## CONSOLIDATED VERSION – FIRE - EXPLOSION

### FIRE (III 5)

**Very serious casualty: Fire on the main vehicle deck resulting in 11 fatalities and 22 others missing, presumed dead**

**What happened?**

A ro-ro passenger vessel was at sea with 417 passengers and 55 crew on board when a fire broke out on the main vehicle deck. The fire most probably started in a truck conveying a refrigerated container. The truck's engine had been left running in order to supply power to the refrigerated container.

The fire quickly intensified. The crew were unable to make a direct attack on the fire due to the intense heat; dense smoke, and the fact the vehicles had been stowed with little space between them. The crew activated the vehicle deck drencher system, but the incorrect valves were selected and water was directed to the deck below where the fire was located.

The ship lost power to the main and auxiliary engines, resulting in a blackout.

The master ordered the passengers and crew to abandon the ship. Not all of the lifesaving equipment was able to be utilized. Most of the survivors were rescued by helicopters. The bodies of 11 people were recovered. A further 22 persons are missing, presumed dead. The ship was substantially damaged.

**Why did it happen?**

- The exact cause of the fire is not known. However, the truck in which the fire probably started had its engine left running because the refrigerated container it was conveying was unable to be plugged into the ship's power supply.

- The system for pre-planning the cargo stowage did not identify the need for the refrigerated container to be powered during the voyage, meaning the truck's engine had to be left running, in contravention of procedures. The running engine and connections to the refrigerated container provided a potential source of fire.

- The shipped blacked out because the fuel shut-off valves were activated and thick smoke invading the engine-room probably starved the engines of oxygen as well.

- The vehicle drencher system was ineffective because the wrong valves were selected, directing the water supply to the wrong deck, and once the ship blacked out the emergency fire pump was unable to deliver sufficient water to the drencher system for it to be effective.

- The crew's response to the fire was not well coordinated.

- The abandon ship procedure was not well coordinated.

**What can we learn**

- Good cargo planning on board ro-ro vessels is essential for ensuring vehicles are located in accordance with operational and regulatory requirements.

- Sufficient space should be left between vehicles on ro-ro vehicle decks so as to allow sufficient access for operational requirement and emergency response.

- Road vehicles located on semi-enclosed ro-ro cargo decks should not be left with their engine running because they pose a significant fire risk.

- Ship crews must be well-practised in the firefighting response procedures for their vessels, and those procedures should be closely followed as far as the circumstances allow.

- Ships crews must be well-practised in the abandon ship procedures for their vessels and those procedures should be closely followed as far as the circumstances allow.

**Who may benefit?**

Seafarers, shipowners and operators, ship designers.

**FIRE (III 4)**

**Very serious marine casualty: Engine-room fire**

**What happened?**

A fire broke out in the engine-room of a passenger/ro-ro ship. As a result, the chief engineer and an engineer apprentice died and two other crew members suffered serious injuries. The seat of the fire was concluded to be in the vicinity of the starboard main engine No.5 fuel injector pump.
When the fire broke out, the first engineer, the engineer apprentice and a repairman were in the engine-room workshop, located outboard of the starboard main engine at cylinder head level. They saw thick black smoke and flames at the forward part of the starboard main engine. They left the workshop via the foremost of two doors but had to pass close by the fire to make their escape through the engine-room. The first engineer and the repairman left the engine-room via a watertight door on the port side of the forward bulkhead. They do not remember seeing the engineer apprentice as they evacuated the engine-room. They made their way through the corridor and up the stairwell to the reception area on deck 3. It was concluded that the engineer apprentice probably followed the same escape route, but instead of stopping on deck 3, he continued to deck 4, where his body was found just inside the door to the stairwell. All three sustained major burn injuries.

The chief engineer and a motorman were in the separator room, located outboard of the port main engine at cylinder head level. The chief engineer had just left the adjoining incinerator room and had been talking to the motorman for about a minute when he realized that the incinerator room had filled with dense black smoke. He returned to the incinerator room to investigate. The motorman initially looked into the engine-room from the aft door of the separator room and then went back to look for the chief engineer. Since he could not find him, he made his escape via the after door of the separator room, down to the engine-room floor plates, and into the auxiliary room through the watertight door located port aft of the engine-room. From there he was able to reach the control room where he called the bridge. The chief engineer's body was subsequently found in the separator room.

The vessel lost all main and auxiliary engine power. The emergency generator started but overheated and failed shortly afterwards. Consequently, the ship's fire pumps and other electrical equipment became inoperative. Fortunately, the ship was close to shore and was taken under tow to a berth where firefighters attended. Meanwhile, all 207 passengers and 55 crew had been evacuated by the two port side lifeboats.

**Why did it happen?**

1 After the fire, two different leakages were found in the fuel system, one from fuel injector pump No.5 fuel return pipe – which was completely fractured just below the pump flange – and one from the shared fuel return line drainage ball valve at the forward end of the starboard engine at floor plate level. The body of this valve was found detached from the pipe and lying on the floor plates. The indicator cock adjacent to No.5 fuel pump was not insulated, and it was concluded that the hot surface had ignited the escaping fuel.

2 All four fastening bolts for the fuel injector pump were found to be loose, allowing the pump housing to move. Subsequent examination of the fracture surfaces showed that the fuel return pipe most probably broke as a result of fatigue fracturing, caused by the cyclical vertical loads caused by the movement of the pump body. The pump body was moving because the holding down bolts had not been correctly secured after the pump had been replaced twelve days previously. The fire spread to vital control equipment. Spray shields/covers were originally fitted by the engine manufacturer in front of each range of fuel pumps. These were not in place at the time of the fire. Had they been in place, they might have prevented fuel and flames impinging on the control equipment.

3 A fixed local application firefighting system was fitted but it was set to manual instead of automatic operation and was not activated manually until sometime after the fire had started. When it was eventually activated, the absence of the spray shields/covers might have rendered the local application fire system less effective since the water nozzles were arranged on the basis that the spray shields were kept in place. Had the water spray system activated automatically, it might have provided a degree of protection to the personnel evacuating the workshop.

4 The fixed carbon dioxide fire extinguishing system was not activated because the Master was uncertain whether the engine-room had been fully evacuated.

5 The quick closing fuel supply valves were not operated. (The fire procedure contained no instructions for shutting off the fuel supply. This instruction was contained in the procedure for activating the carbon dioxide fire extinguishing system).

6 The engine-room air inlets were not closed.

**What can we learn?**

1 A fuel fire in the main engine-room can develop extremely rapidly; in this case the engine-room filled with dense black smoke and both main engines failed within about four minutes of the fire alarm sounding. This highlights the importance of fire prevention – maintaining insulation etc., and keeping on top of leaks. It also demonstrates the importance of thorough emergency planning and regular, meaningful firefighting and evacuation drills.

2 Correctly secure components subject to vibration and/or pulsating loads. When carrying out maintenance, it is essential that all manufacturer's instructions are available to, and understood by, maintenance personnel. In this case, the manufacturer required the

holding down bolts to be secured to a specified torque; this information had not been included in the ship's job description for overhauling injector pumps, and a torque wrench had not been used to secure the bolts. Even had a torque wrench been used, it is beneficial to first ensure that threads run freely, that the component is properly seated and the specified torque is correctly applied; it is also worth considering the application of positive locking devices such as tab washers in addition to applying the specified torque in accordance with manufacturer's recommendations.

3 Ensure spray shields and covers are in place and secure after maintenance.

4 Ensure all hot surfaces are insulated and/or shielded in accordance with IMO MSC.1/Circ.1321 *Guidelines for measures to prevent fires in engine-rooms and cargo pump-rooms*.

5 Carry out periodic checks while machinery is running under full load to identify any hot spots, and insulate or shield them from possible fuel sprays. Infra-red heat detectors are useful to establish surface temperatures.

6 Consider establishing a record of all surfaces required to be insulated and the degree of insulation required.

7 Deal with any fuel leaks immediately.

8 Where automatic fixed local application firefighting systems are installed, ensure that the operating system is normally set to automatic. (Consider introducing an advisory system to clearly show when the system has been temporarily switched to manual to carry out maintenance e.g. a large warning notice in the control room and/or on the system control panel).

9 It is important to provide training to deal with situations in which key personnel are put out of action. A lack of training and a lack of awareness about the responsibilities of stand-ins were among the factors that led to inadequate handling of the situation as it developed, especially since the chief engineer and first engineer could not fulfil their assigned emergency duties.

10 Where prepared job specifications are an established part of the company's safety management system, essential manufacturer's information necessary for completing the task safely (e.g. torque values for tightening securing bolts) should be included. While underpinning knowledge might have led one or more of the ship's engineers to query the absence of this information, the casualty demonstrates that, where a strategy of relying on documented work instructions is being used, it is essential that all necessary steps and data are included.

11 Administrations and classification societies should consider introducing thermal imaging in their annual inspections to identify any non-compliant insulation.

**Who may benefit?**

Seafarers, shipowners, classification societies, Administrations.

**EXPLOSION AND FIRE (III 4)**

**Very serious marine casualty: Explosion in the cargo compressor room while carrying out hot work on deck**

**What happened?**

An LPG carrier was carrying a cargo of butane and propane. Two crew members were attempting to crop out and renew step ladders leading to the loading manifold. The activity was part of work addressing several deficiencies identified during a Port State Control (PSC) inspection. The gas feeding the cutting tool was butane, tapped off the gas compressor inlet pipe. It is reported that the cutting torch was also connected to the vessel's compressed air deck line.

When the crew members lit up the cutting nozzle, there was a flashback along the hose connecting the torch to the cargo compressor inlet pipe resulting in an explosion and fire in the compressor room. The two crew members carrying out the cutting operation were killed, and two other crew members, who were also carrying out maintenance work on deck, were seriously injured. The compressor room, the re-liquefaction plant and other equipment were heavily damaged.

**Why did it happen?**

1 The ship's managers had not made arrangements for the work to be done while the ship was at a repair facility; instead, they allowed it to be carried out during a laden voyage. The facilities and equipment on board were not suitable for the work. No permit to work was issued; risks were not properly assessed and no specific safety precautions were planned. No officer had been assigned to supervise the work.

2 The source of ignition was not established but it is believed to have caused a flashback from the cutting torch along the hose connecting it to a cargo compressor.

3 Since most of the evidence was not available to the investigator, it is not known whether the cutting torch was a) suitable for the gases used or b) fitted with pressure regulators or flashback arresters.

4 The safety culture did not encourage lower ranks to question instructions; the crew simply did as they were told.

**What can we learn?**

1 A strong safety culture has to be cultivated; it will not develop of its own volition. The work starts from top management. Management ashore needs to lead by example. When PSC inspection deficiencies are identified, a careful analysis – including formal risk assessment – needs to be made as to whether the crew have the necessary abilities and equipment to carry out the work during the voyage or whether the work needs to be undertaken in a competent repair facility. This is particularly important in the case of ships carrying flammable cargoes. Ship's crew need to be given the confidence to approach line management for advice or assistance if an onboard risk assessment determines that they do not have the resources or competence to undertake repair work themselves. Shore management cannot assist if they are not aware of a problem.

2 A properly developed and implemented approach to risk assessment can provide a company with a very valuable tool to help it manage safety.

3 The ship's Safety Management System (SMS) and standing instructions should include clear and adequate guidance for "No Hot Work" in areas liable to be exposed to flammable gases, and should include adequate guidance on the control of flammable vapors in and around the cargo tanks or cargo compressor room.

4 Whenever possible, hot work within the cargo area of a vessel carrying flammable

cargoes should be carried out in a repair yard after all gas-freeing processes have been carried out and the area declared safe.

