Australian Government

Australian Transport Safety Bureau

Fire on board *Iron Chieftain*

Port Kembla, New South Wales, on 18 June 2018

ATSB Transport Safety Report

Occurrence Investigation (Systemic)

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Addendum

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Safety summary

What happened

On 18 June 2018, during cargo discharge operations while alongside at Port Kembla, New South Wales (NSW), a fire broke out in the internal cargo handling spaces of the self-unloading (SUL) bulk carrier *Iron Chieftain*.

The ship's crew initiated an emergency response but shipboard efforts to control the fire were ineffective. The fire soon established itself and spread to the exterior of the ship, setting the discharge boom on deck alight. The ship's crew were evacuated and shore firefighting services from Fire and Rescue New South Wales (FRNSW) took charge of the response to the fire. The fire was contained and eventually extinguished about 5 days after it started.

The ship sustained substantial structural damage, including breaches of two fuel oil tanks, and key components of the SUL system were largely destroyed. The ship was declared a constructive total loss and subsequently dispatched to be recycled. There were no serious injuries or pollution of the sea reported.

What the ATSB found

The ATSB investigation concluded that the fire originated in *Iron Chieftain*'s C-Loop space and was likely the result of a failed bearing in the ship's conveyor system which created the heat necessary to ignite the rubber conveyor belt. The ATSB also determined that the ship did not have an emergency contingency plan for responding to fire in the ship's SUL spaces and that there were technical failures of the ship's alarm systems during the emergency response to the fire. Furthermore, some aspects of the shipboard response likely aided the fire's development while others increased risk by removing shipboard capability.

The ATSB found that the risk of fire in *Iron Chieftain*'s C-Loop space was identified and documented by the ship's operators, CSL Australia, as being unacceptable about 5 years before the fire. This risk rating was primarily due to the absence of an effective means of fire detection and fire suppression for the SUL system spaces. However, measures taken to address the risk were either inadequate or ineffective. Furthermore, the lack of adequate regulatory requirements or standards related specifically to the fire safety of SUL ships has been a factor in several fires, including *Iron Chieftain*. The ATSB also identified that the regulatory oversight of *Iron Chieftain* did not identify any deficiencies related to the safety factors identified by this investigation, or to the ship's inherent high fire safety risk and management of that risk.

In addition, the ATSB identified a safety issue related to the marine firefighting capability of FRNSW as well as other safety factors related to the inconsistent conduct of ship's drills and Port Kembla's emergency response plans.

What has been done as a result

In response to this accident, the CSL Group (the parent company of the ship's owners and managers—CSL Australia) initiated a fire risk mitigation project across its global fleet with the aim of:

- improving fire detection and suppression technology
- reviewing firefighting policy
- setting minimum fire safety standards for early fire detection and suppression at the ship design and build stage.

The ship's managers advised that linear heat detection systems and/or closed circuit television camera systems integrated with video analytics to provide or enhance the capability for early fire detection were installed on board six conveyor belt-equipped SUL ships operated by CSL

Australia with installation of similar systems planned for a seventh ship. A CSL Australia-operated SUL ship with internal conveyor spaces was equipped with a Hi-Fog water mist fixed fire-extinguishing system covering the ship's internal SUL spaces. In addition, one ship with external conveyor systems was equipped with a deluge system and installation of a deluge system is intended for at least one other ship. Additionally, ship-specific emergency contingency plans for fires in the SUL spaces have been developed and implemented across the CSL Australia fleet.

The Australian Maritime Safety Authority (AMSA) and Lloyd's Register have undertaken to approach the International Maritime Organization (IMO) and the International Association of Classification Societies (IACS) respectively, to raise the identified safety issue related to the inadequacy of fire safety standards or regulations for SUL system spaces. However, due to limited detail and a timeframe to seek resolution of the safety issue by the IMO, the ATSB has issued a safety recommendation to AMSA. The ATSB will continue to monitor the safety issue while actively working to highlight and promote awareness of the issue.

With respect to the regulatory oversight of SUL bulk carriers, AMSA has provided its inspectors and delegated organisations with updated guidance related to the focus of audits and inspections particularly with regard to the fire safety risk aspects associated with these ships. In addition, AMSA is progressing an inspection campaign concentrating on SUL bulk carriers operating in Australian waters, with a focus on fire safety and emergency preparedness.

Fire and Rescue New South Wales has advised that work is underway through the Australasian Fire and Emergency Service Authorities Council (AFAC) Working Group for Marine Firefighting to produce a nationally consistent approach to marine firefighting which will inform the development of new FRNSW standard operating guidelines. In addition, FRNSW continues to undertake familiarisation and training exercises to improve marine firefighting capability and awareness. While welcoming the safety action, the ATSB has issued a recommendation that FRNSW takes further action to address the safety issue related to marine firefighting capability.

The PANSW advised that the Port Kembla Marine Oil and Chemical Spill Contingency Plan and the Crisis Management Plan were to be updated to reflect the guidelines for responding to fires on a vessel as described in the NSW State Waters Marine Oil and Chemical Spill Contingency Plan.

In addition, the Memorandum of Understanding in relation to Hazardous Material Incidents on Inland and State Waters between Transport for NSW (NSW Maritime), FRNSW and the PANSW was being updated, with changes including specific handover arrangements being considered.

Safety message

The investigation into the fire on board *Iron Chieftain* has highlighted the inadequacy of fire safety regulations and standards for the cargo handling spaces on board self-unloading bulk carriers. The effectiveness of a shipboard response to a fire depends primarily on the ability to detect the fire at an early stage and quickly extinguish it at the source. Where it has been identified that the lack of such systems has resulted in the risk of a fire in a space being unacceptable, suitable control measures need to be implemented in order to reduce the risk to an acceptable level.

The introduction of mandatory minimum standards for suitable fire detection and extinguishing systems, to address the known high fire risk spaces of self-unloading bulk carriers, can significantly reduce the risk of major fires in these spaces. Additionally, the introduction of standards governing the fire resistance properties of conveyor belts used in shipboard systems can help reduce the likelihood of ignition in the first place.

Contents

The occurrence

Overview

On 18 June 2018, a fire broke out on board the Australian registered, 202 m self-unloading (SUL) bulk carrier *Iron Chieftain* during discharge of the ship's cargo of dolomite in Port Kembla, New South Wales. The fire quickly overwhelmed the ship's crew, and it took shore firefighting services about 5 days to contain and extinguish the fire. The ship sustained substantial damage as a result of the fire and was subsequently declared a constructive total loss (CTL)[1] and dispatched for recycling.

Arrival and cargo operations

At about 0222 Eastern Standard Time[2] on 15 June 2018, *Iron Chieftain* (Figure 1) arrived at the pilot station off Port Kembla, New South Wales, following a voyage from Ardrossan, South Australia. The ship was loaded with about 41,832 tonnes (t) of dolomite.[3] At 0530, a pilot embarked the ship and by 0700, *Iron Chieftain* was safely alongside, (starboard side to) at berth number 113, owned and operated by BlueScope Steel.

Figure 1: *Iron Chieftain* on fire at Port Kembla

Source: ATSB

The ship commenced discharging cargo shortly after berthing, at about 0755. The cargo was discharged into trucks through a shore-side hopper using the ship's self-unloading system (Figure 2). The system consisted of a series of hydraulically operated gates under the cargo holds through which cargo was deposited onto conveyor belts running in tunnels under the ship's holds. The cargo was transported to two smaller athwartships transfer conveyor belts, up a vertical conveyor

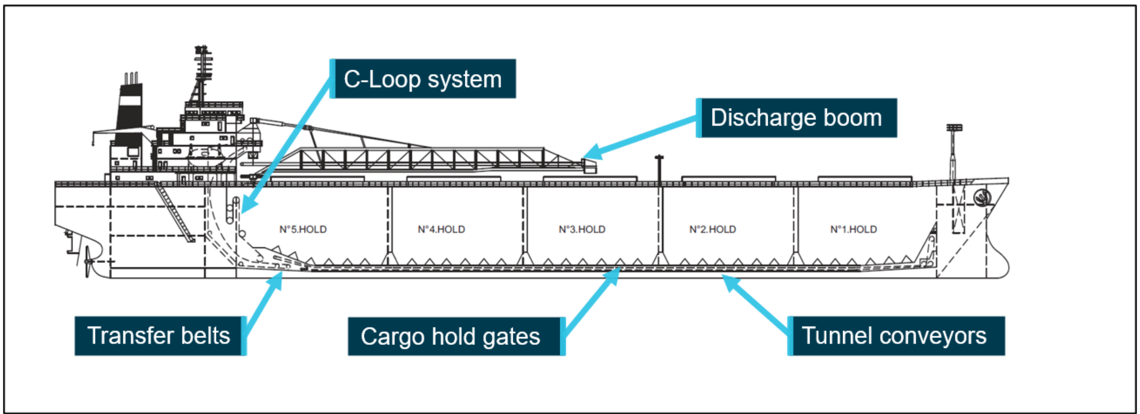
1 A constructive total loss (CTL), in the case of damage to a ship, occurs when the cost of repairing the damage under its insurance terms would exceed the value of the ship when repaired.

2 Eastern Standard Time (EST): Coordinated Universal Time (UTC) + 10 hours.

3 Dolomite is a light yellow or brown coloured mineral stone used as a sintering agent and flux in metal processing. As a bulk cargo, dolomite is considered non-combustible, with a low fire risk.

belt system, known as the C-Loop elevator, and then across the ship's deck to the shore-side hopper and trucks via a discharge boom (see the section titled *The self-unloading system)*.

Figure 2: *Iron Chieftain*'s self-unloading system



Source: CSL Australia, annotated by the ATSB

On 15 June 2018, the first day of discharging, the tunnel conveyors had to be briefly stopped to rectify a frozen conveyor idler roller.[4] Cargo discharge operations proceeded without incident for the next 3 days with the exception of a few unexplained automatic system stoppages. On each occasion, the system's programmable logic controller was reset, and discharge continued without issue. The expected completion time for cargo discharge operations was on the morning of 18 June 2018.

Cargo rounds

The ship's deck officers and integrated ratings (IR)[5] maintained 4-hour cargo watches in port. The officers controlled and monitored the cargo discharge operation at the SUL system control console on the navigation bridge (bridge) while the IRs monitored operations on deck. The ship's engine room was unattended at night,[6] with the duty engineer notified of any alarms through the engineer's alarm panel in their cabins.

As part of their duties during cargo watch, IRs conducted fire and safety rounds of the ship, which included checks of the SUL system. The rounds consisted of checks of the cargo discharge boom on deck, the vertical C-Loop space, the athwartships transfer belts (at the bottom of the C-Loop space), and along each fore and aft tunnel under the cargo holds (Figure 2). These rounds were usually conducted at least twice during every 4-hour watch.

In addition, the ship's deck mechanic conducted regular inspections of the SUL system spaces between the hours of 0800 and 1700, with an additional round at evening (usually between 2000-2100) before retiring for the day. The deck mechanic's inspection consisted of a general visual check of the system and conveyor belts as well as the use of a pyrometer[7] for temperature checks of various components such as bearings, rollers, and motors.

Activity leading up to the fire

On the morning of 16 June 2018, the ship took on heavy fuel oil (HFO) bunkers. Following bunkering, the total quantity of HFO held on board was recorded as being about 952 t, of which about 815 t was held in the port and starboard HFO tanks, adjacent to the C-Loop space, with the remainder in the engine room's settling and service tanks.

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4 A non-driven roller supporting the belt and the load carried on the belt.
5 Integrated ratings are qualified to perform the duties of both an able seaman and an engine rating.
6 The ship was equipped, surveyed, and certified to operate with the machinery spaces periodically unattended.
7 A pyrometer is a device used to remotely measure the temperature of an object or surface.

On the evening of 17 June 2018, during safety rounds of the SUL system, the 1600–2000 IR observed that the rubber coverings had come off a conveyor idler at the base of the C-Loop elevator belts. He reported that this was advised to the chief mate.

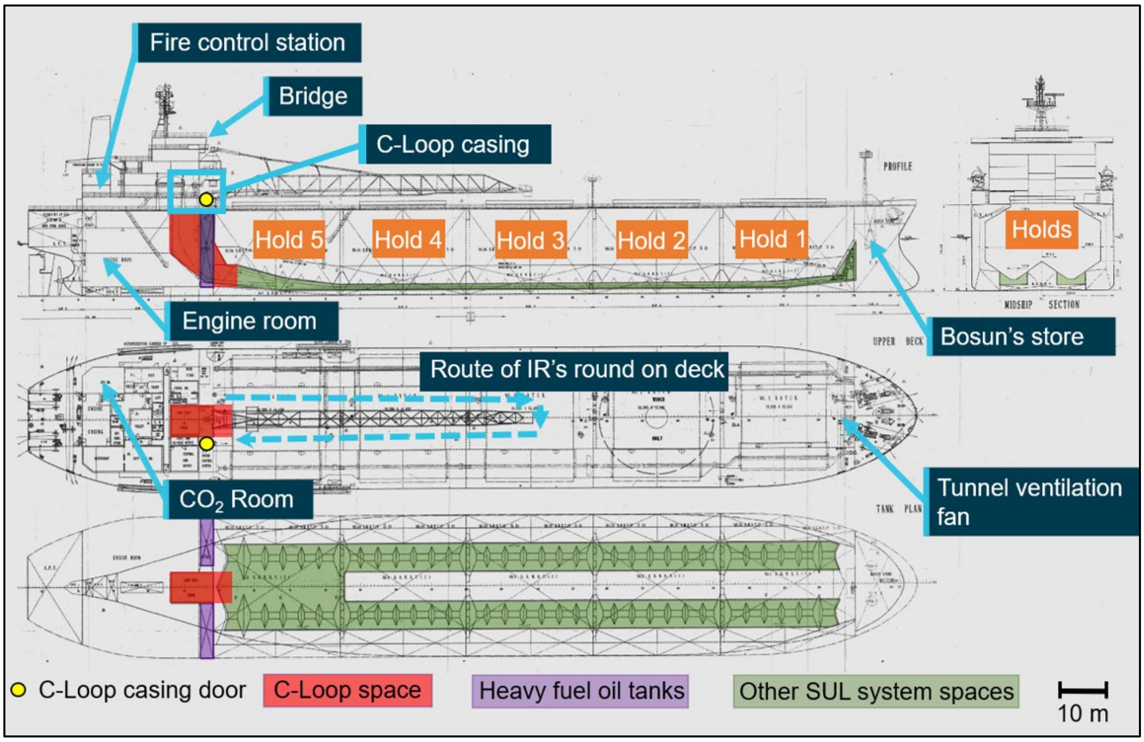
At about 2000, the deck mechanic conducted a safety round of the SUL system. The deck mechanic reported that the system was operating satisfactorily during his round with no issues observed. The 2000–0000 IR also conducted two safety rounds during his watch with nothing of significance reported.

At 0100 on 18 June, the 0000–0400 IR conducted a safety round of the SUL system. At the conclusion of the round, at about 0125, the SUL system was reported to be operating smoothly with no abnormal odour, noise, or observations.

The fire

At 0300, the IR radioed the second mate, who was the officer of the watch, and informed him that he was about to start his rounds again. The second mate started the ventilation fan (located on the foc'sle) which provided airflow through the tunnels from forward to aft. By this time, just under 40,000 t of cargo had been discharged from the ship's five cargo holds with about 2,000 t remaining to be discharged from hold number 3 (Figure 3). The hatch covers on hold number 3 were open with those on the four empty cargo holds closed.

Figure 3: *Iron Chieftain* – Ship's plans highlighting relevant spaces and information



Source: CSL Australia, modified and annotated by the ATSB

At the time the IR commenced his rounds, the wind was south-westerly, at about force three[8] (7-10 knots), blowing offshore across the ship's deck from starboard to port. The IR walked to the aft end of the cargo discharge boom on the ship's main deck and climbed up to the port side of the boom. As the IR walked forward along the port side of the boom, he noticed an unusual smell. The IR quickly continued forward and crossed over to the starboard side at the discharge end of the boom. Once on the starboard side of the boom, the IR smelled something similar to rubber and

8 The Beaufort scale of wind force, developed in 1805 by Admiral Sir Francis Beaufort, enables sailors to estimate wind speeds through visual observations of sea states.

started to walk aft to make his way back down to the deck. As the IR neared the aft end of the boom, he saw something that looked like white smoke or dust coming from the C-Loop casing door on the main deck, which was always open during cargo operations (Figure 4). As the IR climbed down from the boom to the deck and walked to the door, the smoke reportedly abruptly changed from white to black.

Alarm raised

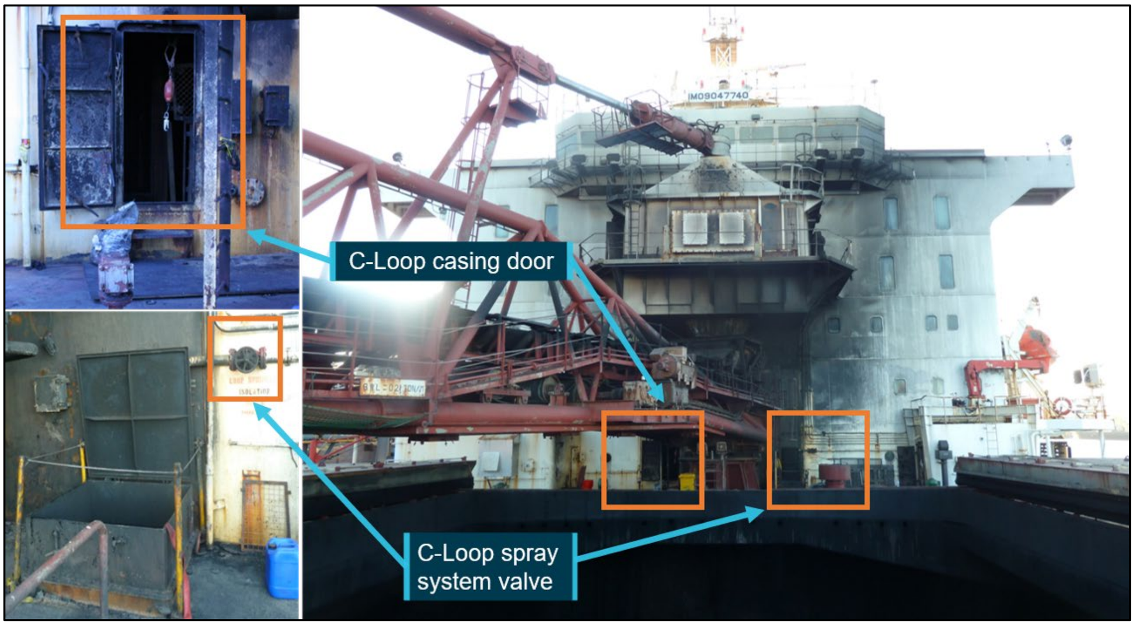
The IR immediately used his radio to report the strange smell and smoke to the second mate on the bridge and requested that cargo discharge be stopped. The IR considered entering the C-Loop space but decided that it was too dangerous due to the large amount of smoke. The second mate acknowledged the IR's report and asked him to confirm his request for the cargo discharge to be stopped. The IR confirmed this and then made his way to the bridge using the ship's elevator. Once on the bridge, the IR and second mate could clearly see black smoke rising from below the bridge front where the C-Loop casing was located.

At 0306, the second mate stopped cargo discharge by closing the gates at the bottom of the cargo hold and shutting down the SUL conveyor belt systems. This stopped the system's conveyor belts in sequence, with the tunnel conveyor belts stopping first, then the transfer belts, the C-Loop belts and finally the discharge boom conveyor belt.

At about 0307, the second mate telephoned the chief mate and first engineer to alert them to the situation and inform that cargo discharge had been stopped. The chief mate acknowledged the report, dressed, and proceeded to the main deck to assess the situation while the first engineer advised the second mate to call the deck mechanic. When the chief mate arrived on deck, he saw black smoke at the aft end of the discharge boom and concluded that there was a fire in the C-Loop space or tunnels and radioed the second mate to raise the alarm.

Shortly after, the chief mate was joined by the deck mechanic. Together they attempted to open the valve for the C-Loop dust suppression spray system, which was in front of the accommodation to port of the C-Loop casing. However, they could not approach it due to the smoke and heat emanating from the C-Loop casing. They decided to go back to the emergency muster station and organise an emergency party to return and open the valve.

Figure 4: C-Loop casing door and C-Loop spray system valve



Source: ATSB, modified and annotated

Meanwhile, the IR went back down to the deck, using the ship's elevator, to start setting up fire hoses for firefighting and boundary cooling. The IR went to the port side of the main deck but due to the amount of smoke being blown to port, made his way around to the starboard side and began to rig the fire hoses for boundary cooling.

At 0311, the second mate activated the ship's fire alarm,[9] which sounded for 13 seconds before unexpectedly stopping. The second mate used the bridge telephone to call the master who had heard the alarm. He then activated the fire alarm again, which sounded for 12 seconds before again stopping. About 8 seconds later, the alarm sounded for 1 second, and soon after, for 2 seconds before going silent. By this time, several crewmembers, including the off-duty IRs, had been woken by the alarms. Most of them turned on their radios, heard reports of the fire and began making their way to the emergency muster station, located outside the fire control station, on the starboard side of A-deck, aft of the accommodation.

At 0312, the master arrived on the bridge. By this time, the second mate had notified shore personnel of the fire and they began to evacuate their trucks from the wharf area. The second mate then left the bridge to go down and assist with firefighting efforts. Once on deck, the second mate joined the 0000–0400 IR in rigging hoses for boundary cooling the C-Loop casing from the starboard side of the main deck.

At 0313, a smoke detector activated the fire alarm, which sounded for 9 seconds. The master checked the fire detection system control panel and saw that a number of zones had activated. The master then attempted to sound the ship's general emergency alarm[10] to muster the ship's crew. The alarm sounded but stopped after four short blasts. The master tried to sound the general emergency alarm again, but it did not work. Shortly after, the master broadcast a request over the radio to the BlueScope Steel shift supervisor ashore requesting that emergency services be notified. The master then made an announcement on the ship's public address system notifying the ship's crew of the fire and instructing them to proceed immediately to the ship's emergency muster station.

Just after 0314, the fire detection system panel indicated 'fire' followed by 'system failure'. This sequence continued for the next minute or so. By this time, the second engineer, who was the duty engineer, had been woken by the engineer's alarm in his cabin (also activated by the fire detection system). He went up to the bridge to see what was happening and, on seeing the activity, decided to proceed to his muster station in the engine control room. On his way down, he met the electrical engineer who accompanied him to the engine room. Shortly after, the second engineer radioed the bridge that he was at his muster station in the engine control room.

At about 0315, some 10 minutes after the initial detection of the fire, the BlueScope Steel shift supervisor ashore called the emergency services and reported a fire on board *Iron Chieftain*. The shift supervisor then advised the master that emergency services had been notified and were on their way.

At 0316, the third mate arrived at his muster station on the bridge to assume his emergency duties of managing external communications. The third mate reminded the master that the general emergency alarm should be sounded to muster the ship's crew. The master told him that he had tried to sound the alarm but that it did not work. The third mate then suggested that he would go around the accommodation and physically check that everyone was awake and aware of the fire. The master agreed and the third mate left the bridge and made his way down through the ship's accommodation notifying personnel along the way, including the chief engineer, first engineer and third engineer.

[9] Continuous ringing of the ship's bells.

[10] The general emergency alarm signal is at least seven short blasts followed by one long blast on the ship's whistle and repeated on the ship's alarm bell system.

Shipboard response to the fire

At about 0318, Fire and Rescue New South Wales (FRNSW) began to assign assets to respond to the fire. As per its standard operational procedures, FRNSW tasked two fire appliances[11] to respond to the incident, which was initially described as a 'fire in galley or crew quarters'.

At about the same time, the chief mate reported to the master that the seat of the fire was still unknown and that he was unable to approach the main deck door to the C-Loop space due to smoke and heat. Meanwhile, several crewmembers had gathered at the ship's emergency muster station.

The chief mate briefed the gathered crew on the situation and gave orders for further actions. These included:

- starting the emergency fire pump
- shutting ventilation flaps around the accommodation
- starting boundary cooling
- organising the emergency party.

The two-person emergency party consisted of the deck mechanic and the chief IR. They were instructed to don the two fireman outfits and self-contained breathing apparatus (SCBA) stored in the fire control station, approach the C-Loop casing, close the C-Loop casing door on the main deck and open the dust suppression spray system valve. The chief mate then went to the bridge and started the cargo hold washing pump that supplied water to the spray system.[12]

At 0319, the second engineer radioed to report that the engine room's forward bulkhead adjoining the C-Loop space was very hot. The master acknowledged the report and asked the second engineer to shut down ventilation to the ship's accommodation. Shortly after, the second engineer reported that the paint on the engine room forward bulkhead was starting to blister.

By this time, the chief engineer had made his way to the bridge. He observed that several fire zones, including those covering the engine room, were active on the ship's fire detection system control panel.

At 0320, the master radioed the chief mate with instructions for two men in fireman outfits and SCBA sets to locate the source of the fire and for at least two men to be sent down into the engine room to set up boundary cooling of the bulkhead. By this time, the master had started the main and emergency fire pumps.

At 0321, the third mate arrived at the muster station and, together with an IR, set off for the foc'sle to retrieve the two fireman outfits, SCBA sets and spare air cylinders stored in the foc'sle store. Once there, they noticed that the ventilation fan blowing air through the tunnels and the SUL system spaces was still operating. The IR reported this over the radio and asked for it to be stopped. The pair then gathered the stored equipment and made their way back to the emergency muster station.

At 0322, the second engineer broadcast multiple reports over the radio that there was a 'big fire' in the engine room. The master acknowledged the report and ordered the chief mate to send any SCBA-equipped crew to the engine room. The master reported the fire in the engine room to the BlueScope Steel shift supervisor ashore who in turn reported this to Port Kembla vessel traffic information centre (VTIC). The master also checked with the shift supervisor as to the status of

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[11] Fire appliance: A fire appliance means any vehicle that forms part of the equipment of a fire brigade and that is equipped with an audible warning device and flashing lights. This includes tankers, pumpers, aerial firefighting appliances and other specialised appliances.

[12] The cargo hold washing pump supplied the C-Loop spray system, tunnel spray system and deck washing line.

shore firefighting services and was reassured that they were not far away. By this time, FRNSW assets were en-route to the port.

Meanwhile, the two-person emergency party, equipped with fireman outfits and SCBA sets, made their way to the front of the accommodation and attempted, unsuccessfully, to open the C-Loop spray valve. They also noticed that the tunnel ventilation fan was still running. They returned to the muster station to replace their air cylinders and to get a tool to help open the pressurised valve.

Shortly after, the chief engineer followed by the master, ordered the engine room to be evacuated as use of the engine room's carbon dioxide (CO_2) fixed fire-extinguishing system was being contemplated. The master and chief engineer then left the bridge for the muster station. Before leaving, and in preparation for the imminent release of CO_2, the chief engineer activated the bridge emergency stops, which shut down the:

- accommodation and cargo hold fans
- other engine room auxiliary machinery, including the diesel and fuel oil transfer pumps.

On the way down, the master went to his cabin to attend to two family members who were visiting, and found the chief mate assisting them prepare for evacuation.

The chief engineer manually stopped the air conditioning system fans and ordered that all fuel quick closing valves (QCVs) be activated, and engine room fire flaps closed in preparation for CO_2 release. At 0323, the second engineer reported that the fuel QCVs in the fire control station had been activated while the first engineer shut the engine room's funnel doors, dampers, and flaps.

The chief engineer then went to the fire control station and checked that the main fire pump, emergency fire pump and the general service pump were running. He also ordered that the emergency generator be started manually but not put on-line while the main generators in the engine room were still powering the ship. The second engineer and third engineer went to the emergency generator room and manually started the emergency generator. Soon after, the activation of the QCVs took effect and the ship's main generators shut down thereby blacking out the ship. The chief engineer then ordered the emergency generator brought on-line.

Arrival of Fire and Rescue New South Wales

At about 0325, about 10 minutes after the initial FRNSW notification and 20 minutes after the fire was first detected, the first FRNSW assets began arriving at the port facility. At about this time, the master ordered all crew to the muster station for a headcount to ensure that there was no one left in the engine room when CO_2 was released.

By 0329, the master had completed a headcount and confirmed that all personnel were accounted for. All engineers were clear of the engine room while the chief mate, second mate, two IRs and one trainee IR were engaged in boundary cooling forward of the accommodation with five fire hoses.

At 0330, Port Kembla VTIC notified the harbour master of the fire on board *Iron Chieftain*. At about the same time, the first FRNSW assets were arriving on the wharf.

Meanwhile, the emergency party returned to the C-Loop casing with a wheel spanner and successfully opened the C-Loop spray valve. This time, the tunnel ventilation fan was reported as being stopped likely as a result of the main generators shutting down. Shortly after, the master ordered all crew to prepare to evacuate the ship.

Fire and Rescue New South Wales operations

18 June 2018

At about 0333, the first FRNSW firefighters boarded the ship. The first arriving firefighters observed that there was heavy, black smoke with significant heat and flame issuing from the C-Loop casing at deck level. They also noted that the discharge boom conveyor belt on deck was smouldering along its entire length but was not alight. The firefighters set up a defensive firefighting strategy and escalated the FRNSW response to a ‘5th alarm level’.[13] Meanwhile, FRNSW began to notify other relevant agencies and organisations including Marine Rescue New South Wales, Environmental Protection Agency (EPA), Roads and Maritime Services (RMS), New South Wales Police and ambulance services.

The ship’s master, aided by other senior officers, briefed FRNSW firefighters on the situation and explained that there was a fire most probably in the C-Loop space. The crew also began to disembark the ship on the master’s orders. The master, chief mate, chief engineer, and the ship’s emergency party (deck mechanic and chief IR) remained on board to assist FRNSW with familiarisation of the ship’s spaces and gaining access to the C-Loop casing.

