THE COMMONWEALTH OF THE BAHAMAS

M.v. Pine Galaxy

IMO Number 9272682

Official Number 8000842

Report of the marine safety investigation into an engine room fire which resulted in the death of an Able Body Seaman on 13th August 2014

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1 GLOSSARY OF ABBREVIATIONS AND ACRONYMS

AB	Able Body Seaman
BMA	Bahamas Maritime Authority
COTP	Captain of the port
CPR	Cardiopulmonary Resuscitation
IMO	International Maritime Organization
KVA	Kilo Volt Ampere
KW	Kilowatt
Length BP	Length between perpendiculars
MSDS	Material Safety Data Sheet
MSO	Marine Safety Office
MT	Metric ton
NKK	Nippon Kaiji Kyokai
Psi	Pounds per square inch
SCBA	Self-contained breathing apparatus
USA	United States of America
USCG	United States Coast Guard
UTC	Universal Time Coordinated

All times noted in this report are given in the style of the standard 24-hour clock without additional annotations. The vessel time used on board at the time of the incident was UTC -7.

2 SUMMARY

2.1 On 09 August 2014, the Pine Galaxy departed Los Angeles, USA for a scheduled voyage to Yeosu, Korea carrying a multi-grade cargo of Tetramar, Canola Oil and several grades of Neutral Oil comprising 12,949.326 MT.

2.2 During the period of 10 August 2014 to 12 August 2014, routine maintenance on the No.3 generator was conducted. The maintenance was completed by late afternoon on 12 August and subsequently, the test run was completed by the Chief Engineer.

2.3 On 13 August 2014, at 0220 hours the Second Assistant Engineer started the No.3 generator to complete further test runs and stopped the No.2 generator at 0330 hours.

2.4 The thermometer on the lube oil system was damaged during routine maintenance on the generator. The duty engineer decided to replace the thermometer and in doing so, removed the complete pocket assembly instead of only the thermometer causing lube oil to spray vertically at approximately 4.5 bar pressure. The lube oil came into direct contact with the exhaust manifold which had an operating temperature of approximately 320° Celsius.

2.5 A fire started immediately at the deckhead area above the generator and passed along the cable run towards the engine room workshop.

2.6 The No. 3 generator tripped, causing a blackout. Subsequently, the emergency generator came online.

2.7 After some attempts to extinguish the fire it was decided to activate the CO_2 system. A fire team was formed 25 minutes after the CO_2 system was activated, consisting of the AB and Oiler who were instructed to enter the engine room to monitor the situation and report back. During this operation, the AB was unable to return back and was subsequently evacuated by the search and rescue team but was unable to survive from the injuries sustained.

2.8 At 1440 hrs the emergency generator failed and could not be restarted. An attempt was then made to start the No. 1 generator locally, which resulted in another fire due to electrical shorting of cable wires. The generator was immediately stopped and the fire was extinguished.

2.9 The operator's technical department instructed the vessel to leave the engine room exactly as it remained and not enter or touch anything.

2.10 On 18 August the tugboat Millennium Falcon arrived on scene with a technician from the builder's yard to try and repair the emergency generator. The vessel was taken under tow at 1945 hrs and was towed to the port of San Francisco where the vessel arrived on 27th August.

2.11 The extent of damage sustained resulted in the vessel remaining without power for 14 days.

2.12 With the exception of one fatality, no further injuries were reported. Additionally, no marine pollution was reported by the vessel or local authorities.

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3 DETAILS OF INVOLVED VESSEL(s) AND OTHER MATTERS

3.1 Details of vessel

3.1.1 The Pine Galaxy is a chemical/products tanker built in the Shin Kurushima Dockyard, Japan and registered in the port of Nassau, Bahamas. The vessel was technically managed and operated by Unix Line Pte Ltd. The vessel had welded steel construction and a raised forecastle. The accommodation and machinery spaces were situated aft.

3.1.2 The vessel was delivered on 12 August 2004 and had been named the Pine Galaxy since delivery.

3.1.3 The vessel had the following principal particulars:

Official Number	-	8000842
IMO Number	-	9272682
Length Overall	-	147.83 metres
Length BP	-	141.00 metres
Breadth	-	24.23 metres
Depth	-	12.85 metres
Gross Tonnage	-	12105.0 m. tons
Net Tonnage	-	6352.0 m. tons
Deadweight	-	19997.0 m. tons
Call Sign	-	C6TT5

3.1.4 The vessel was powered by a Kobe Diesel main engine, producing 8471 KW to drive a single fixed bladed propeller. Additionally, the vessel had three Yanmar 6N18AL-UV generators with capacity of 625 KVA each.

3.1.5 The cargo was carried in a total of twenty-two (22) cargo tanks that were arranged as 1 – 10 port and starboard with two slop tanks located aft of the cargo tanks.

3.1.6 The vessel was fitted with a nitrogen generating system.

3.2 Vessel Certification

3.2.1 The vessel was first registered with The Bahamas Maritime Authority (BMA) in 2004 and was classed with Nippon Kaiji Kyokai (NKK) classification society. At the time of incident, the vessel complied with all statutory and international requirements and certification.

3.2.2 The last Flag State annual inspection was conducted at the port of Vancouver, British Columbia on 23 August 2013. There were no observations or deficiencies raised.

3.2.3 The vessel had a Port State Control Inspection at the port of San Francisco on 19 July 2014 with zero deficiencies recorded. Fire and safety drills had been conducted at that time.

3.3 Details of Crew:

3.3.1 The vessel was manned with a total of 22 crew members. The Officers were all South Korean and the ratings a combination of South Korean and Chinese.

Rank	Number
Master	1
Chief Officer	1
Second Officer	2
Third Officer	1
Apprentice Officer	1
Chief Engineer	1
First Engineer	1
Second Assistant Engineer	1
Second Assistant Engineer- C	1
Bosun	1
AB	3
Ordinary Seaman	2
Oilers	3
Wiper	1
Cook	1
Mess Boy	1
Total	**22**

Table 1: Rank and number of crew members onboard

3.3.2 The Master was on his first assignment in the rank, he had joined the vessel in February 2014 as Chief Officer and was promoted onboard as Master on 21 May 2014.

3.3.3 The Second Assistant Engineer was on his third assignment in the rank and had a total experience of 24 months in the rank. He joined the vessel on 23 February 2014.

3.3.4 The Second Assistant Engineer and AB had both signed on the vessel on 23 February 2014 and had completed the standard familiarization training which was completed on 06 March 2014.

3.3.5 The Second Assistant Engineer held a certificate of competency issued by South Korea to serve as 3rd class engineer on 31 January 2011. He also held a Bahamas endorsement issued on 26 March 2014 and valid through 30 Jan 2016.

