THE COMMONWEALTH OF THE BAHAMAS

"M.v. Freedom of the Seas"

IMO Number 9304033

Official Number 9000147

Report of the investigation into a casing fire in the outer approaches to Falmouth, Jamaica on 22nd July 2015

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GLOSSARY OF TERMS

AC	-	Air conditioning
AEP	-	Advanced emissions purification
CCTV	-	Closed circuit television
CO_2	-	Carbon dioxide
DNV-GL	-	Det Norske Veritas – Germanischer Lloyd
ECDIS	-	Electronic Chart Display Information System
GMT	-	Greenwich mean time
IMO	-	International Maritime Organisation
kW	-	Kilowatt
Length BP	-	Length of vessel between forward and aft perpendicular
MARPOL	-	International Convention for the Prevention of Pollution from Ships
MFG	-	Mobile fire group
MFZ	-	Main fire zone
M.V.	-	Motor vessel
MW	-	Megawatt
PE	-	Polyethylene
SOLAS	-	International Convention for the Safety of Life at Sea
STCW	-	Standards of training, certification and watchkeeping

1 SUMMARY

1.1 The m.v Freedom of the Seas was on passage from Labedee, Haiti to Falmouth, Jamaica, on 22nd July 2015. The vessel had on board a crew complement of 1,428 and 4,454 passengers.

1.2 The vessel's itinerary for the week-long cruise commenced when the vessel departed Port Canaveral, Florida on 19th July and visited Labadee (Haiti), Falmouth (Jamaica), Georgetown (Grand Cayman) and Cozumel (Mexico) returning to Port Canaveral on 26th July.

1.3 At 0911 local time (GMT-4 hours), a Falmouth Harbour pilot boarded the vessel and commenced the inbound transit to the port of Falmouth, Jamaica.

1.4 At 0912 on 22nd July 2015, the Autronica fire alarm system sounded on the bridge and engine control room indicating multiple fire alarms in the engine spaces and funnel casing.

1.5 An emergency was declared on board, and a 'Code BRAVO' announcement made with the fire location as the Forward Separator Room. Shortly thereafter, the location of the fire was identified as the port side funnel casing. Smoke entered the engine spaces via the ventilation system triggering multiple fire alarms.

1.6 At 0922, 7 short and 1 long blasts were sounded indicating to the passengers and crew of a general emergency, this was followed by a public announcement for all crew and passengers to proceed to abandon ship stations.

1.7 At 1052 and 1205 all passengers and crew respectively were accounted for with no injuries reported.

1.8 The fire was extinguished at 1012 however boundary cooling continued until 1130 as a precautionary measure and in accordance with on board firefighting procedures.

1.9 A forensic fire investigation was completed by Burgoynes[1]. The origination of the fire was thought to be at mid-level (between decks 3 and 5) within the port side forward casing in Main Fire Zone 6. The fire consumed all combustible materials present, and consequently, the cause of the fire could not be determined.

[1] Burgoynes Consulting Scientists and Engineers

1.10 This investigation report, without definite evidence of the cause of the fire, concentrates on the contributory factors which had they been identified may have prevented the incident, or as a minimum, reduced the severity.

2 PARTICULARS OF VESSEL

2.1 The Freedom of the Seas is a passenger vessel, registered in Nassau, Bahamas, of all welded steel construction and diesel propulsion. The vessel is owned and operated by Royal Caribbean Cruise Lines Limited, and has the following principal particulars:

Official Number	-	9000147
IMO Number	-	9304033
Built	-	Aker Finnyards, Finland (2006)
Length overall	-	335.5 meters
Length BP	-	302.53 meters
Breadth	-	38.60 meters
Draft	-	8.80 meters
Gross Tonnage	-	154,407
Net Tonnage	-	127,545
Call sign	-	C6UZ7

2.2 The vessel is powered by six diesel-electric engines driving six generators powering twin rotatable pods and one fixed pod rated at 14MW each and 4 bow thrusters of 4,000 kW each.

2.3 At the time of the incident the vessel was classed with Det Norske Veritas - Germanischer Lloyd (DNV-GL) and all statutory certificates remained valid.

2.4 All crew carried appropriate documentation as required by the Standards on Training, Certification and Watchkeeping (STCW). All document holders had the necessary endorsements provided by the Commonwealth of the Bahamas and complied with the vessel's safe manning document.

2.5 The vessel's fire detection and extinguishing systems met required standards under the Safety of Life at Sea (SOLAS) requirements. These systems were all utilised as required to expedite the firefighting efforts.

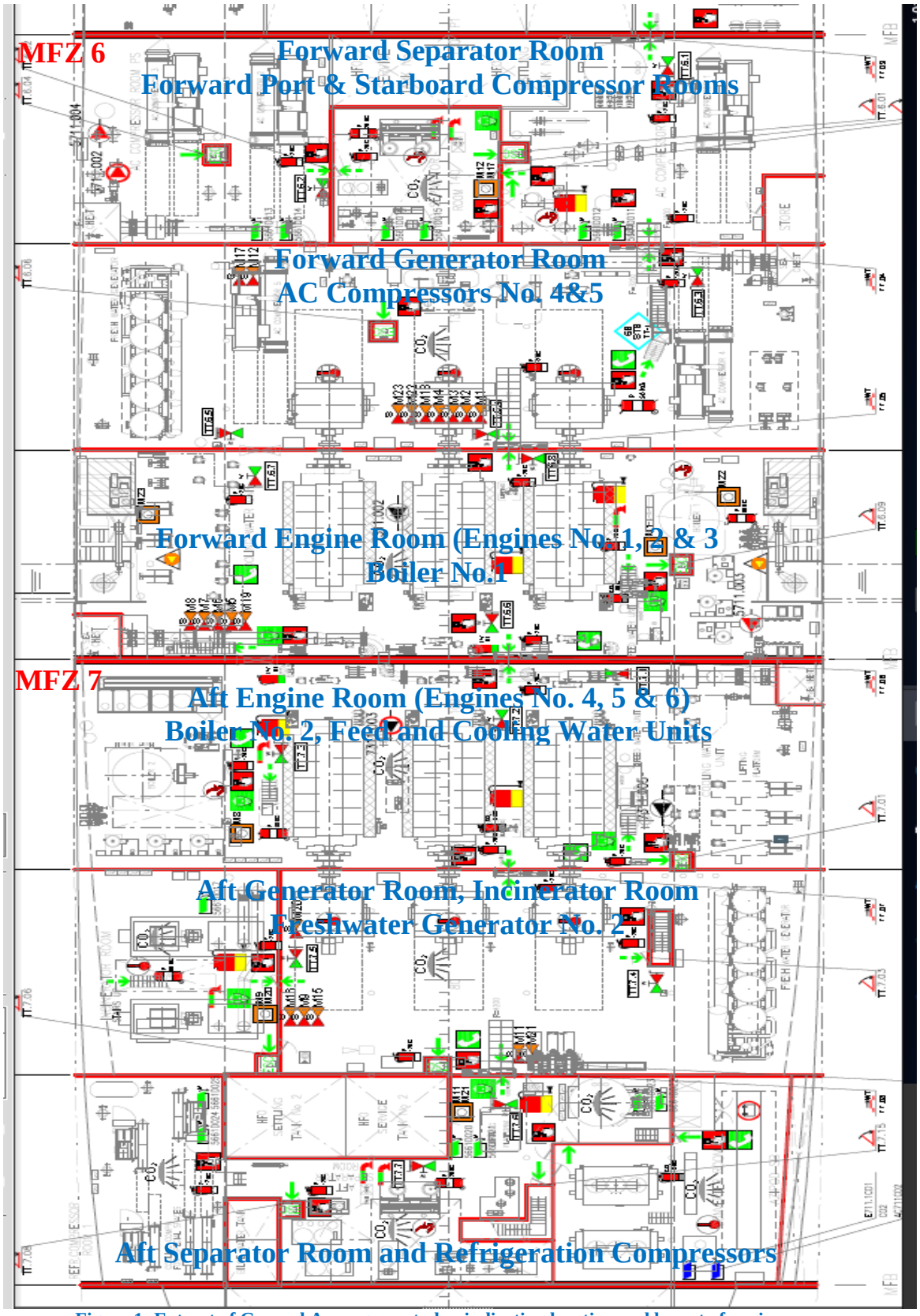


Figure 1: Extract of General Arrangement plan indicating location and layout of engine spaces

3 NARRATIVE OF EVENTS

3.1 The Freedom of the Seas departed Port Canaveral, Florida on 19th July 2015. The cruise included seven scheduled nights, calling at Haiti, Jamaica, Grand Cayman, and Mexico, prior to returning to Port Canaveral on the 26th July.

3.2 At 0911 on 22nd July 2015 a Falmouth harbour pilot boarded the vessel to aid with the port entry to Falmouth, Jamaica. Senior staff were already gathered at the wheelhouse for a scheduled 0855 port entry conference.

3.3 Engine No.2 in the forward Engine Room, and engines 5 and 6 in the Aft Engine room, were running and online. Engines 1 & 3 in the Forward Engine room and engine No. 4 in the Aft Engine room were not required to be online for port entry, but were available for immediate use if required.

3.4 During the port entry planning meeting, the Autronica fire detection system commenced sounding alarms. Although the fire was limited to the main casing on the port side forward, the engine room ventilation system was drawing in and distributing smoke throughout the engine spaces in Main Fire Zone (MFZ) 6. Over the next seven minutes, the following alarms were recorded:

7/22/2015 9:11	FWD SEPARATOR ROOM TT MFZ6
7/22/2015 9:12	AC COMP.ROOM TT PORT MFZ6
7/22/2015 9:12	GEN.ROOM 1 TT STB. MFZ6
7/22/2015 9:12	AC COMP.ROOM TT STB. MFZ6
7/22/2015 9:12	GEN.ROOM 1 TT STB. MFZ6
7/22/2015 9:13	ENG.ROOM 1 DECK0 PORT MFZ6
7/22/2015 9:13	AC COMP.ROOM TT STB. MFZ6
7/22/2015 9:14	ENG.ROOM 1 DECK0 PORT MFZ6
7/22/2015 9:14	ENG.ROOM 1 TT PORT MFZ6
7/22/2015 9:14	ENG.ROOM 1 TT PORT MFZ6
7/22/2015 9:14	ENG.ROOM 1 TT PORT MFZ6
7/22/2015 9:14	ENG.ROOM 1 TT PORT MFZ6
7/22/2015 9:15	ENG. CASING DECK0 PORT MFZ6
7/22/2015 9:15	ENG.ROOM 1 DECK0 STB. MFZ6
7/22/2015 9:15	ENG.ROOM 1 TT PORT MFZ6
7/22/2015 9:15	ENG.ROOM 1 TT PORT MFZ6
7/22/2015 9:15	ENG.ROOM 1 TT PORT MFZ6
7/22/2015 9:15	ENG.ROOM 1 TT STB. MFZ6
7/22/2015 9:15	COMP.ROOM TT STB. MFZ6
7/22/2015 9:15	GEN.ROOM 1 TT STB. MFZ6
7/22/2015 9:17	ENG. CASING DECK9 STB. MFZ6
7/22/2015 9:18	ENG. CASING DECK11 PORT MFZ6