The master discussed the option of activating the engine room CO_2 fixed fire-extinguishing system with FRNSW firefighters and advised that the system was prepared and ready for release. The firefighters concurred with this course of action and, shortly after, the chief engineer flooded the engine room with CO_2. By this time, the emergency generator had been successfully brought on-line although, in the course of completing this task, the first engineer reported smoke and a minor fire in the emergency switchboard.

At 0350, the Port Kembla harbour master declared a port emergency and suspended all shipping activity. The harbour master also established contact with FRNSW over the telephone and delegated incident controller status to them.

By this time, the discharge boom conveyor belt on deck was alight, with the fire spreading rapidly (Figure 5). FRNSW firefighters on scene advised that it would be a protracted response and requested additional resources. The firefighters then focused on extinguishing the visible fire on the discharge boom. FRNSW noted that 22 people, including the ship’s crew, and the master’s family, had been evacuated from the ship. Over the following days, members of the ship’s crew, often including the master and chief engineer, returned to the ship to assist firefighting efforts and assessment activities, including making entry to the C-Loop casing with FRNSW firefighters.

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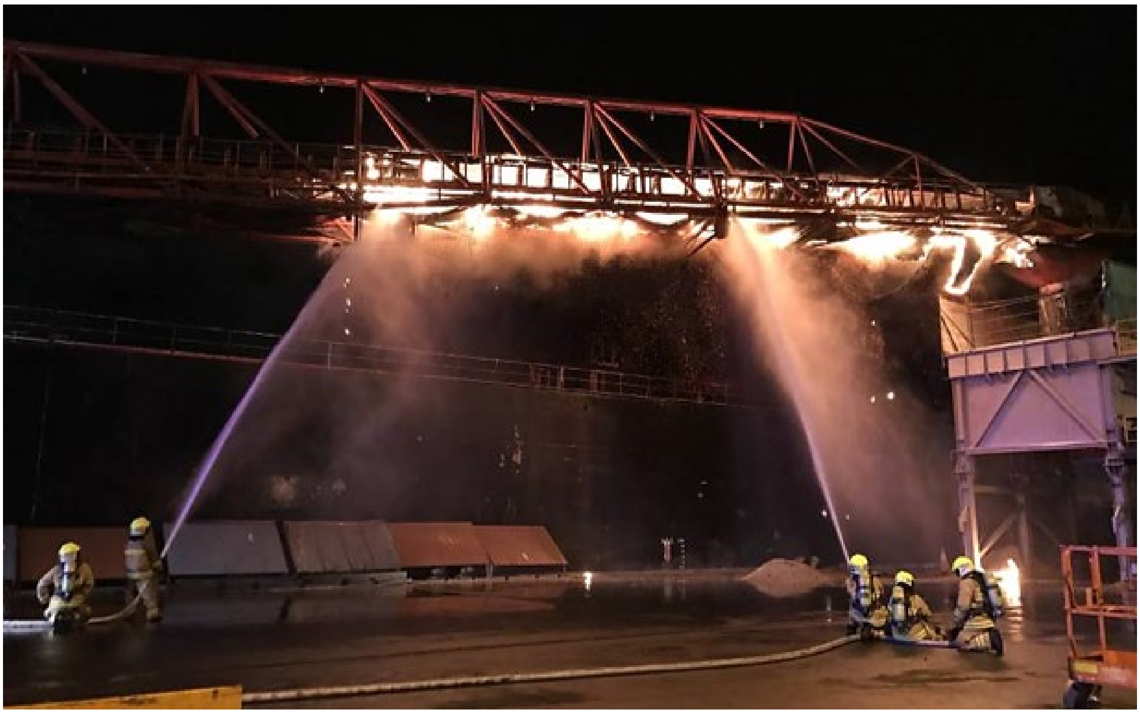
[13] Alarm Response Protocols (ARP) are a standardised response level for incidents within specific areas of NSW. Under FRNSW Standard Operating Guidelines, a 5th alarm level denoted a significant structural fire. At a 5th alarm level, 10 firefighting appliances, three aerial appliances, hazardous material appliances, senior officers and an Incident Management Team, among other resources, are deployed.

Figure 5: Boom conveyor on fire



Source: Port Authority of New South Wales

At about 0351, the tug *Barunga*, assigned by Port Kembla VTIC to assist with firefighting efforts, arrived on scene. VTIC advised FRNSW firefighters that the tug could be contacted on very high frequency (VHF) radio channel 11 and provided the tug master's mobile telephone number. About 20 minutes later, tug *Svitzer Kiama* also arrived on scene. The port's pilot boat, which was equipped with a forward-looking infrared camera, also provided imagery and on-water assistance to FRNSW throughout the response to the incident.

By 0400, FRNSW firefighters decided that internal firefighting operations on the ship were impossible due to the volume of smoke but continued with defensive firefighting operations.

At 0420, on the harbour master's orders, Port Kembla VTIC formally transferred incident controller status from the Port Authority of New South Wales to FRNSW.

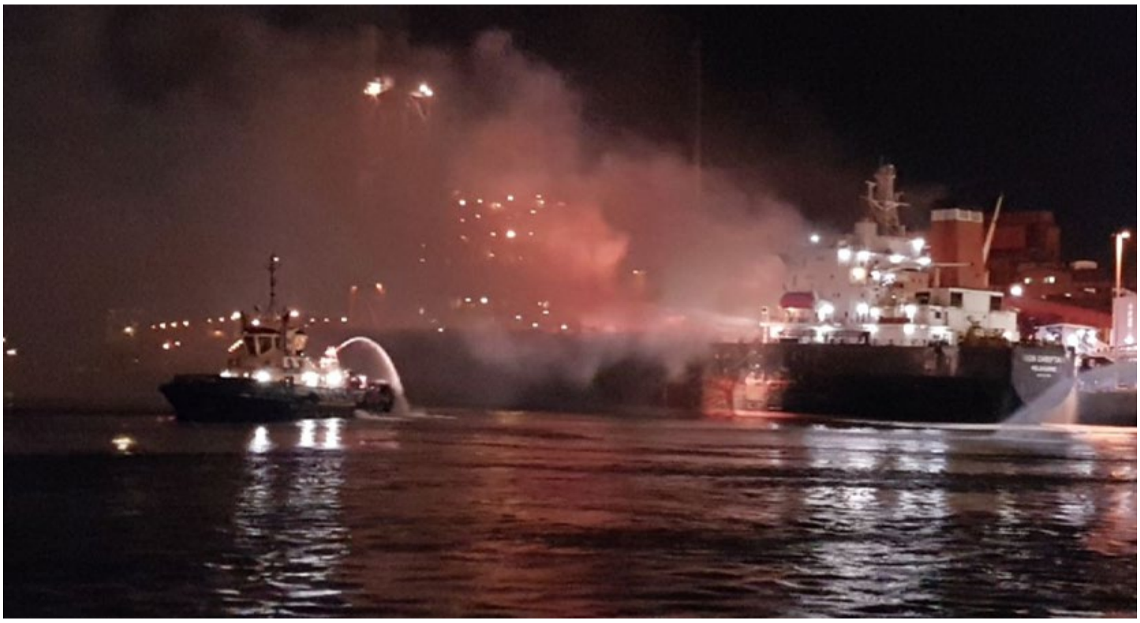
By 0447, firefighting crews began to withdraw from the ship as the fire gained intensity and they became aware of the two HFO tanks adjacent to the C-Loop space. Defensive firefighting continued and the ship was reported to be well alight internally with large volumes of smoke.

At 0457, a senior FRNSW officer arrived on scene, assumed the incident controller (IC) role, and began to set up an Incident Management Team (IMT). By about 0532, a FRNSW mobile command centre (MCC)[14] had arrived on site.

By 0606, the IMT was established and included representatives from FRNSW, the ship, police, and the port authority. An anti-pollution boom was also installed around the ship by the port authority and tug support remained in place (Figure 6). Representatives from the ship's owners, Canada Steamship Lines Australia (CSL Australia) also arrived on site later that day.

14 The Mobile Command Centre (MCC) provides a platform for FRNSW Incident Management Teams (IMT) and interagency liaison officers to command, control and coordinate the response and recovery phases during major emergencies and events.

Figure 6: Port Kembla tugs assisting with firefighting efforts



Source: Port Authority of New South Wales

At about 0703, FRNSW made the decision to stop the emergency generator and isolate all shipboard power. Internal temperatures were measured at about 200 °C with no elevated external temperatures. By 0830, FRNSW considered the fire contained and extinguishment plans were being developed. Meanwhile, high-expansion firefighting foam was being sourced from across NSW and interstate.

By 0942, the firefighting strategy began to transition from defensive to offensive firefighting using foam. At about 1144, firefighters reported zero visibility at the C-Loop casing door with temperatures between 46-56 °C. Shortly after, the ship's master went aboard to provide assistance with opening the bow access hatch to the forward end of the SUL system tunnel spaces. Meanwhile, firefighting continued using aerial appliances and without the firefighters entering the C-Loop space (Figure 7).

Figure 7: Firefighting using aerial appliances

Source: Fire and Rescue New South Wales

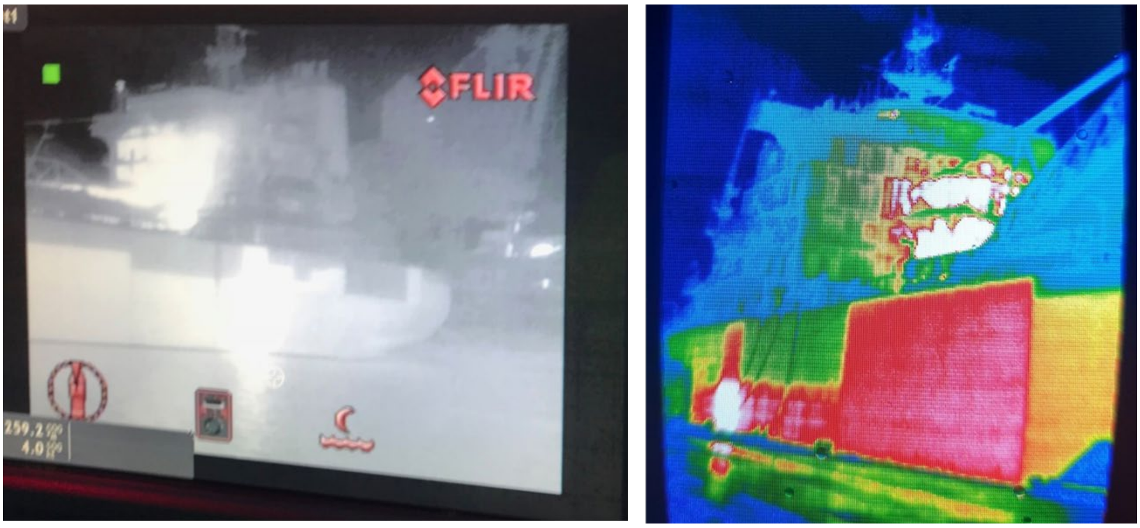
At 1200, the harbour master re-opened the port to shipping.

At 1659, temperatures of about 109 °C were recorded in holds number 3 and 4. Soon after, a changeover of the IMT got underway in accordance with FRNSW Standard Operating Guidelines (SOG) and, at about 1800, crews were rotated.

Sometime that evening, firefighters tasked with conducting an internal assessment, accessed the port tunnel via the bow access hatch. They made their way aft down the port tunnel and reported an active fire at the aft end of the tunnel as well as the sound of falling metal objects.

At 2106 that night, firefighters attempted to gain access to the SUL system spaces through the C-Loop casing door but reported that access was too dangerous for firefighting operations. Infrared imagery indicated that the fire was active in the C-Loop space and aft sections of the tunnels (Figure 8).

Figure 8: Infrared imagery on 18 June



Source: Port Authority of New South Wales (left) and FRNSW (right)

19 June 2018

At 0029 on 19 June 2019, firefighters using SCBA sets entered the tunnel spaces through the access hatch on the ship's bow. The crews proceeded aft down the starboard tunnel and noted minimal indications of fire on the starboard side. At about midships, the crews crossed over from the starboard tunnel to the port tunnel through a communicating passageway.

Once on the port side, the crews saw a fire burning at the aft end of the port tunnel. A fire hose was lowered through an access hatch midships between holds number 2 and 3. The crews advanced as far as the hose would allow before they had to withdraw due to their air cylinders running low. The hose was lashed to the ship's structure and left in place. On deck, firefighting crews connected foam monitors to the hose lines and commenced introducing low-expansion foam into the tunnels. This had the effect of forcing smoke and hot gases aft and out through the C-Loop. The effectiveness of this strategy was then monitored on an hourly basis.

At about 0200, IMT and crew changeovers took place. At 0243, the discharge boom conveyor belt fire on deck was fully extinguished.

By 0428, firefighters reported that access aft in the tunnels was restricted from about 50 m from the C-Loop due to water, foam, and submerged obstructions. The firefighting strategy was modified to using hoses in a vertical attack from the deck through hatches adjacent to the superstructure.

At 0516, firefighters in SCBA sets entered the ship's accommodation to retrieve crew personal effects and documents. The ship's living quarters were identified to have high carbon monoxide (CO) levels.

At 1058, the master and chief engineer boarded the ship to retrieve the HFO tank sounding logs and other records. Shortly after, ship's staff and members of the IMT began considering the risk of the HFO tank bulkheads being breached. While the master and chief engineer worked to assess if there was a leak from the HFO tanks, FRNSW ceased all water application to the C-Loop space.

At 1230, a multi-agency briefing took place. Options were discussed for obtaining temperatures of the HFO tanks. It was considered too dangerous for readings to be taken physically on board the ship. Instead, FRNSW hazardous materials (HAZMAT) crews were assigned to monitor the lower explosive limit (LEL) gas readings[15] from the HFO tanks vents. HAZMAT crews were also assigned to the tug to take temperature readings of the port side HFO tank while an aerial firefighting appliance was assigned to monitor the temperature of the starboard tank. Meanwhile, the strategy of application of low-expansion foam continued while FRNSW awaited receipt of high-expansion foam supplies.

At 1350, HAZMAT crews found LEL readings at the HFO tank vents were negligible.

At 1446, the temperature in the port and starboard HFO tanks had reached 45 °C and 50 °C, respectively.

At 1524, on the master's advice, FRNSW crews began to attempt to activate the C-Loop spray system. However, because the system was not part of the fire main, the ship's international shore connection[16] could not be used to connect to the spray system line. A suitable connection was then fabricated by BlueScope Steel and, by 1552, water application through the C-Loop spray system was activated.

By 1600, temperatures in the post and starboard tanks had increased to 60 °C and 50 °C, respectively.

At 1721, FRNSW assessed that the internal conveyor belt had probably collapsed resulting in a deep-seated rubber fire. All tunnel ventilation was shut to seal the space and to reduce the chimney effect caused by smoke and hot gases being drawn up to the top of the C-Loop space. Foam was being applied through the C-Loop stores hatch and the C-Loop casing door, with boundary cooling being conducted using other FRNSW assets and tugs (Figure 9). LEL levels and temperature readings continued to be monitored at 30-minute intervals. By this time, some high-expansion foam supplies had arrived from the Australian Capital Territory while further deliveries were awaited from Queensland and elsewhere in New South Wales.

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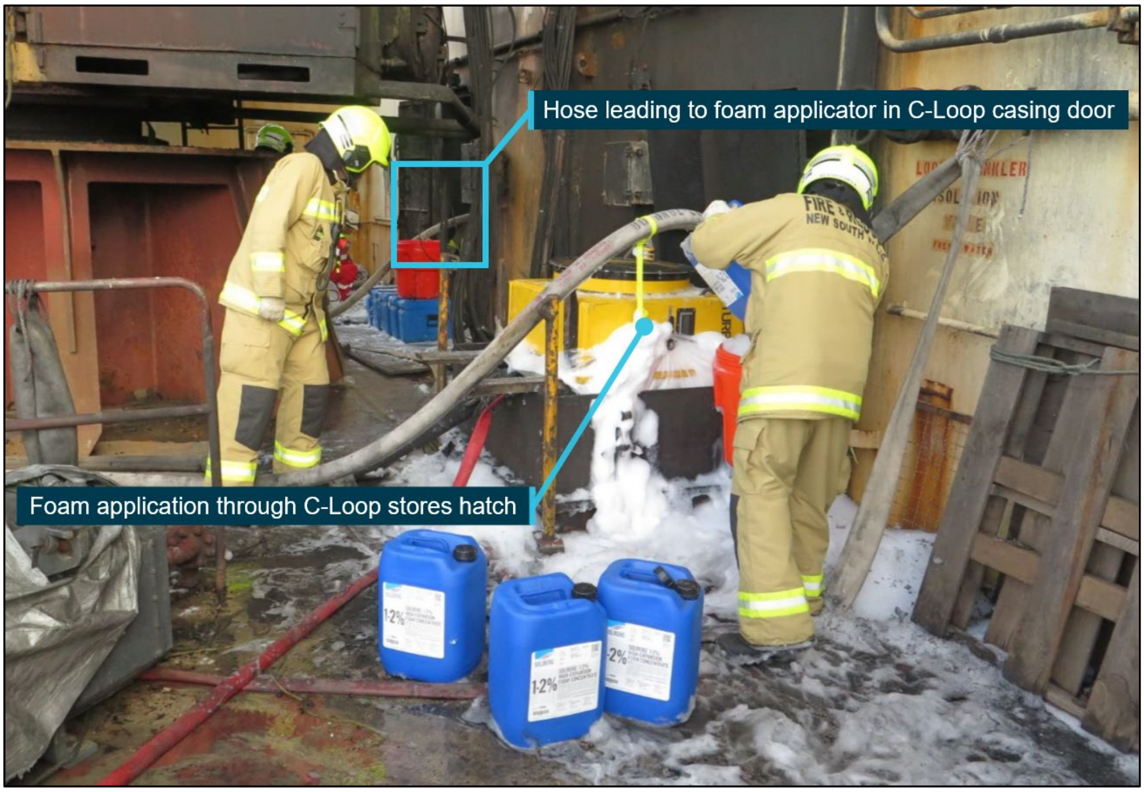
15 Lower explosive limit (LEL) is the concentration (by percentage) of a hydrocarbon gas or vapour in air below which there is insufficient hydrocarbon to support and propagate combustion.

16 An international shore connection consists of a standard flange that is fitted to the ship's fire main. It allows land-based fire services hose to supply the ship's fire main. The ship's part of the international shore connection also has a flange. Once the flanges have been bolted together, fire service pumps can supply water to the ship's fire main.

Figure 9: Foam application to C-Loop space



Foam being introduced through the C-Loop stores hatch aft of cargo hold number 5. In background, note hose leading to foam applicator in the C-Loop casing door.
Source: Fire and Rescue New South Wales, annotated by the ATSB

By 2115, HFO tanks temperatures had increased to 55 °C at the starboard tank and 88 °C at the port tank. An assessment of the ship's stability showed that the ship was stable with a draught of about 9.9 m. It was also assessed that a maximum draught of 11 m was allowable before there was a risk of the ship grounding. Firefighting operations remained in defensive mode and CSL Australia representatives were assigned the task of collating engineering details and assessing the consequences of continued water application.

20 June 2018

At 0343 on 20 June 2018, the FRNSW IC and CSL Australia determined that, based on the ship's stability and volume of water applied, the rubber conveyor belts were likely to be under water. Water application through the C-Loop spray system was therefore shut off.

Shortly after, the tug assisting with boundary cooling on the ship's port side was called away to other duties. At 0427, the FRNSW IC requested that a tug be stationed permanently at the ship to assist with firefighting efforts. Subsequently, tug *Barunga* was permanently assigned to the ship.

At about 0800, a consultant from the Minton, Treharne, and Davies Group (MTD) with expertise in fire science arrived on site. [17] The consultant was engaged to provide liaison services between CSL Australia and other authorities including FRNSW, as well as to provide fire science analysis and advice to expedite the extinguishment of the fire.

At 1132, the local emergency plan was activated. An Emergency Operations Centre (EOC) was set up at a port authority building located a short distance from the wharf. The IC (and incident control) transferred from the FRNSW MCC on the wharf to the EOC at the port authority building.

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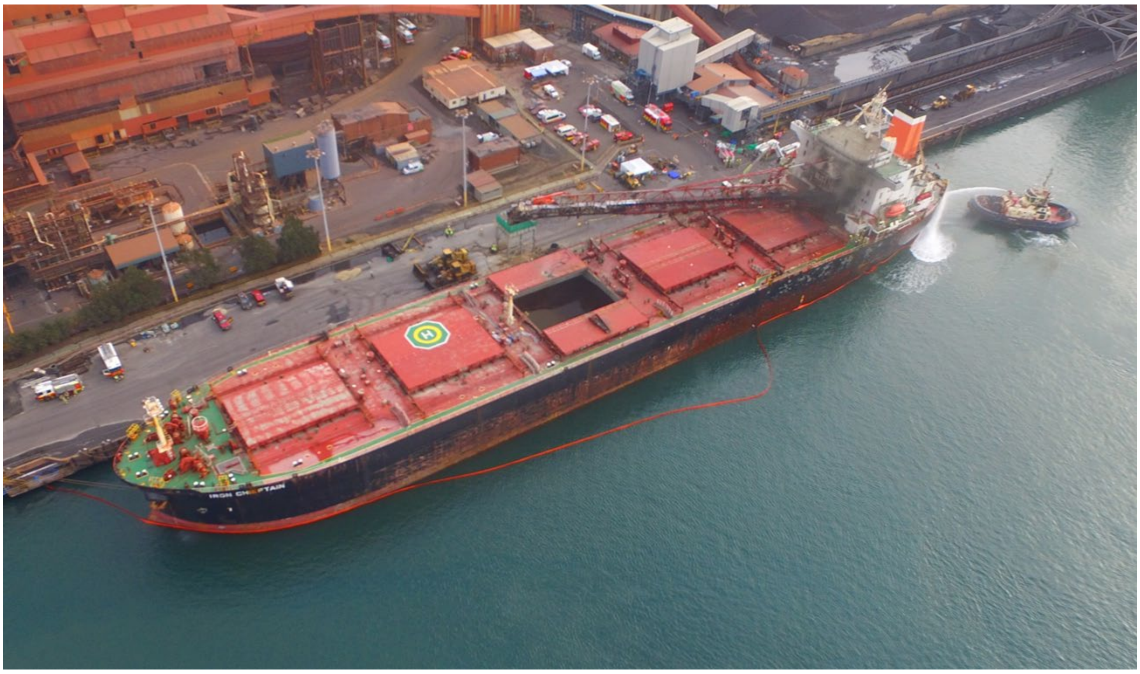
17 The Minton, Treharne and Davies Group (MTD) are a consultancy with expertise in matters relating to science and engineering in the marine industry.

In addition, local and regional emergency operations controllers started to assist with the management of the response.

Separately, the Port Kembla harbour master, acting on behalf of the port authority, engaged a marine salvage firm, Ardent Oceania, to provide salvage and fire advice. Representatives from the salvors arrived late that afternoon.

Shortly after midday, a FRNSW remotely piloted aircraft system (RPAS) was deployed to assist firefighting efforts by providing aerial daylight and thermal imagery (Figure 10).

Figure 10: RPAS footage of *Iron Chieftain* on fire on 20 June



Source: Fire and Rescue New South Wales

At 1309, fire crews accessed the ship's engine room to determine if there were any signs of fire and found that temperatures within the space were normal. At about 1345, the ship's chief engineer went aboard to inspect the engine room and machinery to check temperatures and HFO quantities and, to assess the feasibility of restoring power to the ship.

At 1453, a specialist tank-gauging device was obtained from a nearby fuel storage facility to assist with measuring the temperatures and quantities of HFO in the tanks. Shortly after, preparations were made to resume application of water through the C-Loop spray system and hydrants. At about 1535, the deck discharge boom was freed from the shore hopper, on which it had come to rest as the ship's draught increased. The discharge boom was then stabilised and locked in position.

At 1600, HFO tanks temperatures were recorded as 63 °C at the starboard tank and 105 °C at the port tank.

At 1916, a decision was made to implement a change in firefighting strategy with high-expansion foam to be introduced directly into the C-Loop space using four lines. It was estimated that 1600 cubic metres (m^3) of foam would be required to fill the space. By this time, sufficient foam stocks had arrived to begin to implement this strategy with further stocks expected later that evening to allow for topping-up of the foam.

At 2149, the initial estimate of foam required to fill the C-Loop space was revised to 2500 m^3. By this time, the C-Loop spray system had been stopped because the spray nozzles were found to be completely ineffective.

Fire extinguished

During the night of 20 June 2018 and the morning of 21 June 2018, the C-Loop was filled with foam and tugs continued boundary cooling. The foam was regularly topped up and temperatures continued to be monitored. On 21 June, at 1233, soundings of the HFO tanks indicated a discrepancy in tank levels. By 1352, the port HFO tank was confirmed to be leaking oil, probably into the C-Loop space as inspections of the engine room had found no sign of HFO. By 1645, a leak was confirmed in the starboard HFO tank as well.

On 22 June 2018, at 0755, firefighting crews along with ship's engineers completed an assessment of the cargo holds, engine room and superstructure. The low temperature readings and gas monitoring readings obtained indicated that extinguishment had been achieved (Figure 11). The inspections also revealed that HFO, firefighting water or a combination of both had leaked from the tunnels into cargo hold number 3. FRNSW continued to maintain the foam blanket in the C-Loop space while monitoring the situation and beginning preparations to hand over the site.

Figure 11: *Iron Chieftain*, with the fire extinguished

Source: ATSB

At 0600 on 23 June 2018, temperatures and LEL readings remained stable. At 1837 on 23 June, the hatch covers of cargo hold number 5 were opened with no obvious signs of fire observed although it was evident that HFO and/or firefighting water had leaked into this cargo hold as well.

At 1552 on 24 June, FRNSW handed over the site to New South Wales Police and CSL Australia.

Over the 7-day duration of the incident, a total of 245 FRNSW appliances and 192 officers and specialist staff attended the fire. In addition, marine firefighters from Victoria's Metropolitan Fire and Emergency Services Board (MFB) attended the *Iron Chieftain* incident at FRNSW's invitation to observe and assist the IMT as subject matter experts.

There was no reported pollution to the marine environment and, except for minor damage to the shore discharge hopper, no significant damage to port infrastructure. FRNSW reported minor injuries to several firefighters over the course of the incident.

Fire damage assessment

Iron Chieftain sustained substantial damage including breaches of the two HFO tanks as a result of the fire.

The SUL system components and spaces bore the brunt of the fire damage. The boom was significantly damaged with parts of the conveyor belt and associated structures destroyed. In the C-Loop space, the drive motors, pulleys, idlers and associated belt equipment showed varying degrees of fire, heat and smoke damage. The inner and outer conveyor belts that comprised the C-Loop elevator were destroyed. There was also significant structural damage to support members resulting in the collapse of several conveyor rollers. At the bottom of the C-Loop space, in addition to the fire damage, there was also HFO contamination and water. It was estimated that a total of about 507 m^3 (approximately 456 t) of HFO was lost from the port and starboard HFO tanks into the C-Loop space and tunnels. The aft ends of the port and starboard tunnels sustained fire damage to conveyor belts and associated structures and fittings.

As a result of the substantial damage sustained due to the fire, *Iron Chieftain* was declared a constructive total loss (CTL). The ship remained at Port Kembla for several months while work continued to remove and dispose of the remaining fuel and contaminated firefighting water on board. On 27 March 2019, the ship departed Port Kembla under tow, for Aliaga, Turkey to be recycled (Figure 12).

Figure 12: *Iron Chieftain*, departing Australia under tow

Source: ALP Maritime

Context

Iron Chieftain

Iron Chieftain was a gravity fed, C-Loop, self-unloading bulk carrier built in 1993 by Hyundai Heavy Industries in Ulsan, Republic of Korea. At the time of the fire, the ship was Australian registered and classed with Lloyd's Register.

The ship was purpose-built for Broken Hill Proprietary (BHP)[18] who owned and operated it from 1993 to 2003 carrying coal from Port Kembla, New South Wales (NSW) to Whyalla, South Australia (SA) and iron ore back to Port Kembla. In December 2003, *Iron Chieftain* was purchased from BHP by Canada Steamship Lines Australia (CSL Australia). The ship was operated by CSL Australia and employed on the Australian coast carrying cargoes including coal, iron ore and dolomite.

The ship was equipped with the necessary navigational, firefighting and lifesaving equipment required by SOLAS[19] for a ship of its size (see the section titled *The self-unloading system*). This included a Japan Radio Corporation JCY 1850 voyage data recorder (VDR)[20] from which information useful to the investigation was recovered, including bridge voice recordings.

Ship's crew

Iron Chieftain was manned by crews operating on an 8-week roster with most of the crew assigned to the ship for several years.

At the time of the fire, *Iron Chieftain* had a multi-national crew of 20 Ukrainian, Australian, New Zealand, and Philippines nationals.

The master had about 14 years of seagoing experience, held a Ukrainian master's certificate of competency and the equivalent Australian certificate of recognition. The master had about 10 years' experience on SUL ships most of which was with the CSL Group. He first joined *Iron Chieftain* about 7 years previously (as third mate) and had worked almost exclusively on board the ship since. He had about 8 months experience as master and this was his third trip in command of *Iron Chieftain*. He had joined the ship about 2 weeks before the fire.

The chief mate had about 22 years of seagoing experience, held a Ukrainian master's certificate of competency and the equivalent Australian certificate of recognition. The chief mate had about 16 years' experience on SUL ships of which the last 8 years were with the CSL Group. He had about 11.5 years' experience as chief mate and had worked on *Iron Chieftain* for the previous 2.5 years. He had joined the ship about a month before the fire.

