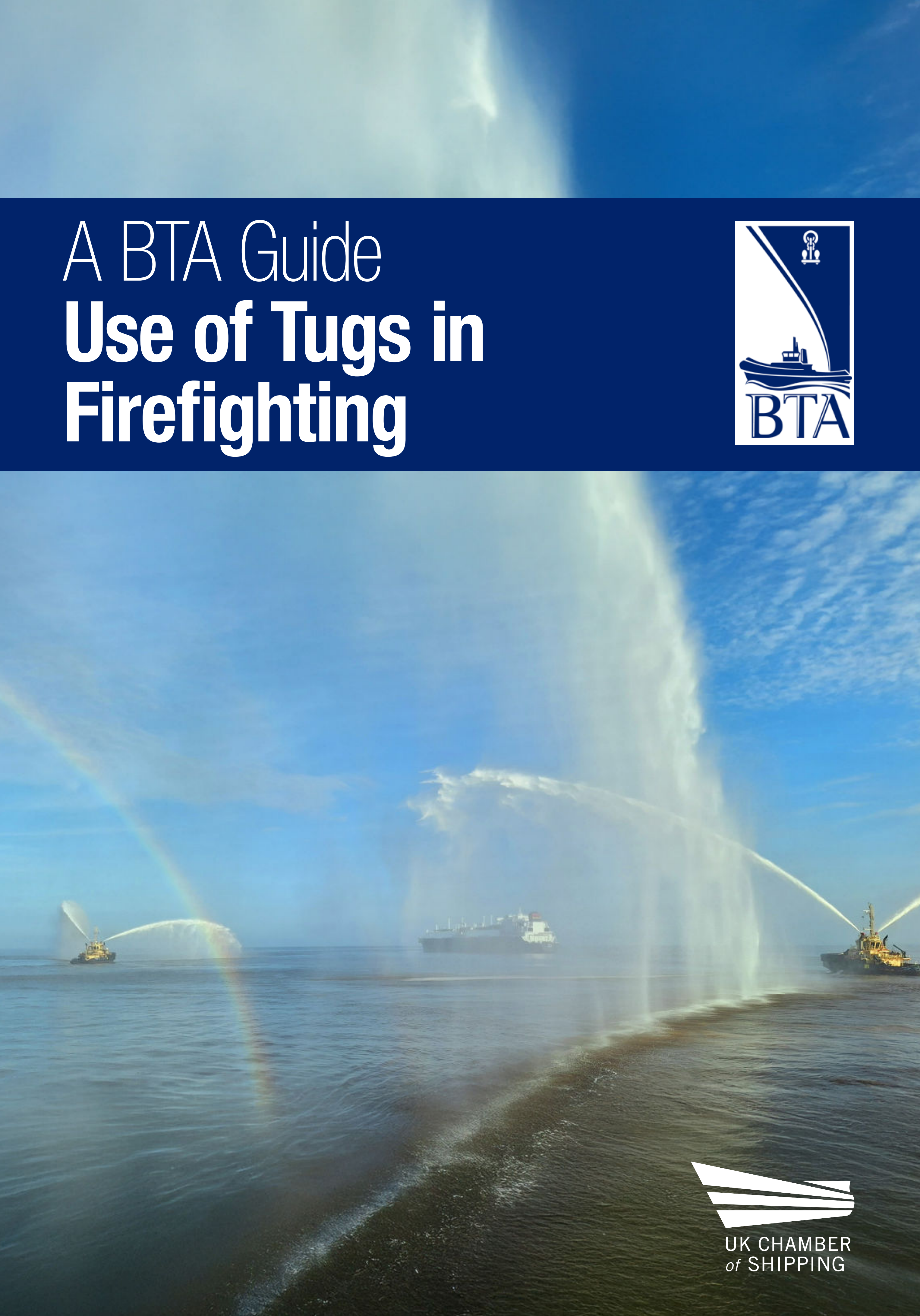
A BTA Guide

Use of Tugs in Firefighting



UK CHAMBER
of SHIPPING

A BTA Guide

Use of Tugs in Firefighting

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While the advice given in this document has been developed using the best information currently available, it is intended purely as guidance to be used at the user's own risk. It is however intended to update and inform users in the development of their Shoreside and Shipboard Contingency Plans in accordance with ISM obligations

Neither the British Tugowners Association nor the UK Chamber of Shipping accept responsibility for the accuracy of any information or advice given in the document or any omission from the document or for any consequence whatsoever resulting directly or indirectly from compliance with or adoption of guidance contained in the document even if caused by failure to exercise reasonable care.

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Foreword

Ship fires have occurred throughout maritime history, often leading to significant loss of life, environmental damage, and changes in maritime safety regulations.

Undoubtedly, it can be said that the deployment of ships with firefighting capabilities is of great importance in controlling and extinguishing ship fires. This applies to ships at sea, in ports, and on rivers and lakes.

Ships with a firefighting role can be deployed for various tasks: direct support in controlling and, when possible, extinguishing ship fires, or, for example, as a platform for firefighters and salvors to approach the ship from the water.

This Guide, produced by the British Tugowners Association, provides advice and guidance on how tug operators should consider deploying a tug with firefighting capacity as effectively as possible.

Equipment and capability are vital, but the expertise of the crew is indispensable. During my career, I have worked with a large variety of tugs, crews, and equipment. This applies to both real deployments and numerous training sessions and exercises. Although it may look the same to a layperson—tugs spraying water over or against a burning ship—experts will immediately recognise the difference between a good, less good, or poor deployment of the tug.

The crew must be able to deploy their tug in the safest and most effective way under a wide range of circumstances. This means that the crew must be able to demonstrate their expertise in preventive, preparatory, and suppressive aspects.

In addition to the crew's expertise to act quickly, efficiently, and safely during an incident, the tug itself must also be in good condition, both from a nautical and firefighting technical perspective. The ship and crew must be able to respond quickly, competently, and safely 24/7 to provide support. This means that, besides maintaining the ship, they must regularly test the equipment, go through the relevant procedures and checklists, and collaborate with other parties and organisations.

This Guide provides a starting point of the towage industry's thinking about how best to approach some of challenges a firefighting scenario presents, whether a traditional hydrocarbon-based fire, or of the variety alternative fuels that are entering the market and have distinct characteristics.

As knowledge, expertise and technology advance, so will this Guide develop over time to incorporate new learnings, new techniques and improve in its guidance.

I commend the BTA and its members and consulted experts for endeavouring to produce such a helpful document.

Ruud Plomp, owner and founder of Artemas Academy, a cooperative of safety experts

1

Introduction

In an era where maritime safety continues to evolve, the threat of shipboard fires remains a significant concern for the industry. With over 200 fire incidents reported in 2023 alone and ship fires posing increasing risks to life, property and the environment, the role of tugs equipped for firefighting has never been more crucial. The British Tugowners Association has developed this comprehensive guide to address a critical gap in practical guidance for deploying tugs in marine firefighting scenarios, especially in the context of emerging challenges such as alternatively fuelled vessels.

This guide aims to support tug owners, operators, port authorities, and emergency planners by outlining legal frameworks (chapter 2) and the roles and responsibilities of tugs (chapter 3) in firefighting. In chapter 4 we discuss the required training and skills for tug crew and in chapter 5 the risks and challenges involved. Chapters 6 and 7 examine everything from command structures and training protocols to equipment capabilities and evolving risks, such as lithium-ion battery fires and the complexities of ultra-large vessels. In chapter 8, we put firefighting in a broader historic context and we analyse a few case studies of incidents that have led to review of equipment and procedures. What lessons can we learn?

While this document serves as a foundation, it is also intended as a living guide—open to updates, feedback, and improvements as technology, regulation and operational knowledge progress. At its core, this guide reaffirms a simple truth: the effectiveness of marine firefighting relies not just on advanced equipment but on the skill, preparedness, and coordination of the people behind it.

Finally, please note that, where possible, reference is made to the main global maritime conventions, but this is supplemented in part with specific reference to United Kingdom legislation and legal mechanisms. Other maritime administrations could have their own interpretation.

2

A Short History of Shipboard Firefighting

The history of firefighting at sea is extensive and reflects the evolution of maritime safety practices. Tugs have been used for marine firefighting since the late 19th century. Initially, steam tugs were equipped with fire-fighting apparatus to assist in extinguishing fires on ships and at docks. One of the earliest documented uses was in the 1880s when specialised tugs were developed in cities like New York and London to provide firefighting support.

The book *Marine Fire Prevention, Firefighting and Fire Safety* written by the Maritime Training Advisory Board of the US Department of Commerce reflected:

> *"Maritime history includes many accounts of fire aboard ships. In some cases, efficient seamanship and the firefighting efforts of the crew saved the ship, its cargo and everyone aboard. In others, mistakes were made; inadequate firefighting could not prevent the loss of lives and property."*

Ship fires have occurred throughout maritime history, often leading to loss of life, environmental damage, and changes in maritime safety regulations. Below is a timeline highlighting some of the most notable ship fires, along with their impact on the shipping industry.

20th Century

1934 – SS Morro Castle

- **Event**: The Morro Castle, an ocean liner en route from Havana to New York, caught fire off the coast of New Jersey. The fire killed 137 people.
- **Impact**: "Titanic of ship fires" led to significant safety reforms and inclusion of specific attention to fire safety in the International Convention for the Safety of Life at Sea (SOLAS), including stricter regulations on fire-resistant materials, lifeboat accessibility, and training and exercises (crew competencies).

1941 – RMS Normandie

- **Event**: The French luxury liner Normandie, which had been seized by the US government during World War II, caught fire while docked in New York. The fire spread rapidly due to flammable materials and the ship capsized during firefighting efforts.
- **Impact**: The loss of the Normandie highlighted the risks associated with storing flammable materials on ships, and how firefighting water from tugs can have significant stability consequences on the vessel.

1965 – SS Yarmouth Castle

- **Event**: The Yarmouth Castle caught fire in the Bahamas while en route from Miami to Nassau. Over 90 people died as the fire quickly engulfed the wooden superstructure.
- **Impact**: The tragedy led to SOLAS 1960 being revised, improving fire safety regulations for passenger ships.

1979 – The Betelgeuse

- **Event**: The MT Betelgeuse, an oil tanker, exploded and sank at the Whiddy Island oil terminal in Bantry Bay, Ireland. The disaster resulted in 50 fatalities and severe environmental damage.
- **Impact**: The investigation focused on the consequences of the absence of stand-by tugs near the jetty, as company policy stated, which could have assisted had they been there.

21st Century

2012 – MSC Flaminia

- **Event**: Containership caught fire mid-Atlantic en route to Europe due to mis-declared cargo under the IMDG Code, resulting in three fatalities. The vessel ultimately berthed in Wilhelmshaven eight weeks after the fire broke out.
- **Impact**: Use of expert salvage tugs and external firefighters, considerable pollution risk concern and delays bringing vessel into port.
- **Role of Tugs**: The coordinated efforts of the tugs were crucial in managing the emergency, controlling the fire, and safely transporting the MSC Flaminia to a European port for further assessment and repairs.

2014 – Norman Atlantic

- **Event**: The Norman Atlantic, an Italian passenger ferry, caught fire in the Adriatic Sea. The blaze spread quickly, and despite a massive rescue effort, 11 people were confirmed dead and 18 more unaccounted for.
- **Impact**: Highlighted ongoing issues with evacuation procedures, fire alarms, and emergency readiness aboard modern ferries. The incident led to the creation of the EU Operational Guidelines on Places of Refuge.
- **Role of Tugs**: Tugs played a vital role in firefighting, rescue & salvage operations, evacuating passengers & crew, towing the damaged ferry and bringing the vessel safely to port. Tragically, during salvage efforts, two crew members from the tug Iliria lost their lives when a cable snapped.

2016 – CCNI Arauco

- **Event**: A container ship fire alongside in Hamburg.
- **Impact**: Incident and response highlighted the ineffectiveness of shipboard marine firefighting equipment, the necessity of external assistance, stability and structural concerns, and the safe disposal of contaminated water.
- **Role of Tugs**: Tugs helped control and extinguish the fire, through continuous water supply to flood the burning cargo hold. When water alone was ineffective, tugs assisted in applying foam-based firefighting methods from both water and land.

2016 – Aframax River

- **Event**: The tanker lost propulsion and struck two mooring dolphins, puncturing hill, spilling 88,000 gallons of LSMGO into the water which ignited and burned for 45 minutes.
- **Impact**: Highlighted action of pilot to manoeuvre vessel to limit damage to third parties and use of tug sprinkler system for tug crew safety.
- **Role of Tugs**: The tugs played a critical role in preventing further disaster through quick and decisive actions. Despite intense heat and danger, they pushed the burning tanker away from nearby ships and port structures, containing the fire and minimising damage.

2020 – MV X-Press Pearl

- **Event**: The X-Press Pearl, a container ship carrying chemicals, caught fire off the coast of Sri Lanka. The fire burned for several days before the vessel sank, leading to severe environmental damage from leaked chemicals and plastics.
- **Impact**: This fire drew attention to the risk posed by shipping hazardous materials and the need for better regulation of cargo storage and handling, along with vessel stability when firefighting.
- **Role of Tugs**: Tugs provided continuous water spray and misting to cool the ship's hull and contain the fire, working alongside emergency teams. Despite efforts, the fire persisted, and tugs remained on-site to support salvage operations and assess towing. Tugs minimised the spread of the fire and reduced environmental risks, although the ship ultimately sank, causing significant pollution.

2022 – MV Zim Kingston

- **Event**: The Zim Kingston, a container ship, caught fire off the coast of British Columbia after losing containers overboard. The fire involved hazardous materials, including chemicals.
- **Impact**: The incident emphasised the risk of container ship fires and the importance of monitoring and handling dangerous goods carefully.
- **Role of Tugs**: Tugs contained the fire through providing boundary cooling, spraying water to prevent fire spread and to protect the ship's structure. The tugs remained on-site for several days, assisting firefighting teams in controlling the hazardous cargo fire.

Ongoing Fire Incidents and Trends

- **Lithium-Ion Battery Fires**: The increasing use of electric vehicles transported on ships has presented new challenges for maritime fire safety. Fires involving lithium-ion batteries are difficult to extinguish and can reignite even after being doused with water.

- **Container Ship Fires**: Several high-profile container ship fires, such as the Maersk Honam in 2018, have underscored the growing danger posed by the transport of hazardous goods and the need for better fire detection, fire suppression, and cargo classification systems and accurate stowage plans.

- **Environmental Concerns**: Fires involving hazardous chemicals, plastics, and oil products have drawn attention to the environmental impact of ship fires, pushing for stricter international regulations on the handling of dangerous cargo.

- **Increasing vessel sizes**: Ultra Large Container Vessels (ULCVs) and some of the largest cruise ships present challenges for firefighting tugs due to their considerable size. The combination of sea conditions, wind, and the height and width of these vessels limits the capacity and reach of a FiFi I vessel (including the throw distance of the water monitors) and may be insufficient to achieve the desired or necessary effect.

- **Alternative Marine Fuels**: The maritime industry's shift towards alternative fuels such as ammonia, methanol, and hydrogen introduces new fire safety considerations. These fuels come with distinct hazards, including toxicity, corrosivity, low ignition energy, and different combustion behaviours compared to traditional marine fuels. For the crews of assisting firefighting tugs, this means increased exposure to invisible, highly flammable or toxic vapours, and a greater reliance on gas detection, remote cooling strategies, and protective equipment to operate safely near vessels using these fuels.

3

Regulations and Compliance

Throughout this Guide, reference is made to regulatory and legal frameworks. While it is written and produced by the British Tugowners Association, it is recognised that it may have global application. Therefore, where possible, reference is made to the main global maritime conventions, but this is supplemented in part with specific reference to United Kingdom legislation and legal mechanisms. Naturally, in most situations, other maritime administrations will have their own interpretation.

LEGISLATION

Fires at Sea and the Duty to Assist

When a person is in distress at sea, including as a result of a vessel encountering a serious fire, there are moral and legal obligations requiring vessels and their master and crew to proceed to provide assistance.

Whilst there is no equivalent duty imposed by law to provide assistance to property in danger such as the vessel and its cargo, the law incentivises and encourages persons to provide assistance to property and take measures to minimise risks to the environment by providing a right to a salvage award where the assistance has a useful result. Tug operators may also agree to provide assistance to the property as part of a commercial contract.

This means that when a tug is called to provide assistance to a fire casualty, the tug and its crew may be undertaking both a rescue and a salvage operation. The master and crew of the tug need to understand their obligations to the people in distress, as well as the property in danger and the environment. They also need to understand the obligations that arise when they step in to assist and the risks that they may encounter in providing assistance, and how this may impact upon their insurance.

Persons

The overriding duty is to provide assistance to persons in distress and the legal obligation to assist persons is set out in international conventions, which are enacted in national law in the UK:

- International Convention for the Safety of Life at Sea, 1974 (SOLAS), as amended.
- International Convention on Salvage, 1989.