3.3.6 All officers held valid national (South Korea) and Bahamas license endorsements.

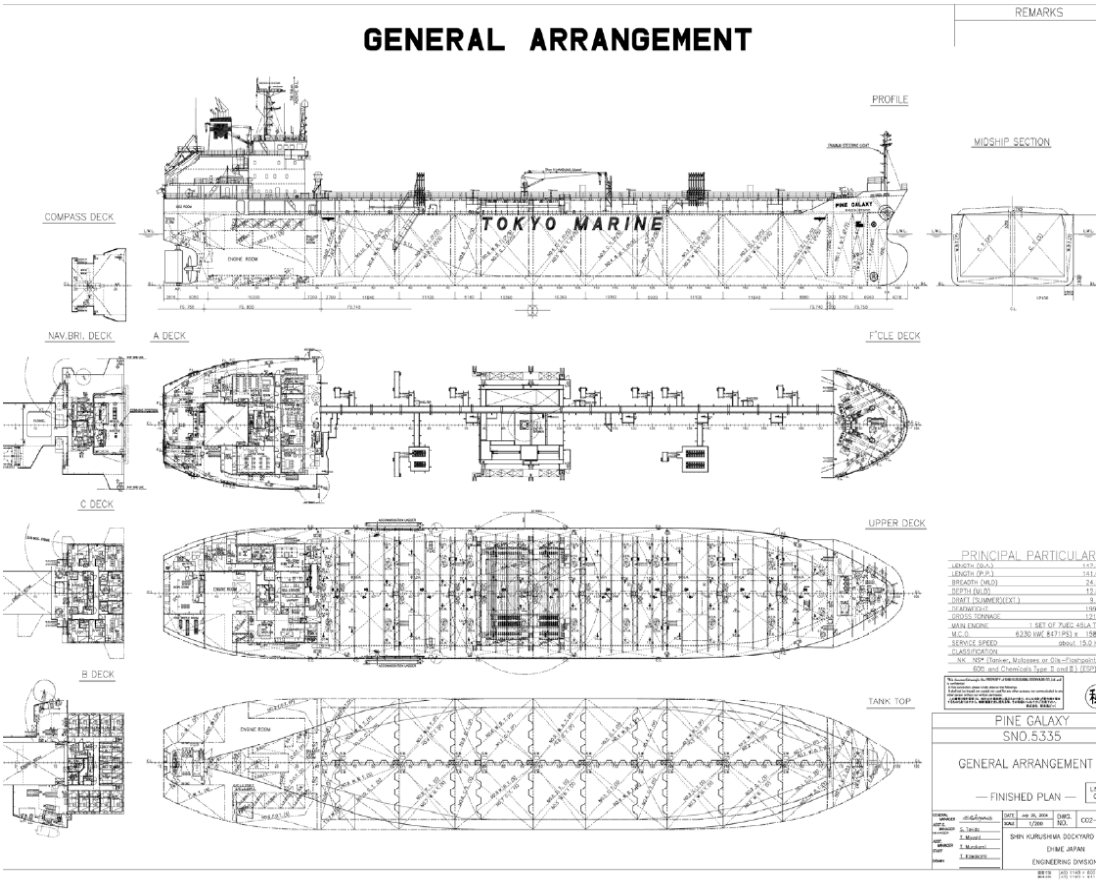

Figure 1: Pine Galaxy General Arrangement plan

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4 NARRATIVE OF EVENTS

4.1 On 9 August 2014, the vessel departed Los Angeles, USA and was carrying a multi-grade cargo of Tetramar, Canola Oil and several grades of Neutral Oil comprising 12,949.326MT.

4.2 The vessel was undertaking a scheduled voyage from Los Angeles, USA to Yeosu, Korea. The machinery space was not classed for unmanned operation. The engine room was always manned by one duty engineer and one engine room rating.

4.3 During the period from 10 August 2014 to 12 August 2014, the engineering staff conducted routine maintenance on the No. 3 generator.

4.4 On 12 August 2014 around 1600 hours the maintenance was completed and the test run was conducted for one hour by the Chief Engineer. After a successful test run, he finished work for the day. The exhaust manifold cover was not replaced at this time.

4.5 On 13 August, at 0220 hours the duty engineer decided to operate the No. 3 generator for additional test purposes[1]. The No. 3 generator was started and subsequently, at 0330 hours the No. 2 generator was stopped and the No. 3 was running at full load for sea passage.

4.6 The generator was running for an extended period with the exhaust manifold cover removed for checking for any leaks.

4.7 At around 0415 hours the Second Assistant Engineer decided to replace the thermometer on the lube oil system and acquired the necessary spare from the store. The old unit had been damaged during the routine maintenance. The spare came with the brass pocket attached.

4.8 The Second Assistant Engineer went to the No. 3 generator with the spare thermometer and pocket. Refer to figure 2, the pocket is marked as ‘B’. He also had a spanner for the correct size for the pocket only. As he removed the pocket, the lube oil escaped through the hole at approximately 4.5 bar pressure contacting the exhaust manifold and igniting instantaneously.

[1] Operator’s internal investigation revealed that the Chief Engineer verbally instructed the Second Assistant Engineer to operate the No. 3 generator for additional test purposes.

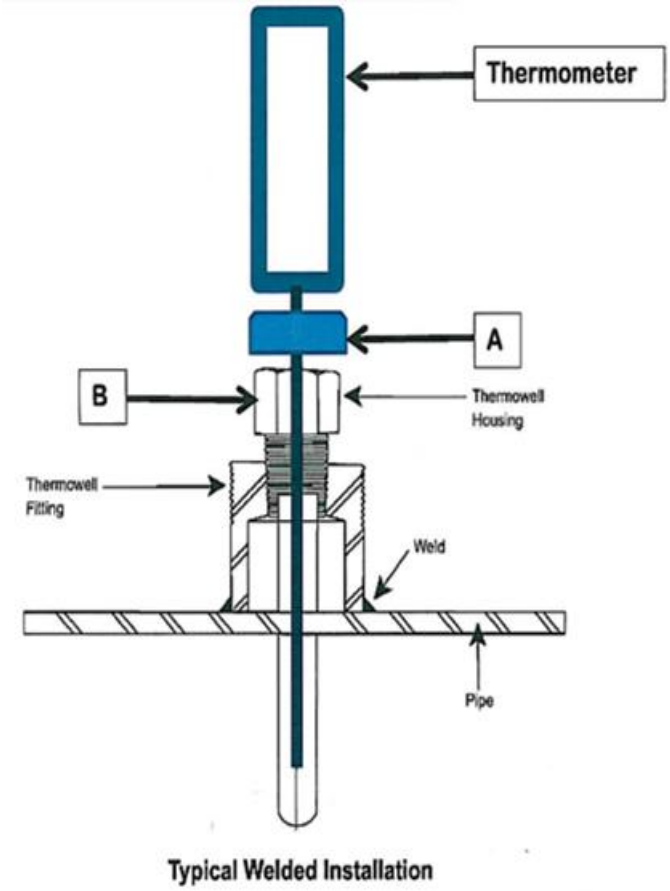

Figure 2: Thermometer installation diagram

4.9 The Second Assistant Engineer was sprayed slightly with hot oil, without any burns reported. He dropped the replacement pocket, thermometer and spanner beside the generator before he exited the vicinity.

Figure 3: Replacement pocket, thermometer and spanner

Figure 4: Old damaged pocket

4.10 The No. 3 generator tripped, causing a blackout. It was not possible to identify why it tripped as there was no automatic logging feature for engine room alarms but likely this was due to low lube oil pressure.