The second mate had about 18 years of seagoing experience, held a Ukrainian chief mate's certificate of competency and the equivalent Australian certificate of recognition. The second mate had about 12 years' experience on SUL ships most of which was with the CSL Group. He had about 10 years' experience as second mate. This was his first trip on board *Iron Chieftain*, which he had joined about 2 weeks before the fire.

The third mate had about 15 years of seagoing experience and held an Australian deck watchkeeper certificate of competency. The third mate had about 8 years' experience on various

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[18] In 2001, BHP merged with Billiton to from BHP Billiton. However, in 2018, 'Billiton' was dropped from the organisation's name and is now known as BHP.

[19] International Maritime Organization, 2014, The International Convention for the Safety of Life at Sea (SOLAS) 1974 as amended, IMO, London.

[20] A voyage data recorder is designed to collect and store data from various shipboard systems in compliance with SOLAS requirements.

ships in the CSL fleet including on SUL ships. He had about 5 years as third mate and had worked on *Iron Chieftain* for about 8 months. He had joined the ship about 2 weeks before the fire.

The chief engineer had about 15 years of seagoing experience, held a Ukrainian chief engineer's certificate of competency and the equivalent Australian certificate of recognition. The chief engineer had about 10 years' experience on SUL ships with the CSL Group. He had worked on *Iron Chieftain* for the previous 5 years and this was his third trip as chief engineer. He had joined the ship about 3 weeks before the fire.

The second engineer had about 12 years of seagoing experience, held a Philippines engineering watchkeeper certificate of competency and the equivalent Australian certificate of recognition. The second engineer had about 7 years' experience in the rank with all of it on board *Iron Chieftain*. He had joined the ship about 3 weeks before the fire.

The deck mechanic had about 12 years of seagoing experience, held a Ukrainian rating's qualifications and the equivalent Australian certification of recognition. The deck mechanic had about 8 years' experience on SUL ships with the CSL Group, all of it on board *Iron Chieftain*. He had joined the ship about 2 weeks before the fire.

The 0000–0400 IR had about 20 years of seagoing experience and held an Australian integrated rating's qualifications. The IR had worked on *Iron Chieftain* for about 7 years and had joined the ship about 3 weeks before the fire.

The rest of the ship's ratings held appropriate qualifications for their roles, and they had all served on board *Iron Chieftain* previously.

Cargo

The ship's cargo for the voyage from Ardrossan, SA to Port Kembla, NSW was granular dolomite in bulk. The ship was carrying three separate parcels of different grades of dolomite in its five cargo holds.[21]

The ship's previous cargo was coal, shipped from Gladstone, Queensland (QLD) to Whyalla, SA. Prior to loading the dolomite in Ardrossan, the ship's cargo holds, and tunnels were cleaned and then washed. Some of the residues from the previous coal cargo were disposed of ashore while some was swept into piles and consolidated near the aft end of the tunnels and near the athwartships transfer belts. The total quantity of remaining coal residues was estimated by ship's staff to have been between 3 and 4 cubic metres (m^3).

Dolomite

Dolomite is a very hard and compact, light yellow or brown coloured mineral stone composed of calcium magnesium carbonate. The International Maritime Solid Bulk Cargoes Code (IMSBC Code)[22] classified dolomite as a Group C cargo. Group C consisted of cargoes which are neither liable to liquefy (Group A) nor possess chemical hazards (Group B).

The IMSBC Code entry for dolomite states that the cargo is 'non-combustible' and has a low fire risk with no special hazards.

21 Granular Dolomite: 10 mm, 20 mm, and 30 mm grades.

22 The primary aim of The International Maritime Solid Bulk Cargoes (IMSBC) Code is to facilitate the safe stowage and shipment of solid bulk cargoes by providing information on the dangers associated with the shipment of certain types of solid bulk cargoes and instructions on the procedures to be adopted when the shipment of solid bulk cargoes is contemplated.

The self-unloading system

General description

Self-unloading bulk carriers were an innovation that originated in the Great Lakes of Canada and the United States. The concept allowed these ships to operate at ports with limited or no traditional bulk-handling facilities and infrastructure.

Iron Chieftain's self-unloading (SUL) system was based on a design by Stephens-Adamson Canada. The system was designed to achieve a maximum discharge rate of 3,000 tonnes (t) per hour for a cargo of coal or iron ore. At the time of the fire, cargo was being discharged to trucks ashore at a slower rate of about 500–700 t per hour.

The SUL system consisted of the cargo holds and gates, the mainly rubber conveyor belt systems (see the section titled *Conveyor belt specifications and condition*), and the discharge boom on deck. The conveyor belt systems in turn comprised the tunnel conveyors (port and starboard), the transfer conveyors (port and starboard), the vertical C-Loop elevator and the boom conveyor on deck. The SUL system also consisted of several pulleys and hundreds of idlers of various types.

Holds

Iron Chieftain's five cargo holds were each designed with tapered hoppers at the bottom that led to hydraulically operated gates. These gates directed cargo on to one of the two tunnel conveyor belts below. There were 66 gates in total (33 on each side)[23] and each gate was fitted with a hydraulically operated vibrator to facilitate the free flow of cargo.

The hopper slopes, hold inclines, and hogbacks[24] were lined with ultra-high molecular weight (UHMW) polyethylene sheeting to reduce friction and assist with the gravity feed of the cargo. The rate of cargo flow through the gates to the hold conveyor belts below was controlled by adjusting the gate openings. The gates provided for cargo flow control but did not form a watertight or airtight seal when closed.

Each of the five cargo holds had a standard, weathertight hatch cover on the main deck. The hatch cover consisted of two panels on a hatch coaming that rolled in an athwartships direction to open and close the hatch.

Tunnel conveyors

There were two hold conveyors (tunnel conveyors), port and starboard, that ran longitudinally under the cargo holds. The tunnels themselves were about 2 m in height with a common area at the forward end near the bow and at the aft end near the C-Loop elevator. Additionally, there was a communicating passage between the two tunnels amidships. The tunnels could be accessed from the C-Loop space aft, through an access hatch at the bow and through access hatches on deck.

Each tunnel conveyor belt was about 2.1 m wide, 20 mm thick and about 278 m long (in total). The tunnel conveyor belts were arranged in a 'trough' profile supported by idler rollers with the drive pulley[25] at the aft end driven by electric motors. The tunnel conveyor belts were hydraulically tensioned at their forward end. The tunnel conveyors transported cargo from the hold gates and deposited them on the transfer conveyor belts at the base of the C-Loop elevator (Step 1 in Figure 13).

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[23] Hold numbers 1 and 5 had six gates each on either side while hold numbers 2, 3 and 4 had seven gates each on either side.

[24] An inverted 'V' shaped steel structure in the cargo holds.

[25] The drive pulley is driven by the drive train (motor). The drive pulley transmits the driving force to the conveyor belt.

Transfer conveyors

There were two transfer conveyor belts, port and starboard, one each at the aft end of each tunnel conveyor belt. The transfer belts were oriented in the athwartships direction, perpendicular to the tunnel belts. Each transfer conveyor belt was about 2.1 m wide, 26 mm thick and about 19 m long (in total). The transfer conveyors were driven by electric motors and were mechanically tensioned. The transfer conveyors moved the cargo from the tunnel conveyors to a discharge hopper above the horizontal section of the C-Loop outer belt at the bottom of the C-Loop space (Step 2 in Figure 13).

C-Loop system

The C-Loop vertical elevator system was situated on the ship's centreline, aft of the transfer belts, with the aft bulkhead of the space contiguous with the engine room's forward bulkhead. The vertical space housing the C-Loop system emerged from the upper deck just forward of the accommodation to form a C-Loop 'casing' or 'tower'. At the bottom of the C-Loop space, forward of the transfer belts and between the port and starboard tunnels, there was a space containing a small workshop and storage area. There were also two small spillage clean-up conveyors on either side at the base of the C-Loop belts.

The C-Loop conveyor belts consisted of an outer electric motor-driven conveyor belt loop onto which the cargo was loaded from the transfer belts (Step 3 in Figure 13). The outer belt was paired with a passive (non-motor driven) inner belt which rotated in the opposite direction to the outer belt so as to 'sandwich' the cargo and transport it vertically up the C-Loop elevator tower (Step 4 in Figure 13). The inner and outer belt loops separated at the top where the cargo was discharged into a chute and on to the discharge boom conveyor (Step 5 in Figure 13).

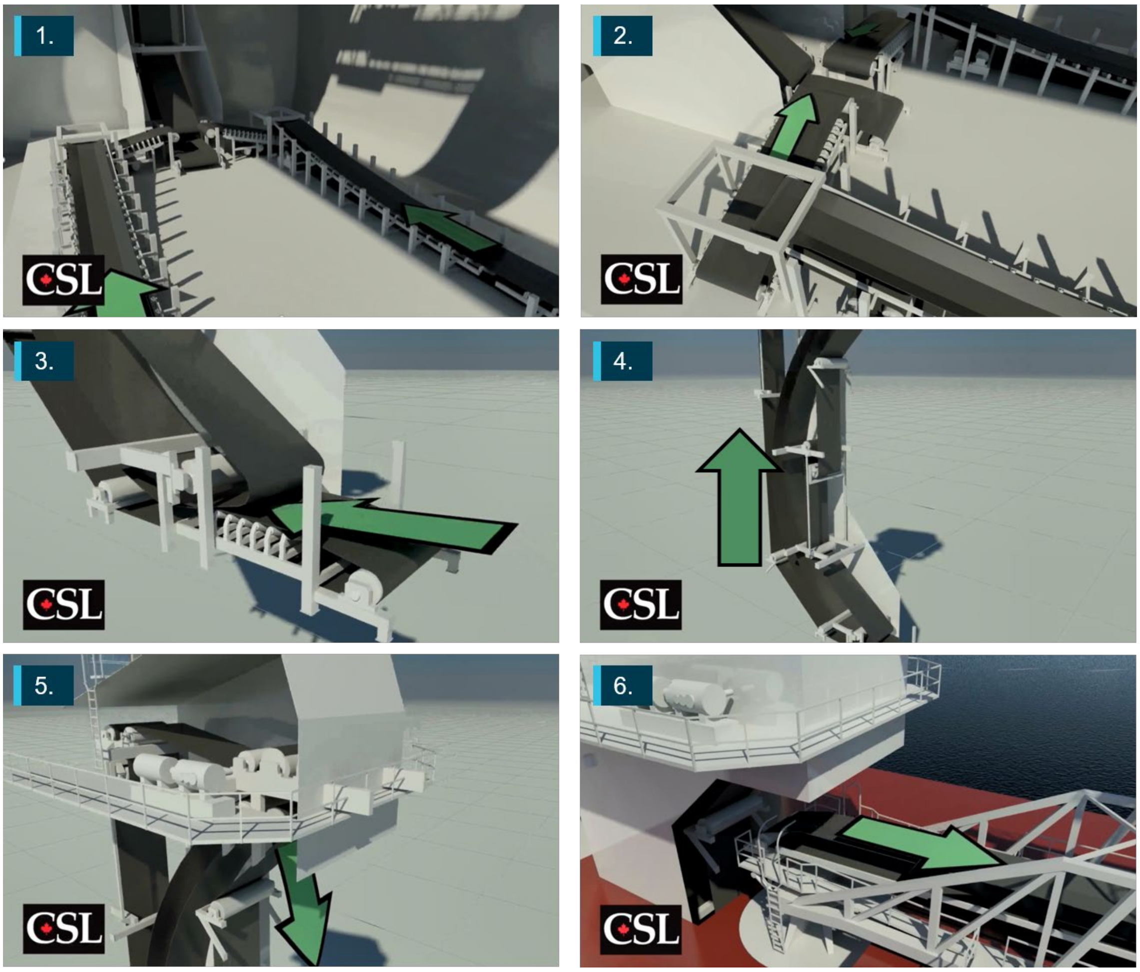
The outer belt was about 2.6 m wide, 23 mm thick and about 95 m long while the inner belt was about 2.7 m wide, 23 mm thick and about 69.5 m long. The C-Loop belts were hydraulically tensioned.

Discharge boom conveyor

The discharge boom conveyor on deck transported the cargo from the termination of the C-Loop elevator belts, just forward of the accommodation, to receiving facilities ashore or on another vessel (Step 6 in Figure 13). The boom conveyor belt was enclosed within corrugated metal roofing with timber anti-spill liners. The boom was 72 m long giving it a working radius of about 56 m from the ship's side. The boom could be hydraulically slewed up to 90° to either side and luffed up to an angle of 18° from the horizontal. The discharge boom conveyor was driven by electrical motors.

The boom conveyor belt was about 1.9 m wide, 22 mm thick and about 165.8 m long.

Figure 13: General operation of *Iron Chieftain*'s SUL system



Source: CSL Group, modified and annotated by the ATSB

Control, monitoring and safety systems

SUL operations console

The SUL system was controlled and operated by the ship's officers from a control console located in the ship's bridge. The control system incorporated a programmable logic controller (PLC) and a computer to provide a display and a control interface for the operation of the system. There was no recoverable data available from the computer system or the PLC. There were no reported alarms or automatic shutdowns of the SUL system prior to the fire.

CCTV

The SUL system included closed-circuit television (CCTV), with the images displayed at the control console on the bridge. The CCTV system comprised 12 cameras with five fixed cameras distributed through each of the port and starboard tunnels. The cameras in the tunnels faced forward and monitored the aftermost gates for each hold. In addition, there were two portable cameras, one used to monitor the cargo hold being discharged and the other positioned at the discharge end of the boom conveyor on deck. There were no cameras in the C-Loop space. The second mate reported that there were no signs of fire on the CCTV in the time leading up to the fire. There was no recorded CCTV data available.

Gas monitoring system

The hold conveyor tunnels had a gas monitoring system with sensors located at the aft and forward end of the tunnels. The system's sensors could monitor oxygen, methane, carbon monoxide and hydrogen sulphide gas levels as well as the concentration of any flammable gases in the tunnel atmosphere (as a percentage of the lower explosive limit described previously). The control and monitoring equipment for this system was in the chief engineer's office on the upper deck, which was unmanned at the time of the fire. The system was not connected to the ship's bridge or fire detection and alarm systems and there was no recoverable data available.

Emergency stops

The SUL system had thirteen emergency stops distributed throughout the tunnel spaces, C-Loop space, and boom conveyor. Activating an emergency stop closed all the hold gates, turned off the gate vibrators and stopped all conveyor belts.

The system had an in-built control that ensured that any stoppage of the conveyor belts occurred in a sequential order. The tunnel conveyor belts stopped first followed by the transfer conveyors, the C-Loop belts and finally the boom conveyor. This ensured that any load on the belt was run off before the system comes to a standstill.

Conveyor belt safety systems

The conveyor belts had additional protection systems installed. These included electrical protection devices offering overcurrent and thermal protection for the belt drive motors as well as belt slippage[26] and belt drift[27] detection systems.

The C-Loop belts did not have belt drift detection sensors installed and misalignment of these belts was prevented by keeping the ship's list to a minimum during cargo operations. Red and green lights on the ship's foremast and on the external SUL casing indicated the ship's list. There were also red, amber, and green lights at regular intervals in the tunnels to indicate load on the tunnel conveyor belts.

There was no evidence to indicate the ship had a list during cargo operations that may have caused a belt misalignment and no indications of a parted conveyor belt in the SUL system. There were also no apparent issues with the various electrical systems and components serving the SUL system.

Rules and regulations

There were no SOLAS regulations or requirements covering the SUL system equipment or conveyor belt standards. Similarly, there are also no classification society rules governing the flammability of conveyor belt systems or the fitting of fire detection or fixed fire extinguishing systems in the SUL system spaces.

Conveyor belt specifications and condition

Rubber conveyor belts are usually composed of two key elements—a central 'carcass' which provides the tensile strength and mechanical characteristics of the belt and, top and bottom rubber covers which protect the carcass. The carcass could be of textile (fabric) or steel cord construction.

Iron Chieftain's conveyor belts were of a multi-ply, polyester/nylon fabric construction with rubber covers. The belt carcasses were made up of layers (or plies) of polyester and nylon adhered to each other. The tunnel belts, transfer belts and boom belt were of 5-ply construction while the C-Loop belts were of 6-ply construction.

26 The belt slip detector worked by detecting any discrepancy between the speed of the drive pulley and the speed of another non-driven pulley or idler on the same belt, in this case, the tail pulley (return pulley).

27 Belt drift occurs when the belt deviates laterally from the system's optimal alignment.

Table 1 summarises key information related to the lifespan, grade, and specifications of the various conveyor belt rubber in use on board *Iron Chieftain,* based on an assessment conducted in April 2018.

Table 1: *Iron Chieftain* - Conveyor belt details

Conveyor belt	Installation date	Grade of belt rubber	Remaining lifespan
Tunnel conveyor (P)	1993 (Original)	RMA 2	1 year
Tunnel conveyor (S)	1993 (Original)	RMA 2	1 year
Transfer conveyor (P)	2014	AS1332-M	2 years
Transfer conveyor (S)	2014	AS1332-M	1 year
Outer C-Loop belt	2014	AS1332-M	1 year
Inner C-Loop belt	2014	AS1332-M	2 years
Boom conveyor	2014	AS1332-M	6 to 12 months

Source: CSL Australia

Grade of conveyor belt rubber

The original design specification for the SUL system required the conveyor belt rubber covers to be of Rubber Manufacturer's Association (RMA) Grade 2 rubber[28] (or an equivalent German Institute for Standardization Grade N rubber).[29] The current international standard equivalent to RMA Grade 2 rubber is Association for Rubber Products Manufacturers (ARPM) Grade 2 rubber.[30]

The port and starboard tunnel conveyor belts were still the original belts installed by the shipbuilders, Hyundai. They had been in use since 1993 and were of RMA Grade 2 rubber (ARPM Grade 2). The C-Loop inner and outer belts, the transfer conveyor belts, and the boom conveyor belts were replaced in January 2014 with belts of AS 1332 Grade M rubber,[31] manufactured by Goodyear.

Properties of the conveyor belt rubber

The RMA Grade 2 (ARPM Grade 2) rubber conveyor belt covers, originally installed on board *Iron Chieftain* and still in use in the tunnels, was classified as a general-purpose rubber cover.[32] ARPM Grade 2 rubber was described as having 'good to excellent abrasion resistance properties' but the description did not include any reference to flame or heat resistance.[33]

Similarly, the AS1332 Grade M rubber covers comprising the other conveyor belts on board were also considered to be general-purpose rubber. The relevant Australian standard (AS1332-2000) did not include any requirements for flame or heat resistance properties for AS1332 Grade M rubber.[34]

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28 RMA (Rubber Manufacturers Association).

29 DIN (Detaches Institut fur Normung): German Institute for Standardization.

30 ARPM (Association for Rubber Products Manufacturers): Formed in 2011, the ARPM took over the rights for the publishing, sale and editing of former RMA publications including those related to standards.

31 Australian Standard 1332-2000: Australian Standard for Conveyor belting – Textile reinforced.

32 Association for Rubber Products Manufacturers, 2011, *Conveyor and Elevator Belt Handbook*, Fourth Edition, Indianapolis, US.

33 Conveyor belt rubber covers with high-temperature service and flame-resistance service classifications were designated ARPM-HR (Classes 1, 2 and 3).

34 Under the AS1332-2000 standard, rubber with fire and heat resistance characteristics were designated Grade R and Grade S.

The AS1332-2000 standard referred to two other standards[35] which described the methods of testing conveyor and elevator belting for ignitability, flame propagation characteristics and maximum surface temperature of belting subjected to friction. Variations of the mandated tests were performed to determine if the AS 1332 Grade M rubber exhibited any flame or heat resistance properties generally tested for in belts (such as self-extinguishing properties or minimal ‘afterglow’ requirements).

The tests were conducted at the ATSB’s laboratories in Canberra and used a sample of spare conveyor belt retrieved from *Iron Chieftain*. The tests showed that the belt was capable of catching fire through the application of flame as well as through the application of heat. Once alight, the flame was self-sustaining, even after the original source of ignition had been removed, and the fire continued burning until the entire test sample had been consumed.

The tests confirmed that the AS1332 Grade M rubber used in *Iron Chieftain*’s C-Loop, transfer belts and boom conveyor did not exhibit any flame or heat resistance properties.

Condition of conveyor belts

An inspection of the ship’s conveyor belts carried out in December 2015 assessed the condition of the C-Loop belts, boom belt and transfer belts as ‘good’, the port tunnel belt as ‘fair’ and the starboard tunnel belt as ‘poor’.

At the time of the fire, the tunnel and boom conveyor belts were generally described as being in a ‘worn’ condition. The C-Loop belts were described as being in a ‘poor’ condition with metal fasteners, which was a common method used to repair existing splices that had started delaminating until permanent repairs were carried out. Repairs were performed on the C-Loop inner belt in December 2015 and on the C-Loop outer belt in December 2017. These repairs involved the splicing of new sections of belt into the existing belt using metal clamps, to repair damaged sections where the belt had started to delaminate. In addition, there were several other minor repairs carried out by the ship’s crew as part of routine maintenance.

Delamination or damage, particularly to the edges of the conveyor belts, can aid ignition and fire spread due to the greater surface area presented and the thinner nature of the rubber material.

Fire detection, containment, and extinguishment

SOLAS regulations, specifically Chapter II-2, sets out the fire protection, fire detection and fire extinction regulations for ships. In Australia, the Australian Maritime Safety Authority’s (AMSA) Marine Order 15 gives effect to Chapter II-2.[36]

As a regulated Australian vessel, *Iron Chieftain* was required to comply with the relevant SOLAS fire safety regulations.

At the time of the fire, *Iron Chieftain* held Cargo Ship Safety Construction and Cargo Ship Safety Equipment Certificates issued by the ship’s classification society, Lloyd’s Register. The certificates and associated surveys showed that the ship complied with the relevant requirements of Chapter II-2 of SOLAS including those requirements regarding fire safety systems, appliances, and plans.

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35 Standards AS1334-10-1994 and AS1334-11-1988 described the methods of testing the fire/heat resistance standards of the Grade R and Grade S rubber belts. The first standard specified a test involving placing a flame under a sample of the belt. The second standard outlined a test involving heating a section of the belt through friction with a rotating metal drum. Due to equipment constraints, an approximation of the second test was simulated by the ATSB with a heat gun.

36 Marine Orders are legal instruments made by AMSA pursuant to powers under Commonwealth legislation. They are also described as regulatory instruments or legislative regulations.

Fire detection system

Iron Chieftain was equipped with a Thorn Minerva T880 32-zone fire detection system. The ship was divided into 17 fire-detection zones utilising 139 individual smoke, flame or temperature detectors spread across the ship's accommodation, machinery, and other spaces.

There were no fire detectors installed in any of the SUL system spaces.

The activation of a detector head would set off an audible alarm on the ship's bridge with a visual indication of the relevant zone and detector. The alarm could then be silenced while the detector activation was investigated and dealt with. If investigation found that there was no cause for concern, then the system was reset at the bridge fire panel. In the event the bridge audible alarm was not silenced within a set period, the ship's fire alarm signal consisting of the continuous ringing of the ship's bells would automatically activate.

Unresolved anomaly

A report from an authorised technician's inspection of the ship's fire detection system from May 2016 noted an anomaly arising from an internal issue with the fire alarm panel. The anomaly meant that when the system was reset from a detector activation, zone 1 detectors would indicate as active and the ship's fire alarm would be activated. The report also noted that the anomaly only occurred at the system reset stage and did not hinder the correct activation of detectors. The report concluded with a recommendation that the fire alarm panel be replaced in the near future. The anomaly was not reported to the Australian Maritime Safety Authority (the ship's flag State administration) as the system was still considered operational.

In November 2017, the fire detection and alarm system was serviced and tested by an authorised technician. The system, including the general alarm system, was noted to have been operating correctly and there was no reference to the anomaly.

At the time of the fire, the fire detection system anomaly remained unresolved. Accounts from several of the ship's crewmembers mentioned the anomaly and the resulting instances of spurious activation of the ship's fire alarm. They reported that, when the ship's fire alarm activated, crew generally waited for a PA announcement or the sounding of the general emergency alarm before responding.

Fire containment

The design and layout of *Iron Chieftain*'s SUL system meant that the 140 m long port and starboard tunnels, along with the vertical C-Loop casing and communicating spaces, formed one large compartment. There were no internal divisions or doors fitted that could be used to further compartmentalise the space. There was also no means of sealing the upper termination of the C-Loop, where the inner and outer belts separated to deposit cargo onto the boom conveyor.

In addition, the cargo hold gates were not airtight making it almost impossible to completely seal off the SUL system space.

Fire extinguishment

Iron Chieftain's fire plan showed the following firefighting appliances covering the ship's C-Loop and tunnel spaces:

- Twenty-four fire hydrants with manual valves
- sixteen fire hose reels with nozzles and 38 mm fire hoses (15 m in length).

In addition, there were 22 fire hydrants and 11 fire hose boxes (with nozzles and hoses) capable of covering the boom conveyor on the ship's upper deck.

The fire hydrants were served by the ship's fire main line (fire main), and water could be supplied by three pumps—a main fire pump, a general service pump and an emergency fire pump. The emergency fire pump was connected to the emergency switchboard and emergency generator. The pumps could be started from the bridge, engine control room, fire control station and locally at each pump. The fire main had two isolation valves located on the upper deck—one isolated the deck from the engine room and the other isolated the deck from the tunnel fire main.

There were five portable dry powder extinguishers located at the bottom of the C-Loop space, although they were not required by the fire plan.

Fixed fire-extinguishing system

There was no fixed fire-extinguishing system fitted to protect the C-Loop or tunnel spaces on board *Iron Chieftain*.

SOLAS required a fixed gas fire-extinguishing system[37] be fitted to protect cargo spaces[38] of ships above a certain size. However, the regulations also allowed ships to be exempt[39] from this requirement if they were constructed and intended solely for the carriage of cargoes that were considered to constitute a low fire risk.[40] *Iron Chieftain* held an exemption certificate on the basis that the ship only carried the cargoes listed in the certificate. *Iron Chieftain*'s list of permitted cargoes included coal, ore and cargoes listed in groups A and C of the IMSBC Code (such as dolomite).

Iron Chieftain's engine room and machinery spaces were protected by a gas (carbon dioxide) fixed fire-extinguishing system.

Dust suppression and cleaning systems

The C-Loop conveyor belts and tunnels were fitted with a dust-suppression and cleaning spray system. These systems were neither designed nor intended for firefighting purposes although the ship's crew treated them as such.

The C-Loop spray system consisted of 39 spray nozzles (20 on the port side and 19 on the starboard side) directed at the belts but not at the bearings supporting either ends of the idler rollers (Figure 14). The C-Loop spray system was not part of the fire main. The system was supplied by a hold washing pump located in the engine room, which usually drew fresh water from a dedicated hold washing tank although it could be set up to draw seawater. The piping to the C-Loop spray system was routed to the upper deck where there was an isolation valve to port of the C-Loop casing, just forward of the accommodation. This isolation valve had to be manually opened to allow water flow to the C-Loop spray system.

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37 SOLAS Ch II-2/Reg 10.7.1.3

38 Cargo spaces are defined as spaces used for cargo, cargo oil tanks, tanks for other liquid cargo and trunks to such spaces.

39 SOLAS Ch II-2/Reg 10.7.1.4

40 IMO Circular MSC.1/Circ.1395/Rev.1 *List of solid bulk cargoes for which a fixed gas fire-extinguishing system may be exempted or for which a fixed gas fire-extinguishing system is ineffective.*

Figure 14: C-Loop spray system nozzle

A C-Loop dust suppression spray system nozzle directed at where the conveyor belt would normally be. Note the exposed idler rollers of the C-Loop elevator belt system.
Source: MTD

The tunnel spray system consisted of eight nozzles (four in each tunnel). The system was supplied by the same hold washing pump that supplied the C-Loop spray system although the manual isolation valve for the tunnel system was in the engine room. In addition, each of the eight spray nozzles had their own individual, manually operated valves that were normally kept shut. At the time of the fire, these valves were shut, and they remained so throughout the incident.

The hold washing pump and its associated suction and discharge valves could be controlled from the bridge. The control panel had instructions attached to it which emphasised the need to ensure that at least one spray valve was open before the pump was started. This was because the system had no pressure relief valve. Operating the pump with the valves closed would pressurise the system and make it harder to operate manual valves.

The C-Loop spray nozzles were reported to have been in very poor condition. Furthermore, when the spray system was set up for dust suppression (as it was at the time of the fire),[41] the water spray pressure was usually too low to be effective for firefighting.

Fire safety on board SUL bulk carriers

The International Safety Management (ISM) Code[42] has as its objective the prevention of human injury or loss of life and the avoidance of damage to the environment and to property. Among other things, it requires companies to provide for safe practices in ship operations, to assess all identified risks to ships, personnel and the environment and, to establish appropriate safeguards against these risks. The Code aims to achieve this by requiring companies to develop, implement and maintain a safety management system (SMS), with instructions and procedures to ensure the

41 The spray system had been set up and used for dust-suppression purposes the day before the fire although it was not in use during cargo discharge operations on the night of the fire.

42 International Maritime Organization, 2018, International Management Code for the Safe Operation of ships and for Pollution Prevention (ISM Code) as amended, IMO, London.

safe operation of ships, to prepare for and respond to emergencies and to conduct regular audits and reviews of the system. SOLAS Chapter IX requires relevant ships to comply with the ISM Code.

Iron Chieftain's shipboard SMS consisted of general procedures and instructions broadly grouped under sections such as fleet operations, company operations and safety and environmental procedures. In addition, the SMS included a specific set of procedures and instructions for the operation of SUL bulk carriers including a section on general safety.

The SMS section on general safety for SUL bulk carriers contained information on safe work practices as well as sub-sections on how to prevent and deal with conveyor belt fires.

