

[MSI Report 2021-006]



# **Marine Safety Investigation Report**

**– Fire Accident onboard the Cable-laying ship Responder –**

Date of Accident : September 11, 2020

Date of Publication : December 30, 2021



**Korea Maritime Safety Tribunal  
Marine Safety Investigation Team**

## Note

This marine safety investigation report aims to identify the cause of the marine accident in question and prevent similar marine accidents or incidents in the future under Article 18.3 of the Act on the Investigation of and Inquiry into Marine Accidents. It is therefore advised that this report not be used for assigning blame or determining liability.

This report quotes the names of the relevant acts and agencies that were in place at the time of writing.

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# Summary of the Accident

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## 1. Summary of the Accident

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- 1.1 Responder was a cable-laying ship of 6,298 gross tonnage, 84.95 meters in length and 20.00 meters wide, launched on August 31, 2000 from the Stralsund shipyard in Germany and was owned by KT Submarine and operated by Sehdong Shipping Co., Ltd.
- 1.2 The vessel departed from her home port located in Geoje, Republic of Korea at around 07:00 on September 8, 2020 for cable laying operation, and set to work after arriving at the working site of approx. 28 miles south-southwest off Jwasari Island in Tongyeong City, Gyeongsangnam-do at around 13:00 on the same day.
- 1.3 While the cable laying installation was ongoing at around 01:30 on September 11, 2020, Second Engineer A, transferred the oil stored in the F.O drain tank to the settling tank, and operated the valve for changing fuel oil tank for use on the same day at around 02:00.
- 1.4 Meanwhile, on the same day at around 02:35, Second Engineer B acknowledged the F.O leakage alarm on the monitor in the Engine Control Room (hereinafter referred to as "ECR") indicating that oil was leaking from the first and second cylinders of the Main Engine.
- 1.5 When Second Engineer B went to the site and checked the condition of the Main Engine, he observed that a large amount of oil was leaking from the surroundings of the jacketed high pressure fuel pipes of the first and second cylinders of the Main Engine.
- 1.6 Second Engineer B went back to the ECR to check the temperature of the exhaust gases of the Main Engine, but no significant deviations were observed, and he called Chief Engineer and First Engineer who were taking a rest in the accommodation to report the situation.

- 1.7 Upon receiving a call from Second Engineer B, Chief and First Engineers came to the Engine Room and smelled strong oil mist. After checking the site, they observed a situation where the flywheel of the No.1 Main Engine rotating at high speed came into contact with the oil at the top of the bilge well right below the flywheel, was creating oil mist.
- 1.8 Chief and First Engineers considered that there was a problem in the No.1 Main Engine, and stopped it. But after figuring out that oil was also leaking from the No.2 Main Engine, they decided to restart the No.1 Main Engine and stop the No.2 Main Engine.
- 1.9 Around 03:35, the Chief Engineer pressed the Air Cricuit Breaker (ACB) button on the monitor in the ECR to restart No.1 Main Engine and stop No.2 Main Engine. A few seconds later, a fire alarm activated and both No.1 and No.2 Engines were stopped as the ship blacked-out.
- 1.10 Engineers in the ECR opened the ECR door to check for a fire and to find the oil leak spot, but they had no choice but to escape to upper deck due to the thick smoke in Engine Room.
- 1.11 Second Engineer A and Third engineer went up to the Bridge and shut down quick closing valve of fuel oil tanks. Then, they went out of the Bridge and headed up to the funnel to close the Engine Room ventilation dampers but failed to close the dampers due to heavy smoke.
- 1.12 Meanwhile, Master reported the outbreak of onboard fire to the TongYeong Coastal VTS via VHF Radio around 03:40.
- 1.13 After Master received a report from First Engineer at around 03:42 on the same day that local fire fighting had been failed, he instructed Chief Officer to use the onboard fixed CO2 fire extinguishing systems.
- 1.14 Master decided to abandon the vessel at around 03:50 on the same day as fire fighting with the onboard fixed CO2 fire extinguishing systems was not successful,



and commended all crews to embark the Youngin 105 which was a work support vessel around the site. All crews boarded on Youngin 105, and then they were transferred to the Mirae-ro which was another cable layer operated by the Sehdong Shipping Co., Ltd. at around 05:00, and arrived at the berth No. 7 of Busan port at around 21:32 on the same day.

- 1.15 While fire was being suppressed by the fire-fighting and the rescue teams dispatched from Tongyeong Fire Station and etc., the vessel sank into the sea about 42 miles south off Yokji Island, Tongyeong City, Gyeongsangnam-do at around 17:42 on September 12, 2020, one day after the fire outbreak.

section

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## Factual Information

## 2. Factual Information

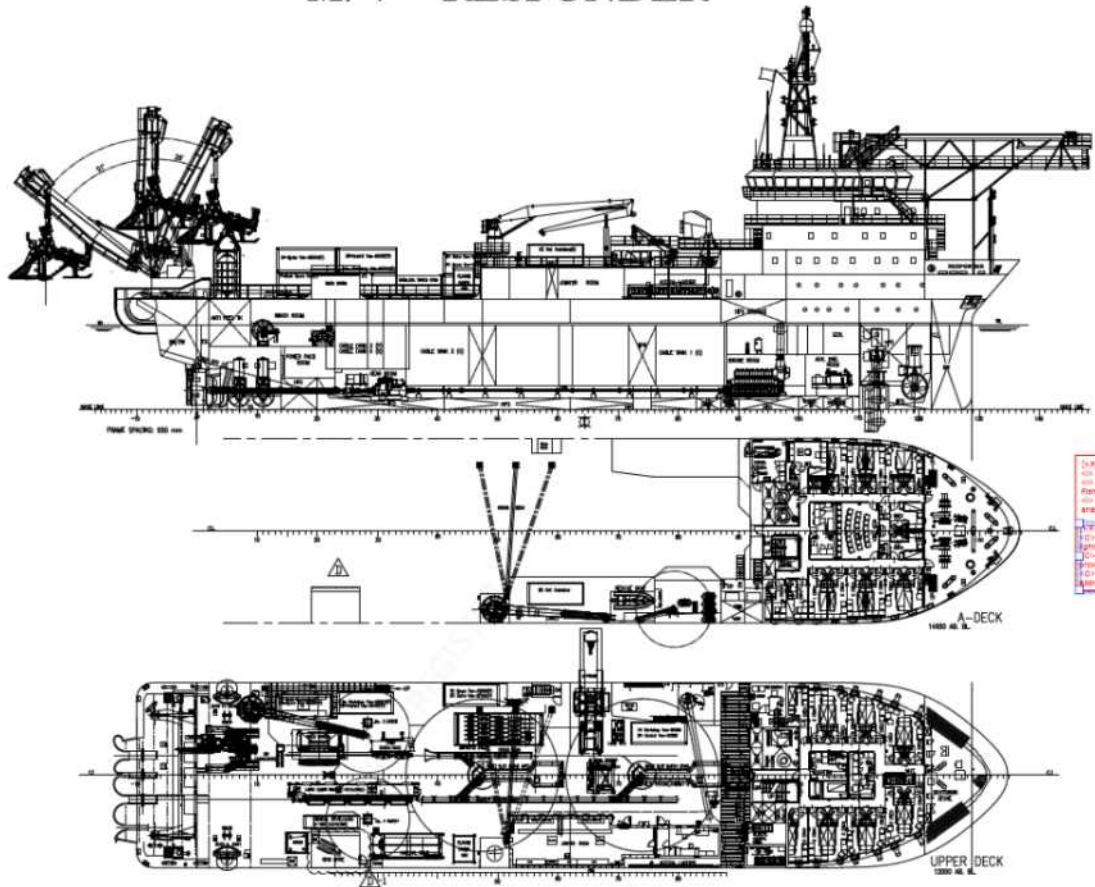
### 2.1 Vessel information

#### 2.1.1 Specifications of Responder

Name of the Ship	Responder
Flag (Port of Registry)	The Republic of Korea (Jeju)
IMO No.	9215206
Call Sign	D7AW
Vessel Type	Cable Layer
Owner	KT Submarine
Manager	Seh Dong Shipping Co., Ltd. Co.Ltd.
Builder	Volkswerft Stralsund GmbH, Germany
Date of Keel Laid	December 23, 1999
Date of Launch	August 31, 2000
Classification Society	Korean Register of Shipping, KR
Length(m)	84.95
Width(m)	20.00
Depth(m)	12.00
Height(m)	43.90
Gross Tonnage(t)	6,298
Deaweight Tonnage(MT)	8,071
Main Engine(number)	MAN B&W Augsburg (2)
Max. Output	5,220
Propeller	2 (Controllable pitched propeller, CPP)
Rudder	2
Bow Thruster	1,200kW × 1
Azimuth Thruster	1,000kW × 1
Stern Thruster	1,200kW × 2
Dynamic Positioning System	Kongsberg (SDP-OS / HiPAP 500)

## GENERAL ARRANGEMENT

### M/V " RESPONDER "



<Figure 1> General arrangement(part) and the overall view of Responder

## 2.2 Ownership and operation of the vessel

- 2.2.1 Responder was a cable-laying ship of 6,298 gross tonnage, 84.95 meters in length, 20.00 meters wide and 12.00 meters in depth, which was built in Volkswerft Stralsund, Germany for laying undersea cables and offshore construction.
- 2.2.2 After launched in August 31, 2000, the vessel was registered in Danish flag after being delivered to Moller-Maersk A/S on December 18, 2000.
- 2.2.3 On May 10, 2013, the vessel was sold to Maersk Supply Service, a offshore oil drilling service provider.
- 2.2.4 The vessel was sold again to KT Submarine<sup>1)</sup> on April 29, 2015, and her flag was changed to the Republic of Korea on June 26, 2015 with Jeju as its port of registry.
- 2.2.5 KT Submarine Co., Ltd., the owner of the vessel, signed a contract with Sehdong Shipping Co., Ltd. entitling it as a management agent responsible for ship operation, management of safety and crews, and insurance business on behalf of KT Submarine Co., Ltd. and renewed the contract every two years.
- 2.2.6 Accordingly, KT Submarine Co., Ltd. paid ship management fees, crew wages, insurance premiums, and ship repair and management costs to Sehdong shipping Co., Ltd., while Sehdong Shipping Co., Ltd. carried out their duties such as crews' boarding, training of crews, ship repair and management, implementation of the ISM Code, negotiations with the insurance company on behalf of the shipowner, and provision of ship supplies.
- 2.2.7 When having not been in operation, Responder usually was berthed at her mother port located in Hacheong-myeon, Geoje-si, Gyeongsangnam-do, and when there requires cable work or offshore construction, it departed the port, supplied with equipment and food and carried out its duty of repairing and laying cables in the sea area of southeast Asia, the north Pacific, the Atlantic and etc.

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1) The KT submarine co., Ltd is a company engaged in the electric and telecommunications business, mainly undersea communication and power cable construction and maintenance, undersea pipeline installation and burial, special cable installation and maintenance and exploration projects, and was established in April 1995 as Korea Submarine and changed its name to the KT Submarine Co., Ltd. in March 2002.

## 2.3 Vessel surveys and safety management

- 2.3.1 Responder was registered in Lloyd's Register after delivery to Moller Maersk A/S in December 2000, but after it was sold to KT Submarine Co., Ltd. of the Republic of Korea, on July 10, 2015 its Class registry was transferred to the Korean Register of Shipping, an organization that carries out vessel surveys on behalf of the Korean government.
- 2.3.2 After it was transferred to the Korean Register of Shipping, it received an annual survey on January 25, 2016, and an intermediate survey on October 24, 2016, and it successfully completed the renewal survey on December 27, 2017, and received a Ship Survey Certificate<sup>2)</sup> valid until December 26, 2022.
- 2.3.3 The vessel received a total of 12 occasional surveys from her classification society, and they were mainly related to remodeling of the jointer room, repair of the steering gear motor and corrective actions for deficiencies pointed out by Port State Control (PSC) inspections, and they were not related to the repair and remodeling of equipment neither in the engine room nor fuel oil tanks.
- 2.3.4 From 2015 to 2020, after delivery to KT Submarine Co., Ltd. and transfer to the Korean Register of Shipping, the vessel received 11 PSC inspections in Denmark, the United States, Japan, P.R.China, and Peru without any major deficiency that would lead to the ship detention. But, some minor deficiencies such as damage to the exterior of a rescue boat, omission of the checklist for fire extinguishing facilities, defects found in radar operation tests, defects identified during the emergency response drills, defects in the machinery space were found and corrected.
- 2.3.5 The defects found in the machinery space were malfunctions of sludge pumps of oil separators that happened in Wakamatsu/Kitakyushu, Japan on January 14, 2016, and inaccurate recordings of the No.1 Engine parameter made in Wakamatsu/Kitakyushu, Japan on March 2, 2018.

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2) SC: Cargo Ship Safety Construction Certificate, SE: Cargo Ship Safety Equipment Certificate, SR: Cargo Ship Safety Radio Certificate, ILL: International Load Line Certificate, IOPP: International Oil Pollution Prevention Certificate

2.3.6 Also, Responder was classified in the White List after inspection based on the condition of the vessel, deficiencies, type of the vessel, and etc. by Tokyo MOU and Paris MOU, which are regional PSC regimes.

## 2.4 Vessel structure

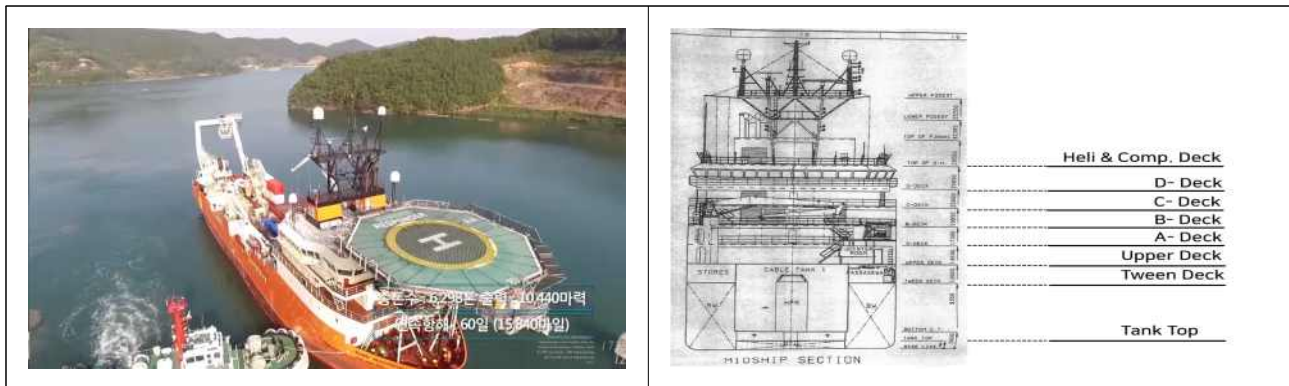
2.4.1 Responder was a fore-bridge type ship that had a bridge, accommodation space, and machinery space on its head. On the very top of the bridge, there were Helideck where helicopters could take off and land and Compass Deck where antennas for navigation equipment were placed.

2.4.2 Beneath Compass Deck, there was Wheel House where navigation and communication equipment were located and D-deck where had work spaces for underwater work such as cable laying, and under D-Deck, there was accommodation spaces (C-Deck ~ Upper Deck) where had crew cabins and recreation areas.

2.4.3 Below Accommodation area (Upper Deck), there was Tween Deck where cafeteria, freezing and refrigerating chamber, gym, etc, were located and below the Tween Deck, Platform Deck was located where had ECR, Workshop and etc., and at the lowest bottom of the vessel, the Tank Top was located where No.1 Engine was placed.

2.4.4 At the mid-part of the vessel, there were three cranes that could load and unload provisions, spare parts, cables, and equipment, and winches that could move cables, the jointer room and lockers where could check and repair cables, and equipment needed for various works. Under the upper deck, there were four cable tanks where cables could be stored. There were ballast tanks to load ballast water on the both sides of Tween Deck.

2.4.5 At the stern of the ship, A-frame crane was located on deck, and there were Steering Gear Room and an anti healing tank for maintaining the ship stability at the ship bottom.



<Figure 2> Vessel Structure of Responder

## 2.5 Fire-extinguishing systems

2.5.1 Responder was equipped with fire extinguishing appliances and systems for fire emergencies on the ship, and the details are as follows:

<Table 1> Fire extinguishing appliances and systems of Responder

Type	Name	No.		
		Deck	Accom.	Eng.RM
Fire extinguishing appliances	Fireman's Outfit	7	-	-
	2kg Powder Ext.	2	-	-
	12kg ABC Powder Fire Ext.	7	20	28
	20kg CO <sub>2</sub> Fire Ext.	2	-	-
	5kg CO <sub>2</sub> Fire Ext.	3	10	11
	25kg Powder Ext.	4	-	4
	50kg Powder Ext.	-	-	2
	20L Portable Foam Applicator Unit	1	-	1
Fire extinguishing systems	Fire Hydrant	43		
	Fire Hose Box with Hose & Nozzle	27	10	7
	Fire Pump : 50M <sup>3</sup> /H	-	-	1
	Fire Pump : 205M <sup>3</sup> /H	-	-	1
	Emergency Fire Pump	-	-	1
	International Shore Connection	-	2	-
	Fire Main Isolating fuel oil	-	1	8
	Vent. Emcy. Stop - Tween & D-deck	1	-	1
	Water Fog Applicator	4		
	Fire Damper In Vent. Duct. with Sys. No.	20	6	11
	Closing Appl. for Exterior Vent. Inlet	39	51	-
	Fixed CO <sub>2</sub> Fire Ext. <sup>3)</sup>	Engine Room 1		



## 2.6 Ventilation systems and fire dampers for fire control

- 2.6.1 Duct was installed in each area of Responder for ventilation, and fire damper was installed in the duct which was opened during the normal time to help air flow inside the duct, and in case of fire, there was a device to block the flow of air inside the duct to prevent the spread of the fire.
- 2.6.2 Types of fire damper<sup>4)</sup> include a manual fire damper which opening and closing of the damper is manually controlled by a crew member, an automatic fire damper which is automatically closed when it is exposed to fire, and a remotely operated fire damper that can be closed remotely far from the fire damper by using a control located at a distance.
- 2.6.3 A total of 127 fire dampers were installed in the ventilation ducts of Responder for fire prevention, and 79 of them were installed in the mechanical ducts (42 for air supply, 37 for exhaust), and 48 of them were installed in the natural ducts (12 for air supply, 36 for exhaust), respectively.
- 2.6.4 Each of six dampers was equipped with one damper for supply and exhaust from Engine Room. A total of three dampers<sup>5)</sup> were installed in each three mechanical supply duct (MS 22~24) that was located on Upper Deck, and they could be automatically closed by remote control at the entrance of the engine room and ECR on Tween Deck. Three other natural exhaust ducts (NE61~63) – one on C-Deck and the other two on the wall of the casing of Engine Room that was located on the Helideck – were installed with a damper<sup>6)</sup> which could be controlled either by a manual handle at the site, or by remote control at the fire control board on Bridge or at the outside the entrance of Engine Room on Tween Deck.

