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China's
NEV Roll on Roll Off (RoRo) Fleet

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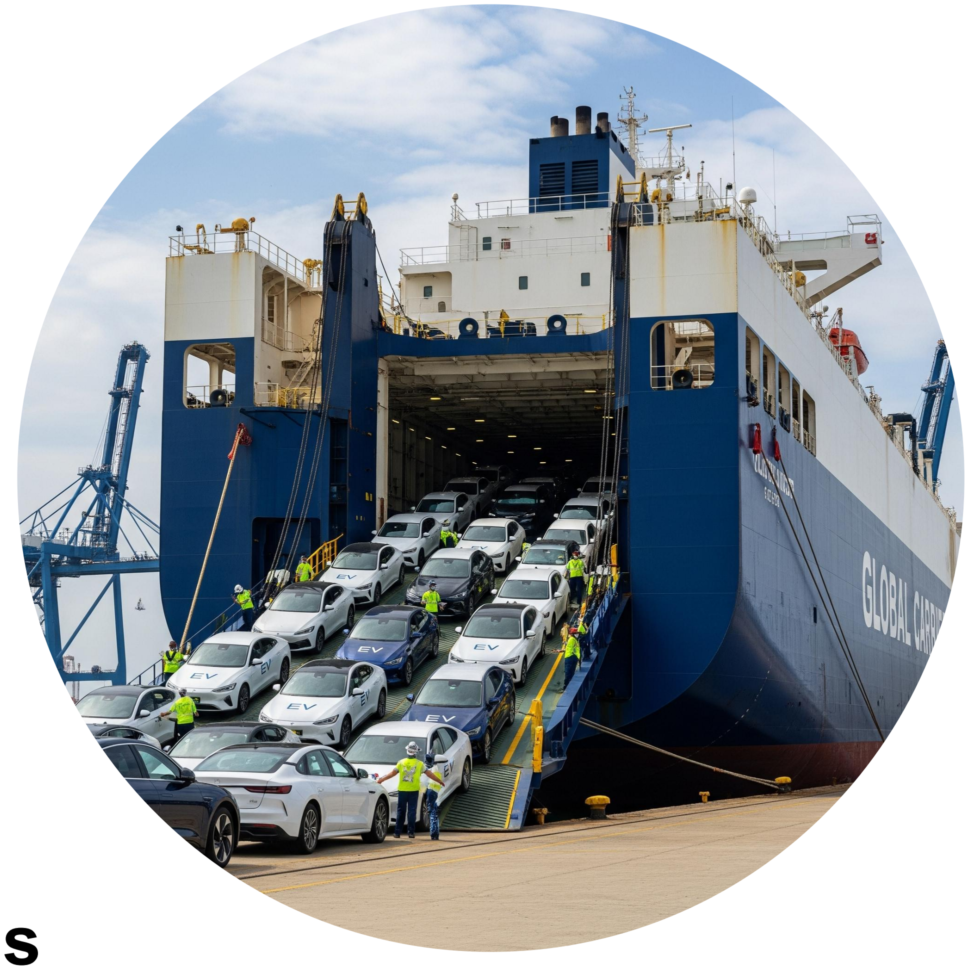

Electrios NEV Transport Services

- Portside Risk Mitigation & Compliance
- Pre-Loading Cargo Screening & Risk Assessment
- Compliance & Documentation Auditing
- Terminal Safety Protocol Development
- State of Charge (SoC) Verification & Management
- Emergency Response
- Stowage & Lashing Plan Auditing
- Strategic Consulting & Advisory Services
- Incident Response & Post-Incident Services

China's New Energy Vehicle (NEV) export market growth in the first half of 2025 reached **1.42 million units**, a YOY **41% increase, 25% of Global shipments**

The rapid growth in **NEV exports** has caused significant logistics challenges, including major **RORO capacity shortages.**

This imbalance spurred leading Chinese automakers—such as **BYD, SAIC, Chery, and Geely**—to invest heavily in building and operating their own massive RORO fleets.