4.11 The fire started immediately and was likely enhanced by the oil spraying vertically on the cable run.

4.12 The engineering staff tried to call the Chief Engineer to advise of the problem and attempted to fight the fire using portable extinguishers. No fire alarm was activated at this stage.

4.13 The fuel shut off valves were activated.

4.14 Initial efforts to fight the fire was made from the main deck cross alleyway inside the accommodation area through the engineers changing room. There was no coordinated response to the initial fire and no coordinated attack was made to fight the fire. There was no muster held, as the Master had sighted that everybody was present at that time.

4.15 A team was created and fireman's suits were donned. The team was equipped with SCBA sets and instructed to enter the engine room from the poop deck via the boiler flat, but this was directly above the seat of the fire and access was not possible despite several attempts.

4.16 The Master made the decision to release the CO_2 into the engine room and conducted several full crew roll calls before he instructed the Chief Engineer to enter the CO_2 room via a vertical ladder from the poop deck and activate the CO_2 system. Due to presence of smoke in the alleyways near the fire station, where the remote CO2 release station was located, it was decided to release CO2 into the engine room by using local controls located in the CO2 room.

4.17 The CO_2 room was provided with one emergency light located in the center of the space. The Chief Engineer entered the space and prepared the system by operating the section valve as instructed (note – the vessel only had a single section system fitted). He released the CO_2 manually and reported hearing the gas release at which point he departed the CO_2 room.

4.18 Subsequent investigation revealed that he had activated a standard bottle, not one of the two marked pilot bottles. It was discovered that only one of the forty-three CO_2 cylinders discharged into the engine room. The pilot bottles were painted in identical colours to the standard bottles but were fitted with small plastic tags to identify them as pilot cylinders.

4.19 The Master contacted his operator's technical department and reported the situation. The office staff indicated that they were in contact with the United States Coast Guard Rescue Co-ordination Centre in Alameda, CA via telephone.

4.20 The Master was monitoring the situation on-board with his other officers for twenty-five (25) minutes after activation of the CO_2 system. They were still observing smoke emitting from the funnel and through the No. 1 ER fan vent.

4.21 At this point in time, no attempts had been made for boundary cooling or monitoring of temperatures in the engine room or on adjacent bulkheads.

4.22 The Master and Engineer Officers decided that they needed to enter the engine room to inspect the area and check for any continued fire, on the basis that the CO_2 system had been discharged.

4.23 Arrangements were made to send a fire team into the engine room via the emergency escape located in the steering flat and two crew members, the Oiler and AB were the designated fire team. The fire team donned the fireman's suits and SCBA set for the entry. The tag line[2] was not used due to the vertical access. However, the fire team was instructed to "*hold hands*" after entering the engine room from the access trunk.

4.24 The fire team was instructed to sight the fire area and report if the fire was suppressed or not and subsequently leave the vicinity.

4.25 The fire team entered the engine room as instructed but the Oiler indicated that he told the AB to remain at the entrance while he went to check the situation.

4.26 The Oiler proceeded towards the area of the fire, climbing up two decks until he saw a deep red glow from the workshop area. He then retraced his route to the lower plates but found that the AB was not in the last known position.

4.27 At that time, Oiler's low air pressure alarm started to sound so he made the assumption that the AB had probably had a low-pressure alarm as well and had exited the engine room, so he decided to exit via the emergency escape trunk.

4.28 On emerging into the steering flat it became evident that the AB had not exited the engine room, so the Master instructed the First Engineer and Oiler No. 2 to don SCBA's and enter to conduct a search for the AB. This search and rescue effort was unsuccessful and the two personnel left the engine room after only a few minutes of searching.

4.29 Subsequently, the Oiler, Second Assistant Engineer- C and another AB[3] entered to continue searching for the missing AB, who was found by the Oiler on the stairs, port side of the engine and 1.5 decks above the bottom plates. The casualty was found with his SCBA removed, helmet missing and gloves off.

[2] A single piece of cord connecting fire team members together with a line
[3] The vessel had 3 AB's on board.

Figure 5: Location where AB was found

Figure 6: Removed SCABA set of AB

4.30 The casualty was moved to the lower plates and taken out from the engine room via the vertical escape trunk.

4.31 CPR was conducted in the steering flat for an extended period of time (over 3 hours) until instructed to stop by operator's technical department.

4.32 At 0610 hours, Master was informed that flames were still observed in the engine room and he instructed Chief officer to enter the area to extinguish the fire with fire hose. This was subsequently reported successful.

4.33 As soon as all crewmembers were withdrawn from the engine room, the space was fully closed up again. Boundary cooling was commenced and a thermometer was hung through the skylight (MMC cargo thermometer with remote readout) to monitor the temperature. The temperature was found to be 41° Celsius and it was not increasing.

4.34 At 1440 hours the emergency generator stopped and was not able to be restarted. The reason for the failure of the emergency generator was later determined to be a faulty voltage regulator.

4.35 The Master then instructed the Chief Officer and Second Assistant Engineer to enter the engine room wearing a SCBA to inspect the area and report. They indicated that the oxygen levels were 20.9% and that no fire was visible in the affected area.

4.36 After some discussion between the Master and operator's technical department, it was decided to open the engine room and send people in to start another generator. Generator No. 1 was started and immediately started sparking resulting in a fire in the cabling run in the workshop area.

4.37 The generator was immediately stopped and the fire was extinguished. No further attempts to start the generator was made. A fire watch was posted near to the affected area.

4.38 The remaining crew members were mustered on the bridge and the Master informed them all that they would sleep on the bridge deck that night due to the lack of power and lighting.

4.39 On 15 August, around 1200 hours the USCG cutter "Stratton" arrived on scene.

4.40 Shortly thereafter the USCG cutter sent personnel onboard the Pine Galaxy to conduct a welfare and medical check of the crew, they also supplied flashlight batteries, some rechargeable emergency lights and some food.

4.41 Later in the afternoon USCG officers returned to conduct an inspection of the engine room and supplied a portable generator, portable GPS and a small fire pump. A USCG engineer inspected the emergency generator and confirmed that repair was not possible without spare parts.

4.42 On 16 August the USCG cutter Stratton notified the Pine Galaxy that they had to leave the location due to an onboard medical emergency.

4.43 On 18 August, the tugboat Millennium Falcon arrived on scene with a technician from the builder's yard to try and repair the emergency generator. The vessel was taken under tow at 1945 hrs and was towed to the port of San Francisco where the vessel arrived on 27 August.

4.44 The San Francisco USCG Marine Safety Office (MSO) created an incident response team and worked with the representatives from the operator's technical department and the tug company to create an incident action plan and a dead ship tow plan to allow the Pine Galaxy to safely enter the port of San Francisco.

4.45 The entry into port went as planned and the vessel was berthed at San Francisco berth 80 initially to allow the cargo tanks containing explosive cargo to be purged with nitrogen.

4.46 On 28 August the vessel was cleared by USCG COTP to be moved to the repair berth at dry-dock facility where repairs were conducted.