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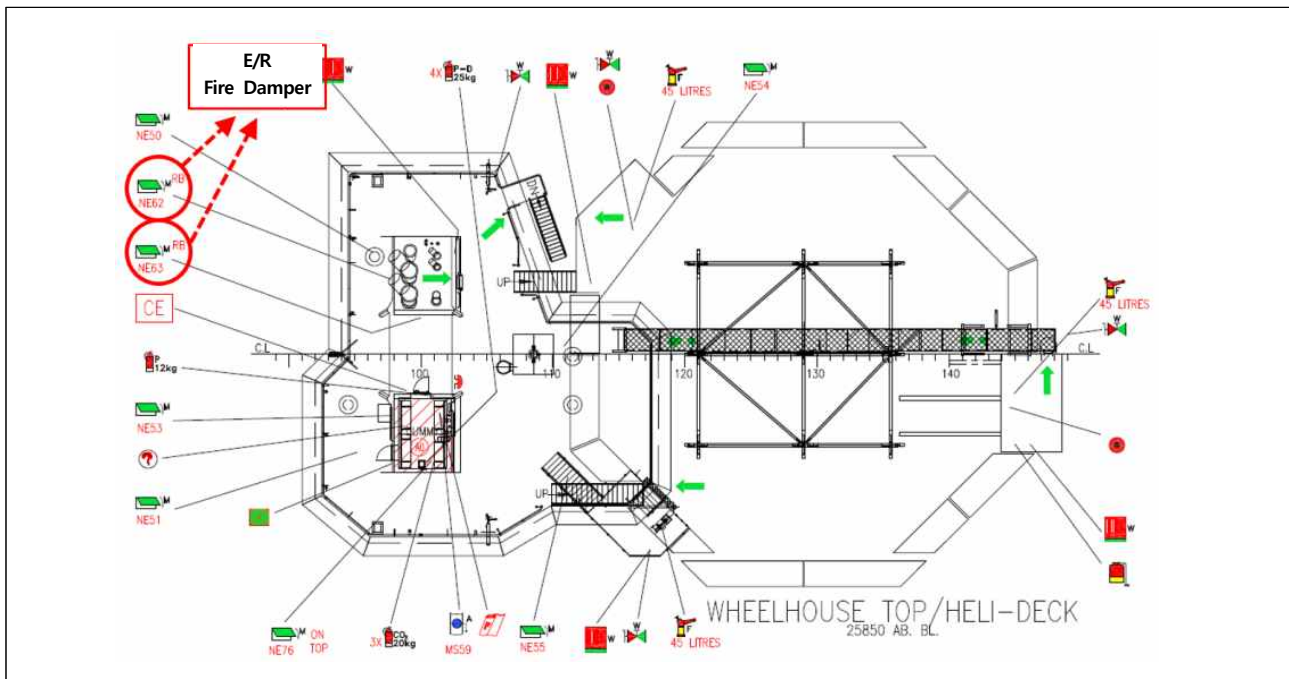
3) The vessel was exempted from the requirement of installing fixed CO2 fire extinguishing systems in the cargo space on condition of loading non-combustible underwater cables

4) International Convention for the Safety of Life at Sea(SOLAS) Chapter II-2, Regulation 3, 54

5) It is marked as Closing Appliance for Exterior Ventilator in fire control plan

6) It is marked as Closing Appliance for Exterior Ventilator

2.6.5 Meanwhile, the three mechanical ventilation fans located on the upper deck for the supply of outside air into Engine Room were capable of reverse rotation, so normally used as an supply for the engine room. But if necessary, they could be used for exhaust of air in Engine Room by reversed rotation.



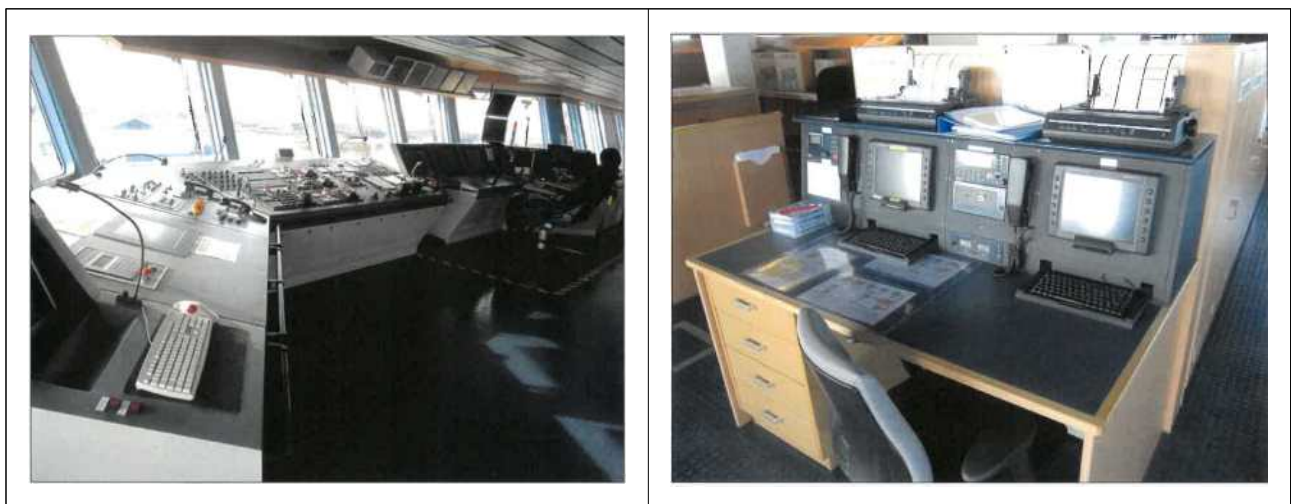
<Figure 3> Location of fire dampers in Responder (funnel of the helideck)



<Figure 4> Location of fire dampers in Responder (Upper deck)

## 2.7 Navigation and communication systems

- 2.7.1 At the center of Wheel House, a steering stand and three radars, electronic chart display and information system (ECDIS), automatic identification system (AIS) were installed, and two differential global positioning system (DGPS), one Loran-C, three Gyro Compasses, and one magnetic compass were also located.
- 2.7.2 At the frontal top of the bridge, doppler speed log, rudder indicators, clinometer, and RPM indicators of the main engines, rate of turn indicator, and anemometers were located.
- 2.7.3 Also, the vessel was equipped with course recorder, echo sounder, ship security alert system (SSAS), search and rescue radar transponder (SART), simplified voyage data recorder (S-VDR), and emergency position indication radio beacon (EPIRB).
- 2.7.4 Main communication systems included VHF radio, MF/HF radio, Navtex receiver, fleet broad band (FBB), and etc.
- 2.7.5 Also, the vessel was equipped with public address system, General emergency alarm system and talk back system for the on board announcement and broadcasting, and communications among crew members.



<Figure 5> Bridge and communication systems of Responder

## 2.8 Dynamic Positioning System and Cable Work

- 2.8.1 Responder was equipped with the dynamic positioning system<sup>7)</sup> (hereinafter referred to as 'DP system') that could maintain the current position of the vessel, and it had a separate space in Bridge for controlling the DP system while observing external weather conditions and the current work status such as lowering of cables under the water.
- 2.8.2 Responder was a DP Class-2 vessel<sup>8)</sup>, with two DP operation stations (Kongsberg SDP-OS). The main DP systems installed on the vessel were a HIPAP system that transmits sound waves to the seabed to detect changes in the vessel's position, three of light weight taut wire system that could identify whether the vessel maintains its position by pulling physical wires, and seven of motion reference units that could measure six degrees of freedom<sup>9)</sup>.
- 2.8.3 Also, the vessel was equipped with two anemometers to measure the direction and speed of the wind when the wind passes by using ultrasonic waves, two DGPS systems, three Gyro Compasses, and four electronic chart systems.



<Figure 6> DP system of Responder

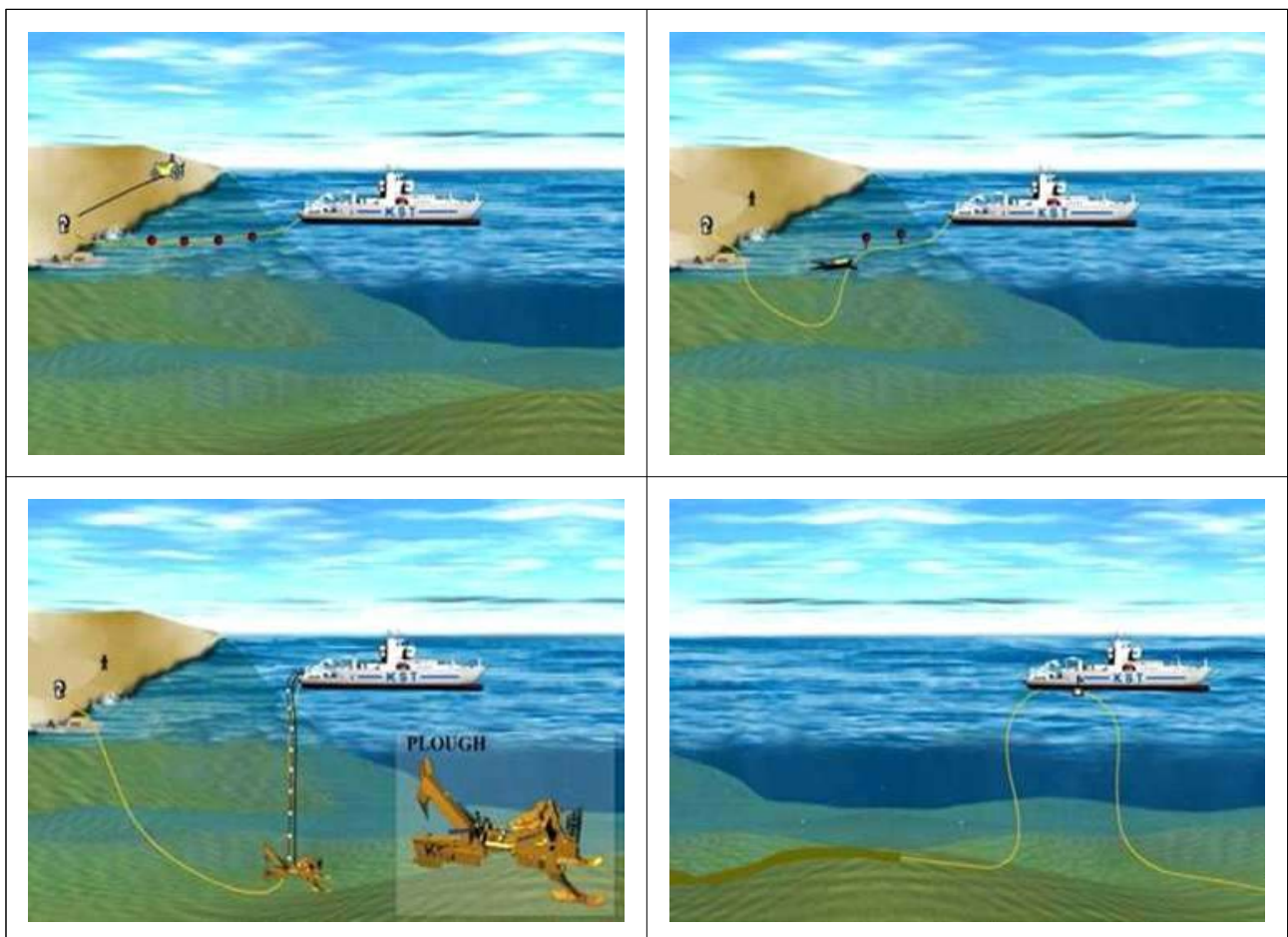
- 7) The system designed for the vessel to stop and maintain the constant location automatically (error range of 3 meters) using transverse propulsion device for undersea work or cable laying,
- 8) In accordance with IMO MSC/Circ.645, DP system is divided into 3 levels, and as the level gets higher, DP system is more reliable (Class-1, loss of position may occur in the event of a single fault, Class-2, Class-3 as the level gets higher, the ability to compensate position keeping function is better)
- 9) ① Rolling: The rotational motion of a vessel about its longitudinal axis ② Pitching: The rotational motion of a vessel about its transverse axis ③ Yawing: The rotational motion of a vessel about its vertical axis ④ Surging: bow and stern vibration of a vessel ⑤ Swaying: transverse vibration of a vessel ⑥ Heaving: vertical vibration of a vessel



2.8.4 Before laying submarine cables, the cleaning process through the paths where the cables would be laid should be conducted primarily and then the cables should be buried and laid. To this end, dedicated equipment such as cable layers, Plough<sup>10)</sup>, and ROV should be used for the work.

2.8.5 Submarine cable laying was carried out at the location where the cables were planned to be buried. Firstly, it took out cables that were loaded in a cable tank of the vessel by using linear cable engine (LCE), cable drum engine (CDE), and laid the cables using a Plough.

2.8.6 Also, the DP system was in operation to prevent the movement of the vessel against waves, swells and winds while repairing or laying cables.



<Figure 7> Development view of cable laying work  
(carrying cables to the land → removing buoys → underwater work → final connection work)

10) The plough is the equipment for creating trench at the surface so that the cable can be inserted

## 2.9 Main engine, auxiliary, and thruster

- 2.9.1 The Main Engines of Responder were B&W Alpha 8L 32/40 type made by MAN Energy Solutions (Manufacture), and the main engine system was a twin propeller type that was composed of two sets of Main Engines with 3,840kW output and two propellers.
- 2.9.2 Two propellers of the vessel were blade types made of Nickel Aluminum Bronze alloys. As controllable pitch propellers (CPP), those propellers could change the direction of the vessel by rotating each propeller blade centered on the axis of the blade to change the pitch angle of the blade.
- 2.9.3 In addition to the Main Engines, the vessel has four auxiliary thrusters. At the bow and stern of the vessel, single and dual thrusters with 1,200kW output were installed, respectively, and one retractable azimuth thruster with 1,000kW output was installed at the bow of the vessel.
- 2.9.4 The vessel had two shaft generators with 3,000kW output that could generate electricity through shaft rotation created by the operation of the Main Engines, two auxiliary generators with 760kW output that could generate electricity using separate engines, and one emergency generators with 183kW output.
- 2.9.5 When the vessel was berthed and moored, it provided electricity to navigation equipment and accommodation area by running two auxiliary generators, and when cable work was underway on the sea, both auxiliary generators and shaft generators were operated to supply power to electric equipment that consumes huge electricity such as Plough, Thruster, Linear Cable Engine (LCE), Cable Drum Engine (CDE), and Remotely Operated Vehicle (ROV).
- 2.9.6 In terms of boilers, the vessel was equipped with one vertical smoke tube oil-fire boiler that could produce 2,000 kg of steam per hour, and one exhaust gas boiler that could produce 1,500kg of steam per hour.

## 2.10 Fuel oil tank and pipe structure of the engine room

2.10.1 Responder was supplied with fuel oil and lubricating oil for operation of the vessel, and low sulfur fuel oil (LSFO) and low sulfur marine gas oil (LSMGO)<sup>11)</sup> were loaded on the vessel as fuel oil, but LSMGO was mainly used as fuel oil for the operation of engine equipment such as the Main Engines and generators.

2.10.2 The vessel had 18 fuel oil tanks under Upper Deck, and the tanks' names starting with the number of 100's or 200's. The 10 tanks with the number 100's and 8 tanks with the number 200's, were not interconnected but the piping systems of the tanks under the same number group were interconnected.