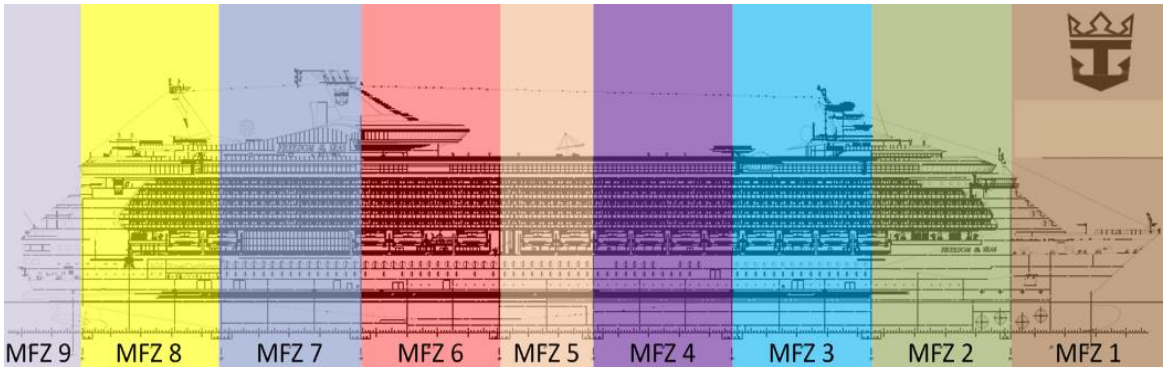


Figure 2: Plan of vessel showing Main Fire Zones (MFZ's)

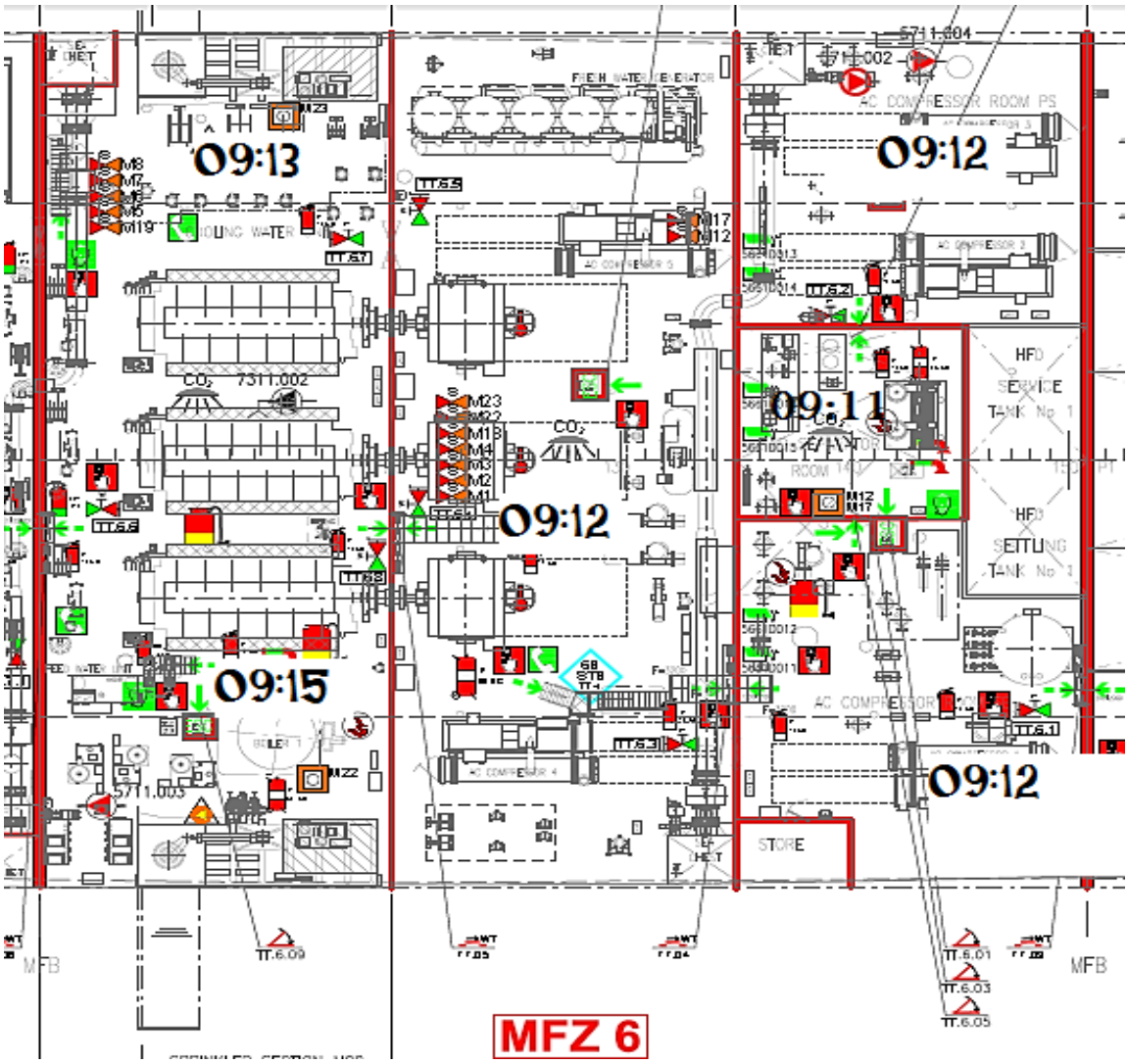


Figure 3: Engine room spaces at MFZ No.6, locations shown of initial fire alarm activation times

3.5 The following sequence of events was determined from the vessel's log books, CCTV records, and Autronica records. All times are local to Jamaica on 22nd July 2015.

3.6 At 0915, Code Bravo was announced over the public address system, the location was given as the Forward Separator Room, MFZ 6.

3.7 The vessel's Chief Officer is also the vessel's Safety Officer. He was dispatched from the Bridge by the Master to coordinate and control the firefighting effort. The Master then remained on the bridge with the Harbour Pilot, to take the vessel to her nominated berth.

3.8 The vessel's power was transferred to the three engines in the aft engine room. This would aid firefighting efforts by stopping the exhaust gases passing through the fire location in the forward port casing.

3.9 The water fog system for the Forward Separator Room was manually activated at 0915.

3.10 The Chief Officer and Mobile Fire Group (MFG) #3 made entry to the engine space via the stairway on the starboard side of the Forward Switchboard Room, down to the Generator room and then through the AC Compressor room to the Separator Room. In all spaces only greyish smoke was observed, emanating from overhead vents. There was no fire present.

3.11 The search continued into the Forward Engine Room. Again, there was no observed fire. The smoke was dark and burning embers were falling from the casing onto Engine #3. The water fog system was started to protect Engine #3.

3.12 Mobile Fire Group #3 was stationed in the Forward Engine Room, to extinguish any remaining embers.

3.13 The Safety Officer proceeded to Deck 1 and opened the door to the casing on the port side. Fire was visible within the casing at Decks 1, 2 and 3. Burning material was falling from above, within the casing.

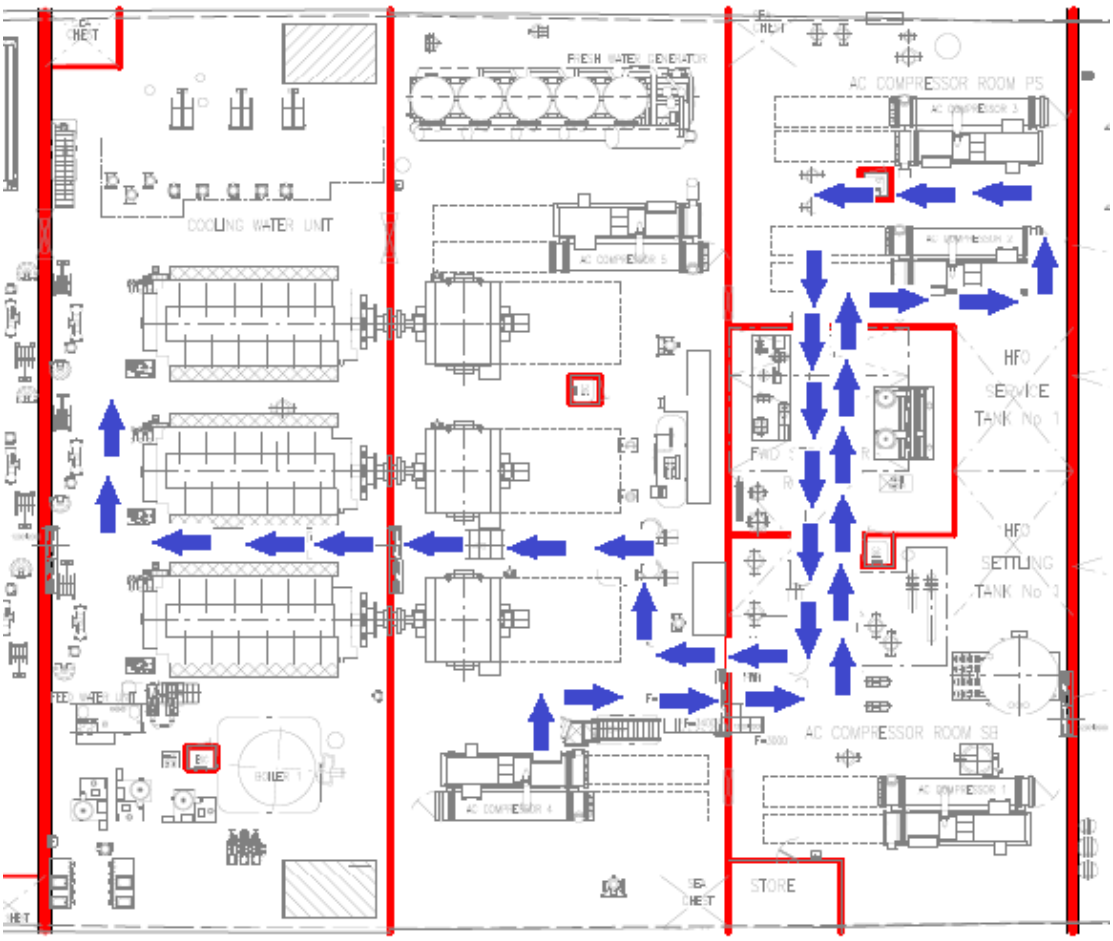


Figure 4: Route taken by Mobile Fire Group No. 3: Route started in starboard switchboard room, forward generator room, starboard compressor room, separator room, port compressor room, forward generator room ending in forward engine room

3.14 At 0928, a second Code Bravo announcement was made, with the fire location given as deck 13.

3.15 MFG No. 4 was assigned to fight the fire from deck 1 casing access on the port side, using hoses they were able to spray water as high as deck 4 within the casing. Water spray was used to extinguish falling embers within the casing. MFG No.1 provided back up with fire extinguishers, additional hoses, and changing out air bottles.