Regulation V/33 SOLAS, enacted into UK law by the Merchant Shipping (Safety of Navigation) Regulations 2002, requires that:

> *The master of a ship at sea which is in a position to be able to provide assistance on receiving a signal from any source that persons are in distress at sea, is bound to proceed with all speed to their assistance, if possible informing them or the search and rescue service that the ship is doing so.*

Masters who, in special circumstances, decide not to respond to a distress must enter their reasons in the logbook and, if they have responded to the distress, inform the appropriate search and rescue authorities of their decision not to proceed.

Where a tug does not comply with that obligation, the master may commit a criminal offence, punishable on summary conviction by a fine not exceeding the statutory maximum and on conviction on indictment by imprisonment for a term not exceeding two years or a fine, or both. Any assistance provided under this duty to property does not affect a right to salvage.

That obligation is reinforced by Article 10 Salvage Convention 1989, which has the force of law under S.224 Merchant Shipping Act (MSA) 1995:

> *Every master is bound, so far as he can do so without serious danger to his vessel and persons thereon, to render assistance to any person in danger of being lost at sea.*

It confirms that the owner of the vessel shall incur no liability for a breach of that duty of the master.

These obligations reflect Article 98 of the United Nations Convention on the Law of the Sea (UNCLOS), 1982, that provides Flag States shall require the master of a ship, in so far as he can do so without serious danger to the ship, the crew or the passengers:
(a) to render assistance to any person found at sea in danger of being lost;
(b) to proceed with all possible speed to the rescue of persons in distress, if informed of their need of assistance, in so far as such action may reasonably be expected of him;
(c) after a collision, to render assistance to the other ship, its crew and its passengers and, where possible, to inform the other ship of the name of his own ship, its port of registry and the nearest port at which it will call.

Property

Where property is in danger, any assistance provided by tugs such as firefighting may form a salvage operation (as defined in Article 1 of the Salvage Convention), whether to assist the persons on board, or the property alone. If the salvage operation has a useful result, the tug operator, master and crews may be entitled to a salvage reward. Even where there is not a useful result, there may be a claim for special compensation as a reward for efforts to prevent or minimise damage to the environment.

Where a tug is carrying out firefighting operations, the salvage convention requires that it:

- carries out the operations with due care;
- exercises due care to prevent or minimise damage to the environment;
- where necessary, seeks or accepts assistance from other salvors.

If a tug is carrying out services under a salvage contract or a commercial contract, the tug operators and crews will need to ensure that they understand the obligations required of them when providing services under that contract.

The master or owners of the vessel may agree that the firefighting services should be provided under a salvage contract, such as Lloyd's Open Form contract (LOF). Under LOF, the obligations are more onerous and include the following obligations:

- Best endeavours to salve the property.
- Best endeavours to prevent or minimise damage to the environment.

LOF is a no cure, no pay contract, under which there needs to be some useful result for the property as a condition to any salvage award, unless the Special Compensation P&I Clause (SCOPIC) is incorporated and invoked, or there is a claim for special compensation as a reward for efforts to prevent or minimise damage to the environment.

Where tug operators are contemplating providing salvage services (either common law or under LOF), it is recommended that the shore-based management of the tug(s) involved consult their legal experts to seek guidance on salvage claims and salvage contracts. This is to help the salvor avoid incurring additional liabilities and improve the prospects of receiving remuneration for the services. Additionally, it is recommended to discuss the proposed salvage operation with the tug's P&I Club to ensure that there is no exposure by having inadequate insurance coverage.

Remuneration

As a matter of policy, persons who are rescued are not obliged to pay their rescuer. That does not relieve a master of a tug from obligations under SOLAS or the Salvage Convention. Whilst there is no claim for pure life salvage, there are possible routes to obtaining remuneration or covering expenses.

Where a tug also preserves or contributes to preserving any vessel, cargo, freight or other recognised subject of salvage from danger, the tug owner and crews involved may have a salvage claim. If life is saved as part of that operation, the salvors should receive an enhanced award which is payable by the property interests.

Where there is life salvage, but no property was saved, there is a provision under the MSA 1995 (schedule 11, Section 2, para 5), under which the UK Government has a discretion to make a payment to a salvor in respect of the services rendered in saving life. This is a rarely used provision, limited in scope and the power is purely discretionary.

P&I Insurance from the International Group (IG) typically will cover expenses for diversions to save life.

Where the firefighting services provide useful result for the property, which typically means some value has been preserved, the tug will usually be able to claim a salvage award (unless it has agreed not to do so under any applicable contract terms). If those services have been provided without any contract, the tug operator, master and crews are likely to have a common law salvage claim against all preserved property. That award will be assessed in accordance with the criteria set down in

Article 13 of the Salvage Convention. It is suggested that legal advice is sought before pursuing any salvage claim, which is usually brought in the High Court.

Where a salvage contract is agreed, payment will be determined in accordance with that contract.

If a Lloyds Open Form ("LOF") salvage agreement is in place, the parties will try to reach agreement following the salvage on the appropriate award. Where agreement cannot be reached, the mechanism for determining remuneration will be arbitration through the Lloyd's Salvage Arbitration Branch, who have a panel of Lloyd's arbitrators specialised in hearing salvage disputes.

Offshore Installations

Operators should be aware that the Salvage Convention does not apply to fixed or floating platforms or to mobile offshore drilling units where they are on location engaged in the exploration, exploitation or production of sea-bed mineral resources. Should the marine firefighting situation involve an offshore oil and gas installation, then the duty holder should be following the guidance as set out within HSE Offshore Information Sheet No. 5/2009, which can be also found online, entitled "Provision of active fire protection on offshore installations" and it is advisable for tugs attending to be aware.

UK REGULATIONS

The UK Fire and Rescue Services (UKFRS) have a responsibility to respond to incidents in order the deliver their statutory functions in its area under the Fire and Rescue Service Act (FRSA) 2004 and work with partners to save life and support the safe resolution of incidents.

This is influenced and supported by a range of partnership documents that include the The Fire & Rescue Services Act 2004.

As part of Fire and Rescue Services statutory duties, an FRS (Fire and Rescue Service) has the power to respond to a fire onboard a vessel alongside. This power is given by:

Fire and Rescue Services Act (2004) Section 11

Power to respond to other eventualities

1) A fire and rescue authority may take any action it considers appropriate...
    (a) in response to an event or situation of a kind mentioned in subsection (2);
    (b) for the purpose of enabling action to be taken in response to such an event or situation.
2) The event or situation is one that causes or is likely to cause...
    (a) one or more individuals to die, be injured or become ill;
    (b) harm to the environment (including the life and health of plants and animals).
3) The power conferred by subsection (1) includes power to secure the provision of equipment.
4) The power conferred by subsection (1) may be exercised by an authority outside as well as within the authority's area.

Fire and Rescue Services Act (2004) Section 20

1) If a fire and rescue authority has power to act, or is required to act, outside the authority's area, the authority may exercise the power, or perform the duty, at sea or under the sea.
2) The references in subsection (1) to "sea" are not restricted to the territorial sea of the UK.

Civil Contingencies Act 2004

As a Category 1 Responder, Fire & Rescue Services are duty bound to respond to 'emergencies' as defined within this act.

Category 1 responders are subject to the full set of civil protection duties. They will be required to:

- assess the risk of emergencies occurring and use this to inform contingency planning;
- put in place emergency plans.

National Contingency Plan for responding to marine pollution incidents

This plan provides a strategic overview of how the UK responds to maritime pollution incidents. This may include a response from UK Fire & Rescue Services and may include the provision of a variety of commercial support vessels including tugboats.

UK Fire Sector Response to Maritime Incidents

As highlighted above, UK Fire & Rescue Services have a responsibility to respond to incidents within their areas. Whilst the response model, the action taken and the approach to incident management will vary around the UK, the end goal will remain consistent with a focus on saving life and the safe resolution of incidents.

As an example, in the UK, major ports require an escort tug to have FiFi (Firefighting) I notation (see Chapter 4 for more information). Terminal owners and port authorities may include their own requirements, for example, based on The International Safety Guide for Oil Tankers and Terminals (ISGOTT) or other requirements. Apart from the class standard for firefighting vessels such as FiFi I, there is very little in the way of international or national UK regulation on tugs used for marine firefighting. By contrast the requirements for vessels, including tugs', own internal firefighting capacity is extensive. The requirements are mainly driven by local port authority regulations and the specific requirements of terminals where hydrocarbons are handled.

If the tug is called to action, the owners and crew of the tug must be aware that they are entering a salvage situation. There can be two elements to this. Firstly, the master of the tug is legally bound (SOLAS Regulation V/33) to render assistance as so far as they can do so to anyone in danger of being lost at sea, without putting the vessel or crew in harm's way or serious danger to the tug and persons thereon. If the master fails to comply with this, they may potentially be liable to prosecution.
The second element is when the tug has been engaged to provide firefighting services, however not with the aim of protecting life, but to control a fire with the objective of salving property or the environment, as per the International Convention on Salvage 1989.

Distinction Between Safety of Life and Salvage

It is important to consider the distinction between these two actions as when saving life, the tug is not acting as a professional salvor, rather discharging the duty to do so at the request of the assisted vessels master to save life, if safe to do so. The use of the tug's firefighting equipment to the end of saving life, is generally covered under the scope of the tug's P&I insurance. Alternatively, if the firefighting tug is engaged to protect property or the environment, the tug is a volunteer engaged in the operation to assist as required, such an action is likely to require specialist cover from the tug's P&I insurance, the detail of the specialist insurance is explained later in the chapter.

In either event, the remuneration mechanism for using the tug for firefighting (unless separate contracts exist) is to make a salvage claim against the vessel. In order to do this, as a minimum the following criteria must be met for a claim to be successful:

- There is a real peril, the danger needs to be real, but not necessarily immediate or absolute. The subject of the salvage must be in real danger, which means the property is exposed to damage or destruction.
- When the tug is acting as a volunteer (that is, without any pre-existing contractual or other legal duty to do so to act).
- Has been willingly engaged by the assisted vessel.
- The tug preserves or contributes to preserving at sea any vessel, cargo, freight, or other recognised subject of salvage.

The tug will be rewarded based on the extent of success on a no cure, no pay basis. However, success need not be total. Partial success, provided that there is some measure of prevention to the owners, is sufficient.

There is the possibility that marine firefighting may be done under a Lloyds Open Form contract (LOF) agreement. Under the LOF, rewards are based on the no cure, no pay principle and Special Compensation (SCOPIC) may be paid however as a compensation for efforts to prevent or minimise damage to the environment, even if no property is saved.

When carrying out firefighting operations the salvor has the following duties:

- To carry out the salvage operations with due care.
- To exercise due care to prevent or minimise damage to the environment.
- To accept the intervention of other salvors when reasonably requested to do so by the owner of the master of the vessel.

It is therefore important not to overlook the importance of building a solid base of evidence to support the above criteria to make a successful claim. The following methods of recording evidence should be considered:

- Logbook entries
- CCTV and voice recording
- Photographs and videos
- Initial statements from crew on scene
- Notes on assisted vessel communication with other parties

Notwithstanding the above types of evidence, recording of events with whatever means available to the tug and its crew is preferable to no evidence.

It is recommended in the initial stages of a marine firefighting situation, that the shore-based management of the tug(s) involved speak to their legal department to seek guidance, in order to avoid being in a situation where a claim will not be possible or the tug / towage company may carry unacceptable liability. Additionally, it is recommended to discuss the proposed salvage operation with their P&I Club to ensure that there is no exposure by having inadequate insurance coverage.

INSURANCE

Specialist insurance is required for tugs engaging in professional salvage activity and operators need to check and confirm with their P&I Club.

Typical P&I insurance cover extends to saving of life at sea, not professional salvage or protection of property. If in doubt, speak with your P&I Club.

Examples, provided by Shipowners P&I, of additional insurance covers include:

- **Salvors A** – Insurance cover for general P&I claims but which arise during professional salvage operations.

- **Salvors B** – Cover for oil pollution during salvage operations, whether or not related to the entered vessel.

- **Salvors C** – Cover for other claims not related to the entered vessel (for example claims related to negligent decision making on the salvage project as a whole).

Other P&I insurers may use alternative wording and or nomenclature for additional insurance cover. Again, if in doubt, speak with your P&I Club.

4

The Role, Tasks and Responsibilities of Tugs with Firefighting Capacity

THE PURPOSE/ROLE OF A TUG WITH FIREFIGHTING CAPACITY

A firefighting tug plays an essential role in ensuring maritime safety by offering emergency firefighting capabilities both at sea and in port areas. Its primary function is to support the containment and extinguishing of fires on vessels or within port facilities. These tugs are outfitted with high-powered water and foam monitors capable of discharging large quantities of water or firefighting foam, addressing fires that might overwhelm standard ships or onshore firefighting systems.

Key roles of a firefighting tug include:

- **Port and terminal fire safety**: firefighting tugs provide critical protection for port facilities, where flammable materials are often handled. Ports handling hazardous substances, such as oil or gas, rely on these tugs for rapid response in case of fires, preventing further fire damage, environmental impact and economic losses.

- **Assisting firefighting operations**: In collaboration with other firefighting units, such as onshore firefighters or rescue services, firefighting tugs can serve as floating work platforms for emergency services. They can also offer additional water supply and firefighting capacity, especially in remote or hard-to-reach areas of ports. Additionally, they can act as evacuation points, or logistical support for firefighters.

- **Firefighting at sea**: In the event of a fire on an oil tanker, cargo ship, or other maritime vessel, firefighting tugs can intervene to prevent further damage. These tugs have the ability to approach burning vessels and direct water or foam from a relatively safe distance, containing or extinguishing the fire until further help arrives.

- **Emergency towing and salvage operations**: Apart from firefighting, these tugs may also be equipped to tow disabled or burning vessels away from critical areas to reduce the risk of fire spreading or causing further damage.

Firefighting tugs play a very important role in high-risk environments like oil terminals, where fires and/or leakages can have severe consequences. Their ability to control and even extinguish fires on water makes them a vital asset in maritime safety.

FIRE FIGHTER CLASSIFICATION SOCIETY RULES

Typical Fire Fighting Classes

Class I firefighting (FF I) includes the lowest grade of external active firefighting provision and own vessel protection. Classes I +, II and III include greater requirements.

Class I FF does not specify the carriage of foam but, if carried, it must be of an approved type with equipment designed to deliver mixed water and foam at the rate specified by the Classification Society.

Requirements for vessels equipped with some firefighting provision (less than class I) may be given the notation ‘Fire Fighter Capability’, this may be called FF 1/2.

The vessel's owner and/or operator must be able to demonstrate crew are suitably trained to operate all equipment when in firefighting mode. Exercise drills must be held and recorded.

Minimum Requirements for Fire Fighter I, II and III

(Correct at time of publication May 2025)

Item	Class Notation				
	FiFi I	FiFi II			FiFi III
Number of water monitors (4)	2	2	3	4	4
Discharge rate per monitor, m3/hr	1,200	3,600	2,400	1,800	2,400
Number of pumps	1-2	2-4			2-4
Total capacity, m3/hr	2,400	7,200			9,600
Monitor range (1), m	120	180		150	150
Height, monitor (2), m	50	110		70	70
Number of hose connections on each side of the vessel	4	8			10

Item	Class Notation		
	FiFi I	FiFi II	FiFi III
Number of firefighting outfits	4	8	10
Fuel oil capacity (3), hours	24	96	96

Notes:

1. Range: measured horizontally from the monitor outlet to the mean impact area.
2. Height: minimum height of the trajectory of water monitor jet measured vertically from sea level assuming a mean impact area located at a horizontal distance not less than 70 m from the nearest part of the firefighting vessel.
3. Fuel oil capacity is to include provisions for continuous operation of all monitors in addition to the total capacity of the vessel's fuel oil tanks required for continuous firefighting operations.
4. The monitors are to be arranged so that the range and height of throw can be achieved with required number of monitors operating simultaneously towards a required direction.

It should be noted that FiFi I tugs monitor range & height (throw) does not extend sufficiently to reach the top of the stacks onboard Ultra Large Container Vessels (ULCVs) or the largest cruise vessels.

Vessels not fully in compliance with Classification Society (Class) firefighting rules, or not specifically built for the services intended to be covered by these notations, but which have special firefighting capabilities in addition to their regular service, may be specially considered and reviewed under the intent of this section as they relate to firefighting.

Such vessels may be given the class notation Fire Fighter (Capability). The standard applied, with relevant data on the extent of this special firefighting capability will be entered into the appendix to the class certificate and such special firefighting systems will be subject to annual surveys.

APPLICATION

Vessels built in compliance with the relevant requirements may be given the class notation Fire Fighter with one or more of the following Class notations I, I+, II or III.

The class notations I and I+ imply that the vessel has been built for early-stage firefighting and for support of rescue operations onboard or close to structures or ships on fire. To meet its objectives, a Fire Fighter I vessel shall be designed with active protection, giving it the capability to withstand higher heat radiation loads from external fires.

