Chapter 2 Trend of Claims Caused by Engine Trouble In Ships Entered With Our Club

In this chapter, we shall consider the claims caused by the engine trouble in the P&I claims handled by our Club, and study and examine specifically what we must pay attention.

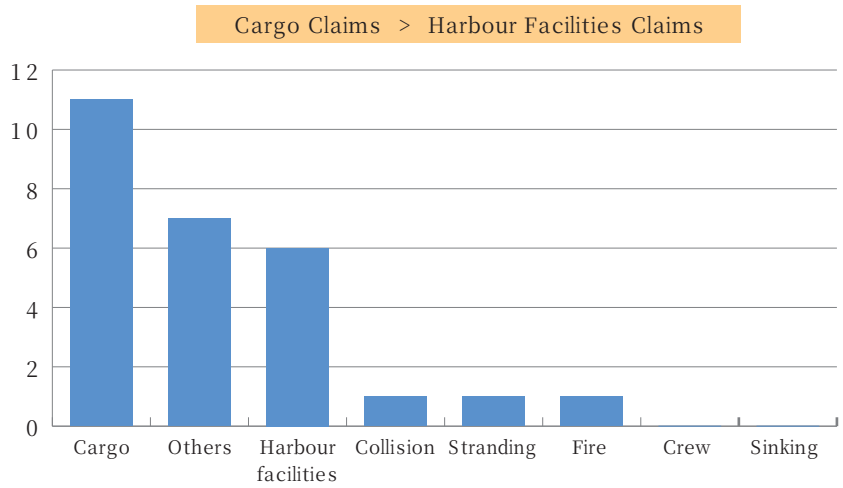
We are going to study the claims caused by the engine trouble from 2008 policy year (hereinafter "PY") to 2014 PY, and first to analyse their trend.
We then discuss case studies, and examine their preventive measures.
In addition, for your reference information, we explain the important points of engine room bilge management, related to the violation of International Convention for the Prevention of Pollution from Ships (hereinafter "MARPOL") which are not covered by P&I insurance.

2.1 Trend in Our Club

2.1.1 Trend of Claims by Risk

When we examined the 7 years of claims caused by the engine trouble from 2008 PY to 2014 PY, we confirmed 27 notable cases. According to a comparison of the number of claims shown in Figure 29, cargo claims, others, and harbour facilities claims are ranked in decreasing order of the number of claims. "Others" include the fine, and the leakages of hydraulic oil from cranes or lubricating oil from lubricating oil coolers in the engine room in addition to unclassifiable claims.

The claims number of collision and grounding is small, but if the engine trouble occurs in a heavy traffic water passage or coastal zone with a large volume of ship traffic, or harbour area, losses can be significant.
For details, we explain in case studies described later.



Note * :
Others: Fine, Oil pollution (hydraulic oil, lubricating oil), and Others

Figure 29 Trend of Claims 27 cases (2008 - 2014PY)

(1) Breakdown of Direct Causes

From Figure 30, it is shown that subtotal trouble of Main engine and Generator Engine / Electricity accounts for the half of the notable cases.

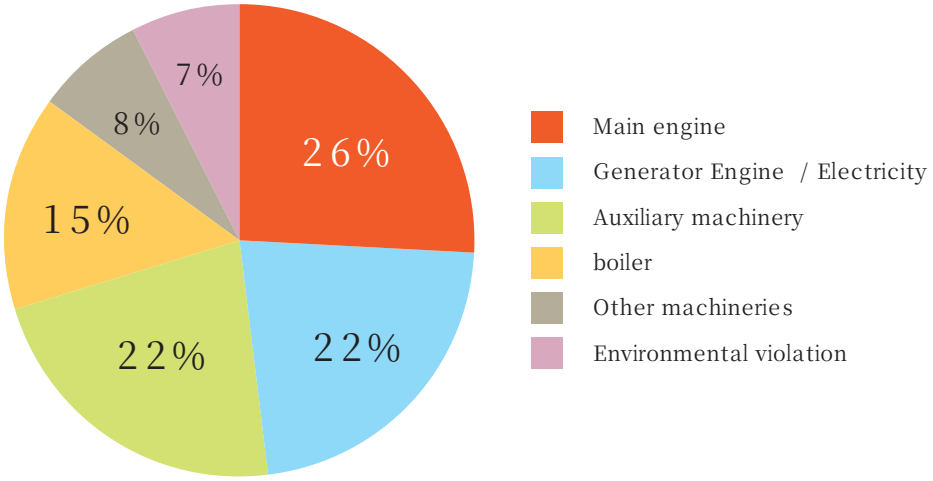


Figure 30 Percentage of direct causes by machinery

(2) Causes of Cargo Claims

From Figure 31, it shows about a percentage of what machinery causes cargo claims. There are many cases involving claims to reefer cargo and reefer containers. The reefer cargo and reefer containers need the electric power to cool. Therefore, the power shortage trouble caused by Generator Engine / electricity system accounts for approx. 40% of the cases

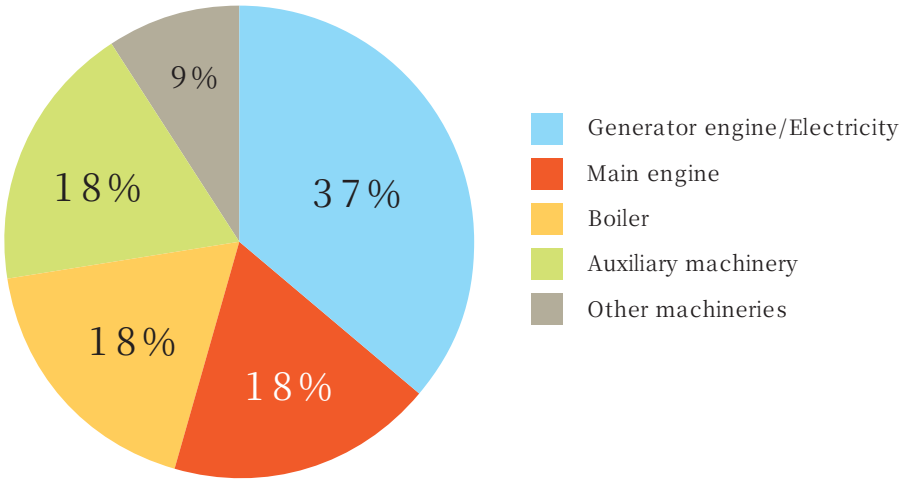


Figure 31 Percentage of direct causes by machinery leading to Cargo Claims

(3) Causes of Harbour Facilities Claims

From Figure 32, it shows about a percentage of what machinery causes harbour facilities claims. The Main engine trouble occurring during harbour maneuvring accounts for approx. 50% of the cases.

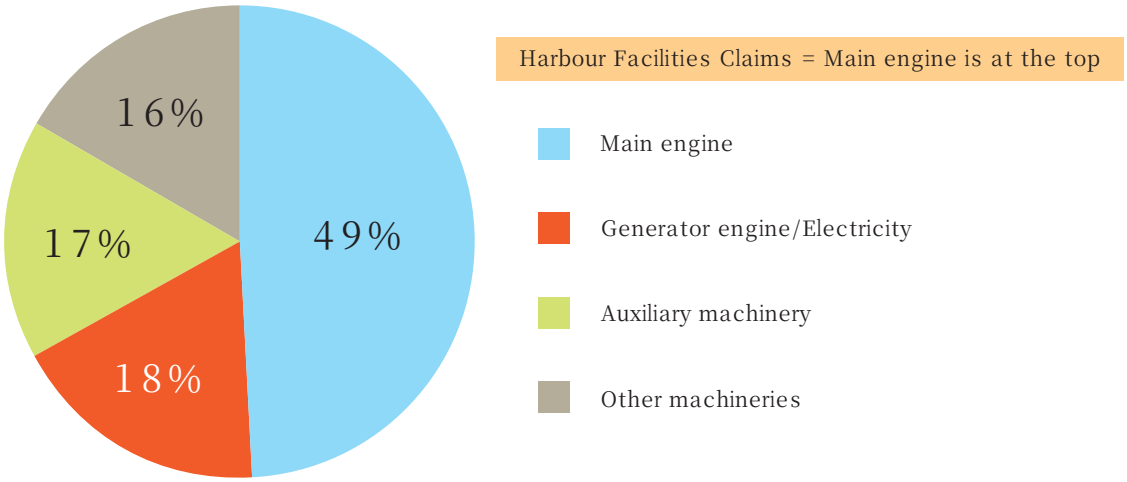


Figure 32 Percentage of direct cause by machinery leading to Harbour Facilities Claims

(4) Causes of Other Claims

From Figure 33, it shows about a percentage of what machinery causes others. The auxiliary devices such as auxiliary machinery and boiler in engine room account for approx.70% of the cases. Environmental claims by auxiliary devices including oil pollution from hydraulic oil leaking from cranes or lubricating oil from the lubricating oil cooler in the engine room, or black smoke due to incomplete combustion in a boiler.

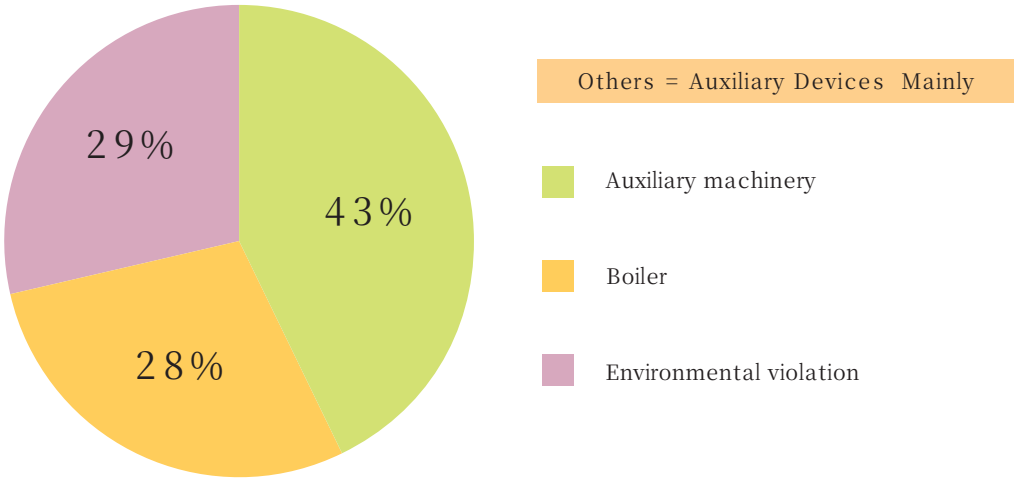


Figure 33 Percentage of direct cause by machinery leading to other claims

2.2 Case Studies

We have extracted 4 case studies of claims caused by engine trouble, as handled by our Club. First we discuss their outline, insurance money, and what happened in their engine room. We then examine their causes and applicable preventive measures.