5 If it is imperative that hot work has to be undertaken during the voyage, it should only be undertaken after a detailed risk assessment has identified ALL significant risks arising out of the work activity – including an evaluation of the suitability of the tools to be used – and suitable mitigation measures have been put in place. This should include procedures for any repairs or maintenance pertaining to any kind of hot work, particularly in areas exposed to hydrocarbons which would cause a serious accident, threatening life and property. The assessment should also take into account any existing precautions to control the risk, such as permits to work, agreed procedures as per SMS, use of personal protective equipment, use of safe tools, and a "Stop Work Policy."

6 Under no circumstances should attempts be made by the crew to tap-off cargo gas to progress repair work. Any modification to cargo lines should be approved by the Administration and the vessel's classification society.

7 While the practice leading to this unfortunate casualty cannot under any circumstances be condoned, flame-cutting using conventional set-ups such as oxy-acetylene, while commonplace, should always be carried out by competent operators and subject to a "permit-to -work." The danger of a flashback is nevertheless always present. The UK's Health and Safety Executive advises in its publication INDG297(rev1).

"Flashbacks are commonly caused by a reverse flow of oxygen into the fuel gas hose (or fuel into the oxygen hose), producing an explosive mixture within the hose. The flame can then burn back through the torch, into the hose and may even reach the regulator and the cylinder. Flashbacks can result in damage or destruction of equipment, and could even cause the cylinder to explode.

- Use the correct lighting-up procedure. Purge the hoses before lighting the torch to remove any potentially explosive gas mixtures. Use a spark igniter and light the gas quickly after turning it on.
- Make sure the blowpipe is fitted with spring-loaded non-return valves.
- Use the correct gas pressures and nozzle size for the job.
- Maintain the equipment in good condition.

These measures will reduce the risk of a flashback but will not completely eliminate it. Non-return valves will not stop a flashback once it has occurred."

**Who may benefit?**

Seafarers, shipowners, ship operators.

**EXPLOSION (III 2)**

Very Serious Marine Casualty: Explosion of observation glass resulting in a fatality

**What happened?**

A bulk carrier was three months into its maiden voyage. An engineer on board was draining accumulated fluid from the main engine starting air receiver as part of a normal daily routine. The fluid drained into a drainage pot which was fitted with a toughened glass observation panel. The glass shattered and severely injured the engineer, who later died from the injuries sustained.

**Why did it happen?**

The observation glass and drainage pot were not fit for the purpose for which they were being used. The drainage pot was originally designed as an open-topped container with a drainage line leading to an appropriate bilge. During the construction of the ship, at the request of the owner's representative, the drainage observation pot was modified by the shipbuilder to incorporate a toughened glass observation panel, the objective being to allow observation of the drainage without any splash-back. The modification could not withstand any significant build-up of pressure within the pot. The modifications were not submitted for classification society or flag Administration approval.

**What can we learn?**

- Compressed air can store a lot of energy, especially at the storage pressure found in main engine starting air receivers (30 bars in this case). It needs to be treated with the utmost respect. Significant back pressure can occur in small bore, lengthy condensate drainage lines, especially if, in the case of effluent from a starting air receiver, the drained fluid contains any emulsified lubricating oil.
- When making any design changes, an appropriate engineering analysis needs to be undertaken, especially for any modifications that effectively change an open drainage system into a pressurised closed one. Design validation and appropriate testing need to be undertaken. The classification society and flag Administration should be consulted and, if so directed, drawings submitted for approval.
- During the final stages of a ship's construction, vigilance is needed by all parties concerned to ensure that any deviation from approved arrangements are carefully and appropriately addressed and agreed. Agreed changes should be recorded.

**Who may benefit?**

Ship builders, owners, operators, classification society surveyors, and crews.

**EXPLOSION (III 2)**

Very Serious Marine Casualty: Explosion in a fuel oil tank resulting in a fatality

**What happened?**

A bulk carrier was in port and had taken on bunkers. It was decided to completely drain a fuel oil settling tank because it contained fuel of poor quality. There was about 2.5 tons of heavy fuel oil in the tank. The flash point was said to be 82ºC. The tank exploded. Five crew members were injured; one subsequently died. There was significant damage to the engine room and machinery.

**Why did it happen?**

- The settling tank had been modified without approval of the flag Administration and class society. The original steam heating coils had been taken out of service and replaced with an internal electric heater, located 1.5 metres above the bottom of the tank. A second electric heater was fitted at a later date; this was located 0.7 metre above the tank bottom. These installations were not submitted to the classification society or flag Administration for approval. Both were equipped with automatic temperature control sensors which were located one metre above the tank bottom and set to maintain an oil temperature between 45-55ºC. However, these needed to be submerged in the fluid to function. No other protective devices were fitted to the heaters to shut off the current in the event that the heater coils were not submerged in oil.

- There was no low-level content alarm fitted to the tank, and the fuel level in the tank dropped below the level of one or both of the electric heaters without the engineers' knowledge. At the time of the explosion there was almost no fuel in the tank but the fuel heaters were still turned on. In such circumstances the temperature of the heater rod surface could rise above the flash point of the fuel/air mixture and even to the point where the heating rod could rupture and cause an arc. The tank contained fuel oil vapour and air drawn down the vent pipe as the fuel was discharged. It was concluded that this mixture was ignited by one of the fuel heater rods.
- There were no instructions on board for the electric fuel heating system and no information had been passed on to successive engineers.

**What can we learn?**

- A full risk assessment should be made prior to undertaking any modifications to fuel systems. Drawings should be submitted to the classification society for approval. When modifications are made, after any necessary approval, records should be kept on board and any modifications to operating instructions should be incorporated into the ship's safety management system (SMS).
- Consideration should be given within the SMS on how new crew members can be informed of any novel or unusual equipment installed in the ship, especially when it involves high-risk installations such as fuel systems.
- Whenever intending to carry out tasks involving a deviation from established work procedures it is particularly important to do a full risk assessment prior to starting the task; all crew members carrying out the task should be fully briefed.

**Who may benefit?**

Shipowners, operators, crews, and surveyors.

**FIRE (III 2)**

Very Serious Marine Casualty: Fire during hot work resulting in a fatality

**What happened?**

A general cargo ship was loaded with large machinery and metallic construction material. The cargo in the lower hold had been secured with wooden blocking and bracing using ropes, wires and turnbuckles. Securings on hatches and tween deck also included welded items.

At the discharge port, workers from ashore were contracted to cut off the lashings and securings. They were instructed by the ship's officer for the job, but a hot work procedure was not conducted in accordance with the ship's safety management system, and a hot work permit was not issued.

Some hours later, as the work went on, smoke was discovered coming from the hold. Though firefighting efforts were initiated quickly, the fire lasted for many hours and caused much damage. Three shore workers were injured, and another was later found deceased in the hold.

**Why did it happen?**

- The lack of a hot work permit procedure meant that no one had done a proper risk assessment for the work.
- The presence of shore workers may have confused the ship's officers, not realising that it was their responsibility to supervise shore workers as well as crew members.
- There was flammable material in the lower hold.

**What can we learn?**

- Ship's officers are responsible not only for supervising crew members, but also for shore workers conducting work on board the ship. Flammable material should be kept in appropriate compartments. The location and proximity of compartments containing flammable matter to hot work areas should be taken into account when hot work permits are issued.
- Fulfilment of hot work permit procedures should include a safety assessment, making it easier to handle the risks identified.
- A ship's safety management system is not just a paperwork exercise; it is done to ensure the safety of the ship and crew.

**Who may benefit?**

Shipowners, operators, crews and shore workers.

**EXPLOSION (III 2)**

Very Serious Marine Casualty: Explosion in cargo area resulting in fatalities

**What happened?**

A 38,000 dwt product oil/chemical tanker was loading methanol. On completing first foot loading in all scheduled tanks, full loading commenced into 1P, 2P & S, and 6P & S tanks. When the quantity loaded into 6P & S tanks had reached 800 tons in each tank, loading was switched from 6P & S to 5P & S tanks, in line with the loading plan. At 0230 and about 30 minutes after this loading switch took place, an AB on deck reported a fire at the1P tank P/V valve. The ship contacted the terminal and the loading was stopped. The delivery valves closed on 1P and 2P & S tanks within seven minutes of the fire being reported. Shortly afterwards, there was an explosion in tanks 1P and 2P & S followed by explosions in tanks 5P & S and 6P & S. Five crew members lost their lives and the ship became a constructive total loss (CTL).

**Why did it happen?**

- CCTV footage showed that a lightning strike caused a fire at the 1P and 2 P & S tank P/V valves. The International Safety Guide for Oil Tankers and Terminals (ISGOTT) 5$^{th}$ Edition Para 26.1.3 – Electrical Storms advises "When an electrical storm is anticipated in the vicinity of a tanker or terminal the following operations must be stopped, whether or not the ship's cargo tanks are inerted: handling of volatile petroleum, handling of non-volatile petroleum in tanks not free of hydrocarbon vapour." Similar – but not identical – advice can be found in the ICS Tanker Safety Guide (Chemicals). Although the ship's SMS reminded officers to monitor the weather conditions and stop the operation in the event of an electrical storm, this storm took the ship's crew by surprise. The P/V valves and associated flame arresters did not prevent the passage of flame into the tank (Note MSC.1/Circ.677 Revised Standards for the Design, Testing and Location of Devices to Prevent the Passage of Flame into Cargo Tanks in Tankers paragraph 1.2.7 states "These Standards do not include consideration of sources of ignition such as lightning discharges…All cargo handling, tank cleaning and ballasting operations should be suspended on the approach of an electrical storm.").

- The cargo tanks were neither inerted nor purged with nitrogen prior to loading as neither the ship nor the loading berth had nitrogen-inerting capabilities.
- Closed-loop loading of methanol was not adopted at the terminal. Loading in this manner would have resulted in methanol vapours being returned to the terminal, rather than being vented through the P/V valves.
- While there can be no certainty that either inerting prior to loading or closed-loop loading with vapour return to the terminal would have prevented fire in the event of a sudden electrical storm hitting the ship, they may well have limited the consequences.

**What can we learn?**

- Weather should be monitored per the ISGOTT and ICS Guide for electrical storm activity when loading/discharging cargoes involving flammable vapours, especially in tropical areas prone to severe electrical storms.
- Both the terminal and the ship should have procedures in place requiring the immediate stoppage of cargo operations in the event of an electrical storm and describing the procedures to be followed; these need to take into account the terminal/ship interface and the respective responsibilities of the terminal and ship's personnel.
- Ship/Shore Safety Checklists set out in the ISGOTT and ICS guide should be carefully followed before and during cargo operations.

**Who may benefit?**

Ship and terminal operators.

**EXPLOSION AND FIRE (III 1)**

Very Serious Marine Casualty: Chemical tanker explosion and fire with loss of life

**What happened?**

A 16,000 gross tonnes chemical tanker was en route to a port to load cargo and the crew were preparing the tanks for loading. The washing of one of the tanks, which had previously carried benzene, had just been completed and the next steps were to strip the tank, ventilate it for a few hours, and then carry out tests to determine the cleanliness of the tank. However, a crew member made known his intention to use steam prior to ventilating the tank. The crew member inserted a steam hose and began to steam the tank. He then indicated that he was going to increase the steam pressure and to start the cargo pump to remove any water collecting in the tank. A few minutes later, there was an explosion and a fire. Unable to contain the fire, the crew abandoned the ship. They were later rescued by another ship. One crew member went missing and was presumed deceased.

**Why did it happen?**

The explosion was the result of the ignition of the tank atmosphere, which contained benzene gas that was within the flammable limit.