Class notation I+ differentiates itself from I with higher reliability and capability. In addition to active protection, the vessel shall have passive protection, giving it the capability to withstand the higher heat radiation loads if the active protection fails. In addition, the vessel incorporates a longer monitor throw length. Vessels with class notations II and III are designed for sustained firefighting operations on large fires from a safe operational distance, as well as for cooling burning structures. FiFi III vessels have higher water pumping capacity and more advanced firefighting equipment than FiFi II, allowing for more effective fire suppression and protection of larger structures.

If a vessel has been fitted with firefighting systems and equipment in accordance with the class notations II or III and has also been designed with passive and/or active heat radiation protection in accordance with the class notation I+ or I, then a combination of the two notations may be given.

Vessels not fully in compliance with class firefighting rules, or not specifically built for the services intended to be covered by these notations, but which have special firefighting capabilities in addition to their regular service, may be specially considered and reviewed under the intent of this section as they relate to firefighting.

Such vessels may be given the class notation Fire Fighter (Capability). The standard applied, with relevant data on the extent of this special firefighting capability, will be entered into the appendix to the class certificate and such special firefighting systems will be subject to annual surveys.

Water Curtain

It is important to emphasise the water curtain required for firefighting ships in proximity to fire. As per class rules, the coverage of all vertical surfaces is extremely important so there are no exposed areas:

> *"Ships which are intended to operate in close proximity to a large fire will require protection from the heat radiated from the fire. Such protection may be afforded by a system which provides a water spray over the surface of the ship, or by a combination of insulation and a water spray system. Alternative arrangements providing an equivalent level of protection may be accepted where it can be demonstrated that such arrangements are effective for the environmental conditions in which the ship is intended to operate.*
>
> *The water spray system is to be a fixed system which is capable of delivering a spray of water over all the exposed external vertical surfaces of the hull in the lightest sea-going condition, including the superstructures and deckhouses and over the monitor position. The water spray system will also be required to cover the areas of deck which form the crowns of machinery spaces and other spaces containing combustible materials."*

Manoeuvrability

Vessels with FF notation are required to be very manoeuvrable. In addition to using multi directional fire monitors, the On-Scene Commander may request the tug to approach a casualty from a particular angle for firefighting or boundary cooling.

Additionally, the tug master must always be able to see an escape route for the vessel and be able to remove the tug from danger if required.

The tug master must also be experienced in manoeuvring the vessel when monitors are in use.

Sea water discharged from monitors may be supplied by independent pumps or main engine driven pumps. Tug manoeuvrability may be affected by reduced propulsive power. Additionally, the water jet from a monitor, if angled at sea level or the side of a structure, will affect position keeping. Tug masters must be prepared for these changes to their normal manoeuvring capability.

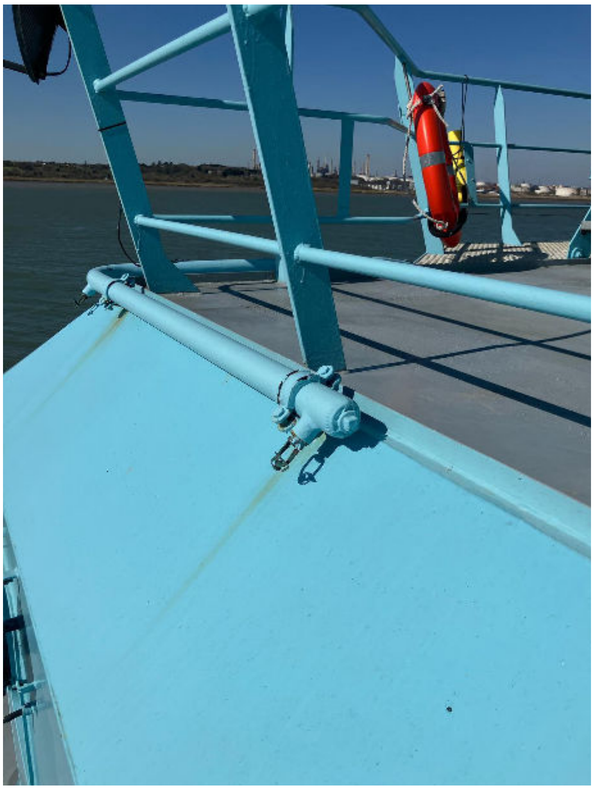
Typical Firefighting Equipment Onboard Tugs

Combined Water & Foam Monitors

SOURCE: BOLUDA

2 x 2000m^3/hr combined foam & water monitors, one port, one starboard aft

PHOTO CREDIT: SVITZER



Accommodation drench system

PHOTO CREDIT: SVITZER

4 x complete fireman's outfits

PHOTO CREDIT: SVITZER

8 x 2.5" hose manifolds, 4 port and 4 starboard on the main deck

PHOTO CREDIT: SVITZER

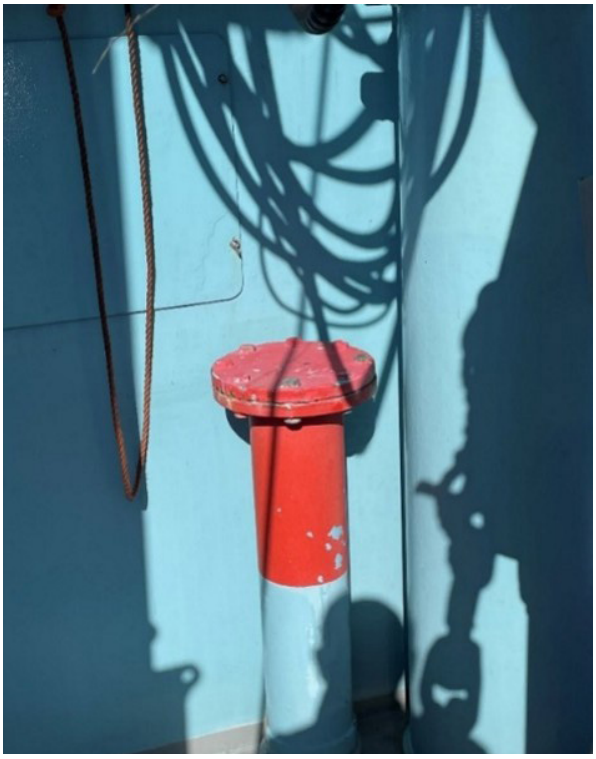
Additional equipment to specific installation's requirements:

In addition to the abovementioned equipment for a vessel classed to FF I, the typical petrochemical installation firefighting tug described above also has the following:

- 2 x 8" manifolds for external delivery of firefighting water to terminal fire main
- 23.4m^3 firefighting foam

2 x 8" manifolds to connect to 2 x risers on main deck, in turn connected to 2 x 6" hoses from the terminal

PHOTO CREDIT: SVITZER



2 x 8" risers, one port and one starboard on main deck aft

PHOTO CREDIT: SVITZER

Additional items you may find for specific vessel types:

- Ship's own defence system for fire protection – separate from any firefighting capability.
- Positive pressure in air-conditioning system.
- Gas monitoring equipment.
- Spark arrestors fitted to the exhaust system to eliminate ignition risk.

Tug showing full monitors and drenching systems activated - **PHOTO CREDIT: NICK JEFFERY**

5

Training and Skill Development for Tug Crews

Vessel fires requiring assistance from firefighting tugs are not common but need to be prepared for and do occur. This presents a challenge, as tug crews responding to a vessel fire may not have hands-on practical experience in real firefighting scenarios.

Companies should, within their respective safety management systems, provide guidance to masters and crews regarding firefighting including but not limited to:

- conducting risk assessments;
- writing and designing practical work instructions;
- utilising supporting check sheets;
- contacting shore-based firefighting experts for assistance.

Towage companies should regularly conduct joint training exercises (drills) with local fire and rescue services, as well as commercial stakeholders. This collaboration ensures coordinated emergency response and enhances crew readiness. This is particularly important where companies are contracted to provide firefighting support such as within terminals.

DRILLS SHOULD BE REALISTIC, INCLUSIVE AND DOCUMENTED

Drills are essential for preparing the vessel's crew to respond to high-pressure, time-sensitive emergencies. So far as practicable, the drills should be conducted as if there was an actual emergency, and scenarios, timings and attendees should be varied. After the drill, a debriefing (wash-up) meeting should be held with all participants to review the exercise and agree on follow-up actions for continuous improvement.

It should be remembered that the pressure of the water from tug firefighting monitors has the potential to cause injury or damage, not forgetting the stability implications of discharging large amounts of water into a stricken vessel's hold or similar space. Water used in firefighting may become contaminated when mixing with the cargo (type-dependent) and may become special / hazardous waste which requires careful discharge and treatment for disposal.

It is therefore important that training is provided to vessel crews. Training should be appropriate and may be conducted internally, jointly with external stakeholders, or via an external training provider.

The firefighting tug is a tool and without informed and trained crews, the vessel will be ineffective and potentially dangerous.

Initial training of tug crew for marine firefighting is necessary. However, the continued training and development in the field is of vital importance. Tug owners and managers should develop systems, together with their crew's induction / familiarisation sign-off and continuing drills / exercises of training. These layers of training are detailed below.

LAYERS OF TRAINING

a) **Baseline knowledge**

Mandatory firefighting training for ship crew (STCW Firefighting and advance firefighting courses, though these only cover internal firefighting on own vessel).

For fires on board LNG vessels the SIGTTO guide for response is strongly recommended.

b) **Tug Familiarisation**

Familiarity with equipment, location, and its operation. Starting and stopping monitors, directing of water with the monitors and adjusting spray characteristic, the operation of the foam system should also be covered.

Crews should be aware that when they are operating down-wind of a fire, smoke or other vapours may enter the air intake of the engine or air conditioning system.

Familiarisation with port authority and terminal emergency plans in areas where the tug operates.

c) **Onboard Training and Drills**
Tabletop exercises, use of monitors live, driving tug and holding position, understanding limitations.

Involvement in multi-agency / party training expected. To stress test communication, command and control and inter-agency coordination. Encounter real life problems and complications.

Standalone training offered by an external expert, for all stakeholders involved in responding to a fire for a particular terminal or area of operation, such as a port.

d) **Experiential Learnings**

Water Monitor Positioning

Learnings from recent incidents have uncovered that modern designed tugs typically locate fire monitors below or at the level of the wheelhouse. Traditionally they have been located on top or above the wheelhouse. The impact of the use of those monitors is that the arc of water may obscures the master’s view from the tug wheelhouse. In particular it has been found that judgement of depth may be difficult. A good proven solution is using a spotter tug or drone in communication to address this limitation.

Tug with monitors positioned above the wheelhouse

SOURCE: SVITZER

Tug with monitors at wheelhouse level

SOURCE: BOLUDA

SOURCE: TARGE TOWING

Example syllabus of an emergency response course:

- Command and Control
- Cannot put an oil fire out with just water
- Boundary cooling to maintain structural integrity of the vessel
- Tabletop exercises
  - Scenario planning
  - Implications to third parties
  - Environmental, pollution and wider knock-on impacts
- Foam (importance of)
- Overview of relevant marine emergencies
  - Fire on ships in port
  - Fire on terminals
  - Coastal and estuary incidents
- Cause of shipboard fires
- Tug use and positioning
- Monitor use – possibility and limitations
- Marine casualty removal from terminals/river
  - Bring vessel alongside
  - Helicopter evacuation
- Counter Pollution & Salvage
- Planned maintenance and use
- Use of exclusion zones
- Dangers of rushing in without preparation

The Importance and Necessity of Multidisciplinary (multi agency) Exercises in Port Environments - Aligned with JESIP Principles

In the highly interconnected and dynamic environment of ports, effective collaboration between multiple stakeholders - such as port authorities, terminal operators, tug services, shipping companies, fire and rescue services, police, and other emergency responders - is essential. Multidisciplinary exercises not only build coordination but also align these actors around common procedures and expectations. Integrating the JESIP principles for joint working into these exercises significantly enhances their effectiveness.
These joint exercises allow each party to understand their roles and responsibilities, identify potential gaps in communication and coordination, and test response protocols in a controlled setting. They simulate realistic scenarios - ranging from ship fires and oil spills to security threats and medical emergencies - helping all participants build mutual trust and improve interoperability.

Moreover, such training fosters a shared understanding of operational constraints and capabilities. For example, fire brigades can better understand the structure of a terminal, while port operators learn how first responders operate under pressure. This cross-sector insight leads to faster, more effective decision-making when real incidents occur.

Ultimately, multidisciplinary exercises are a critical investment in risk management, resilience, and continuous improvement. They transform siloed operations into a unified response system, capable of addressing the challenges of modern maritime logistics and port operations.

Integration of the JESIP Principles

Incorporating the JESIP principles of joint working into these exercises enhances the success of these exercises. These principles (Co-location, Communication, Coordination, Joint Understanding of Risk, and Shared Situational Awareness) provide a structured foundation for how different agencies can operate more effectively together during complex incidents. When embedded into multidisciplinary port exercises, each principle strengthens a specific aspect of the joint response:

1) **Co-location**
Bringing decision-makers together in a single location during an incident fosters better communication, faster decision-making and mutual understanding. In port scenarios, this might mean setting up a unified command post where fire commanders, police, terminal managers and port control work side by side during a drill or real emergency.

2) **Communication**
Using clear, jargon-free language and standardised reporting protocols, such as the M/ETHANE model, ensures that vital information is shared accurately and swiftly. This is crucial in port incidents where time is of the essence and where miscommunication can lead to delays or safety risks.

3) **Coordination**
Establishing clear roles, responsibilities and lead agency designations enables a coordinated and efficient response. For example, during an oil spill or onboard fire exercise, it must be clear who is leading, how resources are being deployed and how priorities are set and shared among agencies.

4) **Joint understanding of risk**
By jointly assessing and understanding the risks, all involved parties can better prepare and allocate resources accordingly. In port exercises, this means identifying shared threats, such as hazardous materials, vessel collisions, or fires and practicing joint mitigation strategies.

5) **Shared situational awareness**
A common operating picture, built from shared, up-to-date information, ensures all responders understand the scope of the situation and act in concert. In practical terms, during a live scenario, this might involve synchronised updates via joint dashboards or real-time briefings from a unified control centre.

6

Challenges and Risk Management

When faced with a firefighting scenario, it is essential that the tug crew avoid rushing into action. In situations where the tug is called upon to assist in firefighting, the master should take time to establish a line of communication with the vessel in distress and utilise all available information to formulate a safe and effective firefighting plan.

It is acknowledged that, in the urgency of the situation, tug crews may feel compelled to prioritise immediate action and aim to get water on the fire as quickly as possible. However, it is crucial that the tug master has a considered plan in place before making an approach, and that they are as well-informed about the situation as possible. The following should be taken into account before commencing firefighting operations:

COMMUNICATION PROTOCOL BETWEEN THE TUG AND THE VESSEL

- Establish clear communication between the firefighting tug (acting as the on-scene commander) and the vessel requiring assistance.
- Determine whether there is a point of contact on the vessel who can provide details about the incident.
- If there is someone available on the vessel or nearby, gather information regarding:
    - the presence and location of personnel onboard, and whether any internal firefighting efforts are underway;
    - the nature of the fire, including what is burning.
    - the extent of the fire, such as the size of a liquid pool, tank involved, or the spread of the fire;
    - any sensitive cargo, fuel bunkers, or personnel sheltered near the fire;
    - the navigational status of the vessel in distress (e.g., anchored, drifting);
    - any potential hazards that may affect the tug's operations.
- The firefighting tug should communicate its capabilities to the distressed vessel and outline the intended external firefighting strategy.
- Seek confirmation from the vessel in distress that they are requesting or willing to accept external firefighting assistance.

PLANNING THE FIREFIGHTING APPROACH

- A Risk Assessment, a dynamic Risk Assessment or Last Minute Risk Analysis (LMRA) must still be undertaken to consider risks, even when a transit it short
- Never approach a fire incident from downwind – assess the hazards presented by vapours, smoke, and so on.
- Develop a firefighting strategy based on all available information to maximise the safety and effectiveness of the operation. This should be done by OSC, Salvage master, Emergency response team leader. Be aware that this plan is a living plan, a Last Minute Risk Analysis (LMRA) is a constantly changing environment. Information will change, weather can change, incident can rapidly expand, and so on. This plan should consist of an offensive or defensive strategy and will maybe change several times during the incident. All of the participating ships should be aware of the strategy or changing strategy. These strategies should be a part of the training of tugs.
- Plan the tug's positioning for boundary cooling or the application of water/foam, taking into account the throw height and distance of the firefighting equipment in relation to prevailing weather conditions.
    - Ensure the tug remains in a safe location for the crew. This should include an appraisal of the prevailing sea state compared to the safe capabilities of the firefighting tug.