2.2.1	Cargo Damage (Cargo shortage)	: Boiler Trouble
2.2.2	Harbour Facilities Claims (Damage to submarine cable)	: Main Engine Start Failure
2.2.3	Cargo Claims	: Generator Re-start Failure (Blackout)
2.2.4	Environmental Claims	: Incomplete Combustion of the Boiler

2.2.1 Cargo Claims (Cargo Shortage) : Boiler Trouble

(1) Outline

During ship's navigating and carrying benzene to its discharging port, a leakage of boiler water was found on board. So, the crew stopped the boiler operation immediately. As a result of this trouble, the ship couldn't heat the cargo during her voyage and entered into port. The temperature of the cargo tank at this time was 5.25℃ on average, which was less than the melting point of benzene (5.5℃).

The ship started unloading cargo operations by receiving heating steam from the shore terminal, but this heating work for unloading was not enough. Some cargo could not be heated and remained on the tank wall, therefore it resulted a cargo shortage.

Cargo interests claimed US$20,000 from owners including supplying the steam. Eventually, this case was settled at US$10,000.

(2) Insurance Money

Settlement amount of cargo claim	: US$ 10,000
Surveyors fee	: US$ 2,000
Correspondent fees	: US$ 3,000
Total	**:approx. US$ 15,000**

(3) What Happened in the Engine Room?

① The crew stopped operating the boiler when water was found leaking in the lower boiler casing in the engine room.

Please refer to the lower boiler casing as shown in Figure 34, the lower drum and manhole as shown in Figure 35, the upper boiler casing as shown in Figure 36.

There are two types of boiler water tube damages:

a Internal damage of area in contact with boiler water

b Outside damage of area in contact with combustion gas

For their damage prevention, it is important for crew “to manage and treat the boiler water (water quality check/chemical treatment/discharge of boiler water (blow-off))” and “to inspect from inside of combustion chamber”.

Figure34 Lower boiler casing
(Water leakage trace from upper part)

Figure35 Lower drum/manhole
(Water leakage trace from upper part)

Figure36 Upper boiler casing
(Paint swelling)

On the other hand, according to the “summary of damage” of Class NK, the following troubles are reported as boiler damage.

a Corrosion and burnout damage of water tubes and smoke tubes

b Corrosion and wear of mounted valve of boiler

c Corrosion of safety valve

② The boiler installed on this ship is a once through boiler shown in Figure 37 “Cross section view of boiler”. Unfortunately there is no detailed information including the extent of the damaged part. Judging from the trouble situation, the main cause of water leakage might be a breakage of the water tube caused by corrosion from both boiler water and combustion gas side, and the second cause might be considered to be the deformation of a drum.

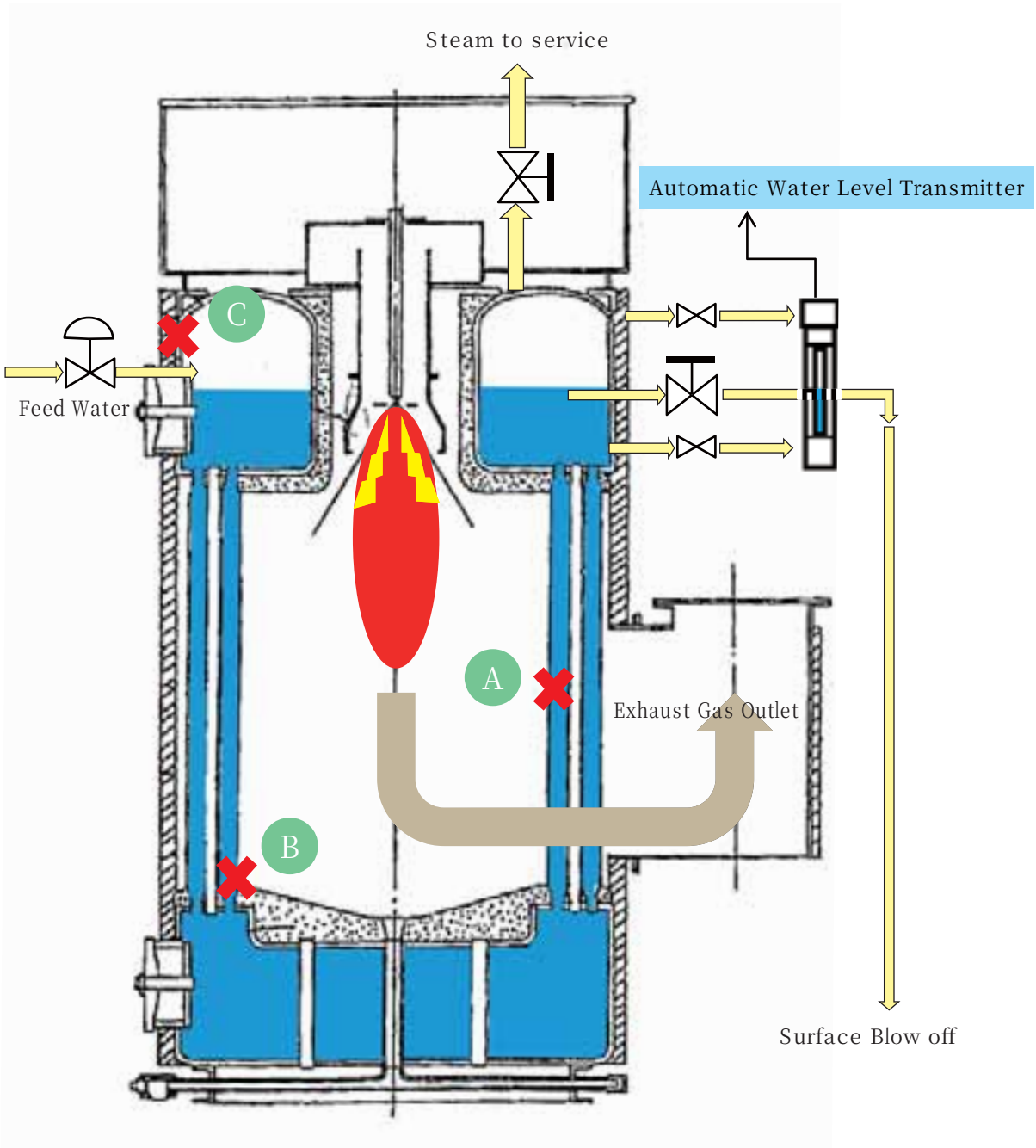


Figure 37　Cross section view of boiler

(4) Cause Analysis - - - Check Point

We set the damaged locations, shown in Figure 37, into three sections based on the assumed cause considered from trouble situation. We will check the important points in the order of A, B, and C.

(4)-1　[Check from the view of Operation Side (Operation management)]

There are several points to be considered on the operations side.

① Location A

In the case of a lack of management of boiler water, it can be considered that thermal conductivity partly declined due to the accumulation of scale in tubes, the tubes over-heated due to the influence, and material strength declined significantly.
As a result of this, the tube was breached and the leak of water occurred. From Figures 38 and 39, it shows about the concern holes in water tubes.

Figure 38 Broken hole due to scales / reference *12

Figure 39 Broken hole due to scales / reference *12

We will explain the example why the scale formation causes the deterioration of material strength. Scaling is easily understood if you imagine white dirt adhering to the inside of kettles and electric pots which we use for boiling water. If thermal conductivity declines due to the adhesion of dirt / scale, and the temperature of water will not meet its required temperature. And then it is boiled for a longer time than before the kettle or similar got dirty. If the degree of dirt is heavy, since excess over heat is necessary, the strength of the metallic material will deteriorate as it is heated more than designed (estimated), and the metal will be holed.

② Location B

The boiler drum and water pipe are connected with the expansion of the tube at the end of the water tube (expanding). From Figure 40 , it shows about the component drawing of the expanding junction. Leakage of water may occur due to the influence of loosening of the same junction, which led to flooding of the bottom of the combustion chamber (furnace).
In addition, the sulphuric acid is created due to the chemical reaction between the leaked water and the sulphur contained in the unburned soot residue accumulated on the side of combustion chamber, and led to sulphuric acid corrosion.

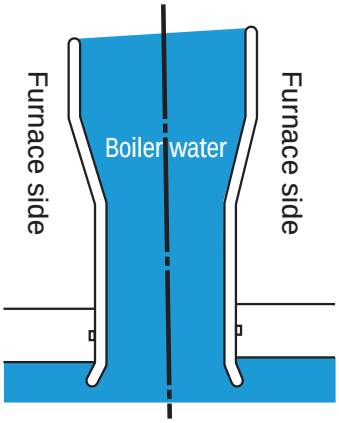


Figure40 Structure of expanding part

(4)-2 [Check from the view of Hardware]

Next, the following are the checkpoints about hardware.

① Location C

It can be considered that the deformation and swelling of the upper drum of the boiler was caused by overheating when the water level in the drum decreased. Safety features such as alarms, fuel shut off, etc., should come into play, based on the automatic detection device of the drum water level transmitter when the water level decreased. However, above mentioned problems will occur if the defects of the water level transmitter are not rectified.

In this way, it can be considered that the cause is not a single incorrect operation or incorrect maintenance. That is, a number of defects overlapping which led to the negative chain (error chain) and the trouble occurred due to a failure of cut-off the error chain.