The source of the ignition was most likely an electrostatic discharge from the end of the steam hose coming into contact with the tank side or other structure. The steaming of the tank, which was performed immediately after washing and before ventilation, also likely gave rise to an electrostatically charged mist.

**What can we learn?**

- Prior to tank cleaning, a pre-cleaning meeting should be held to ensure that crew members understand their duties and the proper procedures to be followed. Any deviation from the procedures must be reported immediately.
- After carrying a flammable cargo, always assume that the atmosphere within a tank is flammable.
- The extreme danger of using steam injection to clean flammable cargo tanks due to the risk of static electricity.
- At all times, take precautions to eliminate sources of ignition.

**Who may benefit?**

Shipowners, operators and crews.

**EXPLOSION AND FIRE (III 1)**

Less Serious Marine Casualty: Charging of Oxygen Breathing Apparatus by air compressor

**What happened?**

A bulk carrier was equipped with self-contained breathing apparatus (BA), spare air cylinders and a portable air compressor for refilling the air cylinders. Despite not being a mandatory requirement, the vessel was provided with oxygen breathing apparatus (OBA) on board. During the voyage at sea, an officer found the pressure of one OBA cylinder low and he used the air compressor to re-charge it. First, he tried to connect the discharge hose connector of the air compressor directly to the OBA cylinder, but it did not fit. Then, he found an adaptor in a box next to the air compressor that could be used so he fitted it to the discharge hose connector of the air compressor and the OBA cylinder. He opened the valve of the OBA cylinder and, as he reached over the compressor to switch it on, the compressor discharge hose exploded. He was engulfed in a ball of flame and sustained serious skin burns. The fire was started on and around the air compressor. It was extinguished with the use of a portable fire extinguisher by another crew member. The injured officer was later winched off the vessel by helicopter and sent to hospital for treatment.

**Why did it happen?**

The immediate cause of the explosion was probably the temperature of the oxygen-rich environment within the discharge hose of the air compressor which had dramatically increased by adiabatic compression. The heat of the oxygen rose beyond the auto-ignition temperature of the oil in the system and resulted in the explosion. The safety management system did not provide appropriate guidance on the operation and maintenance of OBA sets and the officer was not appropriately trained or drilled on the use of the equipment.

**What can we learn?**

- It is important to properly implement the requirements of the ISM Code.
- Any safety and firefighting equipment placed on board in addition to the minimum mandatory requirements should be included in the management company's procedures regarding its safe operation, maintenance and training.
- Crew should be reminded that OBA cylinders, if provided on board, must not be charged using an air compressor.

**Who may benefit?**

Shipowners, operators and crews, and equipment manufacturers.

**EXPLOSION AND FIRE (III 1)**

Serious Marine Casualty: Ignition of gas from cargo

**What happened?**

A general cargo ship, loaded with a cargo of Direct Reduced Iron Fines (DRI (C)), arrived and berthed at its discharge port. An explosion occurred when a crew member used a remote controller to jack up and open a hatch cover. Five crew members in the vicinity were injured by fire. The fire spread into the cargo holds. The vessel was attended by shore firemen and the fire was finally extinguished after injecting $CO_2$ into the cargo hold.

**Why did it happen?**

DRI reacts with moisture to release hydrogen gas. The explosion was caused by ignition of hydrogen gas by an electric spark generated from a defective electric cable of the remote controller. Hydrogen gas had accumulated inside the deckhouse during the voyage.

Based on the master's voyage orders, the ship was to load Iron Ore Powder. The master of the vessel did not pay attention to the cargo loaded on board.

After loading the master was provided the cargo manifest, which indicated that the ship had been loaded with DRI (C). He had limited knowledge of the cargo and did not consult the IMSBC Code[**] and carried the cargo as a non-regulated dry bulk cargo.

**What can we learn?**

- Prior to loading DRI (C), shippers must provide masters with a certificate issued by a competent person recognized by the National Administration of the port of loading stating that the cargo meets the requirements of the IMSBC Code and is suitable for shipment.
- Masters who determine that DRI (C) was loaded without receiving a certificate issued by a competent person or that the requirements of the ISMBC Code have not been met should immediately contact their Designated Person Ashore.

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[**] The individual schedule for DRI (C) in the IMSBC Code contains detailed provisions for the transportation of this cargo, including provisions regarding the maximum moisture limit, inerting and quantitative measurements of hydrogen and oxygen.

- Ship's officers should be fully aware of cargo hazards.

**Who may benefit?**

Shipowners, operators and crews, and shippers of dangerous cargoes.

**EXPLOSION AND FIRE (III 1)**

Very Serious Marine Casualty: Explosion of gas in forecastle

**What happened?**

A tanker was undertaking a scheduled passage loaded with Naptha. An explosion was heard and smoke was seen on the forecastle. Immediately after the explosion, the crew was mustered and accounted for with the bosun reported missing. After checking vessel's stability, the master decided to flood the forecastle area with water to avoid the spread of smoke and fire. The fire was subsequently extinguished but the bosun was not found.

**Why did it happen?**

A number of tanks were losing pressure at a considerable rate so it was decided to top up the pressure with the nitrogen system. Cargo vapour, which was the only possible source to cause the explosion, had leaked through the de-humidifier system located in the forecastle. The de-humidifier system had not been shut down properly before the cargo had been loaded. The work had not been properly supervised by an officer.

**What can we learn?**

- Consider the need to include forecastle areas containing de-humidifier units within the fixed gas detection system.
- Crew members should report to master or OOW when they notice any smell of gas from the cargo.
- The ship's Planned Maintenance System should be reviewed to ensure it adequately covers the de-humidifier system.

**Who may benefit?**

Shipowners, operators and crews.

**FIRE (FSI 21)**

**Very serious casualty: Ro-ro passenger ship fire**

**What happened?**

A 20,000 gross tonnage ro-ro passenger ferry, with 203 passengers, 32 crew members and a full load of cargo units on board, was on a voyage which normally takes about 20 hours. About two hours after departure and just a few minutes before midnight fire broke out in one of the cargo units in the garage deck. The manually-operated drencher system was activated from the bridge but did not deliver any water. An attempt was then made to start the drencher system from the engine control room but this was also unsuccessful. The fire spread rapidly. Fire-fighting was difficult due to the thick smoke and eleven minutes after the first alarm the Master ordered the evacuation of the ship. While all passengers and crew were safely evacuated 23 people were injured, mostly from smoke inhalation.

**Why did it happen?**

The crew were unable to start the vehicle deck drencher system. The inability to start the drencher system pump remotely from either the bridge or the engine control room was most likely because a selector switch, which was located adjacent to the drencher pump and controlled the discharge valve on the drencher pump, was left in the "manual" position.

According to the voyage data recorder a self-closing fire door protecting a stair well from the vehicle deck remained open during the fire, allowing smoke and flames to reach accommodation and public spaces. The fire door was fitted with a self-closing mechanism, but it was not possible to determine whether this mechanism was functioning correctly at the time of the fire.

When the accommodation sprinkler system activated, a pipe connection parted, resulting in an uncontrolled flow of water into the engine room. The engineer-on-watch, concerned about the possibility of water damage to machinery and/or flooding of machinery compartments moved rapidly to the sprinkler room, located some distance from the main machinery room, to stop the sprinkler pump. In so doing he was unable to address other pressing issues such as the failure of the vehicle deck drencher system to operate. For reasons unknown no attempt was made to open the cross-over valve which would have enabled the ship's fire pumps to supply the drencher system. This valve was located in the sprinkler room.

**What can we learn?**

Possibly because of his pre-occupation with dealing rapidly with both the drencher and sprinkler system problems, the engineer-on-watch did not inform the command centre about the leakage from the sprinkler system so an opportunity was lost for him to gain assistance to deal with both issues efficiently. This emphasises the need to maintain good communication at all times.

The specific operation of drencher systems varies between installations. It is essential that crew members responsible for the deployment of the systems are made familiar with all methods of their operation, including necessary valve settings and sequence of actions. This can be assisted by:

- the provision of clear and simple schematic diagrams located at all operating positions, being mindful that operators may not all share a common native language;

- the clear marking of valves and switches – perhaps assisted by standard colour schemes;

- induction training for new crew members; and

- regular and realistic drills.

The limitations of drencher systems need to be recognised. The importance of early deployment if there is to be any chance of containing a fire needs to be stressed.

With regard to the failed coupling in the sprinkler system and the open fire door, while the reasons for these failures are not known, they emphasise the need to report any equipment malfunctions immediately, in order to allow for maintenance and repair work to be carried out.

When fire spreads rapidly through public and accommodation spaces good communication between the crew and the passengers is essential. This can be assisted by:

- crew members wearing high visibility safety vests to make them readily recognizable as a point of contact to passengers; and

- broadcasting emergency announcements in multiple languages to ensure that as many passengers as possible understand the information.

**Who may benefit?**

Seafarers, passenger ship, ro-ro ferry operators and managers, and Administrations.

**FIRE (FSI 21)**

**Very serious casualty: Explosion in machinery space**

**What happened?**

A 2,500 gross tonnage ship was propelled by a 1470kw diesel engine. A few hours after the ship set sail, an air leak from a faulty air regulator was discovered in the main engine air supply. The ship was stopped to allow the faulty regulator to be changed for a spare.

While the repair was taking place the two running diesel generators stopped. Attempts to restart them led to all the starting air being used up. An attempt was made to start one of the generators using oxygen from a welding set bottle connected to one of the engine cylinders. There was an explosion and the Chief Engineer and an Oiler received serious injuries.

**Why did it happen?**

The reason the engines stopped running was not diagnosed and rectified before trying to re-start them. In consequence, starting air was wasted.

The energy released by the ignition of the injected fuel in an oxygen-rich atmosphere was much greater than the engine was designed for.

Personnel present during the preparation to use oxygen to start the engine were aware of the dangers but did not challenge the decision to use oxygen.

**What can we learn?**

Never attempt to use pressurized oxygen to start a combustion engine.

Diagnose the root cause of a machinery failure before attempting to restart the unit.

Cultivate a culture within the Company–ashore and afloat–which encourages justifiable challenges to unsafe decisions of superior ranks.

**Who may benefit?**

Seafarers.

**FIRE (FSI 20)**

**Serious casualty: engine-room fire**

**What happened?**

A 45,000 gt containership's No.4 diesel generator (DG4) suffered a catastrophic failure, disabling the generator and starting a fire. The engine-room was evacuated and the ship's fixed carbon dioxide ($CO_2$) fire extinguishing system was operated. The decision to use the $CO_2$ system was prudent, and together with the prompt use of the ship's fire dampers, remote valves and emergency stops reduced the severity of the damage to the generator room.

**Why did it happen?**

It is possible that one or more of the connecting rod palm nuts or counterweight nuts had not been sufficiently tightened (or overtightened) during recent overhauls and that the resultant failure of one of the retaining studs was the initiator of the catastrophic engine failure.

**What can we learn?**

- It is important to make reference to the engine manufacturer's recommendations when tightening the nuts for the connecting rods or counterweights, and in using the appropriate and calibrated tools, e.g. torque wrench and/or hydraulic tightening devices.

**FIRE (FSI 20)**

**Serious casualty: fire in the auxiliary engine-room**

**What happened?**

On a 32,000 gt ro-ro passenger ferry a fire broke out in the auxiliary engine-room (AER). The seat of the fire was in way of the auxiliary engines' fuel supply module and quickly spread across the compartment. The fire was eventually extinguished by the ship's crew. There were no passengers on board and none of the ship's crew was injured. However, the fire caused the vessel to lose electrical power, which ultimately required her to be towed back into port for repairs.