  - Because of the enormous amount of water/spray coming from the monitors, a correct visual effect of the water on the casualty by the operator of the monitors is almost impossible. Often it looks like the water is hitting the casualty but seen from a different position, the water never touches the casualty because of the distance or wind directions.
  - A spotter tug/drone should give advice and direction to the tug. Also, the adjustment of the water monitor should be advised by the spotter/drone, using a solid stream of water or adjusted towards a water mist/water-screen. The jet throw of a solid stream of water is a lot further then when the monitor is adjusted to a screen. Most of the time, the most benefits are achieved by a water mist combined with the wind, creating the largest area covering with water.
  - A solid beam of water directly applied on the casualty will cool down an area of approximately 16m^2, while a wind-driven water mist can reach up to 120m^2 effectively cooling down area. This should be practiced and recorded in reality during exercises. Showing the recordings in the AAR (after action review) will make it clear to crew and officers of the tugs.
  - Also combined exercises with different tugs, organisations, drone pilots, land-based fire fighters, offshore installations etc. should be done on a regular base.
- Predetermine the tug's positioning based on factors such as fire type, wind direction, the presence of smoke or gas clouds, navigational hazards, and an escape route for the tug if required. It is also dependent on whether an offensive or defensive approach is chosen.
- Test firefighting equipment before approaching the fire, including water monitors, water protection, and foam systems, as foam may take time to be properly discharged from the monitors. It is advised, if it's not in the standard protocol already, to test the following every day except for the foam appliance (because of the environment): the fire pumps, water flow, movement of the monitors, movement of the nozzles on the monitors and movement of the deflectors on the monitors.
- If multiple firefighting assets or tugs are involved, coordinate their efforts to cover protection, boundary cooling, and direct fire attack. It is important that everybody speaks the same language and has had the same training/education in advance.

Training for tug crews expected to participate in firefighting should include communication protocols and planning elements. Incorporate these aspects into onboard training, familiarisation, and drill scenarios to ensure readiness for actual firefighting situations.

OVERALL COMMAND

For incidents afloat, a Maritime Rescue and Coordination Centre (MRCC) will appoint a Search Mission Coordinator (SMC) to be in overall command of the incident. For vessels alongside, the local shoreside fire and rescue service will appoint an Incident Commander.

Preparation

In any incident, information on the nature and scale of the incident is likely to be minimal or confusing or both in the initial phase. Therefore, preparation will be key to a safe and successful response.

Unknowns

The terms "known unknowns" and "unknown unknowns" refer to different types of uncertainties and risks in decision-making, problem-solving, and planning, particularly in complex situations like military strategy, project management, or emergency response.

Known unknowns

- Definition: These are risks or factors that you are aware of, but you do not have enough information to fully understand them or predict their outcomes. You know that there is something you do not know, and you can plan or investigate further to reduce the uncertainty.

Unknown Unknowns

- Definition: These are risks or factors that you are completely unaware of and therefore cannot predict or prepare for. They represent unforeseen challenges or events that you did not anticipate because they were outside of your existing knowledge and experience.

Importance in Decision-Making:

- Known unknowns can be managed through contingency planning, research, and analysis. By acknowledging these uncertainties, you can develop strategies to mitigate their impact.
- Unknown unknowns are more challenging because they are not identified until they occur. These require flexibility, adaptability, and robust systems that can respond to unexpected situations.

CONSIDERATIONS WHEN TRANSITING TO THE INCIDENT

The transit time to reach the incident will vary from minutes to hours to potentially even days. This time should be used to prepare the vessel and equipment likely to be required and to brief the crew on their expected roles and duties.

- A Risk Assessment, a dynamic Risk Assessment or Last Minute Risk Analysis (LMRA) must be undertaken to consider risks, even when a transit it short.
- Never approach a fire incident from downwind – assess the hazards presented by vapours, smoke, and so on.

Firefighting tugs operating in harbour areas will not have a full at-sea crew. Therefore, they will have reduced capacity regarding tasks and duties which small tugs can safely carry out.

Crew numbers notwithstanding, preparations could include but are not limited to:

- Firefighting equipment:
  - Opening firefighting system valves in preparation for a system test
  - Checking and pre-positioning BA sets and air bottles
  - Donning fire suits (or at least boots and leggings) in case they may be required promptly
- Life-saving equipment:
  - Pre-rigging of person in water recovery systems
  - Ensuring that throwing lines are readily available
- First aid equipment:
  - Remove stretchers, medical oxygen and medical equipment from lockers nearer to where they will be required
- Communications:
  - Issue individual UHF radios
  - Ensure notepads and pens are readily available
  - Ensure that someone is designated as the scribe/recorder for all communications

Exclusion Zone

It is likely that there will be an exclusion put around the casualty/stricken vessel monitored by the MRCC, harbour authority or other authority. Before the attending vessel enters the exclusion zone, a system test of the firefighting systems should be carried out which includes:

- Monitors
  - Operating normally
  - Vertical and horizontal tracking
  - Spray and jet settings
- Vessel water spray operating
- Foam (if fitted) nozzles operating correctly on foam

The vessel should only enter the exclusion zone when:

- the firefighting system has been proven to be able to protect the vessel when near a fire
- the crew has been fully briefed
- once permitted by the MRCC or other authority

Statutory authorities

In the event of a serious casualty or a death during the incident, various statutory authorities such the Police, accident investigators and flag state may require logs from those involved.

Persons in Water

In any fire event, there is a high potential for persons to have entered the water and hence the need for recovery of persons from the water. For specific guidance on how to recover persons from the water from small vessels, please refer to the BTA's freely available Recovery of Persons in Water (PIW) Guide to Good Practice for Small Vessels, which is on the BTA website, www.britishtug.com.

Post Incident Management

Those involved in an incident may have been exposed to a Potentially Traumatic Event (PTE). HM Coastguard has established a Trauma Risk Management (TRIM) service to provide support and guidance.

Post Incident Counselling

Persons involved in firefighting or those recovered from the scene may experience psychological trauma and anguish.

In the case of recovery of persons from water or vessel, this is particularly true if the casualty is dead upon recovery or dies during post-rescue support. This is a normal psychological response for the rescuer; it is also normal to have minimal psychological trauma following such events. Each person's response may vary from incident to incident, and different people will have different responses.

Operators should ensure that all crew members have access to suitable support after the event. This may be through facilitated debriefs and referral to external healthcare professionals if required.

7

Command and Control

Command and Control in incident management refers to the structured approach used to coordinate response efforts, allocate resources, and make critical decisions during an emergency. It ensures that all responding parties work together efficiently under a clear chain of command to manage the situation effectively.

Key Components of Command and Control in Incident Management:

1) Command structure and leadership
    - Establishing clear authority: Defines who is in charge and the hierarchical chain of command.
    - Incident Command System (ICS): Many maritime and emergency response operations use an ICS-based framework, where roles such as Incident Commander (IC), Operations, Logistics, Planning, and Communications are clearly assigned.
2) Communication and coordination
    - Centralised decision-making with decentralised execution ensures that frontline teams can act efficiently while following the strategic objectives set by the command team.
    - Inter-agency coordination: Ensuring seamless communication between different responders such as firefighting tugs, port authorities, coast guard, fire brigades and salvage teams.
    - Real-time information flow: Sharing situational updates across all levels of response.
3) Situational awareness and decision-making
    - Gathering and analysing data: Understanding the evolving threat, risks and resource availability.
    - Prioritisation of actions: Deciding on immediate actions to contain the incident, protect lives and minimize damage.
4) Resource allocation and logistics
    - Deploying available assets effectively, including firefighting tugs, rescue boats, aerial surveillance or emergency medical teams.
    - Managing support services such as fuel, supplies, and personnel rotation during prolonged incidents.
5) Risk management and adaptability
    - Evaluating ongoing risks (e.g., structural integrity of a burning ship, hazardous material exposure).
    - Adjusting strategies as conditions change – A dynamic response is critical in rapidly evolving maritime emergencies.

First Asset On- Scene

First Asset On-Scene will normally assume the role of On-Scene Coordinator (OSC).

The safety and recovery of persons - in the water or in life rafts will take precedence over firefighting. Once any persons in the water have been recovered, a 360° assessment (or as much as possible) should be conducted of the state of the casualty for inclusion in the first SITREP to the SMC or IC.

OSC duties

The duties of the OSC are to:

- Coordinate operations of all responding assets which include:
    - Coordination of the firefighting response
    - Management of persons-in-water response
    - Coordinate on-scene communications such that there is ideally a single communication channel with the MRCC or Incident Command
    - Provide relevant information to the other responding assets
    - Monitor the performance of participating assets
    - Ensure that operations are conducted safely including ensuring that there is safe separation of individual assets which may include air operations

- Make periodic situation reports as required by the MRCC or IC
- Start and maintain an accurate of log the operation which may include:
    - On-scene arrival and departure of the responding assets
    - Actions taken
    - Results of actions
- Advise the SMC or IC to release assets on-scene as required
- Report location(s) and number of survivors
- Request additional SMC or IC assistance as and when necessary

On-scene Communications

Typically, the SMC or IC will select SAR-dedicated VHF radio frequencies for use on-scene and inform the OSC and other assets accordingly.

Coordinate operations of all responding assets which include:

- Coordination of the firefighting response
- Management of persons-in-water response
- Coordinate on-scene communications such that there is ideally a single communication channel with the MRCC or Incident Command
- Provide relevant information to the other responding assets
- Monitor the performance of participating assets
- Ensure that operations are conducted safely including ensuring that there is safe separation of individual assets which may include air operations
- Make periodic situation reports as required by the MRCC or IC
- Start and maintain an accurate log of the operation which may include:
    - On-scene arrival and departure of the responding assets
    - Actions taken
    - Results of actions
- Advise the SMC or IC to release assets on-scene as required
- Report location(s) and number of survivors.
- Request additional SMC or IC assistance as and when necessary

OSC Communications with the MRCC

The OSC uses SITREPs to keep the SMC or IC informed of on-scene mission progress and conditions and addresses SITREPs to the SMC unless directed otherwise. Other on-scene assets use SITREPs to keep the OSC informed.

COMPANY OWN COMMAND & CONTROL

Companies need to ensure that their safety management system (SMS) has robust procedures to cover the emergency response to provide marine firefighting, which must include the local command and control arrangements.

In a marine firefighting event, care should be taken not to distract those engaged in firefighting operations. Tug crews should be familiar with local emergency procedures in the area where they are regularly working.

UK FIRE & RESCUE SERVICES

With 11,000 miles of coastline and over 120 large commercial ports, UK Fire & Rescue Services have a responsibility to assess and understand best practice in their approach to incidents in the marine environment, depending on their geographical location.

Incidents involving vessels in the marine and inland waterway environment are not commonplace for fire and rescue services and they can be complex to deal with, ranging from incidents involving small vessels to large sea-going vessels, and can include military vessels.

If a casualty vessel is situated outside of the statutory responsibility (i.e., offshore, mid-stream, mid-lake, outside 'the area' defined under the Fire Services Act 2004 (FRSA)) it must be recognised that the casualty vessel may eventually come alongside and become a statutory duty of the relevant fire authority.

Fires in vessels moored alongside form part of statutory duty under the Fire and Rescue Services Act 2004. Fire Services must make provision for extinguishing fires, protecting life and property in their area. This requirement includes vessels and structures that are secured to the shore. This means that the Fire and Rescue Sector has a duty to respond to incidents on vessels moored or tied up alongside. A liaison officer between the ship (casualty) and the Fire Services should be appointed, to assist the land-based Fire Service during the incident as a translator for the maritime language, fire plans, GAs, and so on.

Making use of local assets, including port authorities and firefighting tugs to support actions and resolve the situation are a key part of the incident management process. Maritime incidents can evolve quickly, involve many organisations (both commercial and regulatory), and take many days, weeks, months and even years to resolve, potentially resulting in a complex response.

The scale of these incidents will depend on the size of the vessel, the ambient environment conditions (sea state, temperature, tides and direction of current and weather), the amount and type of pollutant (for example, different types of oil behave very differently in water), the number of environmentally sensitive receptors and their proximity to point of release causing the pollution. The socio-economic and environmental impacts of any marine incident could be enormous, as well as being very visible and publicly emotive.

To safely extinguish a fire onboard a vessel alongside, the Fire Service Incident Commander must have access to all relevant information. To enhance situational awareness, a full scene survey of the incident should be carried out at the earliest opportunity. This may require using other vessels or resources to assess the incident such as Port Authority vessels (e.g. tugs or pilot vessels).

If the operational plan to resolve the incident requires firefighting or boundary cooling to be carried out from the water, it would be preferable to use a support vessel with dedicated firefighting capability where available.

The support vessels' and crews' capabilities should be appropriate to the weather and sea conditions. It may also be possible to appoint an on-scene commander to a vessel to assist with the scene survey.

Placing a fire service representative or firefighting crew on the tug will enable a clear line of communications back to the Fire Service Incident Commander (FSIC) to support the operational plan.

Where firefighting tugs form part of a joint incident response to a vessel alongside, the FSIC bears responsibility for the use and location of water for firefighting. This decision-making process will be carried out working in partnership with the tug, vessel's master and all relevant stakeholders.

The provision of vessels for incident support may be covered by:

- a local agreement;
- mutual aid;
- a memorandum of understanding (MoU), for example with port or harbour authorities;
- a contractual agreement with private salvage or tugboat companies.

It is imperative that tug operators refer to their Statutory Harbour Authority's (SHA) emergency response plan to understand local firefighting resources.

Fires on Vessels Outside a Statutory Harbour Authority area

The approach when dealing with a fire occurring outside of harbour authority waters will probably be quite different. It is likely that the situation may be passed over to salvors unless the casualty is ultimately to be brought into SHA waters.

Seaborne Transportation for FRS personnel

There may be occasions whereby a support vessel is required for the seaborne transportation of firefighters to enable waterborne emergency operations. The type and seaworthiness of the vessels required for these operations in varying sea state conditions is paramount for the safety and welfare of teams. The vessels must afford all the identified facilities to perform the required functions that are necessary for these types of emergency operations.

The FRS cannot provide or maintain these methods of transport and therefore are reliant upon outside providers to supply the specific needs required.

The use of vessels for the transportation of firefighters raises various Health & Safety issues regarding:

- Suitability of type and design
- Training
- Standard operational procedures
- Emergency procedures and drills
- Personal protective equipment

There is a requirement under Health & Safety at Work Regulations to provide a safe working environment in relation to the above points.

For FRS purposes the definitions of a safety vessel and support vessel are:

Safety vessel

- A dedicated, on-scene vessel used to provide an exit strategy in the event of evacuation from a casualty vessel.

Support vessel

- The primary function of a support vessel is to provide a safe location for the evacuation of firefighters from the casualty vessel and the provision and ability to transport personnel, large heavy quantities of equipment and a secondary supply of firefighting water.

The facility of providing secondary firefighting water is important should the casualty ship's fire mains become inoperable or additional volume be required to contain the incident.

ROLE OF THE HARBOUR MASTER – RESPONSIBLE WITHIN PORT JURISDICTION

The precise response and levels of control may vary depending on the harbour's location, but as a general rule the harbour master will be responsible for the management of any emergency response in accordance with the port's contingency plans. The harbour master will be ultimately responsible for the port's response within their area of jurisdiction and will also be part of the tactical response and will liaise with the fire service, police, salvors and other agencies.

Fires on Vessels Alongside

When looking at shipboard fires, there are a number of considerations, some of which are listed below:

- What is the type of fire and its location on board?
- Is the vessel carrying any dangerous cargo?
- Is the berth that the vessel is located easily accessible by shore-based firefighting response?
- What other vessels and areas of concern are near the vessel that is on fire?
- Are there any casualties or additional issues such as pollution?
- Is the vessel at risk of sinking?

This is not a finite list and other challenges may present themselves as the incident develops.

Firefighting requirements in the port will have been determined by risk assessment, and firefighting capable towage may be part of the risk mitigation. If so, the towage operator must be involved in the development of any contingency plans, setting out the tug's capabilities. The tug crew should be familiar with and test their firefighting capability at regular intervals. They should be exercised and involved in multi-agency exercises.

Whilst engaged in firefighting operations, the crew should follow planned procedures and take direction from the harbour master as incident controller. However, the tug master will remain in charge and responsible for their own vessel and crew safety and should ensure that they can carry out what is required in a safe manner, protecting themselves at all times.

Fires on Vessels at Sea

Within the UK, the FRS will not go onboard vessels at sea to fight fires. Tugs may be requested to undertake firefighting duties within port jurisdictions. As with the above, any requirement will be set out in the port's contingency plans agreed beforehand. In the event of a fire onboard a vessel at sea, the harbour master will direct assets as per the contingency plan. They may also consider directing a vessel to a specific location to mitigate against further pollution or to allow easier access by the FRS. This will depend on a number of factors such as type of fire, location in relation to other vessels and hazards or risk of the situation worsening, for example sinking.

The priority in the response to a ship fire will always be the preservation of life. Firefighting efforts may therefore be used to contain fires to achieve that objective rather than to completely extinguish the fire.

SOSREP – COMMAND & CONTROL OF INCIDENTS

During maritime incidents in UK waters and the UK Exclusive Economic Zone (EEZ), the Secretary of State's Representative for Maritime Salvage and Intervention (SOSREP) represents the Secretaries of State for Transport (relating to ships) and for Energy Security and Net Zero (relating to offshore installations). The overarching aims of the SOSREP's engagement in maritime accidents are the removal or reduction of the risk to safety and the prevention or mitigation of marine pollution to the environment and property. Powers of intervention are delegated to the SOSREP to meet these aims.