3.16 The lower fire damper at deck 1 did not close. This was later found to be blocked with debris from melted polyethylene (PE) piping and burnt embers from scaffold planks. MFG No.4 reported seeing the damper remaining open. The Master testified that with this damper open the use of CO_2 was considered unwise. Carbon Dioxide gas is heavier than air and once released, may escape the casing direct into the forward engine room.

3.17 MFG No.4 was hampered by hot water cascading down the casing from firefighting efforts on the upper decks.

3.18 MFG No.2 reported to deck 14 at 0928. Fire was present at decks 13 and 14 at the funnel ("Viking Crown" logo area). Boundary cooling commenced at decks 12 through 15. The team leader made an inspection via a casing access opened for the scrubber project at deck 12, the access hatch at deck 12 to the lower casing levels had been left open. Fire dampers at this deck were then closed.

3.19 MFG No.5 was dispatched to deck 12 and 13 for boundary cooling and then to deck 14 to provide cooling at the Gas Bottle Storage Locker. MFG's 6, 7 and 9 also provided boundary cooling at deck 14 and above.

3.20 MFG No.6 aided MFG No.2 at deck 12, and made entry into the casing. This was to provide firefighting from the open hatch at deck 12, to lower casing levels.

3.21 MFG No.7 provided support to MFG No's. 2 and 6 respectively and aided boundary cooling efforts at deck 14 through 16.

3.22 Fire hoses with nozzles set to spray were lowered through the open hatch on deck 12 to extinguish the fire.

3.23 At 0946, the fires at decks 1 & 2 and at deck 14 and above were reported extinguished. By 1005, the fire at deck 13 was reported extinguished.

3.24 At 1012, MFG's reported no remaining open fires. Hot spot monitoring continued and the fire was confirmed extinguished at 1140.

3.25 At 1205 all passengers and crew were accounted for. Ten minutes later at 1215, an announcement was made allowing the passengers to return to their cabins.

4 ANALYSIS

CONTRACTORS WORKING INSIDE THE CASING

4.1 During this voyage, a team of contractors were engaged in the ongoing installation of a scrubber system. This was intended to remove sulphur dioxide from exhaust gases produced during consumption of Heavy Fuel Oil in the vessel's engines. This Advanced Emissions Purification (AEP) system ensured compliance with sulphur dioxide emissions standards under the International Convention on the Prevention of Pollution from Ships (MARPOL) Annex VI.

4.2 The layout of this system is as follows:

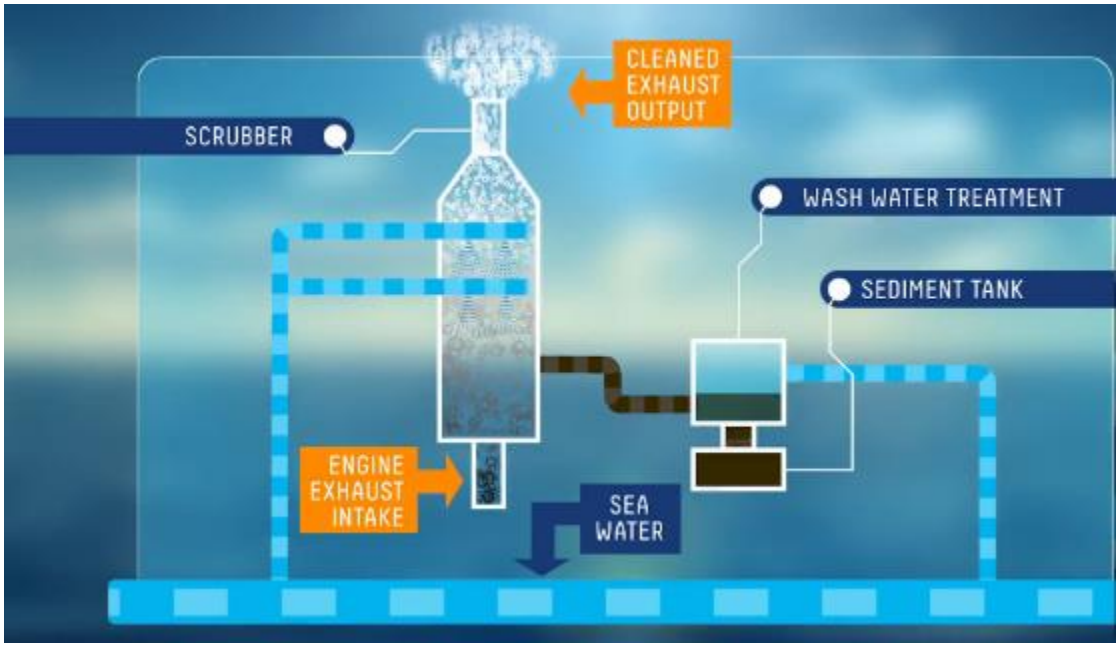


Figure 5: Layout of AEP scrubber system

4.3 The exhaust for the AEP system included two ducts that would transit the forward port side of the casing. These would consist of two thermoplastic pipes, one at 500mm diameter (DN500) and one at 600mm diameter (DN600), each made up of multiple sections of polyethylene piping fused together and held in place by welded metal brackets.

Figure 6: Ducting awaiting installation

The contractor was assigned the deck 14 starboard side Card Room. This afforded easy access to a cordoned off area around the funnel at deck 14 for material storage and preparation, and access to the casing via an opening cut for this project.

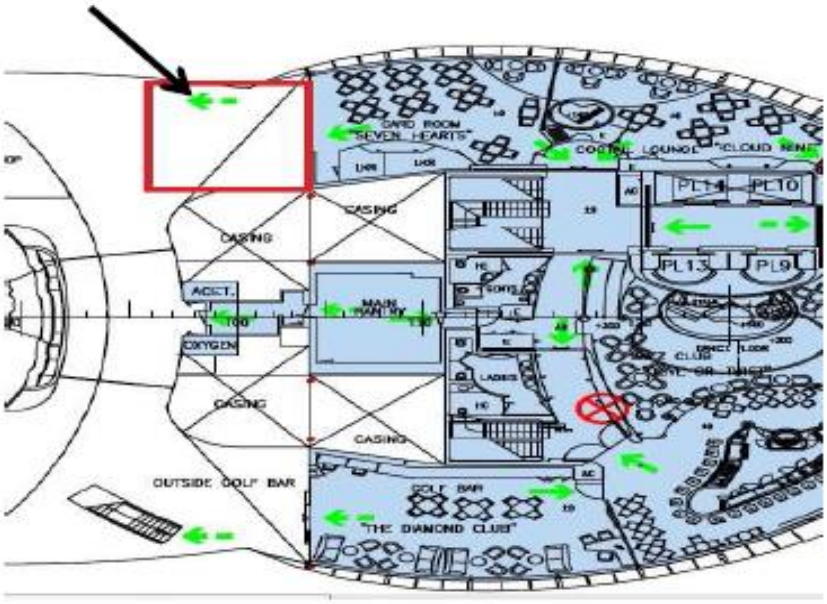


Figure 7: Location of deck 14 Card Room and contractors work area (highlighted in red)

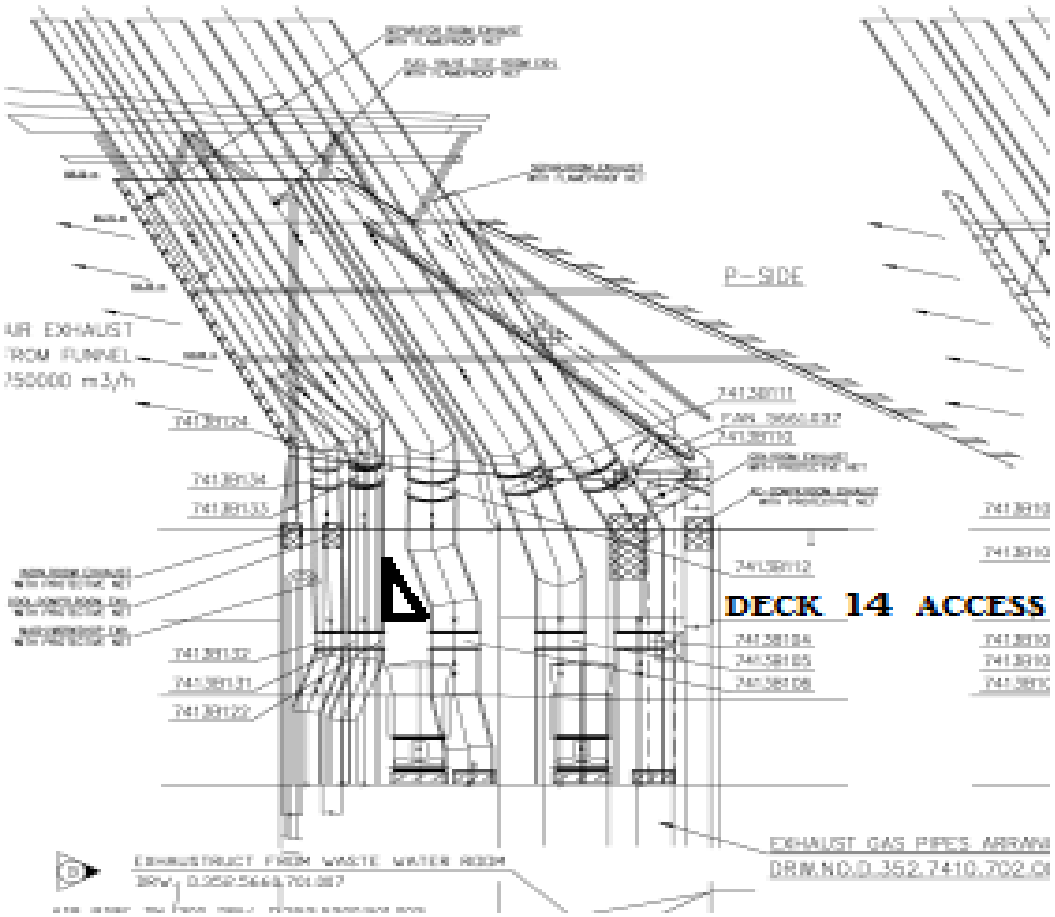


Figure 8: Schematic of deck 14 access to casing

4.4 Scaffolding was installed throughout the casing to provide access to install the ducting. The contractor worked both day and night shifts. During the evening of 21st July 2015, the night shift rigged two 500mm diameter pipe sections. These were lifted into place, but could not be installed as scaffolding required repositioning. Further, installation of a lifting pad eye required welding at the underside of deck 12.