Negative chain

(5) Preventive measures

It is necessary for crew to understand sufficiently basic operation provided by the boiler manufacturer (operation, management and various inspections and maintenance items), and to implement carefully the inspection, management, and maintenance. These are essential to prevent the boiler troubles. Accordingly, following prevention measures are recommended in this case.

(5)-1 [Preventive Measures from the view of Operation Side (Operation management)]

Since the scale is slightly soluble in water, once it adheres, it is very difficult for crew to clean up.
For prevention of adhesion of scale in tubes, the management of quality of boiler water and feeded water must be done thoroughly.

① Water Quality Management of Boiler Water, Condensed Water and Supplied Water

- It is necessary for crew to maintain the result of chloride ion concentration and all sorts analysis within control limit value which are recommended by the boiler manufacturer for prevention of scale adhesion and corrosion and carry over.
- Boiler water analysis must be conducted once a week at the minimum (once in two days in the case of high pressure boiler)
- And, if necessary, please add chemicals. In the case that boiler water is concentrated, it is necessary for crew to discharge the dirty old boiler water out of the ship with sludge and then supply new boiler water with adjusting the water quality.

② Minimization of Impurities which contaminated from Feed Water (management of makeup water)

- It is necessary for crew to set condition to feed pure water to boiler regularly by cleaning inside of cascade tank. The boiler water should be kept the high temperature and control the dissolved oxygen
- It is necessary for crew to maintain and manage chloride content of water and hardness component of fresh water for feed water to the low level.
- In this case that distilled water from fresh water generator was used as feed water, it is necessary for crew to secure the capacity of storage tank and the cleanness inside the tank and to operate properly fresh water generator and to maintain the accuracy of the chloride meter.

③ Prevention of Sea Water Mixing

- In the case of boiler system equipped with condenser cooled by sea water system, there is a risk that sea water mixes into condensate water system of the feed water. In this case, it is necessary for crew to check the concentration of chloride and contents in the condensate water in a cascade tank rigorously and regularly.
- During blow-off (discharging outside to the ship) of boiler water, it is necessary for crew to pay attention to the operation of the valve.
  For example, it is normal for crew to release the valves operation in the order from high pressure side of boiler to low pressure on the overboard side when starting blowing, and close valves in the order from low pressure on the overboard side to high pressure on the side of boiler when finishing blowing.
  In addition, It is important that crew must pay attention that the boiler mounted valve and overboard valve are

opened fully and flow adjustment is conducted with intermediate valve near the overboard valve. It is because intermediate valve can be replaced directly if there is a defect. However, the replacement of mounted valve and overboard valve are impossible to replace during boiler operation under normal sea service condition. It should be done at Dry Docking.

- The reason to detect contamination of sea water strictly can be understood easily from the view of the importance of monitoring chloride ion as explained above ① .

④ Prevention of Low Temperature Corrosion (sulphate corrosion)

To prevent low temperature corrosion means to prevent sulphate corrosion. it is important for crew to understand its mechanism of occurrence, and to implement a preventive measures to eliminate the cause.
As the mechanism of its occurrence, sulphur contents in combustion gas adheres to the outside surface of the boiler water tube, and it combines with water in the part of low temperature. It becomes sulphuric acid and then corrosion occurs. The following preventive measures are recommendable.

- Crew should clean inside the furnace regularly, and continue to implement removal of combustion soot. Also they carry out the observation and recording the condition inside of furnace area.
- As for supplying excess air during combustion, the production of soot can be controlled if excess air ratio is large. However, as there is a risk of sulphate corrosion occurring if the combustion temperature does not go up and localized low temperature occurs, it is important for crew to control excess air ratios in the proper range in order to obtain good combustion.
- It is necessary for crew to prevent to drop drain into the furnace if the boiler is equipped with steam soot blower. If there is the dropped drain from the soot blower, it reacts with soot and combustion gas, as similar mechanism to the previous location B (Figure 40: structure of expanding part) and the broken hole of sulphate corrosion occurs.

(5)-2 [Preventive Measures from the view of Hardware]

We must avoid the too low water level situation. It is important for crew to monitor the water level carefully all the time in order to keep Normal Water Level properly. Thus, the following preventive measures are recommendable.

1. It is important for crew to implement regular and periodical operational checks of safety detection device, and maintain its safety status. If so, the crew can respond the abnormal situation, such as too low water level, alarms, emergency stop, misfiring detector, etc..

2. It is necessary for crew to inspect the proper working condition of automatic water level transmitter and water level controller, and to adjust the working consistency among them and the equipment on the machine side. For example, we must confirm the indication match between “the automatic water level transmitter (remote water level indicator)” and “the local water level gauges on the machine side”. If you find inconsistency between them and don't adjust them at all, it is impossible to take proper management of the boiler and to take the correct response in case of emergency. For “the automatic water level transmitter” and “water level gauges on the machine side”, if the shut off valves between the transmitter and the steam drum are closed, they do not reflect/indicate correct water level. So it is an essential matter for crew to confirm if the shutoff valves are set correctly in daily walk-around check.

3. We show automatic water level transmitter in Figure 37. Even if the automatic water level transmitter and devices related to the transmitter operate normally, and If the pipe line connected with the upper drum is clogged, it does not reflect the correct water level in the upper drum. Therefore, it is necessary for crew to clean these devices regularly for the automatic water level transmitter to operate correctly and constantly without any blockage in this pipe line.

However, above are important matters seeing at technical aspect.
In addition to these, we must pay attention to the followings;

There are many cases that junior engineer takes in charge of auxiliary machinery because of very simple and clear system such as the boiler.
However, even if the devices are simple such as a boiler, and if once trouble occurs on it, it is important for junior engineers to understand always that the boiler failure affects largely to the cargo work such as this case study.

There have been examples where junior engineers do not give a pay attention about maintenance works as they were preoccupied with machinery handling and operation, and they were so devoted to doing work in front of them. They tend to judge the incorrect priority to their work and then to postpone the important matters. Please be careful that there is a trend of carelessness towards thinking about “how important is their work” and “what is the highest priority work for them” on the ship and all engine department.

As a measure related these potential causes, senior engineers such as C/E&1/E must explain and motivate junior engineers how important the equipment they are in charge. And this will be result into the growth of the junior engineers. Specially, in this case, the insurance money of the cargo shortage was not particularly expensive, however, one defect by the crew will lead to losing the trust relationship between owners and charters, and it will require a long time period to restore this relationship. The senior engineers must keep in mind tenaciously that Junior education is one of the important tasks from above view points.

In this case analysis, it is important of course for crew to understand the technical matters as a basic manner of engineers. However, we would like to emphasize the “importance of motivation in the fundamental part”, why we conduct the inspection and maintenance.

(5)-3 [Reference：Figure and Table of Water Treatment]

“The Major treatment items of boiler water and its purpose” is shown in Figure 41. It is "what items and for what the purposes of management of boiler water are to be managed and treated. “Theory Chart of auxiliary boiler water treatment“ is shown in Figure 42. It is shown what to be inspected and looked at chemical mechanisms. Please use this as a reference for treatment works.

Major treatment items	Main purpose
PH (Alkalinity)	1. To prevent corrosion
	2. To prevent scale adhesion by silica or hardness components
	3. To prevent oil & fat adhesion on heating surface
Phosphate ion concentration	1. To prevent scale adhesion by hardness components
	2. In the case of phosphate treatment, to control Ph in boiler water
Chloride ion concentration (Electric conductivity)	1. To manage boiler water concentration (Indirect management of total dissolved solid)
	2. To prevent carrying over
	3. To detect contaminated sea water
	4. To prevent corrosion
Residual hydrazine	To prevent corrosion
Silica	1. To prevent scales by silica
	2. To prevent carrying over by silica in main boiler