Prevention of conveyor belt fires

The procedures emphasised that there were no smoke or heat detectors in the C-Loop space or tunnels and that 'frequent' fire rounds by ship's personnel were necessary, especially when the SUL system was in operation. Therefore, the documented instructions for the prevention of conveyor belt fires concentrated on guidance for personnel conducting fire rounds.

Some key pieces of advice for these fire patrols included the need to use all senses of sight, smell, and hearing during fire rounds and to check for:

- overheating bearings or rollers
- noise or squeaking sounds from bearings
- hydraulic oil leaks, oily rags, or smoke
- normal running of belts
- rubbing of belts against spilled cargo.

During cargo discharge operations on board *Iron Chieftain*, the deck mechanic spent most of his time inspecting the SUL system and monitoring its operation but only between the hours of 0800-1700 (and with one additional inspection at night). The deck mechanic checked temperatures of machinery and other components of the SUL system but did not record these. The ship's IRs conducted fire and safety rounds of the SUL system spaces every 2 hours, but they did not conduct temperature checks and relied largely upon their senses to detect any abnormalities in the system.

Procedures for dealing with belt fires

The general safety procedures for the SUL system provided advice on dealing with conveyor belt fires. It stated that rubber belt fires were highly toxic with acrid smoke and required the use of SCBA sets when fighting these fires. It also stated that the C-Loop casing and tower acted as a high riser encouraging the fire. The procedure also stated that the shore fire brigade should be contacted immediately for assistance.

Other key points in the advice for dealing with belt fires are summarised below:

- if the belt catches fire while running, do not stop the belt
- train fire hoses on the running belt at intervals to cool other parts of the belt
- hose down the seat of the fire
- start loop sprinkler system if fitted
- shut hold gates and gate pumps
- tunnel exhausts must be kept running initially but stopped when entry is made
- evacuate and seal exits if efforts prove insufficient or fire becomes unmanageable.

The procedures clarified that the water sprinkler (dust suppression spray) system was not automatic and that the water output might prove inadequate. Nevertheless, the guidance stated that this system should be started immediately in the event of a fire until fire hoses could be readied. It also advised that the arrangement should be tested regularly to ensure spray nozzles did not become clogged.

In addition to the guidance in the procedures, there was relevant information in an operations checklist that covered the use of the ship's dust suppression, cleaning, and deluge systems. It advised that, in the event of an overheating belt caused by a bearing failure or by fire, one should:

- sound the alarm
- ensure all persons are accounted for (muster)
- open deluge valve located on accommodation front [C-Loop dust suppression spray system valve]
- start hold cleaning pump with seawater suction
- in event of belt fire, do not stop the belt
- reverse tunnel ventilation fan motor direction to suck out smoke
- if the cargo hold above the fire is empty, consider opening the hatch lid and gates to apply water with fire hoses.

By keeping the belt running, the entire length of the belt could be cooled by fire hoses at a single location. The movement of the belt also prevented any one section of belt from coming into prolonged contact with a hot spot such as seized idler or pulley.

Both the general SMS procedures for dealing with belt fires and the water deluge systems operations checklist instructed that, if the conveyor belt was on fire, it was not to be stopped. Most of the ship's crew were also aware that in the event of a conveyor belt fire, the belt should not be stopped. Past instances of overheated frozen idlers and failed bearings had been dealt with by closing the cargo hold gates to stop cargo flow, keeping the belt running and cooling it with water until the failed components had cooled sufficiently for the system to be stopped and repaired.

Response on 18 June 2018

Upon detecting the fire, the IR reported a 'smell' and 'smoke' to the second mate. There was no definitive mention of 'fire'. The IR also requested that cargo discharge be stopped. The second mate promptly shut down the system which stopped the conveyor belts in sequence with the boom conveyor belts being the last to stop.

With the belt stopped, the option of training fire hoses on the running belt at intervals to cool other parts of the belt was lost.

Another firefighting option recommended in the procedures was the opening of the hatch overs of cargo hold number 5 and directly attacking the seat of the fire (at the base of the C-Loop). Cargo hold number 5 was empty at the time of the fire, but this firefighting option was not attempted during the shipboard response.

At the time the fire was detected, the tunnel ventilation fan was operating and blowing air through the tunnels from the forward to aft. The direction of the tunnel ventilation fan was not reversed nor was it manually stopped. The fan eventually stopped with the loss of power as a result of the activation of the fuel quick closing valves (QCVs) in preparation for the release of CO_2 into the engine room.

SUL fire safety risk assessment

The IMSBC Code required on board operational fire safety risk assessments to be carried out by the ship's crew for cargo handling areas on SUL bulk carriers featuring internally installed conveyor systems.[43]

43 In Australia, AMSA's *Marine Order 34 (Solid bulk cargoes) 2016*, gave effect to the IMSBC Code.

The IMSBC Code stated:

> Routine on board operational fire safety risk assessments shall be carried out by the ship's crew for cargo handling areas on self-unloading bulk carriers featuring internally installed conveyor systems within the ship's structure. Due consideration shall be given to fire prevention and the effective operation of fire detection systems, containment and suppression under all anticipated operating conditions and cargoes. The fire safety risk assessments shall be detailed in the ship's Safety Management System (SMS) together with a recommended timing to provide regular assessments.

The Code required these risk assessments be detailed in the ship's SMS together with a recommended interval to provide for regular reviews of the assessments.[44] The IMO resolution amending the Code to introduce the requirement for the risk assessment was adopted in June 2015 and first appeared in its 2016 edition. The inclusion of this requirement in the Code was a result of safety action following an investigation into a fire on board an SUL bulk carrier in the UK in 2010 (see the sub section titled *Yeoman Bontrup* in *Fires involving SUL bulk carriers*). Although the amendments to the Code were adopted in 2015, many SUL ship owners and operators had already implemented this requirement and conducted or started conducting these risk assessments.

Iron Chieftain's SMS section on general safety for SUL bulk carriers included a documented requirement for an annual on-board review of the ship-specific SUL fire safety risk assessment. This requirement was also reflected in the company's schedule of drills, training, and reviews as a part of the master's annual review of the SMS that was required by the ISM Code.

The SMS included general guidance and procedures to support the effective conduct of risk assessments on board. However, there were no specific instructions or guidance in the SMS for the conduct of the SUL fire safety risk assessments.

SUL fire safety risk on board Iron Chieftain

CSL Australia provided the ATSB with a collation of fire safety risk assessments of SUL system spaces for ships owned and operated by them, including one for *Iron Chieftain*. The risk assessments were dated 10 April 2013 and had not been annually reviewed or updated following the initial assessment.

Iron Chieftain's SUL fire safety risk assessment (from 2013) evaluated the operational fire safety risk for the different locations/components that constituted the ship's SUL system—the tunnel spaces, the transfer belts, the C-Loop elevator and the boom (Appendix A). The assessment identified the cargo-handling equipment in each location, associated hazards, and existing control measures before assessing the residual fire safety risk. The risk assessment document also included summaries of past SUL ship fires and their causes.

The hazards identified in the four different SUL system spaces were the same and consisted of hot bearings, hot idlers, and the potential for belt slippage.

Existing risk control measures were divided into fire detection and fire suppression measures. Fire detection measures common to all four locations included belt slippage detectors, temperature checks by the deck mechanic and fire rounds by ship's IRs. The risk assessment also recorded the CCTV in the tunnel spaces as a fire detection control measure.

Fire suppression measures listed in the risk assessment were the ship's fire main as well as the dust suppression and cleaning water spray systems.

[44] International Maritime Organization (IMO), London, 2020, The International Maritime Solid Bulk Cargoes Code (IMSBC Code), Section 3 Safety of personnel and ship, 3.1 General requirements.

The residual risk rating was obtained by multiplying the consequence rating (1—5) by the likelihood rating (1—5). Risk ratings lower than 4 were considered 'generally acceptable' while ratings 15 and higher were considered as 'generally unacceptable'.

The residual fire safety risk for *Iron Chieftain* based on the existing control measures was assessed as follows (Table 2):

Table 2: *Iron Chieftain* SUL fire safety risk ratings

Location	Severity of consequence	Likelihood	Risk
Tunnels	Catastrophic (5)	Remote (2)	Higher than acceptable but not unacceptable (10)
Transfer belts	Catastrophic (5)	Remote (2)	Higher than acceptable but not unacceptable (10)
C-Loop elevator	Catastrophic (5)	Occasional (3)	Generally unacceptable (15)
Discharge boom	Moderate (3)	Remote (2)	Generally acceptable (6)

Source: CSL Australia

The results of the risk assessment showed that, for the C-Loop elevator in particular, the fire safety risk was 'generally unacceptable' in the absence of any further control measures.

The risk assessment included a section on 'planned future control measures' which, if implemented, would reduce the fire safety risk to an acceptable level. These planned future measures included heat detection systems for pulley and idler bearings, a low-pressure sprinkler system and a procedure for use in the event of a fire.

At the time of the fire, these long-planned control measures had not been implemented.

SUL fire safety risk on board other CSL Australia ships

The risk assessment documents from April 2013 showed that two other CSL Australia ships, *CSL Pacific* and *CSL Whyalla*, were assessed as having 'generally unacceptable' levels of fire risk in one or more of their SUL system spaces. Fire safety risk assessments for other CSL Australia SUL ships were updated in September 2018, after the *Iron Chieftain* fire. The updated risk assessment document from 2018 showed that the fire safety risk on one of these ships, *CSL Whyalla*, remained at a 'generally unacceptable' level.

Emergency preparedness and firefighting

Emergency contingency plans

Iron Chieftain's SMS required that any contingencies that might arise during the operation of the ship be dealt with according to the ship's contingency plans. These contingency plans were contained in a master document titled the Emergency Contingency Plan (ECP).

The SMS stated that instruction and training were to be carried out for various emergencies using the relevant contingency plans in the ECP. Following each exercise or drill, a review was to be conducted with the aim of identifying improvements to the contingency plan. The plans were also to be used as tools to familiarise crew with the different circumstances of an emergency and the actions required. The SMS stated that the principle was to use the plans as a framework so that in a genuine emergency or in a training exercise, the ship's crew could act 'confidently and without delay'.

Iron Chieftain's ECP comprised a class-approved Shipboard Oil Pollution Emergency Plan (SOPEP)[45] as well as 26 additional emergency contingency plans covering various potential emergency scenarios such as grounding, collision, and fires. There were emergency contingency plans specifically tailored to fires and explosions in the accommodation, engine room, on deck and during bunkering. However, there were no emergency contingency plans for fires in the SUL system spaces.

ECPs from seven other CSL Australia SUL or conveyor belt equipped vessels were examined and six were found not to have specific contingency plans for SUL system fires or conveyor belt fires.

Drills and exercises

Iron Chieftain's SMS stated that the master was responsible for the effective training and exercising of contingency plans according to the company's schedule of drills, training, and reviews. The schedule described in the SMS included mandatory drills required by the regulations as well as specialised drills required by the company.

Fire and abandon ship drills

Iron Chieftain's SMS reflected SOLAS requirements for mandatory abandon ship and fire drills. SOLAS required that every crewmember participate in at least one abandon ship and one fire drill every month. If more than 25 per cent of the ship's crew had not participated in an abandon ship or fire drill on board that ship in the last month (for example, after a crew change), then drills of the ship's crew had to take place within 24 hours of the ship leaving port.

Emergency drills including an abandon ship drill and a fire drill were last held on board *Iron Chieftain* on 25 May 2018 (24 days before the fire). Following these drills, a crew change of five crewmembers took place on 27 May in Gladstone, QLD. A further crew change of nine crewmembers took place on 5 June at Whyalla, SA. This crew change included the second mate (on duty when the fire started) for his first assignment on the ship. The other regular crew who joined the ship had been off for about 8 weeks and therefore, had not participated in a drill on board the ship in the last month.

On *Iron Chieftain*'s departure from Whyalla on 7 June, 14 of the ship's crew of 20, had not participated in an abandon ship or fire drill in the last month. Despite that, there were no drills conducted in the 24 hours after the ship left port nor were any conducted in the intervening time before the ship called at Port Kembla.

Fire drills involving the SUL system spaces

The company's training schedule included a requirement for additional fire drills on SUL bulk carriers. These drills were focussed on fighting fires in the SUL system spaces and were additional to the SOLAS-mandated fire drills. The drill schedule specified drills involving the C-Loop conveyor belts, the boom conveyor belt, the tunnel conveyor belts and cargo fires on the belts. These additional SUL system fire drills were to be held monthly on a rotating basis.

The ship's record of training showed that no SUL system fire drills had been held in the five months preceding the fire.

The last SUL system fire drill held on board *Iron Chieftain* was a fire drill involving the boom conveyor, held on 17 Jan 2018. However, the participants in this drill, including the master, were predominantly crew from the opposite duty cycle to those who were on board *Iron Chieftain* at the time of the fire. There was a fire drill involving a fire in the SUL system tunnel spaces conducted by the master on duty at the time of the fire on 30 November 2017. However, the other

[45] Under the regulations of the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78), every oil tanker of 150 tons gross tonnage and above and every ship, other than an oil tanker of 400 tons gross tonnage and above, are required to carry an approved Shipboard Oil Pollution Emergency Plan (SOPEP).

participants in this drill were also predominantly crew from the opposite duty cycle. The last SUL system fire drill involving the master and most of the officers who were on board *Iron Chieftain* at the time of the fire was on 29 October 2017.

Analysis of the training records showed that, in the 12 months preceding the fire, only five SUL system fire drills were conducted. Of these five drills, three scenarios involved a fire on the discharge boom and two involved fires in the tunnel spaces. The last documented fire drill involving the C-Loop belts or C-Loop space was reported to have been in January 2016.

Familiarisation

All of *Iron Chieftain*'s crew at the time of the fire had served on board the ship before with the exception of the second mate and the deck cadet. A shipboard familiarisation checklist had been completed for the second mate. The checklists included reminders to ensure the new joiner was made aware of the ship's emergency signals, muster stations, emergency duties and actions in the event smoke or fire was detected.

The checklists also specified role-specific tasks such as familiarisation with the procedures relevant to deck officers. This included a note advising officers to refer to operational checklists that might be relevant to them (such as the one related to the use of the ship's water spray systems).

Alarm signals and mustering

SOLAS regulations required ships to post a muster list detailing, among other things, the ship's alarm signals, actions in the event of the various alarms and emergency duties in the event of different emergencies.

On board *Iron Chieftain*, the muster list identified the fire alarm signal as the 'continuous sounds of the alarm bell'. The muster list also stated that 'fire will be investigated by duty IR/ duty engineer and announced on the PA system'.

The ship's SOLAS fire training manual[46] also identified the fire alarm signal as the 'continuous ringing of the ship's alarm bells'. The training manual stated that it was the duty officer's responsibility to have the cause of the alarm investigated. If a fire was confirmed or, if the duty officer believed the alarm to be of 'a serious nature', the manual required that the general emergency alarm be sounded and that ship's personnel mustered. Alternatively, if the alarm was found to be false, an announcement to that effect was to be made on the ship's PA system.

In addition to the muster list and training manual, a 'Welcome letter' was provided to visitors to the ship which also included information alarms and mustering. The letter described the fire alarm as the 'continuous sounding of the alarms accompanied by four long blasts on the ship's whistle' and instructed visitors to proceed to the muster station immediately on hearing it.

Use of ship's elevator

The ship's SMS stated that, in the event of an emergency alarm being sounded the elevator was not to be used by anyone on board. Signs prohibiting the use of the elevator in emergency situations were posted in the elevator car. However, evidence indicates that the elevator was used by ship's staff early in the response to the fire.

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[46] SOLAS Ch II-2/Reg 15.2.3 requires ships to provide training manuals that contain instructions and information related to the ship's fire safety. The required contents of the manual included meanings of ship's alarms, general fire safety practice and general instructions and procedures on firefighting activities, among others.

Muster and headcount

The muster list and other procedures related to emergency response and firefighting instructed that after mustering, all personnel were to be accounted for and that this was to be reported to the ship's bridge.

Analysis of VDR audio recordings showed no evidence of a headcount being taken or reported to the bridge during the initial muster and response. The first verified report of a headcount was at about the time when shore firefighting services began to arrive, at about 0329, half-an-hour after the fire was first reported. The master ordered all crew to the muster station for a headcount in preparation for the activation of the engine room's carbon dioxide (CO_2) fixed fire-extinguishing system.

Electrical power and firefighting

Electrical power for *Iron Chieftain*'s machinery and equipment including fire pumps, ballast pumps, ventilations fans, alarm systems and SUL system equipment depended on the ship's generators. *Iron Chieftain*'s main power-generating capability when alongside were the main generators and an emergency generator.[47]

Main generators

Iron Chieftain was equipped with three Hyundai 6L28/32H diesel engine-driven main generators each with a rated power output of 1,050 kW. The main generators, located in the ship's engine room, powered the ship's main fire pump, general service pump, fuel transfer pumps, cargo hold washing pump, SUL system conveyor belt drive motors, hydraulic power packs, cargo hold hatch cover operating equipment and ventilation fans. The emergency fire pump was supplied by the main generators but could also be powered by the emergency generator.

Activation of the engine room CO_2 system

The activation of a ship's fixed fire-extinguishing system was a command decision that could only be ordered by the master. Following the arrival of FRNSW at the ship, the master, after consultation with FRNSW, decided to activate the engine room's CO_2 fixed fire-extinguishing system. The master's reasoning behind the activation of the system was that if a fire was active in the engine room, the CO_2 system would extinguish it, and if not, the CO_2 system would 'inert' the engine room and prevent a fire from spreading to the space and causing further damage.

The activation of the emergency stops on the bridge and the fuel QCVs in the fire control station in preparation for the release of CO_2 had the effect of shutting down the main generators. This consequently also rendered almost all equipment and machinery on board inoperable except for those capable of being supplied by the emergency generator. The equipment rendered inoperable included the:

- main fire pump
- general service pump
- fuel transfer pumps
- hold washing pump and C-Loop spray system
- machinery to open and close the hatch covers
- hydraulic power packs and drive motors for the SUL system, including for the hold gates
- tunnel ventilation fan.

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47 The ship was also equipped with a shaft generator which could be used when the ship was steaming.

Emergency generator

SOLAS regulations required that cargo ships have an emergency source of electrical power capable of supplying electrical power, for a certain period, to services deemed essential for safety in an emergency.[48] Where the emergency source of electrical power was an emergency generator, it had to be capable of starting automatically and supplying the required load to the emergency switchboard within 45 seconds of the failure of the main source of electrical power. The services required to be supplied included, among others, emergency lighting at key locations around the ship, the fire detection and alarm system and a fire pump.

Iron Chieftain was equipped with a SsangYong NTA-495-GCM1 diesel engine-driven emergency generator with a rated power output of 120 kW. The emergency generator and switchboard were in a room on the upper deck separate from the ship's engine room. Accounts from the chief engineer and other engineers indicated that when the generator was brought on-line, there was a minor fire in the emergency switchboard. However, this was quickly dealt with and did not interfere with the subsequent operation and supply of power from the emergency generator.

Following neutralisation of the main generators, the emergency generator remained as the sole source of shipboard power. It supplied emergency lighting and shipboard firefighting water through the emergency fire pump, until it was shut down and isolated by Fire and Rescue New South Wales (FRNSW). This was because FRNSW standard practice generally considered electricity a 'critical factor'[49] and it was usually isolated during firefighting operations. When the emergency generator was stopped and isolated, all shipboard power and the use of machinery and equipment it was powering was lost.

Maintenance, testing and inspection

Iron Chieftain's SMS required that all firefighting and lifesaving equipment be inspected on a weekly basis using a checklist. Examination of the checklists for the months preceding the fire showed that these checks were marked as being completed regularly.

Records showed that the ship's fire alarm, general emergency alarm and water spray systems had been regularly checked and marked as satisfactory with no issues logged. The last weekly checks completed were recorded for the week of 4 June to 10 June 2018, about a week before the fire.

Records also showed that the ship's emergency generator, emergency fire pump and main fire pump had not been marked as checked in the last two weekly checklists. The last logged checks were recorded in the week of 21 May to 27 May 2018. Previous checklists indicated that this equipment had been checked and found to be operating satisfactorily.

Origin and cause of the fire

Fire investigations

The *Iron Chieftain* fire was the subject of an investigation by FRNSW Fire Investigation and Research Unit (FIRU). Additionally, the marine consulting group of Minton, Treharne, and Davies (MTD) were engaged by the CSL Group to investigate and report on the origin and cause of the fire.

FIRU and MTD investigators attended the ship both during and after the fire, conducted inspections of accessible spaces and spoke to involved personnel. The following is a summary of relevant observations from both investigations.

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48 SOLAS Ch II-1/Reg 43

49 FRNSW considered critical factors to be elements that, if not dealt with rapidly, could cause expansion of the incident or a threat to firefighters or others.

Cargo

Both the FIRU and MTD investigations considered it highly unlikely that the ship's cargo of dolomite was associated with the cause or origin of the fire.

With regard to the residues of the ship's previous coal cargo, the MTD investigation report noted that these residues may have provided additional fuel for the fire. The FIRU investigation observed that although it was possible that coal dust was the initial ignition source, the conveyor belt rubber would still have been the communicating fuel source that spread the fire.

Accommodation

The exterior of the ship, in particular the front of the accommodation and superstructure, showed significant smoke staining.

The interior of the ship's accommodation was also smoke stained to various degrees. Inspections of the superstructure and accommodation showed that the spaces surrounding the C-Loop tower were the most affected by the fire.

There were areas of localised fire damage due to heat conduction, structural distortion and buckled decks in the spaces and cabins adjacent to (Figure 15) and directly above the C-Loop space. The severity of this damage increased as one progressed upwards in the accommodation. Apart from the few spaces surrounding and above the C-Loop casing, fire had not spread further into the accommodation.

The evidence suggested that the fire did not originate in any of the accommodation spaces or compartments surrounding the C-Loop casing.

Figure 15: Locker in the ship's accommodation adjacent to the C-Loop space

Source: ATSB

Main deck and cargo holds

Inspections of the main deck by the FIRU showed that the hatch covers for hold number 3 were open and that there was evidence of coal dust on deck.

The SUL system boom had been fire-damaged with some of the conveyor belt and timber shuttering destroyed (Figure 16). Other components of the boom such as the idlers, pulleys, drive motors and gear boxes showed signs of heat, fire, or smoke damage. Both the FIRU investigation and the MTD investigation considered the fire on the boom to be consequential to the initial fire and a result of a transfer of heated material from below.

The interior of the cargo holds, particularly holds number 4 and 5, had sustained heat damage and were stained by HFO and water.

Figure 16: Fire damage to the SUL system boom

Source: MTD

Machinery spaces

The engine room showed widespread smoke damage and evidence of heat conduction and damage to the forward bulkhead that separated it from the C-Loop space. The forward bulkhead and the deck head above showed signs of burnt paint, deformation and heat damage to fittings and machinery in the vicinity (Figure 17). The evidence indicated that the heat had been directed from within the C-Loop space and both investigations assessed that the fire did not originate in the engine room.

Figure 17: Heat damage to engine room forward bulkhead

Source: ATSB

Tunnel spaces

At the bow, as the FIRU investigators descended into the tunnel spaces through the access hatch, they noted the tunnel ventilation fan in operation and observed that it forced air down into the tunnels with considerable force.

There was minimal evidence of fire damage at the bow end of the tunnels. The FIRU considered it unlikely that the ignition source was in the tunnel conveyor belts based on the absence of any transported burnt material near the bow end of the tunnels.

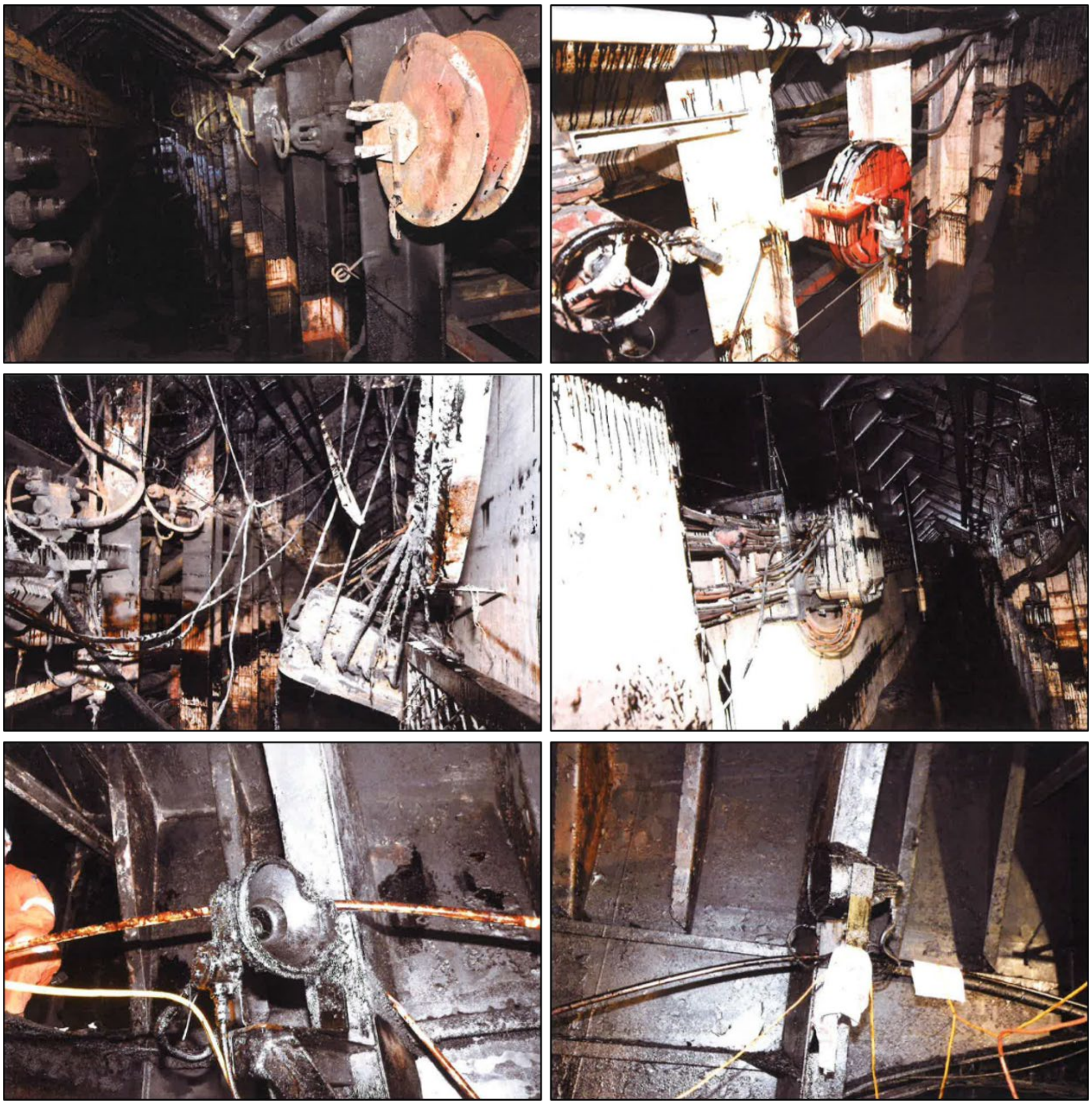
Proceeding aft down the port tunnel, about halfway down, there was increasing fire damage and oxidation further aft. The tunnel conveyor belt in the vicinity of hold number 4 had been completely consumed by the fire. The level of damage increased significantly at the aft end of the tunnel where the transfer belt was located. There were heavy fuel oil (HFO) deposits on the deckhead, and a fire hose reel showed considerable damage with the fire hose itself completely consumed by the fire.

At the aft end of the starboard tunnel, the fire damage was considerably less than on the port side. The corresponding fire hose reel as the one destroyed on the port side showed little fire damage although it was oil-stained, and the rubber conveyor belt was largely intact (Figure 18, top). Both tunnels showed evidence of coal and coal dust on the hold gates, conveyor structures and deck.

The workshop area between the aft ends port and starboard tunnels also showed a greater degree of damage to steel structures and electrical fittings structures located on the port side compared to the starboard side (Figure 18, centre). There was conveyor belt rubber left on the starboard side whereas the belt in a similar position on the port side was missing (most probably consumed in the fire).

The MTD investigation made similar observations to the FIRU above, noting that fire damage appeared to be minimal at the forward end of the tunnels and increased significantly further aft. The MTD investigation also documented the significantly greater damage in the port tunnel compared to the starboard. The investigation noted that this disparity was possibly the result of the greater airflow in the port tunnel due to the open or partially open access hatches that were used to lower fire hoses down to the tunnels.

Figure 18: Disparity in fire damage between port tunnel (left) and starboard tunnel (right)



Source: Fire and Rescue New South Wales

Transfer belts

In the vicinity of the athwartships transfer belts, the cages surrounding the port transfer belt showed greater deformation than the cage surrounding the starboard belt. A fixed floodlight on the port side also showed significantly more damage than the corresponding floodlight on the starboard side (Figure 18, bottom). A 38 mm FRNSW fire hose was observed tied-off , aimed at the port transfer conveyor belt and observed to be leading forward, up the port tunnel to an access hatch on deck.

The MTD investigation also noted the increased levels of fire damage in the area of the port transfer belt compared to the starboard transfer belt and the tied-off fire hose leading to the access hatch. As with the surrounding areas, there were clearly noticeable oil and water residues.

C-Loop space

There was limited access to the C-Loop space for investigators due to safety reasons. The FIRU investigators noted that the upper levels of the C-Loop space showed significant oxidation and deformation of steel structural members. Further down, near the bottom of the C-Loop space, there was a thick coating of HFO with evidence of HFO deposits high up on the bulkheads of the space indicating that the HFO leak occurred sometime after the fire began.

The MTD investigation documented severe smoke damage at the main deck entrance to the C-Loop space and noted that the C-Loop dust suppression spray system valve was in the 'open' position. At the upper, discharge end of the C-Loop, the drive motors, pulleys, idlers, and associated equipment had been damaged by fire, heat, and smoke.