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5 DAMAGES AND CASUALTIES

5.1 The AB who was part of the fire team, which was sent to sight and report any continued fire was the only casualty. The fire team consisting of an Oiler and AB was sent to engine room 25 minutes after the activation of the CO_2 system. However, the AB did not return and was subsequently found unconscious during the search and rescue effort. CPR was maintained for an extended period of time (over 3 hours) but proved unsuccessful and the AB was pronounced dead on 13 August 2014.

5.2 There was minimal structural damage overall and localised deck plating damage in vicinity of the fire.

5.3 Numerous light fittings were destroyed.

5.4 The cabling from the generators to the main switchboard located in the engine control room was heavily damaged. Refer to Appendix 1.

5.5 Generator No. 1 had some oil residue on its surface but sustained negligible heat or direct fire damage. Generator No. 2 had a significant amount of oil on it, especially on the side facing generator No. 3.

Figure 7: Diesel engine of generator number 1

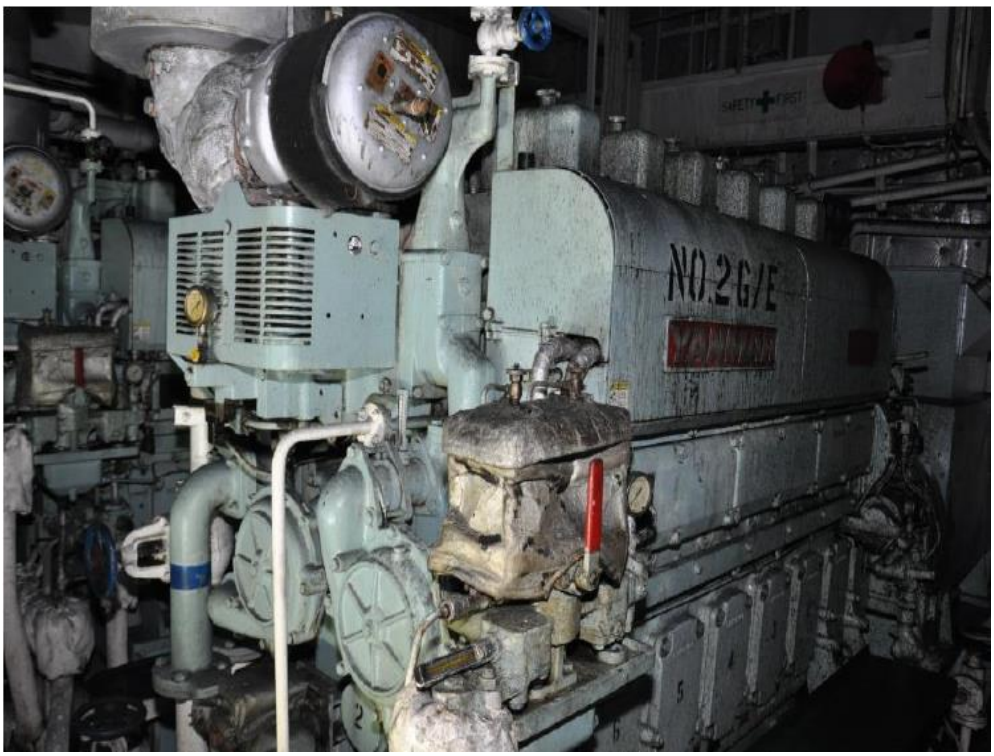

Figure 8: Diesel engine of generator number 2

5.6 Items directly above generators No.2 and No.3 showed signs of significant heat and fire damage, including the cables that carried power from the diesel generators to the engine control room.

5.7 The workshop area was subject to heavy fire and smoke damage.

5.8 The reason for the failure of the emergency generator was later determined to be a faulty voltage regulator.

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6 ANALYSIS AND DISCUSSION

6.1 Aim

6.1.1 The purpose of the analysis is to determine the contributory causes and circumstances of the accident as a basis for making recommendations to prevent similar accidents occurring in the future.

6.2 Risk assessment and maintenance program

6.2.1 Second Assistant Engineer was the person in charge of the generators and it was within his job description.

6.2.2 Generator No. 3 was put to service without the exhaust manifold cover in place. No explanation was given as to why the generator was run for an extended period of time with the exhaust manifold cover removed, other than it was necessary for checking for any leaks.

6.2.3 The thermometer on the lube oil system was damaged during the routine maintenance on generator No.3. To replace the thermometer, the Second Assistant Engineer removed the complete pocket assembly instead of only the thermometer causing lube oil to spray vertically at approximately 4.5 bar pressure and directly contacting the exhaust manifold having a temperature of around 320° Celsius, while the generator was running.

6.2.4 The Material Safety Data Sheet (MSDS) indicated that the lube oil had an open cup flashpoint of 185° Celsius. This means that, if a cup of the oil is heated to 185° Celsius in the presence of a competent ignition source, a flash fire can propagate through the vapour.

Figure 9: Replacement probe and pocket

Figure 10: Location of probe on lube oil system

6.2.5 The fire started immediately at the deck head area above the generator and passed along the cable run towards the engine room workshop.

Figure 11: Workshop cable runs from generators to the main switchboard

Figure 12: Damaged cables

6.2.6 Considering the exhaust manifold was not in place and the Second Assistant Engineer decided to replace the thermometer on his own without Chief Engineer's knowledge. Thus, demonstrating a failure to identify the risk and hazards associated with the task.

6.2.7 From the evidence available at the time of the investigation, it cannot be determined if the risk assessment procedure for unplanned maintenance was not followed or unavailable on board. Had an adequate risk assessment been conducted, the risk associated with this task could have been identified before the task was initiated.

6.3 Fire-fighting efforts

6.3.1 The engineering staff tried to telephone the Chief Engineer to inform about the fire and attempted to fight the fire using portable extinguishers. No fire alarm was activated as per fire in engine room procedures (Refer to Appendix III).

6.3.2 There was no coordinated response to the initial fire, initial efforts were made from the main deck cross alleyway inside the accommodation area through the engineers changing room. No muster was held and no coordinated effort was made to fight the fire. As everyone was already present at that time, Master considered that it was no longer necessary to call for muster. The proper muster could have facilitated to recognise emergency response duties of individuals and a more coordinated response to fire could have been initiated.

6.4 Fixed fire-fighting system

6.4.1 The CO_2 system had been serviced by shore staff on 05 July 2013.

6.4.2 The emergency lighting in the CO_2 room (located one deck below the poop deck) consisted of one light located in the middle of the room.

6.4.3 The CO_2 pilot bottles were not prominently marked to differentiate them from the regular bottles, the only marking consisted of a small plastic tag hanging around the neck of the cylinder.

Figure 13: Tags on pilot bottles

6.4.4 All bottles were painted the same dark green colour.

6.4.5 When the decision was made to activate the CO_2 system, the Chief Engineer activated a standard bottle and not one of the two marked pilot bottles.

6.4.6 The vessel had posted instructions for the operation of the engine room CO_2 system at the operating location in the foam room and also at the manual operation station in the CO_2 room. These were direct copies from the CO_2 system manual.