Figure41　Major treatment items of boiler water and its purpose / reference*13

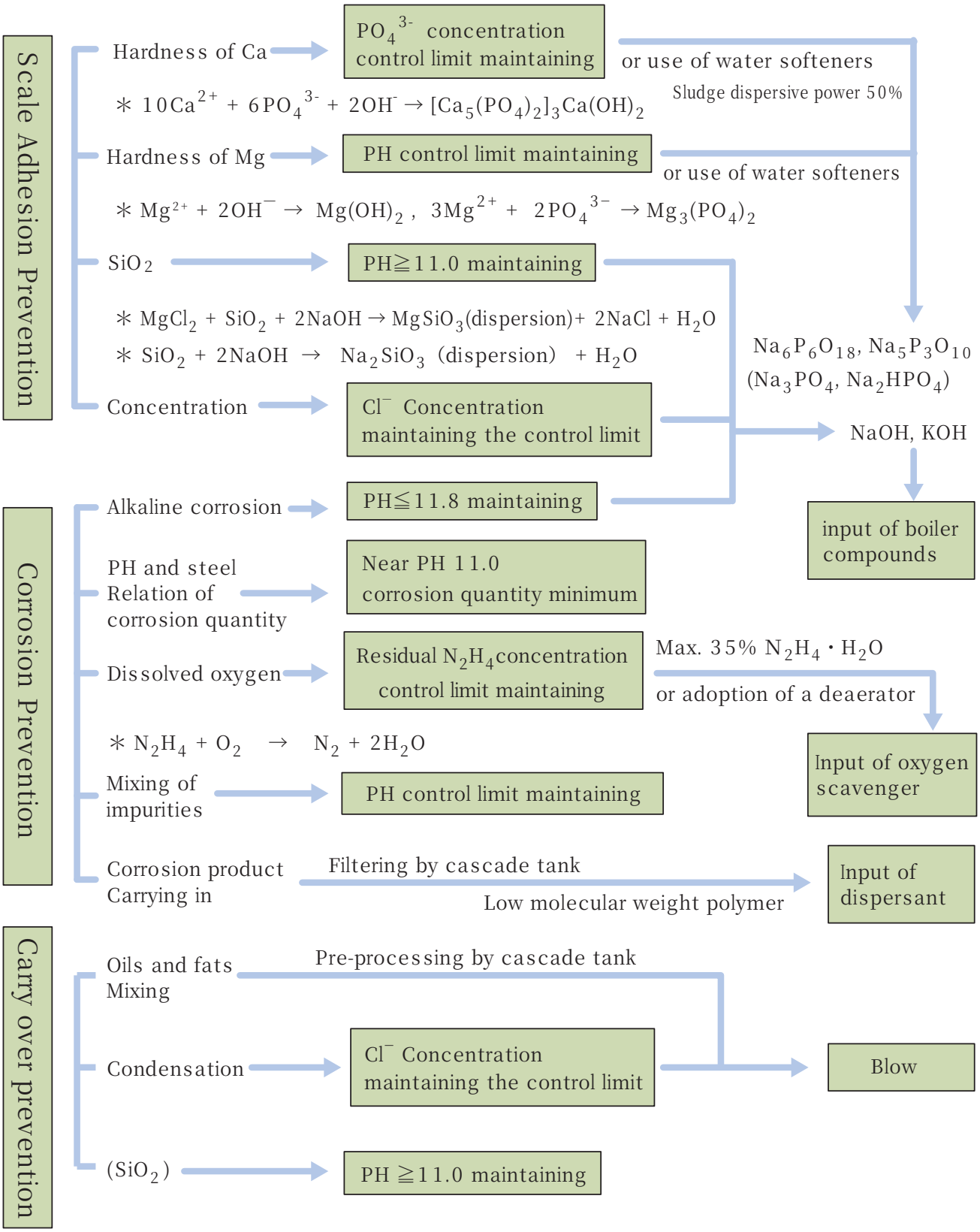


Figure42　Theory Chart of auxiliary boiler water treatment　reference*13

Generally, the status of boiler water is managed by a format such as “Example of boiler water treatment record(monthly) (Figure 43)” (Reference ①).

Please keep in mind that the crew must not leave the water treatment records simply because safety management system instructs these works. It is necessary to share the records as a visible data between ship management staffs and ship’s C/E, and to evaluate the record between engineers in charge and C/E on board. If the status of boiler water deviates to a standard, the engineers should analyse the cause and consider preventive measures effectively.

Boiler Water and Cooling Water Analysis and Cooling Water Treatment Record

M.V. VOY. Chief Engineer:

Date	Boiler Water								Cooling Water						Remarks
	Test Result					Consumed (M.T)	Blow (Tons)	Remarks	Main Engine			Aux Engine			
	PH (PPM)	CL (PPM)	PO4 (PPM)	P-ALK	M-ALK				ppm PH	ppm CL	Supply Quantity m3	ppm PH	ppm CL	Supply Quantity m3	

Figure 43 Example of boiler water control record (monthly)

(5)-4 [Reference Information] Important Points to Prevent Backdraft

We also introduce an additional information as important points when you handle a boiler.

There are cases of the unburned fuel accumulates inside of furnace due to the poor combustion and repetition of an accidental fire. In such a situation, the following troubles may occur.

1. When opening manholes to inspect inside of a furnace, as the backdraft occurs due to the explosive combustion when a large amount of air entered in to the furnace..
2. During re-ignition, the boiler itself exploded, and the crew who are starting the inspection and standing nearby around the burner set place will be died or have serious injured. So we have to send the crew from ship to shore by an emergency transportation

We must give a keen attention to the following points as the backdraft prevention.

- On the operation side, the crew must inspect condition after post-purge inside of furnace manually when an accidental fire happens, and must not repeat the re-ignition automatically. The crew who open the cover of combustion devices must implement this action in a position where they can completely avoid the front cover (dodging).
- On the maintenance side, please carry out inspection and maintenance regularly. Its purpose is that solenoid valves for fuel and burners can work and operate normally and properly without an accidental fire.

2.2.2 Harbour Facilities Claims (Damage to Submarine Cable): Main Engine Start Failure

(1) Outline

After ship departure, engine troubles occurred immediately on the main engine of the ship and she anchored at port area urgently.

When heaving up the anchor after resolving the trouble of the diesel main engine, as shown in Figure 44 and 45, it was found that the anchor was tangled around the submarine cable (transmission line of electric power company). She anchored urgently instructed by the pilot, however, the location was prohibited area for anchoring as shown in Figure 46.

Figure 44 Image figure of submarine cable damage

The anchor chain was cut as shown in Figure 47, and the anchor was removed from a submarine cable by a underwater company.

Still, Maritime Safety Agency did not approve the departure with one side anchor only, and requested installation of new anchor and chains at the repair dock. The shipowner arranged the replacing the anchor and chains as shown in Figure 48 and 49.

Since damage occurred on the submarine cable, the owner of the cable claimed in the total amount of approx. US$140,000 including damage of loss of time (temporary stop of the power) against the shipowners, and finally, this case was settled at approx. US$91,000.

(2) Insurance Money

Settlement amount of claim of a submarine cable	:approx. US$ 91,000
Cost for searching and disposal of an anchor and anchor chain	:approx. US$ 72,000
Lawyers fee	:approx. US$ 30,000
Surveyors fee	:approx. US$ 10,000
Others cost	:approx. US$ 2,000
Total	**:approx. US$ 205,000**

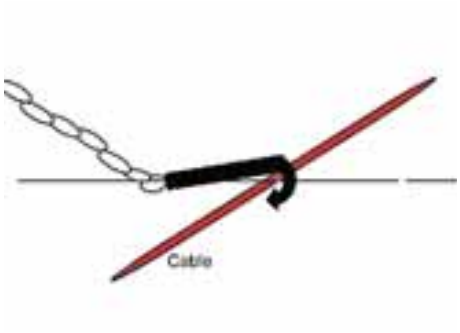


Figure45 Anchor's contacting condition to the cable

Figure 46 Warning sign board for anchorage-forbidden area

Figure 47 Cut Anchor chain

Figure 48 Connecting work of an anchor

Figure49 Functional validation of anchor chain and anchors

(3) What Happened in the Engine Room?

1	The engine department carried out repairing of the main engine while her port staying. So before its port stay, the main engine fuel oil system was switched from HFO to MDO. After completion of maintenance works, the engineers conducted the main engine inspection before departure as usual, and confirmed it in good operation by conducting “Ahead/Astern” for the main engine trial run using MDO. After this, according to the instruction from Bridge, the engine department made the status of the main engine to the standby (hereinafter “S/B”).
2	Then at 15 minutes after S/B, C/E instructed a third engineer (described below as 3/E) to change the setting temperature of the fuel oil heating controller to 90℃. And then, C/E also instructed 3/E to switch the fuel oil from MDO to HFO during leaving port operation under the maneuvering mode of main engine operation. The status of the engine was, as indicated above, S/B status. Since the ship had already departed, the control position of the main engine was on the bridge.
3	After putting S/B engine, there are no engine order during this 15 minutes, then the main engine telegraph was operated at Dead Slow Ahead on the bridge, but it failed to start the main engine. At the time, fuel oil temperature had reached 100℃.
4	After the emergency anchoring, the following work was conducted, and finished the recovery work of the engine. Then it was back to normal service. ● After stopping the fuel oil supply pump and fuel oil circulation pump, and etc., and lowering the temperature of fuel oil system, the heated MDO was discharged from the fuel oil system, and new cool MDO was refilled afresh. ● After that, related auxiliary machinery are re-started and re-operated for engine preparation, and when the main engine was tried to re-start , the crew could confirm it in good operation.

(4) Cause Analysis - - - Check Point

(4)-1 [Check from the view of Operation Side (Operation management)]

In terms of operation, the check points are as follows.

① Instruction of Changing Fuel Oil Temperature Setting to 90℃

The change of temperature setting of fuel oil was carried out on the basis of fuel switching procedure at the time of departure. However, the adjustments based on the status monitoring was not conducted during the operation.

Originally, fuel oil in the system must be adjusted properly depending on the condition, such as transition of consumption, temperature and viscosity of fuel oil. Its purpose is that it can maintain the manufacturer recommended fuel viscosity range at engine inlet.

② Timing of Switching Fuel Oil

It was too long from "changing temperature setting of fuel" to "starting operation of the main engine" because there is an idling S/B duration of No operation of the main engine under the departure ship maneuvering operation.

We will explain the reason why the main engine didn’t work at First Starting Order from the bridge. We will explain in the system review later, however, it was estimated that MDO was vaporised in fuel oil supply pipe, so there were not enough liquid fuel oil for continuous operation in the pipe at first starting order of diesel main engine. That is, the **situation in the pipe was occupied with the mixed oil and gas.**

Essentially, it is important for crew to consider avoiding the incorrect timing of continuous usage of the main engine when changing the fuel oil temperature setting and switching of fuel oil. Before departure, master and C/E must share the information such as timing of continuous usage of the main engine well in advance from the view of the resource management of this ship (Vessel Resource Management). And during S/B, an engine control room must communicate a bridge well. At the same time, the engine department at the engine control room also can intercept the transceiver

communication in the deck department in order to understand the situation by other way.

③ Fuel Pipe System Review on the Basis of Above Estimation

Please refer to Figure 50 “Outline of fuel oil supply system for Main Engine.