**Why did it happen?**

Fuel oil escaped under pressure from the auxiliary engine fuel module pressure regulating valve actuator and came into contact with an exposed high-temperature surface on the adjacent auxiliary engine. The auxiliary engine fuel oil module excess pressure regulating valve actuator diaphragm perished and ruptured because it had been manufactured from a non-oil resistant rubber. The fire could not be contained within the AER because heat from the fire was conducted through an un-insulated section of the fire boundary to electric cables on the deck above. Several spaces above the AER were incorrectly classified at build and were not protected by thermal insulation in accordance with SOLAS requirements.

The performance of the local water-mist system was adversely affected by a delay in activating the system, the inadequate production of water-mist, interruptions to the supply of water-mist, a reduced duration of operation and/or the insufficient water-mist coverage above the seat of the fire. The machinery space high-expansion foam fixed fire-extinguishing system was fully discharged into the AER, but failed to produce any foam because its discharge nozzles were clogged with rust from the internal corrosion of the dry pipe distribution network. The high-expansion foam system distribution pipe network was fabricated from mild steel and was not self-draining, therefore it was extremely susceptible to corrosion.

The fire-fighting effort was impeded by the intermittent loss of fire main pressure due to the emergency pump control cables within the AER being damaged by the fire.

**What can we learn?**

- The fuel oil changeover procedure must be understood by the ship's engineers in charge of the operation; and the harmful effects of closing any valves in isolating the excess pressure regulating valve or prevent fuel returning to the service tanks must be fully understood by all.

- The exhaust lagging or heat shields must be properly replaced after carrying out any work on the main or auxiliary engines.

- It is important that the dry pipe distribution network and the discharge nozzles for use in high expansion foam fixed fire extinguishing system is properly maintained to avoid blockage or clogged with rust resulting from corrosion of the dry pipe.

- It is essential that crews are aware of the location of the ventilation system fire dampers and be provided with onboard guidance.

- It is essential to maintain an effective fire fighting command and control efforts in an emergency situation with adequate knowledge of the fixed fire-extinguishing system, and having good radiocommunication voice procedures.

- It is essential that excess pressure regulating valves for use with fuel oil systems are fitted with appropriate rubber diaphragm suitable for use with fuel oil and incorporated with leakage glands and rupture indicators.

- It is important to be aware of the potential problems associated with the use of low sulphur fuels, e.g. poor lubricating characteristics; undesirable additives or blend components; cleaning action or searching nature which can lead to clogging and increased leakage.

- It is essential that thermal insulation be provided with due regard to the fire risk of the spaces and adjacent spaces in accordance with SOLAS requirements.

- It is important for the manufacturer/shipowner/ship's engineer/surveyor to ensure the performance and effective functioning of water-mist systems, to ensure prompt activation of the system; adequate production of the water-mist; un-interrupt supply of water-mist; endurance of operation and sufficient water-mist coverage above the seat of fire.

- It is essential that the distribution pipe network of high-expansion foam system is fabricated from corrosion free materials and the pipe layout be provided with self draining features.

- It is important to ensure the continuous supply of power to the emergency fire pump. If there is a possibility that the power supply be cut off or damaged by fire, an independent power should be considered, e.g. driven by an independent diesel engine.

- It is important that crews are aware of the hazards to personnel in compartments containing high-expansion foam.

- It is important that decent surveys and tests are properly carried out on high expansion foam systems in accordance with the manufacturers' instructions and current IMO guidelines, which includes blowing through with compressed air, to guarantee the reliability of these safety critical systems.

- It is important to ensure and verify that foam flooding systems are charged with the appropriate type and quantity of foam concentrate.

- It is important that fixed fire-extinguishing systems be maintained in accordance with the manufacturers' instructions and/or the ship's planned maintenance system schedules.

- It may be useful for ships to have its own operating procedure or policy for its high-expansion foam fire-extinguishing system.

**FIRE (FSI 20)**

**Serious casualty: Electrical fire inside cargo hold**

**What happened?**

When a 18 gt cargo ship was sailing in coastal waters, the crew smelled burning plastic. When the crew opened the hatch of the cargo hold to check it, a flame of approximately half a meter appeared and dense smoke came out for approximately 15 seconds. The fire was extinguished in a few minutes by a crew member using two portable dry powder fire extinguishers.

The fire broke out in a fluorescent tube fixture placed on a niche panel in the cargo hold. Six passengers were transferred to another company's vessel. There was only minor damage to the cargo hold after the fire and the ship was able to continue the voyage.

**Why did it happen?**

The fire was caused by electric arcing in the sockets of the fixture for fluorescent tubes. The fluorescent tube fixtures had poor mechanical/electric connection between socket and tube, and without having open circuit and short circuit protection, presented a potential risk of causing a fire on ships that are moving and vibrating. The fluorescent tubes did not fulfil the requirements for preventing overheating causing damaging of cables and surrounding material.

**What can we learn?**

- Fluorescent tube fixtures used on board ships should fullfil guidelines and certain standards and be marked accordingly, allowing the user to choose the right equipment and discard the unsuitable.

**EXPLOSION (FSI 20)**

**Serious casualty: explosion within a ballast tank during hot work**

**What happened?**

A 28,000 gt geared forest product carrier was undergoing repairs in a repair yard. At the time of the incident (late evening), hot work was ongoing within No.2 port ballast tank. Sections of the shell plating were being replaced. Gas cutting of steel plate was ongoing using liquefied petroleum gas (LPG) (in place of acetylene) and oxygen gas cutting equipment. Welding equipment was also in use. An explosion occurred within the tank, killing 2 shipyard workers and injuring seven others; three shipyard workers ended up in the water and were rescued by a shipyard boat. No members of the ship's crew were within the tank or injured.

**Why did it happen?**

Gas cutting equipment had been left in the tank for a prolonged period. Several gas cutters were in the tank and had their gas valves opened up and left on throughout the whole day in question. It is suspected that leakage from the various gas cutters led to an accumulation of LPG in the bottom of the ballast tank. The explosion occurred late in the evening, probably caused by sparks dropping from the hot work to the bottom of the tank.

The ventilation fans fitted to the tank had insufficient power to propel air to the bottom of the tank and therefore did not dispel the gas from the tank.

Gas tests were only made prior to the work starting in the morning – no follow-up gas tests were made during the day at shift change or after breaks, hence the leaking gas was not detected.

**What can we learn?**

- Ventilation needs to be sufficiently powerful to circulate fresh air around the entire tank – the use of trunking to take air to the bottom of the tank is essential.

- Gas tests must be made at frequent regular intervals during the day, and after any break. Gas tests should be made at all levels within the tank.

- Any gas equipment, when not in use, should be isolated and removed from the tank.

**FIRE OR EXPLOSION (FSI 18)**

**Fire in engine-room due to poor housekeeping**

**What happened?**

A fire started in the engine-room. The main fire pump was inaccessible due to thick black smoke and staff evacuated the engine-room, first stopping the main engine. The quick-closing fuel supply valves and the remote stops for the engine-room fans and oil pumps were operated and the emergency fire pump was started. The crew closed the dampers for the engine-room fans and the funnel vents; they rigged fire hoses to boundary cool the engine-room casing and funnel and to spray water through the open engine-room skylight. After about 50 minutes, the fire cut the electrical power supply to the emergency fire pump and water ceased to flow from the fire hoses. The fire was eventually extinguished using the fixed $CO_2$ system.

**Why did it happen?**

From the available evidence it was concluded that the primary fire probably started in the area outside the entrance to the third platform deck store, on the port side of the main engine. Oily rags and cotton waste used for engine-room cleaning were routinely stored there prior to burning them in the nearby incinerator. Moreover, hot ash from the incinerator was also routinely kept there in an open top cut down steel drum where it was left to cool prior to disposal.

**What can we learn?**

- The importance of good housekeeping practices in engine-rooms should be stressed.

- Early use of the fixed $CO_2$ following safe evacuation.

Used oily cotton waste/rags and hot ashes are a significant fire hazard and should be safely stored prior to safe and environmentally-acceptable disposal.

**FIRE OR EXPLOSION (FSI 18)**

**Flame from oxyacetylene torch ignited material**

**What happened?**

Crew members were working in a confined space trying to replace a manhole cover plate. A bulkhead stiffening bracket was making it difficult to put the plate over the opening. They decided to cut away part of the bracket using an oxyacetylene torch. The flame from the torch ignited material in the machinery store on the other side of the bulkhead. The heat caused one or more camping gas cylinders in the store to explode. The explosion and fireball passed through the open manhole severely burning an engineer who was trying to extinguish the fire with a portable extinguisher. He had come straight to the workspace from his cabin and was dressed in tee-shirt and shorts.

**Why did it happen?**

- The crew members embarked on a hazardous enterprise without carrying out a careful risk analysis or informing all interested parties (notably the master) of their intentions.

- Although an oxyacetylene torch was being operated on a bulkhead, shared with a space housing inflammable materials and gas cylinders, this space was not emptied prior to carrying out the work, nor was a fire-watch maintained in the space. Essential fire-fighting equipment was not laid out and checked prior to carrying out the work.

**What can we learn?**

- Always carry out a risk analysis before carrying out hot work. Using oxyacetylene equipment is always hazardous; it is especially so when being used in a confined or restricted space.

- When carrying out hot work, always consider what is on the other side of the bulkhead and arrange a fully briefed fire-watch.

- Double-check that all necessary fire prevention and fire-fighting equipment is at hand and in good order.

- While answering calls for assistance is highly commendable, evaluate the situation and never take unnecessary risks.

## FIRE OR EXPLOSION (FSI 18)

### CARGO HOLD FIRE CAUSED BY HOT WORK ON CARGO HOLD HATCH COVER

**What happened?**

When a fitter was in the process of removing the brackets that had been welded to the hatch covers with oxyacetylene cutting equipment, a hole was inadvertently cut in the aft cargo hold hatch cover. As a result, a fire started in the cargo hold when sparks and molten metal fell into the cargo hold and onto the pallets of cargo stowed below. The crew's attempts to use the fixed fire-extinguishing system to flood the cargo hold with carbon dioxide and high expansion foam were unsuccessful. The fire was finally extinguished when an offshore supply vessel's monitor was used to flood the cargo hold with about 700 tonnes of seawater.

**Why did it happen?**

The fitter removing the stoppers from the cargo hold hatch covers could not read English and hence could not fully understand the requirements of the ship's safety management system hot work permit. Also the ship's cargo stowage plan was neither accurate nor complete.

WHAT CAN WE LEARN?

- Ship's cargo stowage plan especially for the carriage of dangerous goods should be accurate and available on board at all times.

- Always carry out a risk analysis before carrying out hot work. Care must be taken when using oxyacetylene equipment.

- Before the work was started hot work permits should be completed and signed with full understanding of the permit's requirements by the individual carrying out, and the person in charge of the work.

## FIRE OR EXPLOSION (FSI 18)

### ENGINE-ROOM FIRE

**What happened?**

The ship's fire detection system indicated a fire in the engine-room about four hours after the ship departed from port. The second engineer investigated and found that No.3 diesel generator was on fire caused by the failure of a flexible fuel hose. He raised the alarm and discharged a portable extinguisher towards the fire and stopped the engine-room ventilation fans before retreating from the engine-room. The crew mustered quickly, operated systems to stop the engine-room pumps, fuel tanks quick-closing valves and prepared to fight the fire. The fire was put out finally by the engine-room Halon fixed fire-extinguishing system.

**Why did it happen?**

- The failure of a flexible fuel hose on No.3 diesel generator due to long-term rubbing and chafing.

- The maintenance of the generator flexible fuel hoses was inadequate and hoses longer than specified by the generator manufacturer had been used.