6.4.7 Nowhere in the company manuals or posted instructions did it indicate how long a space should be left sealed after releasing of CO_2.

6.4.8 The Kawasaki Safety Services Industries Limited operating manual for the fixed CO_2 system fitted on the Pine Galaxy (document reference G09-3-216R2.doc) stated the following:

This system is used in the event of a fire and must, therefore, always be ready for use. By its nature, this type of emergency system requires regular inspection and maintenance to ensure proper function, which can easily be overlooked. We ask that a properly trained and knowledgeable individual be assigned responsibility for the proper implementation of periodic tests of the system

The manual also addressed the area after use of the CO_2

After CO_2 is discharged in an area, follow the precautions below:

(1) The area of discharge lacks oxygen and may lead to suffocation. Entry prior to ventilation requires a hose type or self-contained breathing apparatus. Do not wear an activated carbon mask.

(2) Ventilate the area after you have verified that the fire has been completely extinguished.

6.4.9 No efforts were initially made by the onboard staff to monitor the machinery space temperatures or to conduct boundary cooling, prior to sending a fire team into the space 25 minutes after activation of the CO_2 system.

6.4.10 The vessel was also fitted with a Kashiwa Hyper Mist fixed water-based local application fire-fighting system covering the following areas of the machinery space:

- Main engine
- Diesel generator engines
- Auxiliary Boiler
- Incinerator
- Fuel Oil Purifiers

6.4.11 The hyper mist system was a manual system and connected to the main switchboard and not emergency power system. No effort was made to activate the system immediately after fire was observed, despite a local activation button being located adjacent to the generators.

6.5 **Training and competency**

6.5.1 The crew members underwent familiarization training on board and while this did include a requirement to understand the use of the CO_2 system it did not specifically mention the main and back up operating system.

6.5.2 At the time of the fire, the crew members tried to contact the Chief Engineer and did not raise any fire alarm as per fire in engine room procedures (refer to Appendix III) therefore delaying the overall reaction time available to extinguish the fire through manual fixed application means.

6.5.3 The Chief Engineer activated a standard bottle and not one of the two marked pilot bottles.

6.5.4 The ship staff stated that they had not conducted any exercise involving the release of CO_2 from the CO_2 room.

6.5.5 The company emergency response and salvage manual states the following (M – 09 – Sec – 05 - Revision – 01 – Page –1)

5 TRAINING & DRILLS

The crew shall be educated and trained aboard simulating cases likely to happen, at fixed frequency to give them necessary knowledge and information about emergency procedures and get accustomed to using emergency

appliances and equipment. The time interval of the training and education aboard should not be less than that required by the provisions of SOLAS. The Masters are required to ensure that by the training and education the crew shall be made well aware of their roles and responsibility to execute their roles properly and become to be capable to perform the roles, lack of which will result in disastrous conclusion such as death of human and/or serious environment pollution.

The following knowledge shall also be given to the crew for safety of their working on the scene, through the education and training.
a) Effect of vapours on personnel including combustion gas which is generally poisonous when chemicals burn and necessity of using protective wear, breathing apparatus and other safety equipment
b) Oxygen deficiency and necessity of measuring of oxygen content and existence of toxic vapour when approaches the scene.
c) Hazard of cargoes
d) Precautions for working in darkness and other unfavourable conditions
e) First aid to a victim in various cases
f) A general familiarization with the mitigation procedure.

When any crew is replaced the new joiner has to be provided familiarization regarding safety & environment protection before the vessels sails from port or takes over the new duties whichever is earlier.

Emergency drills shall be conducted at monthly intervals as per the annual drill schedule provided by the Company. All drills conducted aboard the vessel should be documented in the records of drills and the ship's log as necessary.

6.5.6 The hyper mist system was included in the familiarization training but the interviews with the ship's Officers after this fire incident indicated that they were not aware the hyper mist pump was only powered from the main switchboard.

6.5.7 Even though the local activation button of the hyper mist system was adjacent to the generator, no effort was made to activate the system just after the fire was observed and before the blackout.

6.5.8 After the release of CO_2, no attempts had been made for boundary cooling or monitoring of temperatures in the engine room or on adjacent bulkheads.

6.5.9 The fire team (Oiler and AB), sent to the engine room after 25 minutes of activating the CO_2 system, did not use a tag line and were instructed to "*hold hands*". As they entered the engine room, the Oiler instructed the AB to remain at the entrance to the space on the lower plates aft of the main engine, while he went to check the situation. However, on return the AB was not found at the location and was subsequently found unconscious during the search and rescue efforts.

6.6 **Drills onboard:**

6.6.1 The vessel maintained a drill schedule and record, which indicated that the last engine room fire drill was held on 14 December 2013. There was no indication or requirement that the staff conducted a drill to release CO_2 using the manual secondary system. The ship staff stated that they had not conducted any exercise involving the release of CO_2 from the CO_2 room.

6.6.2 No personnel was designated on the muster list as the responsible person to activate the CO_2 system. Several references were made to indicate that the activation was only on the Master's orders.

6.6.3 Additionally, no fire drills were conducted to exercise the operation of the hyper mist system. An overall lack of understanding resulted in this system not being considered for the purpose of extinguishing an engine room fire. The operation of such a system and its system limitations where not understood and in all probability the reasoning behind its misuse.

6.7 SCBA sets onboard

6.7.1 The SCBA used by the AB was a Draeger, Model PA 90 unit manufactured in 1994. The unit was subjected to ka Posi3 test by Global Fire & Safety Inc, Oakland, California on 15 Dec 2015.

6.7.2 The test results indicated that the SCBA passed its functional tests, but the following faults were recorded:

- The gauge accuracy failed at its lowest pressure test by 16 psi under range. Based on this information the user will have had less air than indicated on the gauge.
- The face mask was found with a broken strap on the head harness.
- A torn diaphragm on the 2nd stage regulator.

6.7.3 Global Fire & Safety concluded that it was likely the unit had not undergone a complete overhaul as required.

6.7.4 Draeger indicated that the 2nd stage regulator diaphragm should be inspected after every use and every six months regardless of use and should be replaced every three years.

6.7.5 The SCBA in question was manufactured in 1994 and the model was discontinued by Draeger in 1996.

6.7.6 The Draeger SCBA unit first appeared onboard the Pine Galaxy sometime between 2010 and 2011 when it was listed on the annual service sheet by the shore-based service company used by the operator.

6.7.7 There is no documentation to verify if the ship staff or the shore servicing company followed the service recommendations issued by Draeger for this equipment.

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7 CONCLUSIONS

7.1 The cause of the fire was concluded to be due to the lube oil sprayed at approximately 4.5 bar pressure contacting the exhaust manifold and igniting instantaneously, when the Second Assistant Engineer tried to change the damaged thermometer along with the complete pocket assembly instead of only the thermometer. The fire was subsequently spread on the cable run on deck head.

7.2 The guidance from the Chief Engineer to his Junior Engineer Officers was not adequate to control the work conducted during the nighttime hours. The Duty Engineer decided to start the generator[4] and replace the broken thermometer without appropriate risk assessment in place.