By owning **RORO fleets,** manufacturers seek to ensure independence, ensure timely delivery, and reduce overall logistics costs by 10% to 20% per vehicle. For example, BYD's self-built fleet aims for an annual transport capacity exceeding one million vehicles by 2026.

Recent **Chinese deliveries** have repeatedly broken global capacity records, featuring vessels like the **BYD** "Shenzhen" (9,200 standard car capacity) and the SAIC "Anji Ansheng" (9,500 capacity), with future designs planned to exceed **10,000** car positions.

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Manufacturer	Activity	Details
BYD	Building and operating a large proprietary fleet.	Fleet of 8 ROROs with capacities of 7,000 and 9,200 CEU.
SAIC (Anji Logistics)	Operates China's largest vehicle logistics fleet.	Fleet of 35+ vessels, including 9,500 CEU record-breakers.
Chery Automobile	Building a dedicated fleet for its exports.	Ordered three 7,000 CEU vessels (e.g., Huanghu, Kunpeng).
Geely Automobile	Establish its own shipping	Launched its first 7,000 CEU vessel, JISU FORTUNE, in 2025.
Tesla	Major RORO charter services.	Dominant user of RORO capacity
Other Chinese Brands	Rely on chartering and partnerships.	GAC, Li Auto, XPeng, Great Wall, Leapmotor, etc., utilize carriers like Anji Logistics and Grimaldi.

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RoRo Fleet

Ship Name	Capacity (CEU)	Status (as of Sep 2025)
BYD EXPLORER NO.1	7,000	Delivered and operational since January 2024.
BYD CHANGZHOU	7,000	Delivered and operational since December 2024.
BYD HEFEI	7,000	Delivered and operational since January 2025.
BYD ZHENGZHOU	7,000	Expected to be delivered in late 2025.
BYD SHENZHEN	9,200	Delivered April 2025; former world record holder for RORO capacity.
BYD CHANGSHA	9,200	Delivered and operational around mid-2025.
BYD XI'AN	9,200	Delivered and operational around mid-2025.
BYD JINAN	9,200	Undergoing sea trials; delivery expected soon.
Total Fleet	67,000	Projected Annual Transport Capacity: > 1 Million NEVs by 2026

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NEV Shipping Routes

Origin Port (China)	Destination Ports/Regions	NEV Manufacturer
China to Europe		
Shanghai Port	**Europe** (General)	SAIC (Anji Logistics), Chery, BYD, Chang'an, Great Wall
Shenzhen Port / Xiaomo Port	**Europe** (General)	BYD
Yantai Port	**Western Europe**	BYD
Taicang Port	**Europe**	Geely
Wenzhou Port	**Europe** (via transit)	N/A (General NEV export)
Quanzhou Port	**Europe** (via Belgium, Norway)	BYD
Qingdao Port	**Foreign ports** (General)	N/A (General NEV export)
China to North/South America		
Taicang Port	**Brazil , Argentina**	BYD SAIC, Chery, Geely
Yantai Port	**Mexico (Lázaro Cárdenas Port)**	Chery, Great Wall, SAIC BYD
China to MENA		
Wenzhou Port	**Dubai (Jebel Ali Port**	BYD SAIC Chery

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NEV Cargo Handling and Stowage on RORO Vessels

- **Deck Structure and Flexibility:** RORO ships, typically have many decks (e.g., **10–13 decks on ROROs, 16 decks** on BYD's 9,200-car carriers) connected by internal ramps or lifts.
- **Dense Stowage:** Vehicles are often stowed very densely to optimize cargo space, with lateral distance potentially as little as **10 cm** and longitudinal distance between **30 cm and 80 cm**. This dense packing, however, impedes quick access for firefighting crews.
- **Fixation/Lashing:** Once loaded, every vehicle must be secured using high-strength lashing belts or systems to binding points on the vehicle and the deck. This is critical to prevent movement, collisions, and resulting battery damage, particularly under adverse weather conditions.
- **NEV-Specific Deck Requirements:** New RORO designs specifically accommodate NEVs, which includes lithium battery vehicles, hydrogen-powered vehicles, and natural gas vehicles. Decks intended for NEV carriage often require **A60-rated separation** from fuel tanks.
- **Loading Logistics:** Loading involves highly skilled dockworkers (stevedores) driving the vehicles onto the ship via ramps. Vehicles are stowed quickly, with ultra-large carriers like the BYD "Xi'an" capable of loading 300 to 400 vehicles per hour.