- Both the generator manufacturer's instruction book and the ship's safety management system provided no guidance for the maintenance or routine replacement of the flexible fuel hoses.

WHAT CAN WE LEARN?

- Flexible fuel hoses must be installed in accordance with manufacturers' specifications and should be inspected regularly for wear and tear. Flexible fuel hoses should be replaced in good time whenever there is doubt as to their suitability to continue in service.

- The value of an effective crew response to an emergency situation.

## FIRE OR EXPLOSION (FSI 18)

### CARGO HOLD FIRE WHEN LOADING MIXED METAL SCRAPS

**What happened?**

The multi-purpose 1,318 GT cargo vessel with a single hold, was loaded with mixed metal scrap composed of compressed cultivators, motorcycle engines, electronic waste, iron scrap and plastics. A fire broke out at about 0825 hrs in the cargo hold. The fire was put out by the shore fire brigade at 0200 hrs the following day. There was no oil pollution resulting from the fire. However, the ship's port forward shell plating and structure were damaged.

**Why did it happen?**

- Flammable materials contained in the mixed metal scrap were ignited by the frictional heat being generated from iron scraps hitting each other during loading operation and being crusted by an excavator in levelling the cargo loaded in the cargo hold.

- Metal scrap mixed with compressed cultivator and motorcycles, which might contain residue fuel, was not treated as flammable material.

WHAT CAN WE LEARN?

- The safety awareness of ship staff was not sufficient. The stevedore and the shipper did not realize that metal scrap mixed with compressed cultivator and motorcycles, which might contain residue fuel, should be treated as flammable material.

- Scrap metal cargo has hidden dangers including possible toxic and flammable materials.

**FIRE OR EXPLOSION (FSI 18)**

DECK FIRE DURING GAS-FREEING OPERATIONS

**What happened?**

The 2,646 GT tanker was at anchor performing gas-freeing operations having completed the discharge of naphtha. A fire broke out on deck at No.4 port manhole opening while gas-freeing operations were being carried out on tanks No.3 and No.4. The fire was put out by ship staff, but the fire left one crew member dead and two injured.

**Why did it happen?**

- Gas-freeing operations were not conducted in accordance with the applicable guidelines and procedures.

- Uncertified ventilation fans were used during gas-freeing operations.

**What can we learn?**

- During gas-freeing operations, properly certified equipment (EG., fan, etc.) should be used.

- During gas-freeing operation the exhaust gas should be discharged from vent posts to avoid dangerous exhaust gas being accumulated on deck.

## FIRE OR EXPLOSION (FSI 18)

### Cargo hold fire caused by light fittings

#### What happened?

A fire broke out in the hold where a large amount of plastic and corrugated cardboard packing was stored. Very dense smoke quickly spread throughout the vessel including the bridge. The fire alarm was activated but functioned only for a short while. The smoke divers' search for personnel in the accommodation was abandoned after a short while due to lack of breathing gas. Fire fighting inside the accommodation had to be abandoned for the same reason. There were no compressors on board to recharge the bottles. One hundred and five crew members were rescued, while 11 lost their lives. The vessel burned for three weeks.

#### Why did it happen?

Sparks were generated in the fluorescent tubes sockets, which resulted in overheating and melting of the surrounding plastic. The burning plastic material dropped down and ignited corrugated cardboard which had been stored close to the tubes. The light fittings were of poor quality not suitable for use on board ships. The storeroom did not have the required fire protection. The fire alarm failed due to the fire destroying the wiring. Fire doors had been kept open by wooden blocks allowing the smoke and fire to spread rapidly. There were no compressors on board to recharge the bottles of breathing gas. Fire drills were insufficient. Not all crew were informed and familiar with emergency procedures.

#### What can we learn?

- Electrical fittings must be suitable for marine use.
- Fire detection systems must be updated along with any modifications on board ships.
- Emergency training is essential to ensure a proper emergency response by all crew members. Seafarers must familiarize themselves with emergency procedures.
- The dangers of propping open fire doors.
- Based on the risk assessment there should be sufficient fire-fighting equipment identified on board to ensure effective fire fighting.

## FIRE OR EXPLOSION (FSI 18)

### Cargo hold fire on a ro-ro

#### What happened?

A fire was detected on the main deck of a ro-ro ship loaded with trucks. Crew members went to check the deck to ensure there was a fire because there had been several misleading alarms earlier triggered by the trucks exhaust rather than a fire. On confirmation of the fire, fire-fighters entered the main deck with water hoses to extinguish the fire. Several attempts to start the fire pumps failed and the fire spread rapidly; 27 minutes after the initial fire alarm, it was decided to activate the sprinklers, but all attempts to start the drencher pump failed. The rapidly expanding fire, together with enormous quantities of dense smoke, blocked the escape route to the lifeboat, rescue boat and raft. The crew then retreated to the foredeck from where they later jumped into the sea.

All 22 crew members and 9 passengers were rescued. The vessel burned for two days and was declared a constructive total loss.

Why did it happen?

The exact cause of the fire has not been identified, but it was concluded that it started in one of the trucks. The fixed fire-fighting system was not activated instantly, and verifying the fire alarm took 10 minutes, thus delaying the fire-fighting actions. The fire spread rapidly and fire-extinguishing equipment then failed. The cause of the pump failures could not be determined.

What can we learn?

- Any fire alarm must be taken seriously. There should be no hesitation when an alarm is raised.

- Due to the narrow gap between the vehicles on ro-ro ships, use of sprinklers or other fixed fire-fighting systems should be considered as the primary fire-extinguishing method and be activated instantly.

**FIRE OR EXPLOSION (FSI 17)**

**What happened?**

A boiler had undergone repairs and during the chemical cleaning process following the repairs, two chemical cleaning specialists were inspecting the inside of the boiler's steam drum when an explosion occurred. One of the specialists later died as a result of his injuries; the other was seriously injured but survived. There was minimal damage to the ship.

**Why did it happen?**

Hydrogen gas was allowed to accumulate in the steam drum because it had not been adequately vented to the atmosphere during the cleaning process.

The accumulated hydrogen gas mixed with air that was sucked into the boiler steam drum when the door was opened and ignited when a non-intrinsically safe halogen lamp was placed inside the drum.

**What can we learn?**

- Boiler cleaning is an inherently dangerous process for which an agreed plan that accounts for all identified risks should be followed.
- Product Data or Material Safety Data Sheets for boiler cleaning chemicals should highlight the risk of evolving hydrogen gas during the cleaning process.
- Adequate ventilation is essential when chemical cleaning boilers to prevent the accumulation of harmful and/or explosive gases.
- The atmosphere in enclosed spaces should be tested for explosive mixtures and/or harmful substances before anybody enters or introduces non-intrinsically safe devices into a space.

**FIRE OR EXPLOSION (FSI 17)**

**What happened?**

A fire started in the engine-room adjacent to the oil-fired thermal fluid heater while the vessel was berthed. Ship staff operated the engine-room fixed fire extinguishing system to extinguish the fire but in vain. The fire was finally extinguished by shore fire brigade using high expansion foam. The engine-room and accommodation were significantly damaged by the fire and the vessel had to be towed to Singapore for permanent repairs.

**Why did it happen?**

A leakage of hot pressurized thermal fluid in the form of a spray, ignited when it came into contact with an unprotected section of the oil-fired thermal fluid heater's exhaust piping. The fire was further fuelled by the contents of other oil tanks, as their quick closing valves were not operated.

**What can we learn?**

- There were no operations, maintenance or emergency procedures/manuals available on board outlining the hazards associated with the ship's thermal fluid system.
- There was no record of shipboard routine inspection and testing of safety equipment consistent with the ship's safety management system requirements.

**FIRE OR EXPLOSION (FSI 17)**

**What happened?**

A fire started in the engine-room when a leak of diesel fuel occurred from a temporary blanking arrangement on the starboard main engine fuel system. The fuel ignited when it came into contact with hot surfaces of the starboard main engine. The fire was finally extinguished using the ship's fixed fire extinguishing system by crew members and the vessel safely returned to port under her own power.

**Why did it happen?**

The fitting of a gasket in an open-ended cap to blank off a fuel pipe was ineffective for the task because the discs probably became loose due to the effect of pressure pulses within the fuel pipe.

**What can we learn?**

The quick decision by the Master and crew members, and the prompt use of the engine-room fixed fire extinguishing system, controlled and extinguished the fire quickly and prevented it from spreading.

The practice of re-opening the fuel quick closing valves after the fire, without first isolating individual fuel circuits, may expose the ship to the risk of another fuel leak and possible re-ignition.

The ship's procedures for re-entry into the engine-room after the operation of the fixed fire extinguishing system did not adequately consider the time required to cool the fire scene and did not provide crew members with adequate guidance about when to safely re-enter the engine-room to prevent potential risk of re-ignition.

**FIRE OR EXPLOSION (FSI 17)**

**What happened?**

While fishing, a fire broke out in the engine-room. The skipper noticed the fire because of its smell. When he opened the door to the engine-room, smoke billowed out. He woke up the crew to inform them and told them to put on their lifejackets. He did not remember whether he had closed the door again. The skipper tried to send a Mayday message by main VHF transmitter on main and emergency power, but this failed. By mobile phone a relative was warned, who in his turn warned the MRSC. Before abandoning the ship, the skipper managed to broadcast a message to the MRSC himself. The message was relayed to a fishing vessel in the vicinity, which later picked up the crew from their life raft.

**Why did it happen?**

Since the vessel sank in deep waters, the source of fire could not be determined. Since no oil spill was sighted, it is assumed that the oil fed the fire at a certain point. Leaving the door to the engine-room open may have aided the fire to spread.

**What can we learn?**

It has been declared that (non-compulsory) fire detection was installed in the engine-room, but no alarm was heard. Maintenance of this vital equipment, as well as the GMDSS installation is of utmost importance.

The crew did not make any attempt to fight the fire, although fire-fighting appliances were available. The investigation has revealed that no fire or abandon ship drills were held for a considerable time. This had a major influence on how the crew responded to both fire and abandon ship situations.

**ENGINE-ROOM FIRE (FSI 17)**

**What happened?**

A fire in the diesel generator room damaged the electrical control cables and resulted in the loss of electrical power and main propulsion. The emergency generator started automatically. A watchkeeper attempted to extinguish the fire with a hand-held dry powder extinguisher, but was driven back by dense black smoke. The fire was eventually extinguished by a fire-fighting party wearing firemen's suits and breathing apparatus. When the fire had been extinguished, propulsion power was re-established from one of the vessel's four main engines which also provided electrical power from one of two shaft-driven generators. Temporary repairs to the cabling in the generator room permitted the start-up of one diesel generator.

**Why did it happen?**

The fire was believed to have started by the escape of hot exhaust gases from an air start valve on one of the generators, since the rocker cover was found lifted off its seat and the air start valve was found to have a broken stud and the securing flange had lifted about 10mm. It was suggested that the hot gases ignited vaporized lubricating oil inside the cover sufficient to lift the cover, from where the fire spread to the deckhead located about 1.5 m above. An ignition test of the deckhead insulation caused it to burn and emit black smoke. This could possibly have been due to the absorption of oil vapour over a period of time since the deckhead surface was irregular and may have presented cleaning difficulties.

**What can we learn?**

1 When removing cylinder head valves for maintenance, the opportunity should be taken to examine fasteners for signs of fatigue. Fasteners should be tightened to the torque specified by the manufacturer – at the same time checking that nuts run freely on their threads.

2 Deckheads – especially those in low-headroom machinery spaces – should be examined periodically for accumulation of combustible deposits and cleaned appropriately.