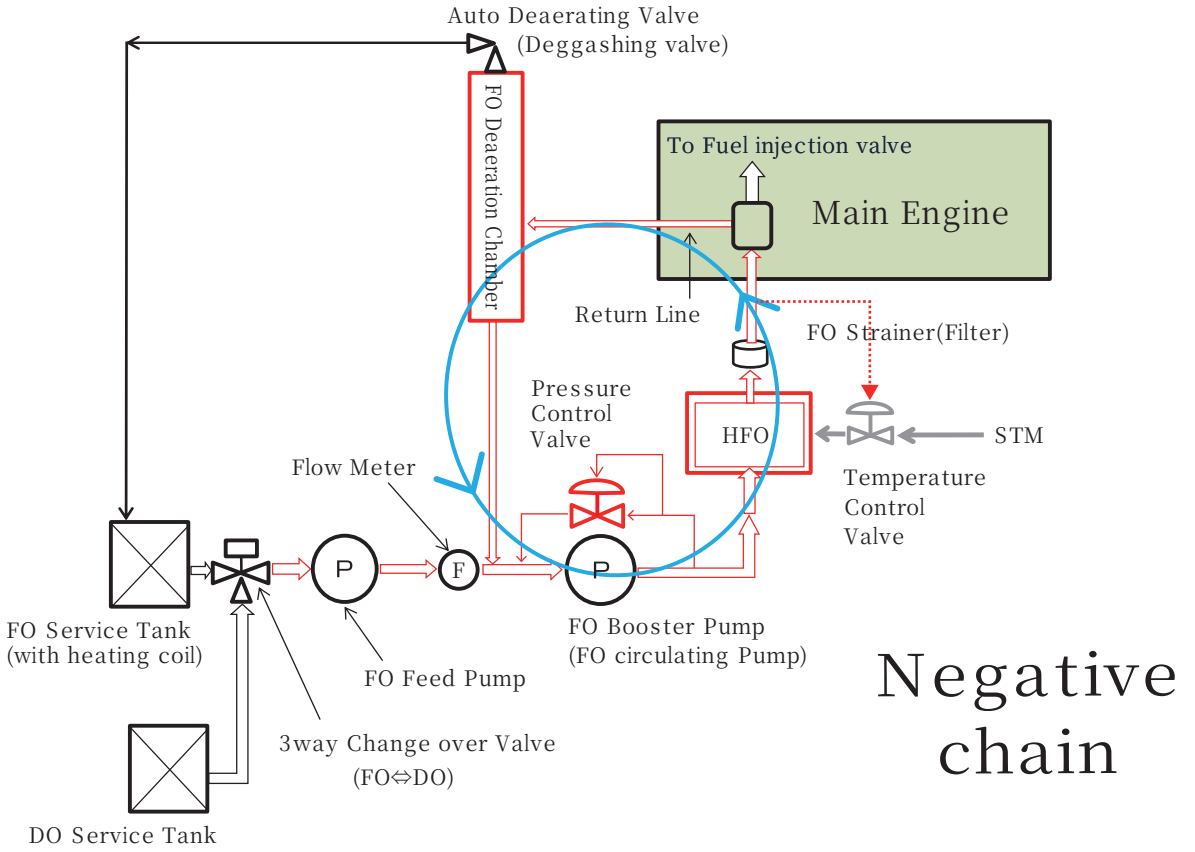


Figure 50　Outline of fuel oiil supply system for Main Engine

- This is a system in which fuel is supplied from left to right and circulates around the main engine.
  HFO is sent from FO Service tank (at left middle) via three-way valve,
  MDO is sent from DO Service tank (at the lower left) via three-way valve,
  to fuel circulation line (in Red with blue circle).
- The fuel is supplied to the main engine from the fuel oil circulation line. Since the fuel oil circulation line loops (in blue circle), unless the fuel oil is consumed in the main engine, the same fuel oil continues to circulate in the pipe line. The amount of required fuel oil by the main engine, which is equivalent to consumed amount, is supplied from the service tank to the loops. The amount is measured and read by working of flow meter.
- In this case, even if switching the three-way valve from MDO to HFO, since the main engine continues to be stopped, there is not consumption of fuel oil, and the HFO is not supplied into the fuel oil circulation line and only the MDO stays and continues to circulate. That is to say, crew try to heat the HFO by increasing the temperature setting to 90°C, however, the only fuel oil heated in circulation line was the MDO.

Eventually, since fuel temperature in circulation line reached 100℃, the vapour lock occurred.

(5) Preventive Measures

In the main diesel engine operation, in the case that you conduct switching from HFO to MDO, the basic for trouble prevention is to understand essential characteristics and features of fuel oil and to understand fully its handling (handling of devices related and fitted on the piping, and state monitoring of pressure, viscosity, temperature, etc.), and dutifully manage and implement them.

Accordingly, the following preventive measures are recommendable in this case.

[Prevention Measures the view of Operation Side (Operation management)]

1. In case that you conduct switching fuel oil from MDO to HFO, at the timing when the engineers can expect the status of continuous operation of the main engine, and please start heating it. Its purpose is that the fuel oil can maintain the manufacturer recommended fuel viscosity range at engine inlet.

2. As for the temperature setting when switching fuel oil, please refer to precaution in the main engine manufacturers instruction manual.
   Example: the speed of heating is less than 1°C per 2 minutes by using viscosity controller on the view of securing safety.

3. When switching the fuel oil from MDO to HFO, please continue to monitor the following state and, in the abnormal case, please take a proper preventive action and response.
   State: Fuel oil temperature, kinetic viscosity, and pressure inside the pipeline, operating state of fuel oil heating valve and supply pump, and etc.

4. The characteristics information of the fuel oil on board is only 1) the Bunker Delivery Note (hereinafter "BDN") delivered by bunker supplier when bunkering and 2) analysis result of sample which took during the bunkering on a voluntary basis. The fuel status in the main engine fuel oil supply systems is different from the above.

   For that reason, it is considered to be difficult to understand the quality of current fuel oil. However, if there is only 1 litre of sample fuel oil on the ship, you can confirm it by commercially available handy oil tester, "float type density meter (Figure 51)","kinetic viscometer using shear force meter (Figure 52)", and "water content meter using the principle of chemical reaction (Figure 53)". Then the ship engineer can grasp and understand characteristics in the fuel oil supply system by sampling fuel before engine regularly.

Figure 51　Density meter / reference*14

Figure 52　Viscometer reference*14

Figure 53　Water content meter /reference*14

5	Please estimate the state of fuel oil by referring to technical data as shown in Figure 54 “Estimated viscosity when mixing HFO and MDO”, and Figure 55 “Relationship between Temperature and Viscosity for Marine Fuels.” For example, about mixed fuel oil in system, since oil amount (X litre) in the fuel circulation line as shown in Figure 50 is calculated by the diameter and length of pipe, if HFO comes to be mixed with MDO in circulation line, the coming fuel amount can be considered as reading amount (Y litre) at flow meter. As the result, we can estimate the viscosity of mixed fuel in system by the ratios of X: (X-Y). In the rough consideration, if the oil amount of fuel oil circulation line equals the reading amount at flow meter (X=Y), the fuel oil in the circulation line may be considered to be replaced completely. Moreover, If we can estimate the viscosity of mixed fuel oil state under continuous use of fuel oil, the proper heating temperature corresponding with that can be estimated
6	Mechanism of Vapour lock. (End of Book: Reference Information (3)Marine Fuel Oil) The occurrence of vapour lock is caused by evaporating the low boiling point fraction in fuel oil and evaporation the water in the fuel oil. In the fuel system of pressurized circulation system like this system, because of the saturated steam temperature going up (the boiling point in high pressure) , vapour lock rarely occurs. However, it is important for crew to check the activation of the degassing valve of the deaeration chamber (auto deaeration valve). Even so, if the valve activation has malfunction, HFO or MDO are likely to cause the vapour lock because HFO/MDO also contain a few amount of volatile components and moisture. So, we still need to pay a careful attention to the valve activation.

(6) Usage Instructions：Example

In order to decrease the viscosity of HFO from 380 mm ^{2}/s (cSt) @50℃ to 60 mm ^{2}/s (cSt), What % (mass) of MDO 10 mm ^{2}/s (cSt) @40℃ as a dilution needs to be mixed? Please refer to Figure 54.

(1) On left side as HFO

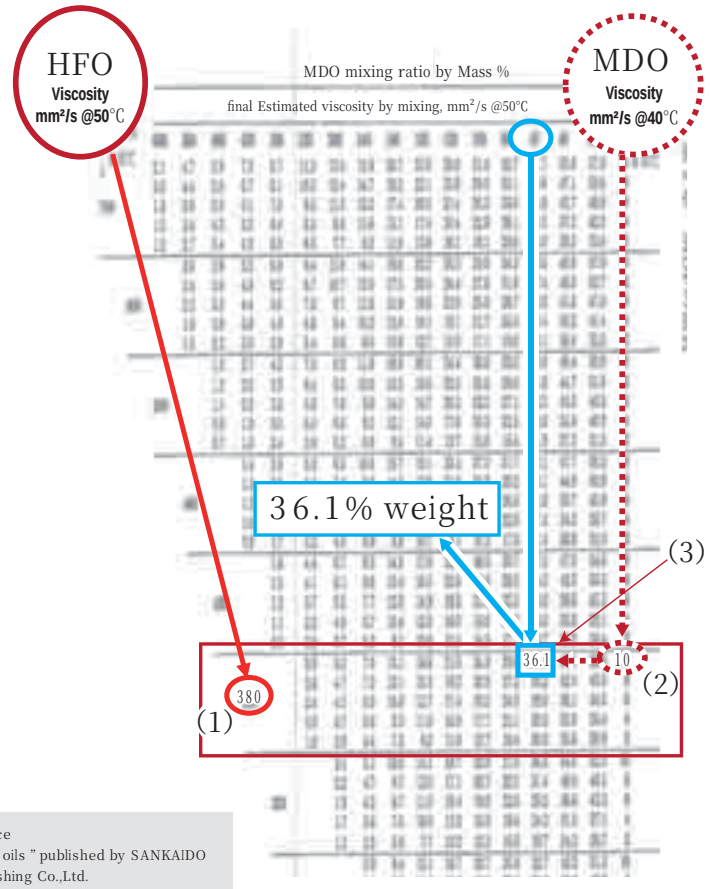
Please search area for 380 mm^2/s (cSt) 50 ℃, showing (1) by red solid line

(2) On right side as MDO

Please search area for 10 mm^2/s (cSt) @40℃ crossing with above (1) showing (2) by red dashed line

(3) On top column as final blended fuel viscosity

Please search 60 mm ^{2}/s (cSt) @50℃ crossing with above (2) Then you can find 36.1.showing (3) by blue line It is the read required mass%
(mixed amount of MDO).



Source
“ Fuel oils ” published by SANKAIDO publishing Co.,Ltd.
Nobuyuki Awai /Osamu Hanashima/Saiji Yokosawa [authors]

Figure 54 Estimated viscosity when mixing HFO and MDO /reference*15 (Reference ②)

(4) On the other hand, if HFO 380mm^2/s (cST) @50℃ is mixed with 36.1% mass of MDO 10mm^2/s (cST) @ 40℃, TFO (Thin Fuel Oil) 60mm^2/s (cST)@50℃ can be made.