L.S.FUEL OIL TANKS									
TANK NO.	Innage m	Corr' m	GROSS CU. M	DENSITY @15 °C	TEMP. °C	V.C.F. T-54B	NET CU. M	W.C.F. T-56	METRIC TONS
T100	Gauge	Gauge	78.810	0.9000	42.5	0.9787	77.131	0.9000	69.418
T101	Gauge	Gauge	39.400	0.9000	51.7	0.9714	38.273	0.9000	34.446
T102	Gauge	Gauge	37.270	0.9000	36.2	0.9835	36.655	0.9000	32.990
T103	Gauge	Gauge	-	0.9000	24.4	0.0000	-	0.9000	-
T104	Gauge	Gauge	-	0.9000	21.4	0.0000	-	0.9000	-
T106	Gauge	Gauge	-	0.9000	34.1	0.0000	-	0.9000	-
T107	Gauge	Gauge	74.410	0.9000	24.1	0.9930	73.889	0.9000	66.500
T115	Gauge	Gauge	34.480	0.9000	34.7	0.9847	33.952	0.9000	30.557
Total Q'ty							259.900 K/L		233.911

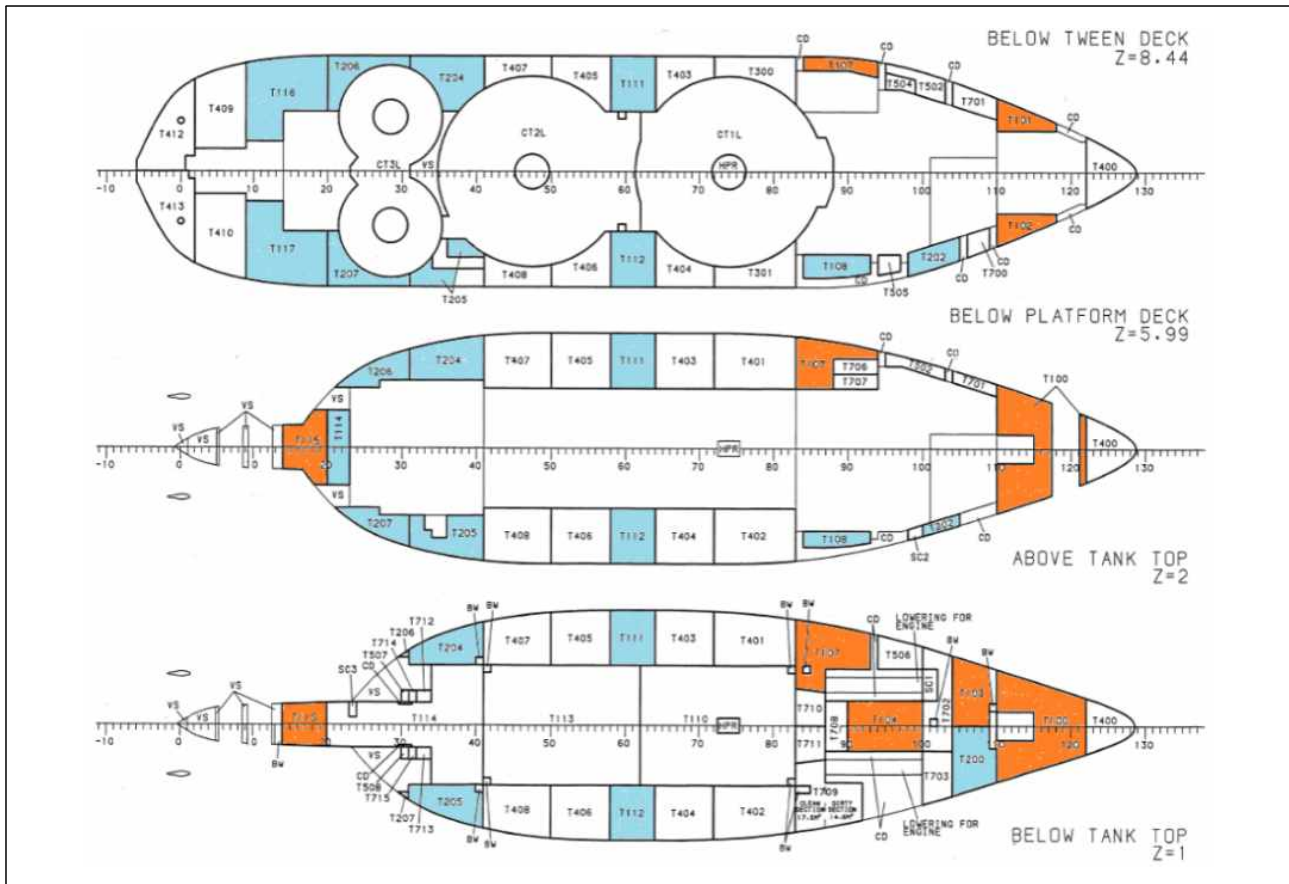
L.S.M.G.O TANKS									
TANK NO.	Innage cm	Corr' cm	GROSS cu. m	DENSITY @15 °C	TEMP. °C	V.C.F. T-54B	NET cu. m	W.C.F. T-56	METRIC TONS
T105	Gauge	Gauge	20.180	0.8462	39.8	0.9792	19.760	0.8462	16.721
T108	Gauge	Gauge	30.260	0.8462	35.2	0.9830	29.746	0.8462	25.171
T109	Gauge	Gauge	22.800	0.8462	40.9	0.9781	22.301	0.8462	18.871
T110	0.67	vol corr'	93.720	0.8462	22.7	0.9535	93.111	0.8462	78.791
T111	Gauge	Gauge	125.670	0.8462	26.3	0.9506	124.489	0.8462	105.343
T112	Gauge	Gauge	125.940	0.8462	31.2	0.9864	124.227	0.8462	105.121
T113	1.00	vol corr'	141.100	0.8462	33.0	0.9849	138.969	0.8462	117.596
T114	Gauge	vol corr'	59.790	0.8462	39.7	0.9792	58.546	0.8462	49.542
T116	Gauge	vol corr'	96.840	0.8462	33.8	0.9843	95.320	0.8462	80.660
T117	Gauge	vol corr'	96.480	0.8462	26.1	0.9908	95.592	0.8462	80.890
T200	Gauge	vol corr'	-	0.8462	22.1	0.0000	-	0.8462	-
T201	Gauge	Gauge	15.780	0.8462	20.1	0.9958	15.714	0.8462	13.297
T202	Gauge	Gauge	18.650	0.8462	20.1	0.9958	18.572	0.8462	15.716
T203	Gauge	vol corr'	11.010	0.8462	20.1	0.9958	10.964	0.8462	9.278
T204	Gauge	vol corr'	142.650	0.8462	20.1	0.9958	142.051	0.8462	120.204
T205	Gauge	vol corr'	110.330	0.8462	20.1	0.9958	109.867	0.8462	92.969
T206	Gauge	Gauge	-	0.8462	20.1	0.0000	-	0.8462	-
T207	Gauge	Gauge	-	0.8462	20.1	0.0000	-	0.8462	-
Total Q'ty							1,099.229 K/L		930.170

<Figure 8> The result of survey of low sulfur marine gas oil (LSMGO)

11) Kinds and characteristics of fuel oils (source : Material Safety Data Sheets, MSDS)

	Kinds of fuel	Sulfur Content	Flash Point	Lower and upper Explosive Range
1	HSFO: High Sulfur Fuel Oil	less than 3.5%	60°C and above	1 ~ 5%
2	LSFO: Low Sulfur Fuel Oil	less than 1.0%	70°C and above	1 ~ 5%
3	MGO: Marine Gas Oil	less than 0.5%	exceeding 70°C	1 ~ 5%
4	LSMGO: Low Sulfur Marine Gas Oil	less than 0.05%	exceeding 62°C	1 ~ 5%

2.10.3 On August 18, 2020, before the accident, the amount of LSFO and LSMGO loaded on the vessel was identified to be 233.9 tonnes and 930.1 tonnes (No.111, 112, 205 tanks included) through the bunker survey.



<Figure 9> The fuel oil loading arrangement at the time(Part,Tween Deck·Platform Deck·Tank Top)  
\* Orange: LSF0, Blue: LSMGO

2.10.4 Also, fuel oil was supplied to the Main Engines from fuel tanks through settling tanks and service tanks.

2.10.5 The bottom of fuel tanks and the top of settling tanks were connected through pipes, and fuel oil should be transferred to settling tanks by the transfer pump.

2.10.6 In addition, a check valve was installed at the outlet side of the transfer pump so that it does not flow back from the settling tank to the fuel tank. If the settling tank was full and overflowed, the overflowed oil was transferred to the F.O overflow tank located near the engine room generator.

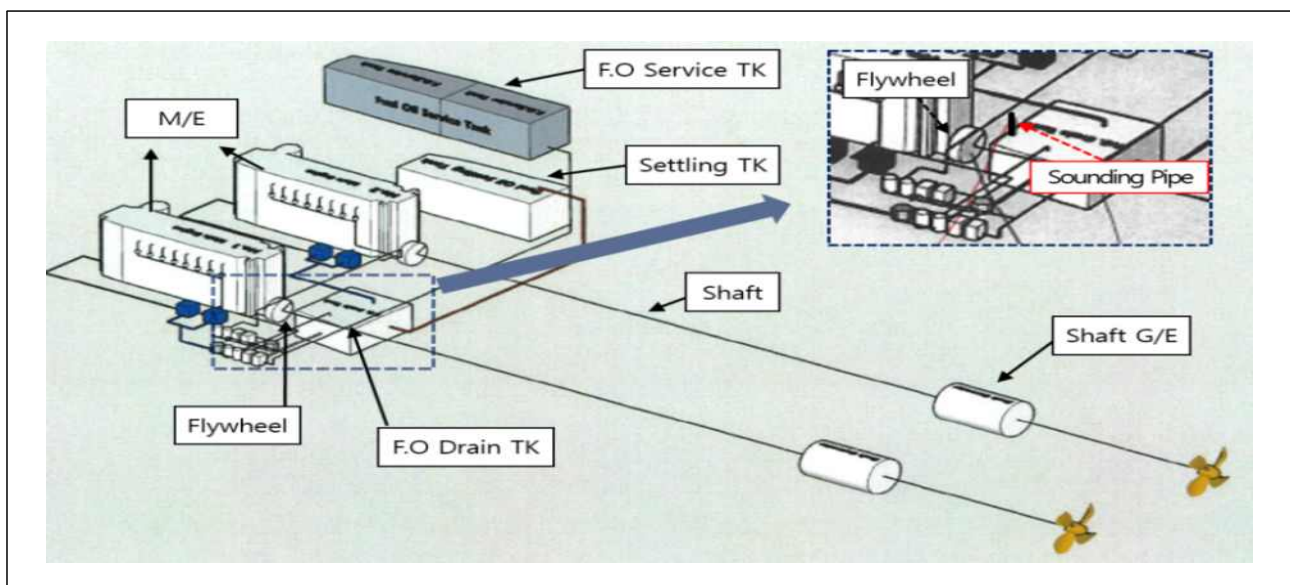


2.10.7 Fuel oil settled by gravity in the settling tank<sup>12)</sup> passed through purifier and F.O auto filter to remove sludge (sediments, impurities) and was transferred to the service tank<sup>13)</sup>, which provided fuel oil to the main engines through a fuel injection pumps.

2.10.8 F.O. drain tank is a tank that would store containing residual oil created by the Main Engine, generators, and various filters, and water generated from the settling tank, which would store the oil with moisture for incineration or reuse after the oil is transferred to sludge tank.

2.10.9 To reuse the fuel oil gathered in the F.O drain tank, oil could be transferred to the settling tank, instead of the sludge tank, and in this case, the transfer valve (A723-048) should be opened manually, and the tank should be connected to the fuel oil supply pipeline and then the fuel oil transfer pump should be operated.

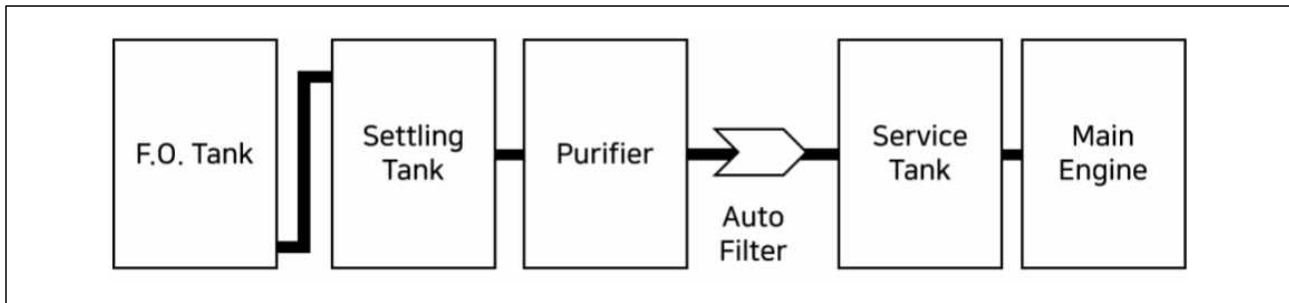
2.10.10 The F.O drain tank was designed to go off an alarm if the oil level in the tank exceeds a certain point, but the alarm installed in the F.O drain tank of Responder had been out of control, so the crew members of Engine Department were subject to manually sounding of the oil level periodically.



<Figure 10> The engine system diagram of Responder

12) Settling tank (capacity): T108(43.4m<sup>3</sup>), T202(27.0m<sup>3</sup>)

13) Service tank (capacity): T102(21.2m<sup>3</sup>), T109(23.5m<sup>3</sup>), T201(21.1m<sup>3</sup>), T203(15.8m<sup>3</sup>)



<Figure 11> The fuel oil-main engine transfer diagram

## 2.11 Crew composition & watch-keeping systems

- 2.11.1 Responder was allowed to accommodate a maximum number of 68 people onboard according to the Ship Survey Certificate issued by the Korean Register of Shipping, and the number of minimum safe manning of 13 people should be onboard in accordance with the International Convention for the Safety of Life at Sea (SOLAS)<sup>14</sup>.
- 2.11.2 At the time of the accident, a total of 60 people were onboard, and 49 of them were Korean, 10 Vietnamese and 1 Italian.
- 2.11.3 At that time, there were one Master, one Chief Officer, one Second Officer, one Third Officer, and one DP system operator were in the deck department, and one Chief Engineer, one First Engineer, three Second Engineers, one Third Engineer were in the engine department, and all of them were Korean.
- 2.11.4 Usually, when the vessel departed after the work site was decided, there should only be essential personnel on board. And after the vessel arrived at the site, a DP operator and a Plough operator<sup>15</sup> get on board via a helicopter. However, in order to prevent the spread of Covid-19 on the vessel, all 60 persons were on board before departure at that time.
- 2.11.5 In the case of installing submarine cables, all crew members including professional workers were divided into Group A or Group B, according to the work schedule.

14) The International Convention for the Safety of Life at Sea (SOLAS, Safety of Life at Sea) Chapter V Regulation 14 'Ship's manning'

15) Professional workers for plough operation were recorded as ordinary seaman in official crew list.

Group A was on duty from 12:00 to 24:00, and Group B from 00:00 to 12:00, and the Master was in charge of overall controlling the operation and work of the vessel.

2.11.6 At that time, Group A included the Chief Officer and one DP operator on Bridge, and the Bosun, one Able Seaman (AB), and one Ordinary Seamen (OS) on the deck and the First Engineer and the Third Engineer in Engine Room. On the other hand, Group B included the Second Officer and the Third Officer on Bridge, one store keeper<sup>16)</sup>, one AB, one OS on the deck, and two Second Engineers in Engine Room.

2.11.7 It was the first time for the Master, DP operator, third officer and third engineer to board Responder, operated by the Sehdong Shipping Co., Ltd., but the Chief Officer, the Second Officer, the Chief Engineer, the First Engineer and the three Second engineers had an experience of boarding Responder, or similar type of vessels, such as Miraero, that were operated by same company

**<Table 2> Experiences of executive ship officer**

Rank	Age	Onboard Experience (Experience of the position)	Onboard Experience of similar vessels)	(Recent onboard date on Responder)
Master	39	10 Year 11Month (1Year7 Month)	Heavy-lift ship 5Year 7Month	July 14, 2020
Chief Office	31	7Year 3Month (1Year 7Month)	DP ship 3Year 8Month	September 6, 2019
Chief Engineer	48	11Year 4Month (3Year 10Month)	Heavy-lift ship 1년 5Month DP ship 1Year 1Month	November 4, 2019
1st Engineer	41	7Year 9Month (4Year 10Month)	Heavy-lift ship 1Year 6Month DP ship 1Year 1Month	June 1, 2020
2nd Engineer A	26	3Year 7Month (12Month)	DP ship 2Year 6Month	September 18 2020
2nd Engineer B	35	5Year 6Month (2Year 8Month)	DP ship 11Month	July 14, 2020

\* Onboard experience refers to net-onboard period excluding the leave days.

16) Store Keeper was the most experienced crewman onboard and went by stokee, who was recorded as able seaman in official crew list

2.11.8 The Master and DP operator had an experiences of boarding a cargo ship and a heavy lift ship prior to the boarding of Responder, but, it was the first time for them to board a DP vessel, Responder, which used a side-thruster.

<Table 3> Crew Composition of Responder

Dept.	Rank		No. of Passengers(Nationality)	Min. No. of Manning
Deck	Officers	Master	1 (ROK)	1
		Chief Officer	1 (ROK)	1
		2nd Officer	1 (ROK)	1
		3rd Officer	1 (ROK)	1
		DP Operator	1 (ROK)	
	Rating	Bosun	1 (ROK)	3
		Able Seaman	3 (ROK)	
		Ordinary Seaman	31 (ROK 23, VNM 7, ITA 1)	
		Chief Steward	1 (ROK)	1
		Cook	1 (ROK)	
		Messman	6 (VNM)	
Engine	Engineers	Chief Engineer	1 (ROK)	1
		1st Engineer	1 (ROK)	1
		2nd Engineer	3 (ROK)	1
		3rd Engineer	1 (ROK)	1
	Rating	No.1 Oiler	1 (ROK)	1
		Oiler	1 (ROK)	
		Wiper	4 (ROK)	
		total	60	13

## 2.12 Emergency response systems and the training status

2.12.1 Responder assigned duties to crew members based on emergency muster list to effectively respond to emergency situations such as a fire, abandoning of the vessel, collisions, stranding, flooding, rescuing, emergency steering, and etc.

2.12.2 In particular, fire drills were conducted at least once a month along with abandon ship drills. According to the emergency muster list, in the event of fire, the Chief Officer was in charge of directing the fire scene and operating the fixed CO2 fire extinguishing systems for EngineRoom, while the Second Engineer A was in charge of quick closing of fuel oil to the Main Engines, shutting down ventilation systems for the engine room, and cut off electric power in selected parts on the vessel.

