Cargo COMPLEXITY

Werner Brandao, Trainer and Consultant, Brandao Staff Training & Consultancy and Kees Kappetijn, Directeur of Kappetijn Safety Specialists, map container terminals, cargo flows and operational risks

From afar they are unmistakable: gigantic container ships, floating warehouses of steel moored in large and small seaports alike. Where in the 1960s a vessel carried only a few hundred containers, the largest ships today can transport more than 24,000 TEU (Twenty-foot Equivalent Units) in a single voyage. Inside: everything from toys, electronics, dry bulk, steel and timber to chemicals and food.

At their core, they are steel boxes, optionally fitted with cooling or heating and, if required, climate control. More than 90% of world trade moves by sea freight, with the container as its silent workhorse. The standardised format, developed in the 1950s, made global flows compatible and efficient. Without that piece of standardisation, transport would look entirely different today.

Behind the imposing sight of a fully loaded container vessel lies a complex web: the container terminal. These terminals are advanced logistics hubs where cargo is delivered, transhipped, checked, stored and redistributed. Here, people and machines work hand in hand. Trucks, trains and gigantic cranes – often higher than a tower block – move containers with centimetre precision.

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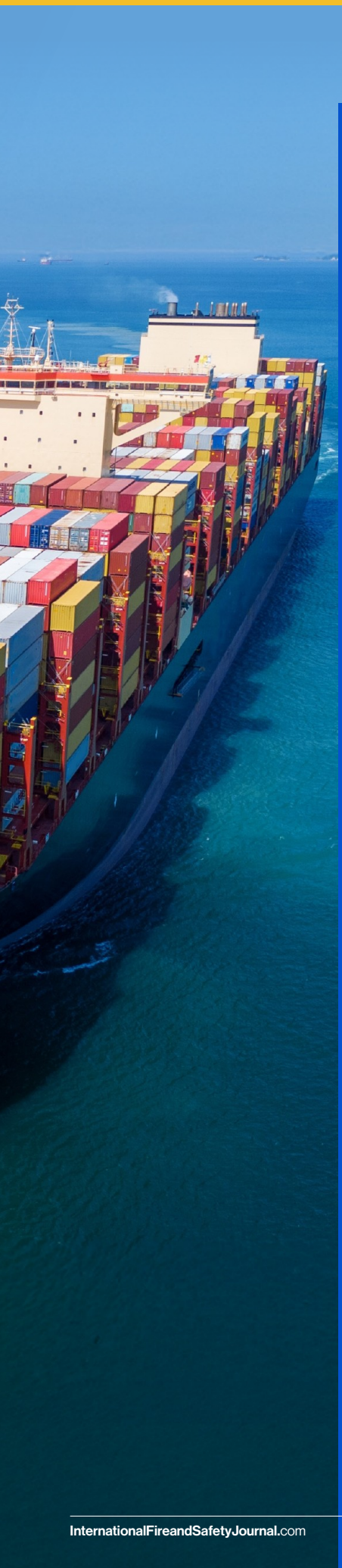

Even automatically guided vehicles (AGVs) and sophisticated software ensure that every container ends up in the right place on modern container terminals.

But the sector does not stand still. Digitalisation, automation and sustainability are rapidly advancing. Terminals invest in zero-emission equipment, stacking innovations (BoxBay), real-time cargo tracking and remote-controlled ship-to-shore cranes. Ships themselves are designed to be ever more energy-efficient, or to run on alternative fuels such as LNG, methanol, ammonia or hydrogen, sometimes even autonomously and electrically. Nuclear propulsion is being considered for container shipping, driven by stricter international environmental regulations.

For safety and incident response professionals this evolution means the playing field is changing. Larger ships and more diverse cargo bring new challenges: bigger volumes, greater spread and more complex logistics. Incidents involving such scale and diversity can have massive impact. Hazardous cargo may be hidden among thousands of containers, while extreme heights and forces complicate loading and unloading.

Understanding this dynamic is crucial. Those who grasp how the container chain operates can better identify where the risks lie and how they can be managed. The container may look like a simple metal box, but in reality it is a multifaceted key to the world – with all the opportunities and challenges that come with it.

A network of actors and interests

A container vessel at sea may look like an independent unit, but in practice it is part of a vast network of organisations, companies and authorities that ensure a voyage runs smoothly from start to finish. Each link has its own responsibilities, interests and risks, making seaborne trade both efficient and complex.

It often begins far from port, with shippers and freight forwarders who book and coordinate cargo. They decide where the container comes from, which route it follows and under what conditions it is carried. Next comes the shipping line – the owner or operator of the container ship. They manage planning, crewing, maintenance and compliance with international maritime regulations.

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At sea, the ship’s crew are central, responsible for navigation, safety and cargo. Along the way, vessels interact with maritime authorities such as coastguards, VTS (Vessel Traffic Services) and harbour masters, who oversee safe passage and arrival. Approaching port, pilots partly take over navigation to guide the ship safely to berth, assisted by tugboats. Once moored at the container terminal, terminal operators take over. Customs and other regulators check goods, taxes and safety, sometimes with hazardous-goods inspectors involved.

Insurers, classification societies and maritime lawyers also play their part, safeguarding technical standards, legal handling and financial cover in case of damage or incident. If a dangerous situation arises, fire brigades, harbour services, environmental inspectors and specialist intervention teams are brought in.

