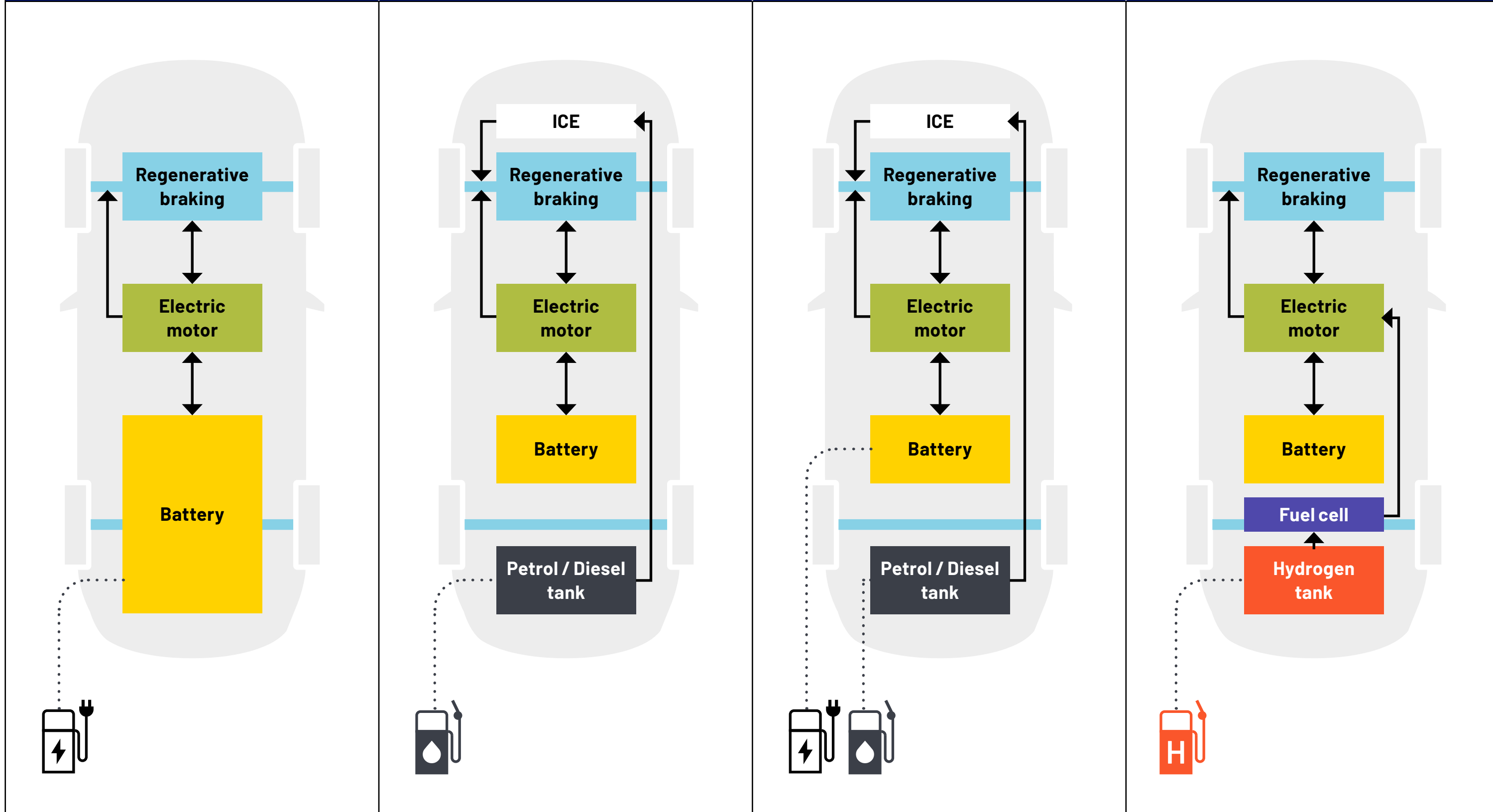
The following is a summary of vehicle carrier casualties where a loss of stability was identified as either the primary cause or a significant contributing factor.

Ship name	Ship type	Date	Location	Brief details
COUGAR ACE	PCTC	23 Jul 2006	North Pacific Ocean	• While en route from Japan to North America, the vessel experienced a severe list during ballast water exchange operations. • All 23 crew members were safely rescued. • The vessel was subsequently salvaged successfully.
HÖEGH OSAKA	PCTC	3 Jan 2015	Solent, UK	• Shortly after departing Southampton, the vessel developed a severe starboard list. • Due to extreme list, the vessel lost steering and propulsion and subsequently grounded. • Cargo shifted and flooding occurred. • All the crew were safely evacuated, and no pollution was reported. • The vessel was subsequently salvaged.
GOLDEN RAY	PCTC	8 Sep 2019	Georgia, USA	• Shortly after departing from the Brunswick port, the vessel executed a sharp turn and heeled to 60° in less than a minute. • Water flooded in via an open pilot door and unlocked watertight doors, ultimately capsizing the ship. • 23 crew members and a pilot were on board at the time of the incident.

Risks associated with the carriage of EVs by sea

To effectively assess the risks involved with carrying EVs, it is essential to understand the technical design of different types of EVs. Broadly speaking, there are currently three types of EVs:

- Fully electric Battery Electric Vehicles (BEVs), which have a battery pack that usually extends under the entire floor of the vehicle. At present, LiBs are the only technology capable of delivering the energy density necessary for practical vehicle operation, although research into other alternatives is ongoing;
- Hybrid Electric Vehicles (HEVs) and Plug-in Hybrid Electric Vehicles (PHEVs), which are powered by an electric motor as well as an internal combustion engine (ICE) that is powered either by gasoline or diesel; and
- Fuel Cell Electric Vehicles (FCEVs), which use compressed hydrogen gas as fuel to generate electricity which in turn drives an electric motor.



BEV (Battery Electric Vehicle)	**HEV** (Hybrid Electric Vehicle)	**PHEV** (Plug-in Hybrid Vehicle)	FCEV (Fuel Cell Electric Vehicle)
BEVs (also popularly called EVs) are fully-electric vehicles with rechargeable high capacity battery packs and have no gasoline engine. There are no harmful emissions.	HEVs & PHEVs are powered by a combination of internal combustion engine and an electric motor, which uses energy from batteries. While, in HEV, the battery can be charged through regenerative braking and by the internal combustion engine, it cannot be plugged in to an external power source for charging. PHEVs can be also charged from an external power source.		FCEVs produce electricity using a fuel cell powered by hydrogen, rather than drawing electricity from only a battery.

Figure 1: Diversified electrical vehicle technologies

For convenience, this guide will use the term EV to encompass BEVs, HEVs and PHEVs. FCEVs will be considered separately.

There are currently no publicly available and reliable statistics that can be used to determine how many ship fires have been initiated by EVs. However, this is not the key issue. What is important is that the fire characteristics of EVs differ significantly from those of conventional ICE vehicles, and these differences can complicate the firefighting response.

It should also be recognised that the potential fire load (the total amount of heat energy that can be released if all the combustible materials completely burn) of automotive vehicles has increased over time. Modern vehicles are generally larger, with bigger fuel tanks, more plastic components and added hazards such as airbag detonators. The rise of 'mild hybrid' vehicles also introduces some battery-related risks similar to those in EVs.

The risks and severity of EV fires differ significantly from those of conventional ICE vehicles. Shipowners and crews must understand these distinctions. The unique characteristics and principal risks of carrying EVs on board are outlined here.

Thermal runaway

Thermal runaway is an exothermic reaction within a battery cell or pack, typically triggered by internal short circuits, manufacturing defects, overcharging, damage due to impact or external heat. It causes a rapid, self-accelerating temperature rise – sometimes above 1200°C – that can spread to neighbouring cells. This critical condition may release large volumes of flammable and toxic gases and, in severe cases, lead to fire or explosion. Failing cells may produce large amounts of black or white smoke, sometimes accompanied by hissing or popping sounds. While white smoke is often mistaken for harmless steam, it can actually contain hydrogen gas, which is extremely flammable and explosive.

Vapour cloud

When a battery is in thermal runaway, it releases flammable gases such as methane, ethane and hydrogen. The density of these gases is lower than air and can accumulate in the upper part of the deck where electrical equipment, such as detectors and lights, may not be explosion-rated.

Once ignited, these gases can produce 'jet-like' flames. Moreover, thermal runaway can lead to vapour cloud explosions, which are still being understood, especially by emergency responders. Research has found that vapour clouds contain small droplets of organic solvent and may be mistaken for smoke or steam.[3] If ignition of the cloud is delayed, a vapour cloud explosion can occur.

In addition to flammable gases, LiBs in thermal runaway also emit toxic gases, such as hydrogen fluoride and hydrogen chloride. Other gases expelled include carbon monoxide, carbon dioxide, hydrogen cyanide and others. Trials carried out in 2025 identified the presence of harmful molecules in the vapour cloud that may cause more severe inhalation injuries than traditional smoke inhalation. Emergency responders and all crew members must be made aware of the toxicity of the gases emanating from a suspected EV fire.