4.5 The vessel's operators issued Hot Work Permits for work involving the casing which has a twelve (12) hour validity. A permit was issued on 21st July 2015 at 1900, specifically for the installation of new pipework in the casing, approving positioning and welding brackets, cutting and grinding. Standard requirements for the permit include; a fire watch at the work site for 30 minutes post hot work, all work areas should be free of flammable materials prior to hot work and areas should be protected from potential fire risk by the use of blankets.

4.6 The permit issued indicates the casing is not a confined space however no guidance exists on the permit that helps to make this determination.

4.7 This permit was closed on 22nd July at 0615. There had been no hot work in the casing during the validity of this permit. Day permits for 22nd July did not

include the casing as no hot work was anticipated on the morning of the 22nd July.

4.8 The contractor held daily toolbox talks; on the 22nd July all 36 contractor's staff attended and signed the report sheet.

CONSIDERATION OF IGNITION SOURCES

4.9 No hot work was reported during the nightshift on 21st to 22nd July. The relocation of a pad eye was scheduled for the afternoon of the 22nd July and not before 1300, after which time an exhaust fan in the casing would be stopped.

4.10 The individual sections of piping were joined together using an electro fusion machine. A wire is placed between the two pipes and then heated, melting the surrounding material around the wire itself. The melt closes the gap between the pipe and fitting. Heat then transitions to the pipe itself, which melts in the welding zone forming a homogeneous welded connection.

4.11 The electro-fusion welding machine was found bundled with its cable into a transport case, ready to be relocated. The machine was removed for laboratory analysis, but the extent of fire damage had destroyed the internal memory. There is no indication this machine had any role in starting the fire.

4.12 Two plasma-cutting torches used in the casing by contractors were found coiled up and disconnected. There had been no requirement for any use of this equipment preceding the fire.

Figure 9: Plasma cutting torch leads pictured after the fire

4.13 Closed circuit camera (CCTV) recordings were reviewed and contractor's crew were interviewed. The two men on day shift in the casing were verified to have exited the casing approximately 20 minutes prior to the start of the fire.

4.14 Fixed electrical equipment within the casing was examined as a potential ignition source. The following were eliminated:

i An exhaust fan at deck 12. The motor itself, the casing and the electrical connections showed no signs of failure. The fan is protected by a variable frequency drive and a breaker.

Figure 10: Deck 12 exhaust fan motor

ii Fluorescent lighting was examined and eliminated as a potential source due to the lack of ability for the light cover to easily ignite.

Figure 11: Florescent light fixture damage

Figure 12: Florescent lighting fire tests

iii Electrical cabling was examined. Minor arcing was noted in two places. This was eliminated as a source for the fire by the forensic fire expert from Burgoynes.

Figure 13: Electrical cables inside casing

4.15 Combustibles within the casing at the time of the fire included the following:

i A total of 1.3 metric tons of polyethylene piping had been installed, either permanently in welded brackets, or rigged awaiting bracket installation within the casing.

ii Approximately 28 wooden scaffold planks of lengths between 1m and 3m. Subsequent to the fire, samples of the scaffolding planks were subjected to Fourier-transform infrared spectroscopy[2]. The IR spectrum

[2] Fourier transform infrared spectroscopy is a technique used to obtain an infrared spectrum of absorption or emission of a solid, liquid or gas. An analytical technique used to identify organic, polymeric, and in some cases, inorganic materials.

showed the wood was consistent with untreated softwood similar to pine. There was no evidence of fire retardant material (Phosphates, Boron or Ammonia compounds) present.

iii A one litre bottle of ethanol cleaner used to clean the joints between piping prior to fusion.

iv Housekeeping is reported to have been good, and each shift was required to remove any incidentals such as rags at the completion of each shift.

4.16 The polyethylene piping and the wooden scaffold boards are both flammable. However to ignite required an energetic and prolonged initiating heat source. The temperatures in the casing were examined as a potential source.

4.17 The main engine exhaust gases downstream of the economizer could be expected to be 228°C. The exterior of the exhaust trunking within the casing would be between 40-60°C, and the ambient temperature within the casing 32°C. Only the exhaust system from engine No.3 was in use in the forward port casing at the time of the fire. In the knowledge that the auto ignition temperatures for polyethylene is 350°C, for wood 300°C and ethanol 365°C it can be considered unlikely that the exhaust system or any part thereof could be considered a credible source of ignition.

4.18 Although one of the two contractors working inside the casing immediately prior to the fire is reported to have been a smoker, both had left the casing for their morning coffee break. A carelessly discarded cigarette is not considered a likely event.

4.19 The possibility of a deliberate act remains viable but unlikely. The CCTV did not indicate any unknown person or persons entering the worksite.

4.20 Fire experts determined that the fire started at mid-level within the casing. All combustible materials were consumed and due to the lack of evidence indicating fire spread pattern, no source of ignition was revealed.

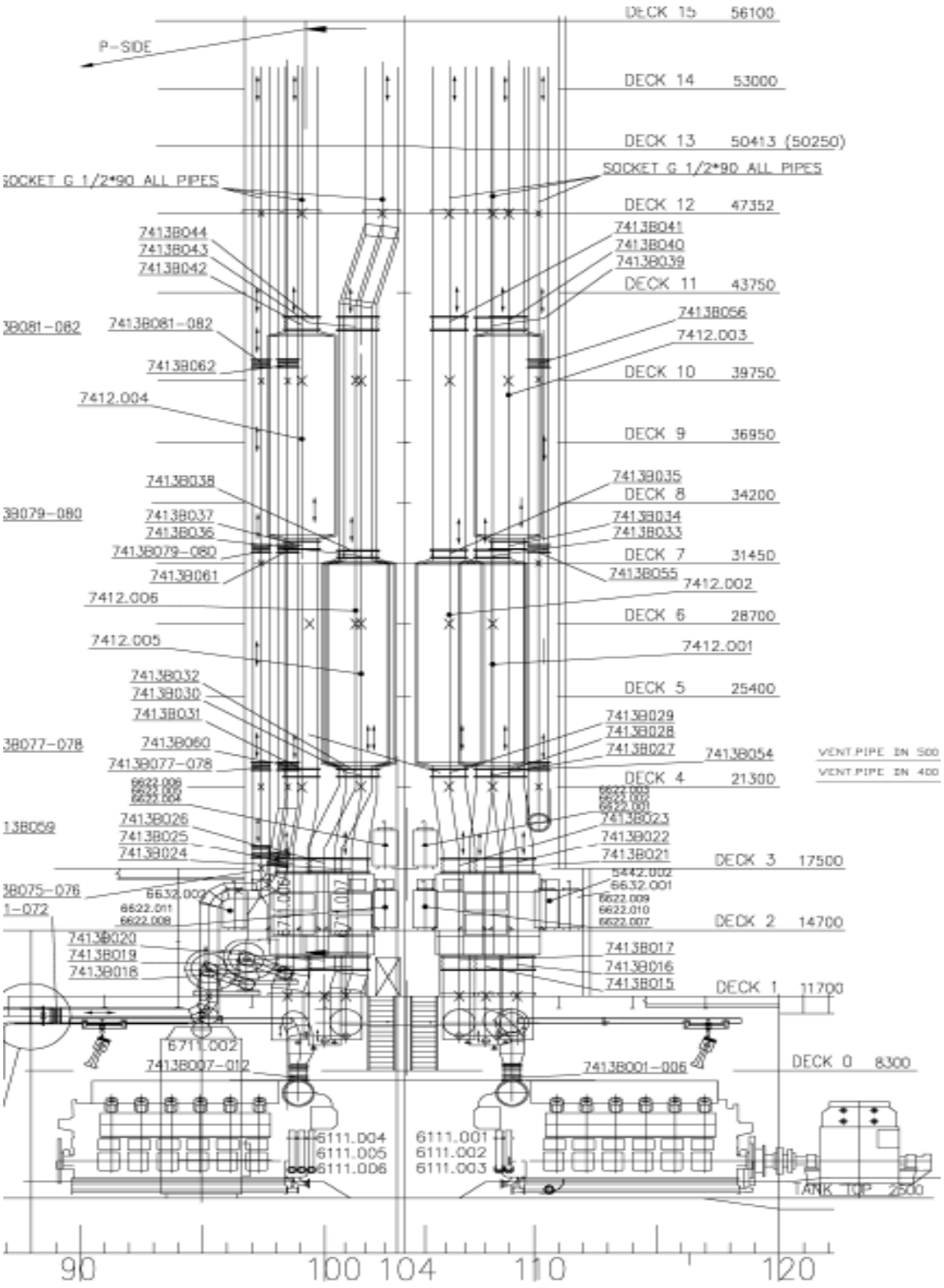


Figure 14: Progression of casing through the vessel by deck level

PASSENGER FEEDBACK

4.21 A passenger survey was created in order to gauge how the vessel controlled the situation from the perspective of the passengers onboard. Of the 3000 passengers onboard, random selections of passengers were surveyed. It was understood that based on the responses, the number of passengers surveyed would increase if needed. Of 120 questionnaires, 30 were returned completed.

4.22 Of the passengers surveyed, the number of people within each group or party varied from 2 to 15. This is important in that surveyed passengers may have answered questions taking concerns from their group into account as they would have likely been together during the incident. A single group member compiled answers. Approximately 48% of the passengers surveyed had at least one handicapped, elderly, or person below the age of 18 in their group. The number of passengers traveling within a group or party was as follows:

Number of passengers within each group	Percent
< 02	38%
03 – 06	35%
07 – 10	14%
> 11	13%

Figure 14: Passenger survey groups

4.23 The primary language of the passengers surveyed was English, with less than 10% responding that English was not their first language. According to the surveys, none of the passengers experienced a language barrier, regardless of their native language. However one passenger expressed that it would be difficult to understand if English was not their primary language.

4.24 The instructions given to the passengers were in English and were reported by most to be clear. Of those surveyed, only 1 passenger claimed that the instructions given were not clear. 97% of those surveyed stated that while they were making their way to the muster stations, the crew did a great job giving them proper instructions.

4.25 The passengers were also asked how informative and readily accessible safety information was throughout the vessel. Of the areas where safety information was posted, 65% read the information on the cabin door, 54% read the info that came with the cruise ship tickets, 100% recall having a safety and lifeboat drill, and of those that read the information, 100% stated that they understood it.

4.26 During the incident, 90% of the passengers stated that they heard the alarm. Of the remaining 10% (3 surveys) stated that they did not hear the alarm, one was playing miniature golf and could smell something burning from the stack, one

passenger heard the bravo announcement over the public address system, and the other passenger who did not hear the alarm, saw smoke from their balcony and was subsequently told by their steward to go to the muster station.

4.27 Approximately 67% of the passengers agreed that the odor from the fire was very strong and was somewhat difficult to tolerate although none of the passengers stated that the smoke was a problem when proceeding to the muster station.

4.28 Based on the responses, it is clear that when the alarm sounded, many passengers did not realize that there was a real emergency. Approximately 61% of the passengers knew right away that it was an actual emergency, and 39% stated that they did not know immediately.