## HOT OIL SPRAY FROM FILTER COVER JOINT (FSI 16)

**What happened?**

Hot heavy fuel oil leaked from a cover joint on a filter provided for emergency diesel oil. The escaping oil impinged on a running auxiliary engine, its turbocharger and exhaust line. The fixed $CO_2$ system had to be used to extinguish the fire.

**Why did it happen?**

The low pressure emergency diesel supply line was not designed to be exposed to high pressure, high temperature fuel oil. Valves intended to isolate the emergency diesel system from the hot heavy oil system were intended to be non-return valves. However, the valves fitted were not non-return valves, one of them was left open and subsequently exposed the diesel filter to the hot oil. A valve fitted upstream of the emergency diesel oil filter was closed at the time of the incident. This fortunately protected the remainder of the emergency diesel system from exposure to the high pressure heavy fuel oil.

Insulation and/or spray deflectors fitted to hot surfaces were not sufficient to prevent the hot fuel spray to ignite.

**What can we learn?**

- Clear Work Instructions, in the form of simple schematic diagrams, should be provided which clearly indicate how manually operated valves should be set during normal and emergency operation. These should refer to identifying labels or markings on the valves.

- Care should be taken that all heat shields, insulation and spray deflectors work as expected.

- During operation, when connecting piping systems with different operating pressures, it should basically be ensured by appropriate valve positions that no closed pipe section results in which the pressure can rise uncontrollably above the structurally designed operating pressure due to an operating fault or leaking valve seat and the valve positions for pipe sections to be kept open should be secured and labelled so that changes can be clearly recognized.

## DIESEL FUEL SPRAYS ONTO UNPROTECTED EXHAUST AND IGNITES (FSI 16)

### What happened?

The fire occurred as a result of fuel oil escaping from a faulty pressure gauge pipe and spraying onto an unprotected engine exhaust. Approximately 10 minutes after the fire started, it had become so intense that a decision was made to flood the engine room with $CO_2$ from the fixed fire smothering system.

### Why did it happen?

The fuel oil pressure gauge pipe, attached to the compression fitting on one bank of one engine was made of copper and had fractured (all gauge connections originally provided by the engine manufacturer were of steel but the copper pipe which fractured had been fitted as a replacement);

- the high-pressure fuel pipes were jacketed, whereas the low-pressure fuel rail was not;
- the thermal heat shields, which should have been arranged on top of the exhaust manifold of the main engine, were missing;
- the exhaust pipes were inadequately lagged.

The compression fitting that connected the failed gauge tubing to the fuel rail had developed a leak two days before the occurrence and was repaired by tightening the compression nut a little further.

A ring around the outer diameter of the tube suggested that it had been partially cut, perhaps during the installation or tightening process.

Engine-generated vibrations caused the copper tube to work-harden and extend the partial cut in the now brittle tube wall in way of the compression ferrule, which was already biting into the outer surface of the tube and producing an area of high stress. This cut allowed some fuel to leak, and the engine room staff, under the mistaken impression that the leakage of fuel was from a loose connection, tightened the compression nut further, driving the ferrule deeper into the wall of the tube.

### What can we learn?

When repairing critical piping systems care should be taken to use appropriate and approved material and/or components.

When insulation material or spray shields are removed for maintenance, care should be taken to replace them correctly before re-entering service.

## MATERIAL BURNS AS A RESULT OF WELDING SPARKS (FSI 16)

### What happened?

A fitter was making a weld repair to a save-all which was an integral part of the deck head of the engine room workshop located immediately below. Sparks from the welding set alight electrical cabling stored in the workshop. This produced so much dense black smoke that it was impossible to approach the fire to extinguish it with portable extinguishers. The fire was subsequently extinguished using the fixed $CO_2$ system. After the main generators were shut down, prior to $CO_2$ release, it was not possible to start the vessels emergency fire pump to assist in fighting the fire because the emergency fire pump space had also filled with smoke. This was because it was located in a space directly below, and accessed from, the steering gear room and the watertight door in the steering gear room/engine room bulkhead was left open.

**Why did it happen?**

It appears that molten metal from the welding process fell into the workshop, landing on coiled electrical cables, causing them to ignite.

Although a hot work permit had been issued and an oiler had been designated to keep a fire watch in the workshop, he was temporarily absent – attending to a problem with a ballast pump. He did not inform the fitter carrying out the welding repair that he had left the workshop.

**What can we learn?**

Instructions contained in work permits should be clear, and unambiguous. Hot-work permits should ensure that all adjacent spaces are monitored during hot work.

When personnel are assigned for fire-watching duties, their responsibilities while undertaking such duties should be clearly defined. The oiler was simply told to standby in the workshop and look out for fire. He was not told that he must remain in the workshop until the hot-work was completed.

Even with a firewatch in place, it is prudent to require all combustible materials to be removed from the immediate vicinity of any repair requiring hot work.

Isolating doors between engine rooms and any space containing an emergency fire pump or its source of power should be kept closed at all times.

Ships' crews should close all means of ventilation before releasing $CO_2$.

In connection with the steering gear door left open, when engine room personnel were re-activating machinery, a pocket of $CO_2$ was discovered in the low-lying emergency fire pump space several hours after the fire was extinguished. This was immediately reported to the chief engineer and the area was cordoned off and ventilated using a portable fan. This emphasizes the importance of carrying out oxygen checks on all spaces which may have been exposed to $CO_2$ before any entry of unprotected personnel is permitted.

## BULK CHEMICAL CARGOES – EXPLOSION DURING TANK CLEANING (FSI 16)

**What happened?**

While in the process of tank cleaning, using the vessel's fixed rotary cleaning equipment, a low pressure explosion occurred in tank 1CS which had previously carried paraffinic solvent. This was followed by another explosion in the adjacent tank 1CP which was fully loaded with ethanol. The deck was fractured in several places and the escaping ethanol caught fire, the fire spreading all the way aft to the deck house. The crew extinguished the fire by using the vessel's foam monitors, and managed to bring the vessel to a nearby roadstead. One able seaman and the Bos'n were badly burned and subsequently died. Had the tanks been correctly inerted the explosion could not have occurred.

**Why did it happen?**

Rotary tank-washing machines were being used with fresh water and detergent to wash tanks which had contained paraffinic solvent which was subsequently found to have a flash point of minus 40ºC. The wash water was being recirculated, contrary to the advice given in the ICS Tanker Safety Guide (Chemicals) and ISGOTT. Although it is not certain, it is highly possible that static electricity was generated by this process.

Although the vessel was fitted with oil burning inert gas generator the cargo tanks were not inerted at the time of the casualty. At the maritime inquiry, the chief mate stated that the inert gas system on board (which was based on oil combustion) was unacceptable to the charterers because of too low purity. However no explanation was given as to why nitrogen was not used for inerting or why, in the absence of an inerting medium the cargo was not rejected.

**What can we learn?**

It is important that the master is provided with data sheets which include all necessary – and correct - information for the safe handling, storage and treatment of the cargo to be carried.

Proven cleaning procedures should be strictly adhered to; uninformed deviations may lead to unforeseen and tragic consequences (ref. ICS Tanker Safety Guide (Chemicals) and ISGOTT).

The cleaning of tanks should be treated by the ship's safety management and quality assurance system as a critical work operation. Where necessary instructions should provide for the use of inert gas; where such information is provided, allowance should be made for gas generating equipment permanently fitted on board or alternatively, the provision of appropriate and sufficient bottled gas.

When masters are presented with cargoes which require specific conditions of carriage which are not available – e.g., inerting with gas of a specified purity – such cargoes should be refused

Although not considered by the investigators as directly contributing to the cause of this incident, rest periods required by the STCW code should be met (or exceeded).

## EXPLOSION ON BOARD A CHEMICAL TANKER (FSI 15)

**What happened?**

A chemical tanker docked at a terminal to discharge a cargo of methanol. About 15-20 minutes into the unloading of the cargo, an explosion occurred in way of one of the cargo tanks. The fire was extinguished by the crew. There was minor damage to the vessel, but there were no injuries.

**Why did it happen?**

There was an accumulation of combustible vapours in the cargo tank – the vessel was not equipped with an inert gas system. The intermediate shaft of the cargo pump was rubbing against the casing, providing a source of ignition. An inert gas system was available in port; however, its use was not imposed by the port authority.

**What can we learn?**

- Suitable maintenance of shipboard machinery and equipment used in hydrocarbon-related cargo operations is necessary to ensure the safety of the vessel and crew.

- Use of systems that effectively inert tankers helps to prevent explosions in cargo tanks.

- Shore-based inert gas systems may be available for use in some ports.

**EMERGENCY DISEMBARKATION AFTER EXPLOSIONS ON BOARD (FSI 15)**

**What happened?**

Six out of 27 crew members survived an explosion on board a chemical tanker. All six had evacuated the vessel in a liferaft. All the other crew members evacuated to the water. Only three of these were recovered by rescue services – one was found dead, the other two died en route to hospital.

In another incident involving explosions on board a dry bulk carrier, the surviving members of the crew evacuated the vessel via a lifeboat. Four crew members remained on board to launch the lifeboat, and then jumped into the sea, one of which was able to swim to the lifeboat. The other three remained in the water for 12 h, arms interlocked, until picked up by a passing vessel.

**Why did it happen?**

In the case of the chemical tanker lack of an organised response to the explosions contributed to the high loss of life. The master abandoned ship without sending a distress signal, without attempting to contact a nearby ship, without conducting a proper muster or search for injured crewmen, and without attempting to launch primary lifesaving appliances. Both the Master and Chief Engineer abandoned ship within 10 minutes of the first explosion, leaving behind crewmembers they knew to be alive. Their premature action exposed the crewmen who entered the water with them to the cold water far earlier than necessary, and contributed to the high loss of life.

In the case of the bulk carrier, it is not known why four men, instead of one, were required on board the vessel, to launch the lifeboat. Neither is it known why none of them managed to enter the boat via the embarkation ladder.

**What can we learn?**

The importance of regular and meaningful emergency and evacuation drills cannot be over-stressed.

## VEHICLE DECK FIRE ON BOARD A RO-RO FERRY (FSI 15)

### What happened?

A fire was discovered on the lower vehicle deck of a non-Convention roll-on/roll-off ferry. The deluge system was activated and the fire was fought by ship staff as the ferry continued to its destination. Passengers were safety evacuated to shore and the fire was declared extinguished by the shore fire brigade. The "vehicle deck 1" suffered extensive smoke damage and considerable heat damage.

### Why did it happen?

The fire originated in or around a tractor-trailer parked on "vehicle deck 1"; the cause of the fire is undetermined. However, one of the possible contributing factors was that passengers, particularly commercial truck drivers, continued to remain in their vehicles during transit despite inherent risks in doing so.

### What can we learn?

- For safety reasons, passengers should not be allowed to remain in their vehicles while the roll-on/roll-off ferry is underway.
- Crew members on board passenger vessels must be readily identifiable to passengers and follow all procedures in the Vessel's Emergency Response Manual in emergencies.
- It is important that crewmembers on board non-Convention passenger vessels should also be provided with training courses in crowd management, crisis management and human behaviour.
- The installation of low-location lighting on board non-Convention passenger vessels can assist passengers and crew to identify escape routes and exits.

## A SERIES OF EXPLOSIONS ON BOARD A CHEMICAL TANKER (FSI 15)

### What happened?

A series of explosions and subsequent fire occurred inside the cargo tanks on a chemical tanker when unloading chemical to a shore terminal. Two seamen on the main cargo deck were killed and the chief officer was injured. The fire was eventually brought under control by the local fire brigade. The damage caused a constructive total loss of the vessel.