State of charge (SOC)

Determining the ignition and the explosion risk associated with the release of flammable gases is influenced by the battery's state of charge (SOC). Put simply, a higher SOC means more stored energy, which can prolong an incident or increase the intensity of a thermal runaway event, whereas a lower SOC reduces the likelihood of ignition – as it has less stored energy – but allows an accumulation of gas to build, which in turn increases the risk of an explosion. Furthermore, a SOC that is too low can cause damage to the battery.

The EMSA's Guidance on the carriage of Alternative Fuel Vehicles in Ro-Ro Spaces recommends that the SOC of the vehicles transported on vessels be between 20% and 50%. Following the publication of the EMSA guidance document, the Association of European Vehicle Logistics (ECG) surveyed the engine manufacturers on their SOC requirements during transportation, the results of which, as of July 2023, are shown in Figure 2.

3 Faraday Insights – Issue 17: July 2023 'Improving the Safety of Lithium-ion Battery Cells'

	0-10%	10-20%	20-30%	30-40%	40-50%	50-60%	60-70%	70-80%	80-90%	90-100%	Update in 2023
BMW											The cars send a "charge me" message in the combi-instrument when 2,5A/h is reached. Charging for 0,5 hour. The vehicles are at max. 15% when arriving at the dealers
Ford											If the HV battery SoC goes below 20% the LSPs will have to charge these back to 50% before delivery to the dealer. Intent is for vehicle to arrive at dealer w/ 20% SoC.
Glovis											Max SoC level: 45-50% on hybrid battery at the end of the line Minimum SoC Level: 15% of SOC level is optimal; <15% is critical; <5% is not possible to start the engine.
Honda											we have Honda e from JPN factory to UK & EU with 10-15% and we will charge up to 20% for cars to go to dealers. New full EV will come soon - info will be updated then
JLR											If the vehicles are below 11% SoC they are charged back to 19% Maximum charge target/ assumption is 40%
Mazda											Vessel transport: over 39% Arrival at port: over 33% Depart from port: over 4% Arrival at dealer: over 1% Charge to 10% if SOC is too low at port or in inland transport
Mercedes											Vehicles leave the production/plant with 26.5% SoC. At display of the message (ca. 19% SoC) charge to 30-55%, although the max. charge level in the supply chain will be 30%
Mitsubishi											Minimum level is 10%, if 11% is reached, charge up to 30%-40%.
Stellantis											All vehicles must enter the logistics flow with 35% SoC. If the SoC is at 15% charge the vehicle to 35%. There are no differences between the different brands
Renault											The Renault vehicles come out of the factories with a 20-50% range of battery charge, depending on the battery size and the intrinsic energy consumtion of the vehicle. In the supply chain when the battery charge is lower than the minimum SOC established for that partiular model, the battery has to be charged to the min. SoC of the model (this is between 30-50%)
Tesla											From the factory to Service Center, we are trying to be at 80% SoC From the factory to Port we are charging at 60% SoC
Volvo											Volvo is considering adopting the 20-50% range recommended by EMSA, but in future models the SoC might be less, at around 10%. When a BEV car today leaves the Volvo plant the average SoC is around 27%. If a HV battery needs to be charged in the distribution chain we charge it to minimum of 25% and a maximum of 40% SoC.
Volkswagen											The vehicle leaves the factory at around 30%, if the SoC gets under 10% in the supply chain, the battery has to be charged to 20%

Figure 2: State of charge requirements for Battery Electric Vehicles in the supply chain (source: Association of European Vehicle Logistics (ECG))[4]

4 EV-charging-requirements-July-2023-v2.pdf

Reignition

Even after an EV fire has been extinguished, there remains a possibility of reignition, as chemical reactions and the emission of flammable gases can continue while the battery pack retains heat. Emergency responders, whether crew or a shoreside fire team, should monitor the vehicle that experienced fire damage. Due to the use of seawater during extinguishment, the risk of reignition is higher, as seawater continues to react with a battery, even after weeks partly or completely submerged and then drying out.

Electrocution risk and EV shutdown

The high voltage (HV) system of an EV may be designed to shut down automatically when the airbags have deployed. It can also be isolated by manually disconnecting.

However, in the event of a fire, emergency responders have no way of confirming if automatic isolation has occurred. As such, it is advisable to always treat an EV as being live and to avoid contact with HV cables. Responders should be on the lookout for exposed orange HV cables and scattered battery cells.

When fighting an EV fire with water, research shows that there is little to no risk of electrocution when using an unbroken stream of water, and there have been no reports of any such cases.[5]

New vs. second-hand EVs: A different risk profile

The risks of transporting new EVs are significantly lower than those of second-hand vehicles. New EVs undergo stringent safety and battery integrity testing. LiBs are subject to the UN Manual of Tests and Criteria Section 38.3, which mandates thermal, electrical and mechanical testing before transport.

The carrier of a used EV will be unaware of the vehicle's history and whether there is any pre-existing damage to the battery pack or a weakness in its protection. EV batteries are not externally visible, making it difficult for shipping lines to assess their condition prior to loading. No specific regulations are in place regarding second-hand EVs.

Why EV batteries fail

A LiB cell may go into thermal runaway when it has been subject to some form of abuse, which then leads to the internal separator (the membrane that acts as an insulator between the positive (cathode) and negative (anode) electrodes) collapsing and causing an internal short circuit.

The main causes of damage leading to an EV battery fire include:

- Impact: Damage to the battery pack from a road traffic collision or running over debris, or some other form of direct impact.
- Submersion: A prolonged period of being submerged in water, especially salt water.
- Manufacturing Defects: Design faults or faults in the manufacture or assembly during production.
- External Heat: Exposure to extreme heat sources or fire that spreads to the vehicle or battery pack.

Current research suggests that it is a misconception that the risk of a battery fire is greater during charging and that most charging-connected EV battery fires have occurred when the EV had already been damaged and then connected to a charger.

5 www.evfiresafe.com – '04.8 Electrocution risk'

Managing the risk

As the industry grapples with the evolving risks associated with the emerging technology, efforts have been made to introduce protocols and mitigating actions to help manage the risk.

The following summarises some of the industry guidance, best practices and safety initiatives that address the safe carriage of EVs on vessels.

Loading protocols

Damaged vehicles may present an increased fire risk and, as such, an effective pre-loading inspection and verification regime is important. Any vehicle which is found to be unsafe, damaged, overweight or not as described must not be allowed to be loaded onto the carrying vessel until all the issues have been addressed.

In 2024, the Vehicle Carrier Safety Forum (VCSF), which is a consortium of vessel operators, insurers and other industry experts, produced Common Guidance on the Presentation and Loading of Vehicles.

The guidelines aim to reduce risks during the shipment of vehicles, including EVs, and safeguard personnel, vessels and cargo. They apply to unaccompanied vehicles on international voyages and complement manufacturer and carrier procedures. Key stages include:

- **Booking and planning:** Provide accurate details on vehicle type, condition, dimensions, weight, propulsion system and lashing points. Include emergency response guides and consider the stability impacts of heavier EVs.
- **Terminal presentation:** Inspect vehicles for compliance with state of charge (SOC), fuel levels and absence of alarms. Clearly mark powertrain details.
- **Loading and securing:** Hold pre-load meetings, conduct safety checks and follow the vessel's Cargo Securing Manual. Stow similar vehicles together where practical, ensuring safe access and emergency response.

These measures promote safe operations and effective risk management throughout the voyage.

Experience suggests that accident-damaged EVs are far more commonly shipped in containers than on Ro-Ro or PCTC vessels. Because the condition of a container's contents cannot be visually verified once sealed, robust know-your-customer processes and thorough pre-shipment checks are essential. These steps help ensure that any critically damaged LiB is properly identified, its condition accurately understood and the cargo correctly declared, thereby reducing the risk of undeclared or poorly assessed hazardous shipments entering the supply chain. A damaged vehicle should not be loaded without prior inspection by a suitably experienced and qualified EV technician.

Stowage guidelines

EVs should be stowed in a way that will allow patrols direct access to all such vehicles. They should be clearly labelled in cargo manifests and stowage plans so they can easily and quickly be identified.

In its publication Best Practices for the Transport of Electric Vehicles On Board Vessels, ABS considered suggestions from industry participants on best practice. The group suggested that designated areas for the stowage of EVs be created, which can allow for early detection of a possible EV fire and inform the appropriate firefighting actions.

It is recommended to stow EVs in well-ventilated areas, away from the vessel's machinery spaces, high voltage charging equipment (on Ro-Ros), heat sources and any other flammable goods.

Vehicles shall be properly secured to prevent movement and therefore reduce the risk of any impact that may lead to battery damage.

Fire detection and monitoring

Early detection systems are crucial in allowing a prompt responsive action to be taken.

The fire detection systems for the vehicle decks on PCTCs and Ro-Ros are regulated as per SOLAS II-2 Regulation 20, where heat and smoke detectors are the legacy methods. However, the use of additional technology can improve the vessel's ability to detect a fire – or potential fire – incident early. By way of example, several companies have been developing 'sniffer' technology, which is designed to detect the presence on the vehicle deck of off-gases.

The MTF guidance on Safe Carriage of Electric Vehicles recommends a layered detection approach combining multiple technologies. These include the use of closed-circuit television (CCTV) with Artificial Intelligence (AI) or video analytics function, infrared (IR) or thermal imaging cameras, and sensors that can detect the gases emitted by a damaged battery and low-visibility vapour clouds.