From Figure 55, it is shown that the relationship between temperature on the horizontal axis and viscosity on the vertical axis for Marine Fuels appears also in the engine manufacturer instruction manual. (For the bigger chart, please refer to Reference ③)

Please draw the horizontal line with the target viscosity from the vertical axis by meeting the curb, then draw the vertical line from the crossing point of the curb to the horizontal axis , you will find the target temperature at horizontal axis.

The following explanation is based on 60 mm^2/s (cSt) which is the result from Figure 54. 60 mm^2/s (cSt) is a red curved line with No.4. If the target fuel viscosity of TFO 60 mm^2/s (cSt) is 15 mm^2/s (cSt), the temperature can be found as 90℃ by drawing a purple line.

Therefore, in this trouble case, if the viscosity in the system is 60 mm^2/s (cSt), and if the situation is a continuous fuel usage, it can be presumed that the setting temperature was not too excessive.

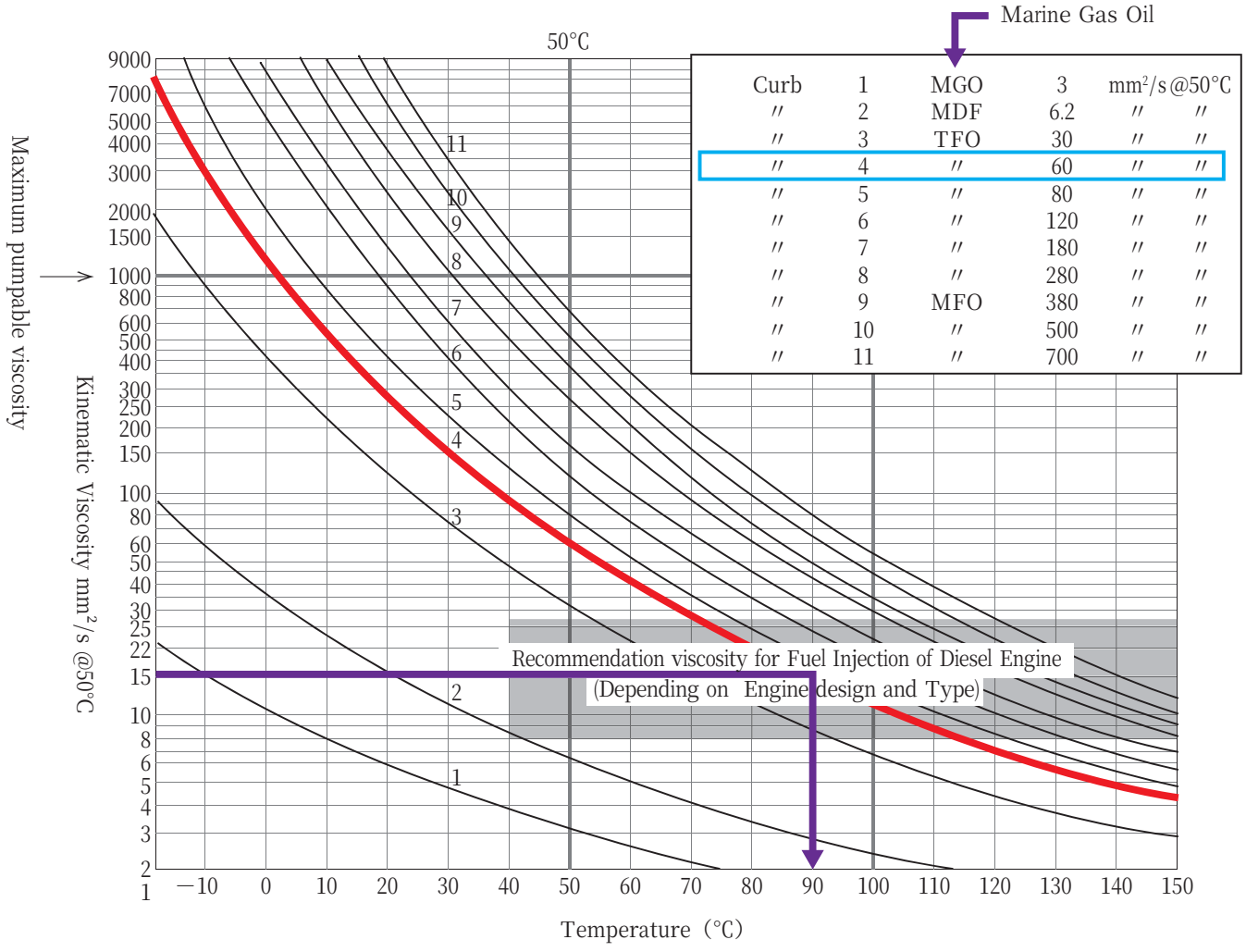


Figure 55 Diagram of viscosity/temperature of marine fuel /reference*15 (Reference ③)

2.2.3 Cargo Claims: Unable to Re-start Generators (Blackout)

(1) Outline

The vessel loaded approx. 2,100 containers, including 23 reefer containers, in the Far East. The power failure (hereinafter "blackout") occurred at the point of approx. 900 miles to the west of Los Angeles while heading for Panama.

The crews tried to re-start generators but failed to do so. A rescue company was to tow the vessel to Los Angeles. The ship must wait for the black out power recovery for 21 days. Moreover, the fact that the reefer containers loading foods and etc. were unable to get power supply brought about cargo damage after the blackout occurred.

Many of the reefer containers became the total loss. The cargo interests claimed the cargo damage which was equivalent 16 containers in the amount of approx. US$1.6 million against shipowners. Finally, this claim settled at US$645,000.

(2) Insurance Money

Settlement Amount of Cargo Claim	: approx. US$ 645,000
Lawyers fees	: approx. US$ 200,000
Surveyors fees	: approx. US$ 35,000
Total	**: approx.US$ 880,000**

(3) What Happened in the Engine Room?

1 **The Situation of Generators Operation**
The vessel had four generators (hereinafter referred to as GE). During navigating, No.3 GE and No.4 GE were operated in parallel, and HFO was used as fuel oil.
Stand-by GE (hereinafter “S/B”) had HFO circulation status; No1. GE was to be the first S/B and No.2 GE was to be the second S/B.

2 **The Emergency Stop of No.4 GE**
No.4 GE emergently stopped.
No.1 GE and No.2 GE, which were in S/B status, were to be started automatically, but they could not start them.

3 **The Close Failure for the Air Circuit-breaker of No.1 GE**
Crews manually started No.1 GE at once.
However, they failed to close the air circuit-breaker (hereinafter “ACB”).

4 **The Emergency Stop of No.3 GE**
Afterwards, No.3 GE also emergently stopped.
In addition, 1 minute later, No.1 GE immediately stopped as well.

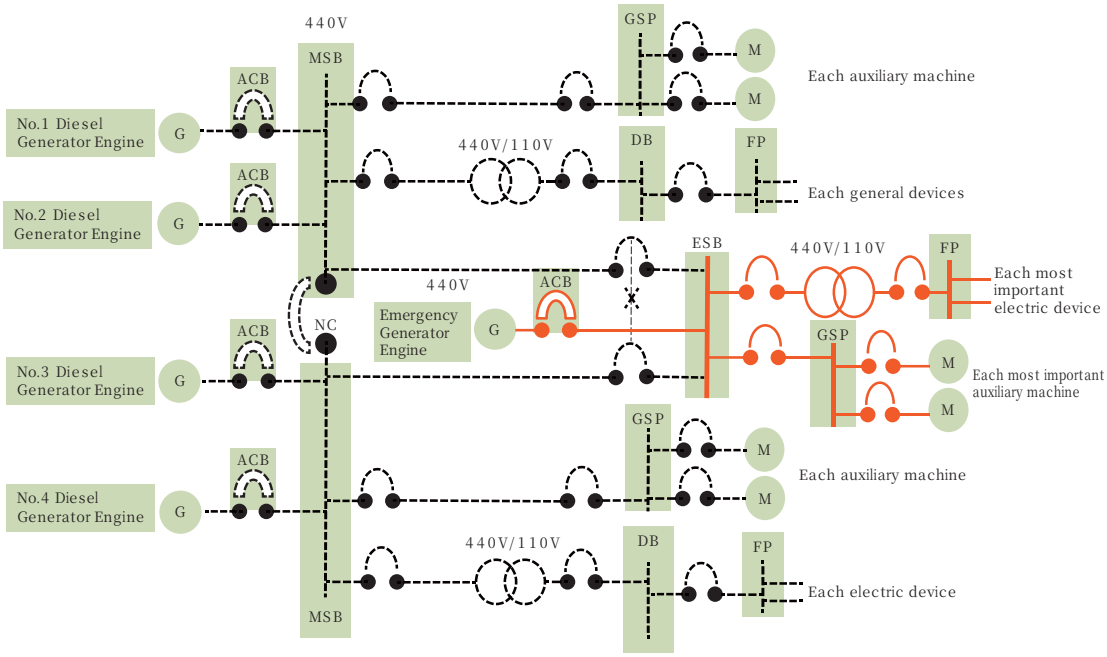
5 **Strainer Inspection**
In order to find out the cause, they checked oil strainer of fuel supply pipeline, but the abnormality was not found.

6

After No.4 GE had Stopped, an Emergency Generator Started Automatically.

As “Outline of power supply system” (Figure 56) shows, after No.4 GE had stopped, power was not supplied from the generators connected with the buses of black dotted main power lines. Then the Emergency Generator started automatically. The power from the emergency generator was exclusively supplied to the equipment, listed below, connected with the red solid lines.

Lighting equipment, steering gear, navigational equipment such as gyro compass and radar, emergency fire pump, battery charger, other small capacity machinery via jumper connection



Color

Black :Main Power Supply

Red :Emergency Power Supply

The most important devices and auxiliary machines of feeding from emergency generators Lighting, steering gear, emergency fire pump, navigation equipment (gyro compass, radar and others), battery charger, other small capacity machinery via jumper connection

Abbreviation	Description
ACB	Air Circuit Breaker
MSB	Main Switch Board
ESB	Emergency Switch Board

Abbreviation	Description
GSP	Group Starter Panel
DB	Distribution Board
FP	Power Supply Feeder Panel

Abbreviation	Description
NC	Normal Connection
M	Motor & Auxiliary Machine
G	Generator

Figure 56 Outline of power supply system

7

Stop the Fuel Oil Circulating Pump and the Boiler

As the result of the blackout caused by the stop of generators, both generator fuel oil circulating pump (GE FO Circ. Pump), and the boiler were stopped. It became impossible to supply heating steam for high viscosity HFO. Therefore, they switched the fuel oil for generators from HFO to MDO

8

The Shortage of Starting Air

After re-starting No.1 GE over and over again, the pressure of air reservoir dropped to 10 bar, which caused the lack of air pressure, and it became impossible to re-start the generators.