The delegated intervention powers available to the SOSREP are derived from UK statute. The powers are available within the limits of UK territorial waters for safety issues. For pollution from shipping, the powers apply to both territorial waters and the UK EEZ. For pollution incidents from offshore installations and associated infrastructure, the powers can be applied inside the UK Continental Shelf (UKCS) limits.

The SOSREP is also authorised to approve or deny requests for places of refuge for vessels in need of assistance. Furthermore, the SOSREP is empowered to direct the removal of shipwrecks in UK waters and the UK EEZ. Decisions in relation to the above issues are based on close stakeholder engagement with, among others, environmental regulators, General Lighthouse Authorities, other government departments, and so on. Inside the area of responsibility of a SHA, the harbour master has responsibility for the safety of navigation via the Port Marine Safety Code. A harbour master will be able to deal with the majority of incidents inside their area of responsibility. In the event of a serious casualty which exceeds the capabilities of a port or harbour, the SOSREP may support the harbour master following discussion and agreement between both authorities.

All parties, responding to an incident inside a port area or where the incident will have an impact on both the land and the sea, will have to be mindful that the response arrangements are distinctly different and all responders will have to co-operate. Where commercial salvors and firefighting vessels become involved in the response, they will require close guidance as they are unlikely to fully understand the local arrangements.

Whether a tug has been engaged on commercial terms or under emergency response arrangements, the SOSREP will work with casualty vessel owners, insurers, salvors (whichever is applicable) to help coordinate the response. This will consider local requirements and the potential for wider implications and unintended consequences.

DEBRIEFING

Hot Debrief

Following the stand down issued by the SMC or IC, there will be a hot debrief. The master will debrief the vessel's crew and in turn debrief the SMC with all assets involved. This is usually done in person, however, given the various circumstances of vessels and the time taken to get back to their berth, this may be done by telephone between the master of each vessel and the SMC.

The main elements of the hot debrief will be:
- What went well?
- What can be improved?
- What can be learned?

The hot debrief should be documented and lessons learned shared with appropriate persons and organisations as permissible.

Cold Debrief

There should be a cold debrief after the incident, normally no later than a month. This should include all those involved to better reflect on the incident. This debrief will be more formal with meeting notes and outcomes disseminated to various authorities.

Reporting

The National Contingency Plan (NCP) for dealing with maritime pollution incidents was developed to clearly identify roles and responsibilities of the many organisations that may become involved in an incident response. Local plans should take account of the national response and be able to come together into the NCP arrangements. An immediate response to reported marine pollution or a risk of significant pollution is important. Incidents at sea should be reported urgently to HM Coastguard (HMCG) at an MCA Maritime Rescue Coordination Centre (MRCC).
If an incident occurs in a harbour, it should be reported to the harbour master who will inform an MRCC.

MRCCs act as coordinators during incidents and circulate all pollution or situation reports to the Marine Management Organisation (MMO) for English waters. In Scotland, those are sent to the Marine Directorate, in Wales to Natural Resources Wales and in Northern Ireland to the Northern Ireland Environment Agency.

Copies are also sent to national and regional statutory nature conservation agencies, and local councils that may be affected by the pollution event.

Stakeholders seeking engagement with the SOSREP should, in the first instance, contact HM Coastguard at an MRCC who will put them in contact with the organisation's Duty Counter Pollution and Salvage Officer (DCPSO).

Tugs may use water monitors to disperse minor oil spills to help break down the pool.

PHOTO CREDIT: ANDY AMOR

Stakeholder Engagement & Communications

Towage operators have various stakeholders within their operations, from shipping agents and customers to port authorities and regulators. The provision of firefighting support may be established through contracted services or at the request of a stakeholder. It is therefore important to ensure that stakeholders, particularly local stakeholders, fully understand the capabilities and limitations of tugs and crews. The presence of firefighting monitors on a tug may lead to false conclusions regarding the tug's firefighting capabilities.

Equally, where towage operators form an integral part of a port authority's emergency response plan, the port should not only be aware of the tugs' firefighting capabilities and limitations, but also of its ability to provide emergency towage services.

Fire & Rescue Commanders may expect the tugs to "do nothing" before they arrive on scene to control the incident. Tug operators should be aware however that the local public will see them testing their firefighting monitors on a regular basis and should they observe a terminal or ship fire and tugs sitting at buoys doing nothing, it will be perceived poorly as well as irresponsible. Tugs must respond and even just test their monitors; better still, boundary cool safely.

Media Engagement

Major incidents are likely to attract significant interest from the media. Companies should have processes in place for dealing with the media. All enquiries should be directed to an appropriately trained press representative who will act as a single point of contact for all media requests and no other employee should respond to or engage with the media. It is important that staff at all levels and in all departments, are aware of this process.

Publicly available telephone numbers may connect media representatives directly with operations coordinators or other response personnel. Those individuals will therefore be mindful of this possibility and should take care with whom they share a situational update on the telephone. Although the importance of the media's role is acknowledged, it is equally important the information provided is accurate and based on facts alone.

Some companies may wish to consider contracting the services of Crisis Response Specialists to manage the media response to incidents. Those specialist services provide a transparent and timely response to public and media interests whilst minimising any risk of reputational damage. In addition, these firms can provide media training on how to respond appropriately during the pressure of an incident.

Furthermore, from the outset of a large-scale incident, the MCA may establish a Crisis Media Team. One of the team's roles is to liaise on behalf of MCA and the SOSREP with the press and other government press offices, for example Department for Transport. Therefore, no information should be provided to the media by the company on behalf of the MCA and requests should be referred to the MCAs press office.

Lessons from a PR expert:

- Do not say "That's not an Exxon Valdez situation out there" because the public will only hear "Exxon Valdez" and nothing more and panic.
- Leave PR to the professionals unless specially trained.

8

Firefighting

'Rushbrook's Fire Aboard' (1979)

> *It is a surprising fact that even today, millions of years after the discovery of fire making, water is still the most effective medium for fighting fire. There are, of course, new extinguishing agents available for specialised risks, but, basically, water still reigns supreme.*

EXTINGUISHING FIRES

Tugs may be called to assist with scrap or dry-dock fires as much as fires on board other vessels

PHOTO CREDIT: TARGE TOWING

Even fires on small vessels can produce large volumes of smoke and vapours. Approach upwind and with care.

PHOTO CREDIT: NICK JEFFERY

Preparation is Essential

For firefighting tugs attending a fire, whether conventional or alternative fuels and cargoes, the crew should have the correct personal protective equipment, breathing apparatus and equipment to safely address the hazards. Operators should refer to specific expert guidance on what the requirements and recommendations may be, and all aspects should be dynamically assessed to maintain crew safety at all times.

Expanding on the principle of "not rushing in" before and in attempting to extinguish a fire or provide boundary cooling, planning is vital. The following subjects should be assessed:

- Wind direction and safety of approach / escape to location where monitors can be effectively used. Approach should ideally be made from upwind not just for protection but for accuracy of water/foam jet, not being affected by a cross wind.
  - **Note**: Vessels adrift generally lay beam to the wind, vessels at anchor keep their head to it.
- Detail and properties of the burning material(s) and burndown rate can be assessed to determine the estimated duration of the fire. It may be most effective to boundary cool and allow substances to burn off, particularly for highly volatile liquids.

HYDROCARBON FIRES

Use of water to boundary cool

Boundary cooling is a vital firefighting technique used to control and/or prevent the spread of fire by applying water to the external surfaces of compartments, tanks or cargo adjacent to the source of a blaze. On ships, where compartmentalisation is a critical fire containment measure, boundary cooling helps to reduce heat transfer through steel bulkheads.

This supports the protection of structural integrity and mitigates the risk of fire propagation.

Use of Tugs for Boundary Cooling

If firefighting tugs are equipped with FiFi-I classified pumps and monitors, they are capable of delivering large volumes of water over extended distances. These monitors are key tools for boundary cooling, enabling the application of water to hull, superstructure surfaces and cargo in close proximity to the fire.

Cooling effectiveness is influenced by:

a) Water flow and pressure:

The cooling effect is determined not only by the overall capacity of the firefighting system, but more importantly by the amount of water that actually reaches the intended target. This includes:

- **Direct cooling**: Water that makes physical contact with heated surfaces near or at the site of combustion.
- **Indirect cooling**: Water that reaches surrounding structures affected by radiant heat, such as adjacent steel bulkheads or decks.
  Factors such as distance, spray pattern, wind drift, and sea conditions all affect how much water ultimately contributes to cooling. High pressure and well-aimed flow increase the likelihood of effective thermal absorption.

b) Coverage and duration:

Effective boundary cooling depends on both how much of the surface area is consistently reached (coverage), and for how long the cooling effort is sustained (duration).

- Coverage refers to the ability to distribute water evenly over all exposed or critical surfaces. Incomplete or uneven coverage can leave hotspots where heat continues to build up.
- Duration is critical because boundary cooling is not a one-time intervention - continuous or regularly repeated application is required to maintain reduced temperatures and prevent re-heating due to residual thermal conduction.
  Sustained cooling helps prevent fire spread, protects structural elements, and allows onboard crews or other assets time to suppress the source fire.

c) Surface insulation:

Cooling is most effective when the water comes into direct contact with exposed steel surfaces. Where insulation or cladding is present, the water may be unable to absorb heat effectively from the underlying structure. In such cases, the thermal barrier slows heat transfer, but it also limits the cooling benefit of external water application.

Cooling capacity of water on steel

Water's high specific heat capacity makes it especially suitable for absorbing heat from heated steel surfaces. When applied, it removes thermal energy, reducing temperatures and preventing the transfer of heat to adjacent compartments.
This process:

- slows or halts fire spread;
- helps retain the vessel's structural strength;
- prevents deformation or collapse of structural elements.

Water application: FiFi-I capabilities in practice

1) Flow rate guidelines

Two general application rates are used in fire scenarios:

Exposure type	Recommended flow rate
Radiant heat only	4.0 L/min/m²
Direct flame impingement	12.0 L/min/m²

A FiFi-I tug with two monitors delivering a combined output of up to 40,000 L/min can, in theory:

- Cool up to 5,000 m² under radiant heat conditions
- Cool approximately 1,600 m² under flame impingement

2) Operational realities

These calculations are theoretical. In real-world deployments, effectiveness is constrained by:

- Sea and weather conditions
- Manoeuvrability and safety margins
- Fire intensity and location
- Vessel/cargo geometry (e.g., freeboard, container height, etc)

Consequently, actual application and monitor positioning are determined through an operational risk assessment, often conducted by the tug master in consultation with the incident commander and ship's crew.

Strengths and limitations of FiFi-I tugs

Strengths

- High-volume water delivery capacity.
- Continuous and adjustable water output.
- Valuable for boundary cooling and structural protection during (early) fire suppression.

Limitations

- Limited monitor elevation: Monitors typically have a vertical reach of ~45 metres, which may be insufficient for reaching higher superstructures or elevated deck equipment on Ultra Large Container Ships, cruise ships, or large RoRo carriers.
- Horizontal range constraints: With a theoretical range of ~120 metres, actual effectiveness depends

heavily on positioning, which can be restricted by sea state, proximity to hazards, and ship manoeuvrability.
- Sea and weather sensitivity: Wind, swell, and vessel movement can cause spray dispersion, reduce water accuracy, and limit cooling coverage.
  - Stability limitations: In open sea, FiFi-I tugs may be unable to maintain a steady position for prolonged periods, especially when exposed to wind or when operating beam-on to heavy swell.
  - Limited tactical flexibility: Monitors are fixed in elevation and rotation range. They may not be able to cool lower or obstructed parts of the hull without repositioning the vessel — something that may not be possible under dynamic fire conditions.

Avoiding Water Ingress

While boundary cooling is crucial, uncontrolled ingress of water into a vessel can pose severe risks:

1) Stability risks
- The free surface effect reduces the metacentric height (GM), potentially destabilising the vessel.
- Water accumulation can cause listing or capsizing.

2) Structural overload
- Heated steel weakens quickly.
- Water accumulation may lead to deck collapse.
- Bulkhead pressure may exceed structural limits.

3) Loss of buoyancy
- Water below the waterline may compromise buoyancy.
- Damage to bilge systems exacerbates this risk.

Best practices to prevent water ingress
a) Controlled application
  - Avoid spraying into open hatches, vents, or intakes.
  - Focus on external cooling.
  - Use thermal imaging to optimise water usage.

b) Drainage awareness
  - Activate bilge pumps where possible.

c) Crew coordination
  - Maintain close communication with ship crew.
  - Confirm closure of watertight compartments.
  - Adjust strategy based on real-time water accumulation and structural conditions.

Boundary cooling using tug monitors is a powerful tool, particularly during the early phases of a shipboard fire. When applied with strategic intent, technical understanding, and operational coordination, it plays a decisive role in limiting fire spread, protecting critical ship infrastructure, and buying time for additional response measures.

Hydrocarbon Fires Extinguishment

A hydrocarbon fire requires foam to be extinguished. Specific volumes of foam are required depending on the fire and tug crews' need to be proficient in calculating the required volumes and techniques required for effective application.

The calculation should be made to determine the required foam concentrate and the minimum duration of application to ensure the fire is fully extinguished and reignition is prevented. Several factors must be considered, including the size of the burning area, the type of foam concentrate, the foam application rate, and the duration for which the foam needs to be applied.

Prior to approaching the position to deploy the foam, the monitors and foam eductor system should be tested while at safe distance, as well as water spray protection being activated if fitted.

A plan should be made on how to apply the foam indirectly through soft application or roll-on-method, i.e. by aiming for a tank bulkhead or the ship's side above or adjacent to the liquid pool, to allow the foam to flow down and create a blanket over the burning material. Hard application directly on to fire can be carried out, if other options are not available, allowing the foam to pool out from application point.

The US National Fire Protection Association (NFPA) (Issue 11: 2024) provides basic guidelines for calculating foam requirements.

1) **Determining the Surface Area** in square metres (m^2).

2) **Foam Application Rate**: NFPA 11 specifies the application rate of foam in litres per minute per square metre ($I/min/m^2$), depending on the type of fuel and the risks involved.

3) **Concentration of the Foam Agent**: The concentration of the foam agent (usually expressed as a percentage) is critical to ensure the effectiveness of the foam. This depends on the type of foam being used.

4) **Duration**: NFPA 11 recommends a minimum duration for the application of foam to ensure the fire is fully extinguished and reignition is prevented.

Application rate (multiplied by surface area to give pre-mix litres per minute)

1. Fixed installations 4 l/min/m^2
- Mobile installations 6.5 l/min/m^2
- Large distances 10.4 l/min/m^2 (tug monitors with foam)

Capacity of monitors

- Pre-mix of 3%
    - 600 m^3/h monitor = 300 litres of foam concentrate per minute
    - 1200 m^3/h monitor = 600 litres of foam concentrate per minute

- Pre-mix of 1%
    - 600 m^3/h monitor = 100 litres of foam concentrate per minute
    - 1200 m^3/h monitor = 200 litres of foam concentrate per minute

Foam Application Time

- Shallow spill non bunded = 15 minutes
- Shallow pool bunded = 30 minutes
- Liquid pool with flashpoint > 35 degree C = 50 minutes
- Liquid pool with flashpoint < 35 degree C = 65 minutes

Worked example:
Liquid pool fire with surface area of 18 x 44 meters, using 1x1200 m^3/h monitor with 3% premix foam:

- Surface measures: 18m x 44m = 792 m^2
- Application rate premix: 792 x 10.4 = 8.237 l/min
- Based on 3% foam concentrate = 247.1 l/min foam required
- Foam application time: 65 minutes x 16,062 litres of foam required.

In real world scenarios foam may be lost during application due to wind and burn back effects. This may result in between 10-45% additional foam concentrate needed above calculated requirement. Furthermore, the flow of the water may have an effect on the type of application. Different applications can be used, depending on the situation for example, rain on, direct, indirect, roll on.

Producing such a calculation in the heat of a real-life situation is a skill which should be incorporated into drills.

Mobile applications exist to help simplify this calculation, such as H2K foam calculator (as shown below).

SOURCE: APPLE STORE

ALTERNATIVE FUELS

In 2018 at its 72nd session, the International Maritime Organization's (IMO) Marine Environment Protection Committee (MEPC) adopted the Initial IMO Strategy on reduction of greenhouse gas (GHG) emissions from ships. In 2023, at the 80th session of the MEPC, it adopted the Strategy on Reduction of GHG Emissions from Ships.

The 2023 Strategy set out the revised level of ambition for the sector to reach net zero GHG emissions by or around 2050, with accompanying indicative checkpoints in 2030 and 2040. It was recognised that one approach to direct the 2023 Strategy would be to increase the uptake of zero or near-zero GHG emission technologies, fuels and/or energy sources (as distinct from traditional bunker fuels).

In the interim, however, it is recognised that to enable an equitable and global transition towards decarbonisation, transition fuels have a key role to ensure the continued running of the industry until such time that greener alternatives are commercially scaled for larger and smaller operators.