Other advanced methods include using remote telemetry from the EV's battery management system (BMS) for real-time monitoring of the batteries' health and status. Some EVs are capable of emitting audible and visual alarms such as the sound of a horn and flashing headlights when the BMS detects issues such as high battery voltage or temperature.

The latest amendments to SOLAS Chapter II-2/20, introduced by IMO Resolution MSC.550(108), aim to improve early detection of fire in vehicle, special category and Ro-Ro spaces. These requirements are applicable to ships constructed on or after 1 January 2026, and include:

- Individually identifiable smoke and heat detector systems (including linear heat detectors) for open and closed vehicle Ro-Ro spaces.
- Fire detection and alarm system requirements for weather decks intended for the carriage vehicles, including a safety distance from vehicle lanes to accommodation spaces, control stations and normally occupied service spaces.
- Video monitoring on vehicle spaces, open and closed Ro-Ro spaces, and special category spaces.

Ships constructed before 1 January 2026 will be required to comply with certain paragraphs of the amended SOLAS regulation as detailed in IMO Resolution MSC.550(108).

Similarly, the amendments to the Fire Safety Systems (FSS) Code address:

- the requirements on linear heat detectors and positioning of detectors for combined smoke and heat detectors, which will apply to all vessels constructed on or after 1 January 2026; and
- the requirements on the visual and audible fire signals on Ro-Ro passenger ships constructed on or after 1 January 2026.

Emergency response and incident management

Vessel-specific emergency response plans are vital in the event of a fire on a vehicle deck and, in particular, a suspected EV fire. The plan should include coordination with shore-based fire and rescue services, especially for incidents during port calls.

In April 2025, the VCSF published its second industry good practice guidelines, titled Fire Response – High Level Guidelines. These guidelines aim to assist vessel operators and crews in preparing for vehicle fires, with a particular emphasis on using existing fixed firefighting systems for early fire control.

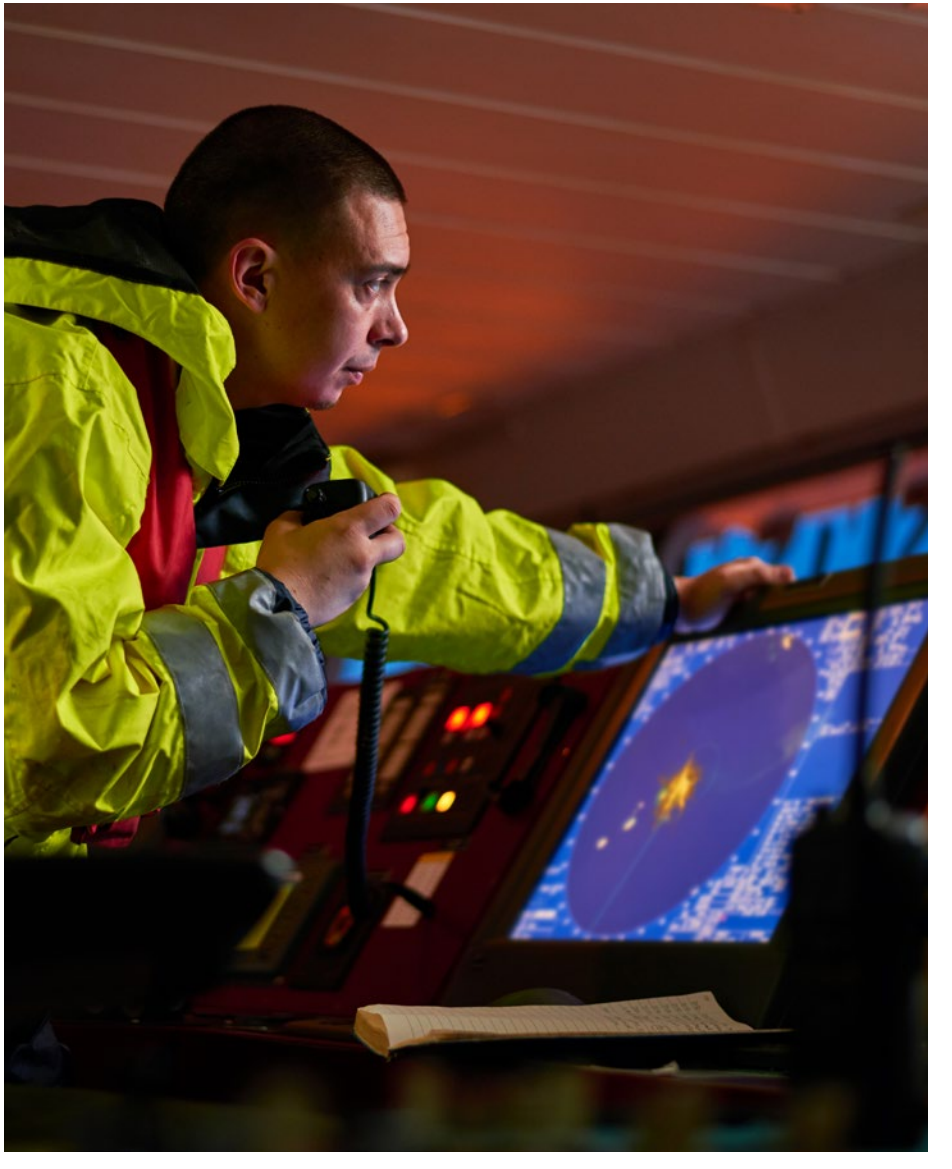
The VCSF guidelines urge companies to introduce policies that clearly authorise vessels' masters to deploy fixed firefighting systems when a trigger event occurs and emphasise the importance of crew training in their use.

For fires in port, the guidelines recommend developing modified response plans and liaising with local fire services in frequently visited ports.

They also stress the importance of maintaining up-to-date stowage plans with essential information, including vehicle engine type.

The VCSF's findings are intended to complement the IMO's initiatives and should be used in conjunction with specific procedures from vehicle manufacturers, shippers, terminals or carriers regarding vehicle separation and emergency response.

Learning from prior incidents shows that an event may occur while a vessel is alongside or that a ship may need to berth immediately after an incident, creating an operational environment very different from that faced by shoreside emergency responders. This reinforces the vital need for early engagement and close collaboration with port authorities and shoreside fire and rescue services, ensuring they understand the unique conditions, constraints and risks present on board. Because shipboard environments differ significantly from the scenarios shoreside responders typically train for, proactive education and joint familiarisation are essential. Equally important is establishing clarity around primacy, command structures and strategic decision-making well in advance – matters far better resolved during preparedness planning than debated amid the pressures of a live incident.



Vehicle deck firefighting and EV incidents

1. Hazards

1.1 Access constraints and obstructions

Loaded vehicle decks can restrict access to the site of a fire. Vehicles are stowed with minimal clearance, limiting movement and hampering hose advancement. Lashings and deck fittings create pronounced trip and entanglement hazards, especially under reduced visibility. These factors materially increase the probability of falls, loss of orientation and delayed withdrawal of responders.

1.2 Extended attack routes and limited breathing-air reserves

Modern vehicle decks are expansive and may be subdivided into multiple sections with ramps, level changes and physical obstructions. In practice, a single two-person team is frequently unable to reach the fire location, apply an effective intervention and return to a tenable area while maintaining adequate breathing-air reserves, particularly where smoke production and disorientation are present.

1.3 Rapid heat build-up, overhead heat effects and steam generation

Vehicle decks often have limited vertical clearance, allowing heat and gases to accumulate quickly. In developed fires, flames and radiant heat roll on deckheads and structural steel, accelerating environmental heating. Water application in a hot steel environment can generate significant amounts of steam. As an operational reference point, one litre of water converted to steam at 100°C produces approximately 1.7 m^3 (around 1,700 litres) of steam, creating a severe scalding risk and further degrading visibility in enclosed or semi-enclosed conditions. Standard firefighting PPE provides only limited protection against steam.

1.4 Visibility collapse, disorientation and loss of escape route

Smoke and, where water is applied, steam can rapidly cause 'zero-visibility' conditions. This significantly increases the risk of disorientation, missed exits and a loss of the return route. On board, these risks are compounded by ship motion, constrained escape routes and limited capacity for external support. Once conditions have developed at sea, the scope for safe manual intervention can narrow rapidly.

1.5 Moving components and changing geometry (ramps, lashings, vehicle shift)

Under high heat, ramps and structural elements can deform, and lashings can weaken or fail. Combined with vessel motion and sea state, this may lead to vehicle movement or route obstruction. Vehicle-deck fires are therefore dynamic: routes viable at entry may become unusable during the operation, creating an entrapment risk.

1.6 Toxic and explosive atmosphere

Heavy gases could flow to spaces low down in the ship, away from any actual fire, creating unforeseen toxic hazards on decks and in confined spaces. Likewise, the same could occur for lighter gases in the upper decks and confined spaces.

2. Operational implications

2.1 Strategic emphasis: containment and ship integrity

Vehicle-deck incidents should be approached with a containment-first mindset. Early detection, rapid activation of fixed fire-control systems and disciplined ventilation/smoke management are the primary levers to prevent escalation. Manual entry should be considered only where it is demonstrably feasible and can be executed within defined risk controls.