9

Accumulate the Pressure of Emergency Air Reservoir by Emergency Manual Air Compressor

Crew operated the emergency manual air compressor by themselves, and accumulated the pressure of emergency air reservoir, but they still could not re-start the generators.

10

Start Towing

8 days later the ocean tug arrived, and they started towing.

11

Arrange Power Pack

It was predicted that they would be unable to re-start the generators for a long period, therefore, the ship arranged power pack (large transportable generator) .

12	11 Days Later, the Tug Loading the Power Pack Arrived.	11 days later of starting towing, the Tug supplied the power pack.
13	Plant Up	On the same day, the plant up was completed, and the ship resumed the navigation heading to the destination. **(Blackout for about 21 days)**
14	Arrival at Destination	2.5 days later of plant up, the ship arrived at the destination and completed unloading.
15	Safety Notice	A few days later, a ship management company reviewed the safety notice as a countermeasure for the incident.

(4) Cause Analysis - - - Check Point

About operation and safety, the check points are as follows.

(4)-1 [Check from the view of Operation Side (Operation management)]

① Why Could No.1 GE and No.2 GE Not Be Started?

- The starting air valve was still closed, thus the starting air was not supplied and could not start automatically. Please refer to "Outline of Fuel oil and Starting air system for diesel generator engine " (Figure 57).
- The engineer in charge (3/E) did not follow work instructions and operated with the starting air valve closed. However he followed work instructions from another ship, **[Breach of work instructions]**.
  (Of course, the starting air valve should be closed for safety at engine maintenance work. However, if it is not opened in S/B, it cannot be started automatically.)

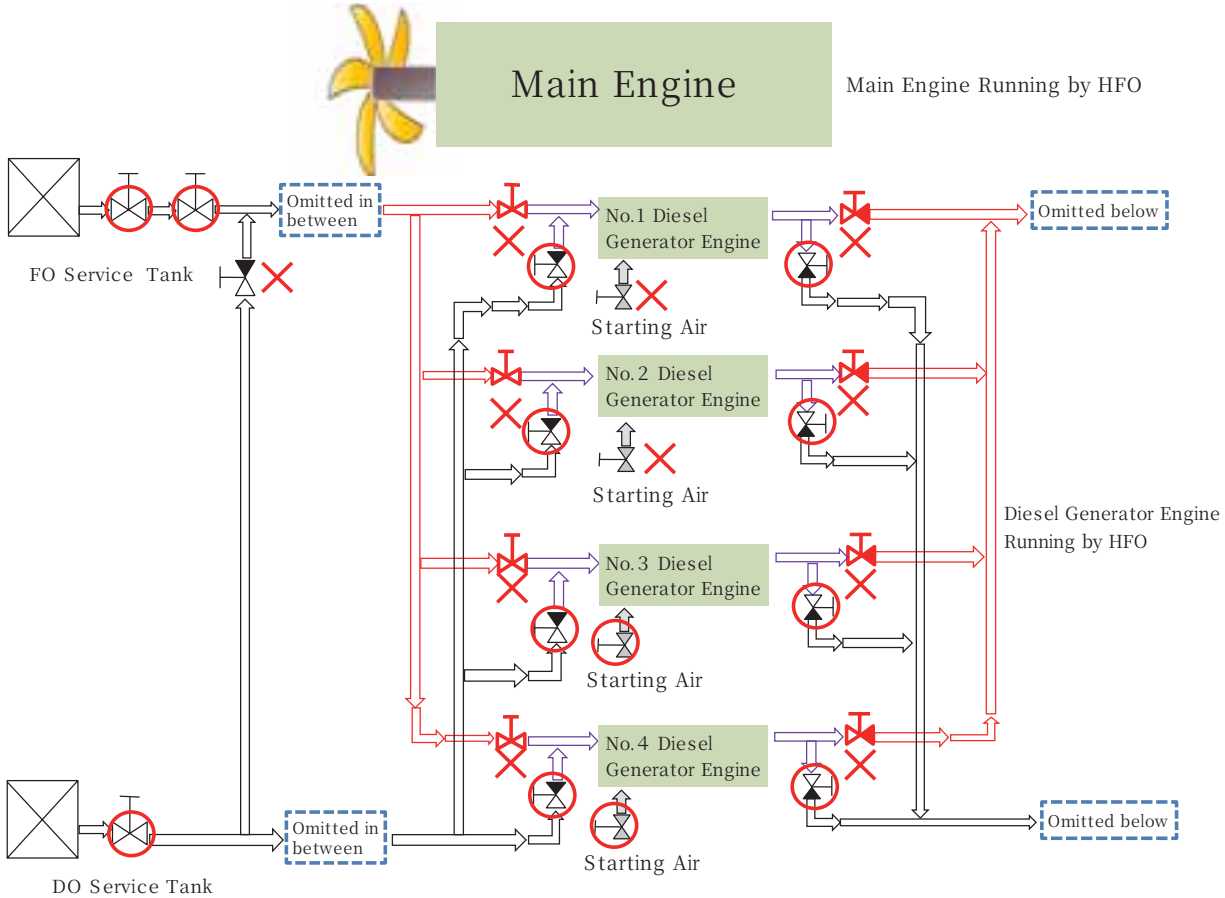


Figure 57 Outline of Fuel oil and Starting air system for Diesel Generator Engine

② Why Did Crews Fail to Re-start the Generators Over and Over Again?

- Crew repeated re-starting without finding the cause of the starting failure for the generators,
- After the blackout, the HFO heating steam could not be supplied from the boiler, and the fluidity of HFO in the pipeline for generator fuel supply became low. As the result, the fuel oil supply pipeline was clogged.
- In other words, the crew made incorrect procedure of the changing fuel oil for the generator from HFO to MDO.

③ Why Did the Air Reservoir Become Empty?

- According to the work instructions, during a normal voyage, there are two delivery valves fitted on the air reservoirs, and only one should be opened and the other should be closed to be used for preparation. However, both of them were left open when the accident occurred. **[Breach of work instructions]**
- Since the crew repeated the re-starting operation with opening the delivery valves of both two air reservoirs, the pressure of the two air reservoirs are lost at the same time.

(4)-2 [Check from the view of Safety Instruction and Safety Notice]

① Why Could No.1 GE and No.2 GE Not be Started?

- The engineer in charge (3/E) did not follow the work instructions, and the starting air valve of the S/B generator was still closed. **[Breach of work instructions]**

② Why Did They Fail to Re-start the Generators Over and Over Again?

- Crew did not understand the recovery procedure from the cold condition of engine system. (Blackout recovery drill was not carried out)

③ Was the Safety Notice Issued by the Ship Management Company Later Appropriate?

- The safety notice was just warning against trouble due to close of starting air valve on S/B generator. There was no further instruction or reminder of the preventive measures based on root cause analysis.

Next, the following are the check points about the hardware.

(4)-2 [Check from the view of Hardware]

(4)-2-1 Maintenance System Management

① Maintenance System of Generators

- We focus on the generator's operating record, which is the relation between output and load indicator figure. At the trial operation before the ship delivery, the engine rated output 1,470kW and load indicator 8.6. But, the measurement record during a year before this incident was shown output 500kW, which was approx. 30% output, and load indicator to reach 10,
- Moreover, in the process of investigation, worn-down plungers (parts for fuel pressurisation) were found when they opened and inspect the fuel injection pump of No.1 GE after this incident.

② Why Could Crew Not closed ACB?

- Generally, ACB's closed condition requires the establishment of generator engine speed, voltage and frequency. When these conditions are satisfied, ACB's closed signal will transmit.

- However, as we mentioned above ① , inadequate maintenance of generator engine lead to unstable running. It is likely that the ACB control system was detected generator engine start failure, and the ACB closed signal was not transmitted.

③ Why Did it Take Long to Accumulate the Pressure of the Emergency Air Reservoir?

- It took for 18 hours to accumulate the pressure with the emergency manual air compressor for 0.6m^2 capacities of emergency air reservoir, but again they failed to start the generator.
- It took too long time to accumulate the pressure because the performance of the emergency manual air compressor, which was designed to fill up the emergency air reservoir, was deteriorated. The fact that crew did not carry out the maintenance or operation tests, assuming the case of emergencies and shortages of shipboard spare parts, caused this problem.
- While accumulating the pressure, it is likely that the temperature of the generator engine became low (cold), which became more difficult to start.

(4)-2-2 Design

① Were There Any Problems With the Design?

According to the International Convention for the Safety of Life at Sea (hereinafter “SOLAS”), the chapter II-1 regulation 41 1.4 stipulates the system which can be started in under cold conditions (dead ship).

About fuel, as “Generators, The Yellow Line on “Outline of fuel oil supply system for Diesel Generator Engine (Figure 58)” shows, if you operate only the valve connected with the MDO service tank, the fuel oil could be supplied with gravity to the point just before the fuel supply pump directly driven by the diesel generator engine. Therefore, if the starting air is supplied into the generator, and then engine can be run, because the direct driven fuel supply pump will be driven. Then fuel will be led into the fuel injection pump, fuel will be injected into the cylinder by cam drive.

About the starting air, compressed air will be filled in the emergency air reservoir by the emergency manual air compressor.

Therefore, this system is the one which can start the diesel generator engine under cold conditions, and meets the requirements of the SOLAS.

Then, Why could they not re-start even if there were met the requirements? Following are the possible causes.

② Why Did it Take Long to Accumulate the Pressure Emergency Air Reservoir of the Generator?

- It can say that the spare parts of the shipboard for the usage of emergency equipment were not good enough.