**<Table 4> Muster list and duties for fire**

Rank	Location	Duties and responsibilities
Master	Bridge	Supervision, operational report, external affairs, walkie-talkie
Chief Officer	On-site	Supervision of the site after personnel check
2nd Officer (A)	On-site	Supervision of rescue team( team mate: chief steward and cook), walkie-talkie
2nd Officer (B)	On-site	Assist supervision of the site (chief of cooling team), walkie-talkie
2nd Officer (C)	Bridge	Assist the master, record of jobsheet
Chief Engineer	Engine Room	Supervision of engine room, walkie-talkie
1st Engineer	On-site	Assist the site after turn on the emergency fire pump
2nd Engineer (A)	On-site	Assist the site after shut off the fuel, ventilation, and power
2nd Engineer (B)	Engine Room	Assist chief engineer
2nd Engineer (C)	Engine Room	Assist chief engineer
3rd Engineer	Engine Room	Assist chief engineer
Bosun	On-site	Assist fire fighting operation(cooling team), roll out fire hose
Store Keeper	On-site	Fire fighting operation, wearing of fire-fighter's outfit

Rank	Location	Duties and responsibilities
Able Seaman (A)	Bridge	Steering, hanging of flag
Able Seaman (B)	On-site	Assist fire fighting operation(cooling team), roll out fire hose
Able Seaman (C)	On-site	Assist fire fighting operation and wearing of fire-fighter's outfit
Ordinary Seaman	On-site	Assist fire fighting operation and wearing of fire-fighter's outfit
No.1 Oiler	On-site	Assist fire fighting operation(cooling team), roll out fire hose
Oiler (A)	On-site	Fire fighting operation, wearing of fire-fighter's outfit
Oiler (B)	On-site	Assist fire fighting operation, assist 2nd Engineer (B)
Oiler (C)	On-site	Assist fire fighting operation(cooling team), roll out fire hose
Chief Steward	On-site	Transport the injured, emergency medical equipment, blanket
Cook	On-site	Transport the injured, stretcher
Other Crews	Muster station	Muster station/stand by
Temporary Passengers	Muster station	Muster station/stand by

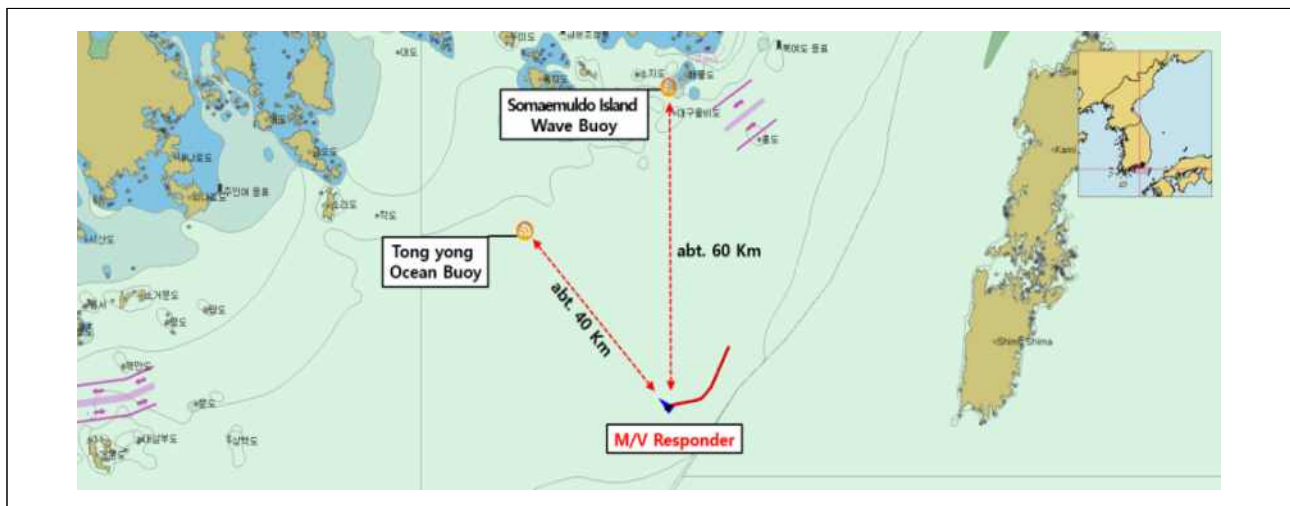
## 2.13 Weather conditions

2.13.1 Korea Meteorological Administration (KMA) monitored marine weather conditions through ocean data buoys and light beacons. With Tongyeong ocean data buoys that were located about 40km northwest from the location of the fire accident of Responder, KMA also monitored the direction and speed of winds, and wave height. And Somaemuldo buoys that were located about 60km north of the accident location monitored weather conditions such as the average wave height, significant wave height, and the maximum wave height. Meteorological data<sup>17)</sup> collected by the ocean data buoys and light beacons at the time of accident were as follows:

17) Tongyeong ocean data buoys(22188), Somaemuldo buoys(22485)

&lt;Table 5&gt; Wind direction, wind speed and wave height (Meteorological Administration)

Date	Ocean Data Buoys(Tongyeong)					Wave Bouys(Somaemuldo)	
	Wind Direction (Deg)		Wind Speed(m/s)	Average Wave Height(m)	Significant Wave(m)	Average Wave Height(m)	Significant Wave(m)
Sep. 11, 2020 00:01	224	SSW	2.3	0.3	0.5	0.1	0.2
Sep. 11, 2020 01:00	227	SSW	0.8	0.3	0.4	0.2	0.3
Sep. 11, 2020 02:00	276	W	1.9	0.3	0.4	0.2	0.2
Sep. 11, 2020 03:00	207	SSW	3.3	0.2	0.3	0.2	0.2
Sep. 11, 2020 04:00	220	SSW	2.4	0.2	0.3	0.2	0.2
Sep. 11, 2020 05:00	191	S	3.0	0.2	0.3	0.1	0.2
Sep. 11, 2020 06:00	282	W	4.8	0.2	0.3	0.2	0.2
Sep. 11, 2020 07:00	106	E	6.5	0.3	0.4	0.2	0.3
Sep. 11, 2020 08:00	251	WSW	7.0	0.4	0.5	0.2	0.2
Sep. 11, 2020 09:00	258	WSW	6.6	0.4	0.6	0.2	0.2



&lt;Figure 12&gt; The weather buoys in nearby area of the accident

2.13.2 According to the statement of a crew on board at the time, the wind blew from the northeast with the speed of 7~10 knots (3.6~5.1 m/s), the wave height was about 0.5~1.0 meters with good visibility about 5~6 miles (9.2~11.1 km).

## 2.14 Damages

2.14.1 The attempt of the Master to suppress the fire by using the fixed CO2 fire

extinguishing systems failed, and he ordered all crew members to abandon the vessel and transfer to Youngin 105, a tug boat with gross tonnage of 92 tons.

- 2.14.2 Afterwards, the crew members who got on board to Youngin 105, were rescued by Mirearo, a cable layer ship operated by the Sehdong Shipping Co., Ltd., and Miraero entered Busan port with the rescued crews. There were no major casualties except for some minor injuries.
- 2.14.3 Meanwhile, after the accident was reported, the Tongyeong Coast Guard dispatched two KCG guardian ships 1501, 1006, and an oil spill response ship Bangje 11, aircrafts (helicopters) to the scene to suppress the fire and rescue crews. Also, several fire boats owned by Tongyeong, Yeosu, and Changwon fire stations were dispatched to the scene.
- 2.14.4 Afterwards, the vessel sank<sup>18)</sup> due to a sudden inclination at the bow of the vessel while the coast guard and fire department suppressed the fire, and clean up operation was carried out to remove a thin oil band and oil slick created at sinking waters.
- 2.14.5 Additional measures, such as closure of tanks and fuel oil transfer, to prevent marine pollution were taken, but there is no plan for the salvage of the vessel until now.<sup>19)</sup>



**<Figure13> Fire and fire extinguishing work of Responder**

18) Estimated amount of damage: cost of vessel, approximately 58.6 billion won (insurance amount estimated by insurance company) / Depth of sunken area of ship, approximately 88 meters.

19) It refers to the moment of the publication date of the investigation report



section

**3**

## Development of Accident

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## 3. Development of Accident

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### 3.1 Navigation before the accident

- 3.1.1 Responder was a special-purpose ship for cable laying which was engaged in cable laying operation, the South East Asia Japan Cable Project #2 (SJC2), that connected about 847km from Haeundae, Busan to East China Sea during the period from May to September 2020.
- 3.1.2 The vessel loaded the submarine cables that was planned to be laid in Japanese territorial waters, at the Moji port in Japan on May 22, 2020. And after being supplied with the supplies at a ship base in Geoje-do on May 27, the vessel departed and carried out cable laying operation on the sea near Japan from June 6 to June 17, 2020.
- 3.1.3 Also, after arriving at Geoje ship base, the vessel waited at the base due to renovations of working space(joint room) for cable operations and deteriorating weather condition. On July 24, 2020, it departed the base and loaded the submarine cables at Moji port in Japan the next day.
- 3.1.4 After completing cable laying work on the waters near Japan on August 11, 2020, the vessel was supplied with fuel oil, food, and ship stores. Afterwards, the vessel carried out cable laying operation from near Haeundae in Busan heading toward Jeju Island.
- 3.1.5 From August 31 to September 8 of the same year, the vessel avoided to the Geoje ship base due to harsh weather conditions caused by Typhoon Maisak and Haishen moving northward. And then, the ship departed the Geoje ship base at 07:00 September 8 toward the previous cable laying work site.

3.1.6 At this time, Responder departed with the tug boat Youngin 105. Youngin 105 joined Responder's work for the purpose of conducting safety monitoring such as preventing the access of nearby ships while cable laying operation was underway and removing illegally set fishing net buoys.



<Figure 14> Cable laying route and photo of construction

## 3.2 Before the fire outbreak

3.2.1 Responder arrived at the sea about 13.5 miles south of Hongdo, Tongyeong-si, Gyeongsangnam-do on September 8, 2020 at around 13:00, and the vessel started cable laying work from 13:20 on the same day, sailing southward at the speed of less than 1 knot.

3.2.2 The vessel was carrying out the cable laying operation on the waters about 28 miles south-southwest of Jwasari-do, Tongyoung-si, Gyeongsangnam-do on September 10, 2020 at around 23:00.

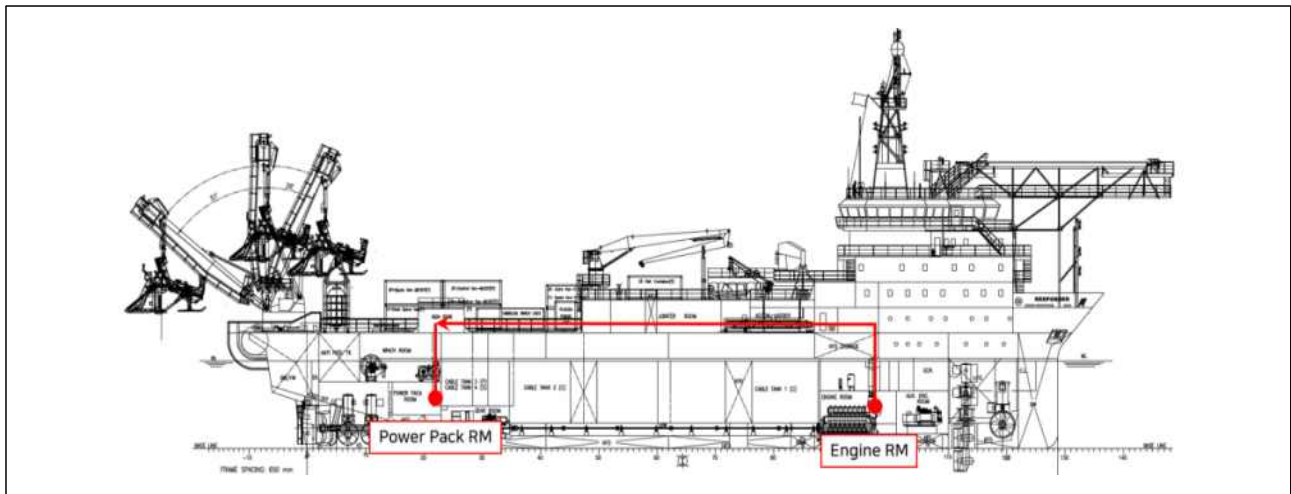
- 3.2.3 The third engineer who was on duty at that time, he sounded the level of oil in the F.O drain tank<sup>20)</sup> before relieving the duty, and it was measured to be 65cm deep (about 5.5 tonnes, 65% of the total capacity).
- 3.2.4 At around 23:30 on the same day, the First and Third Engineers handed over the duty to the Second Engineers A and B in ECR, and at around the midnight on the same day, the Second Engineers A and B moved to the purifier, located on the tank top that was at the very bottom deck of the engine room, to change over in-use fuel oil tanks and transfer oil in the F.O drain tank, as per the order<sup>21)</sup> from the Chief Engineer of the previous day.
- 3.2.5 The Second Engineers A and B stopped the purifier connected to the fuel oil tank for the change to another fuel oil tank. After starting the purifier connected to the new oil tank, they went to the ECR and monitored the conditions of the engine room.
- 3.2.6 On September 11, 2020 at around 01:30, the second engineer A who went to the tank top alone to transfer oil sludge in the F.O drain tank to the settling tank<sup>22)</sup>, which was also ordered by the chief engineer, opened the transfer valve and operated the transfer pumps and then came back to the ECR.
- 3.2.7 At around 01:50 on the same day, the Second Engineer A considered that the oil transfer was completed after he checked the monitor in ECR which showed the oil level in the settling tank did not rise anymore, so he stopped F.O transfer pump.
- 3.2.8 At around 02:00 on the same day, the Second Engineer A went to the upper deck at the stern of the vessel outside the engineer room and went down through stairways to the power pack room where the fuel oil tank valves can be operated.

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20) A tank that stores fuel oil leaked from the main engines and residue oil filtered through an auto filter.

21) The day before the accident, the chief engineer instructed that "Use up the remaining fuel in D.O. storage tank by next morning(The day of accident, September 11th ) and change to F.O bunker and transfer the oil from the F.O. drain tank to the setting tank."

22) When the vessel is supplied with fuel oil, it performs purification operation to improve the safety and efficiency of main engine and generator, and the fuel oil transfers to the service tank, after purification process through the settling tank, purifier, and auto filter, to prepare for supply to facilities and gears such as main engine or generator

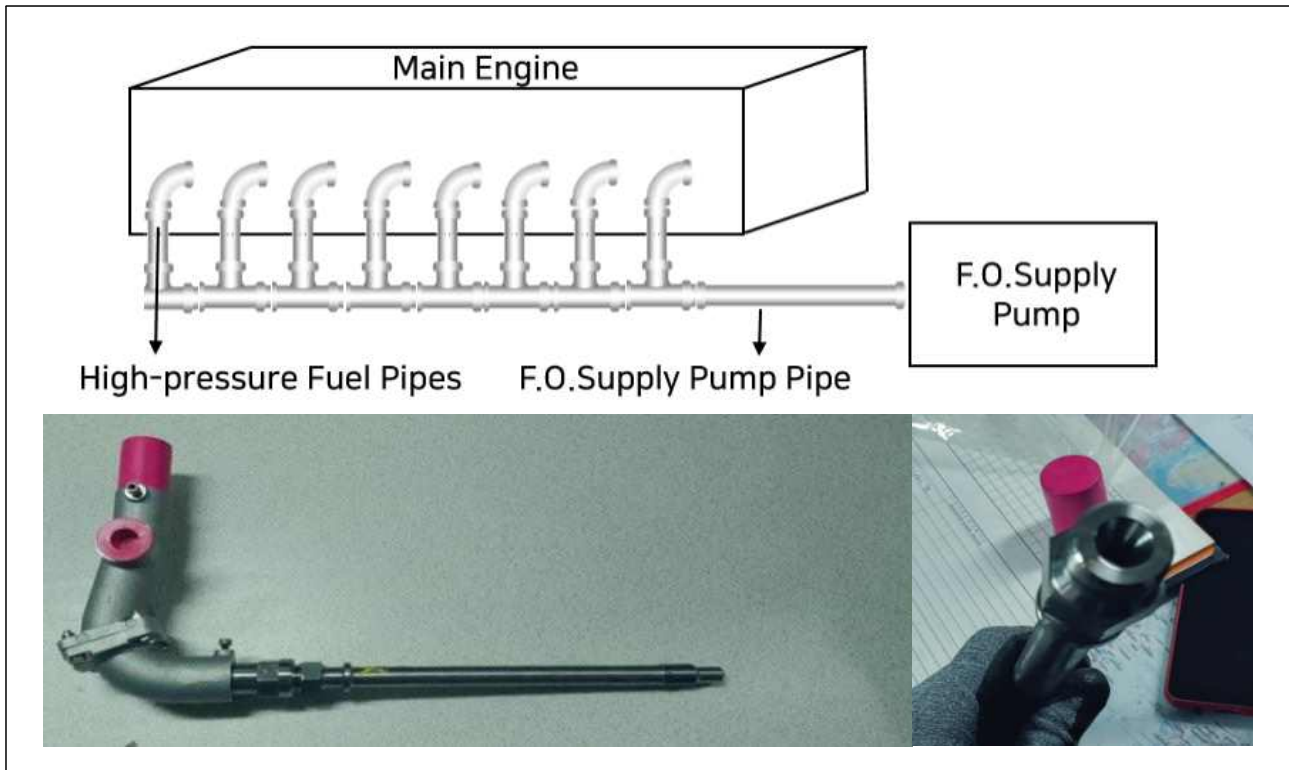


<Figure 15> The route of second engineer A (Main engine room→Power pack room)

- 3.2.9 The second engineer A opened the tank valves T116 and T204 and closed the valves T111, T112, and T205 for the fuel oil tanks which had used up the oil, and he came back to the ECR at around 02:50 on the same day without operating the transfer pump (settling tank).
- 3.2.10 Meanwhile, at around 02:35 on the same day, the second engineer B who was on duty in the ECR, acknowledged two F.O leakage alarms on the monitor in the ECR which indicated that oil was leaking in the 5th to 8th cylinders of both Main Engines.
- 3.2.11 The Second Engineer B went down to the site to check the condition of the Main Engines, and he found that large amounts of oil were leaking from the high-pressure fuel pipes<sup>23)</sup> of the 4th and 6th cylinders of No.2 Main Engine, and he also observed<sup>24)</sup> the oil leak on the outside of the No.8 crank case of the No.2 Main Engine. Lots of oil was flowing on the surface of several high-pressure fuel pipes of the cylinders of the No.1 Main Engine, some of which were gathered in the bilge well of the Main Engine.