About midway down the C-Loop space, the inner and outer conveyor belts of the C-Loop were absent and the associated conveyor components were severely fire damaged. There was significant deformation of the athwartship ship's structural members with several pulling free of the bulkheads. Several idlers had pulled free of their supports and fallen down into the C-Loop space.

Further down, near the bottom of the C-Loop space, in addition to the fire damage, there was also HFO and water contamination (Figure 19). There was also clear evidence of the further tensional structural damage to ship's support members. There were remnants of the burnt conveyor belts as well as displaced idlers that had fallen from above.

Figure 19: Bottom of C-Loop space, looking aft

Note HFO coating on bulkheads at height above the deck.
Source: MTD

At the base of the C-Loop, where the transfer belts deposited cargo into the C-Loop loading hopper, there were collapsed idlers and a few cubic metres of coal residues mixed with water and HFO.

There was also significant damage to the various hydraulic systems serving the SUL system. However, the reservoirs of hydraulic oil for the various systems showed little or no decrease in oil levels and engine room alarm logs showed no hydraulic system alarms leading up to the fire.

HFO tanks

On either side of the central C-Loop space and tower were bulkheads forming the forward boundary of the HFO tanks. The ship's structural strength members in this area had buckled under compressive forces. On the port side of the C-Loop space, including on the HFO tank bulkhead, there were significant, solidified carbonaceous residues. Clearing the residues exposed a crack that penetrated the full thickness of the bulkhead to the HFO tank. Further examination showed another larger crack, at least 5 mm in breadth extending the full thickness of the plate. There was also evidence of a further potential crack extending upwards.

There were also cracks identified in the starboard HFO tank bulkhead, albeit smaller than on the port side.

Idlers and pulleys

As part of the MTD investigation, accessible SUL system conveyor belt idlers and pulleys were examined. Some of the idlers and pulleys associated with the tunnel conveyors were in the fire-affected area and displayed damage consistent with attack by fire. Other idlers forming part of the C-Loop elevator system had collapsed and were buried in the debris at the base of the C-Loop. These idlers and their bearings could not be examined and consequently could not be discounted as potential sources of ignition. However, examinations of their mounting brackets did not show any severe localised heat damage, metal deformation, mechanical damage or any of the other signs usually associated with a failed idler or idler bearing.

The investigation found four specific areas of interest during the examination of the accessible C-Loop idlers and pulleys (Figure 20).

C-Loop inner belt support idler

A C-Loop inner belt support idler (Figure 20, Component A) about mid-way up the C-Loop space exhibited signs of impact damage possibly associated with the collapse of the tension pulley or fire damage to the conveyor belt or both. The idler had fallen and impacted ship's structure below. However, it was considered unlikely it interfered with the belt's movement even if it collapsed before the fire began. The damage was assessed as probably a result of the fire rather than causative.

C-Loop inner belt tensioning pulley

The tensioning pulley for the C-Loop inner belt (Figure 20, Component B) had also collapsed and wedged near the base of the C-Loop. One of its bearings was found to be displaced and showed evidence of heat damage. However, the damage was more consistent with mechanical impact from falling down into the C-Loop space followed by exposure to the fire rather than due to a failure during normal operations.

C-Loop outer belt return pulley

The cover of the C-Loop outer belt return pulley's (Figure 20, Component C) port side bearing showed signs of being slightly displaced from its original position. However, this was more consistent with a bearing in the early stages of a potential failure rather than a bearing that had already failed.

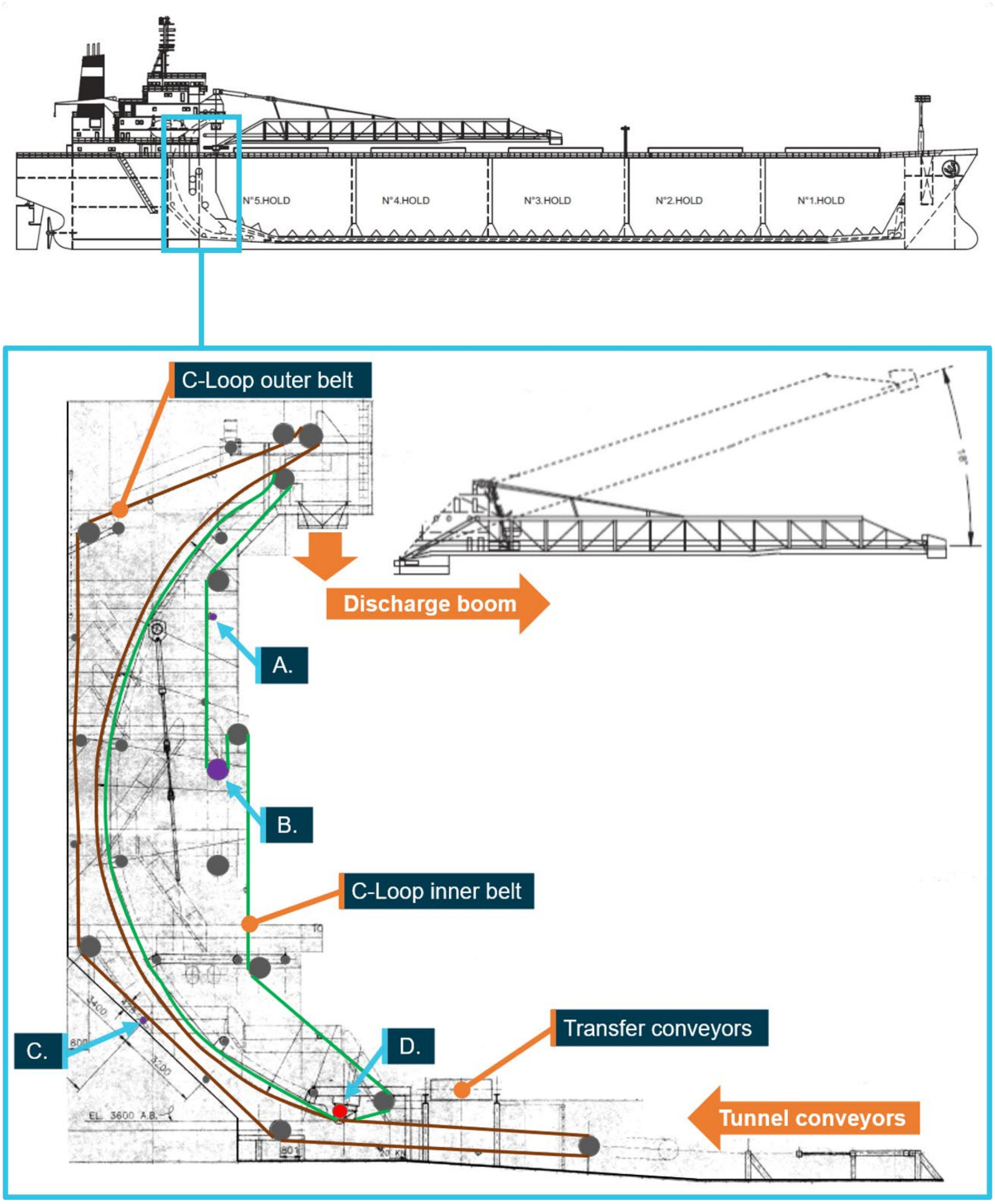
Starboard lower snub impact idler assembly

At the base of the C-Loop was a series of idler rollers and impact idlers[50] collectively known as the lower snub impact assembly (Figure 20, Component D).[51] The lower snub impact idler of the C-Loop inner belt assembly consisted of aft and forward components.

[50] An 'impact idler' is a steel roller idler, fitted with rubber rings or other resilient shock-absorbing material to resist or absorb energy where cargo falls on the belts.

[51] A 'snub pulley' is a pulley located close to the drive pulley to increase the 'wrap' of the conveyor belt around the drive pulley.

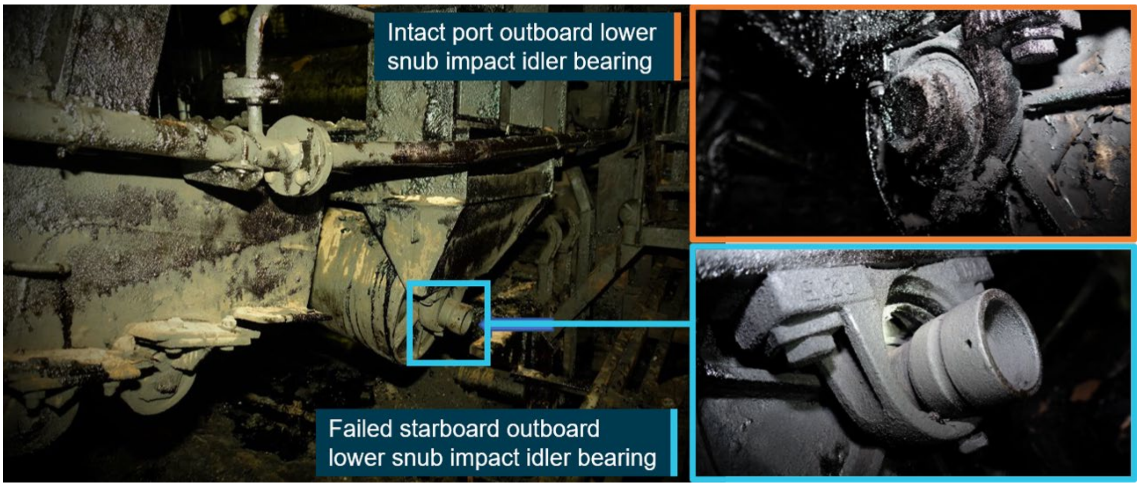
Figure 20: Location of idlers and pulleys of relevance to the fire investigation



Source: CSL Australia, modified and annotated by the ATSB

The forward component comprised an impact idler covered with rubber impact discs which remained intact, although fire damaged. The aft component consisted of five idlers and served the inner belt of the C-Loop. The bearings of the port side outboard idler showed no signs of mechanical failure, nor did the central idlers. However, the bearing of the starboard side outboard idler and most of its metal components were destroyed (Figure 21). The degree of damage was considered highly unlikely to have been the result of fire damage and was not observed at any other bearings.

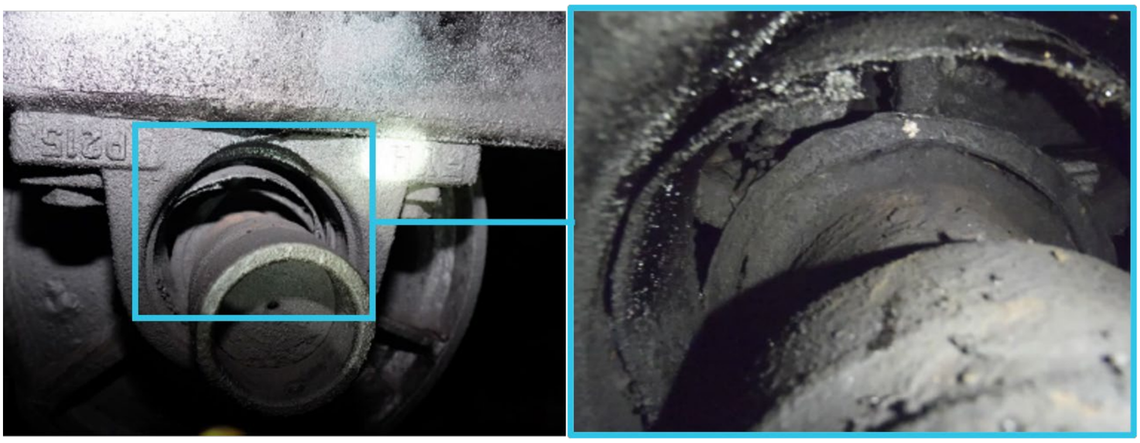
Figure 21: Failed starboard outboard bearing of lower snub impact idler and intact bearing on port side (for comparison)



Source: MTD

Visual examination of the damaged bearing indicated that the bearing shaft was displaced laterally from the bearing housing by about 35 mm. There was also visible damage to the idler shaft as well as evidence of erosion of the inner surface of the idler-shaft interface (Figure 22).

Figure 22: Image showing damage to idler bearing



Source: MTD

The ship's original drawings showed that, of the five idlers comprising the aft components of the snub impact assembly, the central three idlers were rubber-cushioned impact idlers while the outer two were solid-type rollers. The MTD investigator's examination indicated that the installed idlers all appeared to be metal idlers with remnants of burnt conveyor belt stuck to them but no evidence of rubber impact discs.

During a safety round of the SUL system on 17 June 2018, the 1600–2000 IR had reported that some rubber impact discs had come free from an idler roller at the base of the C-Loop. The IR also stated that the observed idler missing the rubber impact cushions was situated under the C-Loop outer belt and therefore, unlikely to be related to the failure of the inner belt's lower snub impact idler bearing. Additionally, it was reported that it was a relatively regular occurrence for impact idlers to lose the rubber impact discs.

It is possible that the central three rubber-cushioned impact idlers had been replaced with solid metal idlers at some point in time. This change may have increased the loading on the outboard idlers which may in turn have increased wear and tear and reduced the life of the bearing. *Iron Chieftain*'s planned maintenance system (PMS) records indicated that the lower snub impact idler's bearings had been replaced during the ship's last drydock in 2014. The ship's PMS also required annual inspections of the impact idler and its bearings with the last inspection logged in

November 2017. Greasing of the bearings was undertaken using a semi-automatic system. While there were no records of greasing in the PMS system, statements from the ship's officers and crew generally indicated that the idlers were usually well lubricated.

FIRU investigation conclusions

The FIRU investigation concluded that the fire originated in the conveyor belt system, possibly in the port transfer conveyor belt, although a full excavation and examination of the transfer conveyor belts could not be conducted. The most likely hypothesis developed by the FIRU was that a roller beneath the port transfer conveyor belt had seized creating friction and resulting in the thermal runaway[52] of the belt which brought the rubber to its ignition temperature (between 260-316 °C). The short length of the transfer conveyor belt meant there was minimal time for any heat to dissipate and the likely fuel source was rubber, which disintegrated and was transported up the C-Loop along the conveyor belt system.

The C-Loop space, which was open at the top, acted as a chimney allowing it to draw smoke, heat and hot gases from below. The combustion process was aided and accelerated by the tunnel ventilation fan forcing air through the tunnels towards the C-Loop and by the open hatch covers of cargo hold number 3. The situation was further exacerbated by the fact that the C-Loop space had a fuel source (the rubber of the inner and outer belts) distributed throughout its height.

The breach of the HFO tanks during the fire allowed HFO to leak out and become an additional fuel source.

CSL-commissioned investigation conclusions

Based on the available evidence and pattern of damage, the MTD investigation concluded that the fire originated in the SUL system of the ship, most probably in the C-Loop space. The most likely cause of the fire was assessed as being the failure of the starboard outboard bearing of the lower snub impact idler of the C-Loop inner belt. The bearing failure resulted in the overheating of an idler and consequent ignition of the conveyor belt.

The fire acted upon the HFO tank bulkheads and the resulting movement, expansion and buckling of the bulkheads exceeded the strength of HFO tank structures. This resulted in fractures to the HFO tank bulkheads that extended through the tank plate thickness and allowed HFO to flow into the C-Loop space, adding fuel to the fire. The height of the water and oil marks on the C-Loop space bulkheads suggest that a significant amount of firefighting water had been delivered to the space before the HFO started to leak. That is, the HFO leaks occurred after the fire had been burning for some time.

CSL Australia

Canada Steamship Lines Australia (CSL Australia) is part of the CSL Group headquartered in Montreal, Canada. CSL Group owns and operates fleets of specialised SUL vessels, offshore transhippers, and bulk carriers worldwide.

CSL Australia was established in 1999, based in Sydney, NSW. In 2021, the company operated a fleet of 14 vessels including 10 Australian- and Bahamas-registered vessels equipped with some form of SUL or conveyor belt systems. These included hybrid SUL vessels, transhipment shuttles, a floating offshore transfer barge and SUL transhipment barges.

Following purchase from BHP in December 2003, *Iron Chieftain* was initially managed by Inco Ships. However, in April 2015, CSL Australia took over management of *Iron Chieftain*.

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52 Thermal runaway: An unstable condition when the heat generated exceeds the heat losses within the material to the environment.

Safety management system

With the change of ship management, a new SMS, titled the Australian Vessel Management System (AVMS) was implemented on board *Iron Chieftain*. The effectiveness of the implementation of the various policies, procedures, instructions and processes comprising the company's SMS was regularly audited both internally, by the company, and externally, by commercial vetting organisations. Additionally, AMSA, as the organisation responsible for regulation of the ISM Code and its requirements in Australia, also conducted certain ISM Code audit and certification activity (see the section titled *Australian Maritime Safety Authority* for details).

Audits and inspections

Annual internal ISM audits were conducted by CSL Australia in 2015 and 2016, and by a marine safety consultant, on behalf of CSL Australia, in 2017. The audits identified a number of minor safety-related and administrative observations and non-conformances. None identified any issues relevant to the unacceptably high fire safety risk identified in the SUL system or to the absence of a reviewed or updated SUL fire safety risk assessment as required by the SMS and training schedule. The 2017 audit noted that the basic cause of the identified observations and non-conformances was that the ship's management team was not thoroughly familiarised with the AVMS.

The ship was also subject to annual inspections by RightShip[53], who were engaged by CSL Australia. The most recent survey, in November 2017, identified minor deficiencies related to the ship's lifeboat engine and oil leaks in the engine room and forecastle.

Australian Maritime Safety Authority

As the flag State administration, the Australian Maritime Safety Authority (AMSA) is responsible for checking and monitoring that Australian vessels comply with the requirements of various Acts and subordinate legislation including those that give effect to relevant mandatory international conventions.

Class certification and surveys

AMSA delegates certain flag State administration functions to recognised organisations. These recognised organisations, usually classification societies, take on certain survey and certification functions on behalf of AMSA for vessels registered in Australia.

Iron Chieftain was classed with Lloyd's Register. As a recognised organisation acting on behalf of AMSA, Lloyd's Register surveyed the ship to ensure compliance with relevant legislation and issued the appropriate statutory certificates under the applicable marine orders.

In November 2017, Lloyd's Register conducted annual surveys for *Iron Chieftain*'s safety construction and safety equipment certificates, among others. The safety surveys did not identify any issues related to the ship's fire safety or emergency preparedness. Following completion of the surveys, the relevant certificates were appropriately endorsed.

There were other special surveys conducted in May 2018, however these were related to hull and structural issues and not relevant to fire safety or emergency preparedness.

[53] RightShip is a commercial organisation that provides risk management and environmental assessment services to the maritime industry.

ISM Code compliance

AMSA is the competent authority responsible for regulation of the ISM Code and its requirements in Australia. As such, AMSA[54] conducted audit activity and certification related to the ISM Code for Australian-registered vessels, including for the issue and maintenance of documents of compliance (DOC)[55] and safety management certificates (SMC).[56]

Following CSL Australia's assumption of ship management responsibilities and the implementation of the new SMS in April 2015, AMSA conducted an initial SMC audit of *Iron Chieftain* on 23 September 2015. As an initial SMC audit, all elements of the ISM Code were audited by the AMSA auditor. The audit included interaction with ship's officers with safety-relevant responsibilities and the audit report recorded that subjects such as emergency preparedness, drill plans and records, and fire prevention were covered with the relevant officers.

The audit recorded one minor observation regarding training in the use of the new SMS not being provided to the ship's officers. Following the audit, the ship was issued with a full-term SMC (valid for five years) subject to an intermediate audit between the second and third anniversary of the SMC issue date. The intermediate SMC audit was planned for July 2018 (the fire occurred in June).

In addition to ISM Code certification activity, AMSA monitored ISM Code compliance in conjunction with flag State inspections, in line with AMSA procedures.

Flag State inspections

International conventions give responsibilities to Australia (and other States) to check and control ships in a State's waters to ensure that they do not pose a threat to the safety of the ship, crew, cargo or the environment. AMSA is empowered to perform this enforcement function through the implementation of flag State control (FSC) and port State control (PSC) regimes. Under the FSC program, AMSA is responsible for monitoring the operational safety standards of Australian-flagged ships. According to AMSA, compliance with regulations is monitored through a sampling process as AMSA, like many other regulators, is not resourced to be able to ensure compliance. The obligation to ensure compliance rests with the regulated entity (for example, the ship owner) while the role of AMSA is to hold the regulated entity to account in meeting its obligations.

AMSA employs marine surveyors to conduct PSC and FSC inspections among other duties. AMSA surveyors conduct inspections on Australian-flagged vessels, in a similar manner to arrangements applied to foreign-flagged ships.

Iron Chieftain was subject to AMSA flag State inspections on a roughly biannual basis. Between September 2015 and April 2017, five flag State inspections were conducted. Of these, two inspections identified no deficiencies and the other three identified a small number of safety-related deficiencies none of which resulted in the ship's detention. The flag State inspections did not identify any issues relevant to the unacceptably high fire safety risk identified in the 2013 SUL fire safety risk assessment.

The most recent flag State inspections were conducted in October 2017 in Gladstone, Queensland and in April 2018 in Port Kembla, NSW. The reports from these flag State inspections showed that they did not identify any deficiencies on board the ship. AMSA ship inspection checklists used in the FSC inspections were unavailable for examination.

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[54] As of 1 July 2020, AMSA has delegated ISM authorisation, to conduct required audits and issue applicable certificates, to recognised organisations.

[55] A document of compliance (DOC) is issued to a company (or organisation), which complies with the requirements of the ISM Code.

[56] A safety management certificate (SMC) is issued to a ship to signify that the company and shipboard management operate in accordance with the approved SMS.

AMSA investigations

According to AMSA, the primary purpose of its regulatory investigations is prosecution. AMSA's decisions to investigate are informed by several elements including the existence/extent of fatalities, injuries or pollution, the prospect for success, any precedent that may be set and the potential deterrence any outcome might provide to encourage future voluntary compliance.

In the case of the *Iron Chieftain* fire, noting that the ATSB had initiated an investigation, AMSA determined that there was little value in it also investigating the fire.

Emergency management in New South Wales

Emergency management arrangements

In NSW, the *State Emergency and Rescue Management Act 1989* (*SERM Act 1989*) sets out the general legal and governance framework for emergency management. Emergency management planning within the state is a structured process that comprises three types of plans at state, regional or local level—emergency management plans, supporting plans and sub-plans.

Emergency management plans are the main plans which outline the overarching management arrangements and documents the agreed roles and functions of various agencies.

Supporting plans are prepared by NSW government agencies or 'functional area' to describe the arrangements by which support services will be coordinated. For example, 'functional areas' include Transport Services, Environmental Services and Health Services.

Sub-plans are action plans for a specific hazard, critical task, or special event. A sub plan may be required where the planning is more specialised or detailed than can be provided for in an emergency management plan. For example, a sub-plan may be required specifically to deal with bushfires, floods, fires, or storms.

Emergency Management Plans

The NSW State Emergency Management Plan (EMPLAN)[57] set out the State-level approach to emergency management, the governance and coordination arrangements and roles and responsibilities of agencies. The State EMPLAN and other NSW emergency response plans do not require formal activation as they are always considered active.

The State EMPLAN identified responsible agencies, known as 'combat agencies', in relation to specific hazards and emergencies (Table 3). A combat agency was defined as 'the agency primarily responsible for controlling the response to a particular emergency'.

Table 3: NSW EMPLAN - Emergencies and responsible agencies

Emergency	Responsible agency
Fire (within a fire district)	Fire and Rescue NSW
Hazardous materials • On land • Inland waters • State waters	 • Fire and Rescue NSW • Fire and Rescue NSW • Relevant port authority
Marine oil and chemical spills	Relevant port authority

Source: Resilience NSW

57 State Emergency Management Committee, 2012, New South Wales State Emergency Management Plan.

In addition to a combat agency, the State EMPLAN also defined a 'lead agency' as 'the agency who has overall leadership in a given situation'. The lead agency could be the combat agency or some other agency. The plan did not specify responsible lead agencies identified emergencies.

The State EMPLAN did not include guidance for a shipboard fire nor did it specifically list such an emergency or assign a responsible agency.

Regional EMPLAN

The Illawarra South Coast Regional Emergency Management Plan (2012)[58] detailed the arrangements for emergencies that had the potential to impact the Illawarra South Coast Region Emergency Management area. The Regional EMPLAN covered the local government areas (LGA) of Wollongong, Shellharbour, Kiama, Shoalhaven, Eurobodalla, and Bega Valley. Port Kembla is located in the Wollongong LGA.

The Regional EMPLAN used the term 'lead agency' and defined it as 'the agency identified in the State EMPLAN as the agency primarily responsible for controlling the response to a particular emergency'. The plan identified Fire and Rescue NSW (FRNSW) as the lead agency for urban industrial and commercial fires and for bush and grass fires within a fire district. NSW Maritime (NSW Roads and Maritime Services)[59] was identified as the lead agency for a major marine transportation incident and for marine oil and chemical spills.

There was no specific information for a shipboard fire in the Regional EMPLAN that was in force at the time of the fire. In February 2019, an updated version of the Regional EMPLAN was published.[60]

Local EMPLAN

The Illawarra Local Emergency Management Plan (2017)[61] detailed the arrangements for emergencies within the LGAs of Wollongong, Shellharbour, and Kiama.

The Local EMPLAN used the term 'combat agency' to identify responsible agencies for specific emergencies. The plan identified FRNSW as the combat agency responsible for fires including industrial, commercial, and residential fires. The relevant port or maritime authorities were identified as the responsible combat agency for sea-based transport emergencies.

There was no specific information for a shipboard fire in the Local EMPLAN.

NSW State Waters Marine Oil and Chemical Spill Contingency Plan

The NSW State Waters Marine Oil and Chemical Spill Contingency Plan (State spill contingency plan)[62], issued in December 2016, was a sub-plan to the State EMPLAN and the National Plan,[63] produced by NSW Roads and Maritime Services (RMS).

The plan outlined the arrangements to deal with marine oil or chemical spills and maritime incidents such as groundings, collisions, disabled vessels or fire on a vessel that could result in an

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[58] Illawarra South Coast Region Emergency Management Committee, 2012, Illawarra South Coast Region Emergency Management Plan.

[59] NSW Maritime was the agency responsible for marine safety, regulation of commercial and recreational boating and the safety functions of NSW port corporations. In November 2011, NSW Maritime was merged with the Roads and Traffic Authority to form the NSW Roads and Maritime Services (RMS). Any reference to NSW Maritime in this report refers to RMS.

[60] The updated plan assigned combat agency responsibilities for a 'Transport Emergency (Maritime)' to the relevant port/NSW Maritime/FRNSW. The updated plan also referred to the NSW State Waters Marine Oil and Chemical Spill Contingency Plan, which contained guidelines on responding to shipboard fires.

[61] Illawarra Local Emergency Management Committee, 2017, Illawarra Local Emergency Management Plan.

[62] NSW Roads and Maritime Services, 2016, NSW State Waters Marine Oil and Chemical Spill Contingency Plan.

[63] The National Plan for Maritime Environmental Emergencies (National Plan).

oil or chemical spill into State waters of NSW.[64] Responsibility for responding to incidents in NSW State waters was based on geographical divisions and shared between NSW Maritime (RMS) and the three major ports managed by the Port Authority of New South Wales (PANSW): Newcastle, Sydney and Port Kembla. Incidents on the high seas (outside State waters) were dealt with by AMSA.

The State spill contingency plan used the term 'combat agency' to refer to the agency responsible for controlling the response to a maritime incident. The PANSW (Port Kembla) was the assigned combat agency with responsibility for responding to maritime incidents and emergencies between Garie Beach to Gerroa, including Port Kembla.

All combat agencies for maritime incidents use a version of the Australasian Inter-Service Incident Management System (AIIMS)[65] incident control system, called the Oil Spill Response Incident Control System (OSRICS),[66] to control and manage maritime incident and emergency response. The system provided for four main functions: planning, operations, logistics and, finance and administration. Officers were appointed to oversee each function with an Incident Controller (IC) responsible for controlling all operational activity in response to an incident.

Roles and responsibilities

The plan required the PANSW, in its capacity as combat agency, to:

- notify appropriate agencies and higher-level control within an agency of an incident or emergency
- provide an incident controller
- provide trained emergency response staff to control the incident or emergency response
- provide trained equipment operators
- make available emergency response equipment under its control
- establish an incident control centre (ICC) from which the incident or emergency will be controlled.

Where the PANSW was supporting a combat agency, it was required to:

- provide trained emergency response staff
- make available emergency response equipment under its control
- provide a liaison officer.

According to the State spill contingency plan, FRNSW were a supporting agency for marine oil and chemical spills and could be called upon to provide advice and support to the combat agency.[67]

Guidelines for responding to a fire on a vessel

Appendix 17 of the State spill contingency plan, the Guidelines for Responding to a Fire on a Vessel, was developed to:

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64 State waters means coastal waters extending from the low water mark or other baseline to 3 nautical miles seaward of that mark or baseline as well as other waters within the limits of the State as prescribed by the regulations.

65 AIIMS was developed in Australia in the 1980s based on the US National Inter-agency Incident Management System (NIIMS). AIIMS is the system of incident management adopted nationally by Australia's emergency management services. It provides a common management framework for organisations working in emergency management roles and is based on the principles of management by objectives, functional management, and span of control.

66 OSRICS is the system used to manage marine spills and emergency response. Although based on the AIIMS incident control system, it has been modified to take into account the emphasis placed on record keeping and cost recovery from the polluter.

67 In NSW, FRNSW was the designated combat agency for inland waters and land based hazardous materials (HAZMAT) incidents and emergencies.

> …complement the maritime incident response arrangements described in the NSW State Waters Marine Oil and Chemical Spill Contingency Plan in recognition of the additional coordination required and complexities involved in responding to a fire on a vessel, either at sea or in a port.