4.29 Half of the passengers agreed that the biggest problem during the evolution was crowding in the hallways. Surveyed passengers stated that passengers did not put on their lifejackets, nor were they instructed to do so by the crew.

4.30 Of the passengers traveling with children, all of the parents were able to locate their children and get them to the muster station without any difficulty.

4.31 No passengers reported experiencing any power loss in the areas that they were located.

4.32 Very few passengers commented on the behavior of the other guests. Those that did replied with comments such as: some of the guests were “overdramatic”, “rude towards the crew”, and that some kept eating plates of food while in the hallways heading towards their muster stations.

4.33 Of those surveyed, 94% agreed that they felt overall there was good communication from the Captain and crew. 13% of passengers had some difficulty understanding what was broadcast over the public address system. A few commented that they could hear it out on deck but not in their cabins.

4.34 Concerns that were brought up and listed in the comments section of the survey were as follows:

i A passenger stated that she observed a fellow passenger being separated from her children by two muster stations. They were worried about their children and did not understand why they were separated when the trip was booked all in one. This passenger also stated that some passengers were missing for over 2 hours after the incident. Investigation revealed a lack of reporting between muster points and the evacuation control center, the “missing” guests had reported in early on.

ii Comments were made that multiple passengers and crew could not

differentiate between this being a drill or an actual event.

iii Multiple passengers stated that they heard no announcement in their cabin and that they believe something should be changed.

iv The lingering smell after the fire was unpleasant to some passengers.

v A passenger thought that announcements would be helpful if they were made in other languages used by passengers.

vi Another passenger did not like the idea that some passengers got to stay inside and some had to remain outside and that his wife had a "stress attack" because of this.

vii One passenger stated that they were not offered any food or water while at the muster station for 3 hours.

viii Another comment stated that handicapped people may not have heard the alarm and that more communication was needed to inform guests as to what was going on.

DAMAGES (refer also to Appendix II)

4.35 Damages within the guest areas were noted as follows:

i Deck 15 – Wedding Chapel wallpaper and carpet water damage

ii Deck 14 – Wallpaper and carpet water damage

iii Deck 13 – Stairwell wallpaper and carpet water damage

iv Deck 12 – Alleyway and Arcade wallpaper and carpet water damage

v Deck 11 – Carpet water damage on starboard side of Jade lounge, wet ceiling insulation in galley

4.36 Damages within the casing

i Deck 15 – Expansion tanks (preheat and reheat), plumbing and electrical installations

ii Deck 14 – Insulation

iii Deck 13 – Insulation

iv Deck 12 – Fire integrity (CO_2 hatch damaged), two main engine exhaust fans, AWP Room exhaust fan, fire dampers, generator room

supply fan No.2 and exhaust fan, exhaust fan for grey water tanks, vacuum interface for AWP air duct.

v Decks 1 to 11 - Smoke detectors, light fixtures, CO_2 system nozzles, speakers, emergency lighting, electrical cabling and outlets, air supply solenoids, 7 fan units, bulkhead coating and insulation, utility piping.

4.37 External damage

i Crown deck failure

PROCEDURAL REVIEW

4.38 The vessel's crewmembers are assigned to nine firefighting teams each identified by the title Mobile Fire Group and then a number. Firefighting teams are selected primarily from the vessel's deck and engine crewmembers. The vessel's other departments are assigned supporting roles. The vessel's Environmental Staff are assigned to the staging area to record events.

4.39 Post-incident, all individual fire groups were interviewed to provide feedback on their team roles.

4.40 Mobile Fire Group (MFG) 3 was the first on scene at the nominated staging area on deck 1 aft at the provisions area and were dispatched to the Forward Separator Room to assess the situation. They were questioned on the response training for engine room fires. This scenario is practised frequently.

4.41 MFG 1 was assigned to set up fire hoses for fire teams, replace and refill breathing air bottles.

4.42 MFG 4 was assigned firefighting duty at deck 2.

4.43 MFG 2 was assigned firefighting duty at decks 12, 13 and 14 and boundary cooling at decks 12 through 15.

4.44 MFG 5 was assigned boundary cooling at deck 14, notably the gas bottle storage area aft of the casing.

4.45 MFG 6 took over firefighting from MFG 2 to avoid any heat or stress casualties.

4.46 MFG's 7 & 9 assisted MFG 2 with boundary cooling.

4.47 MFG 8 was held in reserve at the staging area.

4.48 The overall success in fighting this fire is primarily due to the crewmembers following the operator's practices and procedures. The Staff Chief Engineer as Staging Co-ordinator handled the firefighting on the upper levels and the Safety Officer handled firefighting on the lower levels. Both followed their onboard

training, which consisted of fire drills being rehearsed in the casing on a regular basis.

4.49 The vessel's navigation plan and procedures were reviewed. The details follow from the vessel's bridge display. The pilotage was under the Master's direction and assisted by a local harbour pilot. The vessel was safely brought alongside in a manoeuvre that required the vessel to be turned and berthed stern first starboard side alongside Falmouth North Pier. The Master decided to continue to the berth in anticipation that in the event a full evacuation was required, doing so at the berth would be the safest and quickest method.

Figure 15: ECDIS screenshot of vessel's inbound pilotage to Falmouth, North Pier

5 CONCLUSIONS

5.1 The crewmembers of the vessel whilst under pilotage and with the casing fire responded professionally and capably to manage the situation. The fire was extinguished rapidly, despite the time required to systematically determine its location.

5.2 The decision not to use the fixed Carbon Dioxide (CO_2) system is considered correct. The gas is heavier than air. With the lower dampers blocked open by falling debris, considering the inability to close, the gas would have flooded the Forward Engine Room. Additionally, with the Deck 12 access door open, the fire progressed upwards to the Crown Deck where there is no fixed system installation. The CO_2 would likely have hampered the firefighting effort in this area.

5.3 Testing of the scaffold boards subsequent to the incident revealed they had no fire retardant capability. Interviews of the operator's and contractor's staff indicated they mistakenly believed the boards used in the casing had been so treated.

5.4 The casing with scaffolding and with polyethylene piping installed, contained a substantial volume of combustible materials. This provided adequate fuel for the fire.

5.5 The passenger muster was timely. The questionnaire identified some problem areas, and these are discussed in the recommendations section of this report.

6 RECOMMENDATIONS

Recommendations for the operator:

6.1 In regards to work permits:

i Rigidly enforce the conditions of the hot work permit that require hot work locations be free of combustible and flammable materials. This is recognized as a hazard in the Job Safety Analysis.

ii Rigidly follow the Job Safety Analysis requirements on maintaining fire watches post work, and prior to closing the permit.

iii Expand the permit to properly define "a confined space", within which additional precautions are required.

iv Require regular safety checks by the safety department to verify that the permit requirements are being followed in such areas as housekeeping and the presence of flammable materials.

6.2 Signage should be installed at all protected boundary openings, such as the trap door at deck 12, requiring it to be closed at all times the space is unoccupied. There was no visible signage to direct the contractors to maintain the access hatch closed.

6.3 Review emergency procedures to address passenger needs during prolonged periods at muster points.

Crowd control procedures are included in training onboard the vessel to meet the requirements of Section A-V/3 Paragraph 1 of the STCW Code. This section of the STCW Code requires the following:

The following seafarers must have completed training in crowd management as specified in section A-V/3, paragraph 1 of the STCW Code-

(a) masters;
(b) officers; and
(c) ratings and other personnel designated on muster lists to assist passengers in emergency situations.

The investigation determined that all officers and crewmembers onboard were properly trained and drilled in crowd-control procedures.

These procedures do not address the physical requirements of passengers that remain at the muster points for prolonged periods of time. Individual requirements should be considered, such as supply of drinking water and availability of bathrooms. It is recognized that this will vary depending on the nature and extent of the emergency that required the muster.

6.4 Review muster requirements such that families are grouped at the same point i.e. parents and children are not separated.

i This was thoroughly investigated. The sole potential cause was identified where families travelling in groups place younger family members in one cabin and adults in another. Muster points are cabin dependent.

7 ACTIONS TAKEN

7.1 The Owners have upgraded fire detection and firefighting systems in areas where additional equipment has been installed. In the casing, this includes additional fire detectors and a water mist system.

7.2 In addition to 7.1, the Owners are considering additional CCTV camera installations in the casing.

7.3 The Owners have removed all scaffold boards in use on similar installations on other Company operated vessels.

7.4 The Owners require all scaffold materials to be non-combustible for use on board all vessels within their fleet.

LIST OF APPENDICES

I. Additional pictures

II. General information on damage in engine casing from deck 11 to deck 15

III. AEP exhaust piping progress through casing, on each deck

IV. Vessel's timeline of events on 22nd July 2015.

V. CCTV extracts

VI. Analysis report on PE piping and scaffold boards

APPENDIX 1: Additional pictures

Figure 16: External damage at the Viking Crown, deck 16

Figure 17: Internal damage at Viking Crown, deck 16. Exhaust duct from generator No.3, pre-heating cooling system, scupper drain lines, exhaust gas line from boilers, safety valves and air conditioning drain lines damaged

Figure 18: Deck 16 air sealing fan installation, recently installed but not commissioned

Figure 19: Deck 15 expansion tanks and level indicators

Figure 20: Deck 14 ducting for generator air supply, bioreactor exhaust fan, scupper drains, exhaust gas boiler safety valves, air conditioning system drains and pre-heating cooling system drains

Figure 21: Deck 12, main engine casing exhaust duct

Figure 22: Deck 11, scaffolding poles

Figure 23: Deck 8, insulation and coating damages

Figure 24: View of deck 4 below

APPENDIX II: General information for damage in engine casing from deck 11 to deck 15

- Smoke filter water damage
- Burned smoke detectors
- Burned Light Fixtures
- Possible CO_2 nozzle damage
- Burned speakers
- Burned emergency lights
- Burned cables
- Burned outlets
- Damaged Air supply solenoids
- Burned fans 7 Units
- Burned paint on bulkheads
- Damaged fire insulation
- Damaged piping