2.2 Entry is conditional, not assumed

Entry operations must be treated as conditional activities, dependent on route viability, risk assessment, communications stability and robust contingency (backup) arrangements. Where these conditions are not met, continued internal operations increase the likelihood of responder harm without a commensurate probability of effective control.

2.3 Ventilation and smoke management require command discipline

Ventilation decisions materially influence fire development, smoke spread and the behaviour of flammable gases. Ventilation should be managed deliberately, coordinated with fixed-system operation and tactical objectives, and reflected in a clear command decision model with defined triggers and stop criteria.

3. EV-specific considerations on vehicle decks

3.1 Thermal runaway: sustained hazard profile

Many EV incidents are dominated by thermal runaway, a self-sustaining decomposition process within parts of a battery pack that releases heat together with flammable and toxic gases. Once initiated, there is rarely an immediate intervention that 'stops' the process outright. Operational outcomes therefore depend on controlling escalation, effectively venting flammable and toxic gases, sustained cooling where feasible and preventing spread to adjacent vehicles.

3.2 Shipboard constraints versus shore-based practice

Some shore-based measures (including vehicle submersion in water containers) are not practicable on board. Targeted cooling of a battery pack on a vehicle deck may also be limited by access, intense radiant heat, and the secondary hazards of steam and visibility loss. Accordingly, shipboard priorities must focus on limiting spread, maintaining responder safety and protecting overall vessel integrity, supported by fixed, water-based fire-control systems approved for Ro-Ro and vehicle spaces.

3.3 Two operationally distinct EV scenarios

Scenario A – EV fire (flaming combustion): EV incidents can produce intense heat release and, in some cases, directional 'jetting' flames. These conditions can accelerate the heating and off-gassing of nearby materials, and increase the likelihood of rapid spread to adjacent vehicles. Conventional assumptions used in legacy fire-development training do not always translate directly to LiB behaviour; teams must therefore interpret conditions carefully before entry and apply strict stop criteria.

Scenario B – Vapour cloud (gas release without immediate fire): Thermal runaway can also produce a flammable and toxic gas mixture that does not ignite immediately. In enclosed or poorly ventilated conditions, delayed ignition can occur and may result in a violent event. In this scenario, the primary immediate hazard is the unpredictable ignition of an explosive mixture rather than visible flame. Preventing accumulation of unignited gases, establishing stand-off and controlling ignition sources should become dominant considerations.

Fixed firefighting installations:

SOLAS Chapter II-2 Regulation 20 requires one of the following fixed fire-extinguishing systems in vehicle spaces: a gas fire-extinguishing system, a high expansion foam fire-extinguishing system or a water-based fire extinguishing system.

- ***Water:*** The advantage of water extinguishing systems is that the supply is unlimited, and it provides the most effective cooling. However, the uncontrolled use of water during firefighting operations can have an adverse effect on vessel stability. It should also be remembered that the application of water suppression will not stop thermal runaway.
- ***Carbon dioxide:*** Regardless of the type of fire, the effective use of CO_2 requires the space to be sealed to prevent the escape of CO_2 gas. This is challenging on the vehicle deck of a vessel, especially when alongside and engaging in cargo operations, as it is likely that the loading ramps will be open. CO_2 does not have any cooling effect and is designed to only starve the fire of oxygen. Therefore, it should it not be the sole suppression method when tackling an EV fire. Vessels that have CO_2 fixed systems installed should ensure that they have sufficient CO_2 capacity. The International Union of Marine Insurance (IUMI) recommends that to improve its usefulness, the CO_2 capacity on board PCTCs should be at least doubled.
- ***Foam:*** The primary operational value of foam is surface coverage. When correctly applied, a foam blanket suppresses the release of flammable vapours from liquid fuels and helps separate the fuel surface from the surrounding atmosphere. Foam can also contribute limited cooling, driven by the water content of the foam solution – typically more pronounced with low-expansion foams than with high-expansion foams. In professional doctrine, foam is not limited to 'extinguishment' alone; it is also applied for controlling fires, covering hazardous substances/pools and consolidating a foam blanket for longer-term vapour suppression, depending on whether a loss of containment has been stopped and whether fire is present. In incidents involving LiBs , the key constraint is that foam does not address the underlying thermal runaway process inside battery cells. Critically, thermal runaway may continue to produce large volumes of flammable and toxic gases, meaning that a vapour cloud can still develop; in such cases, the dominant hazard may shift from 'fire control'

to delayed ignition/vapour-cloud explosion risk, particularly in enclosed or poorly ventilated environments. Finally, EV battery events can include directional jet flames (jet fires) from venting gases. These high-velocity, high-intensity flames can rapidly degrade a foam blanket and reduce its effectiveness for coverage and vapour suppression.

Water-based extinguishing systems are more commonly found on Ro-Ros, whereas it is currently more typical for the cargo areas of PCTC vessels to be protected by CO_2 systems.

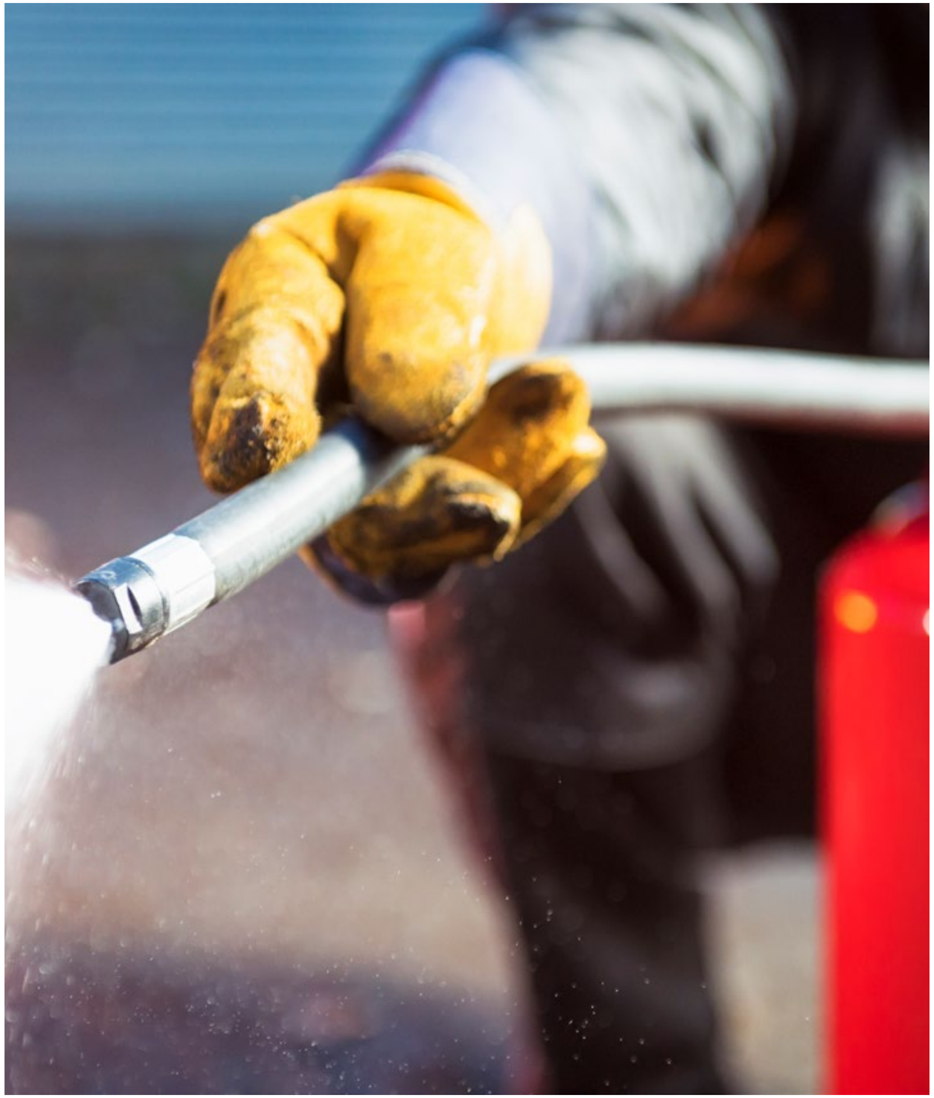
The latest amendments to SOLAS Chapter II-2 require fixed water-based fire-extinguishing systems to protect weather decks using water monitors. The corresponding amendments to the FSS Code address the specifications for fixed water-based fire-extinguishing systems on Ro-Ro passenger ships fitted with weather decks intended for the carriage of vehicles.

Boundary cooling:

The strategic application of water to the bulkheads and decks around the fire-affected area can prevent heat from spreading to adjacent areas and, therefore, mitigate the risk of fire spreading. The water used in boundary cooling absorbs heat, which is critical for containing a fire. However, the use of water during boundary cooling operations can in some cases have an adverse effect on vessel stability. It is therefore important to carry out excess water removal operations at the same time as boundary cooling or firefighting operations to prevent excess water accumulation and ensure that scuppers are not clogged or otherwise blocked by burnt residues or other materials.