Regulatory Landscape for RORO Transport of NEVs

Current Regulatory Gaps

- **IMO/SOLAS:** There are currently no mandatory international regulations from the IMO specifically governing the carriage of electric vehicles on passenger or cargo RORO vessels. While the SOLAS convention addresses fire safety in vehicle spaces (Regulation II-2/20), it primarily addresses risks related to flammable liquids and does not specifically account for the unique characteristics of EV fires, such as the thermal runaway and toxic gas release.
- **IMDG Code Exemptions:** The IMDG Code generally governs the transport of hazardous cargo. However, Special Provision (SP) 961 excludes vehicles (including EVs) transported on their own wheels on a RORO ship or in a cargo space specifically designed for vehicles, from the typical IMDG requirements for battery-powered equipment. This exemption means carriers often do not have specific information about the presence or location of EVs on board.

Evolving Regulatory Focus

Development efforts include recommendations for revising the fire safety requirements for ships carrying electric and alternative fuel vehicles. The IMO is actively engaged in developing mandatory international regulations specifically for the maritime carriage of EVs on vehicle carriers, targeted for completion by 2027.

The need for purpose-built vessels (a new class of EV carrier). These future vessels would be designed specifically to manage Li-ion fire risks by featuring enhanced fire-rated divisions between cargo blocks, integrated and optimized cooling-based suppression systems (like drenchers and water mist), advanced gas detection, and specialized ventilation systems.

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<u>Existing RORO designs present challenges when dealing with EV fires</u>

The main threat is **thermal runaway**, an unstable chemical reaction in the lithium battery that generates immense heat, toxic gases , and flammable gases. This process is difficult to bring under control, and currently, **no extinguishing agent or system has been proven to interrupt the chemical chain reaction**. Furthermore, EVs have a higher risk of re-ignition over a longer period compared to internal combustion engine vehicles (ICEVs).

- **Explosion Risk:** The release of flammable gases during thermal runaway poses an explosion risk.
- **Stability Risks:** A critical problem associated with fighting EV fires on RORO ships is managing the stability of the vessel. LIB fires require large amounts of water for cooling and extinguishing. If this firefighting water cannot be discharged efficiently from the vehicle deck (e.g., if scuppers are blocked by fire debris), the accumulation of water can lead to serious ship stability problems due to the free surface effect, potentially leading to the loss of the vessel.

RORO Transport of NEVs

NEV Classification

- **Hazard Classification:**
    - Lithium battery EVs are classified as **Class 9 Dangerous Goods** (UN3171) under (IMDG) Code.
    - **UN 3171**: BATTERY-POWERED VEHICLE or BATTERY-POWERED EQUIPMENT, which applies to pure electric vehicles.
    - **UN 3166**: VEHICLE, FLAMMABLE LIQUID POWERED, used for hybrid electric vehicles containing both a Li-ion battery and a conventional engine.
    - New, **UN 3556**, VEHICLE, LITHIUM-ION BATTERY POWERED, is set to become mandatory under the IMDG Code starting January 1, 2026.
- **RORO Exception:** Crucially, while container transport requires NEVs to be handled strictly as dangerous goods, NEVs transported via RORO vessels and stowed in designated spaces are often treated as **ordinary cargo**. This flexibility helps maintain the high loading efficiency characteristic of RORO operations.

Safety Measures and Modern Design

Fire Spread: RoRo often feature large, undivided horizontal fire zones and full-length decks to maximize cargo capacity. This design allows fire, smoke, and heat to spread rapidly across large areas. Vehicles are stowed densely, often with as little as 10 cm lateral space, impeding quick access for firefighting crews.