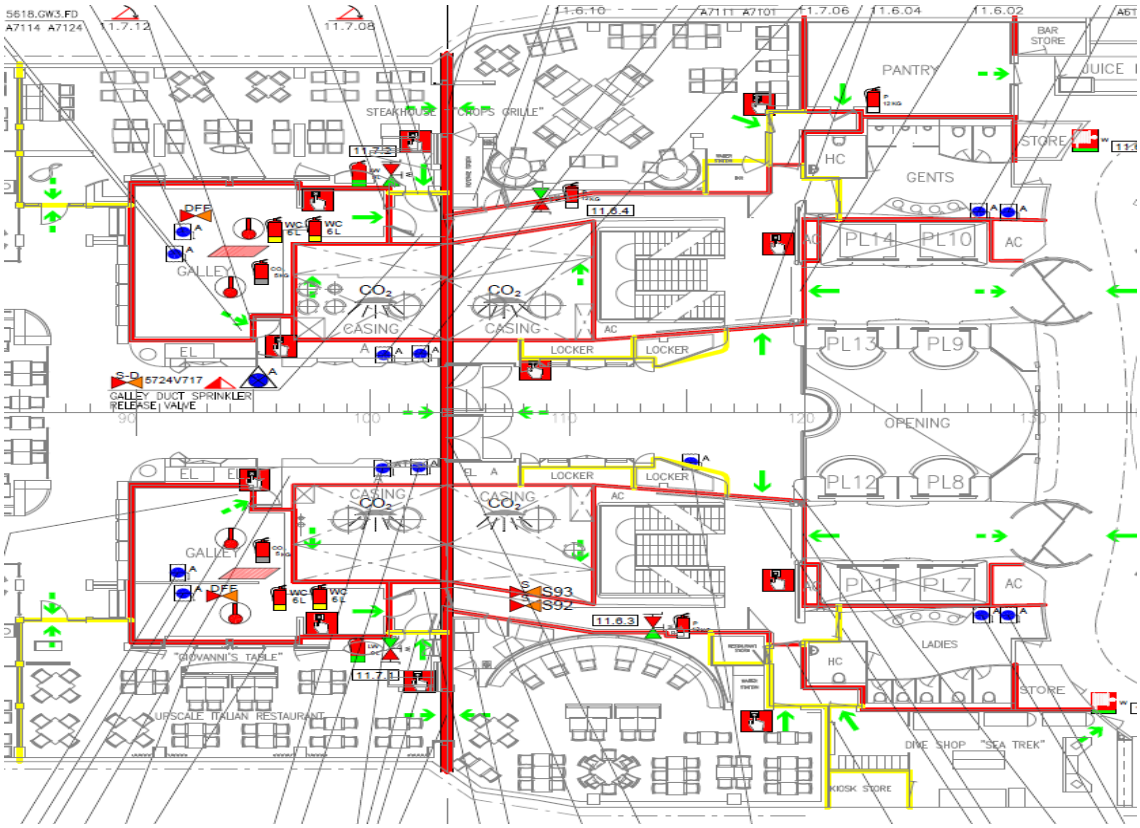


Figure 25: Deck 11 and above suffered water damage to carpets and ceilings

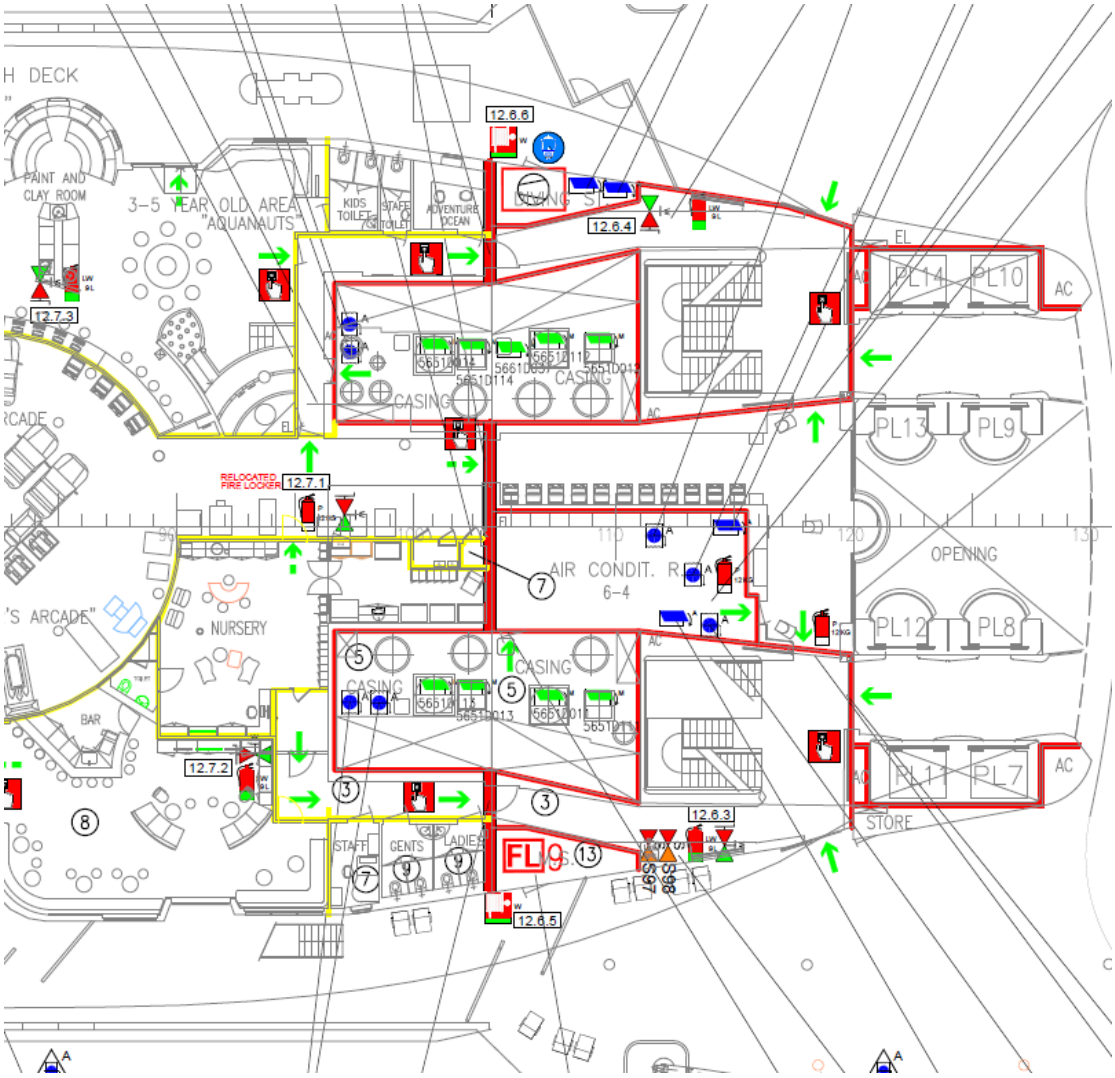


Figure 26: Deck 12

Damage for Deck 12 and above:

- Structural Damage
- Fire integrity damage
- CO_2 protect. hatch damage
- Exhaust fan Main Engine Room portside - 2 units
- Supply fan for FWD Main Engine room - 2 units
- Exhaust fan from AWP room
- All fire dampers
- Generator room supply fan 2 and also exhaust fan
- Exhaust fan for FWD grey water tanks
- Vacuum interface unit connected to AWP air duct