Portable extinguishers:

Portable fire extinguishers cannot access cells within sealed modules or packs, and their deployment requires the user to be in proximity to the fire and the toxic gases that may be emitted. At the time of writing, EV Firesafe is not aware of any real-world incident in which portable fire extinguishers have been successfully used to suppress an EV battery fire.[6]



6 www.evfiresafe.com '04.10 EV battery fire suppression'

Fire blankets:

There are a number of companies that claim fire blankets could offer an effective solution for the containment and suppression of EV fires. Fire blankets work by eliminating the flames by restricting oxygen, but there are challenges in their use on a vessel's vehicle deck:

- Access to and around the affected vehicle is constrained by the proximity to other vehicles, and therefore, a blanket cannot easily be deployed or secured.
- Deployment of a blanket requires placing people in potentially dangerous positions.
- The blankets are large and heavy (7x3 metres – 32 kg), meaning that they are difficult to manoeuvre into position.
- Thermal runaway will continue under the cover of a blanket, leading to the accumulation of flammable gases under the blanket and an explosion risk when air is reintroduced.
- There are concerns about whether a fire blanket can withstand a vapour cloud explosion.
- The blanket can never be completely closed on a car deck due to the lashings.

Underbody spray:

Underbody spray systems can provide cooling water more directly to the battery pack. Units can be expensive and difficult to carry or position under a vehicle in a tightly packed stow on a vehicle deck and only have a cooling effect.

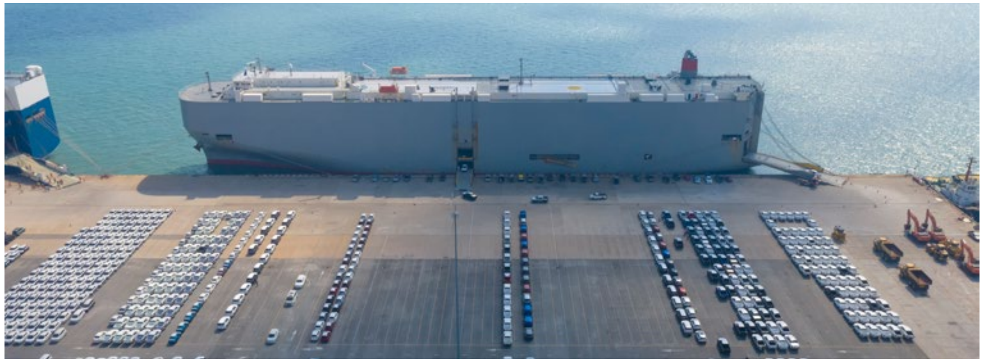
Containment and protection measures:

The latest amendments to SOLAS Chapter II-2 require enhanced structural fire protection of vehicle, special category and Ro-Ro spaces on ships built on or after 1 January 2026. This includes protection from openings, which has been extended to include access to embarkation and assembly stations, as well as intakes for machinery.

Ventilation and emergency shutdown systems:

A fully functioning and effective confinement and ventilation system is essential in the tackling of vehicle deck fires.

Closure of the ventilation system fans and dampers, watertight doors and fire doors is vital in preventing the spread of fire and smoke, as well as restricting the ingress of fresh oxygen that may feed the fire. Furthermore, the space must be fully closed if using CO_2 as a firefighting medium; otherwise, it will likely escape and its effectiveness will be diminished. The strategic use of the ventilation system to exhaust smoke or gasses as and when required can also be useful. The isolation of any other systems that might introduce additional fuel or oxygen to the fire must also be considered. Particularly during thermal runaway without visible flaming, an adjusted ventilation strategy may be required. The primary objective is to prevent the accumulation of unignited and explosive gas mixtures, and to keep concentrations below flammability limits through controlled ventilation.



It is equally critical to avoid flammable gases being transported through the ventilation system into adjacent spaces where they may encounter an ignition source. The location and discharge direction of ventilation outlets must therefore be confirmed in advance and actively monitored throughout the incident. Outlets must be verified not to discharge toward, or near, muster stations and lifeboat embarkation areas, to prevent these locations from being exposed to toxic and flammable gases.

Given their importance, these systems must be well maintained and regularly tested. Over time, and without appropriate maintenance, fire doors and dampers may seize or not close fully, and automatic release systems may fail.

Crew training requirements

Training and shipboard drills for vehicle-deck incidents, particularly those involving EVs, should include, at a minimum:

1. **Adopt a containment-first doctrine for vehicle decks.** Prioritise early detection, rapid activation of fixed water-based systems and controlled ventilation/smoke management to prevent escalation.
2. **Treat manual entry as conditional.** Only commit teams when tenability, route viability, communications and backup capacity are confirmed – and enforce clear stop criteria.
3. **Institutionalise strict breathing-air management.** Require sectorisation, staging points, entry control and turnaround limits that reflect realistic travel distance and deteriorating visibility.
4. **Plan explicitly for steam and zero-visibility conditions.** Train nozzle technique, stand-off, positioning and 'no-visibility' navigation; recognise that PPE provides limited protection against hot steam.
5. **Differentiate EV scenarios in procedures and drills.** Train crews to distinguish between (a) flaming EV fires and (b) vapour cloud releases with delayed ignition risk, and to apply appropriate stand-off and gas discipline.
6. **Strengthen command decision-making and escalation control.** Ensure a clear decision model for fixed-system activation, ventilation actions and escalation triggers, aligned with SOLAS/IMO expectations for Ro-Ro and vehicle spaces.
7. **Shore Interactions.** In the event that the vessel is alongside, ensure that early communications are established with the port authority and shoreside emergency responders.

Recommendations

1. Revise the Standard Operating Procedures (SOP) to prioritise controlled containment.

Avoid immediate entry. The first objective is to prevent large-scale fire spread, followed by a deliberate, risk-based decision on any further actions.

2. Enhance detection and remote situational awareness (minimum: CCTV coverage).

Provide sufficient CCTV/remote monitoring so the crew can assess conditions without having to enter the vehicle deck to 'take a look', particularly where an explosive atmosphere is possible.

3. Increase SCBA capacity to a realistic operational minimum.

Two SCBA sets are insufficient for any planned entry. If entry may be required, even for an emergency rescue attempt, six SCBA sets is a practical minimum to support an entry team, a backup team and a controlled withdrawal. Store these sets in a dedicated, accessible location rather than dispersing them throughout the vessel.

4. Add escape-respiratory protection for prolonged exposure scenarios.

Equip the vessel with filter masks/escape respiratory protection to allow personnel waiting at muster stations or preparing for evacuation to remain protected for longer periods against toxic atmospheres, subject to the specific hazards identified in the vessel's risk assessment.

5. Maintain clear visibility of EV stowage locations.

Ensure the crew can quickly identify where EVs are stowed, as this materially affects tactics and available options.

6. Assign a defined, accessible stowage area for suspect or high-risk vehicles.

If accepted on board, vehicles of concern (including damaged, recalled, or otherwise flagged vehicles) should be placed in a known, readily accessible location to facilitate monitoring, early intervention, and isolation measures.

7. Procure thermal imaging capability for inspections and early recognition.

Provide thermal imaging cameras so the crew can conduct safer inspections and, where accessible, identify abnormal heating trends at an early stage.

8. Increase compartmentation and establish defensible boundaries.

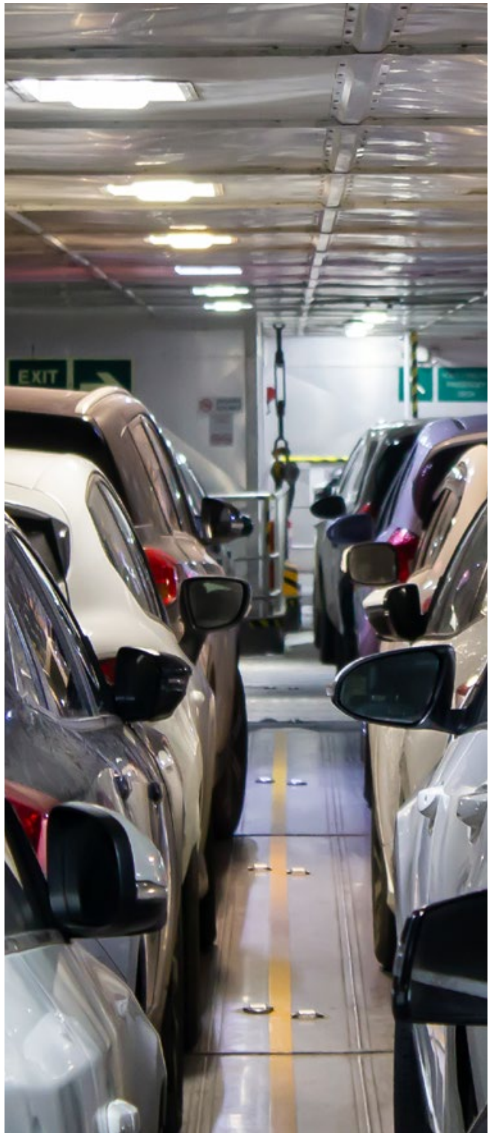
Use fixed systems and/or supplementary measures to create defensible boundaries. The more effective the segmentation available, the higher the likelihood of containing escalation and protecting critical routes and ship integrity.

9. Provide explicit decision thresholds for termination and abandonment.

Give the crew clear, pre-defined criteria for when to discontinue internal operations and prepare to evacuate/abandon ship. Decision-making and escalation control are critical in vehicle-deck incidents and must be supported by unambiguous guidance.