### Why did it happen?

The most probable cause of the initial explosion was due to a static or electrical discharge of sufficient strength to create an ignition source within a volatile environment that had developed on board the vessel.

**What can we learn?**

- General confusion surrounding the actual connection of the ship/shore electrical continuity bonding cable, particular when the national or local regulations are not in line with the current industry guidelines. There is a clear need for agreement on International Standards to be adopted with respect to the precautions required to minimize the risks associated with static, electrical charge generation and discharge.
- The use of systems that effectively inert tanks on board of chemical tankers, irrespective of ships' size, can enhance fire or explosion safety.

**HAZARDOUS CARGO FIRE AND DEATH OF A SEAFARER (FSI 14)**

What happened?

A container holding calcium hypochlorite, which was not declared by the shippers as dangerous cargo, was loaded in the bottom of a hold close to a fuel tank. Two weeks later at about 07:55 hours, whilst the vessel was at anchor, an explosion occurred and large "fire balls" were observed coming from the hold. The hold was just aft of the crew mess where most of the crew were having breakfast.

Because there was no obvious escape route, the crew's escape from the mess-room was confused. Consequently, some of the crew escaped through mess room port holes and onto the outside deck.

During the subsequent muster, a non-swimmer member of the crew was found to be missing. He was presumed to have jumped or have been blown overboard as he tried to escape out of the accommodation using an aft facing door. When confronted by the fire, he probably jumped overboard and drowned.

Why did it happen?

1 The container filled with calcium hypochlorite, which is prone to instability, was stowed below deck.

2 This container should have been stowed above deck, shaded from direct sunlight and stowed away from sources of heat.

3 At temperatures above 35 degrees Celsius, the calcium hypochlorite may have caused the explosion and fire.

**What can we learn?**

Accommodation and service spaces should have clearly marked escape routes. Crew should be fully aware of the means of escape from spaces on board. Also, it is advisable that all seafarers should know how to swim.

**HAZARDOUS CARGO FIRE IN CONTAINER (FSI 14)**

What happened?

A container vessel was discharging containers when a hold smoke detector alarm sounded. White smoke was seen and there was a persistent smell of suffocating gas. Information on the contents of the containers in the hold was not available. Thermal imaging in the direction of a container suspected of containing dangerous goods indicated temperatures of 40 to 45 degrees Celsius.

Due to the presence of sulphur dioxide, all cargo work was stopped and the crew was sent ashore. The suspect container was removed ashore and five persons were hospitalized.

Why did it happen?

1 The contained thiourea dioxide (UN number 3341, IMDG Class 4.2) was stowed below deck in non-compliance with the IMDG Code.

2 This substance can decompose at temperatures below 50 degrees Celsius with the consequential generation of sulphur dioxide, ammonia, carbon monoxide and carbon dioxide gases.

3 Furthermore, the suspect container was in a hold adjacent to the machinery space, thus increasing the danger to personnel.

4 The vessel had been loaded using a computer program and the master was unaware of the hold's contents until after the vessel sailed from the loading port.

What can we learn?

A manual check should be made on the location of all containers containing dangerous goods. Total reliance should not be placed on computer programs. Further, masters should be provided with, and if necessary should request, full information on the contents of each hold at the time of loading.

**MACHINERY SPACE FIRE AND SERIOUS BURNS TO THE MASTER (FSI 14)**

What happened?

A fire broke out in the engine-room of a fishing vessel and spread to the wheelhouse causing severe damage to the installations and serious burns to the master.

The master had noticed that a high pressure line from the lubricating oil filter to the super-charger was leaking. He had tried to tighten the screw connection when it broke off and fire broke out immediately. All the master could do was to leave the space to save himself and jump overboard to extinguish the flames on his body. The deckhand threw the master a lifebuoy and pulled him back on deck and arranged medical assistance for the 50% of body area burns.

Why did it happen?

1 The high pressure lubricating oil sprayed onto the nearby exhaust gas turbo charger.

2 It was evident that the oil ignited as it infiltrated beneath the insulation at the joint between the exhaust gas turbo charger and exhaust gas line which was heated up to 600 degrees Celsius.

3 The spontaneous ignition temperature of the oil was later tested and found to be 580 degrees Celsius.

4 The entrance cover between the wheelhouse and engine-room had been opened up for the inspection and the hot and partly burning gas thus spread from the machinery space to the wheelhouse and thence to the mess/galley causing major damage.

What can we learn?

No attempt should be made to tighten connections when the contents of the system are under pressure. The area requiring maintenance should be isolated from other pressurized systems and thorough checks made to ensure that no pressure is present.

When using a spanner to tighten connections, both sides of the connection should be supported such that only a rotation of the spanner side of the connection is produced.

**TANKER EXPLOSION DURING TANK CLEANING** (FSI 14)

**What happened?**

While en route to port to load cargo, two crew members began cleaning the cargo holds of an oil tanker. The tanker had just discharged its cargo of unleaded gasoline. A loud whistling noise was heard immediately before the three instantaneous explosions and fire. The deck between the aft superstructure and the midship cargo manifold was completely destroyed. The crew member who was at the tanks being cleaned was killed. The other crew member at the midship cargo manifold was unharmed.

**Why did it happen?**

1 The explosion was the result of ignition of the accumulated gasoline vapours in the tanks.

2 While it is possible that the source of ignition may have been the result of a malfunction of a cargo pump causing an increase in temperature, it is more likely that it was the result of a build-up of electrostatic charges caused by the cargo pump or washing nozzle.

**What can we learn?**

Precautions should be taken to minimize or eliminate the generation of static electricity during cargo operations and tank washings. Further, cargo tank atmospheric testing should be carried out prior to performing tank cleaning operations and cargo tanks gas freed and monitored.

**FIRE IN THE ENGINE-ROOM OF A FISHING BOAT (FSI 14)**

**What happened?**

A fire broke out in the engine-room of a multi-purpose trawler. There was no time to attack the fire as the wheelhouse and accommodation rapidly filled with dense smoke. Crew members abandoned the vessel. The area behind the electrical distribution panel was completely destroyed, and there was smoke damage in the engine-room, accommodation area and the wheelhouse.

**Why did it happen?**

1 The engine-room fire was probably caused by an electrical defect, which ignited cable insulation, the wooden after bulkhead and the main electrical distribution panel.

2 The fire was quickly out of control as the access to the engine-room water sprinkler system was completely blocked by the large number of creels stowed on deck in the vicinity of the wheelhouse.

3 The sprinkler system was badly maintained and inoperable.

**What can we learn?**

Fishing equipment should be stowed so as not to restrict access to fire fighting equipment.

It is important for fishing vessel skippers to have appropriate safety training.

Smoke detection system equipment is more effective than heat detection systems for an unmanned machinery space to achieve an early detection of fire before the build up of smoke makes entry into the engine-room impossible.

**OXY-ACETYLENE EXPLOSION (FSI 14)**

**What happened?**

There was an explosion in the welding area of the engine-room workshop. An engine fitter who was carrying out welding work was killed by broken pieces of a gas welding equipment cabinet, which had disintegrated as a result of a gas explosion.

**Why did it happen?**

1 There had been an escape of acetylene gas from the acetylene supply line (pipe length, pressure gauges, shut off valve, pressure regulators) in the cabinet or in the pipe union fittings.

2 A spark or welding spatter ignited the explosive mixture of air and acetylene trapped in the cabinet.

**What can we learn?**

Prior approval should be obtained from the manufacturers before modifications are made to gas welding installations. Modifications that are undertaken should be carried out by experienced workers.

In case of leaks cabinets of gas welding facilities should be ventilated sufficiently to prevent the formation of explosive gas concentrations within the cabinets. Maintenance record should be provided for gas welding installations.

### FISH FACTORY VESSEL FIRE (FSI 14)

### What happened?

The fish factory vessel caught fire in No.2 Deck (processing area) and spread quickly to the rest of upper decks, and to the accommodation. The fire was out of control and crew members abandoned the vessel. The vessel continued to burn for 5 days before being towed and berthed in port. The local fire brigade put out the fire.

### Why did it happen?

1 Combustible packing materials were not properly stored and were ignited by careless disposal of smoking materials by stevedores or crew members.

### What can we learn?

It is important to ensure that all personnel onboard fish factory vessels, i.e. stevedores or crew members, are properly trained to strengthen their safety culture and to deal with emergency situations. A "no smoking policy" around processing areas or other high fire risk areas should be strictly enforced. Crew fatigue can reduce safety vigilance.

### MISSING FUEL OIL VENTILATION PLUG RESULTS IN A FIRE (FSI 14)

### What happened?

Two engine-room fires happened onboard the fishing vessel in less than 3 months. The first engine-room fire was caused by leakage of fuel oil from a ventilation hole on a main fuel filter whose ventilation plug was missing. The fuel oil ignited as it came into contact with hot exhaust manifold. The skipper operated the CO2 system. However, he did not know whether or not the gas had been released into the engine-room because he did not fully understand how the CO2 system worked, and because the system was poorly maintained. The skipper and the engineer entered the engine-room, without considering the dangers that the presence of CO2 in the space might hold. Fortunately, the fire was put out by crew members, although the engine-room was extensively smoke and heat damaged. The cause for the second engine-room fire could not be established because evidence was lost when the vessel sank.

### Why did it happen?

1 The ventilation plug on the after duplex fuel oil filter probably became loosened by the continued impact of the brass connection of a refrigerant charging hose. The hose was suspended above the plug, and swung freely under the influence of the rough sea conditions.

2 Once the ventilation plug became loose, further impact by the charging hose combined with engine vibration, caused the plug to finally come away from the filter top.

**What can we learn?**

Standing instructions should be provided for watch-keepers who have to visit the engine-room or to monitor the space. Fishermen should be properly trained on the maintenance of the $CO_2$ system, its operation, and personal safety issues following the use of $CO_2$.

Also in unmanned machinery spaces, smoke detection systems can be more effective than heat detection systems for early detection of fire, and before the build up of smoke makes entry into the engine-room impossible.

**FIRE (FSI 13)**

**4.1 What happened?**

A fire broke out in the aft engine room of a passenger ro-ro ferry. The watchkeeping engineer tried to extinguish the fire using portable fire extinguisher but was not successful. Further attempt by the engineers to extinguish the fire from within the engine room was aborted due to dense smoke. The fire was eventually extinguished by closing down the aft engine room and injecting $CO_2$ into it. The ferry then resumed her passage under own power. Subsequent inspection on the $CO_2$ fire smothering system revealed that a total of 86 $CO_2$ bottles had been discharged into the aft engine room instead of 34 as per design of the system for the engine room.

**Why did it happen?**

• The fire was caused by leakage of fuel from the fretting failure of a low-pressure fuel pipe on the aft diesel driven generator because of incomplete securing arrangements.
• Ignition of the associated vapour was probably from contact with the diesel engine's exhaust manifold.
• The fretting failure was not detected as the routine inspection for the engine did not include a check on low pressure fuel pipe securing arrangements.
• The over-discharge of number of $CO_2$ bottles was probably caused by leakage of manifold in-line check valves due to presence of dirt and water in the manifold.

**What can we learn?**

• The hazards associated with low-pressure fuel system of diesel engines should not be under-estimated. Low-pressure fuel pipes should be adequately secured to avoid fretting and the fuel pipes regularly checked to verify their conditions.
• Over-discharge of number of $CO_2$ bottles would exhaust the $CO_2$ reserve of the fire extinguishing system such that a second injection would not be possible.
• When compressed air is used to test $CO_2$ system, clean and dry air should be used as dirt and water entering the system may lead to system malfunction.