Firefighting Limitations: Conventional CO_2 or foam systems may struggle to contain fires involving thermal runaway. Moreover, the application of water for boundary cooling or suppression on must be approached cautiously due to the risk of water accumulation reducing vehicle friction, potentially causing a catastrophic cargo shift and stability loss.To mitigate these risks, industry recommendations, developed by organizations like IUMI, and new vessel designs emphasize enhanced safety procedures:

- **State of Charge (SoC) Control:** It is recommended that the battery SoC for transport on board car carriers be kept **as low as practically and technically possible**. Batteries at high SoCs experience more violent reactions during thermal runaway.
- **Firefighting Protocol (Fixed First):** The **timely activation of fixed firefighting systems** is crucial to suppress the fire before it spreads to the battery and adjacent cars, making manual firefighting a last resort.
- **Integrated Gas Management:** A comprehensive firefighting strategy must include procedures for **managing potentially explosive gases** through coordinated ventilation operations, without compromising the effectiveness of the extinguishing system.

Modern RORO ships purpose-built for NEVs incorporate enhanced safety features:

- **NEV Deck Requirements:** Decks intended for NEV carriage often require A60-rated separation from fuel tanks.
- **Monitoring and Detection:** New vessels feature extensive monitoring systems, such as thermal imaging cameras, gas detection systems (hydrogen/methane detectors), and AI-powered systems to enable early fire detection and verification.
- **Layered Design:** New Chinese vessels, such as SAIC's, feature complex layered designs to satisfy the loading requirements for various NEV types (lithium battery, hydrogen, natural gas) and dangerous goods.
- **State of Charge (SoC):** The battery charge level is a critical safety parameter. Industry guidance generally recommends limiting the SoC of the vehicle's battery to between 30% and 50% during transit to reduce the risk of thermal runaway..
- Specific ports, such as Xiamen and Taicang, have stipulated that the initial (starting) SOC should be controlled at 30% and below

Operational Best Practices for RORO Transport

Vehicle Preparation and Condition

- **Pre-Loading Checks:** Only vehicles in good condition, free from damage or leaks, should be accepted. Accident-damaged vehicles should be refused, or at least be thoroughly inspected by a competent person before transport to assess the fire risk.

State of Charge (SoC) is a critical safety parameter that directly influences the severity of a thermal event, thus making it a crucial consideration during stowage planning.

- **Recommended Range for EVs:** Consensus for EVs is moving toward an optimal transport SoC of **30% to 50%**.
- **Risk Profile based on SoC:** A **lower SoC reduces the amount of stored energy** available to fuel a thermal runaway event, reducing the risk of fire and jet flames (for SoC > 50%). However, studies suggest that a **lower state of charge (< 50%) tends to lead to the release of white vapours** (flammable and toxic), increasing the risk of a Vapour Cloud Explosion (VCE) if an ignition source is present.
- **Shipper Responsibility:** The shipper should check that the cargo falls within defined SoC parameters and **inform the carrier of the charge level**

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Stowage, Securing, and Stability

- **Weight and Stability:** EVs are typically about 25% heavier than comparable conventional vehicles and have a different center of gravity. These factors must be incorporated into the vessel's weight and stability calculations.
- **Securing Standards:** All cargo must be properly **secured, blocked, and braced** to prevent shifting during transit. The securing methods should be verified by documentation such as a certified **lashing plan**..
- **Lashing Points:** The RORO decks must be equipped with tie-down devices and free of sharp edges.
- **Clearance and Damage Prevention:** For loading vehicles, the angle of the loading ramp should be low enough (recommended maximum of **8 degrees**) to avoid damaging the undercarriage of the vehicle being transported.