7.3 The immediate response to the fire was not in accordance with company procedures. There was no coordinated firefighting effort conducted in the early stages of the fire resulting in members of the crew operating independently from procedures.

7.4 The onboard training was not sufficient to ensure the crew members had adequate knowledge to properly operate the CO_2 system manually from the CO_2 room if required.

7.5 The onboard training and the company policies and procedures did not address how long a space should be sealed and monitored for temperature drop after activation of the CO_2 system and prior to re-entry.

7.6 The fire team consisting of the Oiler and AB were instructed to proceed to the engine room without a tag line, to determine if the activation of the CO_2 system had been successful in extinguishing the fire. The two crew members opted to separate from one another, ultimately resulting in the AB being found located within a compartment, in an unconscious condition, in which he was instructed not to enter.

7.7 On 18 August the tugboat Millennium Falcon arrived on scene with a technician from the builder's yard to try and repair the emergency generator. The vessel was taken under tow at 1945 hrs and was towed to the port of San Francisco where the vessel arrived on 27 August.

***

[4] Operator's internal investigation revealed that the Chief Engineer verbally instructed the Second Assistant Engineer to operate the No. 3 generator for additional test purposes.

8 RECOMMENDATIONS

8.1 It is recommended to review and improve familiarization training onboard for all emergency systems and initiate a safety campaign to ensure all crew members are educated on the importance of following established procedures in emergency response activities.

8.2 It is recommend to revise the safety management system to set clear training requirements for the operation of CO_2 systems and to ensure these requirements are verified during internal management audits.

8.3 It is recommended to initiate a safety campaign to ensure all staff are aware of the hazards of running diesel engines with critical safety features removed.

8.4 Consider a review of the work planning procedures and risk assessments to be implemented for unplanned maintenance following any major overhaul operation.

8.5 It is recommended to review the competency and experience requirements of Officers onboard with responsibilities of designated equipment.

8.6 Consider clearly marking CO_2 system pilot bottles to differentiate them from normal bottles.

8.7 Consider additional emergency lighting within the CO_2 room to ensure the space is properly illuminated.

8.8 Consider making a modification for hyper mist pumps to be connected to the emergency switchboard.

***

9 ACTIONS TAKEN

9.1 The operator subsequently supplied documentation to indicate they had instigated the following actions and procedures for their fleet of vessels:

9.1.1 Detailed technical bulletins were issued to the fleet, including detailed training on the activation procedures for the CO_2 system, which was conducted both onboard and at the home locations/manning source offices.

9.1.2 Work planning procedures were revised and reissued including the implementation of safety barriers and specific instructions relating to machinery following major overhauls.

9.1.3 Superintendents visited ships in the fleet for an extended onboard sailing visit to monitor and ensure compliance with a target of all the ships to be completed within 24 months.

9.1.4 The lessons learned from this incident were being used in safety briefings with all senior staff attending the main and local offices prior to embarkation.

9.1.5 Company seminars were held in each home country of crews used to review the lessons learned and changes in procedures.

9.1.6 Markings in the CO_2 room were modified and improved to highlight the pilot bottles.

9.1.7 Emergency lighting would be modified in the CO_2 room to provide better lighting at the control location, as of February 2015 three vessels had been completed and others were scheduled.

9.1.8 The operator decided to create company-specific fire-fighting training courses ashore for officers. The training centers had been selected and training was continuing as crew members were available.

9.1.9 After discussion with the classification societies for the vessels and the equipment manufacturer, the company had commenced a program to modify the power source for the hyper mist systems to come from the emergency power source. This will be accomplished when the fleet vessels are in drydock. Thirty vessels were determined to need the modification and as of February 2015 three vessel had completed this modification.

9.1.10 To improve SCBA communications throat microphones (2 per ship) had been sent to the fleet.

9.1.11 Service stations used for annual servicing of the SCBA sets to be better evaluated for compliance with manufacturers requirements and recommendations.