The purpose of the guidelines was to ensure a coordinated approach to responding to a fire on a vessel, regardless of the vessel location, and to describe the approach and the communications arrangements between the incident controller, the vessel and the supporting agencies.

Combat agency for a fire on a vessel

The guidelines designated the responsible combat agency for a shipboard fire based on geographical divisions in a similar manner to marine spills. The guidelines stated:

> Fire on a vessel in port will normally be responded to according to the port's local incident response contingency plan. A vessel when in a port including moored at a wharf is in State waters and under the NSW emergency management arrangements the Port Authority of NSW or NSW Maritime is the combat agency for the response unless control is handed to Fire & Rescue NSW. It is preferable that the Port Authority of NSW or NSW Maritime is in control of the response and work closely with Fire & Rescue NSW using an MAICT approach.

Based on the geographical divisions outlined in the appendix, the responsible combat agency for a shipboard fire in Port Kembla was the PANSW (Port Kembla). On the morning of 18 June 2018, however, when Port Kembla's harbour master formally transferred incident controller status from PANSW to FRNSW, control of the response to the incident (the combat agency role) transitioned to FRNSW (which was allowed under the guidelines). FRNSW subsequently maintained the incident controller and combat agency roles until the conclusion of the incident response on 24 June 2018.

MAICT approach

For maritime incidents, such as a shipboard fire, involving large commitments of FRNSW personnel and resources, the maritime combat agencies agreed to use a Multi-Agency Incident Control Team (MAICT) approach based on the OSRICS structure. The MAICT approach used the following principles:

- the combat agency would provide the incident controller (IC), planning and administration functions
- FRNSW would provide the operations officer
- the logistics function would be provided by either the combat agency or FRNSW, depending on the size and complexity of the required response
- the combat agency would establish the incident control centre (ICC) at a suitable location
- a forward command post may be established and managed by the operations officer
- additional positions, such as vessel coordinator and fire operations coordinator, may be appointed.

The guidelines stated that the vessel coordinator should be 'a marine officer of a Port Authority of NSW, marine pilot or marine surveyor'. A vessel coordinator was to be appointed when there was a need to have a person on the ship to act as a single point of contact for communications to and from the vessel and reporting to the IC. The guidelines also stated that 'such a person should have a strong marine background to provide accurate information about the vessel, its cargo (if any) and the location and nature of the fire'.

The guidelines stated that the fire operations coordinator should be an experienced FRNSW officer. A fire operations coordinator was to be appointed to provide advice and assistance when the ship's crew needs assistance to fight a fire.

There was no documented record of the roles of vessel coordinator or fire operations coordinator being appointed in response to this occurrence. Accounts of the incident response, however, indicated that the intent of these roles were fulfilled by personnel performing other functions, from other organisations or on an as-needed basis.

NSW South Coast Marine Oil and Chemical Spill Contingency Plan

The NSW South Coast Marine Oil and Chemical Spill Contingency Plan (NSW South Coast spill contingency plan)[68] was a supporting plan to the NSW State spill contingency plan and was used to coordinate local resources in responding to a maritime incident in the NSW South Coast regional area. The plan indicated that reference to an oil or chemical spill in the plan included any maritime incident that had the potential to result in an oil or chemical spill (such as a fire).

As with the State spill contingency plan, PANSW was identified as the combat agency for maritime incidents in certain areas, including Port Kembla and the surrounding area. The South Coast regional spill contingency plan did not include specific guidelines for responding to shipboard fires although it was stated that it was to be read in conjunction with the State spill contingency plan (which did contain such guidelines).

Other arrangements

In addition to the arrangements contained in the State spill contingency plan, a memorandum of understanding (MoU) existed between NSW Maritime, FRNSW and the former port corporations that were subsequently amalgamated to form the PANSW (see the section titled *Port Authority of New South Wales*). The MoU outlined combat agency responsibilities and supporting arrangements in relation to hazardous materials incidents including oil and chemical spills. Similar to the arrangements in the State spill contingency plan, combat agency responsibility for hazardous materials incidents in the waters of Port Kembla was assigned to the relevant port corporation.

Port Authority of New South Wales

On 1 July 2014, the port corporations of Sydney, Newcastle and Port Kembla were amalgamated to create the Port Authority of New South Wales (PANSW). The PANSW manages the navigation, security and operational safety needs of commercial shipping in six NSW ports, including Port Kembla, and appoints their harbour masters.

Transport for NSW issues a Port Safety Operating Licence (PSOL) to the PANSW. The PSOL covers port safety functions that must be undertaken in designated NSW ports. The PSOL also sets out the relevant performance standards and requirements that must be met by the licensee (PANSW) in the fulfillment of these functions. Port safety functions performed by the port authority include port communications, investigation of marine pollution incidents and emergency response, among others.

The licence required PANSW to respond to port-related emergencies and incidents as required by the relevant NSW emergency plans and by the State spill contingency plan. The licence also required the port authority to have emergency response plans with documented operational procedures for its emergency response activities and conduct annual exercises.

Port Kembla

Port Kembla is the deepest harbour on the eastern seaboard of Australia and is one of three major ports in the State of NSW. Port Kembla was established in the late 1890’s to service the needs of regional industries such as the export of coal from the Illawarra region and the import of raw materials and steel products for the steel industry. Over time, the port diversified its trade base to include general and break-bulk cargoes, containers, and motor vehicle imports.

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68 NSW Roads and Maritime Services, 2017, NSW South Coast Marine Oil and Chemical Spill Contingency Plan.

The port operates across two precincts, the inner harbour, and the outer harbour. The outer harbour accommodates the common user terminals and bulk liquids facility while the inner harbour includes coal, grain, car, container, and general cargo terminals. The BlueScope Steel terminals, where *Iron Chieftain* was berthed, were in the inner harbour.

Svitzer Australia held the licence to provide towage services at Port Kembla. As part of their services, Svitzer were required to provide a certain number of tugs with specified firefighting capabilities to respond to any emergencies within the port limits when required by the harbour master.

Emergency response plans and exercises

As part of this investigation, the ATSB sought procedures and plans relevant to a shipboard fire in Port Kembla. The documents provided included a PANSW Crisis Management Plan and a Port Kembla Marine Oil and Chemical Spill Contingency Plan.

Additional documents provided included standard operating procedures for Port Kembla's vessel traffic information centre (VTIC) and a suite of documents being prepared for Port Kembla's proposed future transition from a VTIC to a vessel traffic service (VTS). The sections of the VTIC operating procedures that dealt with emergencies were largely restricted to information gathering and notification while the proposed future VTS procedures were considered irrelevant to the investigation.

Port Kembla Marine Oil and Chemical Spill Contingency Plan

According to the PANSW, the Port Kembla Marine Oil and Chemical Spill Contingency Plan (Port Kembla spill contingency plan) was applicable to a shipboard fire response in the port. The plan was dated August 2015, was a sub-plan to the Illawarra Local EMPLAN and referenced a superseded, 2012 version of the State spill contingency plan.

The stated aim of the plan was to outline the arrangements to deal with marine oil and chemical spills or potential spills within the Port Kembla harbour boundaries. The plan used the term 'combat agency' as defined in the Illawarra Local EMPLAN and confirmed that, for the area covered by the plan, the PANSW (Port Kembla) was the relevant combat agency.

The Port Kembla spill contingency plan went into detail on the arrangements in place to respond to a marine spill. The practical arrangements outlined in the plan, including the use of the OSRICS concept and the key roles required to be filled by PANSW as a combat agency for a marine spill, were largely similar to those in the 2016 State spill contingency plan. However, the Port Kembla spill contingency plan did not contain any information related to the response to a shipboard fire, nor did it include any reference to the guidelines for such a response as described in the 2016 State spill contingency plan.

PANSW Crisis Management Plan

The port authority's crisis management plan (May 2016) provided the main guidelines for managing the strategic response to a major incident affecting the port authority's activities and was to be applied in conjunction with other response procedures, including State plans. The plan stated that it was not intended to provide comprehensive instructions or precise actions for any given situation but to provide simple, clear checklists, guidelines, and reminders about the main elements and key factors in an effective response. The crisis management plan was not specific to Port Kembla but applied generally to the PANSW.

The plan included guidelines for various incident scenarios. For each scenario, the guidelines documented a lead agency, a combat agency, and a support agency. They also provided some guidance on the port authority's role in each scenario and a few key high-level steps that the port authority could take in the immediate response to the incident.

One of the incident scenarios described was for a fire or explosion aboard vessels. In such a scenario, the guidelines delegated the lead agency and support agency roles to the PANSW with responsibility for the overall coordination of the response, exercise of harbour master powers and provision of technical advice, transport and logistics support. The plan delegated the combat agency role for a shipboard fire to FRNSW. In addition to the advice on key roles, the guidelines outlined certain key steps that could be facilitated by the port such as cessation of shipboard operations, notifications, communications, evacuation, liaison operations and information gathering.

The crisis management plan did not include detailed operational procedures and very little other information for the emergency response to a shipboard fire in port. The plan also did not integrate or reflect details of the guidelines for responding to fires on a vessel described in the NSW State spill contingency plan.

Annual exercises

The conduct of annual exercises was a requirement of the PSOL. Port Kembla also had a maritime firefighting training agreement with FRNSW that covered the familiarisation of shore firefighters with the port's tugs and their firefighting arrangements. The harbour master also reported that familiarisation visits to ships were organised for FRNSW firefighters however there was no documented record of these visits available.

On 17 May 2018, the PANSW led a multi-agency maritime incident response exercise, designated 'Exercise Whale', in Port Kembla's outer harbour. The exercise scenario was based on a large visiting oil tanker catching fire and involved an explosion, missing casualties, and an oil spill within the port. Although the drill was based on a shipboard fire, there was no actual ship involved in the exercise. Participants included PANSW, FRNSW, NSW Police, NSW RMS, Svitzer tugs and Park Fuels (operators of the bunkering service at Port Kembla).

The drill's stated objectives were to engage FRNSW and other stakeholders to deploy to the port in an incident, to engage NSW RMS and NSW Police in the maintenance of on-water safety while the emergency response proceeded and to demonstrate effective use of the port's spill containment boom.

The exercise was initiated by notifications to VTIC, followed by onward notifications to the harbour master, FRNSW and other agencies based on the Port Kembla spill contingency plan. An ICC was set up by the harbour master with a VTIC officer acting as IC. The simulated fire at the oil tanker berth was dealt with by tugs, shore-based fire monitors and FRNSW who established an on-scene commander. Meanwhile, a NSW Police patrol vessel and the port's pilot boat patrolled the waters around the affected area. The port's oil pollution resources and spill containment booms were also deployed during the drill.

The delegation of roles and functions in the exercise implied that PANSW assumed the combat agency role, with FRNSW conducting the operational response with the support of the tugs and the berth's firefighting assets.

Overall, the drill was considered to have met its objectives by the organisers. Outcomes of the drill included recommendations for reviews of the communications plan for emergencies and the need to make familiarisation of the port a priority for local FRNSW personnel.

BlueScope Steel

BlueScope Steel owns and operates the Port Kembla Steelworks and, at the time of the fire, operated five berths in Port Kembla.

BlueScope Steel's emergency response plan for incidents at the bulk berths covered alert signals for various situations and response actions to incidents affecting the facility. While the plan did not specifically address the scenario of a shipboard fire, it did provide guidance on general actions in the event of an external emergency. In such a scenario, the plan designated a department emergency controller who would oversee the assembly of personnel in a suitable area and attempt to address the cause of the emergency.

If on-site resources were insufficient to manage the emergency, the controller would attempt to contain it while additional resources such as FRNSW arrived. The plan also detailed the firefighting resources available at the facility, such as the fire hydrants located on the wharf.

Port Kembla's emergency response plans did not allocate any specific responsibilities to BlueScope Steel, in the event of an emergency. In practice, BlueScope Steel had a supporting role and were responsible for the safety of their own personnel and controlling access to the site. In addition, BlueScope Steel personnel notified FRNSW and Port Kembla VTIC of the fire and provided meeting rooms and office space when necessary during the response.

Fire and Rescue New South Wales

Fire and Rescue NSW (FRNSW) is the State Government agency responsible for the provision of fire, rescue, and HAZMAT services in urban areas across New South Wales. FRNSW is also a key agency involved in the response phase of most emergency or disaster events throughout NSW.

The ATSB incident database indicates that 34 shipboard fires occurred in NSW ports or off the NSW coast in the last three decades.[69] Of these notified occurrences, only five reports had information indicating FRNSW involvement in the fire (including *Iron Chieftain*). Major shipboard fires in NSW have been a relatively rare occurrence and ones involving FRNSW participation even rarer.

Marine firefighting in NSW

FRNSW did not maintain a specialised marine firefighting capability. Firefighters were provided a range of skills and training in the course of their progression through the organisation. Incident management teams (IMT),[70] usually comprised of senior officers, were trained to respond to a wide variety of scenarios across a range of industries and communities through familiarisation, training, drills, exercises, and engagement. In addition, FRNSW capability incorporated marine assessment teams, although these were largely focussed on HAZMAT incidents.

According to FRNSW, the most likely risks and scenarios that firefighters could be expected to encounter based on the nature of the local industry and community were to be captured and assessed in station-level or zone office-level risk registers.[71] The assessment in the risk registers could then be used to tailor training and resourcing best equip firefighting personnel for their local area. For example, in the Port Kembla area, resourcing could be concentrated on preparing firefighters for port and shipboard fires and large industrial fires among others. However, at the time of the ATSB investigation, these registers had not been developed.

Training

FRNSW training material included a shipping training manual that was issued in 1996. Shipping-related training was to be provided to FRNSW firefighters as part of station training plans. The ATSB requested copies of the station training plans showing when shipping training was last provided to the first responders[72] to the *Iron Chieftain* fire. However, no documented evidence of the provision of specific shipping training was provided.

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[69] The database for the most part covered reports received from SOLAS ships and did not include data on fire aboard domestic commercial vessels or small recreational vessels.

[70] The deployment of an IMT was usually triggered by a request from first responders when there was a requirement to escalate the strategic level of an incident structure or when incidents surpassed certain limits in relation to location, size and type of incident.

[71] A zone covered 16 stations.

[72] The first firefighters that arrived on scene at the *Iron Chieftain* incident at Port Kembla were from the Wollongong station (503) and Warrawong station (422).

The training manual compared ship fires to shore fires with similar features such as warehouse fires, workshop fires and hotel fires. The manual included a general introduction to ships and ship types, information on shipboard fire firefighting systems and techniques and other aspects of firefighting unique to ships such as ship stability and other safety considerations. The information in it was generally relevant in certain areas but in places was outdated or inaccurate. Some examples of the anomalies and errors, the training manual stated that:

- ‘In a cargo vessel, the engine and boiler rooms are usually located amidships.’
  - [The vast majority of modern ships have the machinery spaces located aft]
- ‘Container ships are designed to carry up to 3,600 containers…’
  - [Modern container ships calling at Australian ports can carry more than 7,000 containers with the largest ships in existence capable of carrying over 21,000 containers.]
- ‘If you do use CO_2, leave the affected area closed for at least ten minutes to allow burning materials to cool below their ignition temperature.’
  - [CO_2 has limited cooling effect and premature entry into a space can cause a fire to re-ignite.]
- ‘You should enter the engine room through the shaft tunnel.’
  - [Any entry into a fire-affected space should be by the safest means of access based on a risk assessment under the prevailing circumstances.]
- ‘All ships over 1000 t are required by International Maritime Law to provide an international shore connection on both sides of the ship.’
  - [SOLAS requires ships above 500 gross tonnage to carry at least one international shore connection.]

The FRNSW shipping training manual included brief descriptions of various types of ships such as container ships, car carriers and tankers. However, there was no section on bulk carriers. The manual also made no mention of the ship’s emergency generator or of its significance in firefighting operations.

Standard Operating Guidelines

FRNSW issued Standard Operating Guidelines (SOG) to describe the standardised method used to manage all emergency incidents attended by FRNSW resources. The SOG document provided general incident management guidelines as well as more detailed ones for specific scenarios and functions such as bushfires, aircraft incidents, land transport and tunnel incidents, rescue, and special incidents among others.

There were no specific FRNSW guidelines for a marine- or shipping-related emergency, although FRNSW, using the AIIMS system, would generally seek the advice of subject matter experts to assist in the formulation of incident action plans.

Equipment and resources

FRNSW firefighters and fire appliances were not provided with marine-specific firefighting resources, tools, or equipment as standard.

Evidence indicates that FRNSW first responders were initially not equipped with an international shore connection that could be used to pressurise the ship’s fire main. Communication with the port’s tugs was also hampered by the absence of a suitable communication method and by the lack of very high frequency (VHF) radios, which is standard marine voice communication equipment.

Foam was identified as key to the extinguishment of the C-Loop fire early in the response. However, obtaining the type(s) of foam in the necessary quantities required to implement a successful extinguishment strategy took time and required FRNSW to call on foam stocks in NSW and from interstate.

There were no marine-specific documentary resources or aide-memoires for use by first responders when confronted with a shipboard fire. Generic incident action plan templates were available, but first responders needed to rely upon recalling past marine training or experience when developing firefighting strategies and applying tactics for a shipboard fire.

Marine firefighting in Australia

ATSB investigations

The ATSB has investigated a number of shipboard fires across Australia, some of them major. Prior to *Iron Chieftain*, the most recent shipboard fires that resulted in substantial damage to the involved ships were both in Western Australia (WA). In 2014, the ATSB investigated fires on the livestock carrier *Ocean Drover* in Fremantle and the bulk carrier *Marigold* in Port Hedland, WA. These investigations offered an insight into the organisational and operational marine firefighting arrangements in WA, and their development over the last two decades.

Department of Fire and Emergency Services, WA

WA's Department of Fire and Emergency Services (DFES) arranged brigades into three classifications based on their marine firefighting capability:

- Marine fire assessment and suppression capability (MFASC) brigades
  - An MFASC brigade has the training, specialist equipment, procedures, and crews to respond to and suppress a marine fire alongside or at sea.
- Marine fire support (MFS) brigades
  - An MFS brigade has the appropriate training and understanding of equipment to support an MFASC brigade in the response to a marine fire alongside but were not expected to enter the interior of a burning vessel.
- Marine fire assessment and containment (MFAC) brigades
  - An MFAC brigade is a volunteer brigade that has the appropriate training and equipment to mount an initial response to a marine fire incident alongside, assess the fire and contain it until additional expertise could be mobilised.

Marine firefighting training was targeted at each of these brigades based on their classification and the capabilities required of each.

The ATSB investigations into the fires in WA identified that training was delivered using the 2014 edition of the DFES marine firefighting manual. The manual included shipping-related material similar to that in the FRNSW manual although updated, with greater detail and with more information relevant to modern shipping. In addition, the DFES manual included a section on dry bulk carriers with a description of an SUL vessel similar to *Iron Chieftain*. The DFES manual also included case studies and examples of previous ship fires highlighting important lessons relevant to shipboard firefighting.

Brigades located at select WA ports were provided with a 'ship firefighting cache' in easily transportable boxes. The cache contained an international shore connection, spanners, specialised thermometers, couplings, fittings, and other tools to enable firefighters to readily operate onboard a ship on fire.

Crews are also provided a 'ship fire response checklist', stored in the ship firefighting cache. The checklist was a response guide to assist fire crews in dealing with a marine fire and recording incident information. The ship firefighting checklist was part of a larger, ready-use document called a 'marine fire emergency response guide'. The guide included information for use by ICs or IMTs when assessing priorities and determining strategy and tactics at a ship fire incident. The guide also contained a flowchart that provided a sequence of actions to take based on the effectiveness of firefighting efforts and forms to record shipboard temperature and stability parameters.

Fire Rescue Victoria

Fire Rescue Victoria (FRV)[73] has a legislated responsibility for fire and HAZMAT incidents within the waters of the Port of Melbourne, an area covering approximately 1,000 sq. km of Port Philip Bay, Victoria, and a developed marine firefighting capability.

FRV organisational structure includes a marine commander to oversee marine operations and specialist marine firefighters are located at selected stations around Melbourne in close proximity to port infrastructure. These career firefighters are provided specialist marine firefighting training[74] to respond to shipboard fires, rescues, and other incidents like chemical spills on ships and in ports.

FRV also operate several marine firefighting vessels (fireboats) and marine firefighters have access to dedicated caches of equipment.

National initiatives

During the course of this investigation, the Australasian Fire and Emergency Service Authorities Council (AFAC)[75] established a marine working group (including representatives from FRNSW and FRV) to develop common doctrine and minimum standards for equipment and training related to national marine firefighting capability. AFAC members include FRNSW, DFES and FRV as well as other fire and emergency services organisations from across Australia and New Zealand. Additionally, AMSA is an AFAC affiliate.

FRNSW review of Iron Chieftain incident

Following the *Iron Chieftain* fire and emergency response, FRNSW conducted several reviews at various organisational levels in an effort to identify aspects of the response that worked well and areas for improvement.

Overall, these reviews concluded that a good outcome had been achieved with good incident command and with extinguishment achieved without the ship grounding, pollution, serious injury or damage to port infrastructure and facilities.

A number of positive strategic elements were identified. On the other hand, some of the key observations and areas of improvement identified by FRNSW, included:

- communication with external agencies was not always effective
  - Initially there was no direct way to contact the tug masters. Mobile phones were the main source of communication once contact numbers were obtained.
- critical factors must be identified and dealt with based on the conditions of the incident, not in a generic way based on previous incidents
  - Electricity was identified as a critical factor and switched off. This affected a number of the ship's systems, including stability.
- the role of Planning Officer was not filled for some of the incident

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73 In 1994, Victoria's *Port Services Act* was amended to include port waters as part of the Metropolitan Fire and Emergency Services Board's (MFB) response district. This change saw MFB's response area double in size, with the addition of nearly 1,000 square kilometres of Port Phillip Bay to the existing 1,000 square kilometres of land in metropolitan Melbourne. On 1 July 2020, the MFB, its stations and firefighters, were absorbed into the newly created Fire Rescue Victoria.

74 The firefighting training adhered closely to National Fire Protection Association Standard 1405 (NFPA 1405) – *Guide for Land-Based Fire Departments that Respond to Marine Vessel Fires*. The National Fire Protection Association (NFPA) is an international, non-profit organisation devoted to eliminating death, injury and, property and economic loss due to fire, electrical and related hazards.

75 The Australasian Fire and Emergency Service Authorities Council (AFAC) is the peak body responsible for representing fire, emergency services and land management agencies in the Australasian region.

  - As a result, certain longer-term planning functions did not occur, for example, consideration for the duration of the incident and handover requirements.
- the number of handovers and change of IMT roles that took place with the change of shift meant that there were unnecessary changes to strategies and tactics
- senior Officers did not report to the assigned staging location
  - This led to delays with handovers taking place and officers being released at the end of their shift
- fatigue for members of the IMT working on night shifts.

Fires involving SUL bulk carriers

A review of past fires involving SUL bulk carriers with conveyor belt systems identified several occurrences with circumstances relevant to this investigation.

Halifax

On 6 April 1993, a fire broke out in the tunnel spaces of the Canada registered, SUL bulk carrier *Halifax* whilst underway on the St. Mary's River, Ontario, Canada. The fire resulted in damage to the ship with a loss of one life but was successfully extinguished by the ship's crew with an hour.

The Transportation Safety Board of Canada (TSB) investigated the fire and published report number M93C0001. The investigation found that the fire started when hydraulic oil mist from a disconnected hose was ignited by a halogen lamp that was missing its protective cover. The ship's crew fought the fire by making entry to the tunnels from the forward end, opening the cargo hold hatch covers and directing fire hoses at the seat of the fire. The cooling of the cargo holds, and flooding of the tunnel proved effective in preventing the fire from spreading. The tunnel ventilations fans were not used for fear of feeding the fire and the sprinkler system in the loop belt casing area was turned on to cool the belts.

Ambassador

On 31 December 1994, a fire broke out in the conveyor belt system of the Vanuatu-registered, SUL bulk carrier *Ambassador* during cargo (rock phosphate) discharge operations at the port of Belledune, New Brunswick, Canada. The fire spread to the ship's accommodation, and the combined efforts of the ship's crew and shore fire departments were required to extinguish it, some 28 hours later. The fire resulted in significant damage to the ship's SUL system, tunnels and part of the accommodation.

Canada's TSB investigated the fire and published report number M94M0057. The investigation found that, during a suspension of cargo operations, a section of a conveyor belt ignited, probably because the belt was in contact with an overheated roller. The investigation concluded that the roller probably overheated due to a bearing failure or to being jammed with refuse.

The investigation also found that:

- the fixed sprinkler system in the loop belt casing was ineffective in controlling a major fire
- the open top of the loop belt casing and the hold gates to cargo hold number 3, which were not airtight, allowed a continuous supply of oxygen to the fire
- some of the shipboard firefighting equipment was sub-standard
- the crew had not been drilled in firefighting during weekly emergency drills
- none of the shore-based firefighters had been trained in fighting shipboard fires

The investigation report noted that *Ambassador* complied with SOLAS, Vanuatu and Canadian regulations.

The report stated that early detection and prompt extinguishing of fires in cargo conveyor systems depends on the presence of personnel in the area. Furthermore, on board *Ambassador*, the sprinkler system proved inadequate and the area of the fire was not covered by a fixed fire-extinguishing system.

TSB records indicated that, in the 15 years before the *Ambassador* fire, there had been at least eight fires on board Canadian SUL ships. These included the fire on *Algosoo* in 1986 and the fire on *H.M. Griffith* in 1989, both at Port Colborne, Ontario, Canada. None of the ships involved were fitted with a fire-detection or fixed fire-extinguishing system capable of suppressing large fires, and all the fires required direct firefighting by ship personnel.

The TSB recommended that the Canadian Department of Transport review the requirements for fire protection systems for tunnel areas on Canadian self-unloaders, with a view to ensuring a capability for suppressing large fires. It was subsequently assessed that improved procedural approaches to fire prevention adopted by operators appeared to be effective and therefore, no further regulatory amendments were pursued.

The TSB also recommended that the Canadian Department of Transport seek support from the International Maritime Organization (IMO) in addressing the need for enhanced fire detection and extinguishing systems in the tunnel area of SUL ships. This recommendation received insufficient support and no approach was made to the IMO.

Yeoman Bontrup

On 2 July 2010, a major fire and explosion occurred on board the Bahamas-registered, SUL bulk carrier *Yeoman Bontrup* during cargo (granite) loading at Glensanda Quarry, Loch Linhe, United Kingdom (UK). The fire was discovered near the bottom of the vertical conveyor belt system during repair work to a hopper and it spread rapidly to the adjacent engine room, accommodation and steering gear compartment. The ship's crew attempted to fight the fire, but they eventually evacuated the ship, and it was left to burn out. The fire resulted in significant damage to the ship including a violent explosion which tore the poop deck from the ship.

The United Kingdom's Marine Accident Investigation Branch (MAIB) investigated the grounding and published Report No. 5/2011. The MAIB determined that the most likely cause of the fire was the ignition of the vertical conveyor belt by hot debris from the hopper repair work.

The investigation found that although *Yeoman Bontrup* complied with the extant standards, attempts to contain and fight the fire were hampered by the following factors:

- the conveyor belt systems posed a high fire risk
- the lack of an effective means of early detection meant that the fire was already well established by the time it was detected
- the fire spread quickly through the compartment, making manual firefighting difficult due to the absence of means of containing the fire
- the compartment was not equipped with a fixed fire-extinguishing system.

The investigation also found that the ship's crew were not practised in fighting a fire in the cargo handling spaces and the drill schedule did not specify requirements for such drills despite the recognised high risk.

Following the fire, *Yeoman Bontrup*'s owners established an SUL operator and owners forum with representation covering 90 per cent of the SUL industry, including CSL. The forum agreed to jointly fund the testing of suitable fire detection and extinguishing systems

The MAIB recommended that the Bahamas Maritime Authority (BMA), supported by the UK's Maritime and Coastguard Agency (MCA), submit proposals to the IMO to review and improve fire detection, containment and extinguishing standards for cargo handling areas on board SUL vessels and to develop standards for conveyor belt fire resistance properties. The BMA proposed that a general requirement to perform fire safety risk assessments for cargo conveyor spaces on SUL bulk carriers be placed in the IMSBC Code while testing and assessment of suitable fire detection and extinguishing systems for SUL vessels continued.

The proposed amendments to the IMSBC Code were adopted in June 2015 and entered into force from 1 January 2017 (and could be applied voluntarily from 1 January 2016). With regard to the development of standards for conveyor belt fire resistance properties, the BMA noted there was an existing International Organization for Standardization (ISO) standard regarding flammability and that the SUL group considered the issue emphasised but noted the need for balance between fire resistance and flexibility. Consequently, the BMA did not take this recommendation forward.

In addition to safety action by the ship's flag State, the ship's manager implemented a number of safety actions including amending the drill schedule to include a requirement for fire drills in the cargo handling areas of SUL vessels.

Fires on board CSL Australia ships

By the time of the fire, CSL Australia was almost certainly aware of the safety concerns highlighted by past SUL ship fires and of the lessons learned as a result. The CSL Group participated in the SUL forum organised in response to the *Yeoman Bontrup* fire and was instrumental in the development and trialling of new fire detection and extinguishment technology. Safety action prompted by some of these fires had also been incorporated into CSL Australia procedures, including the added requirement for SUL system fire drills and the need for annual fire safety risk assessments of SUL system spaces.

Spencer Gulf (2017)

On 11 January 2017, a fire broke out in the external conveyor belt system of the Australia registered domestic commercial vessel (DCV), *Spencer Gulf*, following cargo transfer operations off Whyalla, SA. The fire was detected on the vessel's external conveyor and boom conveyor whilst alongside a bulk carrier. The fire was extinguished, about two hours after it was detected, by ship's crew with firefighting assistance from the bulk carrier and tugs. The vessel sustained damage to the boom, supporting conveyor structure, electrical systems, and instrumentation.