Placement on the RORO vessel is governed by safety considerations:

- **Deck Strength:** The ship operator must confirm that the **deck strength and local strength** of the cargo holds meet the requirements for the loaded cargo.
- **Fire Integrity:** Certain areas where lithium battery EVs are stowed, such as the open deck adjacent to enclosed spaces, must have bulkheads with **A-60 class fire integrity**.
- **Segregation:** NEVs and their components must be stowed away from **heat sources, living quarters (life areas), machinery spaces, and flammable/explosive dangerous goods**. The location must also allow for easy monitoring and emergency response.
- **Ventilation:** If stowed on enclosed decks, the crew should operate the ship's ventilation system continuously where possible, and **no less frequently than hourly**.

Stowage Principles

Vehicle Alignment and Proximity

RORO loading principles dictate that vehicles must be stowed to maximize capacity while ensuring safety:

- Vehicles should, as far as possible, be aligned in a **fore and aft direction**.
- They should be closely stowed athwartships to restrict transverse movement in case securing arrangements fail.
- However, sufficient distance must be provided between vehicles to allow **safe access** for the crew.
- Stowage must not obstruct critical safety equipment, including firefighting equipment, controls to deck scupper valves, fire dampers in ventilation trunks, or water spray fire curtains.

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Lashing and Securing NEVs

Lashing is essential to prevent vehicles from moving during the voyage,

Lashing Method: Once vehicles are driven onto the designated deck, they are secured using **high-strength lashing belts or systems**. The process involves fixing the vehicle to **binding points** on the vehicle and the deck.

- **Stability Risk:** RoRo have a **high center of gravity** and large, open decks, making their stability sensitive to cargo movements. If lashing is inadequate, vehicles can shift, potentially causing a **catastrophic cargo shift** and loss of ship stability, especially during rough seas.
- **Advanced Securing:** Modern, ultra-large RORO ships, like the 9,500-car carriers built by SAIC's Anji Logistics, feature new technology such as **hydraulic adjustable fixing devices** that automatically adapt based on the vehicle wheelbase to achieve "zero collision" during transport.
- **Lashing Strength:** The lashing systems are designed to **withstand 12-level wind and wave impact**, preventing vehicle displacement.

Lashing and Securing Requirements

Lashing aims to prevent vehicle movement (which could cause mechanical damage and trigger thermal runaway in LIBs)

General Lashing Procedures

- **Attachment Points:** Lashings should, wherever possible, be attached to **specially designed securing points** on the vehicles. Only one lashing should be attached to any one aperture, loop, or lashing ring at each securing point.
- **Lashing Tension:** All lashings on a vehicle should be under **equal tension**.
- **Tightening and Inspection:** Lashings must be inspected regularly during the voyage to ensure vehicles remain safely secured. They should be attached so that, provided there is safe access, they can be tightened if they become slack.
- **Device Security:** Hooks and other devices used for attachment must be applied in a manner that prevents them from detaching if the lashing slackens during the voyage.

Optimizing Lashing Angles

The effectiveness of the securing depends heavily on the geometry of the lashings:

- **Angle:** The lashings are most effective when they make an angle with the deck of **between 30° and 60°**.
- **Directional Restraint:** Lashings should be angled to provide some fore and aft restraint.

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Port Operations Logistics

Logistics and preparation steps must be completed:

- **Compliance and Certification:** All vehicles must adhere to international mandatory standards, such as obtaining **EU WVTA whole-vehicle type approval** before entering the European Economic Area (EEA).
- **Domestic Transport and Consolidation:** Vehicles are transported by rail or truck from various manufacturing bases (e.g., Shenzhen, Hefei) to the designated export port logistics center (e.g., Shanghai Port, Guangzhou Port).
- **Pre-Delivery Inspection (PDI):** Standard PDI checks are performed at the domestic logistics center to ensure the vehicle is in perfect condition and ready for the ocean voyage.
- **Customs Procedures:** Export documents, commodity inspection, and customs declaration procedures must be properly handled to ensure compliant departure.
- **"Factory-to-Port":** Manufacturers like BYD utilize "ground run" methods for newly produced export models, moving them directly from the factory to the port for loading. For example, 1,105 BYD NEVs from the Deep Shan base arrived at Xiaomo Port for loading in only five minutes.
- Modern, ultra-large RORO ships are designed for extreme efficiency; for instance, the BYD "Xi'an" can complete loading operations at a rate of **300 to 400 vehicles per hour**.
- **Optimizing Port Infrastructure:** Ports like Shenzhen's are specializing in NEV RORO operations. The port is adjusting its multi-purpose berths to specifically meet the demands of RORO ships, aiming for simultaneous berthing and loading/unloading of two 9,200-car carriers.