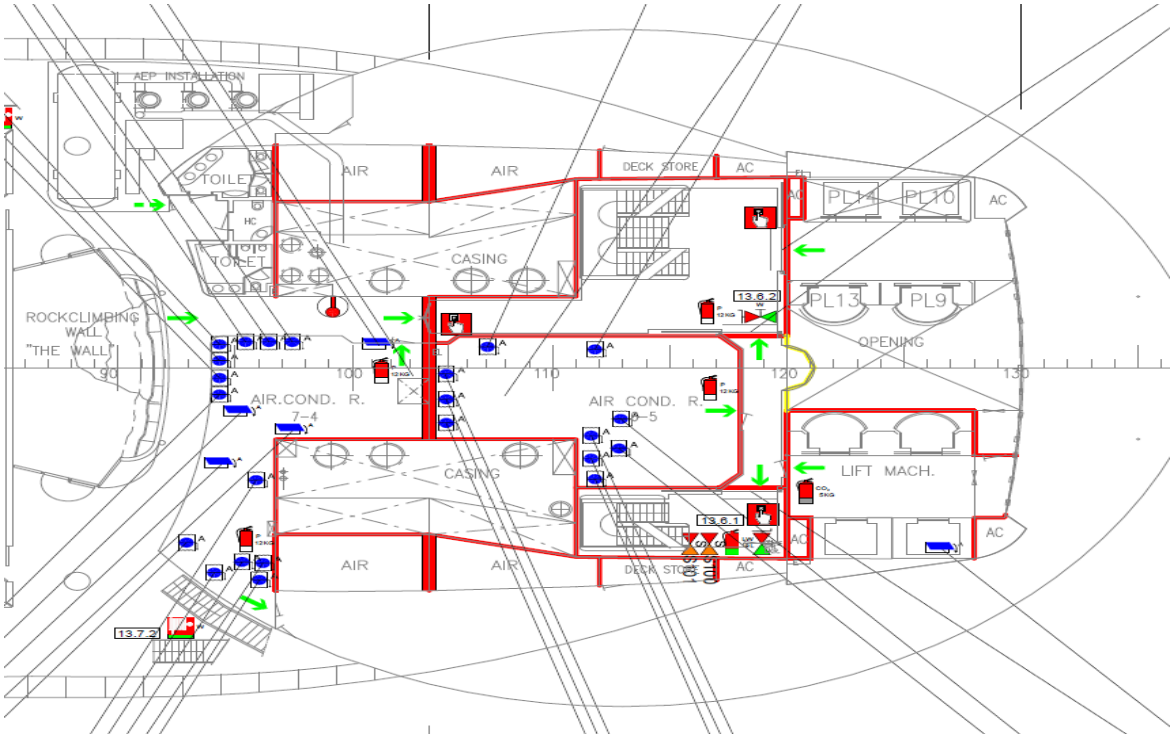


Figure 27: Deck 13

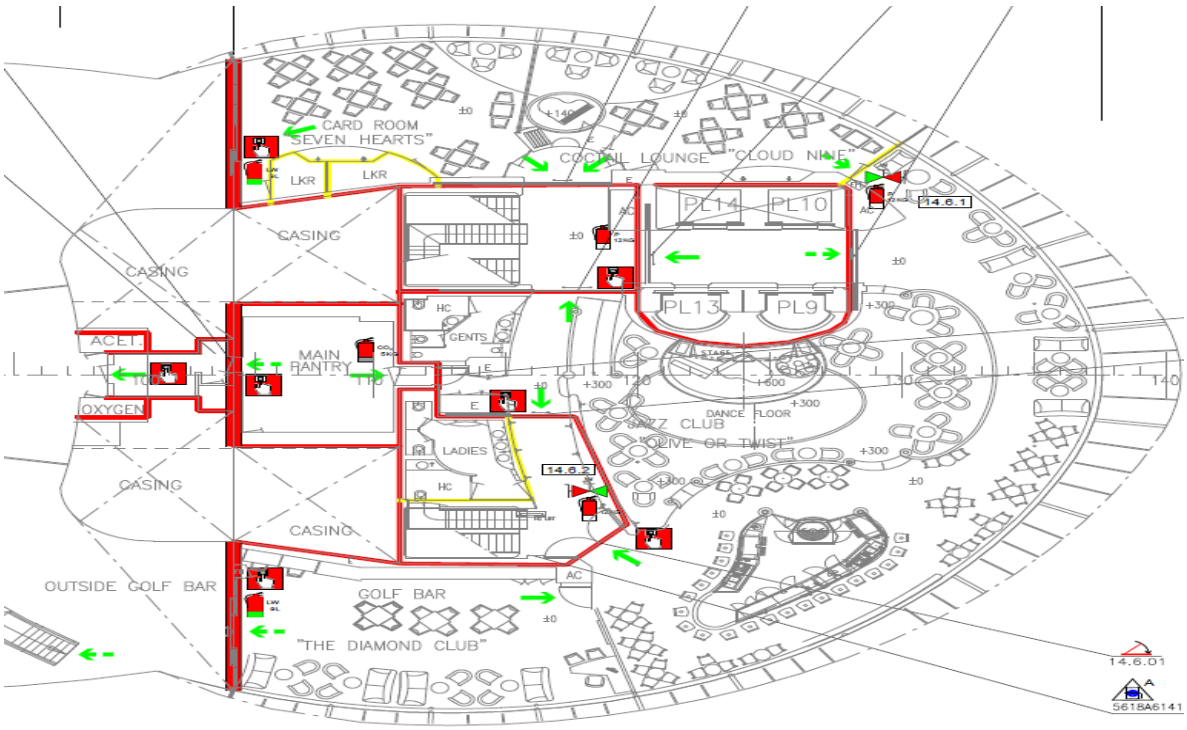


Figure 28: Deck 14

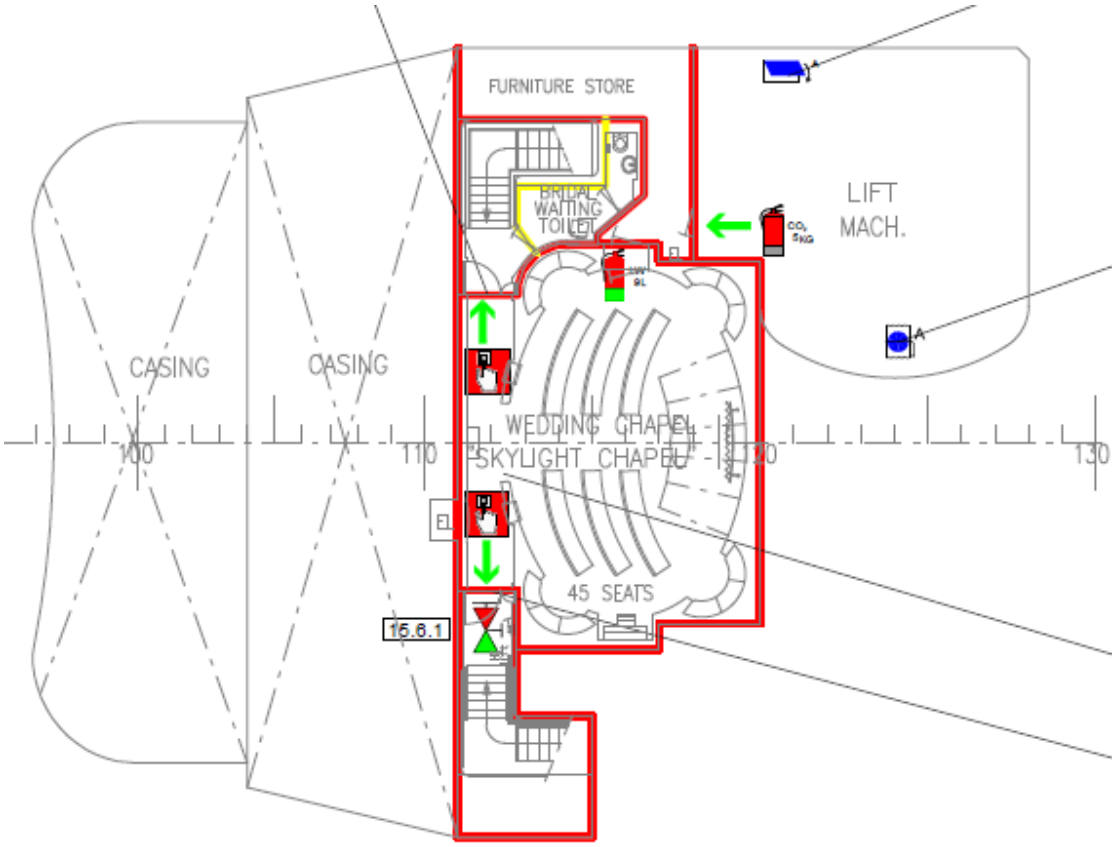


Figure 29: Deck 15

Damage assessment on Deck 15:

- Structural damage to the casing
- Expansion tanks (preheating, reheating) technical space
- Damaged plumbing and electrical installations - 4 units in total
- Carpet and wallpaper water damage

APPENDIX III: AEP exhaust piping progress through casing on each deck

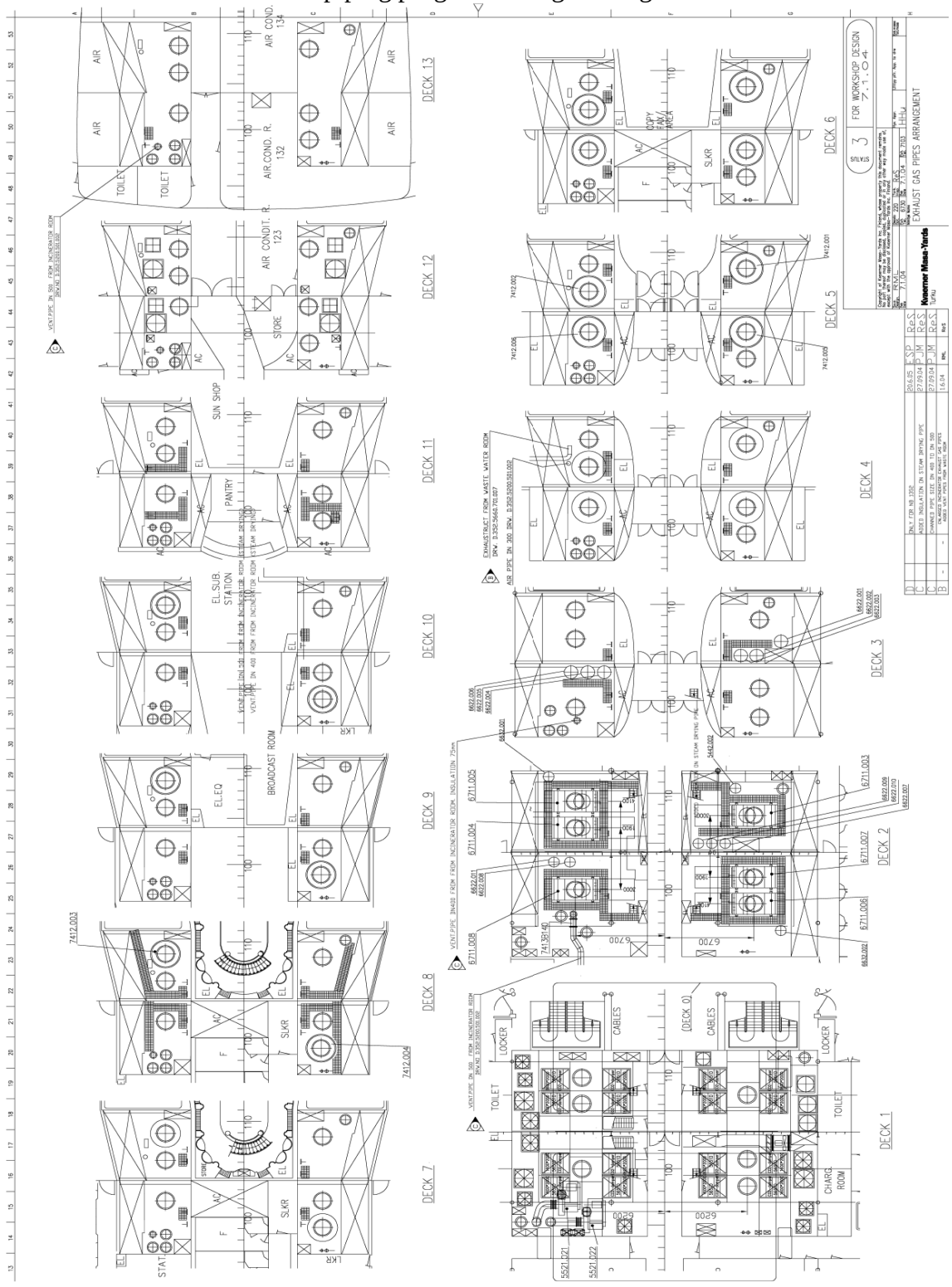


Figure 30: AEP exhaust piping progress through casing for each deck

APENDIX IV: Vessel's timeline of events on 22nd July 2015

0911	First fire alarm received on the Autronica at FWD Separator room, tank top zone 6
0915	Master, Chief Engineer and other key positions informed by phone
9015	Bravo Bravo Bravo + location- FWD SEPARATOR ROOM
0915	Chief Officer Safety on scene
0915	High fog activated in FWD Separator room
0918	Low Location Lighting activated
0918	Started isolating area
0919	Began mustering mobile groups
0920	Started deploying mobile groups
0920	MFG 6 to staging area
920	Ship brought on a course to give firefighters best advantage
0920	MFG 4 went on air
0921	MFG 2 and 9 at staging
0922	MFG 3 attacked the fire, other teams dispatched to top decks
0922	Set port condition on the bridge
0922	Bravo team assembled
0922	7 short one long blast
0922	Fire on the top of the Viking Crown (VC)
0924	Medical staff reported to the bridge- mustered and ready
0927	All mobile teams reported
0928	Bravo was called 2nd time - deck 13 VC
0928	MFG 6, 7, 9 and back-up 2 proceeding to VC
0930	No hot spots in the generator room
0934	I-95 Staging area moved (Smoke bound), deck 11 staging area established/ provision area staging area established
934	Pool area evacuated
0935	Deck 13 fire spreading
0935	All zone leaders are out
0935	Viking Crown evacuated
0936	Start boundary cooling (BC) on deck 12 and VC
0938	Deck 3 fwd casing fire identified
0939	OFCS on the I-95, Team No. 1 is standby with Environmental Officer on the pool deck
0940	Medical Team divided- pool and provision area
0940	MFG 3 and 4 with OFCS
0940	2, 5, 6, 7, 9 to VC
0942	Power isolated in deck 11 & up
0945	All fire teams engaged
0946	Fire on deck 1, 2 & deck 14 extinguished
0946	BC established both sides of VC