This strategy will require the introduction and use of low, or zero, carbon fuels across the maritime industry. All of these have their own challenges from a firefighting perspective, with some already well known to the maritime industry, for example the bulk shipping risks and firefighting challenges for LNG are well known, with terminals and tugs trained and equipped for emergency situations.

The shipping industry already has a strong safety record for the safe carriage of these products on specialist vessels as cargo, but new risks are emerging when considering their wider use as energy sources across the global fleet.

As the adoption of these fuels expands across the industry, vessels using them for propulsion will become more common in port areas. While tug vessels and their crews are not necessarily designated as firefighting tugs, many possess some firefighting capabilities. It is reasonable to assume that the port authority would request assistance from harbour tugs operating within the port to aid a vessel in distress. In this section, we consider the emerging alternative fuels in the maritime sector, the challenges they present, and the currently known firefighting systems. This information will help tug operators and crews incorporate awareness training, risk assessments, and operational procedures into their safety management systems, preparing them to assist an alternatively fuelled vessel in distress if required.

Alternative Fuel Types

- Batteries
- Liquefied Natural gas (LNG)
- Liquefied Petroleum Gas (LPG)
- Methanol
- Ethanol
- Hydrotreated Vegetable Oil (HVO) & Fatty Acid Methyl Esters (FAME)
- Ammonia & drop in fuel
- Hydrogen (liquid vs gaseous)
- Nuclear

As of May 2025, according to Clarkson's World Fleet Register 2,224 vessels in the global fleet, 2% were alternative fuel capable in addition to an order book of 1,991 vessels, representing 52% of the tonnage in the global orderbook.

Liquid Volatile Organic Compound (LVOC) fuelled crude tanker

PHOTO CREDIT: ANDY AMOR – FAWLEY, SOUTHAMPTON

ALTERNATIVE FUEL TYPES & FIRE HANDLING

LNG and LPG Fires

A liquefied gas release (LNG or LPG) will initially form a vapour cloud that behaves differently depending on the gas. LNG vapour, being initially denser than air due to its low temperature, will warm and become lighter than air, rising and dispersing upward. On the other hand, LPG vapour is heavier than air and will initially spread along the ground before dispersing laterally as it warms up. Both vapours will move with the prevailing wind, mixing with air until they are either diluted to a point where they are no longer flammable, or they ignite upon contact with a source of ignition.

It is strongly recommended that any tug operating at an LNG or LPG facility should refer to the Society of International Gas Tanker & Terminal Operators (SIGTTO) publications for "Support Craft at Liquefied Gas Facilities, Principles of Emergency Response and Protection – Onshore and Offshore". This section of the guide has been written referencing the above guides, using the same terminology and methodology to allow the guides to be used in combination.

LNG can be found aboard vessels as either a cargo being carried in bulk, or as fuel for means of propulsion of the vessel, or both. The discussed methodology of LNG is also applicable to LPG.

The hazard to the firefighting tug is the presence of a dangerous substance with the potential to create damage to human health and/or environment and property.

When liquefied gas is being transported, contained within its tanks and pipelines, the situation is safe and does not pose a risk. It is generally only in the event of a loss of containment that liquefied gas becomes a hazard.

The main hazard associated with LPG and LNG vapours is their flammability. There are further hazards of LNG and LPG related to the low temperature and pressures at which they may be carried. LPG may be carried at ambient temperature in pressurised tanks, however LNG is always carried at low temperatures, even in pressure tanks, as it does not remain liquefied at ambient temperatures.

Boiling Liquid Expanding Vapour Explosion (BLEVE) is an explosion caused by the rupture of a vessel containing a pressurised liquid, such as LNG, which has been heated by an external source (typically a fire) to a temperature sufficiently higher than its boiling point. The heat source causes the pressure inside the vessel to rise and gas is vented through the pressure relief system to maintain pressure. If the fire is intense enough, the pressure relief system may not be able to vent gas quickly enough to maintain safe pressure levels, leading to a potential rupture.

The rupture of the tank results in the rapid expansion of gas, which can create a fireball and high-velocity missile hazards. The failure process can be accelerated if the flames impinge on areas where the LNG has vaporised into gas, as the lack of liquid cooling in these areas allows the temperature to rise more rapidly, weakening the steel structure and leading to faster rupture.

While BLEVEs are major events with the potential for widespread impact, they generally take time to develop, particularly in insulated tanks such as those used for LNG, which slow the heat transfer. This provides a window for emergency responders to cool the vessel, extinguish the fire and/or evacuate the area. The potential severity of the BLEVE is influenced by the type of tank, the intensity of the fire, and the rate at which pressure builds up within the tank.

Further reading: SGMF Recommendation of Controlled Zones during LNG Bunkering section A7

Rapid Phase Transition (RPT) is an explosive boiling phenomenon that occurs when liquefied natural gas comes into contact with water at a temperature significantly higher than that of the LNG. This rapid phase change leads to a physical explosion, not involving combustion, but rather the sudden release of energy as heat is transferred from the warmer water to the LNG. The temperature difference between the LNG (around -162°C) and the water can vary, but it must be sufficient to cause the LNG to vaporise violently, creating a powerful shockwave.

Loss of containment

The primary hazard to the firefighting tug arises from LNG, as it is both highly flammable and stored at very low temperatures. While propane is also hazardous, LNG presents a more immediate threat due to its extremely low storage temperature of -162°C, which can cause asphyxiation, brittle fracture of steels and the potential for explosive releases if containment is lost.

The characteristics of a gas release are different depending on the pressure, which will affect the consequence. Most LNG carriers carry their cargo at atmospheric pressure, with the LNG being pressurised when being transferred and during cooling down operations. If gas or liquid gas is released to the deck or the water around the vessel, there is a danger to tugs providing assistance to the vessel.

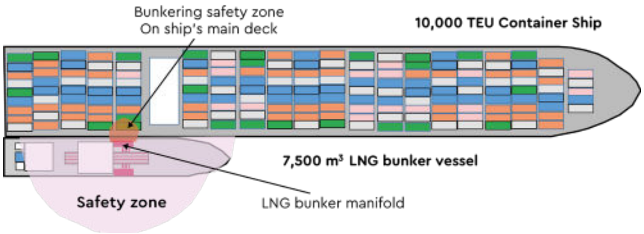
According to SGMF guidance, the “safety zone” is specifically defined as the area within which there is a recognised potential for harm to life or damage to equipment/infrastructure due to a gas/LNG leak. The size of the safety zone is temporary and directly linked to bunkering operations. The zone must be controlled by the Person in Charge (PIC), and its size depends on various factors, including:

- Design and configuration of the LNG bunkering infrastructure
- Flow rate, pressure, and inventory of the LNG involved
- Weather conditions, ambient temperature, and location layout

For a liquid LNG release the size of the resulting gas cloud would depend on several critical parameters, particularly the flow rate, pressure and environmental conditions. SGMF guidance suggests that bunkering scenarios and safety distances should be defined prior to the first operation, considering all relevant variables, rather than relying on generic models or estimates that may not account for local conditions or specific bunkering setups.

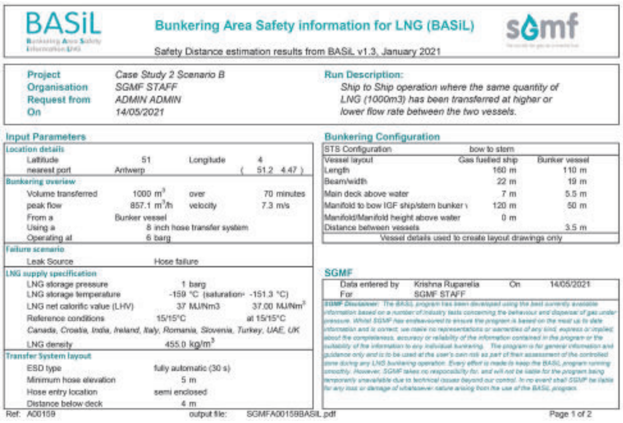
The safety zone should be carefully assessed before each bunkering operation and verified by the PIC, in consultation with the port/terminal owner and competent authorities. This includes using specific risk assessments to calculate the appropriate distances based on the infrastructure, gas transfer systems and other operational factors. Furthermore, the safety distances must fall within the operating/bunkering permit issued by the competent authority and the area should be controlled through proper access restrictions, training and contingency planning.

To ensure that safety measures are adequate and aligned with SGMF recommendations, it is critical that the actual safety zone and leak dispersion calculations are validated using scenario-specific modelling, rather than relying on generalised estimates that might lead to over- or underestimation of the risk.



SOURCE: SGMF

SGMF has developed a tool called BASiL where users can input their specific bunkering scenario. This will then calculate the potential failure situation and provide distances around the leak source to be considered as the safety zone. The example below calculated the safety distances.



BASiL

Bunkering Area Safety information for LNG (BASiL)

Safety Distance estimation results from BASiL v1.3, January 2021

Project	*Case Study 2 Scenario B*
Organisation	*SGMF STAFF*
Request from	*ADMIN ADMIN*
On	*14/05/2021*

Run Description:
Ship to Ship operation where the same quantity of LNG (1000m3) has been transferred at higher or lower flow rate between the two vessels.

Input Parameters

Location details

Latitude	51	Longitude	4
nearest port	Antwerp		(51.2 4.47)

Bunkering overview

Volume transferred	1000 m³	over	70 minutes
peak flow	857.1 m³/h	velocity	7.3 m/s
From a	Bunker vessel		
Using a	8 inch hose transfer system		
Operating at	6 barg		

Failure scenario

Leak Source	Hose failure

LNG supply specification

LNG storage pressure	1 barg	
LNG storage temperature	-159 °C (saturation-	-151.3 °C)
LNG net calorific value (LHV)	37 MJ/Nm3	37.00 MJ/Nm³
Reference conditions	15/15°C	at 15/15°C
Canada, Croatia, India, Ireland, Italy, Romania, Slovenia, Turkey, UAE, UK		
LNG density	455.0 kg/m³	

Transfer System layout

ESD type	fully automatic (30 s)
Minimum hose elevation	5 m
Hose entry location	semi enclosed
Distance below deck	4 m

Bunkering Configuration

STS Configuration	bow to stern	
Vessel layout	Gas fuelled ship	Bunker vessel
Length	160 m	110 m
Beam/width	22 m	19 m
Main deck above water	7 m	5.5 m
Manifold to bow IGF ship/stern bunker v	120 m	50 m
Manifold/Manifold height above water	0 m	
Distance between vessels		3.5 m

Vessel details used to create layout drawings only

SGMF

Data entered by	Krishna Ruparelia	On	14/05/2021
For	SGMF STAFF		

SGMF Disclaimer:

Ref: A00159 output file: SGMFA00159BASiL.pdf Page 1 of 2

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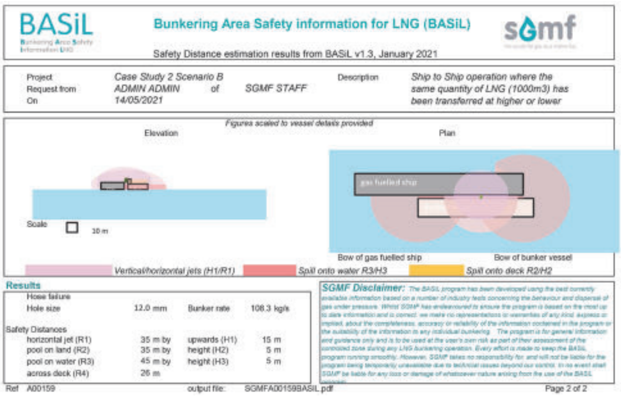

BASiL

Bunkering Area Safety information for LNG (BASiL)

Safety Distance estimation results from BASiL v1.3, January 2021

Project	*Case Study 2 Scenario B*		
Request from	*ADMIN ADMIN*	of	*SGMF STAFF*
On	*14/05/2021*		

Description *Ship to Ship operation where the same quantity of LNG (1000m3) has been transferred at higher or lower*

Figures scaled to vessel details provided

Results

Hose failure			
Hole size	12.0 mm	Bunker rate	108.3 kg/s
Safety Distances			
horizontal jet (R1)	35 m by	upwards (H1)	15 m
pool on land (R2)	35 m by	height (H2)	5 m
pool on water (R3)	45 m by	height (H3)	5 m
across deck (R4)	26 m		

SGMF Disclaimer:

Ref A00159 output file: SGMFA00159BASiL.pdf Page 2 of 2

SOURCE: SGMF

Ignited Release

If loss of containment is of sufficient size, the vapour cloud may reach a source of ignition and cause the gas to burn back to the source, causing a fire at the release location. Giving the example of a significant LPG leak into the drip tray of an LPG carrier, being would produce sufficient heat to burn unprotected skin 100m downwind and 40m upwind. In this example the tug with FiFi I water spray protection may be able to approach to 70m downwind and 20m upwind. For an LPG jet fire, a FiFi I tug may be able to operate at around 40m downwind and 20m upwind.

For more specific guidance and details, it is recommended that readers refer directly to the SIGGTO guide "Support Craft at Liquefied Gas Facilities, Principles of Emergency Response and Protection – Onshore and Offshore" on flammable range diagrams.

Cold Spill

A cold spill of liquified gas could result in the brittle fracture of steel or other structures not specifically designed to withstand low temperatures and could cause reduction or failure of structural integrity of the stricken vessel/asset. This could lead to complications such as further loss of containment.

Response

1) Unignited release

There is little the assisting firefighting tug can do to mitigate the effects of a release of gas vapour or liquid. In the first instance, the tug should be used to maintain communication with the casualty vessel and manoeuvre well clear and upwind of the vapour cloud. A wind driven water spray could help to dilute the gas cloud and help to avoid the ignition of this cloud.

2) Ignited release

Leaks from pipelines (whether on board or ashore) are typically under pressure and if ignited would typically result in a jet flame. Emergency Shut Down Systems (ESDs) should be activated, however residual pressure will remain until liquid in the pipelines has vapourised and escaped. If this scenario is not assessed to be making the situation worse, the best course of action may be to allow the fire to burn out, rather than to allow a gas cloud to develop. In this case, boundary cooling should take place to the surrounding area to maintain structural integrity and to stop any spread of fire.

Vessels either transporting or using gas either in high pressure or liquid form should have their own systems in place to be able to manage a credible incident during their operations. The effect of water from monitors of the firefighting tug may be limited in comparison to the vessel's fixed systems. The use of the fire monitors on a pool fire may significantly increase the burn rate and resultant radiant heat and may spread the fire beyond where it is pooling. This is the same concept of not using water on a deep fat fryer fire; therefore, a high degree of caution is required. Do not rush in with a direct water attack.

In the event of a large leak of cargo or bunkers, for example as the result of a collision, it may not be possible to extinguish the fire. It is therefore likely that the role of the tug will be to provide boundary cooling to structures within the heat radiation zone to protect structural integrity of the vessel from a position of safety.

LNG Fuelled Vessels

It is easy to think that an LNG fire will only be experienced by tugs operating at an LNG terminal, however it should be considered that many vessels are now LNG fuelled. Fires aboard these vessels require planning for both the scenario of fighting an LNG fire, but also that a hydrocarbons fire could develop into an LNG fire if appropriate boundary cooling is not provided.

LNG Vessel with on deck storage LNG

PHOTO CREDIT: ANDY AMOR

LNG Vessel Berthing

PHOTO CREDIT: ANDY AMOR

Hydrogen

The main hazards associated with liquid hydrogen are cryogenic temperature and high flammability. Hydrogen has a very wide flammability range and requires low ignition energy, for example electrostatic discharge. It should be assumed that any hydrogen leak is likely to result in a fire.

Hydrogen is colourless, odourless, burns with an almost invisible flame (especially in sunlight) and gives off relatively little radiant heat, a hydrogen fire is often difficult to detect. Detection is best achieved using a thermal imaging camera. Although hydrogen does not produce any smoke, flammable materials in the vicinity of the fire can result in smoke being present.
The primary risks associated with compressed hydrogen are fires and explosions caused by ignition or leaks, particularly when stored at high pressure. If ignited, hydrogen can cause intense fires or explosions, while unignited hydrogen will rise rapidly into the atmosphere or accumulate in high points within the vessel. A leak from a high-pressure storage vessel or piping system could release a large volume of hydrogen in a very short time, potentially in an explosive manner. This risk is heightened if the system is compromised by physical damage or fire, leading to a sudden release of hydrogen. The pressure involved in such scenarios poses significant risks to life, as well as the potential for further damage and release of energy if a tank or piping system is breached. In the event of a fire, it may manifest as either an explosion or an intense flare fire. Firefighting efforts should focus on isolation, ventilation, and boundary cooling from a safe distance.

Liquid hydrogen will disperse in a similar manner to the abovementioned LNG and LPG. However, the gas clouds and exclusion zones will be inherently smaller, due to hydrogen's relative density compared to that of air, causing it to evaporate readily and disperse more rapidly than other gases. This cloud will have a larger vertical element cloud than an LNG/LPG event, potentially causing a larger hazardous area.
The method of fighting a hydrogen fire is as described above for LNG/LPG by allowing the gas to burn off, while conducting boundary cooling. It is noted that due to high storage pressures of hydrogen, jet fires may be larger and extend farther than with LNG/LPG.