***

Appendix I: Additional photographs

Figure 14: The No. 3 generator exhaust manifold cover not in Position

Figure 15: Aerosol cans in Engine room workshop

Figure 16: Damaged workshop area

Figure 17: Damaged cables

Figure 18: Wire runs in engine room workshop

Figure 19: Engine room workshop entrance

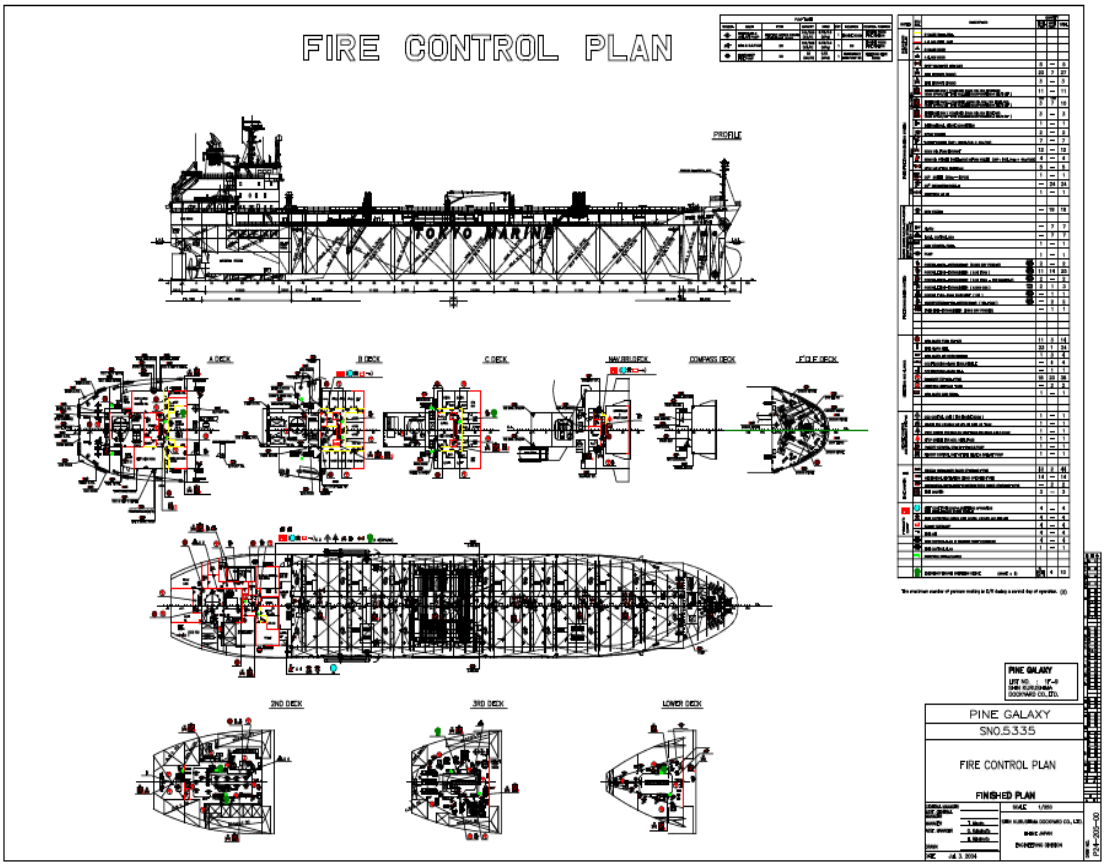
Figure 20: Engine room workshop area

Figure 21: Deck above workshop buckled due to heat

Figure 22: Light fitting

Figure 23: Location of removed pocket

Appendix II: Fire control plan

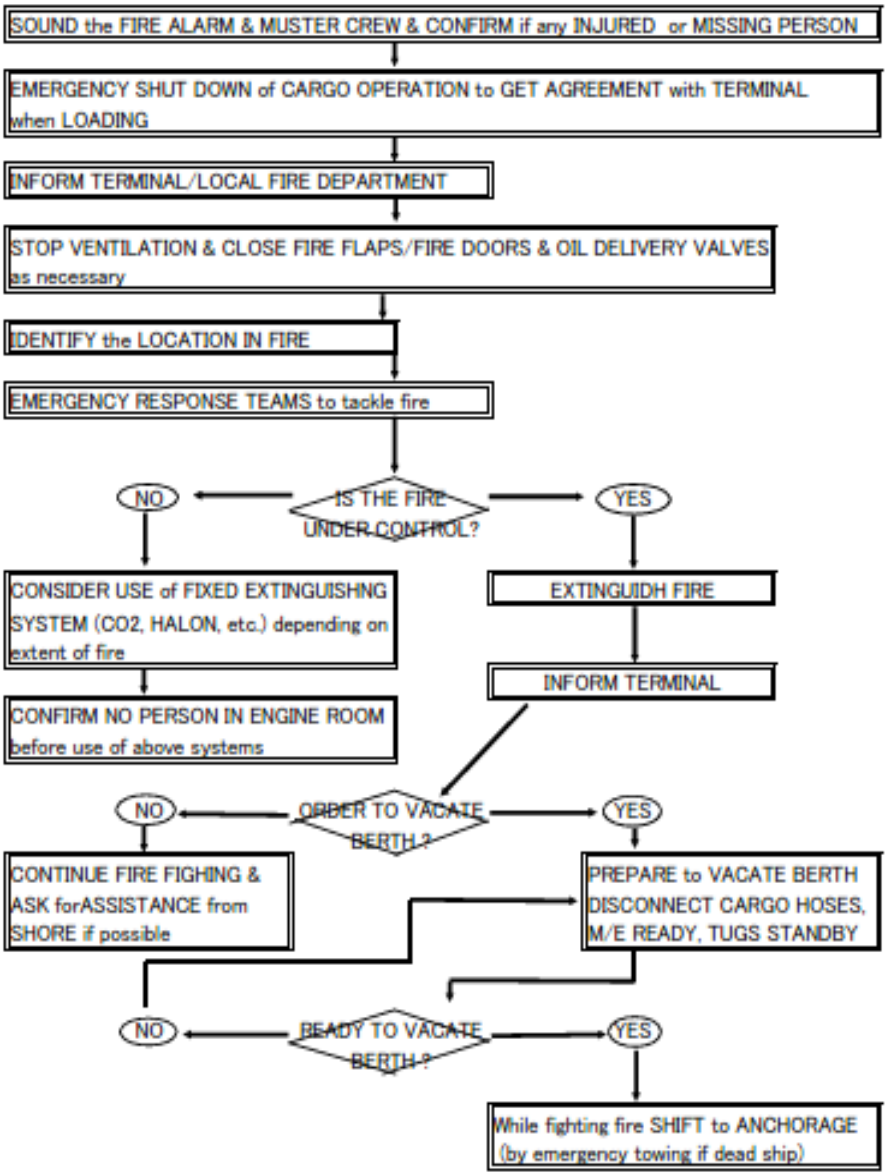


Appendix III: Fire in engine room procedures

UNIX LINE PTE LTD EMERGENCY PROCEDURE

FIRE IN ENGINE ROOM

*AT BERTH



(CAUTION)

In order to under control of fire in Eng. Room and Pump room, CO2 Fire Extinguishing system must be operated by Master's order only and after the fire has been extinguished the area should be throughly ventilated. If it is necessary to enter the area before ventilating, suitable breathing apparatus should be used.

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Appendix IV: Generator overhaul plan

Record of Work Planning Meeting

M/T PINE GALAXY DATE : 2014.08.10

Work Place	ENGINE ROOM
Work Content	NO.3 G.E PISTON & LINER & CYLINDER COVER OVERHAUL

ATTENDENTS : ALL ENGINE CREW

1. 작업 전에 2기사는 발전기 스페어 다시 한 번 체크하고 준비 바람.
2. L.O DRAIN, 청수 DRIAN 실시.
3. 작업 실시
   1) 액세서리 제거 (EXH.PIPE & COVER & COOLING PIPE)-2/E, No.2 CLR
   2) CYLINDER COVER 취외 및 PISTON & LINER 방출, CYL.HEAD 를 담그기.-DAY WORK TEAM
   3) CYLINDER COVER CLEANIG & LAPPING, CON-ROD BIG END & CRANK PIN METAL CHECK -ALL CREAN
   4) L.O SUMP TANK & CRANK CHANVER, PISTON & LINER 소제 및 점검.-NO.2 CLR
   5) PISTON & LINER ,CYLINDER COVER 조립.CYL.HEAD COVER TIGHTING TORQUES:58.8 MPA - DAY TIME, DAY WORK, DUTY TEAM
   6) 액세서리 조립, L.O & 냉각수 보충,-2/E,NO.2 CLR
   7) TAPPET CLEANRANCE CHECK - 2/E, 3/E
   8) F.O & L.O 스트레이너 소제- NO.2 CLR
   9) 시운전 실시.-C/E & ENGINEERS
   10) ENGINE PERFORMANCE REPORT WHEN TRIAL TEST
4. 작업 시 주의 사항
   -L.O SUMP TANK 소제 시에 미음질, 헤이스 가 남아 있지 않도록 확인 할 것.
   -CYLINDER COVER 분해시 2기사는 STEM SEAL RING 공실 우려가 있으므로 따로 한 곳에 보관해 두기 바람.
   -PISTON & CYLINDER COVER 들고 올릴 때 조심 할 것.
   -VALVE 조립시 배기변과 소기변이 바뀌지 않았는지 확인 할 것.
   -시운전 시 L.O 압력 주의 및 CYL. HEAD 주에서 청수나 L.O 누설 여부 체크하고 정상 운전 시 주의 깊게 체크 할 것.
   -배기관 측에 GAS 누설 여부 체크 할 것.