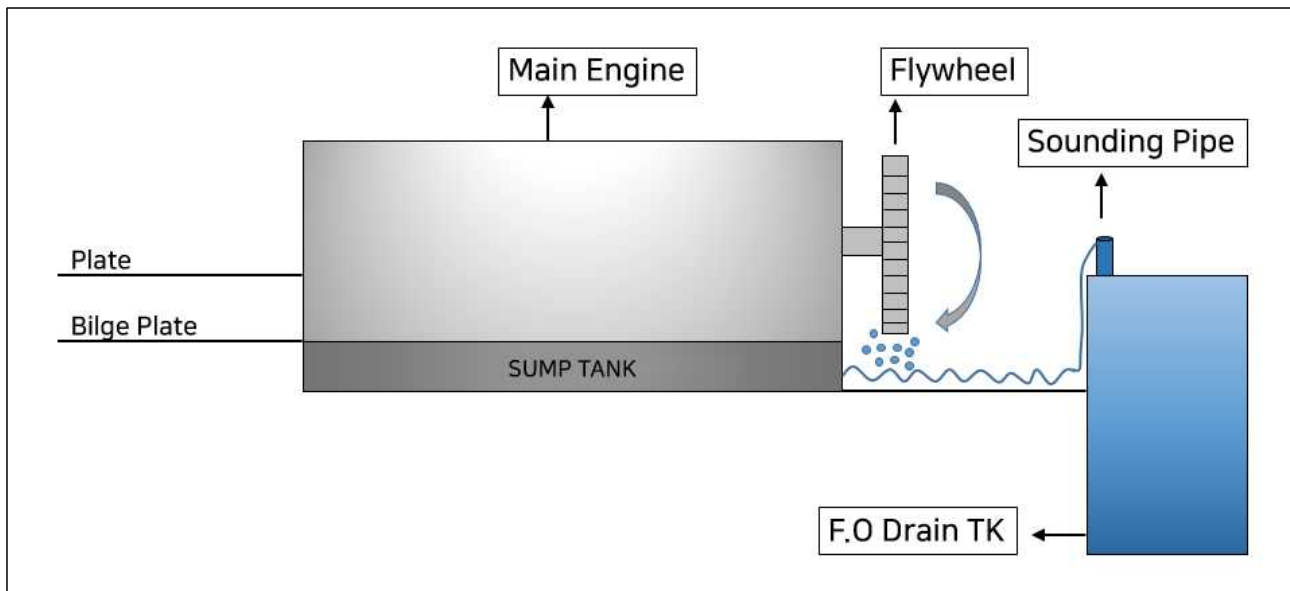
23) A high-pressure pipeline that connects the fuel injection pump (a pump that supplies fuel oil into the main engine) to the main engine, and the high-pressure pipe of Responder was a steel pipe which was manufactured in Germany with an outer diameter of approx. 20 millimeters and an inner diameter of approx. 5 millimeters.

24) According to the engineer's statement ,the amount and the speed of oil leaking at the time were about 'the 200ml milk carton could be fully filled in about 15 seconds .'



<Figure 16> The piping arrangement of main engine(reconstructed according to the statement of crew) and high pressure pipe (sample of Miraero)

- 3.2.12 At around 02:43 on the same day, the second engineer B went back to the ECR and checked the temperature of the exhaust gas on the monitor, but there was nothing significant to report such as the changes in temperature. An additional F.O. leakage alarm went off indicating oil leakage occurred from the 1st to 4th cylinders of the No.1 engine, and the second engineer B called the chief engineer and first engineer to report the situation.
- 3.2.13 The Chief Engineer and the First Engineer who were taking a rest in their cabins, went down to the Engine Room after receiving a call from the Second Engineer B. When they entered the Engine Room, they detected a strong smell of oil and a slight mist of oil in the air.
- 3.2.14 At around 02:50 on the same day, the Chief Engineer and the First Engineer received a brief report from the Second Engineer B in ECR and went down to the Main Engines to check their condition. They observed the oil mist originating from the splash of the oil which was generated by the spinning flywheel.<sup>25)</sup>



**<Figure 17> Arrangement of main engine and F.O drain tank (reconstructed according to the statement of engine room crew)**

- 3.2.15 The Chief Engineer and the First Engineer thought that considering there was a severe oil leak, the pipe might have been broken or holed, not just a small crack, so they decided to stop the main engines to prevent the leakage.
- 3.2.16 But due to the scattering of oil caused by the spinning flywheel, the source of oil leakage was not easily identifiable. So the Chief Engineer and the First Engineer decided to stop the No.1 Main Engine on the assumption that oil leakage might occur from the pipeline connected from the F.O boost pump<sup>26)</sup> to the Main Engine. Then, they reported the situation to the bridge and stopped the No.1 Main Engine.
- 3.2.17 After observing large amounts of oil accumulated in the bilge well under the flywheel of the No.1 Main Engine, the First Engineer asked the Second Engineer A, "Which tank's manhole is under the flywheel of the No.1 Maine Engine?". The Second Engineer answered that he would check it and he went up to the ECR to check and replied, "there would be the tank 107 or the drain tank."

25) A circular wheel attached to the end of the rotating shaft of the engine to even out the rotational speed of the rotating object, it serves to allow each cylinder of the engine to rotate at a constant speed

26) A pump for smooth supplement of fuel oil to main engine by increasing the pressure after going through purification process.

- 3.2.18 But, even after the No.1 Main Engine stopped, oil was keep leaking from the No.2 Main Engine and the sounding pipe of the F.O drain tank. Hence, the Chief Engineer and the First Engineer decided to stop the No.2 Main Engine while restarting the No.1 Main Engine to inspect the condition of No.2 Main Engine, and tried to restart the No.1 Main Engine in the ECR.
- 3.2.19 The Chief Engineer reported to the Bridge that "there might be a problem with the No.2 Main Engine, not the No.1 Main Engine, so we will stop the No.2 Main Engine", and they pressed the ACB button on the monitor of the main engine room to change over the generators for changing the Main Engines in the ECR.
- 3.2.20 At around 03:35 on the same day, the Chief Engineer recognised that the electric power shift time was taking much longer than usual. While the generators' change-over process was still ongoing, a fire alarm<sup>27)</sup> went off, the lights in the Engine Room flickered and the power went out. As the No.1 and No.2 Main Engines stopped operating, he noticed that a fire<sup>28)</sup> broke out.

### 3.3 Fire outbreak and initial response

- 3.3.1 Right after the fire outbreak, the Main Engines stopped operating and the vessel blacked out. As the Emergency Generator was operated automatically, there were only the emergency lights turned on in the Engine Room.
- 3.3.2 The Chief Engineer and other engineers in the Engine Room opened the door of the ECR to confirm whether a fire broke out and find the leak point. They noticed the fire when they saw full of smoke<sup>29)</sup> in the Engine Room, so they all went up to the upper deck, and the Second Engineer A and the Third Engineer went up to the Bridge to close the fuel oil tanks valves and to stop ventilation for the Engine Room.

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27) Until this moment, the chief engineer and other engine room crews thought that the fire alarm was malfunctioning due to oil vapor.

28) The fire occurred at the sea area of 160 degrees, approximately 28 miles from Jwasari Island in Tongyeong City, Gyeongsangnam-do, where is approximately Latitude 34°06'23"N, Longitude 128° 31'51"E.

29) The master observed thick smoke(white) from the damper under the engine room funnel and chief engineer observed thick smoke(black or gray) when escaping from ECR through engine room.



- 3.3.3 Meanwhile, at that time the Master who was taking a rest in the bed room, received a report of fire outbreak from the Third Officer, a duty officer, on the Bridge, and he went up to the Bridge. Even he did not receive a detailed report on the accident, he recognized the seriousness of the situation after watching that engineers were controlling the shutoff valves of fuel oil in the Engine Room using the bridge control panel, and he issued an order for fire emergency arrangement to all crews.
- 3.3.4 At that time, the Second Engineer A and the Third Engineer controlled the buttons on the fire control board on the Bridge and operated shutoff valve of fuel oil that was connected to the Engine Room. And the Second Engineer came out of the Bridge and approached the damper, installed on the outer wall of the casing in the Engine Room located on the Helideck, to close the damper manually by pulling down the lever in order to block the ventilation. But due to thick smoke and toxic gas, they failed to approach the damper, so he went back to the Bridge and reported to the Master that they had failed to close the fire damper.
- 3.3.5 At around 03:38 on the same day, the Chief Officer took a roll call at the Muster station on the Upper Deck and reported it to the Master. After receiving the report from the Chief Officer, the Master went down to the Upper Deck to check the scale of the fire, and asked the First Engineer whether it would be possible to suppress the fire on their own, but the First Engineer answered that it was impossible.
- 3.3.6 After that, the Master ordered the Chief Officer to prepare to use the fixed CO2 fire extinguishing systems. Although the Master was aware of the fact that the Engine Room was not completely sealed off, he decided to use the fixed CO2 fire extinguishing systems with the intention to use all possible means available on the vessel to suppress the fire. The Chief Officer went to fixed CO2 operation room located on the right side of Upper Deck.
- 3.3.7 At around 03:40 on the same day, the Master reported to the Tongyeong Coastal VTS by using the VHF Radio via channel 16, "the vessel is on fire, the fire broke out in the Engine Room, and we are preparing to discharge CO2 fire extinguishing gas."
- 3.3.8 At around 03:42 on the same day, though the chief officer tried to use the fixed CO2

fire extinguishing systems, following the order of the master, he failed to suppress the fire.

- 3.3.9 And the Chief Officer thought that the fire in the engine room already spread to cable tank after he saw flames and smoke rising from the No.1 cable tank located behind the Engine Room and the accommodation spaces and he reported this situation to the Master.
- 3.3.10 At around 03:50 on the same day, as the flames and smoke did not subside and continued to spread, the Master ordered all crew members to abandon the vessel, and to move to the Youngin 105, a tug boat located nearby.
- 3.3.11 At around 04:27 on the same day, all crew members were transferred to Youngin 105 and rescued. In case of the explosion of Responder, Youngin 105 was waiting for Mirarero, another cable layer, operated by the Sehdong Shipping Co., Ltd. at the sea two miles northwest of Responder.
- 3.3.12 At 05:00 on the same day, when Miraero arrived near the accident area, all crew members of Responder were transferred to Miraero which arrived at berth No. 7 of the Busan Port at around 21:32 on the same day.

## **3.4 Suppression of fire and response to the accident**

- 3.4.1 Meanwhile, at around 03:51 on the same day, the fire on Responder was reported to the Tongyeong Coast Guard through the Tongyeong Coastal VTS, and the Tongyeong Coast Guard dispatched the KCG patrol vessel (1501, 1006, P-86, P-101, P-27), oil spill response ship (Banje-11), and etc to the scene.
- 3.4.2 At around 05:16 on the same day, the KCG guardian ship 1501 firstly arrived at the fire scene, and they used fire monitor to suppress the fire.
- 3.4.3 At around 05:40 on the same day, the vessel 1006 arrived at the scene and began to suppress the fire also using fire monitor. At around 06:55 and 07:05 on the same day,

Tongyoung fire-fighting boat and the vessel 1005 arrived at the scene respectively and engaged in fire suppression operations using fire monitor.

3.4.4 At around 09:28 on the same day, the fire that started from the Engine Room of Responder spread to the Bridge and the upper part of the ship's mast. The vessel started to list about 5 degrees to the starboard side, and the list was getting more severe. In the end, the vessel listed about 12 degrees to the starboard side at around 11:05 on the same day.

3.4.5 At around 11:45 on the same day, the vessel 512 of the Tongyeong Coast Guard decided to switch to the method of spraying and cooling the outer shell of the vessel based on the assumption that the vessel was listing to one side due to the entering of water for fire fighting. At around 21:35 on the same day, the special purpose ship of KCG equipped with chemical cleaning and fire fighting systems arrived at the scene and the flames on the outer deck were somewhat suppressed, but at around 23:10 on the same day, the fire restarted at the Bridge, cabins, and the stern of the vessel.

3.4.6 On the next day, at around 16:55 on September 12, 2020, the bow of Responder began to sink and at around 17:42 of the same day, Responder completely sank<sup>30)</sup> into the sea 42 miles south of the Yokjin Island, Tongyeong-si, Gyeongsangnam-do (Latitude 33°54'20"N, Longitude 128°14'34"E)



<Figure 18> The picture of fire and sinking of Responder

30) Responder sank in a position about 050 degrees, approximately 19 miles away from the location of initial fire

section

4

# Analysis

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## 4. Analysis

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### 4.1 Fire Outbreak

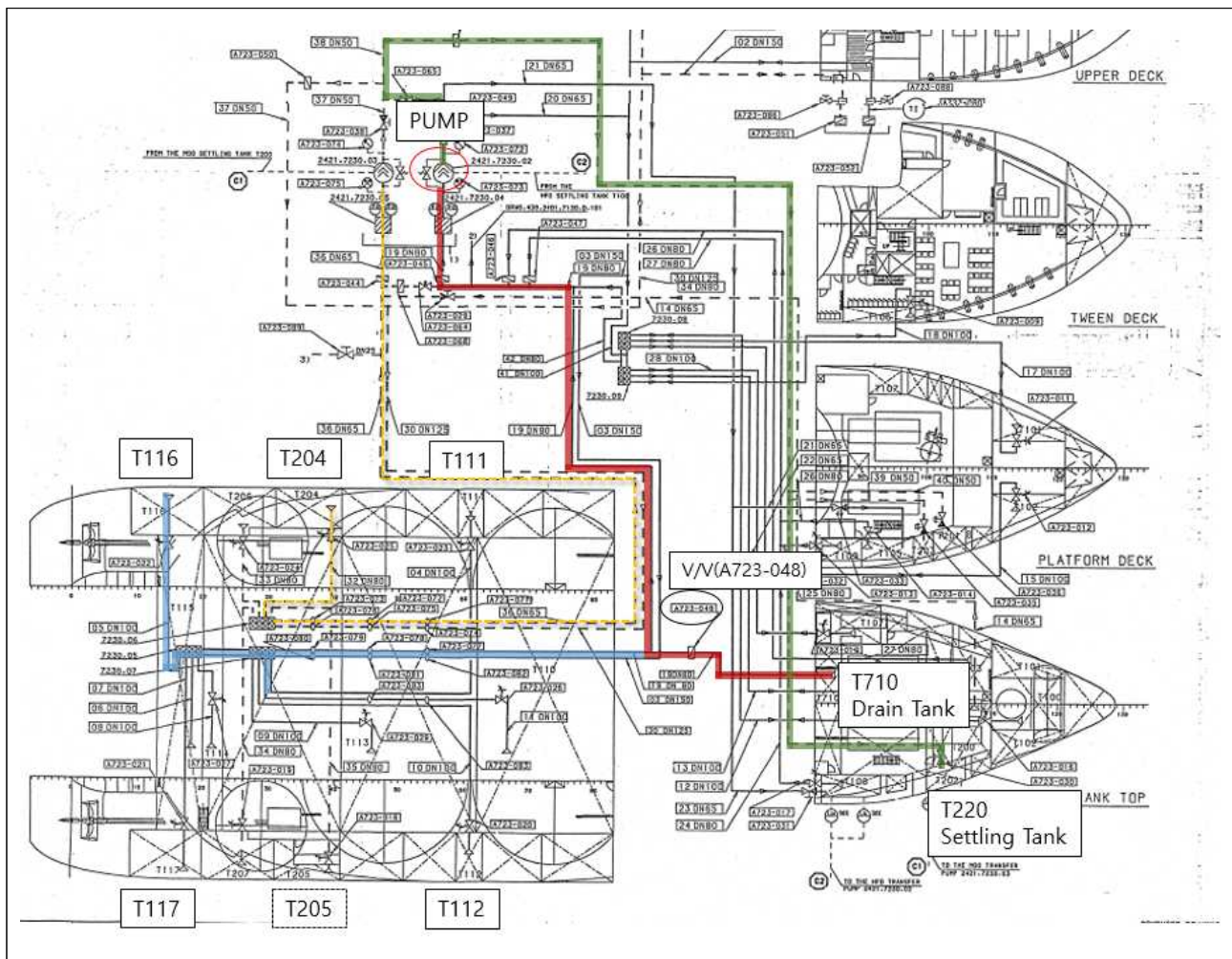
#### 4.1.1 Influx and overflow of fuel oil in the F.O drain tank

- 4.1.1.1 The F.O drain tank is where the remaining oil of the engine room is collected. And it also collects the oil that is generated or leaked from the main engine or generators and the oil residue containing moisture that is generated from the settling tank.
- 4.1.1.2 At around 24:00 on September 10, 2020, when the Second Engineer A was handed over the overnight watch duty by the Third Engineer, he checked that there were 5.5 tonnes of oil remaining in the F.O drain tank. On the day before the accident, in order to follow the order from the chief engineer, he tried to transfer oil sludge and remaining oil in the F.O drain tank to the settling tank for reuse.
- 4.1.1.3 At 02:00 on the same day, the Second Engineer A opened the outlet valve of the F.O drain tank (T710) and the oil transfer valve (A723-048) to transfer the remaining oil in the F.O drain tank to the settling tank through the fuel oil transfer pump.
- 4.1.1.4 At around 02:50 on September 11, 2020, after receiving a call from the second engineer B, the Chief Engineer and the First Engineer went down to the Engine Room and observed that the F.O drain tank was full and the oil was overflowing from the sounding pipe of the F.O drain tank. And some of the oil was flowing into the bilge well, so they began to look for the cause of the inflow of the oil to the drain tank which brought about the over-flow.
- 4.1.1.5 The Second Engineer A stated that he shut the transfer valve (A723-048) off with a manual handle at the scene after the oil transfer. However, he did not confirm

whether the valve was completely closed and whether the oil transfer from the fuel oil tank to the settling tank went properly, which could be checked by the amount of remaining oil in the F.O drain tank or settling tank after shutting off the valve.