Due to hydrogen's lower density when compared to air, it rises and therefore gas pockets may form in enclosed areas and become trapped under flat surfaces.

The failure of vacuum insulation in a liquid hydrogen storage tank or piping can result in surface temperatures low enough for air to liquefy. Oxygen will condense at -183°C, and nitrogen at -196°C. The presence of pure oxygen, including in its liquid form, greatly increases the flammability of substances that are usually non-combustible, such as waxes, greases, hydrocarbon residues, dirt, clothing and lubricants. Additionally, many materials, such as plastics, epoxies and rubbers, become brittle at these extremely low temperatures, which may lead to seal failures and further leakage.

Ammonia

Liquid ammonia poses a significant risk due to its toxicity to humans and marine life. Ammonia is toxic when inhaled and high concentrations of ammonia vapour can cause immediate irritation to the eyes, nose, throat and respiratory system. Prolonged exposure to elevated levels can lead to severe respiratory distress, lung damage and even death. The strong odour and low detection threshold of ammonia, which enables it to be sensed at levels much lower than those considered hazardous, is often viewed as an advantage, providing an early warning. Tugs should be aware that ammonia concentrations can rapidly increase upon approach, particular if the tug is not positioned correctly (approaching downwind).

A liquid ammonia leak or spill requires a larger exclusion zone than LNG or LPG due to ammonia's high relative density, which causes the ammonia vapour cloud to sink and pool on the deck or water surface. It is more persistent and takes longer to dissipate compared to LNG or LPG, requiring larger exclusion zones.

Ammonia is difficult to ignite, requiring the lower flammable limit to be reached, which is 16%, this is three times higher than methane. This can typically only occur if ammonia is released into a confined space or an open area where heat is applied to increase the rate of vaporisation, combined with a sufficiently high ignition source, roughly 1,000 times more intense than that needed for methane and around 10,000 times more than hydrogen. In the event of an ammonia gas cloud explosion, the combustion rate is much slower, approximately one fifth that of methane.

When responding to ammonia fires, applying water via water spray is the most effective method to extinguish the fire. However, applying large quantities of water to an ammonia liquid pool will increase the evaporation rate, making the fire larger. Water spray on ammonia vapour should be applied with caution, as it may result in the formation of ammonium hydroxide, a corrosive by-product. Recondensing ammonia vapour, in certain scenarios, can reduce the intensity of the release but must be carefully managed to avoid further liquid release.

Firefighting tugs likely to attend an ammonia fire should have gas detector(s) which are calibrated to the safe exposure limits of the chemical.
Given that ammonia is less likely to ignite than other gas fires encountered, deploying tugs into to an area where the tugs crew could be exposed to hazardous vapour concentrations should be avoided if only being done as a precautionary measure.

Personal protective equipment (PPE) is critical in ammonia leak response scenarios. Chemical suits with self-contained breathing apparatus (SCBA) are necessary when handling ammonia vapour concentrations above the AEGL-1 level (30ppm). These suits provide protection against the toxic and caustic effects of ammonia exposure. However, the limits of PPE must be considered carefully. For example, full chemical suits are required for high-risk exposure areas, where there is a significant likelihood of encountering ammonia vapour concentrations above the AEGL-1 level. Lighter chemical suits with splash protection and standard PPE with escape device and gas detector provide varying levels of protection based on the risk, with full chemical suits being the most protective for ammonia spill scenarios, ensuring comprehensive coverage against both vapour and liquid exposure.

It is also crucial to consider the working time limits associated with chemical suits. When using SCBA, and other high-level PPE, the working time is typically limited due to the breathing apparatus, the potential for heat stress, fatigue and local regulations.

The SGMF publication FP25-01_Ammonia – Accidental Release Preparedness and Response is suggested for further reading on this subject.

Methanol

Methanol is a liquid alcohol at ambient temperatures, with relative ease of storage and handling onboard vessels. Methanol has a low flashpoint of 11°C, making it highly flammable and volatile. Methanol burns at low temperatures with an almost invisible blue flame and little smoke, making detection almost impossible. Due to the invisibility of methanol flames, the use of thermal imaging cameras is strongly advised in firefighting scenarios.

Methanol is toxic and harmful to health through inhalation, ingestion and absorption through the skin. Poisoning effects may not become apparent until 1-72 hours after exposure. The acute exposure guideline levels (AEGLs) for methanol are as follows:

- AEGL-1: 670 ppm for 10 minutes (non-disabling effects)
- AEGL-2: 1100 ppm for 10 minutes (long-lasting health effects or impaired ability to escape)
- AEGL-3: 40,000 ppm for 10 minutes (life-threatening or fatal effects).

Aqueous Film-Forming Foam (AFFF) is recommended for extinguishing a methanol fire. Water should be used only for boundary cooling, as methanol can continue to burn even when diluted 90% with water, which makes vessel stability a significant concern if only water is used to fight a methanol fire.
Methanol's relatively slow evaporation rate means it can accumulate in a confined area, leading to an increased risk of toxicity. Firefighting tugs attending a methanol fire should be equipped with gas detectors calibrated to safe exposure limits of methanol and personnel should wear appropriate PPE such as chemical suits with SCBA to prevent exposure during firefighting operations.

The SGMF publication FP17-01 Methanol as a marine fuel is recommended for further reading.

Lithium-ion Batteries

Lithium-ion batteries (LIBs) and their various derivatives are everywhere as part of modern life. Whether carried as cargo, equipment, vehicles or as a propulsion means, lithium-ion batteries are present throughout the supply chain. As a means of propulsion, they are becoming more common place in a variety of vessels, both newbuilds and through retrofits, as a means to reduce fuel consumption and emissions, whether fully battery electric propulsion or hybrid propulsion.

LIBs can store very high quantities of energy. If one becomes too hot, it can start a chain reaction in which yet more heat is created – a state known as thermal runaway. Thermal runaway generates large volumes of flammable gases that can catch fire very quickly and may also cause a vapour cloud explosion. Gasses of a LIB fire are extremely white and should not be confused with a steam cloud.

LIBs are generally considered safe and stable. However, fire challenge can arise in the event of battery cell damage.
Cell damage may be caused through:

1. Mechanical abuse through physical damage to the cell.
2. Electrical abuse through overcharging or over-discharging.
3. Through a defect of the battery management system.
4. Thermal abuse through exposure to extreme temperatures.

Thermal runaway is where the battery cell enters an uncontrollable, self-heating state. This leads to sudden and quick temperature rise, up to 1600°C+, along with violent cell venting where gas, flame and shrapnel are ejected from the cell. This has the risk of affecting other Lithium-Ion battery cells (in the case of a battery bank) or other flammable material nearby, with the potential to increase the size and ferocity of the fire in a very short time period after initial ignition.

During thermal runaway, the battery cell will eject large volume of toxic gases in a vapour cloud. These gases of vapour cloud will quickly build to their so-called lower explosive limit, increasing the risk of explosion within a space. Maximising ventilation to the wider atmosphere is important to reduce explosion risk.

Lithium-ion battery fires are extremely difficult to extinguish and boundary cooling of the affected area or vessel until the fire burns itself out is often the best course of action. The use of fixed firefighting systems on board and water jets for boundary cooling is the most effective known method for control.

For tugs called in to assist a casualty vessel in the event of a lithium-ion battery fire the crew should take into consideration the following factors:

- Internal location of the fire: due to the intense heat, it is possible there will be structural damage or hull integrity compromised which could be exasperated through thermal shocking from boundary cooling water.
- Vapour Cloud venting: the assisting vessel should remain upwind, and where possible on the weather side, of the area where the vapour cloud is being vented due to the potential toxic gases and toxic soot.
- Explosion Risk: the assisting vessel should remain a safe distance from the casualty vessel due to the explosion risk from the vapour cloud.

Lithium-ion battery fires can reignite unexpectedly, even days after the initial fire has burned out or been extinguished. This is because residual chemical energy in the battery can cause it to reignite. Therefore, prolonged application of water is recommended, subject to overall vessel stability.

Water used to extinguish lithium-ion battery fires can become contaminated with toxic metals and other pollutants, which can have harmful effects on the environment and human health. Correct PPE should be utilised for personnel coming into contact.

9

Case Studies

Case Study: Morro Castle - 1934

The SS Morro Castle was an American passenger ship on the New York-Havana route. In September 1934, the Morro Castle returned from Havana with 316 passengers and 231 crew members on board. The captain died of a heart attack and a day later a fire was discovered when the vessel was located just 6 miles off the coast of New Jersey.

A steward initially tried to extinguish the fire but failed to inform the bridge. The bridge was only notified of the fire an hour later. Due to a lack of fire drills and working fire hoses, the crew was unable to control the fire. It was decided to evacuate the passengers and crew, with the crew members being the first to abandon.

The rescuers were slow to react. Three ships were slow in acting after receiving the SOS signal but eventually arrived. The Coast Guard vessels Tampa and Cahoone positioned themselves too far away to see casualties in the water and provided little assistance. The incident resulted in 137 fatalities, with the ship later running aground.

Factors contributing to the fire

The ship design and construction materials significantly contributed to the outcome, but two other important human element conclusions were also drawn:

- The whole crew must be thoroughly trained to provide the competence to work promptly, efficiently and effectively, both in normal duties and in any emergency.
- Well-planned and well-conducted training is absolutely necessary, not only in seamanship but also for emergency situations.

These two conclusions are still of great importance for all ships and their crews today. A well-trained and practiced crew is crucial, both on board the incident ship itself and on the assisting vessels, when the fighting ship fires.

The Morro Castle disaster prompted revisions to SOLAS on:

- **Fire Safety**: Stricter regulations regarding fire-resistant materials, fire detection systems, and the availability of fire-fighting equipment on ships.
- **Crew Training**: Emphasis on regular fire drills and better training for crew members to ensure they could effectively respond to emergencies.
- **Life-Saving Equipment**: Improvements in the design, availability, and accessibility of life-saving equipment, including lifeboats and life vests.
- **Emergency Communication**: Enhanced communication protocols to ensure timely and efficient coordination during emergencies.

Case Study: Seawise University - 1972

On January 9, 1972, multiple fires broke out across the Seawise University. Unfortunately, the fire protection system was incomplete. Firefighting crew struggled to contain the rapidly spreading flames, which soon engulfed the vessel.

The crew abandoned the ship as tugs and fireboats worked to extinguish the flames. Despite their efforts, the vessel was completely destroyed and ultimately declared a shipping hazard. The water sprayed by the fireboats caused the charred wreck to capsize and sink. An investigation into the mysterious fire yielded inconclusive results. Although arson was widely suspected, no suspects were ever identified.

Learning:

The amount of water sprayed onto a vessel should be closely monitored to ensure it does not adversely affect the stability of the vessel.

Case Study: Betelgeuse - 1979

The 61,776 GT crude tanker Betelgeuse was berthed portside at the offshore jetty at Whiddy Island, Ireland, which had no service connection with the shore, nearly 400 metres away.

Early on the 8th of January, the vessel suddenly broke in two by the number 4 permanent ballast tanks, releasing an estimated 15,000 tonnes of crude oil. Almost immediately, a catastrophic fire engulfed the ship and jetty. Sadly, the 43 persons on the tanker, along with the 7 Gulf Oil employees on the jetty, died.

The 'Report on the Disaster at Whiddy Island, Bantry, Co. Cork on 8th January 1979,' provides a good and comprehensive overview of, among other things, the events as they occurred on the day of the fire.

The disaster began shortly after 0030. The initiating event caused the hull to collapse and a fire to burn on the water not far forward of the ship's manifold. In its early stages, the fire was not of large proportions. During this first phase, which lasted for about 10 minutes, the fire was growing in intensity, but it remained localised at a point in the centre of the ship. At 0040, the fire spread to both sides of the ship. The initial hull failure had caused large quantities of oil to pour into the sea. The vapours from these ignited and the fire spread under the centre platform and the catwalk of the jetty. At approximately 0050, the flames from the fire on the sea had not reached the height of the catwalk, nor Dolphin 22, and the fire remained localised at the centre of the ship. A few minutes later, a dramatic increase in the intensity and size of the fire occurred and the whole of the jetty became enveloped in flames.

It is reasonable to assume that if the fire had been observed at approximately 0031, immediate assistance could have been summoned. Both the 'Donemark' and the 'Snave' were at the Ascon Jetty.

The report criticises the operating company for not having firefighting tugs near the jetty. Gulf's "Policy and Procedures" manual provided that "two tugs were to be on 24-hour standby duty when a tanker of the size of the 'Betelgeuse' was berthed at the jetty and to be available immediately in the event of an emergency."

On the night of the disaster only one tug, the 'Bantry Bay', was manned and on 'standby duty'. It was moored to a buoy east of Whiddy Point East, about 2.8 miles from the jetty and out of sight of it, and any tanker berthed there. She was equipped with two pumps, each with a capacity of 4091 litres per minutes (LPM) and a pressure of 13.8 bar. She had four elevated monitors, the topmost of which was of 'superjet' capacity 22,730 LPM whilst the other three had capacities of 8364 LPM. The Bantry Bay carried 24,548 litres of standard protein foam concentrate.

It is considered that had Gulf maintained the stand-by tug close to and in sight of the jetty, it is reasonably probable that, notwithstanding the absence from the control room of the dispatcher on the night of the disaster, the lives of the jetty crew and those on board the ship may have been saved. The crewmember on watch on the tug would have seen the fire at its commencement.

By slipping its mooring the tug could have been at the scene of the fire before 0040, when the fire spread alongside the ship, and it is possible the fire could have been contained or extinguished.

Case Study: British Trent - 1993

On 3 June 1993 at 0543, the British Trent and Western Winner collided in thick fog in the British North Sea. Both vessels' hulls were breached on the port side and spilt cargo from British Trent immediately caught fire. The resultant fire meant that British Trent had to be abandoned. Seven crew were evacuated by pilot launches and the remainder were required to leave via the vessel's starboard lifeboat. The side of the vessel became enveloped in smoke and flames forcing the crew to jump into the sea amongst patches of burning cargo. 20 crew were rescued from the sea by the pilot launches but nine died due to smoke inhalation.

British Trent was taken under tow and eventually extinguished by firefighting tugs. Examination of the vessel after the fire revealed the collision had damaged the fire-main so that, even if the main or emergency fire pumps had been started, it is unlikely there would have been much water available. The fire was only brought under control after several firefighting tugs were used for many hours. However, the ability to start the fire pumps from the bridge would have saved time and reduced the risk to the crew members. The damage to the fire-main might also have been noticed if it had been possible to start the fire pumps from the bridge, and if the master had known this, he may have decided to abandon ship at an earlier stage.

Learnings:

The Bermuda Registry of Shipping was recommended by IMO along with interested parties to identify practicable improvements which could be incorporated into new and existing tankers to deal with such emergencies, for example the starting of fire pumps from the vessel's bridge.

The MAIB report is available here (https://www.gov.uk/maib-reports/collision-between-oil-tanker-british-trent-and-bulk-carrier-western-winner-near-akkaert-bank-belgium-resulting-in-a-fire-on-british-trent-with-loss-of-9-lives or can be found online by searching for the names of the two ships involved.

Case Study: Yeoman Bontrup - 2010

Yeoman Bontrup, a self-loading and unloading bulk carrier, suffered a major fire and subsequent explosion on the 2nd of July, 2010, whilst alongside Glensanda Quarry, Scotland. The fire was discovered midafternoon near the bottom of the vertical cargo conveyor belt and whilst attempts were made to extinguish the fire, it spread to the engine room. Due to the scale of the fire, the vessel was evacuated. The fire spread to the accommodation and steering room compartment which contained various operational chemicals. A violent explosion occurred which tore the poop deck from the vessel.

The fire was discovered by an able seaman who raised the alarm and the cargo engineer quickly started fighting using one of the ship's fire hoses. The master contacted the harbour master, requesting firefighting support, and the harbour master contacted the coastguard who in turn alerted the shoreside fire and rescue service.

The crew continued to fight the fire with additional hoses directed at the fire and the tower wash down system was activated. Attempts were also made to extinguish the fire with foam fire extinguishers, but this had no effect. Despite the efforts of the crew, the fire spread up the conveyor.

Twelve minutes after sounding the fire alarm, the Glensanda Quarry fire team arrived. The team connected fire hoses to the shoreside fire hydrants and provided boundary cooling.

The master, in consultation with the harbour master, quarry manager and engineer manager, strongly advised evacuating the ship, as it was evident to those on scene that the situation was getting out of control. When all his crew were safe and accounted for, the master evacuated the ship.

Whilst on route to the scene, the shoreside fire and rescue service Silver Commander contacted Inverness Incident Command which was set up to support Silver Command, and expert advice was requested from the Fire Service Marine Incident Response Group (MIRG) who would be transported to the scene by helicopter.
As boundary cooling could only be provided to one side of the ship from the shore, the Silver Commander requested the support of a firefighting tug, as there were no suitable vessels locally the use of the Maritime and Coastguard Agency's emergency towing vessel was approved with an ETA of early the following morning, the 3rd of July.