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Firefighting Strategy:Boundary Cooling

- **Early detection of a fire is key** to successful firefighting operations. Technologies supported for early detection include gas detection systems, thermal imaging cameras, video monitoring.
- **Critical Actions:** If a fire breaks out, the critical actions are **early fire suppression and boundary cooling** to stop the fire from spreading to the battery and adjacent vehicles.
- **"Fixed First" Approach:** the fixed firefighting systems should be **applied early, correctly, and safely first**, rather than manual firefighting. The timely activation of the fixed system is crucial to avoid catastrophic consequences, as accessing the burning unit may be difficult and dangerous. Manual fire fighting should be pursued only to save life or complement the fixed system. This approach aims to extinguish the car fire before it reaches the traction battery (which typically occurs after about 30 minutes into the fire).
- **Crew Training and Safety:** Crew on all RORO vessel types must receive **specific training on car fires** (regardless of drive train). Personnel dealing with burning vehicles must stay out of the smoke plume and wear **adequate personal protective equipment** due to the toxicity of combustion gases.

Fixed Extinguishing Systems and Their Limitations

- **CO_2 Systems:** CO_2 systems can work successfully if applied **quickly** after detection and verification, and **before thermal runaway has occurred**. However, CO_2 cannot stop thermal runaway. A major challenge is the systematic delay required for crew muster and system verification. To improve effectiveness, IUMI recommends that the **CO_2 capacity onboard ROROs should be at least doubled**.
- **Foam Systems (High-Expansion Foam):** High-expansion foam systems can **hinder the ignition of flammable gas** and effectively prevent heat transmission from a vehicle on fire as long as it is submerged in the foam. However, they cannot stop thermal runaway. Drawbacks include complexity, reliance on electricity, reduced capabilities in new environmentally approved foams, and a high threshold for "fixed first" deployment due to the consequences of unnecessary release.
- **Fixed Water-Based Systems (Alternative):** A total flood **high-pressure water mist sprinkler system** (fresh water based) is suggested as an alternative, offering the major advantage of a **cooling effect** and potential for effective boundary cooling, and can be activated even with crew present. However, water-based systems, while unable to prevent thermal runaway, require current ship design and construction limitations to be resolved before broad application.

RoRo/RoPax Vessels

- **Drencher Systems (Water-Based): drencher systems are effective to fight fires** on RoRo and RoPax vessels, having the same impact on the fire regardless of whether the source is an ICEV or an EV. **Drencher systems are effective for managing and controlling EV fires, but cannot stop thermal runaway**.
- **IMO/SOLAS Amendments:** Revised requirements for new passenger ships include a fixed fire detection and alarm system for vehicle carriage areas on the weather deck, an effective video monitoring system, and a **fixed water-based fire extinguishing system** (e.g., based on monitors) covering weather decks.

Managing Explosion Risk and Gas Accumulation

A comprehensive firefighting strategy must specifically address the risk of **explosion** due to flammable gases emitted during thermal runaway.

- **Explosive Atmospheres:** If flammable gases (like hydrogen and carbon monoxide) are not immediately ignited upon release, they can accumulate in closed, unventilated spaces and form explosive atmospheres.
- **Ventilation Strategy:** The strategy must integrate **firefighting and ventilation operations** without limiting the effectiveness of the overall extinguishing system. Shipowners must carefully consider appropriate ventilation procedures for the specific extinguishing system installed on the vessel. This is critical because traditional fixed extinguishing procedures often require shutting down ventilation, which temporarily traps explosive gases.