**What happened?**

A general cargo ship carrying a cargo of cocoa beans suffered a fire in her No. 2 cargo hold. The ship's crew attempted to smother the fire by $CO_2$ flooding but the process was interrupted due to leakage in the manifold. Subsequently all the $CO_2$ bottles of the ship's fixed fire extinguishing system were discharged into the cargo hold in a sequential manner but it failed to extinguish the fire. The ship was diverted to a port of refuge and additional bulk $CO_2$ was delivered and injected into the cargo hold. However the fire still could not be extinguished completely. Finally, after the hatch covers were opened and the flames doused by local fire brigade, all the cocoa bean cargo in No. 2 cargo hold were discharged into sand bungs on the wharf and the ship sailed to her next port.

**Why did it happen?**

The exact cause of the fire could not be ascertained, however four possibilities were identified:

• self-heating of the cocoa beans promoted by the growth of fungus initiated by the presence of water, which was exacerbated by poor ventilation;
• combustion initiated by decomposition of aluminium phosphide into phosphine gas used for fumigation of the cargo;
• smoking material discarded in the hold during loading cargo; and/or
• a cargo light left in the hold after the completion of cargo loading.

**What can we learn?**

• For the carriage of organic cargo, ship's staff should be provided with adequate information on the shipping, stowage, ventilation, fumigation and associated hazards.
• No smoking policy around cargo holds should be strictly enforced.
• All electrical equipment used in holds for cargo works should be appropriately isolated and stowed upon completion of loading cargo.
• To ensure effectiveness of $CO_2$ fixed firefighting system in extinguishing cargo hold fire, sufficient number of $CO_2$ bottles in accordance with manufacturer's instructions must be released to provide the required concentration of gas in the hold.

**What happened?**

While approaching port, a container ship suffered a fire that started in an above deck container on the foredeck. The container was carrying a cargo of activated carbon pellets.
As shore-based fire fighting resources were not able to board the ship due to high winds and seas, the crew fought the fire. The fire was eventually extinguished and the damaged containers off-loaded.

**Why did it happen?**

The exact source of ignition could not be determined. However, since activated carbon pellets are self-heating, any increase in heat might have contributed to the likelihood of the fire.

**What can we learn?**

Activated carbon pellets are self-heating. Although in small packages they are not required to be classified as dangerous goods under the IMDG Code, they may still pose a
fire risk.

**FIRE (FSI 12)**

**What happened?**

While loading a cargo of benzene into 12 tanks, a vessel was boarded by a cargo surveyor. The pumpman observed the cargo surveyor taking samples from the aftermost tanks and working forward. Approximately 25 minutes after the last tank was loaded, an explosion occurred and fire developed near the forward part of the cargo area. The fire was extinguished in several minutes by the Master and another crewmember using deck monitors. The no. 1 port cargo tank lid was blown off and other damage was noted on nearby structures and pipework. The cargo surveyor was injured.

**Why did it happen?**

A static charge had developed in the cargo tank prior to the explosion. The cargo surveyor used a metallic can attached to a fiber rope to obtain samples which caused a discharge of static electricity within the tank. The cargo surveyor was not aware of the risks associated with the equipment he was using and had not followed established procedures. Vessel crewmembers did not confer with the cargo surveyor regarding his methods and equipment.

**What can we learn?**

Cargo surveyors may not understand the risks of their activities and may not employ safety procedures adequate for a particular cargo or vessel.
Deck officers should ensure that cargo surveyors equipment and procedures are safe.

**What happened?**

A fire broke out in the provision room of a general cargo ship having only a crew of five. The crew were unable to contain the fire and the fire spread to the accommodation. The Master was forced to abandon the ship and all crew were rescued by a helicopter. The whole accommodation block was subsequently burned out.

**Why did it happen?**

There was only one self-contained breathing apparatus (SCBA) set on board which inhibited the capability of the crew in fighting the fire. A $CO_2$ extinguisher was used to knock down the fire; however, it re-ignited as the space was not effectively sealed. The spread of the fire into the accommodation could not be controlled because the crew failed to follow boundary cooling techniques and monitor all sides of the provision room. Further, the senior officers had failed to take control of the fire party, to assess the situation and consider using different medium to fight the fire.

**What can we learn?**

$CO_2$ can knock down a fire quickly, however its cooling effect is limited. To prevent re- ignition, the space containing the seat of fire should be effectively sealed.
When applying boundary cooling to contain a fire, all sides of the space should be monitored.
Smoke helmets are not as effective as SCBA's for fire-fighting, especially on vessels with only a small number of crew. The Maritime Safety Committee has a circular highlighting problems associated with the use of smoke helmet-type breathing apparatus (MSC/Circ.1085).
The fire party should be led by a more senior officer, who should use his experience and knowledge to assess the situation and consider the most appropriate means to fight the fire.

**What happened?**

While at anchor, the crew was engaged in cleaning and painting the topside ballast tank as part of an ongoing maintenance program. The tank had been opened some days before and the Mate tested the tank for oxygen levels a few times and found them to be 21%. After approximately 2 hours of painting, using a spray gun to apply epoxy paint with thinners, there was an explosion which blew the tank apart. Five crew members died and three were missing.

**Why did it happen?**

The epoxy paint contained more than 30% thinners and spray painting using such a mixture can create vapour concentrations within the explosive range of the mixture's compounds. The tank was ventilated using a fan blowing air through a manhole and a compressed air line situated in the tank which was inadequate. A cargo light was used to illuminate the work area which was not intrinsically safe/explosion proof.

**What can we learn?**

The crew needs to appreciate the potential of an explosion when spray painting. The safety management system should set out procedures for painting in enclosed spaces and the material safety data sheets which provide flash points, explosive limits and ignition points for the paint base, hardener and thinner should be onboard the vessel.

**What Happened?**

During a short transit to the next port, the crew started tank cleaning operations. They fitted a water-driven fan to ventilate the tank with ducting extending to the lower portion of the tank.
After completing the ventilation of the tank, two crew members entered the tank to remove residual oil. There was an explosion which tore away bulk heads to adjoining tanks and A-1 Jet Fuel and Kerosene slops were ignited. The hull was breached in

way of the tanks and the engine room and the ship flooded rapidly, developed a starboard list and sank. The crew escaped by jumping into the sea and seven were recovered by passing ships, 3 died and 6 were missing.

**Why did it happen?**

The source of ignition was not identified; however, it was highly probable either due to a discharge of static electricity from winter clothing or from the ventilation ducting, or to an ordinary metal paint can that was used to carry tools into the tanks coming in contact with metal and causing a spark. The crew was under pressure to complete the tank cleaning operation due to the short duration of the transit.

**What can we learn?**

There is a need to ensure sufficient time for tank cleaning operations to minimise the possibility of missing steps or not paying adequate attention to the operation.
Crews are required to take training in tanker operations; however, there is a need to continually reinforce that training onboard and to ensure that it is properly applied.

**What happened?**

The ship was alongside with containers onboard containing explosives. An engineer was transferring heavy fuel oil and did not monitor the operation. The tank and vents filled resulted in the fuel oil becoming mixed with diesel fuel in another tank. The oily mixture continued up vent piping to a vent collection chamber where a flange was not connected and spilled on the deck and down into engine room spaces below. The oily mixture ignited, the fire developed rapidly and the engine room spaces filled with smoke. The crew and shore fire fighting personnel fought the fire but were hindered by the smoke. They tried to activate the $CO_2$ system twice and thought that it had discharged. After several hours of effort, the fire was brought under control and extinguished. Two crew members died.

**Why did it happen?**

The ignition source could not be determined but was probably as a result of some of the oily mixture coming in contact with an incinerator.
The engineer did not properly monitor the fuel transfer operation and the tank level monitoring systems were fitted with alarms which had been over-ridden by placing a pencil in a toggle switch used to acknowledge alarms.

The venting system was in the process of being cleared of blockages and several flanges had been disconnected at a collection chamber where several vents come together.
Fire and watertight doors were open which allowed the smoke to enter various spaces including the Fire Control Room and $CO_2$ room, hampering the response and an attempt to release the $CO_2$ manually.

**What can we learn?**

With the venting system being open to clear blockages, procedures with physical "lock-outs" were needed to ensure there is no transferring of fuel.
If automatic alarm systems are not functioning, a safe guard that was required is not being maintained. Appropriate actions by the company or officer responsible have to be taken to either repair the system or introduce procedures to ensure the safe-guard is maintained.
The ship's fire response plan should be followed. The less than adequate command and control of the response resulted in delays and uncoordinated actions such as the failure to establish fire boundaries and communications and to activate the $CO_2$ system.
A lack of training and awareness of the operation of certain fitted fire-fighting systems underlines the need to be able to demonstrate their ability to function through drills and exercises.
Awareness of possible means to evacuate an engine room may have allowed the crew members to consider alternative escape routes.

**What happened?**

The ship was alongside undergoing repairs following a period of time that it had been laid up.
During the process of replacing an expansion joint in one of the tanks, it was realized there was a quantity of Premium Motor Spirit in the tank. An electrical submersible pump was to be used to pump the oily water mixture. The pump was lowered in the tanks and soon after it was started, an explosion occurred severely rupturing the cargo tanks. As a result of the explosion, 6 shore workers and one of the ship's officers died. As well, 1 shore worker and another of the ship's officers were admitted to hospital.

**Why did it happen?**

There was an explosive meter on board and tanks had been tested some time before; however, there is nothing to indicate that the atmosphere in the tank had been tested on the day of the explosion.
The ship's eduction pump was not used and the electrical submersible pump that was used was faulty or not intrinsically safe to be used in such conditions.

**What can we learn?**

When working with oily water mixtures in tanks, ship's crew members should not assume that the tank is gas free and should only use equipment designed for such purposes.

**FIRE (FSI 11)**

**What happened?**

A cargo of medium-density fibreboards (MDF) caught fire during loading.

**Why did it happen?**

The fire was probably started by a discarded lit cigarette end.

**What can we learn?**

Strictly adhere to the prohibition of smoking. Smoke only in designated areas where it is safe to do so and fully extinguish cigarette ends.

**EXPLOSION**

**What happened?**

An explosion occurred during tank cleaning operations resulting in severe injuries and the death of two people.

**Why did it happen?**

Sparks from grind ing work on the tanker's catwalk caused the ignition through an open tank cleaning hatch.

**What can we learn?**

Always follow strictly the safety procedures and adhere to safe working practices.
Cutting and other hot works should not be conducted while tank cleaning, gas-freeing and other tank operation where flammable gas and vapour may come out from the tanks.

**What happened?**

An economizer (waste heat boiler) on a passenger ship ruptured during sea trials after a repair period. Two people died from steam burns and three others were injured as a result of the failure.

**Why did it happen?**

The shipboard economizers were not to be used, or be pressurized, during the sea trials. The necessary steam was to be provided by a temporarily installed oil fired boiler. The engineers decided not to drain the water from the economizers. Instead, they intended to vent them by using the hand easing gear to lift the economizer safety valves from their seats. They did not realize that the safety valves on the port economizer had corroded in the closed position and that they were not venting the economizer despite the position of the indicators on the hand easing gear. When sufficient pressure developed, the port economizer ruptured in way of a circumferential welded joint.

**What can we learn?**

The pre-occupation of the engineering staff with the shipboard repairs and sea trials may have prevented them from thoroughly considering the consequences of not draining the economizers.
The work underway may also have interfered with the engine room staff making appropriate engine room rounds to verify that the economizer was actually being vented.
The investigation into the casualty also revealed inadequacies in the Safety Management System (SMS). The SMS did not contain adequate procedures to ensure the maintenance and safe operation of the steam generating plant. Adequate risk assessment of boiler safety devices, alarms, means of control and indication; and strict adherence to sea trials procedures may have prevented this accident.