10. PPE, first aid and personal gas detectors.

Owners and operators are encouraged to review what PPE, first aid equipment and personal gas detectors are currently carried on board and to consider whether the inventory, quality and performance of this equipment remain appropriate for vehicle-deck fire, toxic gas and prolonged exposure scenarios.



Fuel Cell Electric Vehicles (FCEVs)

Hydrogen FCEVs do not rely solely on electricity stored in a battery. Instead, they generate electricity through an electrochemical reaction between hydrogen and oxygen within a fuel cell stack. Hydrogen is supplied from one or more high-pressure tanks in the vehicle, while oxygen is drawn from the surrounding air.

Because the battery in an FCEV serves only as a temporary energy buffer and is much smaller than the one in a BEV, the risks associated with BEVs are significantly reduced when compared with LiBs.

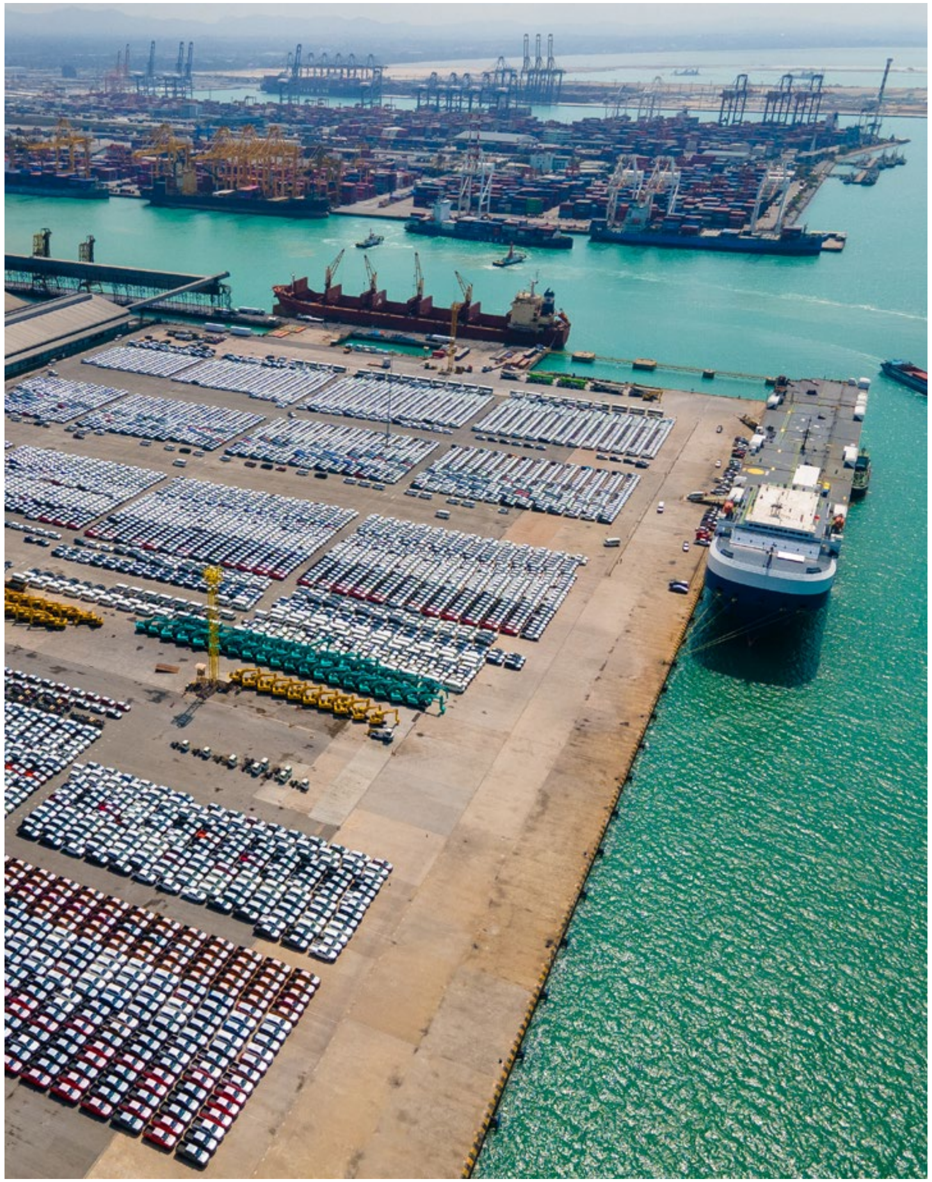
However, FCEVs introduce different hazards, primarily due to the presence of stored hydrogen. Hydrogen is an extremely flammable gas that forms explosive mixtures with air, having a very wide explosive range – between 4% and 74% of hydrogen to air mixtures. Hydrogen flames are nearly invisible in daylight and emit very low radiant heat, making them extremely hazardous.

To prevent an uncontrolled reaction with oxygen, the hydrogen in the vehicle is stored as a compressed gas, typically in a composite overwrapped pressure vessel. These tanks are fitted with thermally activated pressure relief devices (TPRDs), which vent hydrogen in a controlled manner during a fire to prevent over pressurisation and catastrophic failure.

Currently, there is little published guidance for shipowners and seafarers on the carriage of FCEVs at sea, and instruction should be sought from the vehicle manufacturer and/or the shipper. According to the EMSA Guidance for AFVs Carriage in Ro-Ro Spaces, a rupture can cause very high concentrations of hydrogen in the vicinity of the vehicle, which can accumulate in confined areas and introduce a significant explosion risk.

The most effective way to extinguish a hydrogen fire is to stop the gas supply. This typically requires activating the emergency shut-off valve, which may not be feasible during a vehicle fire on a congested deck. An alternative strategy is to allow the controlled burn of hydrogen through the TPRD, which consumes the tank's contents and reduces the risk of a vapour cloud explosion.

Vessels transporting FCEVs should be equipped with gas detection instruments on vehicle decks that are capable of identifying hydrogen leaks. The use of the ship's ventilation system into the fire response strategy for FCEVs should also be considered.



Stability

Recent high-profile casualties within the vehicle carrier sector reveal a consistent pattern of underlying issues. These primarily involve inadequate stability calculations, systemic non-compliance with established procedures and insufficient crew training. These operational deficiencies frequently combine with commercial pressures and gaps in oversight, culminating in severe consequences ranging from substantial financial losses and environmental damage to tragic loss of life.

As illustrated in the case studies detailed earlier, numerous operational and environmental factors frequently contribute to a loss of stability in vehicle carriers:

- *Incorrect loading or stowage:* the improper distribution of cargo, especially placing heavier vehicles on higher decks, can lead to an excessively high centre of gravity, significantly compromising stability.
- *Errors in ballast water management*: which include carrying insufficient ballast water for the given cargo condition or carrying out ballast water exchange procedures incorrectly, can drastically reduce stability.
- *Failure to accurately calculate and verify stability*: neglecting to perform or incorrectly performing pre-departure stability calculations can lead to a vessel sailing with inadequate stability margins. It is of note that EVs are considerably heavier than standard ICE vehicles and this should be considered in stability calculations.
- *Lack of familiarity with loading and stability computers*: as illustrated in the case of 'GOLDEN RAY', the officers had limited training, and therefore limited capability in the use of the vessel's 'LOADCOM' system.
- *Failure to maintain watertight integrity*: unsecured or open watertight doors and openings can allow rapid and progressive flooding into internal compartments, turning a manageable stability incident into a catastrophic loss.
- *Internal and external forces*: while not primary causes of stability loss themselves, factors such as the shifting of cargo, strong winds, large waves or sharp turns can trigger a severe list if the vessel's inherent stability is already compromised.
- *Procedural drift*: in several cases, the absence of a comprehensive departure stability calculation was identified as a contributing factor to instability.

  Behavioural issues, such as procedural drift – where unsafe practices gradually become accepted as normal – have led to the erosion of established safety standards over time.

Influence of vessel design

For vehicle carriers, maintaining adequate stability is particularly critical due to their distinct design features. These include a high superstructure and the typical distribution of cargo across numerous higher decks, which elevates the vessel's vertical centre of gravity (VCG). Also, large, unobstructed deck spaces create areas of significant free surface effect if water ingress occurs or, in the event of a fire, extinguishing water has accumulated. This design makes these ships significantly more sensitive to even minor changes in loading conditions or external forces, increasing their susceptibility to listing or capsizing if stability is compromised.

An awareness of the unique design features of vehicle carriers and their influence in the context of vessel safety is helpful when considering best practices for operating these ships. Large external doors close to the water line are a necessary feature in order to facilitate the loading and unloading of vehicles, but inevitably, this results in an inherent risk of water ingress should there be any issue relating to the watertight integrity of these doors.

Large open decks and few internal bulkheads are required to allow for the efficient movement and stowage of vehicles. The inherent risk with this aspect of the ship arrangement is the rapid loss in stability due to very large free surface moments, should these decks become flooded.

Movable internal decks provide flexibility to accommodate various sizes of cargoes, i.e. more automobiles can be carried with the movable decks in place. The decks can be raised to allow for larger vehicles, such as mobile cranes or earth-moving equipment, which are significantly greater in height than the average car or truck, to be loaded and carried as cargo. Such cargo can result in a high vertical centre of gravity, which can lead to these ships operating close to the minimum requirements for stability.

A high, wall-sided design encloses and protects cargo spaces, but this results in large windage areas.