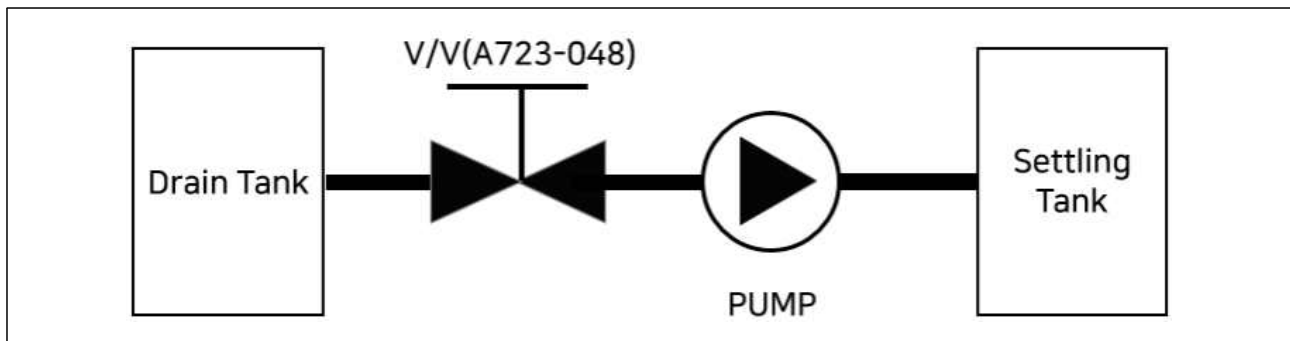
- 4.1.1.6 Then, the Second Engineer A rearranged the fuel oil pipe lines to change over the oil tank which already ran out of oil. He opened the valve of T116 and T204 tanks which has sufficient amount of oil, and shut off the valve of T111, T112, and T205 that already ran out of oil. As a result, the fuel oil in the T116 and T204 tanks were connected to be transferred to the settling tank via the transfer pump.
- 4.1.1.7 But, the F.O drain tank which was completely emptied just before the accident, was fully filled with oil again in about 35 minutes, and the First Engineer and others witnessed that oil was flowing over the sounding pipeline of the drain tank.
- 4.1.1.8 In order to investigate the inflow of oil in the F.O drain tank, the pipe arrangement of the fuel oil system has to be examined. The pipes connected to this tank have an arrangement in which leaked oil from the Main Engines, generators, fuel oil auto filter, and settling tank, inflows to the drain tank, and when the tank is full of oil, it overflows through the sounding piping systems.
- 4.1.1.9 The F.O drain tank was located on the tank top area at the bottom of the vessel and the fuel oil tanks were located above the drain tank, so oil flows downward from the fuel oil tank to the F.O drain tank by gravity along the pipe connected between fuel tanks and F.O drain tank. In particular, contrary to the fuel oil tank with number 200's, the fuel oil tanks with number 100's, are connected to the F.O drain tank via transfer valves (A723-048), so when the valve (A723-048) was open, fuel oil flows into the F.O drain tank by gravity. T116 tank belonged to the above-mentioned tanks and it was the tank that the Second Engineer A opened for the change over, according to his testimony.
- 4.1.1.10 The capacity of the F.O drain tank was 10.2 m<sup>3</sup>, which was about 8.6 tonnes, and due to the characteristics of oil collected in this tank, the amount of the oil leaked from the Main Engines or oil sludge filtered through the fuel oil auto filter was hardly enough to fill the tank up in just 35 minutes.

4.1.1.11 Considering this fact and the pipe connection arrangement, there was a high possibility that oil flowed into the drain tank via the transfer valve (A723-048) of the T116 tank which was opened by the Second Engineer A for the change over of the fuel tank. In other words, it is presumed that the transfer valve that the Second Engineer A shut off according to his statement, was not properly closed for some reasons such as mechanical malfunction or human operation error in valve operation.



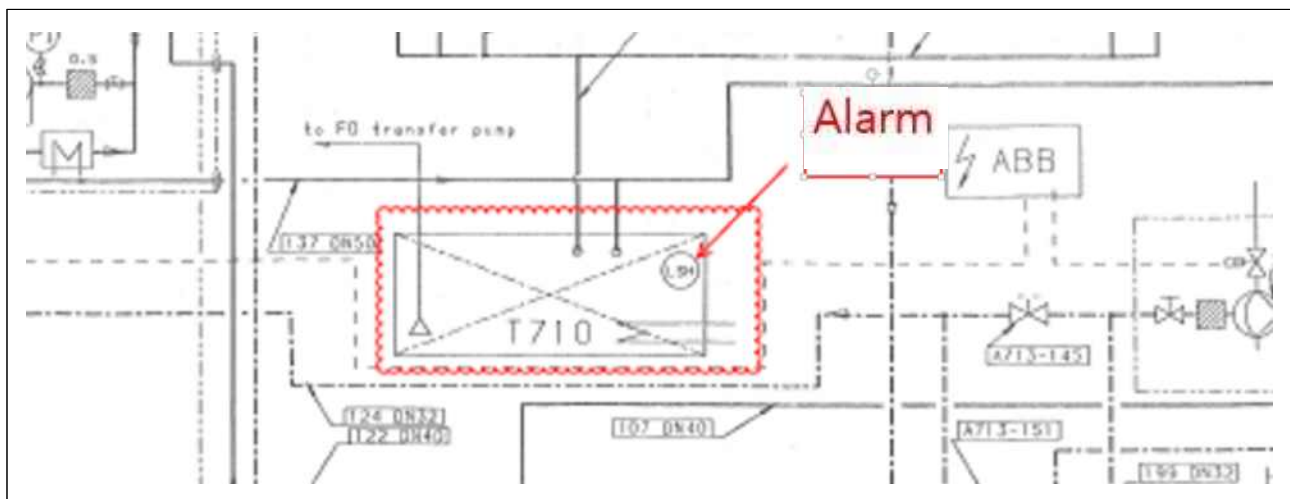
<Figure 19> The pipeline of main engine room (MDO / HFO Transfer Sys. floor plan)

\* **Blue** : Transfer line of No.116 tank, **Yellow** : Transfer line of No.204 tank,  
**Red** : Connection line to drain tank, **Green** : Connection line to settling tank



<Figure 20> Transfer diagram from F.O drain tank to settling tank

4.1.1.12 As such, the most probable scenario for the cause of the 35 minutes of inflow of 8.6 tonnes of oil in the F.O drain tank, was that the transfer valve (A723-048) connected to the F.O drain tank and T116 was open, and fuel oil in T116 flowed into the F.O drain tank via the pipe of the valve (A723-048)



<Figure 21> The alarm sensor of the F.O drain tank (M127, F.O Service System, floor plan)

#### 4.1.2 Leakage of oil to the floor of the engine room and scattering of oil in the bilge well

4.1.2.1 The oil in the F.O drain tank was emptied at around 02:00 when the Second Engineer A transferred the oil to the drain tank, but when the First Engineer went down to the Engine Room from the accommodation space at around 02:50, he observed that a large amount of oil was overflowing from the sounding pipe of the F.O drain tank.



- 4.1.2.2 Also, the oil leaked from the sounding pipe of the F.O drain tank and the fuel oil leaked from the high pressure pipes for fuel supply to the Main Engines were combined and gathered together, so a lot of oil was accumulated in the bilge well of the Main Engines. Crew members observed the oil mists created by scattered oil which was generated by the rotating flywheel of the Main Engines.
- 4.1.2.3 Accordingly, at the early stage of the accident, crews in the Engine Room thought that the oil in the F.O drain tank overflowed as the oil leaked from the Main Engine flowed into the drain tank, and they made effort to find the cause of the oil leak around the high-pressure pipes. Crew members believed that a hole or a large-sized crack on the high-pressure pipe would be the cause of the oil leak since the it happened near the fuel supply high pressure pipe of the main engine. So, they operated the main engines in turns to confirm the damaged part by checking the oil leak while the main engine was stopped.
- 4.1.2.4 Even though it was possible for the high pressure pipe of the Main Engine to have a crack or a hole, due to the high pressure generated from the F.O supply pump of the main engine, and create the oil leak, but considering Responder regularly replaced<sup>31)</sup> and repaired the high pressure pipes, it was highly unlikely to happen. Particularly, it seemed most infrequent to have problems in the high pressure pipes between the 5th to 8th cylinders of the No.1 Main Engine and the 5th to 8th cylinders of the No.2 Main Engine simultaneously.
- 4.1.2.5 There was a statement that in the moments before the accident, when the Engine Room was full of oil mists and an oil leak alarm sounded from the No.1 and NO.2 Main Engines, the engineers checked the temperature of exhaust gas of the Main Engines, but there was nothing significant<sup>32)</sup> with the fuel supply.
- 4.1.2.6 In addition, the engineers stated that the leak did not stop even when they stopped the Main Engines to check whether there was an oil leak near the high-pressure

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31) According to the statement of the chief engineer, the high pressure pipe was replaced regularly once or twice a year.

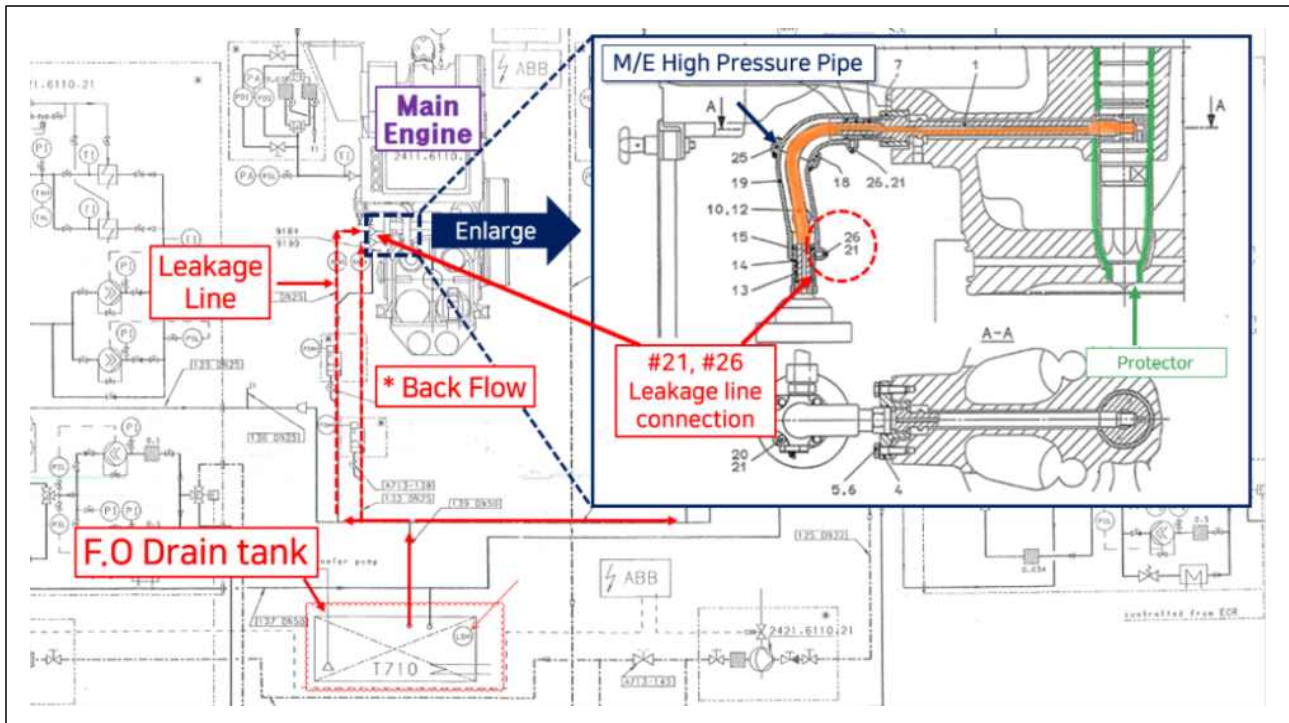
32) If fuel oil leak is due to cracks or holes in the high pressure pipe of the main engine, the temperature of the exhaust gas of the main engine may decrease

pipes of the No. 1 and No. 2 Main Engines and the fuel oil continued to overflow through the sounding pipe of the F.O drain tank.

- 4.1.2.7 On this account, it was relatively rare that multiple high-pressure pipes for fuel supply to the Main Engines were damaged simultaneously. Also, considering there was no major malfunction in supplying fuel oil to the main engine which was in operation, and the fact that oil leakage did not stop near the fuel supply high pressure pipe of the Main Engine which was not in operation, it is presumed that the oil leak was not caused by the damage of the high-pressure pipes.
- 4.1.2.8 Meanwhile, looking at the fuel oil piping system of the engine room of Responder, when oil was leaked from the fuel supply high pressure pipe of the Main Engine, the oil was gathered in the F.O drain tank by gravity along the leakage line connected to the high-pressure pipe. However, in conflict with the original purpose of its design, when the F.O drain tank was full of oil, the oil could go upward through the leakage line and backflowed<sup>33)</sup> to the fuel oil high pressure pipes.
- 4.1.2.9 Considering the fact that the F.O drain tank was fully filled again in about 35 minutes and the oil overflowed to the sounding pipe, it is presumed that the amount of oil and pressure that flowed into the F.O drain tank at that time were quite considerable.

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33) In a normal case, the waste oil of the main engine in operation should be transferred to the F.O drain tank



<Figure 22> Piping diagram of transfer pipe (leakage line) of leaked fuel oil in main engine(M127, F.O Service System floor plan)

- 4.1.2.10 According to the statement of an engine room crew, the nuts (#21 and #26 of the Figure 22) which connected the fuel supply high pressure pipe and leakage line were loosened <sup>34)</sup> to check visually the oil leakage of the fuel supply high pressure pipe. That means if there was no oil leakage caused by the damage of the fuel supply high pressure pipe, when the fuel oil flowed backward from the F.O drain tank, the oil could leak out of the fuel supply high pressure pipe through connecting nuts of leakage line. Then, the F.O leakage alarm would go off, if there were oil leakage near the fuel supply high pressure pipe.
- 4.1.2.11 In other words, judging from the piping arrangement or the possibility of backflow of oil from the F.O drain tank, presumably, the part of the Main Engine where the oil leak occurred might not be the part where the high-pressure pipe was damaged by the main engine fuel injection pump, but the part connecting the high-pressure pipe and the leakage line. In addition, it is hard to rule out the

34) If the nuts of the leaked fuel oil transfer pipe (leakage Line) connector are loosened when operating the main engine, oil may leak at the bottom of the engine room when leakage occurs in the high pressure pipe of the main engine, which does not correspond to the normal main engine management method that must completely transfer the leaked oil of main engine to F.O drain tank.

possibility that some of the fuel oil scattered by the main engine flywheel got on the high-pressure pipe and flowed down.

- 4.1.2.12 As a result, it is presumed that the oil leak from the vicinity of the fuel supply high pressure pipe was highly unlikely caused by a crack or a hole on the pipe, but rather it could be more likely caused by the fuel oil that flowed back from the F.O drain tank along the leakage line which leaked through the pipeline connector of the high-pressure pipe. In addition, the oil might have flowed downward along the outside surface of the high-pressure pipe and overflowed from the sounding pipe of the F.O drain tank to the bottom of the engine room which eventually scattered into the air by the high speed rotating flywheel.

### **4.1.3 Occurrence of oil mist in the engine room**

- 4.1.3.1 At around 02:50 on September 11, 2020, the engine room crews including the Chief Engineer came down to the Engine Room and examined the vicinity of the Main Engines to figure out why the leakage alarm went off and witnessed that the oil which was spewing out of the sounding pipe of the F.O drain tank was flowing into the bilge well.
- 4.1.3.2 The Chief Engineer and the First Engineer witnessed the oil mists spreading as the oil accumulated in the bilge well, which were full of oil, scattered around after reaching the tip of the flywheel of the Main Engine which was rotating at high speed.
- 4.1.3.3 The engine room crews stated the Engine Room was fully filled with oil mist that was even visible. The main type of oil that was used for operating the Main Engines and generators of Responder was Low Sulfur Marine Gas Oil (LSMGO), so it is presumed that the oil mist that filled the engine room at that time was formed by LSMGO.
- 4.1.3.4 Oil mist in the Engine Room was one of the combustible substances that could easily cause a fire. When the concentration of oil mist reaches the low explosive

limit<sup>35)</sup>, it might cause a fire or explosion when it contacts with a heat source higher than the ignition point or a spark caused by static electricity. In other words, when the concentration of oil mist in an enclosed space such as the engine room increases, it can reach the low explosive limit which can lead to fire or explosion when it is in contact with a heat source higher than the ignition point such as sparks.

4.1.3.5 Although the concentration level of oil mist in the engine room at the time of the accident could not be confirmed, considering the statement of the engine room crews that the oil mist was visible, it is estimated that the concentration level of the oil mist in the engine room might be significantly high.

4.1.3.6 According to the test report<sup>36)</sup> of the LSMGO that was loaded on Responder at the time of the accident, its flash point<sup>37)</sup> is 64 degrees Celsius, which is the temperature that can cause a fire or an explosion even with a spark or a small ignition source when it is vaporized. Considering the atmospheric condition of the Engine Room at the time of the accident where external air was sufficiently supplied for the operation of the Main Engines, it is presumed that the oil mist formed by LSMGO was highly likely to serve as a combustible material.

#### **4.1.4 Occurrence of electric sparks in the engine room**

4.1.4.1 The Engine Room had a high temperature environment where sparks or flames are easily occurred by various electrical devices, and a fire could be occurred when sparks from purifiers, boilers for heating fuel oil, high temperature turbo chargers, various switchboards, and ignition sources from incinerators that treat sludge and waste from the engine room were combined with oil mist in the air.

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35) IACS UR M67 / LEL, Low explosive level: 50 mg/l

36) The test result and sampling of LSMGO that was supplied to Responder on July 20, 2020

37) Vapour generated from a gas or volatile liquid mixes with air to form a combustible or completely explosive mixed gas, and when a flame is brought close to it, it combust with a flash in the moment, i.e. the lowest temperature to be ignited.