The fire was investigated by CSL Australia with external expert assistance. The cause of the fire was determined to be heat generated due to friction as a result of stoppage in the boom conveyor while the main drive pulley continued to run. The investigation report noted that that there was no fire suppression system covering the vessel's SUL system and that the firefighting capabilities of the vessel alone were insufficient to handle a fire of this magnitude.

The investigation examined the SUL fire safety risk assessment for *Spencer Gulf*[76] and noted that there had been a failure to implement identified 'planned future control measures' such as linear heat detection systems that may have provided advanced warning and additional response time. The investigation concluded that there was a failure to manage the risk of fire on board the vessel.

Although notified of the incident, AMSA did not have direct regulatory responsibility for DCVs at that time as State regulators effectively regulated DCVs through delegations from the National regulator (AMSA). The incident was also not reported to the ATSB nor was it required to be as the fire occurred while the vessel's operations were exclusively within State waters.

Spencer Gulf (2020)

On 20 September 2020, a fire was detected in *Spencer Gulf*'s main hopper during cargo operations off Whyalla, SA. The fire was visually detected during checks by the vessel's deck mechanic following a shutdown of the vessel's conveyor system initiated by an alarm for a high material level in the hopper. The fire was extinguished by crew within an hour of detection with no

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[76] The same risk assessments dated 10 April 2013, that identified and documented an unacceptable level of fire risk on board *Iron Chieftain*.

injuries reported. The vessel sustained fire damage to a conveyor belt, three impact idlers and an electrical sensor.

CSL Australia's investigation identified failed bearings on two rubber-covered impact idlers. The idlers had seized following the bearing failures which resulted in friction, heat build-up and subsequent smouldering of the conveyor belt. There was no system in place to detect high temperatures in the impact idler's bearings. The heat from the fire damaged a sensor in the vicinity of the idlers which resulted in the high material level alarm and shutdown of the conveyor system.

Donnacona

On 8 September 2020, a fire was detected on the boom of the Australia registered, SUL bulk carrier *Donnacona* during cargo (magnetite) transfer operations off Cape Preston, Western Australia. The fire was detected visually by the duty rating who witnessed smoke and flames issuing from the boom whilst the ship was alongside a bulk carrier. The fire was extinguished within an hour of detection by the ship's crew using fire hoses with the conveyor belt kept running. The fire resulted in damage to the pulley bearings on the boom and minor injury to a crewmember.

CSL Australia's investigation identified a collapsed bearing as the cause of the fire with the resulting friction from the collapsed bearing likely igniting the grease in the bearing housing. The ship was equipped with a high bearing temperature alarm and monitoring system however, the system was not set up with a hierarchy of critical alarms and that the number of alarms generated overwhelmed the user.

Safety analysis

Introduction

On 18 June 2018, during cargo discharge operations while alongside at Port Kembla, New South Wales (NSW), a fire broke out in the internal cargo handling spaces of the self-unloading (SUL) bulk carrier *Iron Chieftain*.

The ship's crew initiated an emergency response, but their efforts to control the fire were ineffective. As a result, the crew were evacuated and shore firefighting services from Fire and Rescue New South Wales (FRNSW) took over the response to the fire. The fire was subsequently contained and extinguished about 5 days after it started.

The ship sustained substantial damage with major elements of the SUL system destroyed and two heavy fuel oil (HFO) tanks breached. The ship was declared a constructive total loss and subsequently dispatched to be recycled. There were no serious injuries or pollution of the sea reported.

The following analysis will examine the cause of the fire, the emergency response and fire safety risk management on board SUL ships.

Cause of the fire

The fire on board *Iron Chieftain* was initially detected by the observation of smoke issuing from the C-Loop casing door leading to the C-Loop and SUL system spaces. Subsequent investigations by FRNSW and an expert engaged by the ship's managers confirmed that the fire originated within the conveyor belts of the ship's SUL system.

The most likely cause of the fire was assessed to be a failed idler bearing in a component of the SUL system at the bottom of the C-Loop space. The SUL system contained hundreds of idlers and the potential fire hazard from overheated bearings and rollers was well known from past fires overseas and was documented in the ship's SMS and risk assessment. The failure most likely occurred in an idler under the port transfer conveyor belt at the base of the C-Loop or in a bearing associated with an impact idler at the lower end of the C-Loop inner conveyor belt. In either case, the seized component created friction which generated sufficient heat to ignite the rubber conveyor belts.

The SUL system spaces contained a large quantity of rubber in the form of conveyor belts, which provided an ample source of fuel, and the vertical nature of the C-Loop space aided air flow and facilitated the development of the fire. The dolomite cargo was discounted as an ignition source, or contributor to the fire, due its high ignition temperature.

The inability to extinguish the fire at an early stage allowed it to act upon the bulkheads of the ship's HFO tanks situated adjacent to the C-Loop space. Thermal stresses imposed by the fire likely resulted in deformation of the bulkheads and the subsequent breach of the HFO tanks. This resulted in the introduction of HFO as an additional fuel source which added a layer of complexity in controlling the fire.

Regulations and standards

Investigations into past SUL ship fires overseas, particularly *Ambassador* and *Yeoman Bontrup*, had highlighted the high fire risk associated with SUL ship cargo handling spaces and the inadequacy of existing regulations for fire detection and extinguishment in these spaces. Safety action in response to recommendations following these fires had resulted in efforts to improve international fire safety regulations and requirements for SUL ships and had prompted the development of suitable detection and extinguishment technologies.

However, at the time of the *Iron Chieftain* fire, the situation regarding regulations and standards had not changed. There were no SOLAS regulations or classification society rules related to fire detection, containment and extinction that were specific to the cargo handling spaces of SUL vessels, nor were there standards governing the properties of conveyor belt rubber used in SUL systems.

Iron Chieftain was designed, constructed, and equipped in accordance with the prevailing regulations and standards. However, in the absence of any requirement to do so, the ship's SUL system spaces were not equipped with an automated fire detection system or a remotely activated fixed fire-extinguishing system and the conveyor belt rubber did not possess any fire resistance properties.

Consequently, the fire on board *Iron Chieftain* was able to establish itself and develop rapidly with few viable firefighting options available to the ship's crew.

Management of risk

The ISM Code placed a responsibility on companies to assess all identified risks to its ships, personnel and the environment and establish appropriate safeguards against these risks. More specifically, the IMSBC Code required operational fire safety risk assessments to be conducted regularly for the cargo handling areas of SUL ships equipped with internal conveyor systems. This measure was a direct result of safety action taken in response to previous major SUL ship fires.

Iron Chieftain's SMS reflected the requirements for the SUL system operational fire safety risk assessment and furthermore, required the risk assessment to be reviewed annually. The SUL fire safety risk assessment conducted for the ship's SUL system spaces in April 2013 assessed the fire risk associated with the ship's C-Loop as being unacceptable.

The unacceptably high fire risk for the space was based on the existing control measures in place at the time which included safety rounds by the ship's IRs, temperature checks by the deck mechanic, the ship's fire main and the dust suppression spray system. These control measures were ineffective in detecting a fire in sufficient time to be able to respond effectively using the ship's available firefighting resources. While the IRs took rounds every 2 hours, temperature checks were only performed by the deck mechanic during daylight hours and once at night. The spray system was not designed for firefighting, was not connected to the fire main and was ineffective against a fire while the ship's hydrants could not be effectively deployed once the space was on fire.

Other safety measures such as the requirement for monthly SUL fire drills (also a lesson from past fires) were also not implemented effectively as these drills were not conducted as required by the SMS.

The risk assessment identified 'planned future control measures', which, if implemented, would reduce the risk to an acceptable level. These proposed control measures included the installation of heat detection systems for bearings, installation of a low-pressure sprinkler system and the development of a procedure for use in the event of a fire.

Despite being identified in 2013, at the time of the fire in June 2018, none of these planned control measures had been implemented. Fire detection and suppression systems had not been upgraded to address the identified unacceptable fire risk, nor were there emergency contingency plans for fires in the SUL system spaces. Furthermore, the risk assessment was neither reviewed nor updated after the initial assessment in 2013.

Shipboard response to the fire

In addition to the inherent high fire risk associated with *Iron Chieftain*'s SUL system spaces, there were also elements of the ship's emergency preparedness and initial emergency response that influenced the outcome of the fire and/or increased safety risk in general.

Emergency contingency plans

Iron Chieftain's SMS required that emergency situations be dealt with according to plans in the ship's Emergency Contingency Plan (ECP) document. However, while the ECP contained plans for responding to various shipboard emergencies, including fires in certain locations on the ship, there were no contingency plans for responding to fires in the ship's SUL system spaces. Furthermore, a number of other CSL Australia ships were also found not to have contingency plans in place for responding to conveyor belt fires or fires in the SUL system spaces.

The contingency plans in the ECP were to be used as a framework to ensure that crew could act confidently in the event of an emergency with drills and training exercises to be used as learning experiences to make improvements to the plans. The importance of having an available plan was clearly understood as evidenced by the fact that development of a procedure for use in the event of a fire was identified as planned future control measure in *Iron Chieftain*'s SUL system fire safety risk assessment.

The absence of contingency plans for SUL system fires meant that there was no practiced plan that could be implemented in the event of a fire in those spaces. It also meant that there was no plan to use as a framework to practice with or build upon when conducting fire drills in these spaces. This increased the risk that the shipboard emergency response to a fire in the SUL spaces would be ineffective.

Drills

SOLAS and AMSA regulations, as well as *Iron Chieftain*'s SMS, required that drills of the ship's crew be conducted within 24 hours of the ship leaving port if more than 25 per cent of the ship's crew had not participated in drills aboard the ship in the previous month. These drills served to familiarise crew, particularly new crew, to the ship, its emergency arrangements and the actions required of them in the event of an emergency.

By the time of the fire, 14 of the ship's crew of 20, including the second mate who was new to the ship, had not participated in a fire drill on board in the last month. Consequently, when the fire broke out, the new second mate who was, coincidentally, the officer on duty at the time, had not participated in a fire drill on board *Iron Chieftain*. The officer was called upon to respond to a genuine emergency less than 2 weeks after joining the ship for the first time and having never participated in a drill or exercise on board.

In addition to the drills required by the regulations, *Iron Chieftain*'s SMS required additional monthly fire drills focussed on fires involving the SUL system spaces. The inclusion of these additional drills was an outcome of safety action from a past major SUL ship fire overseas in recognition of the high fire risk and unique firefighting circumstances of SUL system spaces. However, *Iron Chieftain*'s drills records showed that in the 12 months before the fire, only five SUL system fire drills had been conducted and none of them involved a fire in the C-Loop space. The irregular conduct of drills that were required specifically to improve preparedness to respond to fires in the SUL spaces increased the risk of an incorrect response to a real fire.

Alarms and mustering

During the immediate response to the fire, the ship's fire alarm, general emergency alarm and public address (PA) system all failed to work as expected. Nevertheless, most crew were woken by the sound of the intermittent alarms and were then alerted to the unfolding emergency by radio traffic from crew already involved in the response to the fire.

While the poor performance of the ship's alarm and PA systems probably did not delay the muster of the ship's crew significantly, it nevertheless hindered an effective muster as it required the diversion of the third mate from his usual muster duties on the bridge to ensure that all crew were alerted to the fire.

The anomaly in *Iron Chieftain*'s fire detection and alarm system was reported to have been a cause of frequent false alarms. However, the instructions in the ship's muster list and fire training manual clearly stated that an audible fire alarm signal would be followed by an investigation of the alarm. A muster of the ship's crew would only be prompted by a PA announcement or the general emergency alarm if the original alarm was found to be substantiated.

Therefore, it is unlikely that the anomaly had a significant influence on crew behaviour and on the muster in the response to the fire. Nevertheless, unresolved faults and anomalies in critical safety equipment such as the ship's fire detection and alarm systems can hamper the response to an emergency.

Emergency response actions

The detection of the fire on board *Iron Chieftain* resulted in a number of actions and decisions in response with some of these early actions being influential to subsequent events and the eventual outcome of the fire.

Among the most influential of the early decisions was the second mate's decision to stop the conveyor belts. All available guidance, instructions, and procedures for dealing with shipboard conveyor belt fires indicated that the belts should not be stopped. The action of stopping the belts had a clearly observable effect on events on the night.

Upon first discovering the fire, the IR was able to approach the C-Loop casing door although there was smoke issuing from it. Later, shortly after the belts were stopped, the chief mate reported difficulty approaching the area due to the heat and volume of smoke. By the time FRNSW attempted to enter the space, the heat, smoke, and flame made access impossible. Similarly, when FRNSW firefighters first arrived, the boom conveyor on deck (the last conveyor to be stopped in the sequence) was reported to be smouldering but not alight. Shortly after, the boom conveyor burst into flame. It is likely that at the time the decision to stop the belts was made, the second mate was uncertain as to the precise nature of the unfolding emergency. Nevertheless, the decision to stop the belts almost certainly aided the development of the fire.

Another factor that likely aided the fire's development was the failure to stop the forward tunnel ventilation fan. This fan blew significant volumes of air down into the tunnels toward the C-Loop with great force and almost certainly facilitated the early development and growth of fire in the space. The fan was not stopped until the ship lost power following the activation of the fuel quick closing valves (QCVs) and the release of CO_2 into the engine room.

A viable firefighting option in response to *Iron Chieftain*'s C-Loop fire was described in the ship's SMS. The suggested tactic involved opening the hatch covers and hold gates of an empty cargo hold and attacking the seat of the fire directly. Cargo hold number 5, located above the aftermost end of the tunnels, was empty. Opening the hatch covers and gates may have allowed firefighters to train fire hoses directly at or close to the seat of the fire at the base of the C-Loop. However, this tactic was not attempted by ship staff and, in any case, when the ship lost main generator power, the option of pursuing this tactic was lost as opening of the hatch cover required electrical power.

During the shipboard response to the fire, there were other actions that increased safety risk even if they did not directly influence the fire or adversely affect the response. These included the use of the ship's elevator by the 0000—0400 IR following the detection of the fire and the omission of an initial headcount to account for all personnel following the activation of the ship's alarms and initiation of the emergency response.

Another factor that likely increased risk was the chief mate's decision to start the hold washing pump supplying the C-Loop spray system before opening the manual valve on deck. The action of starting the pump first probably made it harder to open the manual C-Loop spray valve adjacent to the C-Loop casing due to the associated water pressure. Opening this valve eventually required multiple attempts by the ship's fire party, putting them in harm's way unnecessarily.

Use of fixed fire-extinguishing system

Post-fire examinations of *Iron Chieftain*'s engine room indicated that the fire did not originate in the space nor was there evidence of significant fire spread apart from localised damage due to heat conduction.

The ship's second engineer, whose muster station was in the engine control room, broadcast multiple reports of a 'big fire' in the engine room on the radio. It is likely that the second engineer's belief that there was a big fire was influenced by the blistering paint and associated smoke from the engine room's forward bulkhead. The master relied on the second engineer's information and consequently proceeded under the assumption that there was probably a fire in the engine room. The engine room's carbon dioxide (CO_2) fixed fire-extinguishing system was subsequently activated, with FRNSW agreement. While this would likely have extinguished any active fire and supressed any potential fire in the space, it also had implications for firefighting efforts directed at the actual fire in the ship's C-Loop space.

In preparation for the activation of the engine room's CO_2 system, the ship's crew activated the fuel QCVs and other emergency stops, in advance of FRNSW arrival on board. This shut down much of the ship's machinery and equipment in the engine room. The subsequent CO_2 release meant it was no longer possible to occupy the engine room and maintain normal operation of machinery. While it is difficult to speculate how the availability of ship's machinery and equipment might have influenced the eventual outcome of the fire, it nevertheless affected the ship's capability in a number of ways. For example:

- The loss of the main fire pump reduced capability to the single emergency fire pump.
- The loss of the ship's ballast and general service pumps removed the capability to influence the ship's draught, stability, trim and list.
- The loss of the ship's fuel and transfer pumps removed the capability to influence the volume of HFO exposed to the fire in the HFO tanks.
- The loss of hold washing pump meant that the C-Loop spray system ceased operation, although it is unlikely that this system would have influenced the outcome of the fire.
- The inability to open and shut hatch covers meant that cargo hold number 3 could not be closed to restrict air supply to the tunnels.
- The hatch covers to cargo hold number 5 and the hold gates below could not be opened to try and attack the fire directly.

The decision to deploy the ship's engine room fixed fire-extinguishing system should be one that is carefully considered after weighing up all relevant factors. In this case, the master's decision was probably influenced by factors such as the chief engineer's advice, the belief that there was a fire reported in the engine room, FRNSW practice of isolating machinery and electricity, and the fact that FRNSW firefighters concurred with the master's proposed course of action.

The decision possibly even resulted in some advantages such as the assurance that the CO_2 limited the potential for fire spread to the engine room where there were significant quantities of oil and other combustibles and that electrical circuits associated with machinery were de-energised and could be discounted as a hazard.

While acknowledging the master's reasoning, the possible advantages conferred by the use of the CO_2 system and the potential difficulties associated with manning an operational engine room adjacent to a space on fire, the decision to activate the fuel QCVs and subsequently flood the engine room with CO_2 thereby isolating it, nevertheless influenced firefighting capability and removed options that might otherwise have existed.

Shore response to the fire

The fire on board *Iron Chieftain* quickly overwhelmed the firefighting capabilities of the ship and its crew with shore assistance being requested at an early stage. The subsequent management of the response drew on elements of State, regional, local and Port Kembla's emergency management arrangements, with FRNSW acting as the combat agency.

The ATSB investigation examined the shore response to the fire with a view to identifying any safety learnings. The investigation identified safety factors which, although found not to be contributory, were nevertheless worth highlighting. These factors related to FRNSW capability with regard to marine fires and the port's documented plans for emergency response.

FRNSW capability

On boarding *Iron Chieftain*, FRNSW first responders were confronted with an intense, well-developed fire in the unfamiliar environment of an SUL bulk carrier. The fire had already overwhelmed the ship's inadequate firefighting capabilities and, at an early stage in the response, incident control (and combat agency responsibility) was delegated to FRNSW. It therefore fell to FRNSW firefighters to adapt to the shipboard environment, contain the fire and associated hazards, and ultimately lead the development and implementation of an extinguishment strategy. However, FRNSW did not maintain a specialist marine firefighting capability. The relatively rare occurrence of major shipboard fires in New South Wales (NSW) waters and ports also meant that there was limited opportunity for FRNSW to gain practical experience in fighting such fires.

Furthermore, while FRNSW training material included a section on shipboard firefighting and incident management teams (IMT) were generally trained to respond to a variety of scenarios (utilising skills applicable and transferrable to shipboard firefighting), there was no documented evidence of the FRNSW shipboard firefighting training being delivered to local firefighters or to the IMT personnel who first responded to the fire. A review of the FRNSW shipping training manual indicated that it was last updated in May 1996 and that it contained some information that was outdated or inaccurate.

In addition, FRNSW first-responders were not provided with marine-specific documentary resources to assist with tactical familiarisation and strategic planning when responding at a shipboard fire nor was there evidence of stations in Port Kembla's vicinity being equipped with marine firefighting tools such as an international shore connection or couplings. There were also logistical challenges with obtaining the quantity and type of foam required to implement a decisive extinguishment strategy although these were eventually overcome.

The ATSB's investigation included an evaluation of contemporary agencies in Western Australia and Victoria, which offer examples of organisations (with legislated responsibilities) that maintain a specialist marine firefighting capability integrated into the organisation's general structure and supported by up-to-date training, specialist equipment and documentary resources.

In submission to the draft of this report, FRNSW stated that it did not maintain a specialist marine firefighting capability for the following reasons:

> …FRNSW were not the combat agency but a support agency. … [and]
>
> FRNSW are not designated as the combat agency under statue in NSW until control is passed from the harbour master to FRNSW.
>
> FRNSW were the combat agency for the major part of the response to the *Iron Chieftain* fire commencing at the time when control was passed from the harbour master to FRNSW on 18 June 2018 until its conclusion on 24 June 2018.
>
> The intention of submissions… above is to make clear that FRNSW is not explicitly denoted as a shipboard firefighting combat agency. This is in contrast to the situation in Melbourne where the MFB [Fire Rescue Victoria's predecessor] have been the combat agency for shipboard fires since amendments in 1994 to the Port Services Act to include port waters as part of MFB's response district.

The ATSB acknowledges the stated position of FRNSW, including that NSW emergency management arrangements do not explicitly assign the combat agency responsibility for a shipboard fire in port to FRNSW and that the documented, preferred arrangement is for the Port

Authority of NSW (PANSW) to maintain this role. However, the arrangements do allow for control of the response to such a fire to be passed to FRNSW at which time it becomes the combat agency for a shipboard fire in NSW. Furthermore, the port's crisis management plan documented FRNSW as the combat agency for a shipboard fire.

On the night of the fire, incident control was handed to FRNSW early and, FRNSW assumed and maintained control of the response to the fire, performing the combat agency role until the incident was concluded. Therefore, while FRNSW may not be 'designated as the combat agency under statute in NSW', in practice it is very likely that FRNSW will be called upon to assume the responsibility in the event of a major marine fire, as was the case in the *Iron Chieftain* fire.

In the *Iron Chieftain* incident, FRNSW were presented with a complex, multi-dimensional fire, with several associated challenges and its contribution in bringing the fire to a safe conclusion with no serious injuries, infrastructure damage or pollution of the sea is commendable. It should be noted that the joint exercises, such as those conducted at Port Kembla, contributed to building a close working relationship between the Port Authority of NSW (PANSW), NSW Maritime and FRNSW. This had a positive impact on operations both during the initial response and hand-over as well as during the extended response to the incident.

Following the fire, FRNSW conducted a robust performance review and identified several potential areas for improvement. These included improving communications with external agencies, filling key roles promptly, better management of the change of IMTs, the setting up of clear staging locations and incident-specific management of critical factors. However, there were other aspects of FRNSW training, organisation, and resourcing with regard to marine firefighting which should be addressed. Such safety action will almost certainly result in an improved level of marine firefighting capability and preparedness in NSW.

Port Kembla contingency plans

The PANSW's operating licence required ports to respond to emergencies and incidents as required by State plans. It also required the port authority to have emergency response plans with documented operational procedures to guide its emergency response activities. For shipboard fires in port, the State spill contingency plan required that the response be conducted according to the port's local incident response contingency plans. For Port Kembla, this was the Port Kembla Marine Oil and Chemical Spill Contingency Plan (Port Kembla spill contingency plan).

The Port Kembla spill contingency plan reflected the State spill contingency plan's arrangements and instructions for the response to a marine spill. However, the State plan also included specific guidelines that provided practical advice on implementing the coordinated, multi-agency approach required of a response to a shipboard fire. Port Kembla's spill contingency plan did not include any reference to the State plan's guidelines for responding to a shipboard fire. Consequently, it did not contain the useful information specific to the response arrangements to a shipboard fire such as the combat agency arrangements, the multi-agency approach and, the need for vessel coordinators and fire operations coordinators. The omission of any reference to the vessel coordinator was particularly relevant given that the guidelines recommended the appointment of a PANSW officer to the role. While the intent of these specific roles appears to have been met during the *Iron Chieftain* incident, the absence of a reference to the need for these roles in the port's plans increased the risk that they may be overlooked during future incidents.

Similarly, while the PANSW's crisis management plan included some guidance of a general nature on responding to a shipboard fire in port, it did not integrate specific details from the State guidelines such as the preference that PANSW take on the combat agency role. Furthermore, the crisis management plan made reference to the terms 'lead agency' as well as 'combat agency' in assigning responsibilities. While both these terms were used in the State plan in force at the time, it was inconsistent with the State spill contingency plan which only used the term 'combat agency' with regard to the arrangements for responding to a shipboard fire in port. This had the potential to create significant role confusion.

Regulatory oversight of *Iron Chieftain*

The ATSB investigation identified several factors related to safety and emergency preparedness at the shipboard and management levels. For example, the intermittent functioning of *Iron Chieftain*'s alarm bells and PA system during the fire. The ATSB considered it far more likely that these were pre-existing issues, rather than an improbable coincidence that night.

The irregular emergency drills (contrary to procedures) particularly the SUL system fire drills, and the absence of a contingency plan for SUL system fires indicated the ship's emergency preparedness, at least for fires involving the SUL system, was non-compliant with the SMS and below any acceptable standard.

The vulnerability of SUL ships to fire was a known factor from past fires and had resulted in an IMSBC Code requirement for the conduct of fire safety risk assessments of SUL system spaces. *Iron Chieftain*'s risk assessment identified an unacceptable level of fire risk in the C-Loop space. However, the risk went unaddressed for more than 5 years and the risk assessment was not reviewed or updated following the initial assessment. This eventually culminated in a major fire resulting in significant damage and the ship consequently being declared a constructive total loss.

The Australian Maritime Safety Authority (AMSA) is responsible for checking and monitoring that ships flying the Australian flag comply with the relevant international regulations and obligations, including the ISM Code. AMSA also monitored the operational safety standards of Australian-flagged ships through the flag state control regime.

The ATSB acknowledges the challenges AMSA has in identifying specific indicators of risk during ship inspections within the limited time frame of ports calls amid competing priorities. Nevertheless, the last two AMSA flag State inspections of *Iron Chieftain* before the fire did not identify any deficiencies on board the ship and flag State inspections from previous years did not identify any shortcomings with regard to the management of risks, in particular fire risk, on board CSL Australia vessels.

Similarly, while *Iron Chieftain*'s SUL fire safety risk assessment was dated April 2013, the ship's initial ISM audit in September 2015 did not identify any deficiencies related to the inadequate management of fire risk on board. However, it should also be acknowledged that the amendment to the IMSBC Code requiring these assessments had only been adopted about 3 months earlier, in June 2015. It is therefore justifiable that such a new requirement may not have been audited or the risk assessment sighted.

As indicated earlier, AMSA investigation activities are primarily directed towards prosecution with a reliance on ATSB investigations to inform awareness of any identified safety issues and the need for safety improvement.

AMSA is not prevented from investigating in parallel to the ATSB to identify any readily apparent regulatory or oversight issues. However, in the case of *Iron Chieftain*, noting that there were no fatalities or pollution and that the ATSB was investigating, AMSA determined that there was little value in a regulatory investigation.

The fire on board CSL Australia's *Spencer Gulf* in 2017 provided another opportunity for intervention and scrutiny of the management of fire risk on board Australian-flagged SUL ships. However:

- its status as a domestic commercial vessel operating within State waters
- the fact that AMSA did not have direct regulatory responsibility for it
- no requirement for the fire to be reported to the ATSB

resulted in no investigation or regulatory action being undertaken by the ATSB or AMSA. Consequently, an opportunity to identify safety issues and potentially improve oversight of high fire-risk SUL ships was missed.

Findings

ATSB investigation report findings focus on safety factors (that is, events and conditions that increase risk). Safety factors include 'contributing factors' and 'other factors that increased risk' (that is, factors that did not meet the definition of a contributing factor for this occurrence but were still considered important to include in the report for the purpose of increasing awareness and enhancing safety). In addition, 'other findings' may be included to provide important information about topics other than safety factors.

Safety issues are highlighted in bold to emphasise their importance. A safety issue is a safety factor that (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operating environment at a specific point in time.

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

From the evidence available, the following findings are made with respect to the fire on board *Iron Chieftain* at Port Kembla, New South Wales on 18 June 2018.

Contributing factors

- The fire on board *Iron Chieftain* originated within the C-Loop space of the ship's self-unloading system. The fire was probably the result of a failed conveyor idler bearing, which created the necessary heat for the ignition of the rubber conveyor belt.
- The officer of the watch's immediate response to being notified of an irregularity in the self-unloading system was to stop the cargo discharging process including stopping the conveyor belts. This action, and other aspects of the shipboard response, aided the fire's development and increased the risk of damage, injury, and loss of life.
- ***Iron Chieftain*'s operators had formally identified the fire risk in the ship's cargo self-unloading system spaces, particularly the C-Loop, as being unacceptably high 5 years before the fire due to the absence of fire detection or fixed fire extinguishing system. However, at the time of the fire, the prevention and recovery risk mitigation measures had not reduced the risk to an acceptable level. [Safety issue]**
- **The cargo handling spaces of specialised self-unloading bulk carriers continue to present a very high fire risk due to the inadequacy of standards or regulations for self-unloading systems, including for conveyor belts, and dedicated fire detection/fixed fire-extinguishing systems. This has been a factor in at least three major fires over a 25-year period, including *Iron Chieftain*'s constructive total loss. [Safety issue]**

Other factors that increased risk

- In the course of the shipboard emergency response to the fire, there were intermittent failures of the ship's fire alarm system, general emergency alarm system and public announcement system. This probably hindered an effective muster of the ship's crew as it required the delegation of an officer to physically ensure that all crew were notified of the emergency.
- *Iron Chieftain*'s fire detection system, covering the accommodation and machinery spaces, had an unresolved anomaly, which increased the incidence of false alarms being generated. This increased the risk that crew would not react effectively to a fire alarm emergency signal.
- Although based on the belief that there was a fire in the engine room, the activation of the space's fuel quick closing valves, fuel pump shut-offs, ventilation shut-offs and CO_2 fixed fire extinguishing system rendered ship's machinery and equipment ineffective. That impacted the firefighting response by removing options such as the ability to pressurise the fire main, operate cargo hatch covers/hold gates and control the ship's stability and fuel tank levels.
- Emergency drills, generally required by regulations following a change of more than a quarter of the ship's crew, were not carried out after crew changes that occurred about 3 weeks before

the fire. Furthermore, additional fire drills in the ship's self-unloading system were not carried out in accordance with the ship's safety management system requirements. Consequently, the officer of the watch at the time of the fire had not participated in a fire drill on board *Iron Chieftain*.