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It requires cooperation between commercial companies, government and emergency services, often coordinated internationally. Those who know in advance who plays what role can act faster during an incident, request targeted information and align measures more effectively. No container stands alone; behind each box lies a chain of people, organisations and interests – and that is where the key to effective safety and incident management is found.

Regulations and realities

Fire safety in the container sector is defined by a mix of international and national rules. The foundation is the SOLAS Convention (Safety of Life at Sea), which sets out requirements for construction, fire detection, suppression systems and crew training. In addition, the International Maritime Dangerous Goods (IMDG) Code prescribes how dangerous goods must be packaged, labelled and stowed. On paper this creates a clear theoretical framework.

Practice shows a different picture. Container ships often carry thousands of containers, of which only a fraction can be physically inspected by the crew. Incorrect or incomplete documentation occurs, meaning dangerous goods are not always recognised as such. In case of fire, crucial information may be delayed or absent altogether.

Firefighting on board a container ship is highly specialised and offers no simple, standard approach. Containers are made of steel, often hermetically sealed, allowing fire to develop inside for a long time without being visible. Water cannot easily reach the seat of the fire, and opening a container – rarely possible at sea – can suddenly add oxygen, creating explosive combustion.

The scale of modern container ships adds further complexity. A fire in one container can spread to others on deck or in the hold. Wind, waves and limited manoeuvrability make firefighting dangerous. Crews are trained but not specifically for cargo fires, and they work with limited

means, often relying on fixed CO^2 systems or water curtains that are not always sufficient for complex deck or hold fires. Until the ship reaches port, the crew is largely on its own. External help may take hours or days to arrive, sometimes flown in by helicopter.

Regulation provides the framework, but reality demands creative, risk-aware and well-trained action, both at sea and in port.

Typical fire scenarios

Fires on container vessels usually arise from specific circumstances. Common scenarios are:

- Fires in containerised cargo involving chemicals and flammable goods.
- Fires in the engine room or fuel system.
- Short-circuit, failure or overheating of reefers.
- Electrical systems and filters.
- Fires caused by “hot work” such as welding.

Cargo fires often involve chemical powders, lithium-ion batteries or solvents. Misdeclared or wrongly stowed, these can ignite through reaction, short-circuit or leakage.

Steel walls trap heat, allowing temperatures to rise unseen. Below deck, limited ventilation and poor smoke detection make early recognition difficult. By the time smoke appears, the blaze is often advanced.

Engine rooms, with high temperatures, fuel and oil, are another source. Although well protected, severe fires can spread through cable runs or ventilation into nearby cargo. Fires may also result from sparks during hot work, faulty reefers or even lightning strikes. Self-combustion is a risk with bulk goods such as charcoal, certain metals or agricultural produce if not cooled or ventilated.

All these scenarios share one thing: inaccessible fire seats, extreme heat, toxic smoke and the risk of container stack collapse. Indirect methods – cooling, isolation and controlled ventilation – are often the only option.

Difficult choices

Container ship fires are inherently complex, with complicating factors such as: Long distances to reach a fire seat; narrow, low ship infrastructure hindering responders; poor visibility; limited firefighting water, with stability risks from contaminated runoff; difficult access to high or deep-stowed containers;

uncertainty over container contents; container strength delaying access; and no option to remove or isolate containers.

Dilemmas then follow. Extinguish or isolate? Opening risks explosive combustion, but isolating takes time. People or cargo? Crews must be protected, but commercial pressure weighs heavily. Stay at sea or head for port? At sea, resources are scarce; in port, communities are at risk.

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Information gaps complicate everything. Incomplete manifests mean responders may not know what burns. Finally, international coordination is fraught: different flags, crews, owners and laws raise the question of who decides when every second counts.

These dilemmas show that container ship firefighting demands not just technology but leadership, judgement and balance under extreme pressure.

From ship to shore

At sea the crew, under the captain, are first responders. They activate emergency plans: alarm, locate the fire, consu lt cargo information, deploy CO^2, water curtains or boundary cooling. Simultaneously, they safeguard life on board, shut down ventilation, isolate fire zones and prepare for evacuation. Communication with the company and authorities starts immediately.

External responders arrive only when reachable: on arrival in port, by helicopter or via other ships. Assistance may also come from nearby vessels or salvage ships carrying specialists.

The transition from shipboard to shore-based action is critical. In port, firefighters, harbour services and intervention teams take over. Success depends on one factor: clear, complete information on the fire and cargo. The better the crew transfers knowledge, the faster and safer responders can act.

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From water to high-tech

Firefighting requires tools that match the scale and complexity of container ships. Traditional systems include monitors, hoses and fixed CO^2 installations, but these cannot always reach the seat of a blaze.

New tools are emerging. Water-mist lances drill through container walls to deliver water, foam or mist directly inside. The HydroPen, developed in Denmark, allows early attack on high deck containers without opening doors. Foam systems are increasingly used for hazardous cargoes. On shore, high-reach platforms help firefighters access burning containers stacked above. Some ports now deploy unmanned robots to operate in hot or unstable zones.

Newest of all are drones with thermal cameras. They provide instant insight into heat distribution and hidden fire seats, reducing risks for personnel.

Yet no tool replaces the fundamentals: prevention is always better, detection and information save critical time, and preparation largely determines success. Container ship fires cannot be solved with one tool or strategy. Only collective awareness, knowledge-sharing and cooperation build real resilience. ■