Stability calculations

The chief officer, or officer responsible to the master for the ship's stability, should ensure all the relevant information relating to the cargo, both discharged and loaded in the current port, as well as the ballast and fuel distribution, is provided to the master. The chief officer should also ensure that the master is aware of any cargo that has been repositioned within the ship during cargo operations, as this will influence the final distribution of loads within the ship and the final departure condition. The ship's actual tank condition should be accurately checked by soundings, properly recorded and included in the calculation prior to departure; this should include all fuel oil and water ballast tanks.

It is also important to ensure that the ullage within the tanks is minimised to reduce any free surface effect on the ship's stability. If sounding gauges are not available, then manual soundings should be taken to confirm tank volume. Inaccurate tank soundings can quickly add up and lead to critical losses in stability, which cannot be identified until the ballast arrangements are confirmed.

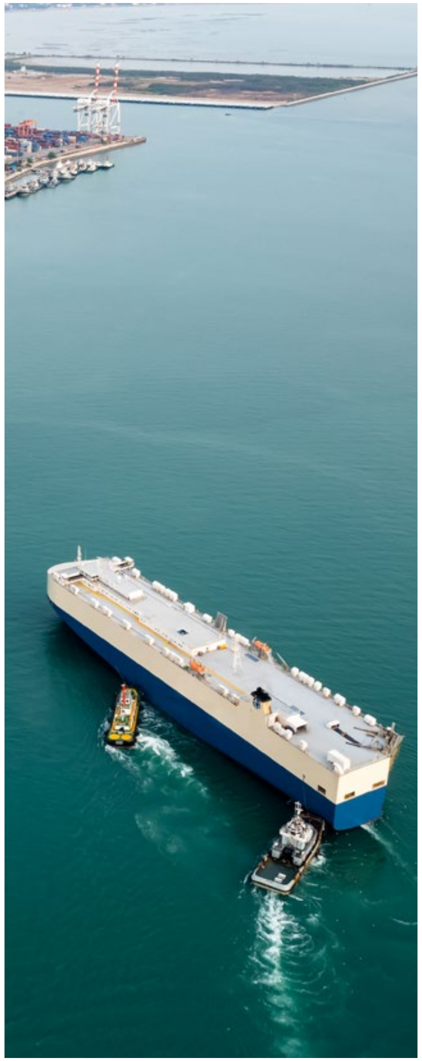
The stability calculation to determine the ship's departure condition should be carried out on completion of cargo operations and prior to the ship's departure. The calculation should take into account the actual tank conditions/soundings and be reconciled with the draught readings observed on completion of cargo, ballasting and bunkering operations. Any discrepancies between the loading computer/calculated results and the draughts/soundings should be investigated and clarified before departure.

Sufficient time should be allowed for the stability calculation to be completed following the completion of cargo operations and prior to the departure of the ship. The chief officer and master should ensure that open communication is maintained to ensure that any issues can be dealt with as required.

A procedure should be established for the final stability calculation to be verified before every departure. The master should ensure that the ship's calculated stability meets or exceeds the stability requirements for the entire duration of the intended voyage. If there is any doubt as to the actual stability condition of the ship, then departure should be delayed until such time that the master is satisfied that adequate stability is demonstrated for the intended voyage.

In the event of a fire in port, procedures should be in place to ensure that the master retains oversight of stability implications, including close coordination with shore-based fire-fighting authorities to monitor, control and, where possible, influence the quantity, rate and location of water applied on board.

For vessels that have not yet been fitted with ballast water treatment systems, or if the onboard system is non-operational, there should be detailed and vessel-specific plans for ballast water exchange operations that prioritise stability at all stages of the transfer.



Cargo stowage and securing[7]

The movement, stowage and securing of cargo should be supervised by a responsible officer and always in accordance with the cargo securing manual (CSM). The CSM should be read and understood by the deck officers, and a working copy should be readily available for the officers to consult.

Cargo stowage

Generally, stowage should only be in the fore and aft direction. If athwartships stowage is necessary, then this should be discussed with the master and always be in accordance with the CSM.

Stowage should not obstruct any equipment, controls for access doors, access to sounding pipes, stairways or controls for deck scupper valves.

Where there is a low degree of frictional resistance, as found with tracked vehicles stowed on deck, special consideration is required and soft board, plywood, dunnage or rubber mats should be deployed prior to being secured.

Cargo securing

Cargo should always be secured in accordance with the vessel's approved cargo securing manual. The following points should be considered:

- EVs are, on average, 25% heavier than similarly sized conventional ICE vehicles and have a different centre of gravity.
- Cargo securing equipment should be well maintained and meet the requirements of the CSM and the vessel's Safety Management System (SMS). Old or damaged equipment should be removed from use.
- Vehicles should be properly parked, the engine switched off and the brakes applied prior to being secured. Wheels should also be chocked as required by the CSM. Follow the vehicle manufacturer's guidance on whether to leave the vehicles in gear.
- Lashings on vehicles should all be under equal tension.
- Special consideration should be made for large vehicles, tracked vehicles and any cargo with a high centre of gravity, with additional lashings of suitable strength applied.
- Consideration should be given to the weight of cargo, dimensions, expected sea conditions and stowage position on the ship (e.g. high outboard cargo will be subjected to higher accelerations).
- Fragile cargo should be stowed towards the centreline of the ship and on lower decks.
- Where cargo is stowed at the ends of the ship and on the upper cargo decks, additional precautions should be taken when lashing to minimise the large forces that will act on cargo in heavy seas due to pitching.
- Equipment used for cargo operations should be fit for purpose, regularly inspected, certified and not subjected to more than its certified safe working load (SWL).
- Cargo securing gear should be of sufficient strength for the cargo carried.
- Cargo vehicles without suitable lashing points should be rejected for carriage.
- Cargo on trailers should be checked to ensure it is properly secured and safe for carriage.
- Securing should be completed prior to leaving the berth.

IMDG cargo

Detailed guidance is provided by the IMO in ***MSC.1-Circ.1440*** – *Illustrations of Segregation of Cargo Transport Units on Board Containerships and Ro-Ro Ships.* The following main points should be considered by way of a summary.

- IMDG cargo should be properly labelled, segregated and declared in accordance with the IMDG Code.
- The correct dangerous goods labels should be clearly visible on the outside of containers or vehicles.
- Vehicles carrying dangerous goods should be inspected for damage or leakage prior to loading. If damage is found, the vehicle should be rejected for shipment and the master informed.

Preventing cargo contamination damage

Vehicle cargoes can become damaged through exposure to contaminants, such as particles, paints and chemicals. The source of these contaminants can be environmental or originate from shipboard activities or failures.

7 Also refer to MCA MGN 418 'Roll-on/Roll-off Ships: Stowage and Securing of Vehicles

In the event of dust or sandstorms, it may be appropriate to close the ventilation for the enclosed vehicle decks to prevent the ingress of particles. If possible, before restarting the mechanical ventilation, brush the fire dampers to remove any accumulated sand or dust. Vehicle cargo on open vehicle decks may be protected by the rigging of tarpaulins where safe and appropriate to do so. Scrutiny of weather forecasts is recommended to provide as much time as possible to carry out any precautions considered necessary.

Vehicle decks should be inspected regularly when cargo is not laden to check for any leakages from the vessel's pipework and systems. Oil leakages from the vessel's hydraulic systems can attack vehicle paintwork, and seawater leakages into the space can cause corrosion of the cargo. Any leakages should be quickly repaired, and any oil contamination of the deck should be cleaned using suitable detergents.

Ventilation should be designed to prevent the ingress of funnel engine exhaust gases that may affect the paint work of the cargo.

Vehicle cargoes may also become damaged by contamination through the careless application of paint when maintenance is being undertaken on the vessel. It is therefore recommended that any paint application by spray is prohibited when cargo is on board. Paint application by brush or roller should only be permitted on vehicle decks which are empty of cargo.

The painting of vehicle decks should be scheduled accordingly to ensure there is sufficient time for the coatings to cure before any cargo is loaded.

The use of welding machines, angle grinders and similar cutting or hot work equipment should not be permitted on the loaded vehicle decks.

Preventing physical cargo damage

Monitoring and controlling of the terminal's stevedores driving cars on and off the vessel is difficult. It requires the vigilance of the crew, who should record and report any improper handling. It may be appropriate for the master to issue a Note of Protest if there are concerns about the stevedores' behaviour.

Vehicles that are visibly damaged, particularly electric or hybrid vehicles, present an increased fire and safety risk and should not be loaded unless they have been inspected and cleared by a suitably experienced and qualified technician, with the outcome of that inspection appropriately documented.

Highlight areas where overhead clearance is marginal. The use of photocell alarms, high-visibility paints, fluorescent warning boards, flashing lights or lighting to illuminate and draw attention to the hazards should be considered.

Ensure lane markings and guidance arrows are painted conspicuously on the deck so cars may be guided around obstructions and correctly parked.