\* Ignition Point: The minimum temperature at which combustion starts by igniting itself due to the increase in peripheral temperature, generally higher than flash point

- 4.1.4.2 But, it is difficult to pinpoint the exact source of the fire because the scene of the accident can not be inspected since the vessel is currently sunk and has not been salvaged.
- 4.1.4.3 However, based on the statements of some engine room crews that there was a switchboard just above the sounding pipe of the F.O drain tank, and that they observed a flame from the No.2 main engine, there is a possibility that the fire may have occurred due to an electric spark in the switchboard during the process of shutting off the No.1 main engine and restarting the No.2 main engine.
- 4.1.4.4 Also, the possibility of the fire ignited by the scattered oil mist contacted with the ignition spark of the boiler burner or the high temperature surface of the turbocharger, can not be ruled out.

#### **4.1.5 Sub-conclusion**

- 4.1.5.1 Considering the statements of the engine room crews and the investigation results of the coast guard collected from the time of the accident to the time when this report was written, it is presumed that there is no possibility of intentional arson or an accidental fire by a crew member in the engine room.
- 4.1.5.2 This fire incident occurred around 03:35 on September 11, 2020. As the fuel oil transfer valve was not completely closed, the fuel oil in the fuel oil tank was transferred to the F.O drain tank by gravity, and the fuel oil filled in the F.O drain tank flowed back to the sounding pipe of the drain tank and the leakage line of the main engine. As the oil was leaked out of the joint of the leakage line, flowing into the bottom of the engine room and filling up the bilge well of the main engine, the oil was being scattered in the air by the high speed rotating flywheel, located above the bilge well of the Main Engine, which formed lots of oil mist in the Engine Room.
- 4.1.5.3 As Responder sank, it is hard to specify the ignition source because it was not possible to inspect the fire scene and estimate how the fire spread. However, ignition sources always existed in the engine room, such as electric sparks or

static electricity that might have created by various switchboards, boilers or high-temperature surfaces of turbo chargers, etc. The thermal energy they possessed was considered to be high enough to serve as an ignition source when it was in contact with the oil mist formed in the engine room. In particular, just before the fire outbreak, electrical signals such as starting of generator for alternate operation of the No.1 and No.2 main engines, were continuously shown. Therefore, in the case of this fire incident, it is presumed that electric sparks, static electricity, or the high temperature surface such as the turbo charger surface in the engine room served as the ignition source.

## **4.2 Cargo management and crew response to fire emergency**

### **4.2.1 Cargo management system of Responder**

- 4.2.1.1 Responder was exempted from the requirement to install the fixed CO2 fire extinguishing systems in the cargo holds on condition that Responder was fitted with steel hatch covers and effective means of closing ventilators and other openings leading to the cargo spaces, and only non-combustible submarine cables were loaded on the vessel.
- 4.2.1.2 However, on May 7, 2020, when submarine cables were being loaded on the vessel, the owner of the vessel, safety manager and cargo manager did not take any measures to check whether those cables were non-combustible or not by looking into the detailed cargo data.

### **4.2.2 Hazard evaluation and actions of fire caused by oil mist in the engine room**

- 4.2.2.1 At 02:50 on the day of the accident, when the chief engineer and the first engineer entered the engine room, they felt a strong smell of oil and oil mist in the air, and first noticed that there was something different from usual in the Engine Room.
- 4.2.2.2 At that time, the engine room crews believed that a lot of oil was leaking from the pipe which was connected with the main engines. And, after witnessing the oil mist

that was formed by scattering oil near the flywheel of the No.1 main engine, they tried to find the leak point near the No.1 and No.2 main engine.

- 4.2.2.3 At around 03:35 on the same day, they stopped the No.2 main engine which was in operation, and then fire alarm went off while restarting the No.1 main engine. They opened the door of the ECR to check whether the fire actually broke out, but after watching thick smoke in the engine room, they noticed that there was a threat from the fire, and immediately evacuated from the engine room.
- 4.2.2.4 Considering the situation above, it is presumed that the engine room crews only focused on repairing the oil leak point in the engine room, and there was no attempt to remove the fire hazard by discharging oil mist which was generated inside the engine room for at least 45 minutes.
- 4.2.2.5 According to the SOLAS Chapter II-2, part C, Regulation 8.3, machinery spaces classified as machinery spaces of category A<sup>38)</sup> are required to be equipped with appropriate facilities for discharging smoke<sup>39)</sup> and etc. in preparation for fire incident. The Responder was equipped with a total of 6 mechanical or natural ventilation ducts, among these, the fans installed in the 3 mechanical supply ducts (MS22~24) located on the upper deck, normally operated in the supply direction, but if necessary, they could be reversely operated by the emergency switch board for discharging of air.
- 4.2.2.6 Therefore, when the concentration level of oil mist in an enclosed space such as the engine room was gradually increasing, primarily, it would be desirable to take active measures to discharge the oil mist in the engine room in order to reduce the risk of fire and explosion, and then to find the leak point which created the oil mist.

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38) Class A machinery spaces refers to a place that accommodates one of the following and a trunk leading to this place.

(1) The internal combustion engine used for the main propulsion.

(2) An internal combustion engine with a total output of 375 kilowatts or more used for purposes other than the main propulsion

(3) A device that uses oil other than a boiler as fuel, such as an oil boiler or fuel oil device, or an inert gas generator or incinerator

39) Since release of smoke from machinery spaces in regulation 8.3 is the requirement that is only applied to the vessels built after July 1st 2002, so it was not applied to Responder



At that time, it is presumed that the engine room crews neglected to eliminate fire risks by discharging smoke in the engine room, such as operating a fan (a mechanical supply fan on the upper deck) that discharges the air inside the engine room to the outside.

### **4.2.3 Initial response of crews in the Engine Room after fire**

- 4.2.3.1 When crews in ECR heard the fire alarm, they thought it was a false alarm due to the oil mist. But, as they opened the door of the ECR, they observed that the room was full of smoke which caused extremely low visibility.
- 4.2.3.2 The engine room crews stated that it was hard to conduct initial response operations such as use of a portable fire extinguisher, since the engine room was full of thick smoke at the time, so it was inaccessible and impossible to specify the ignition point as the fire already progressed beyond incipient stage. Afterwards, they reported the fire to the bridge, while evacuating from the engine room.
- 4.2.3.3 After escaping from the Engine Room, the Second Engineer A and the Third Engineer went up to the Bridge and operated every fuel oil shutoff valve leading to the Engine Room. Without Master's order and in accordance with the assigned duty in the fire response manual, the Second Engineer A made his own decision to go out of the Bridge to shut off the ventilation system of the Engine Room by controlling the handle of the fire damper on the Helideck, but failed to do so as the handle was inaccessible due to the heavy smoke.
- 4.2.3.4 In accordance with the fire response procedure, after recognizing the fire outbreak in the engine room, crews in the engine room should primarily have reported to the master about the fire outbreak, the estimated cause, the spread of the fire, and the means of extinguishing fire. Then they should have carried out the fire suppression operations by positions following the direction of the master, but it is presumed that the response procedure was not systematically carried out. In other words, it is presumed that the situation was not effectively reported to the master and the crews neglected to control and manage the fire extinguishing measures during the initial response operation.

## 4.2.4 Initial attempt to extinguish the fire

- 4.2.4.1 At around 03:35 on day of the accident, a fire broke out in the engine room of Responder, and the master received a report of the fire from the third officer and went up to the bridge to issue fire emergency arrangement order. At around 03:38 on the same day, the chief officer took a roll call and reported it to the master.
- 4.2.4.2 At that time, the master went down to the upper deck to check the scale of the fire, and asked the first engineer who escaped from the engine room to the upper deck, if the fire was extinguishable on their own, and the first engineer answered that it was impossible. Accordingly, the master judged that it was beyond their capability to extinguish the fire.
- 4.2.4.3 However, it is presumed that the first engineer could not accurately figure out whether the fire could be extinguished by themselves because he was not clearly aware of the location and scale of the fire when he escaped from the engine room.
- 4.2.4.4 As such, even if receiving an answer from the first engineer that it was inextinguishable, the Master should have reviewed whether to attempt the fire extinguishing operation by reexamining the scale of the fire, the ignition point, the spread of fire, and how to seal the engine room.

## 4.3 Use of Fixed CO2 fire extinguishing system

- 4.3.1 At around 03:40 on the day of the accident, after the Master heard from the First Engineer that the fire was inextinguishable, he reported to the Tongyeong Coastal VTS using the VHF Radio that he would use the fixed CO2 fire extinguishing system.
- 4.3.2 Though receiving a report from the Second Engineer A that the Engine room was not completely sealed off as he failed to close the fire damper on the funnel, the Master tried to use the fixed CO2 fire extinguishing system to suppress the fire.
- 4.3.3 In the end, the Master ordered the Chief Officer to release CO2 extinguishing gas by operating the extinguishing system at the fixed CO2 fire extinguishing system room

located on the Upper Deck, but the flames and smoke in the Engine Room did not subside even after the operation of the extinguishing system.

- 4.3.4 The reason of the failure of fire suppression was that the suffocation effect which should have come from the fixed CO2 fire extinguishing system, was unobtainable as the Engine Room was not sealed off completely.
- 4.3.5 The Master stated that he used the fixed CO2 fire extinguishing system just before escaping from the vessel, and decided to order all crews to abandon the vessel immediately for the safety of 60 persons including crews, technicians for laying submarine cables, and professional workers who were on board Responder at the time.



<Figure 23> The manual damper of the similar vessel (The Miraero)

- 4.3.6 However, the fixed CO2 fire extinguishing system was the most effective and ultimate measure of fire suppression that could only be used once on the vessel. In order to use the system, the fire area must be completely sealed off. If the fixed CO2 fire extinguishing system was operated without the fire area being completely sealed off, even though the fire might temporarily subside in the area, but the fire would not be completely extinguishable. Therefore, the operation of the fixed CO2 fire extinguishing system should be carefully prepared and implemented.

- 4.3.7 The decision to operate the fixed CO<sub>2</sub> fire extinguishing system after recognizing of the fact that the fire was inextinguishable at around 03:40, appears to be appropriate, considering the severity of the fire in the Engine Room at the time of the accident. However, the decision to operate the fixed CO<sub>2</sub> fire extinguishing system without closing the fire damper, only 5 minutes after recognizing the fire, is regrettable as turning to be an ineffective action, even if the decision was made to prioritize human life.
- 4.3.8 Looking into the fire progression<sup>40)</sup> until the time of 04:27, 52 minutes from recognizing the fire outbreak, to all crews were transferred to Yeongin 207, it is appeared that more time should have been spent in judging the initial situation of the fire outbreak, and attempt to close the fire damper on the funnel side, while crews were escaping from the vessel.
- 4.3.9 In other words, presumably, when the Master heard from the First Engineer that the fire in the Engine Room was inextinguishable, he should have reviewed the scale of the fire in the Engine Room, initial ignition points, fire progression, and how to seal the engine room against air ingress.
- 4.3.10 Also, it is considered that the Master could have instructed the crews, in charge of the duty to wear a self-contained breathing apparatus (SCBA), etc., to approach the fire damper located on the side of the funnel while the other crews were leaving the vessel. If the Engine Room had sealed by shutting off all ventilation systems in the Engine Room, the fire suppression using the fixed CO<sub>2</sub> fire extinguishing system would have been successful.

40) The timeline and response for the fire of Responder

Date	Content
2020.9.11 03:35	Fire break out in the main engine room
2020.9.11 03:40	Master took on scene command and decided to use the fixed CO <sub>2</sub> extinguishing system
2020.9.11 03:42	The use of fixed CO <sub>2</sub> extinguishing system and fire extinguishing failed
2020.9.11 03:50	Master decided to evacuate from the ship
2020.9.11 04:27	All crews transferred to the Youngyin 207
2020.9.11 09:28	The flame spread to the bridge and top of the mast
2020.9.12 17:42	The sinking of the Responder

## 4.4 Adequacy of fire drill

- 4.4.1 Responder was a vessel engaged on international voyage with gross tonnage of 500 and above and was obliged to conduct emergency response drills such as fire drills and abandon ship drills on a monthly basis in accordance with requirements of SOLAS.
- 4.4.2 According to the vessel's annual emergency response drill plan and the result report, the emergency response drills for fire suppression, ship abandonment and drills for preventing marine accidents had been carried out every month as planned.
- 4.4.3 However, according to the statements of the Master and crews of Responder, this vessel did not actually conduct emergency drills, but posted the results of the drills on the notice board of the ship on the day of the drill, and then each crew member signed the signature box. The records of drills were maintained and managed in this way.
- 4.4.4 This demonstrates a lack of awareness of risks and safety in emergency situations, indicating the capability of the crew members on the vessel to respond to emergencies was insufficient.
- 4.4.5 In this case, it is judged that the effective response to the fire was not properly carried out, on account of the fact that the information regarding the fire such as the prediction of the fire spread due to the emission of oil mist, preparation for fire risk factors, and initial fire response, were not promptly reported.

## 4.5 Fire suppression

- 4.5.1 According to the situation report by the Tongyeong Coast Guard, at around 03:51 on September 11, 2020, Tongyeong Coast Guard dispatched the rescue teams which consist of KCG patrol vessel (1501, 1006, P-86, P-101, P-27), oil spill response ship (Banje-11), and etc to the scene to suppress the fire, and arrived at the scene promptly at around 05:16 on the same day.

- 4.5.2 The Engine Room of Responder was a place where various equipment and facilities such as the Main Engines, generators, and boilers were gathered and being operated. Considering the complex structure of the room, it would have been very difficult to extinguish the fire since it was inaccessible to the engine room even after the ignition source was specified.
- 4.5.3 When the rescue teams arrived at Responder, it was impossible for rescuers to board the vessel as its deck and shell were already heated up, and it was difficult to accurately estimate the scale of the fire. Therefore, the rescue ships dispatched to the scene tried to suppress the fire by shooting fire water towards the door of the engine room so that water can flow down to the inside of the room and the outer plate of the vessel that could be cooled off.
- 4.5.4 However, despite the continuous fire-fighting operations, Responder began to tilt at around 09:28 on the same day, and at around 11:45 on the same day the rescue teams decided to switch to the shell cooling method on the assumption that the vessel was tilting due to the weight of fire water flowing into the vessel, but the fire recurred at around 23:10 on the same day. As a result, it is presumed that only by above-mentioned method, there would have been limitation to sufficiently lower the thermal energy accumulated in the Engine Room of the vessel without entering into the hull.

## 4.6 Sink of the ship

- 4.6.1 According to the situation report by the Tongyeong Coast Guard, at around 16:47 on September 12, 2020, the next day, Responder trimmed sharply toward the bow of the vessel, and at around 16:55 on the same day, an explosion occurred<sup>41)</sup> at the bottom of Responder, and the bow began to sink further, and at around 17:42 on the same day, the vessel completely sank.
- 4.6.2 Nippon Salvage Co., Ltd., a rescue and salvage ship company, examined<sup>42)</sup> Responder

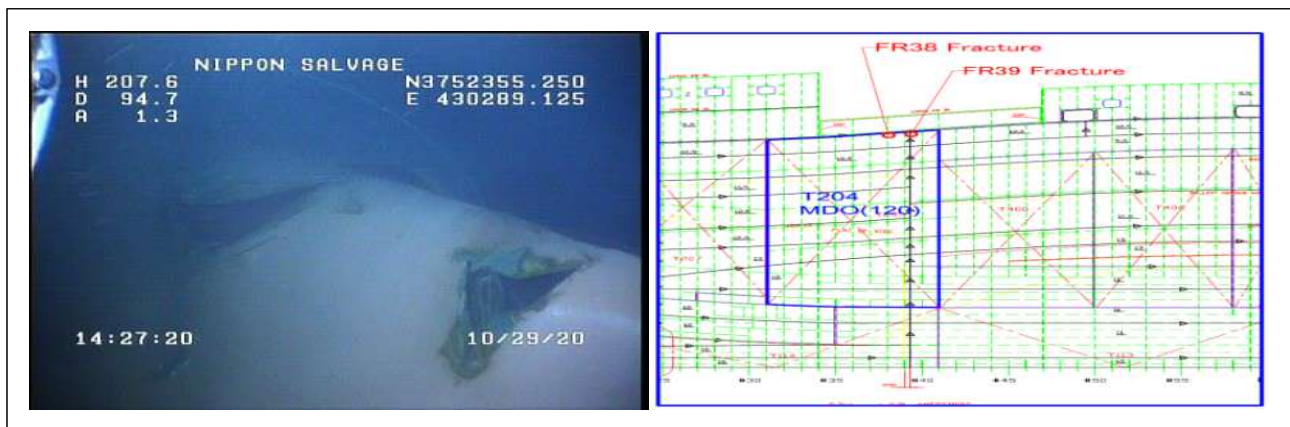
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41) The Coast Guard's No.1501 ship reported to the situation room that there was an explosion on Responder.

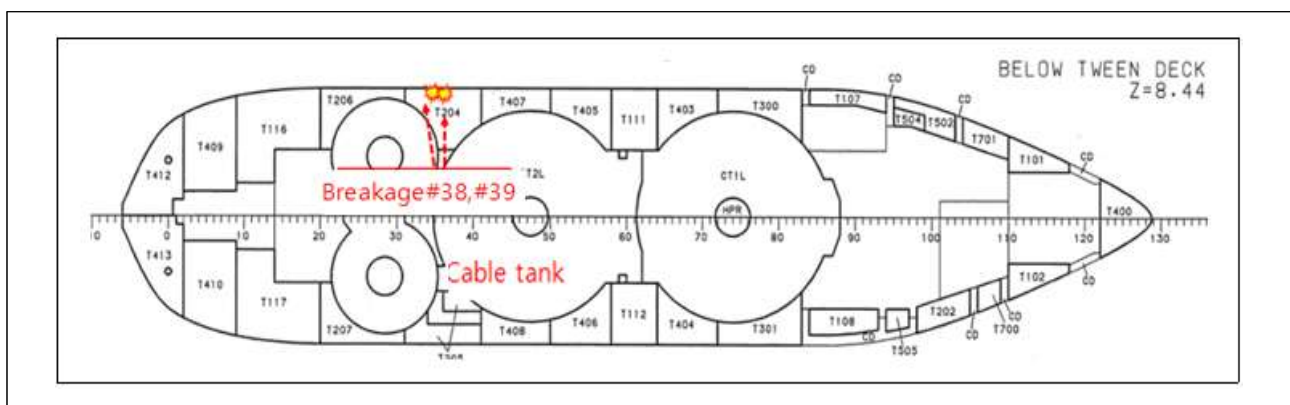
42) October 29, 2020

sunk in the seabed to transfer remaining oil in the vessel to prevent marine pollution, and confirmed that there were two holes that appeared to be created by the explosion from the inside to the outside on the shell plate where the fuel oil tank NO. 204 was located.