1/E: 2/E : 3/E :

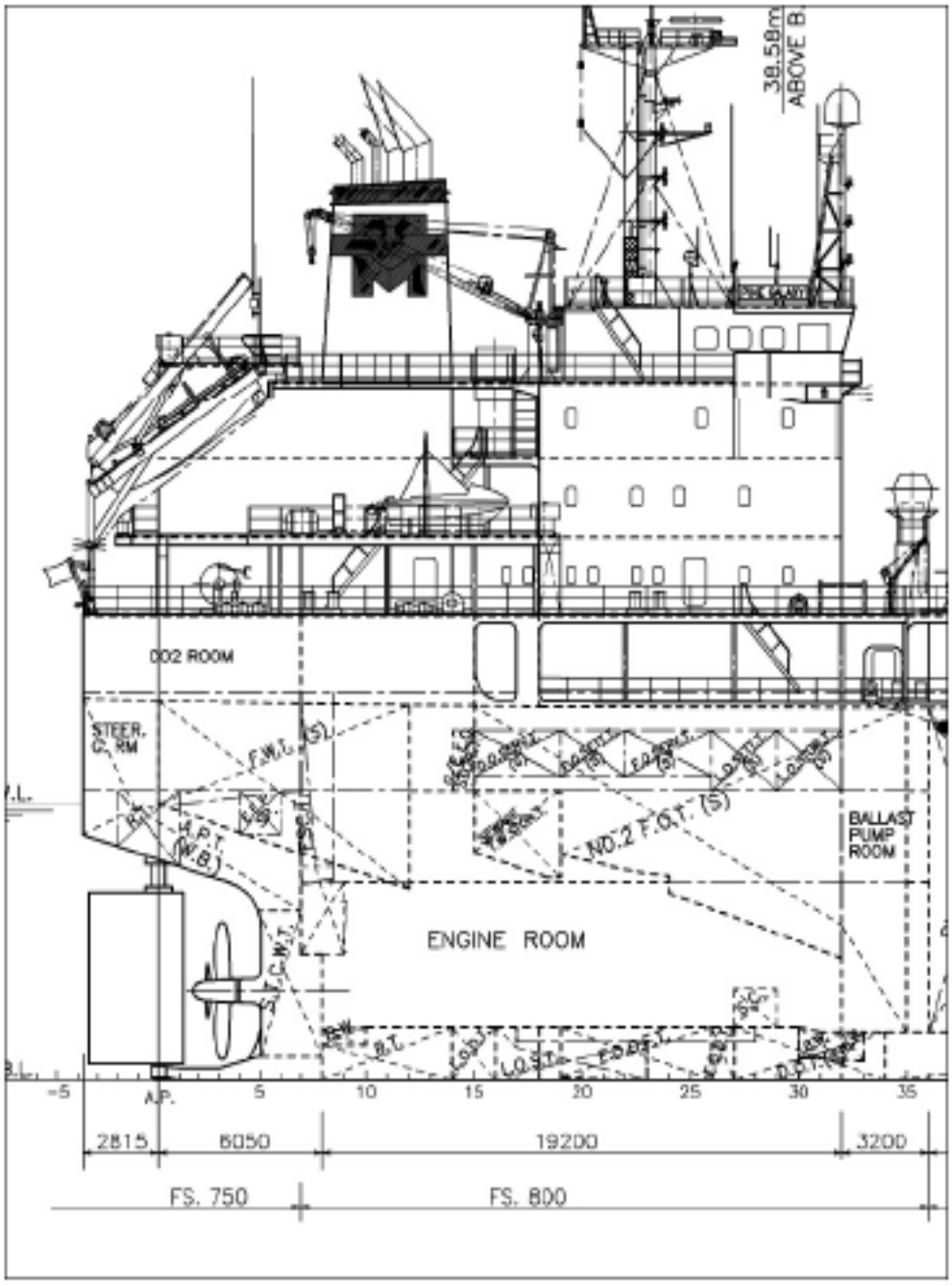
NO.1 CLR: NO.2 CLR: NO.3 CLR:

WIPER:

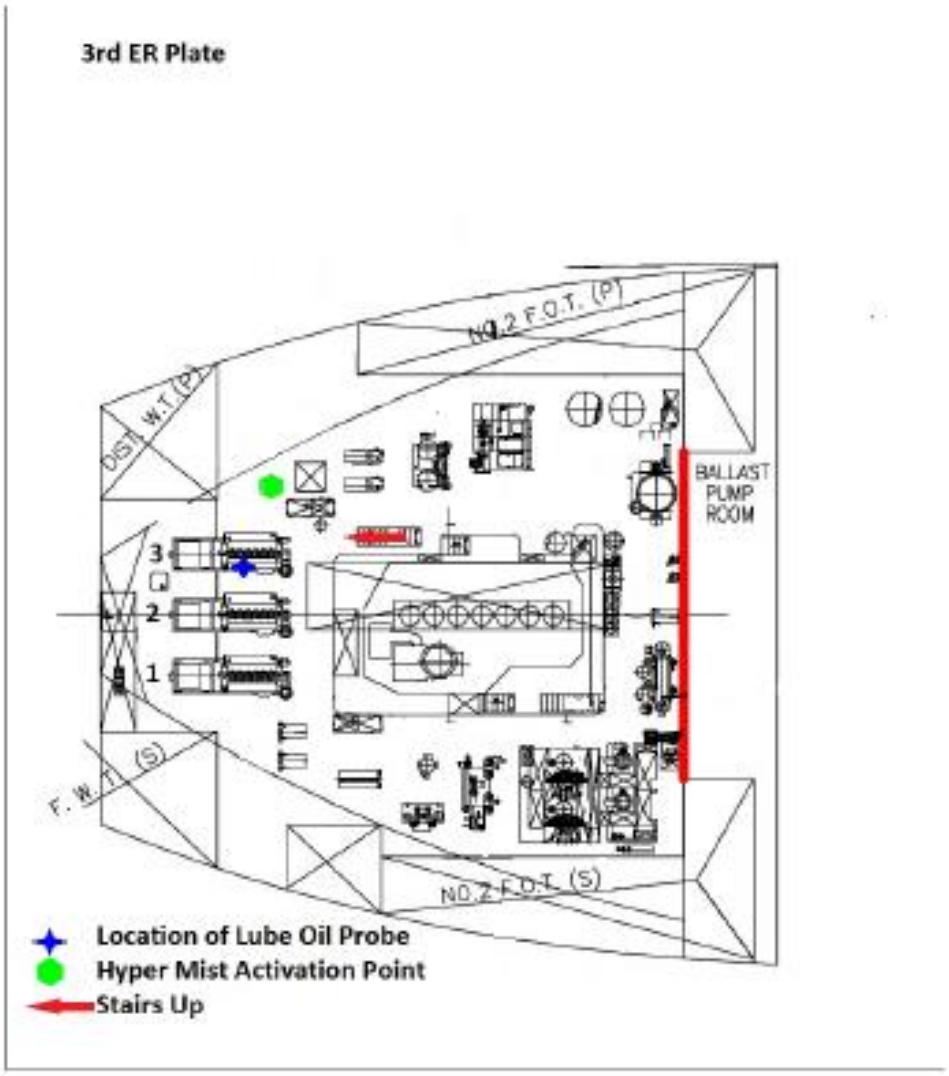
Chief Engineer :

Appendix V: Pine Galaxy Aft profile

PINE GALAXY AFT PROFILE



Appendix VI: Engine room 3rd deck



Appendix VII: Upper C deck aft