Boundary Cooling and Stability Concerns

Boundary cooling—applying water to cool decks and bulkheads—is crucial to prevent heat transfer and fire spread to adjacent compartments. However, it is especially complicated on ROROs due to design limitations.

- **RORO Design Conflicts:** ROROs feature large, undivided horizontal fire zones and lack transverse bulkheads, enabling rapid fire spread. Furthermore, introducing water onto the vehicle decks of ROROs must be done cautiously, as water accumulation can **reduce or completely eliminate vehicle friction**, potentially causing a **major/catastrophic cargo shift** and stability loss.
- **RORO Recommendation:** On ROROs, boundary cooling should only be established in parallel with the fixed firefighting system. It is recommended to apply only **locally applied small amounts of water in calm weather** (without swell and wind waves).
- **RoRo/RoPax Design:** Boundary cooling is extremely important on RoRo vessels to contain the fire and prevent heat spreading into the next fire compartment.

6. Design and Port Operation Limitations

RORO design constraints and port operations create additional hurdles for fire suppression:

- **Alongside Fires in Port:** During cargo loading/unloading in port, fixed extinguishing systems like CO_2 often **cannot be contained or operated effectively** because the internal doors and stern/side ramps are open. Foam systems are also less effective due to uneven air flow.
- **Inaccessible Cargo:** The dense stowage of vehicles (lateral distance sometimes as little as 10 cm) impedes quick access for firefighting crews.
- **External Assistance:** Seeking **external help from professional marine firefighters or salvors is recommended whenever possible**. Guidance is essential for onshore firefighters who are unfamiliar with the complex vessel environment.

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Manual Firefighting Techniques and Equipment

Crew interventions involve high risk and require specialized equipment.

1. Water Hoses and Lances

Manual application of water is crucial for targeting cooling efforts.

- **Water Spray:** Charged hoses using the ship's fire pumps are necessary. The use of water fog lances has been shown to successfully extinguish the vehicle fire.
- **Extinguishing Lances:** These specialized tools pierce the battery casing to deliver water or other media directly to the cells for internal cooling. However, their use should be reserved for firefighting professionals due to the risk of further damaging the battery and provoking additional ignition.

2. Fire Blankets and Boundaries

Alternative methods focus on fire containment and suppression.

- **Fire Blankets:** Specialized vehicle fire blankets can be used to restrict flame and heat spread until sufficient water is available. They may be best deployed as a precautionary measure on vehicles identified as high risk.
- **Practical Limitations and Risks:** Deploying fire blankets in a tightly packed RORO deck is challenging and risky for the crew. Although a blanket contains the flame, the thermal runaway continues, potentially generating an explosive gas mix underneath.
- **Specialized Remote Monitors:** Remote-operated fixed fire monitors can be installed on vehicle decks, allowing crew to spray water continuously from a distance while monitoring via CCTV, ensuring a safer response without entering the fire area.

Monitoring, Post-Fire Procedures, and Personnel Safety

Procedures extend beyond immediate extinguishing to include continuous safety monitoring and personnel protection.

- **Continuous Monitoring:** Due to the **major risk of re-ignition** until the chemical reaction inside the battery is exhausted, the fire site must be continuously monitored by an equipped fire team.
- **Temperature Verification: Thermal imaging cameras** or other detection devices should be used to monitor battery temperature. The vehicle should only be moved to a safe area once the battery temperature is confirmed to be **below 50℃ and shows no temperature increase**.
- **Personnel Protective Equipment (PPE):** Emergency teams must be equipped with specialized gear:
  - Firefighter outfits that **comply with SOLAS II-2 regulation 10.10**.
  - **Insulated footwear, insulated gloves, and electrically insulating firefighter suits**.
  - Equipment for monitoring the atmosphere, such as **toxic and flammable gas detectors**.
  - Additional safety equipment, such as **full-face respirators** (to protect against toxic fumes)

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Contact

info@electrios.com