By evening, Gold Command was established to support the Silver Commander on scene, links were also established with the local council Emergency Planning Officer, the ambulance service and the Secretary of State's Representative for Maritime Salvage and Intervention. Still unable to access the vessel, the Silver Commander used MIRG's expertise to assess the situation and develop a tactical plan.

As the immediate danger was over and all personnel were accounted for, Gold Command stood down in favour of multi-agency on-site briefings. The emergency towing vessel arrived on site and provided boundary cooling to the vessel using her firefighting monitors. By early morning, following continuous colling, MIRG were stood down.

The Bahamas Maritime Authority report can be found online here (https://www.bahamasmaritime.com/wp-content/uploads/2020/10/BMA-Investigation-Report-Fire-and-explosion-onboard-the-Yeoman-Bontrup.pdf) or by searching for the ship's name, Yeoman Bontrup, along with the Bahamas Maritime Authority.

Case Study: MSC Flaminia - 2012

At 0542 on the 14th of July, 2012, the MSC Flaminia, a 85,823 dwt containership that was mid-Atlantic on route to Europe with 2,878 containers on board, had the cargo hold ventilation extraction system sound an alarm indicating that there was smoke in cargo hold 4. The hold fire was confirmed by crew.

At 0642, the vessel's CO_2 flooding system was discharged into the hold and the surrounding area and boundary cooling was initiated by spraying sea water to the steelworks adjacent to the hold but inside. At 0804, a fire party of seven crew were working in the vicinity of hold 4, when a large explosion occurred followed by a rapid escalation of the fire. The escalation isolated the fire party towards the bow of the vessel, with one person missing and four injured, some seriously.

The decision was made to abandon the ship. The lifeboat was launched after some difficulties and reached the forward section of the vessel to rescue those trapped. All crew boarded the lifeboat and were later picked up by the tanker DS Dawn at 1100 that same day. The seriously injured crewmember died shortly afterwards on board the tanker, whilst other casualties were transferred to meet a rescue helicopter and another casualty subsequently died in hospital in

Portugal. The DS Dawn landed the remaining crew members in Falmouth, UK.

Salvage experts SMIT Salvage were brought in and consequently dispatched three salvage tugs to the Flaminia for firefighting and towing the ship to Europe, about 200 to 300 miles away. Initial firefighting efforts were carried out from the tugs but also from a salvage team that boarded the vessel.

The original intention was for the vessel to seek a safe refuge in Germany. Given the concerns over the state of the vessel and consequential concerns over a potential pollution incident by various interested parties, permission to transit the English Channel was not granted until an onboard assessment by experts from the UK, France and Germany was carried out on August 28, 2012.

On the 9th of September, eight weeks after the fire broke out, MSC Flaminia made fast in the port of Wilhelmshaven where she was unloaded as far as practicable of debris and pollutants during a complicated process that lasted several months before sailing for repairs in Romania on the 15th of March, 2013.

The initial fire and explosion had multiple causes including inappropriate classification of a dangerous substance within the internationally recognised labelling system as well as the location of the cargo deep within the vessel.

The investigative report can be found here (https://www.bsu-bund.de/SharedDocs/pdf/EN/Investigation_Report/2014/Investigation_Report_255_12.html) or online by searching for Federal Bureau of Maritime Casualty Investigation report of MSC Flaminia.

Case Study: CCNI Arauco - 2016

Berthed alongside in Hamburg, the 112,588 dwt container ship CCNI Arauco caught fire during welding operations on a container in the aft hold. In the ensuing conflagration, flames spread through the lower decks with smoke reaching 50 metres above the vessel.

300 firefighters along with fire boats arrived on scene and the initial attempt to tackle the fire using the ship's CO_2 flooding system was unsuccessful. The fire continued into the next day, and an estimated 5,000 tonnes of water were pumped into the vessel. Extinguishing attempts were ceased due to instability concerns. The next day, the fire was extinguished using 12,000 gallons of firefighting foam. Three persons suffered minor injuries requiring hospitalisation.

The fire took four days to extinguish. Authorities took the risk of flooding her holds, and breaking her back due to thermal shock, when local fireboats failed to extinguish the fire.

The aft hold was partly flooded during the emergency response and the water in the hold was contaminated with firefighting foam. Modern firefighting foams proved highly effective but contain perfluorocarbon compounds. The contaminated water was pumped into tankers to bring it to off-site disposal facilities.

The fire prompted the International Union of Marine Insurance (IUMI) to call for a review of shipboard marine firefighting equipment. Repeated CO_2 discharges from the ship's own fixed firefighting system were not sufficient to halt the fire in the hold and a major shorebased intervention was required instead.

Note: In the two case studies above, the amount of water used to fight fires aboard a ship has a number of consequences including on the stability of a vessel. Also, when the firefighting water mixes with the products of combustion and cargo, it can form a hazardous mixture and must be treated as 'special waste'. This special waste must be handled, stored and disposed of properly, which in the case of MSC Flaminia took months.

Case Study: Aframax River - 2016

The tanker Aframax River struck two mooring dolphins in the Houston Ship Channel due to a loss of control of the propulsion system, resulting in a collision puncturing the ship's hull plating, and about 88,000 gallons of low-sulphur marine gas oil spilling into the water. The oil ignited and burned for about 45 minutes. The two onboard pilots sustained minor burns, and the property damage exceeded $1.5 million.

The friction and the cutting of the hull plating generated heat, which ignited the MGO and triggered a large fire that engulfed the ship's port quarter and the adjacent main deck. Fire on the water's surface extended to the bow of the connected tug, which was secured to the tanker's port quarter. The tugboat's deckhand closed all doors and activated the fire sprinkler system.

Boat crews from Coast Guard Station Houston and Station Galveston and personnel from the Harris County Sheriff's Office marine division responded to the emergency. Several other tugs assisted. Despite the serious danger to life and property, the vessels remained alongside Aframax River, manoeuvring the disabled ship away from the other tankers and adjacent chemical facilities.

The conning pilot helped manoeuvre the tanker to the middle of the channel to prevent the flames from spreading further. Applying their firefighting training, the crew extinguished the fire around 0118. Several of the tugboats involved in the response effort also sustained damage to their equipment.

The accident report can be found here (https://www.ntsb.gov/investigations/AccidentReports/Reports/MAB1806.pdf or online by searching for NTSB and the ship's name Aframax River.

Case Study: X-Press Pearl - 2021

On May 20th, 2021, at 1030, the container ship X-Press Pearl, carrying 1,486 containers, encountered a fire starting in the cargo area while at anchor about 9nm miles from Colombo Port, Sri Lanka.

The crew of the X-Press Pearl responded to fight the fire through boundary cooling and subsequently released of carbon dioxide. The master called Colombo Port Control and requested shore tugs' assistance. The response from port control was deemed limited. There was no follow-up after a team of shoreside firemen had assessed the situation onboard. The tugs sent for firefighting had various limitations and the port did not offer continuous firefighting support.

After two hours, the first firefighting tug Megha arrived. The X-Press Pearl's master instructed the Megha to direct its firefighting effort on containers on fire at bay 10. The Megha began directing water on the burning containers and shortly after, the X-Press Pearl's crew stopped firefighting operation and returned to the poop deck.

The Megha's firefighting capability was deemed ineffective as the tug's throw from the monitors could barely reach the containers on fire. The X-Press Pearl's crew resumed firefighting, and the situation was reported to port control.

By daybreak the following morning, two more tugs, Hercules and Maha Wewa from port control, arrived to assist in firefighting. The increased firefighting capability by the other two tugs enabled the X-Press Pearl's master to instruct crew to return to the poop deck again. The master commended the ability of Hercules in firefighting as the water outreach and manoeuvrability of the tug was effective.

Later, a 12-man team of salvors boarded the X-Press Pearl on the 23rd of May, 2021, and took over the firefighting command and control onboard the ship from the master and crew and coordinated the efforts with tugs dispatched by the port authority and other assets. Despite the best efforts of the crew and the salvors, the ship ultimately sank.

Overall learnings from case studies: The critical role—and limits—of Firefighting tugs

Firefighting tugs play a vital role in marine emergency response, especially for boundary cooling, external suppression, and manoeuvring damaged vessels away from danger. However, their effectiveness is highly dependent on:

1) Timely availability and proximity
    - In multiple cases (e.g. Betelgeuse, X-Press Pearl), the delayed arrival or distant standby position of tugs limited early intervention. Had tugs been closer and ready, the escalation of fire and loss of life or vessel might have been prevented.
    - Prompt action, particularly in the early growth phase of a fire, can be decisive in controlling or even extinguishing the fire before it spreads uncontrollably.

2) Operational capability
    - The case studies show that not all firefighting tugs are equally equipped. Their throw range, pump pressure, and foam capacity significantly affect their impact, especially on large container ships (X-Press Pearl, CCNI Arauco).
    - Tugs with FiFi-class systems and trained crews can make a measurable difference but their effect diminishes if the fire is internal or deep within the superstructure.

3) Limitations of tug-based firefighting
    - Several incidents (MSC Flaminia, Yeoman Bontrup, CCNI Arauco) show that external firefighting alone is not sufficient when:
        - Fires originate inside cargo holds or engine rooms.
        - The vessel's firefighting systems fail or are overwhelmed.
        - Accurate stowage or hazardous materials data is unavailable.
    - In some cases (Seawise University, British Trent), water from firefighting tugs contributed to stability loss or capsizing, underlining the need for careful water management and real-time assessment.

4) Need for coordination with shore and salvage resources
    - Cases like Yeoman Bontrup and MSC Flaminia show that firefighting tugs must be integrated into a broader command structure, including

MIRG teams, salvage crews, and Gold/Silver Command where applicable.
- Effective outcomes depend on inter-agency communication, joint tactical planning, and clear command handovers during protracted incidents.

Strategic implications for Port Authorities and Operators

- Pre-positioning and standby requirements must be enforced, especially when high-risk vessels (tankers, container ships) are berthed or at anchor.
- Capabilities of tugs (range, foam, pressure) should match the scale of the risk, particularly for large modern vessels.
- Joint training and exercises are essential to ensure tug crews, port authorities, fire brigades, and salvage teams can respond seamlessly.
- Real-time assessment and decision-making (e.g. to prioritise boundary cooling, evacuation, or foam application) are vital and must be supported by updated data and trained personnel.

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Glossary

Application Rate: The rate at which foam solution is applied to a fire. Expressed as litres of foam solution per square metre of fire area per minute (l/m2/min). Typically, between 4 and 10 l/m^2/min.

Application Time: The duration of time over which foam is applied. This can be broken down into three definitions, Critical Application Rate, Optimum Application Rate and Overkill Application Rate.

Aqueous Film-Forming Foam (AFFF): Pronounced A-triple-F. **For** instance, TridolC6. A synthetic foam concentrate containing detergent and fluorocarbon surfactant that forms a foam capable of producing a vapour-suppressing aqueous film on the surface of some hydrocarbon fuels. Provides rapid flame knockdown on short preburn, shallow spill fires (e.g. aircraft crash fires), but not suited for use on long preburn, deep-seated fires (e.g. storage tank fires). Developed in the 1960s, AFFF has been largely replaced by the more sophisticated FFFP nowadays.

BLEVE: Acronym for Boiling Liquid Expanding Vapour Explosion. Explosive fire ball caused by the rapid escape of flammable gas discharging from sealed pressurised containers which have ruptured due to adverse heat exposure.

Boilover: Violent ejection of flammable liquid from its container caused by vapourisation of a water layer beneath the body of a liquid. It will generally only occur after a lengthy burning period in wide flash point range products such as crude oil.

Burnback Resistance: The ability of a foam blanket to resist direct flame and heat impingement such as would be evident in a partially extinguished fire.

Critical Application Rate (CAR): The minimum rate at which foam solution needs to be applied to a fire in order to achieve extinguishment.

Eduction Rate: The percentage of foam concentrate mixed or introduced into the water supply line to produce foam solution. Also called Induction Rate or Proportioning Rate or Pick-Up Rate.

Fire Triangle: This is the method of describing how a fire can be started and extinguished. Each side is represented by Heat, Fuel and Oxygen. If all three are present, then combustion may occur. Once a fire has been lit (and combustion is taking place), it can be extinguished by removing one side of the fire triangle.

Flash Point: The lowest temperature at which a flame can propagate in the vapours above a liquid.

FRS: Fire & Rescue Service

FSIC: Fire Service Incident Commander

Fluorine Free Foam: For instance, Syndura, JetFoam or Respondol. (May also be referred to as FFF or 3F, or F3 although beware of confusion with other foam types). Fluorine-free foams are manufactured not using any added fluoro-surfactants. Each risk must be looked into when comparing FF as some are specifically for Class A fires, whilst some foams are specifically designed for Class B fires. Always check approvals as to what ratings these foams claim.

FFFP (Film-Forming Fluoroprotein Foam): Film-Forming Fluoroprotein or FFFP is a specialised foam concentrate used for flammable liquid fire suppression applications. It is a foam formulation that combines the properties of both aqueous film-forming foam (AFFF) and protein foam. FFFP contains a blend of hydrocarbon-surfactants, fluorochemicals, and protein additives.

International Convention on Salvage 1989: Treaty governing marine salvage.
Article 10 "*Duty to render assistance*"

1. Every master is bound, so far as he can do so without serious danger to his vessel and persons thereon, to render assistance to any person in danger of being lost at sea.
2. The States Parties shall adopt the measures necessary to enforce the duty set out in paragraph 1.
3. The owner of the vessel shall incur no liability for a breach of the duty of the master under paragraph 1.

Liquefied Natural Gas (LNG): Cryogenic flammable liquid consisting mostly of methane. The recommended fire protection comprises a specialist high expansion foam system (e.g. Angus Fire LNG Fixed Turbex System and Expandol foam).

Merchant Shipping Act: This Act consolidates the law relative to merchant shipping in the United Kingdom. It provides for the nationality and registration of British ships, regulates navigation and related matters and contains provisions relative to the prevention of pollution by ships. Please find it here online: Merchant Shipping Act 1995 (legislation.gov.uk).

Monitor Throw Length: Distance (in metres) water can be projected from the monitors

OSC On Scene Commander: The role is to manage incidents and direct firefighting operations.

OSCo: On Scene Coordinator

PFOA: Perfluorooctanoic acid (PFOA), also known as perfluorooctanoate, is a synthetic perfluorinated carboxylic acid. This is a C8 contaminant found in some firefighting foams.

PFOS: Perfluorooctanesulfonic acid or perfluorooctane sulfonate (PFOS) is a man-made fluorosurfactant and global pollutant.

SCBA: Self-Contained Breathing Apparatus

SOSREP: The Secretary of State's Representative (SOSREP) Maritime Salvage & Intervention provides strategic oversight of a maritime incident on behalf of the UK Government. The individual role holder has the ability and legal power to exercise ultimate control and make a final decision during national maritime emergencies.

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Further Reading

Allianz Commercial Safety and Shipping Review 2024 - https://commercial.allianz.com/news-and-insights/reports/shipping-safety.html

Board of the US Department of Commerce. Historical but freely available as digitised pdf online.

BTA Guidance: Recovery of Persons in Water (PIW) Guide to Good Practice for Small Vessels

Collision between oil tanker British Trent and bulk carrier Western Winner resulting in fire on British Trent with loss of 9 lives - GOV.UK

Fire and explosion on bulk carrier Yeoman Bontrup - GOV.UK

IAMSAR Volume II (2022)

IMO Strategy on Reduction of GHG Emissions from Ships -https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/annex/MEPC%2080/Annex%2015.pdf

Marine Fire Prevention, Firefighting and Fire Safety: Book published in 1980 by the Maritime Training Advisory

Port Marine Safety Code & Guide to Good Practice – link

Rushbrook's Fire Aboard – A reference book on marine fire-fighting and fire-fighting equipment.

SGMF publication FP25-01 Ammonia – Accidental Release Preparedness and Response

SGMF publication FP17-01 – Methanol as a marine fuel

SGMF Recommendation of Controlled Zones during LNG Bunkering section A7

US National Fire Protection Association (NFPA) Standard for Low-, Medium-, and High-Expansion Foam (Issue 11: 2024

Appendix 1

Gas properties of Alternative Fuels

Property	**LNG (Methane)**	**LPG (Propane)**	**Hydrogen**	**Ammonia**	**Methanol**
Flammability	Flammable	Flammable	Flammable	Flammable	Flammable
Toxicity	Non-toxic	Non-toxic	Non-toxic	Toxic	Toxic
Flash point (degrees C)	-175	-105	-253	11	9
Flammability range (% by volume in air)	5.3 - 14	2.1 - 9.5	4.0 - 75	16 - 26	6.0 – 36.5
Auto-ignition temperature (Degrees C)	595	468	583	651	470
Relative vapour density	0.554	1.55	0.07	0.57	1.11
Boiling point (Degrees C) at atmospheric pressure	-162	-42	-253	-33	64.7
Critical temperature	-82.5	-96.8	-239.9	132	240.2
Critical pressure (bar)	46	10	13	111	82.2