0946	BC taking place inside the VC
0947	Fire extinguished deck 1 & 2
0948	Deck 14 fire extinguished
0948	Fighting fire on deck 13
0949	MFG 6 going to deck 13
0954	Captain informed guests about the situation
0954	Deck 14 fire extinguished
0955	No fire in and around Acetylene locker
0956	MFG 3 sent back to OFCS
0956	All the personnel in the response team are accounted for
0957	Marine operations informed
0957	HD was called to contact local authorities
0957	BC taking place all around deck 13
0957	Deck 3 fire extinguished ENVO
0958	BC established on deck 10, 11, 12 no hot spot
0958	Started getting a lot of alarms on deck 15 by Chapel
0959	Staging area confirmed no injuries
1000	Staff Chief proceeding to chapel
1001	No hotspot on deck 10 & 11
1002	Hot spot found on deck 15, boundary cooling started
1004	All zone leaders back, 26 crew and 1 guest missing
1005	Fire extinguished deck 13 port side
1005	Aft Atrium firewall opened, OFCD moving with mobile team through engine casing, no fire up to deck 5
1008	Separator room FWD, generator room and FWD Casing room – no hot spot
1010	MFG 4 being prepared
1010	Crew member number 89 escorted to medical for 1at degree burns
1011	Continuing BC on deck 15
1012	No open fires reported
1013	MFG 4 being relieved by team 1
1018	Deck 11 smoke reported coming from fire door in Windjammer
1019	Deck 11 port side smoke coming
1020	Enviro asked for water to be aimed down the exhaust for cooling
1023	Windjammer fire doors to be closed
1024	Captain established contact with emergency room in Miami
1025	Opening hatch on deck 13 for cooling the exhaust
1027	No smoke just steam in the engine casing
1029	Security dispatched to the lift machinery room deck 15
1030	No hotspots on deck 15, lift machinery room
1031	Deck 13 cooling in progress
1031	Deck 12 OFCS opening hatch to cooling exhaust
1032	Hot spot still reported in deck 15 chapel

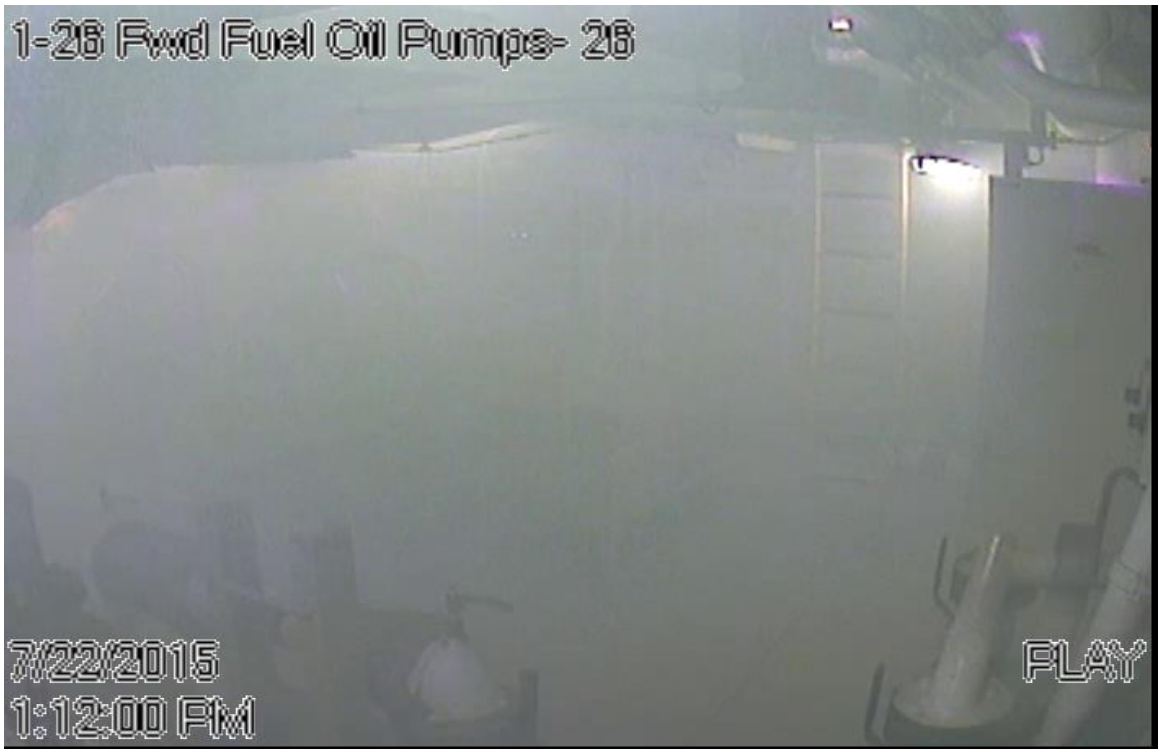
1034	Deck 12 hatch open, cooling exhaust
1034	Deck 11 PS fire door opened, water coming out
1035	Deck 15 high fog activated and FWD casing
1037	Boundary cooling completed on deck 13 and 14
1043	Security Officer dispatched to guest corridors aft to check for damage deck 9 and deck 10
1045	Steam and smoke reported on deck 1, I-95
1047	No hot spot reported in the Chapel
1047	Deck 15 being cooled from outside
1052	All the guests accounted for. No injuries reported to guests, 24 crewmembers still unaccounted for
1053	No more smoke on the I-95, only steam
1055	Opening seaside incinerator room shell door to create escape path for steam
1100	Port agent informed of situation, no shoreside assistance required
1100	24 crew and 5 guest unaccounted
1100	Boundary cooling reduced to 1 hose
1101	Captain informed situation room- fire has been extinguished
1102	Deck 11 still hot – reported by Safety Officer
1102	At this time, fire is believed to be extinguished, teams checking all areas for hot spot
1103	Sparks reported from engine casing deck 11, boundary cooling resumed with two hoses, sparks on deck 12
1104	No sparks from deck 5 to 1
1110	All crew cabins evacuated, 24 crew unaccounted for(23 crew and 1 contractor)
1113	Announcements being made for missing crew
1115	Gangway being prepared as a precaution
1116	Boundary cooling being prepared on deck 1, still some heat reported on deck 1 &2
1120	Boundary cooling now with 1 hose
1122	All water stopped
1127	Contractor found
1129	From 11 to 15 power secured
1130	Deck 1-10 fire extinguished, boundary cooling stopped in all the areas
1133	Mobile group 2 dispatched to deck 14, OFCS moving up through casing
1135	All the guests accounted for
1140	Funnel cleared, fire extinguished deck 1 to deck 12. No one in engine casing
1142	Executive Housekeeper checking passenger cabins in Zone 6 for damage. Crowd control dispatched on upper decks
1143	Deck 11-15 no fire, fire extinguished, temperature cooling down
1145	Sewage reported on deck 1
1147	MG 2 standby on deck 14
1157	4 mobile team at the staging deck 1
1200	4 crewmembers unaccounted for- 1024, 1370, 827, 803
1205	Shell door # 1 being opened, preparing fwd and mid-ship gangway
1205	All crew and all passengers accounted for

1215	Announcement made allowing passengers to return to their cabins, crew dismissed except stairway control

APPENDIX V: CCTV extracts

SEPARATOR ROOM AT 09:11:30 - LIGHT HAZE

SEPARATOR ROOM AT 09:12



RADAR MAST VIEW AT 09:25 – Smoke and Flames present

RADAR MAST VIEW AT 09:52 – Boundary cooling taking place

APPENDIX VI: Analysis report on PE piping and scaffold boards

NATIONAL TRANSPORTATION SAFETY BOARD
Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594

February 23, 2016

MATERIALS LABORATORY FACTUAL REPORT Report No. 16-014

A. ACCIDENT INFORMATION

Place	: Falmouth Harbor, Jamaica
Date	: July 22, 2105
Vehicle	: RCCL Freedom of the Seas
NTSB No.	: DCA15RM028
Investigator	: Eric Stolzenberg

B. COMPONENTS EXAMINED

A section of polymeric piping and a section of support scaffolding

C. DETAILS OF THE EXAMINATION

A section of the polymeric piping and a section of scaffolding material sample were submitted to the Materials Laboratory for examination. The samples were submitted to verify that the piping and scaffolding materials were the same materials specified by the operator doing the installation work. Both samples were examined using Fourier-transform infrared spectroscopy (FTIR) with a diamond attenuated total reflectance (ATR) accessory in accordance to ASTM E1252-98 (American Society for Testing Materials E1252-98: *Standard Practice for General Techniques for Obtaining Infrared Spectra for Qualitative Analysis and American Society for Testing Materials*). The spectrometer was used to collect and process infrared wavelength absorbance spectra of the unknown material.

The spectrum for the piping material contained spectral peaks that corresponded to particular functional groups found within the molecular structure of the piping material. The presence of a doublet peak at ~2923 cm^{-1} and ~2853 cm^{-1} corresponds to a carbon-hydrogen stretching bond. A single medium peak at ~1457 cm^{-1} is indicative of a carbon-hydrogen(2) bending bond. A doublet peak at ~729 cm^{-1} and ~718 cm^{-1} is indicative of multiple carbon-hydrogen(2) bonds. A spectral library search was done on the piping material spectrum and it was found to be a very strong match to polyethylene. This was verified visually by the examiner. There were no peaks present in the spectrum consistent with the presence of typical fire retardant materials (aluminum, iron, and/or nickel compounds, calcium carbonate or zinc borate). FTIR cannot differentiate between low density polyethylene and high density polyethylene, however, information provided by the piping manufacturer stated that the piping material was high density polyethylene. The

physical characteristics of the section of piping material (color, thickness and markings) were consistent with the material described in the piping manufacturer's information. According to published flammability data, polyethylene has a crystalline melting temperature of 130 ºC, an auto-ignition temperature of 350 ºC and a heating value of 20,050 Btu/lb[1].

The spectrum for the scaffolding material contained spectral peaks that corresponded to particular functional groups found within the molecular structure of the scaffolding material. The presence of a large, broad peak between ~3575 cm^{-1} and ~2900 cm^{-1} is indicative of an oxygen-hydrogen bond as well as a carbon-hydrogen stretching bond in aromatics. A doublet peak at ~2923 cm^{-1} and ~2853 cm^{-1} corresponds to a carbon-hydrogen stretching bond. A series of weak peaks at ~1600 cm^{-1} is indicative of a double bonded carbon stretching bond. A single peak at ~1256 cm^{-1} is indicative of a carbon-oxygen rocking bond. A single peak at ~1159 cm^{-1} is indicative of a carbon-oxygen-carbon symmetrical stretching bond. A single peak at ~1104 cm^{-1} is indicative of a carbon-oxygen-carbon asymmetrical stretching bond. A doublet peak at ~1055 cm^{-1} and ~1032 cm^{-1} is indicative of a carbon-oxygen, carbon-carbon and carbon-hydrogen side group vibrational bonds. A spectral library search was done on the scaffolding material spectrum and it was found to be a match to cellulose hemicellulose, and lignins consistent with untreated wood similar to pine wood. This was verified visually by the examiner. There were no peaks present in the spectrum consistent with the presence of typical fire retardant materials (phosphates, antimony compounds, boron compounds and/or ammonium compounds).

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Nancy B. McAtee
Chemist/Fire and Explosion Specialist

[1] Hilado, C.J; *Flammability Handbook for Plastics*" Ed. and Georg Fischer Piping Systems *Technical Manual for Plastic Piping in Utilities*.