- ***Iron Chieftain*'s Emergency Contingency Plan did not include a response plan for fire in the high fire risk self-unloading system spaces. Consequently, there was no clear plan or practiced sequence of actions that could aid emergency preparedness. [Safety issue]**
- Port Kembla's local emergency response plans had not adequately integrated key elements of the state's guidelines for responding to a fire on a vessel.
- **The capability of Fire and Rescue New South Wales to effectively respond to a shipboard fire in Port Kembla, was limited by:**
  - **a lack of specialised marine firefighting expertise**
  - **outdated marine training for firefighters**
  - **relative inexperience in shipboard firefighting associated with the rarity of major shipboard fires**
  - **an absence of marine-specific firefighting resources and aids for use by first responders. [Safety issue]**
- **Regulatory safety oversight of *Iron Chieftain*, which comprised flag State audits, surveys and inspections had not identified safety deficiencies with respect to the ship's fire safety, risk management, emergency preparedness and emergency response. [Safety issue]**

Safety issues and actions

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues. The ATSB expects relevant organisations will address all safety issues an investigation identifies.

Depending on the level of risk of a safety issue, the extent of corrective action taken by the relevant organisation(s), or the desirability of directing a broad safety message to the marine industry, the ATSB may issue a formal safety recommendation or safety advisory notice as part of the final report.

All of the directly involved parties were provided with a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

The initial public version of these safety issues and actions are provided separately on the ATSB website, to facilitate monitoring by interested parties. Where relevant, the safety issues and actions will be updated on the ATSB website as further information about safety action comes to hand.

Management of risk

Safety issue description

Iron Chieftain's operators had formally identified the fire risk in the ship's cargo self-unloading system spaces, particularly the C-Loop, as being unacceptably high 5 years before the fire due to the absence of fire detection or fixed fire extinguishing system. However, at the time of the fire, the prevention and recovery risk mitigation measures had not reduced the risk to an acceptable level.

Issue number:	MO-2018-011-SI-01
Issue owner:	Canada Steamship Lines Australia
Transport function:	Marine: Shore-based operations
Current issue status:	Closed - Adequately addressed
Issue status justification:	The installation of systems to provide early heat and fire detection as well as the provision of fixed fire-extinguishing capability in the self-unloading system spaces should reduce the high level of fire risk associated with these spaces to an acceptable level.

Proactive safety action taken by Canada Steamship Lines Australia

Action number:	MO-2018-011-NSA-011
Action organisation:	Canada Steamship Lines Australia
Action status:	Closed

On 3 March 2020, Canada Steamship Lines Australia (CSL Australia) advised the ATSB that, following the fire on board *Iron Chieftain*, the CSL Group (the parent company) launched the Fire Integrated Risk Mitigation (FiRM) project across its global fleet. The FiRM project working group was tasked with a review of CSL's policies, procedures, and technologies in place for the prevention, detection and fighting of fires.

FiRM initiatives were developed under the project's four pillars of:

- Prevention and maintenance: The strategic objective is to supply and install safety devices for fire prevention, as well as review and improve maintenance procedures for high fire risk equipment.
- Firefighting: The strategic objective is to review and improve CSL's firefighting policy. This strategic objective also aims to upgrade and standardize the global fleet's supply and storage of firefighting equipment (FFE) and personal protection equipment (PPE).

- Detection and suppression: The strategic objective is to enhance the global fleet's capabilities for early heat detection, fire detection and fire suppression by installing new technology. Examples include early heat detection (thermal imaging cameras for SUL high risk areas), fire detection (SUL linear heat detection alarm systems integrated with closed circuit television camera systems (CCTV) and water mist suppression systems and, engine room cameras with flame/smoke/mist video analytics).
- Newbuild and conversion design: The strategic objective is to improve newbuild and conversion of SUL design from a safety perspective by defining the standard for minimum requirements for early heat detection and fire detection. This strategic objective also aims to induce discussions for tactical layout of SUL equipment to mitigate fire risk during the design phase.

On 21 April 2020, CSL Australia provided the following update on the progress of the proposed safety action with respect to the CSL Australia fleet and operations:

- Full CCTV was installed on board ten CSL Australia ships [including on board ships not equipped with conveyor belt systems].
- In addition, CCTV was integrated with video data analytics on board five ships.
- Six CSL Australia ships equipped with conveyor belt systems were equipped with linear heat detection systems.
- The single CSL Australia-operated ship with an internal conveyor system was fitted with a Hi-Fog water mist fire suppression system covering the ship's C-Loop and tunnel spaces.
- Further work is in progress to equip one other ship with CCTV, data analytics and linear heat detection systems.
- All systems were reported to have user interface and alarm panels in the cargo control room, engine control room and bridge.

On 9 March 2021, CSL Australia further advised that the ATSB that:

- A CSL Australia ship with external conveyor systems had also been fitted with a deluge system.
- CCTV was now integrated with video data analytics on board eight vessels.
- Annual reviews of the SUL system fire safety risk assessments were now being conducted with the latest review completed in February 2021.
- SUL fire safety risks on board CSL Australia SUL ships have been addressed to be acceptable.

In summary, of the fleet of seven conveyor belt-equipped SUL ships operated by CSL Australia, six have been equipped with linear heat detection systems and/or CCTV integrated with video analytics to provide or enhance the capability for early fire detection with installation planned for the seventh ship.

The single SUL ship with internal conveyor spaces was equipped with a Hi-Fog water mist fixed fire-extinguishing system covering the ship's internal SUL spaces. In addition, one ship with external conveyor systems was equipped with a deluge system and installation of a deluge system is intended for at least one other ship. Further, the rollout of the FiRM project's initiatives across the CSL Group's global fleet can be expected to further reduce the fire safety risk on board its SUL bulk carriers worldwide.

Inadequate standards and regulation

Safety issue description

The cargo handling spaces of specialised self-unloading bulk carriers continue to present a very high fire risk due to the inadequacy of standards or regulations for self-unloading systems, including for conveyor belts, and dedicated fire detection/fixed fire-extinguishing systems. This has been a factor in at least three major fires over a 25-year period, including *Iron Chieftain*'s constructive total loss.

Issue number:	MO-2018-011-SI-02
Issue owner:	Australian Maritime Safety Authority, Lloyd's Register, and International Association of Classification Societies
Transport function:	Marine: Other
Current issue status:	Open - Safety action pending.
Issue status justification:	The ATSB acknowledges the proposals of the Australian Maritime Safety Authority and Lloyd's Register to initiate action to address this safety issue by raising it with the International Maritime Organization (IMO) and the International Association of Classification Societies (IACS) respectively. As the process of progressing safety action at IMO and IACS can be prolonged, the ATSB will monitor progress to regularly reassess the status of the safety issue and publish updates on its website.

Response by the Australian Maritime Safety Authority

On 18 February 2021, the Australian Maritime Safety Authority (AMSA), advised that it would work with the ATSB to raise the deficiencies highlighted by the investigation report with the International Maritime Organization (IMO).

On 8 April 2021, in response to ATSB's request for relevant detail on AMSA's proposed course of action, AMSA advised that as the IMO's Maritime Safety Committee (MSC) must approve new work items based on papers submitted by Member States (countries) and IMO sub-committees, Australia (AMSA and ATSB) would use the Sub-Committee on Implementation of IMO Instruments (III) and the Casualty Analysis Working Group (CAWG) that reports to III to initially highlight the issue and to seek like-minded support.

ATSB comment

The ATSB welcomes the intent of the safety action proposed by AMSA and undertakes to assist AMSA as required by highlighting this safety issue at IMO forums to seek improved regulations and standards. However, given the importance of this safety issue, the ATSB is concerned by the absence of a detailed proposal and/or timeframe to raise this issue with IMO through the appropriate process and best ensure the MSC approves work items aimed at addressing this issue.

Any such work items assigned to the CAWG will be actively promoted by the ATSB as a member of that group. In addition, the ATSB will use its membership in the IMO's Casualty Analysis Correspondence Group (CACG) and the Marine Accident Investigators' International Forum (MAIIF) to highlight the safety issue and seek like-minded support. In the interim, the ATSB issues the following safety recommendation.

Safety recommendation to the Australian Maritime Safety Authority

The ATSB makes a formal safety recommendation, either during or at the end of an investigation, based on the level of risk associated with a safety issue and the extent of corrective action already undertaken. Rather than being prescriptive about the form of corrective action to be taken, the recommendation focuses on the safety issue of concern. It is a matter for the responsible organisation to assess the costs and benefits of any particular method of addressing a safety issue.

Recommendation number:	MO-2018-011-SR-015
Responsible organisation:	Australian Maritime Safety Authority
Recommendation status:	Released

The Australian Transport Safety Bureau recommends that the Australian Maritime Safety Authority takes steps to formally raise this safety issue with the International Maritime Organization to seek safety action aimed at addressing the risk of fire in the cargo handling spaces of self-unloading bulk carriers due to the inadequacy of the current associated standards/regulations.

Proactive safety action taken by Lloyd's Register

Action number:	MO-2018-011-NSA-018
Action organisation:	Lloyd's Register
Action status:	Monitor

On 19 February 2021, in response to a draft of this investigation report, Lloyd's Register noted the investigation's conclusions and agreed that the arrangements of conveying machinery spaces of self-unloading bulk carriers merited improvement to address the risk.

Lloyd's Register proposed to support an approach to the International Association of Classification Societies (IACS) to seek a Unified Interpretation for the requirements for conveying spaces, to mitigate the fire risk in these spaces.

On 8 April 2021, Lloyd's Register advised that a submission had been made to the General Policy Group of the International Association of Classification Societies (IACS) and was awaiting a decision as to when this would be assigned to the IACS Safety Panel.

Lloyd's Register advised that the support received from other IACS members would dictate proceedings and that an interim approach via an IACS Unified Requirement (UR) may be desirable as it was a quicker route to action given the long gestation time for a Regulation change at the International Maritime Organization (IMO). This approach would at least get IACS members to a position of implementing a preventative requirement for new ships, although retrospective application may be problematic.

Lloyd's Register provided the following estimated timeline to develop a UR should the approach to the IACS safety panel progress:

- End of May 2021 – agreement by IACS Members at Safety Panel to develop a UR
- June 2021-June 2022 – IACS internal governance and development activity
- 1 July 2023 – UR enters into force in members' Rules

Lloyd's Register advised that, while an IACS-based action would provide a more expedient interim solution, in the longer term, changes to the International Convention for the Safety of Life at Sea (SOLAS) 1974, as amended, and associated IMO instruments would also be required to ensure safety across the board.

ATSB comment

The ATSB welcomes the course of safety action proposed by Lloyd's Register with regard to addressing this safety issue and seeking improved standards and regulations, and the action it has taken to initiate that process. It is also acknowledged that safety action may take some time. Consequently, the ATSB will continue to monitor the safety issue.

Proactive safety action taken by the International Association of Classification Societies

Action number:	MO-2018-011-NSA-019
Action organisation:	International Association of Classification Societies
Action status:	Monitor

On 18 January 2021, the International Association of Classification Societies (IACS) advised the ATSB that, in accordance with its guidelines, draft marine accident investigation reports containing matters relevant to class were to be directed to the classification society that classed the involved ship, in this case, Lloyd's Register.

On 8 April 2021, consistent with those IACS guidelines, Lloyd's Register confirmed it had initiated the process for an IACS Unified Requirement (UR) aimed at providing an expedient interim solution to addressing the safety issue through class rules pending changes to International Maritime Organization (IMO) regulations. Lloyd's Register also indicated that the process, if successful, should result in the UR entering force on 1 July 2023.

ATSB comment

The ATSB welcomes the proposed course of safety action being progressed through the International Association of Classification Societies (IACS) by Lloyd's Register to address this safety issue and will continue to monitor the issue.

Shipboard emergency contingency plans

Safety issue description

Iron Chieftain's Emergency Contingency Plan did not include a response plan to fire in the high fire risk self-unloading system spaces. Consequently, there was no clear plan or practiced sequence of actions that could aid emergency preparedness.

Issue number:	MO-2018-011-SI-03
Issue owner:	Canada Steamship Lines Australia
Transport function:	Marine: Shipboard operations
Current issue status:	Closed - Adequately addressed
Issue status justification:	The development of ship-specific emergency contingency plans for responding to fire in the self-unloading system spaces should provide a useful framework to build and improve upon. These plans, exercised in conjunction with regular and realistic emergency drills, should adequately address this safety issue.

Proactive safety action taken by Canada Steamship Lines Australia

Action number:	MO-2018-011-NSA-012
Action organisation:	Canada Steamship Lines Australia
Action status:	Closed

On 18 February 2021, Canada Steamship Lines Australia (CSL Australia) advised the ATSB that CSL Australia continued to develop emergency contingency plans specific to SUL ships as part of a continued improvement of its safety management system. In an update on 9 March 2021, CSL Australia confirmed that ship-specific emergency contingency plans for responding to fires in the self-unloading system spaces had been developed and implemented across the organisation's SUL ships.

Fire and Rescue New South Wales marine firefighting capability

Safety issue description

The capability of Fire and Rescue New South Wales to effectively respond to a shipboard fire in Port Kembla, was limited by:

- a lack of specialised marine firefighting expertise
- outdated marine training for firefighters
- relative inexperience in shipboard firefighting associated with the rarity of major shipboard fires
- an absence of marine-specific firefighting resources and aids for use by first responders.

Issue number:	MO-2018-011-SI-04

Issue owner:	Fire and Rescue New South Wales
Transport function:	Marine: Other
Current issue status:	Open – Safety action pending
Issue status justification:	The ATSB welcomes the action taken Fire and Rescue New South Wales but considers that further action is required to adequately address the safety issue.

Proactive safety action taken by Fire and Rescue New South Wales

Action number:	MO-2018-011-NSA-016
Action organisation:	Fire and Rescue New South Wales
Action status:	Monitor

On 18 February 2021, Fire and Rescue New South Wales (FRNSW) advised the ATSB of the following safety action, as summarised below, taken to improve marine firefighting awareness and capability since the *Iron Chieftain* incident:

- FRNSW currently has a representative on the Australasian Fire and Emergency Service Authorities Council (AFAC) Working Group for Marine Firefighting. FRNSW is working with all member agencies to produce a nationally consistent approach and, when completed, will release a Standard Operations Guideline (SOG).
- FRNSW has undertaken two training exercises with the Royal Australian Navy.
- FRNSW has a schedule of familiarisation and training visits with Svitzer Tugs at Port Kembla with the goal of improving interoperability. In addition, a tabletop exercise (Exercise Whale two) was conducted as a follow-on from Exercise Whale.
- FRNSW, through AMSA, was involved in a ‘policy sprint’ workshop to commence the development of a national framework for maritime emergencies. FRNSW continues to be the Hazardous Noxious Substance response team for AMSA, although training has been on hold due to COVID-19.
- FRNSW, in collaboration with NSW Maritime (Transport for NSW), have reviewed and updated the Memorandum of Understanding in Relation to Hazardous Materials Incidents on Inland and State Waters.

In addition, FRNSW commented that the *Iron Chieftain* fire was safely extinguished and the incident brought to a safe conclusion with no loss of life, major injury to crew or firefighters, escape of pollutants into the environment or damage to port infrastructure despite FRNSW not being the initial combat agency.

Additionally, FRNSW stated that, while not a marine firefighting specialist, the use of subject matter experts (as denoted within the Australian Inter-Service Incident Management System (AIIMS)), from the vessel, port authorities, marine consultants and the Victorian Metropolitan Fire Brigade’s Marine Command, assisted firefighting efforts with instantaneous specialist advice and input into the formulation of Incident Action Plans (IAP).

Finally, FRNSW advised that, although located on a vessel, the fire was similar to ones that FRNSW routinely attend that involve fire in underground basements and confined spaces, involving deep seated rubber fires and the use of breathing apparatus, atmospheric monitoring and foam. FRNSW was therefore able to adapt its many Standard Operational Guidelines to safely respond to and conclude this incident.

ATSB comment

The ATSB acknowledges the safety action taken and proposed by Fire and Rescue New South Wales (FRNSW) in response to the ATSB investigation. However, the ATSB considers that further safety action by FRNSW, in particular, action potentially resulting from work underway through the

Australasian Fire and Emergency Service Authorities Council (AFAC) is necessary to address the safety issue. Therefore, the ATSB issues the following safety recommendation to FRNSW.

Safety recommendation to Fire and Rescue New South Wales

The ATSB makes a formal safety recommendation, either during or at the end of an investigation, based on the level of risk associated with a safety issue and the extent of corrective action already undertaken. Rather than being prescriptive about the form of corrective action to be taken, the recommendation focuses on the safety issue of concern. It is a matter for the responsible organisation to assess the costs and benefits of any particular method of addressing a safety issue.

Recommendation number:	MO-2018-011-SR-014
Responsible organisation:	Fire and Rescue New South Wales
Recommendation status:	Released

The Australian Transport Safety Bureau recommends that Fire and Rescue New South Wales takes further action to address the limited marine firefighting capability in Port Kembla due to the lack of specialised marine firefighting expertise, experience, updated training and resources.

Regulatory oversight

Safety issue description

Regulatory safety oversight of *Iron Chieftain*, which comprised flag State audits, surveys and inspections had not identified safety deficiencies with respect to the ship's fire safety, risk management, emergency preparedness and emergency response.

Issue number:	MO-2018-011-SI-05
Issue owner:	Australian Maritime Safety Authority
Transport function:	Marine: Other
Current issue status:	Closed - Adequately addressed
Issue status justification:	The safety action taken by the Australian Maritime Safety Authority should serve to augment the existing regulatory oversight activity of Australian flagged ships particularly with regard to the fire safety risk and risk management on board self-unloading ships, and therefore address the identified safety issue.

Proactive safety action taken by the Australian Maritime Safety Authority

Action number:	MO-2018-011-NSA-013
Action organisation:	Australian Maritime Safety Authority
Action status:	Closed

On 18 February 2021, the Australian Maritime Safety Authority (AMSA) advised the ATSB of the following safety action taken to address the identified safety issue:

- AMSA has provided its inspectors with procedural updates that cover fire risk assessment requirements of the IMSBC Code.

In addition, AMSA has the advised the ATSB that it will also:

- Provide its inspectors with training that covers the fire risk assessment requirements of the IMBSC Code at its next inspectors training workshops
- review existing internal processes for communicating convention requirement changes to the AMSA inspectors, to ensure they are effective
- carry out an inspection campaign concentrating on SUL ships operating in Australian waters, with a particular focus on fire safety and emergency preparedness

- provide guidance to all AMSA Recognised Organisations (ROs) who conduct ISM Code audits on behalf of AMSA with respect to the need to focus on emergency preparedness during future ISM Code audits, particularly those audits associated with SUL ships and the companies that operate them
- discuss with AMSA ROs who deliver statutory surveys on behalf of AMSA, the contents of this report in regard to the depth and scope of surveys particularly in regard to fire detection and alarm signals; and
- review its training regime, and update as appropriate, for the verification of drills at flag and port State inspections.

In an update provided on 5 March 2021, AMSA advised the ATSB that:

- AMSA internal instructions had been updated to provide inspectors with guidance with respect to IMBSC Code requirements and the updated instructions had been promulgated to inspectors.
- Similarly, updated instructions had been promulgated to ROs with particular emphasis on ISM Code audit focus.
- AMSA ISM Code certification guidelines had been updated to include a reference to the IMSBC code and the requirement for a fire risk assessment for self-discharging vessels which should be part of the vessel's SMS.
- AMSA is progressing an inspection campaign concentrating on SUL ships operating in Australian waters as soon as possible, with a particular focus on fire safety and emergency preparedness.
- Work was underway to develop an updated instruction with the aim of bedding down an effective process that ensures that changes to convention(s) are identified and that inspectorate activities are suitably informed and updated as necessary, and in a timely manner.

Safety action not associated with an identified safety issue

Whether or not the ATSB identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk. The ATSB has been advised of the following proactive safety action in response to this occurrence.

Additional safety action by the Port Authority of New South Wales

On 15 February 2021, in response to the ATSB draft report, the Port Authority of New South Wales advised the ATSB of the following safety action:

- Port Authority intends to update its Port Kembla Marine Oil and Chemical Spill Contingency Plan to include information related to the response to a shipboard fire consistent with the latest version of the NSW State Waters Marine Oil Chemical Spill Contingency Plan.
- Port Authority is in the process of updating its Crisis Management Plan and will ensure that the Plan integrates the details of the guidelines for responding to fires on a vessel described in NSW State Waters Marine Oil Chemical Spill Contingency Plan.
- The Memorandum of Understanding in relation to Hazardous Material Incidents on Inland and State Waters between Transport for NSW (NSW Maritime division), Fire and Rescue NSW and Port Authority of New South Wales is currently being updated and Port Authority will now seek to amend the MoU to implement the findings of the Report.
- Port Authority intends to approach Transport for NSW's marine division to consult on amendments to NSW State Waters Marine Oil Chemical Spill Contingency Plan, including Appendix 17 to reach agreement on the appropriate circumstances in which the combat agency role should be transferred from Port Authority to FRNSW when responding to a

shipboard fire. Port Authority will request that these circumstances be appropriately documented in either Appendix 17 or the appropriate subplan and internal plans and will ensure that all future exercises in relation to this issue incorporate these elements.

- Port Authority will also approach Transport for NSW to identify and correct the inconsistencies between the Regional EMPLAN and the NSW subplan to reflect the NSW State plan and subplans.

General details

Occurrence details

Date and time:	18 June 2018 – 0300 EST	
Occurrence category:	Accident	
Primary occurrence type:	Fire/explosion	
Location:	Berth 113, Port Kembla, New South Wales	
	Latitude: 34º 27.580' S	Longitude: 150º 53.750' E

Ship details

Name:	*Iron Chieftain*	
IMO number:	9047740	
Call sign:	VNVD	
Flag:	Australia	
Classification society:	Lloyd's Register	
Departure:	Ardrossan, South Australia	
Destination:	Port Kembla, New South Wales	
Ship type:	Self-discharging dry bulk carrier	
Builder:	Hyundai Heavy Industries	
Year built:	1993	
Owner(s):	Canada Steamship Lines Australia	
Manager:	Canada Steamship Lines Australia	
Gross tonnage:	34,422	
Deadweight (summer):	50,587 t	
Summer draught:	12.018 m	
Length overall:	202 m	
Moulded breadth:	32.30 m	
Moulded depth:	19.24 m	
Main engine:	Hyundai Heavy Industries 5S60MC	
Total power:	11,628 kW	
Speed:	13.5 knots	
Injuries:	Crew – 0	Passengers – 0
Damage:	CTL (Constructive total loss)	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- ALP Maritime
- Australian Maritime Safety Authority
- BlueScope Steel
- CSL Australia
- Department of Fire and Emergency Services, Western Australia
- directly involved officers and crew of *Iron Chieftain*
- Fire and Rescue New South Wales
- Fire Rescue Victoria
- information from the Bahamas Maritime Authority
- investigation reports from the Marine Accident Investigation Branch, United Kingdom
- investigation reports from the Transportation Safety Board of Canada.
- Lloyd's Register
- Minton, Treharne, and Davies
- New South Wales Police Force
- Port Authority of New South Wales
- recorded information from *Iron Chieftain*'s voyage data recorder (VDR)
- records, documents, manuals, and logbooks from *Iron Chieftain*
- Resilience NSW.

References

Australian Maritime Safety Authority, 2014, Marine Order 15 – Construction—fire protection, fire detection and fire extinction, AMSA, Canberra. Available at www.amsa.gov.au

Australian Maritime Safety Authority, 2016, Marine Order 21 – Safety and emergency arrangements, AMSA, Canberra. Available at www.amsa.gov.au

Australian Maritime Safety Authority, 2016, Marine Order 34 – Solid bulk cargoes, AMSA, Canberra. Available at www.amsa.gov.au

Australian Maritime Safety Authority, 2020, ISM Code Certification Guidelines for Regulated Australian Vessels, AMSA, Canberra. Available at www.amsa.gov.au

International Maritime Organization (IMO) 1995, International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code) as amended, IMO, London.

International Maritime Organization (IMO) 2014, The International Convention for the Safety of Life at Sea (SOLAS) 1974 as amended, IMO, London.

International Maritime Organization (IMO), 2020, The International Maritime Solid Bulk Cargoes Code (IMSBC Code) as amended, IMO, London.

Submissions

Under section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. That section allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the following directly involved parties:

- directly involved officers and crew of *Iron Chieftain*
- CSL Australia
- Fire and Rescue New South Wales
- Port Authority of New South Wales
- Resilience NSW
- Australian Maritime Safety Authority
- Lloyd's Register
- BlueScope Steel
- New South Wales Police Force
- Transport for New South Wales.

Submissions were received from:

- *Iron Chieftain*'s master
- CSL Australia
- Fire and Rescue New South Wales
- Port Authority of New South Wales
- Australian Maritime Safety Authority
- Lloyd's Register
- Transport for New South Wales.

The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.

Appendices

Appendix A – *Iron Chieftain* SUL fire safety risk assessment

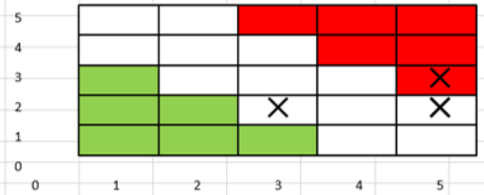
Risk assessment with existing control measures

SUL Operations Risk Assessment

Vessel/Class- **Iron Chieftain (Gravity)**

Severity		
Verbal	**Numeric**	**Description**
Catastrophic	5	Likely to result in death and or major damage
Critical	4	Likely to result in severe injury and or significant damage
Moderate	3	Potential for modertae injury and or moderate damage
Minor	2	Potential for minor injury and or minor damage
Negligible	1	No significant risk iof injury or damage

Frequency / Likelyhood		
Verbal	**Numeric**	**Description**
Frequent	5	Hazard is likely to occur
Probable	4	Hazard will be experienced
Occasional	3	Some manifestation of the hazard are likely to occur
Remote	2	Manfestations of the hazard are possible but unlikely
Improbable	1	Manfestations of the hazard are very unlikely



Generally Acceptable Risk
Generally Unacceptable risk

Risk Evaluation for Self Unloaders during Discharge Operations

Location	No of Belts	Equipment description	Identified Hazards	Existing Control Measures: Detection	Existing Control Measures: Suppression	Severity	Frequency	Risk
Tunnel	2	Open access, remote operation, 5 CCTV on the each port and Stbd tunnel conveyor	Belt slippage,Hot pulley bearings, hot idlers	Belt slippage detector DSD3, CCTV, bearing temperature measuring by Deck mechanic ,IR round in the tunnel	Fire main for port &stbd. conveyor , sprinkler system	5	2	10
Transfer/Cross	2	Open access, remote operation,impact idlers	Belt slippage,Hot pulley bearings, hot idlers	Belt slippage detector DSD3, bearing temperature measuring by Deck mechanic ,IR round in the tunnel every 4 hrs	Fire main for port &stbd. conveyor , sprinkler system	5	2	10
Elevator	2	Located aft hold No.5, Loop system with centre impacts, remote operation	Belt slippage,Hot pulley bearings, hot idlers	Belt slippage detector DSD3, bearing temperature measuring by Deck mechanic . IR rounds in the tunnel every 4 hrs	Fire main for port &stbd. conveyor , sprinkler system	5	3	15
Boom	1	Open Boom conveyor with impact idlers in the way of loading chute, remote operation	Belt slippage,Hot pulley bearings, hot idlers	Belt slippage detector DSD3, bearing temperature measuring by Deck mechanic , manned deck	Fire main on the main deck ,sprinkler system for hopper	3	2	6

Source: CSL Australia

Risk assessment with planned future control measures

Form Version- 3

Thought Process on updating Severity and Frequency after Planned future Control measures-
Unless Changing SUL Hardware upgrades to Detection & Fire Suppression will only reduce the Severity of fire

Planned Future control measures					
Upgrade description			Updated Risk Assessment		
SUL Equipment	**Detection**	Suppression	**Severity**	**Frequency**	**Risk**
Tunnel	Pulley/idler bearings Heat Detection , use NDT eq-nt,greasing, protect belt during hot works, cleanliness	Low pressure sprinkler system, procedure in the event of fire in the tunnel	2	2	4
Transfer	Pulley/idler bearings Heat Detection , use NDT eq-nt,greasing, protect belt during hot works, cleanliness	Low pressure sprinkler system, procedure in the event of fire in the tunnel	2	2	4
Loop	Pulley/idler bearings Heat Detection , use NDT eq-nt,greasing, protect belt during hot works, cleanliness	Low pressure sprinkler system, procedure in the event of fire in the tunnel	1	3	3
Boom	Pulley/idler bearings Heat Detection , use NDT eq-nt,greasing, protect belt during hot works , cleanliness	Sprinkler system for hopper,Fire main,procedure in event of fire	1	1	1

Source: CSL Australia

Australian Transport Safety Bureau

About the ATSB

The ATSB is an independent Commonwealth Government statutory agency. It is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers.

The ATSB's purpose is to improve the safety of, and public confidence in, aviation, rail and marine transport through:

- independent investigation of transport accidents and other safety occurrences
- safety data recording, analysis and research
- fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia, as well as participating in overseas investigations involving Australian-registered aircraft and ships. It prioritises investigations that have the potential to deliver the greatest public benefit through improvements to transport safety.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, international agreements.

Purpose of safety investigations

The objective of a safety investigation is to enhance transport safety. This is done through:

- identifying safety issues and facilitating safety action to address those issues
- providing information about occurrences and their associated safety factors to facilitate learning within the transport industry.

It is not a function of the ATSB to apportion blame or provide a means for determining liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner. The ATSB does not investigate for the purpose of taking administrative, regulatory or criminal action.

Terminology

An explanation of terminology used in ATSB investigation reports is available on the ATSB website. This includes terms such as occurrence, contributing factor, other factor that increased risk, and safety issue.