4.6.3 As such, Responder began to sink toward the bow during its fire suppression operation, and as the fire from the Engine Room spread in the adjacent area of the cable tank, and the cables with high thermal conductivity were ignited which led the fire to spread further. As the fire in the cable tanks spread to the fuel oil tanks, the remaining oil and steam in the fuel oil tank<sup>43)</sup> exploded, which created a hole on the shell plate. As large amounts of seawater flowed into the vessel, the sinking of the hull accelerated and the vessel eventually sank.



<Figure24> Picture and floor plan of No.204 tank(breakage point) where the explosion occurred



<Figure 25> The floor plan and location of the breakage in No.204 tank

43) The No.204 fuel oil tank where the explosion occurred was surrounded by a cable tank at the time and had the largest amount of remaining fuel oil.

section

5

# Conclusion



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## 5. Conclusion

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### 5.1 Fire outbreak

5.1.1. This fire accident is presumed to have occurred at around 02:35 on September 11, 2020, when Responder was working on submarine cable laying, the Engine Room was full of oil mist and ignited by a spark or touch with high-temperature equipment in the Engine Room.

5.1.2 The cause of the formation of oil mist and the fire outbreak in the Engine Room of Responder are presumed as follows:

- At the time of the accident, around 02:00 on September 11, 2020, the fuel oil transfer valve (A723-048) connecting the fuel oil tank (T116) and the F.O drain tank (Capacity: 8.6 tons) was not closed properly or was opened due to mechanical malfunction or an operational error. Due to this, approximately 80 tonnes of fuel oil in the fuel oil tank (T116) flowed into the F.O drain tank (Capacity: 8.6 tons) by gravity.
- Some of the fuel oil in the F.O drain tank overflowed to the sounding pipe of the upper side of the drain tank and flowed into the engine room floor. And some of the fuel oil which could not flow through the sounding pipe overflowed to the leakage line of the Main Engine by gravity pressure, leaked from the leakage line joint and flowed into the bottom of the Engine Room.
- At that time, oil mist which was generated from the fuel oil that has contacted with the flywheel rotating at high speed right above the bilge well of the main engine, may be contacted an electric spark or highly heated surface of equipment when it splashed and scattered. And it brought out the fire.

5.1.3 In addition, when loading the submarine cables on Responder, it was judged that the ship owner, shipping company, and cargo manager had failed to check whether the

submarine cables would be non-combustible and suitable for loading under the exemption condition for a fixed fire extinguishing system in cargo holds.

## **5.2 Insufficiency of response and recognition of the risk of fire caused by oil mist**

5.2.1 It is presumed that the fire prevention/fighting actions were inappropriate. For example, neglecting efforts to discharge oil mist by overlooking the risk of fire caused by oil mist in the engine room.

- Before the accident, the Chief Engineer and the engine room crews felt a strong smell of oil and oil mist and witnessed that the oil was scattering in the room. Nevertheless, they only focused on finding the leak point, and did not recognize the risk of fire caused by oil mist which is a combustible. They did not make any effort to discharge the oil mist which eventually led to the failure of suppression in the early stages.
- In addition, the Chief Engineer and the engine room crews did not promptly inform the Bridge of the fact that an oil leak occurred in the engine room and it was full of oil mist, so the dangerous situation in the engine room was not shared to all crews, and as the risk of fire was not shared to the Bridge in advance, the initial emergency response measures such as cessation of cable laying operations, in preparation for the shutdown of the Maine Engine, were not properly implemented.

5.2.2 Meanwhile, it is judged that there were some regrets in the initial fire response and fire fighting operations, even considering that it was imperative to prioritize the safety of crews in an emergency fire situation.

- The Chief Engineer and the engine room crews were unable to identify the ignition point or the scale of the fire while escaping the Engine Room immediately after recognizing the outbreak of the fire.
- The Master tried to extinguish the fire only with limited information, such as the opinion of the First Engineer who said, 'it seems like it is beyond our ability to

extinguish the fire by ourselves.’ without accurate information on the fire, namely the cause, ignition point, scale, and spread of the fire. Without reviewing the detailed and specific fire fighting plan, he decided to use the fixed CO2 fire extinguishing system in the Engine Room, which was used as the last resort on the premise of abandoning the vessel.

- Due to the characteristics of the fixed CO2 fire extinguishing system in the Engine Room that suppresses a fire through the cooling effects and reduction of the oxygen concentration level, the fire fighting can only be successful when the Engine Room is properly sealed off before CO2 is released. If the room is not completely sealed off, the flame will only temporarily subside by the temporary cooling effect, but it will spread again after a while. At the time of the accident, the fire damper on the funnel side which was for ventilation of the Engine Room was open, and the Master and the engineer in charge were aware of the opening of the damper, but they did not actively attempt to seal the Engine Room off by closing the fire damper.
- By releasing CO2 gas into an unsealed Engine Room, they missed the opportunity to extinguish the fire as their only means to extinguish the fire on their own.

## **5.3 Incompetence of crewman to response to fire**

5.3.1 It is judged that the crews of the vessel did not have adequate fire response capabilities or failed to demonstrate their fire response ability because they had not properly conducted fire response drills according to the emergency response manual.

- The vessel crews only signed the fire drill record without actually engaging in the emergency response drill that should have been conducted on monthly basis. Since the ability to properly control the emergency situation through such drills was not demonstrated, it is presumed that crews could not build the capabilities to predict the possibility of a fire caused by an oil mist, to initially respond to the fire, to promptly report the fire outbreak, and to establish and operate a control system for fire suppression.

## 5.4 Vessel flooding and sinking

- 5.4.1 When Responder failed to extinguish the fire with the fixed CO2 fire extinguishing system, all crew members transferred to the tug boat Yeongin 105, and then transferred to Miraero, which belonged to Sehdong Shipping Co., Ltd., to complete the evacuation operations without any casualties.
- 5.4.2 After the accident, the rescue teams belonged to the Tongyeong Coast Guard and the Tongyeong Fire Station arrived at the scene and began to extinguish the fire, but due to the heavy weight of the extinguishing water, the vessel began to tilt.
- 5.4.3 Therefore, the rescue team switched to the shell cooling method and suppressed some fires on the deck by using chemical fire extinguishing methods such as foam, but the fire spread to cable tanks and accommodation space of the vessel as the extinguishing and recurrence of the fire were repeated.
- 5.4.4 Afterwards, the fire spread to the submarine cables stored in the cable tank, and as thermal energy was conducted to the oil and gas in the fuel tank in the engine room, an explosion occurred in the nearby fuel oil tank (NO. 204), causing two holes on the bottom of the vessel.
- 5.4.5 Therefore, it is judged that the sinking of the ship was accelerated due to the holes created by the explosion, and the bow of Responder also began to sink, at last, the vessel sank about 42 miles south of Yokjido, Tongyeong-si, Gyeongsangnam-do at around 17:42 on September 12, 2020.

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# Recommendation

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## 6. Recommendation

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### 6.1 Installation of prevention system for backflowing between fuel oil tank and F.O drain tank

- 6.1.1 The piping system of Responder was arranged to connect each oil storage tank such as fuel oil tank, F.O drain tank, and settling tank for smooth transfer of engine room oil.
- 6.1.2 In the vessels where the fuel oil tank is installed higher than the F.O drain tank, the fuel oil in the fuel oil tank can be transferred to the F.O drain tank through the pipe by gravity. To prevent this, a isolating valve is installed in the pipe connected to the fuel oil tank and the F.O drain tank.
- 6.1.3 However, since there are no specific regulations regarding the type and size of this valve, ship owners can install check valves, butterfly valves, globe valves (stop valves), and etc. at their convenience.
- 6.1.4 Unlike a check valve in which the flow of the fluid is set to one direction, when a butterfly valve<sup>44)</sup> or globe valve is open, fuel oil can freely move back and forth by gravity.
- 6.1.5 Therefore, when a pipe is connected between the fuel oil tank and the F.O drain tank and the pipe is used only for fuel oil transfer, shipowner and operator should take measures such as installing check valve, a device for controlling the fuel oil transfer pipe, to prevent the backflow of the oil from the fuel oil tank to the F.O drain tank.
- 6.1.6 In addition, the Ministry of Oceans and Fisheries should review the enactment or revision of the regulations such as 「Ship Engine Regulations」 and consider guidelines

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44) The device that allows automatic control for fluid to flow through it in only one direction without flowing backward (valve)

for installation of backflow preventing devices or check valves in order to prevent the overflow oil in the F.O drain tank.

## **6.2 Enact of related regulations and installation of water level alarm circuit in F.O drain tank in the engine room**

- 6.2.1 The F.O drain tank collects leaked oil and oil sludge from the main engine, so the engine room crews should check the amount of oil in the tank periodically in order to prevent the overflow of the oil.
- 6.2.2 In some vessels, an alarm goes off when the amount of oil in the F.O drain tank exceeds a certain level so that engine room crews could recognize the overflow of the oil.
- 6.2.3 In Responder, since the engine room crews already recognized of the fact that the overflow alarm was broken, they would periodically check the amount of the fluid in the drain tank by manual sounding its level, but they did not recognize the overflowing of the oil in the tank on the day of accident.
- 6.2.4 Therefore, ship owners and operators should install an alarm device in the F.O drain tank and set maintenance guidelines so that the engine room crews can check whether the alarm device is operating properly.
- 6.2.5 In addition, the Ministry of Oceans and Fisheries should consider to enact or revise related regulations in order to provide guideline for installing a device that can sound an alarm when the oil reaches high status in the F.O drain tank.

## **6.3 Reinforcement of the onshore corporation system of expertise of supporting organizations for fire fighting operation**

- 6.3.1 The machinery space of the vessel had a complex structure with large facilities and equipment such as main engines and generators, and when suppressing a fire, the Engine Room, as a main vertical zone, should be quarantined as one single section.

- 6.3.2 Therefore, if the openings and ventilation ports leading to the outside of the Engine Room were quickly blocked in order to seal the entire machinery space off, there would have been high possibility that the fire inside the machinery space would not be spread any further. When the fire was subsided by cooling the shell of the vessel, the fire fighters could have boarded the vessel to suppress the fire using carbon dioxide or foam.
- 6.3.3 However, when discharging fire water monitor toward the openings of the Engine Room, it is difficult to maximize the fire extinguishing effect because the extinguishing water cannot reach the ignition point since the opening is narrower than the size of the Engine Room, and the longer discharging time gets, the more extinguishing water is accumulated on the Upper Deck and accommodation space of the vessel which will eventually lead the ship to tilt or sink.
- 6.3.4 Therefore, by taking the characteristics of ship fire into account, the relevant organizations should consider a plan to conduct joint fire drills for effective respond to the fire at sea.
- 6.3.5 In addition, in the event of a fire incident on a vessel, the shipping company that manages the vessel should promptly provide drawings and procedure plan such as general arrangement (GA) of the vessel and fire control plan to fire response organizations, fire stations and the coast guards, and actively discuss measures and cooperate to suppress the fire.
- 6.3.6 In addition, shipping companies should periodically educate the masters on how to cooperate with fire response organizations in case of a fire on the vessel so that the master can promptly and actively present their opinions to related organizations in case of emergency.

## **6.4 Reinforcement of onboard emergency response education and training**

- 6.4.1 In accordance with Chapter 3, Rule 19 of SOLAS, ships engaged on international



voyages of 500 gross tonnage and upward, such as Responder, must conduct fire drills and abandon ship drills on a monthly basis.

- 6.4.2 According to the annual emergency response training plan, fire fighting drills and abandon ship drills which were not actually conducted, was recorded as conducted on a monthly basis. So it is presumed that the crews were not clearly aware of their duties at the time of the accident. Considering that the engine room crews were only focused on finding the leak point, it was judged that they was not able to recognize the seriousness of the risk of fire caused by an oil mist.
- 6.4.3 In the large vessels as Responder in which a large number of people get on board, such as crew members and professional workers, each onboard personnel must clearly understand and fulfill their duties in order to quickly take a roll call and establish an efficient command and control system in case of an emergency such as a fire. Each onboard personnel should be aware of the occurrence of an emergency by consistently engaging in drills.
- 6.4.4 Therefore, ship owners and operators must ensure that emergency response drills is conducted on their vessels in accordance with requirements in international conventions and domestic laws for personnels on board to properly respond to emergency situations such as fire outbreak, Also, crews should be trained so that they are always aware of the risk factors of fire such as oil mist.
- 6.4.5 And, ship owners and operators need to specify specific details of work location, given duties, and how to operate equipment, so that the crews in charge can actually perform their duties in response to an emergency. Also, a proper training should be provided to the crews so that they can be fully aware of how they should respond to an emergency.
- 6.4.6 Also, crew training institutions should educate crews to recognize and prepare for the risk of fire in advance when they find oil mist or combustible materials while on board, and a specific and practical education program (practice for closing a damper, and etc.) should be conducted so that crews can respond quickly in the event of a fire.

- 6.4.7 In addition, since in the DP vessels such as cable layers, a large number of personnel including crews and professional workers are aboard, ship owners and operators should consider measures for a professional safety manager in charge of emergency response, education and training to be on board the vessel.

## 6.5 Reinforcement of installation of remote open/close device of fire damper and enactment of regulations

- 6.5.1 The fire damper on the funnel side connected to the engine room of Responder was a manual switchgear that must be closed by a person manually at the site outside the engine room. Though an engineer tried to go up the upper side of the bridge to close the fire damper on the funnel side as an emergency response procedure, but he failed to do so due to thick smoke and toxic gas.
- 6.5.2 For this reason, the machinery space of the vessel was not completely blocked from the outside air, and even when the master tried to extinguish the fire in the machinery space using the fixed CO<sub>2</sub> fire extinguishing system, the suffocating effect of the CO<sub>2</sub> extinguishing gas did not occur effectively, so he failed to suppress the fire.
- 6.5.3 Relevant regulations in international conventions stipulate that the area of the fire incident such as an engine room, must be completely sealed up. In accordance with Chapter II-2 Regulation 10 (10.4.2)<sup>45)</sup> and Chapter II-2 Regulation 5 (5.2.2.1)<sup>46)</sup> of SOLAS, vessels shall be designed that openings for a protected space shall be capable of being closed from outside the protected space and means of control shall be provided for closure of openings in funnels."

45) The International Convention for the Safety of Life at Sea(SOLAS)Chapter2-2,Regulation10(10.4.2)

10.4.2 Closing appliances for fixed gas fire-extinguishing systems

Where a fixed gas fire-extinguishing system is used, openings which may admit air to, or allow gas to escape from, a protected space shall be capable of being closed from outside the protected space.

46) The International Convention for the Safety of Life at Sea(SOLAS) Chapter2-2,Regulation5(5.2.2.1)

2.2 Means of control in machinery spaces

2.2.1 Means of control shall be provided for opening and closure of skylights, closure of openings in funnels which normally allow exhaust ventilation and closure of ventilator dampers.

- 6.5.4 However, there is no provision for installation of a remote control system to close the fire damper in the places other than the site in case of when thick smoke and toxic gases are being emitted from the funnel side of fire damper, just as the fire incident that occurred in the engine room of Responder.
- 6.5.5 On the other hand, some newly-built vessels are having a remote control system to shut off ventilation systems such as fire dampers all at once by controlling an air valves from the Bridge or on the Upper Deck swiftly and safely to seal off the fire zone.
- 6.5.6 Even in the fire incident of Responder, the fire in the Engine Room would have been suppressed to a degree if the fixed CO<sub>2</sub> fire extinguishing system was used after the engine room was completely sealed off. The sinking of the ship could have been prevented by creating the condition for onshore fire rescue team to board the vessel and getting sufficient support from fire boats and coast guard ships.
- 6.5.7 Therefore, it is required for the International Maritime Organization (IMO) to establish regulations on the installation of a remote switchgear of the fire damper to improve the efficiency of the onboard fire extinguishing system, such as a fixed CO<sub>2</sub> fire extinguishing system, to respond to various types of fire. And, the regulation on the installation of a system that automatically shuts off ventilation systems in the fire zone when a fixed CO<sub>2</sub> fire extinguishing system is used, also need to be considered.
- 6.5.8 In addition, it is judged that ship owners and safety managers should actively consider installing a device that can remotely open and close the fire damper on the vessel in order to swiftly and safely respond to a fire onboard.

## **6.6 Reinforcement of confirmation of suitability for cargo loading**

- 6.6.1 Responder was exempted from the requirement to install the fixed Co<sub>2</sub> fire extinguishing systems in the cargo holds on condition that Responder should be equipped with a steel hatch cover and effective means of closing all ventilators and

other openings leading to the cargo spaces and “only non-combustible underwater cables are loaded” on the vessel.

- 6.6.2 However, on May 7, 2020, when underwater cables were being loaded on the vessel, the owner of the vessel, safety manager and cargo manager did not take any measures to check whether those cables were non-combustible or not by looking into the detailed cargo data.
- 6.6.3 Therefore, it is judged that it is necessary for the ship owner, safety manager, and cargo manager to check whether the cargo is non-combustible by checking cargo specifications and cargo details before loading the cargo such as underwater cables in the cable tank of Responder.

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Ministry of Oceans and Fisheries

Korea Maritime Safety Tribunal