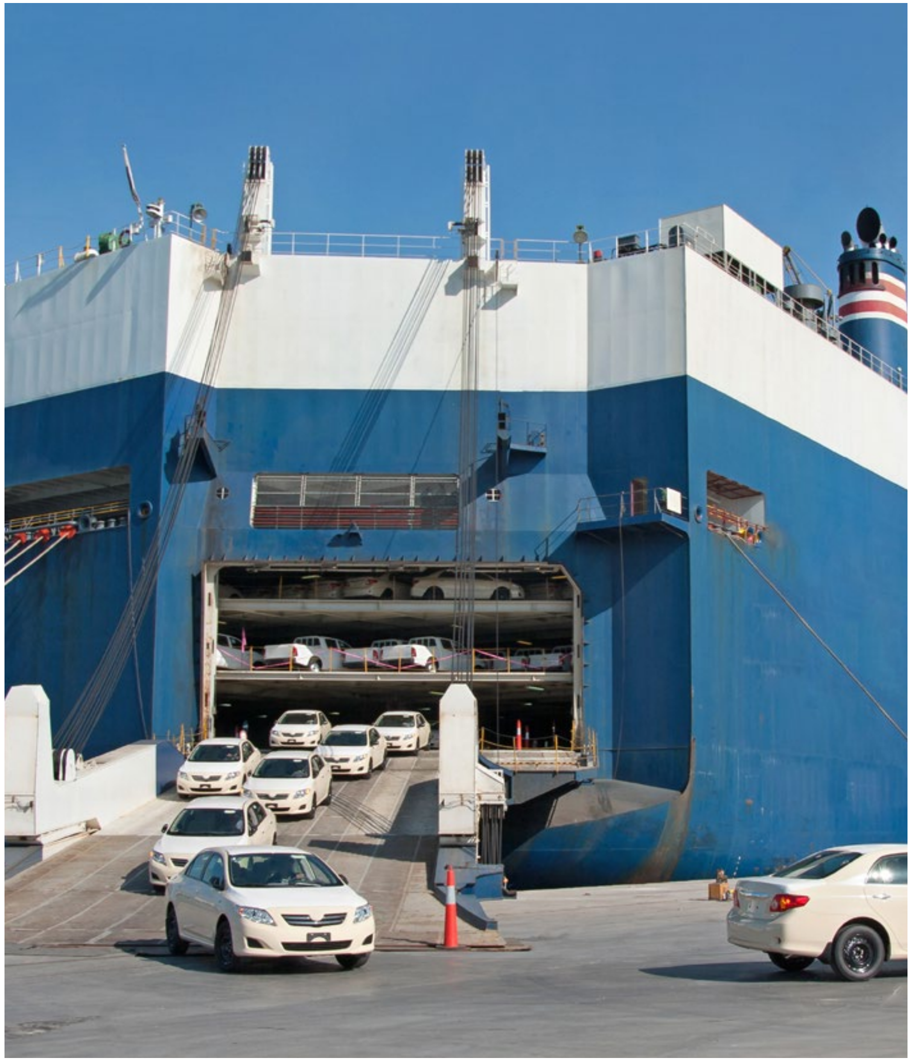
Where possible, the crew should only carry out maintenance work on the vehicle decks when they are free of cargo to avoid any accidental impact damage in the course of their work or when moving equipment.

Preventing cargo theft

Vigilance by the ship's crew is essential in identifying any suspected pilferage. CCTV systems may provide useful evidence if there are concerns about the conduct of the crew, the stevedores or any visitors.

As should be usual practice in any port, maintain an effective gangway and ramp watch, and fulfil the vessel's ISPS obligations with regard to security to prevent any unauthorised persons from embarking the vessel.

The vessel's owner or manager should have in place a robust policy that addresses theft prevention, making it very clear to the crew of the penalties that will result if theft from car cargo is suspected.



Personal injury and illness

Vehicle decks of vessels are high-risk working areas, particularly when the vessel is in port and undergoing cargo operations. Moving vehicles, lack of visibility, blind spots, high noise levels, noxious fumes from vehicles, unclean surfaces and inadequate floor markings can all present as hazards.

Ventilation

Vehicle decks should be adequately ventilated, in accordance with SOLAS requirements and operated as designed. Ventilation fans should be operated to remove any accumulation of harmful gases and fumes and to achieve the required air changes per hour.

Officers should pay particular attention during loading or discharge when there may be an accumulation of fumes on the vehicle decks. In addition, the carriage of flammable gases or liquids will require additional ventilation.

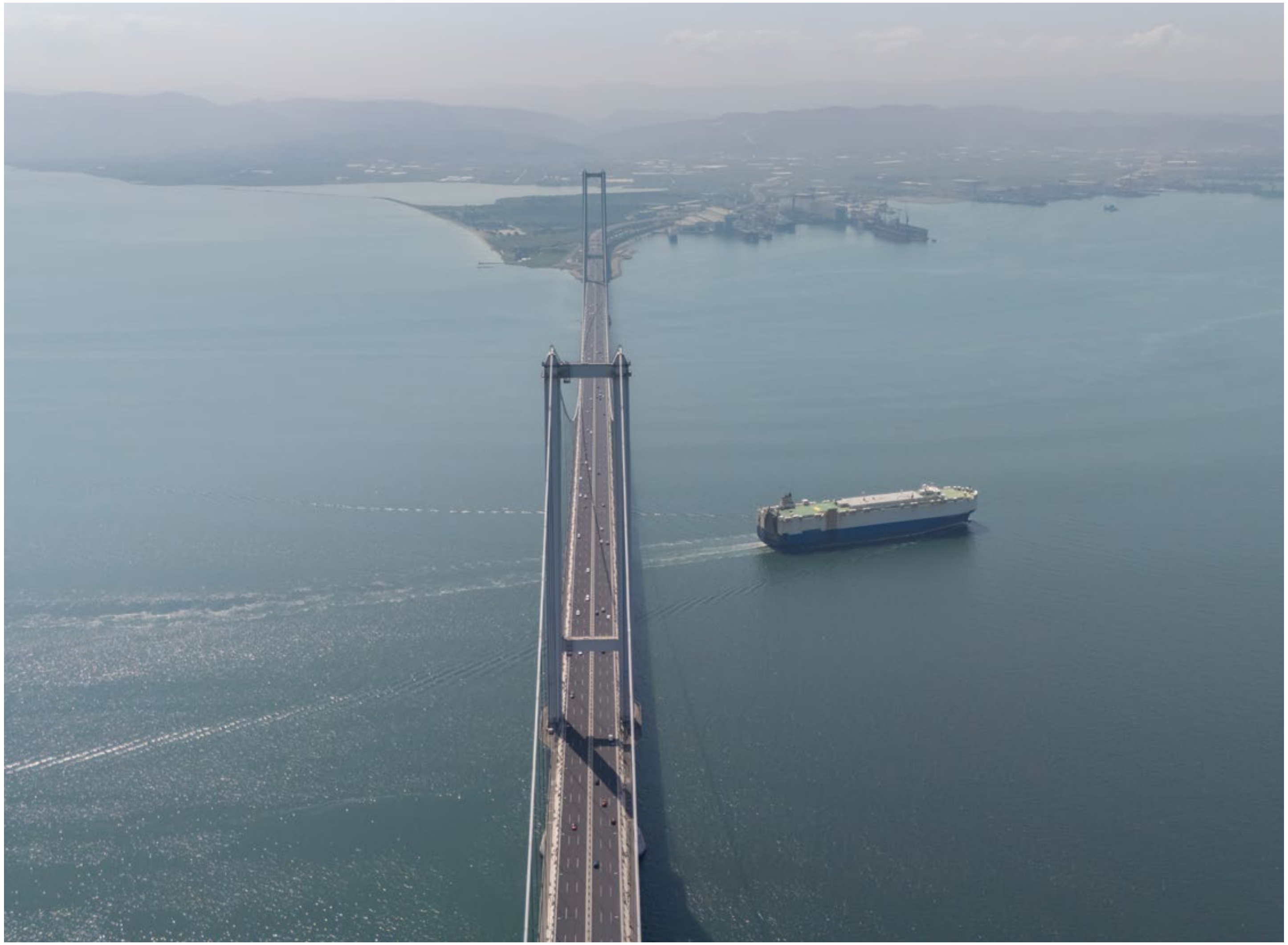
Safe working on deck and quayside

Working on vehicle decks, particularly on ferries, Ro-Ro ships and vehicle carriers, poses significant risks to workers and passengers. The UK Chamber of Shipping's Guidelines to Shipping Companies on Vehicle Deck Safety' and '10 Golden Rules of Vehicle Deck Safety highlight that inadequate segregation of people and vehicles, especially during loading and unloading, can lead to serious injuries or even fatalities. These risks are heightened when vehicles are reversing or when individuals are in a driver's blind spot.

The UK Chamber's guidance, along with the Together in Safety initiative, provides useful information to shipowners and operators.

References and Further Reading

- MGN 653 (M) Amendment 1 electric vehicles onboard passenger roll-on/ roll-off (ro-ro) ferries
- IUMI: Best practice & recommendations for the safe carriage of electric vehicles (EVs)
- IUMI: Best practice paper update: Risk mitigation for the safe ocean and short-sea carriage of electric vehicles
- EV Fire Safe website
- EMSA Guidance on the carriage of AFVs in RO-RO spaces
- LASH FIRE: an international research project aiming to significantly reduce the risk of fires on board Ro-Ro ships
- Maritime Technologies Forum (MTF) guidance on the Safe Carriage of Electric Vehicles
- ABS Best Practices for the Transport of Electric Vehicles On Board Vessels



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