③ Why Was the Power Pack arranged?

- There is no electric wiring to connect the power supply from the emergency generator to the air compressor. So, in order to establishing the compressor’s operation, there is no choice to depend on another power source. Similarly, there is no electric wiring to connect from the emergency generator to the fuel oil supply pump or the fuel oil circulating pump of diesel generator engine.

Negative chain

Therefore, it can be considered that it was not a single cause that brought about the long-term blackout accident, but an error chain coming from several causes.

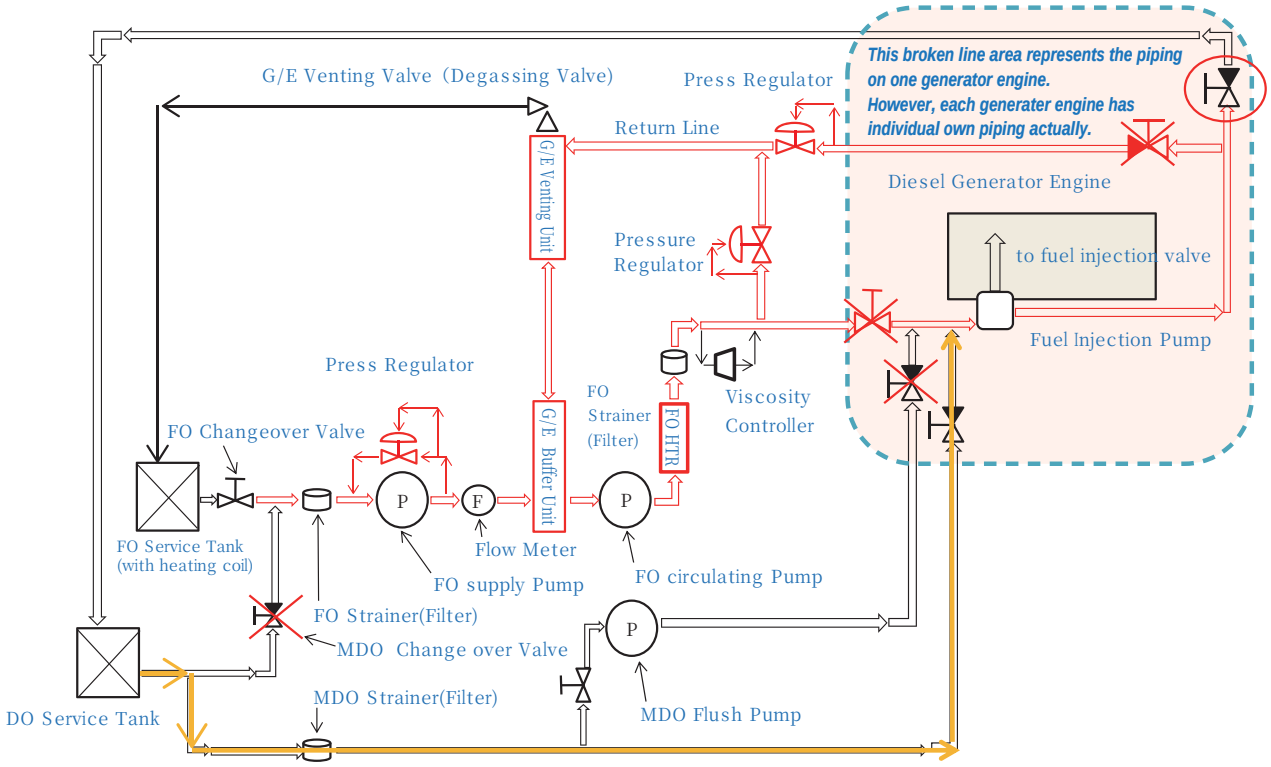


Figure 58 Outline of fuel oil supply system for Diesel Generator Engine

(5) Preventive Measures

As it was confirmed information about the trouble of this blackout, several points to be noted such as operation, safety instruction, safety notice, and hardware were recognised. Based on these, the following preventive measures should be considered.

(5)-1 [Measures from the view of Operation]

① Before Stoppage Generator engine, Switch the Supply Fuel Oil to MDO.

The blackouts will occur due to unexpected causes. Even if it cannot be avoided, it is necessary for crew to establish the structure to re-start and restore the generator engine as an emergency response, under any circumstances. Therefore, about the generator in S/B, it is desirable that they should switch the fuel oil from HFO to MDO before stopping. Its purpose is that the stopped generator can re-start even if the fuel oil can't be heated.

So, if switching the fuel oil of stopped generator engine to MDO, the generator shall be capable of providing the electrical services from a cold condition stipulated by the SOLAS, Chapter II-1 regulation 41. The safety level is upgraded.

(a) Rigid enforcement of switching the fuel oil to MDO

When the generator is stopped, please switch the fuel oil from HFO to MDO while a load of the generator is still enough.

When starting the generator, please switch the fuel oil from MDO to HFO after in a stable load operation.

(b) It is necessary for shipowners to make an agreement with charterers.

- The fuel cost will be paid by the charterers. So it is important for shipowners and charterers to understand the necessity of MDO usage and cost allocation. The safety environment can be upgraded.

- For example, the MDO consumption will be increased approx. Q = 0.6 Mt of monthly under the following condition. Even if MDO is US$1,000 per Mt (metric tons), security levels will be upgraded greatly and precisely by approx. US$600.

  The conditions are as follows:

  The number of starting and stopping the generator is 20 times in a month (stop: 10 times, start: 10 times).

  The MDO is consumed during 15 minutes before stop load sharing, 15 minutes after starting and parallel operation (if the load is 500 kW). The average fuel consumption rate of generator is 220 g/kWh.

  The MDO's consumption amount will be as follows;

  Monthly Fuel Consumption (Q Mt/month)
  = 220 g/kWh × load 500 kW × (15 minutes/time × 20 times/month)
  = 220 g/kWh × load 500 kW × 5 Hr/month
  = 0.6 Mt/month

  We recommend you to check the operation method or performance level of equipment installed on the each vessel again in order to conduct the simulation calculations precisely.

② Establish the Feasible Fuel Switching Instructions Firmly

- As explained in the case of 2.2.2 Harbour Facilities Claims, it is important for crew to establish the switching instructions firmly. At the same time, please understand the essential characteristics and features of each fuel oil type.

  For example, in case that intense pressure fluctuation occurs in the fuel supply pipeline during the switching operation, the gas may be generated in the line. It should remove the gas from a higher place in the line as much as possible. Its location is the air vent pipe of strainer or that of the fuel oil heater.

③ Understand Fuel Oil Characteristics and Manage Adequately

- The fuel oil quality of the vessel was indicated on BDN delivered by the fuel oil supplier. However, there are some cases that the received fuel oil from several ports or supplier, which have different fuel oil characteristics, which is different from the state in the line or in the settling tank. Crew should understand that the characteristics is not always the same.
- Therefore, it is important for crew to understand the fuel oil used in the vessel and analyse by using commercially available handy oil testers, shown from Figure 51 to 53. Its purpose is that it can examine at the site how to deal with it.

④ Manage Engine Operation Thoroughly to Meet Operation Status

- The status of the engine plant will be different in each situation: the navigation, anchorage, and entering & departure of the port. So, you should manage the engine operation appropriately in each situation.
- While S/B of entering or departure, the following equipment are operated. The electric consumption during S/B is more than that during the navigation. So during S/B, the multiple generator operation is required as below.

  Engine Department:
  - Auxiliary Blower used in main engine

  Deck Department:
  - The Multiple Operation of Steering Gear Drive Equipment for the Improvement of control effectiveness
  - Mooring Arrangement (including Anchor Windlass),
  - Bow Thruster

  On the other hand, during navigation, number of generator is minimum.

- For example, two generators were 30% of load. However, if the generator is fully maintained, one generator can manage enough with 60% of load. If you operate more generators than minimum, you should be careful because you must carry out more maintenance work.

⑤ Rigid Enforcement of Daily Check of S/B Generator and Correction of the Defect

- C/E and 1/E also should do the following things as routine works:

> (a) to check the engine room regularly,
>
> (b) to understand the situation of S/B generator, and
>
> (c) to check if the S/B generator is in a situation that can start automatically in an emergency.
>
> In the case if abnormality is found, please correct it immediately and understand that it is important for all members of the engine department to share the information.

- On the other hand, about the important valves which are conducted the following switching operations, it is important to put and arrange the sign plate. Its purpose is that it can recognise the situation (open and close) and easily detect the abnormality, starting air inlet valve, air reservoir discharge valve, the change-over valve of fuel supply pipeline, the air vent pipe of oil strainer and etc

(5)-2 [Measures from the view of Safety Instruction or Safety Notice]

① Don't breach Work Instructions (including the elements of safety instructions)

- At the site, crew handle the engine operations based on the work instructions for maintenance or operation. Crew will get the maximum effect from the instructions if they fully understand the following points,.

> (a)The meaning of each procedure described in the work instructions.
>
> (b)The relationship between pipeline and equipment actuation

- It is important for crew to make an effort to read between the lines of each work instructions during on-board training or study sessions on board. For example, crew should learn what problem will be occurred in the pipeline by switching from HFO to MDO.
- If the work instructions do not fit for the truth, crew should consider the procedure to amend them with the reasonable verification. (Crew should not allow the shortcuts with the work instructions!)

② Carry Out Blackout Recovery Drill Regularly

- About the plant-up from a cold condition of engine plant, its opportunity is limited only in the dry dock which is once every from 2.5 to 3 years.
  Even if crew make a few mistakes during restoring the procedure in the dock, it is possible to restore even if crew take time, except for a fire or an explosion.
- Therefore, the crew, who don’t have work experience in the dock, sometimes fail to understand the recovery procedure of the power supply system precisely.
- So, it is one of the options that crew carry out the blackout recovery by meaning of both the on-board training and the equipment work test during normal navigation.
- There are some methods of the blackout recovery drill. One is to carry out drill by actually stopping the generators emergently. The other is to confirm and follow the recovery procedure by finger pointing & calling with allocating crew.
- However, in the case of actually executing a blackout, it takes time to restore and may affect the vessel’s schedule. So shipowners is recommended to obtain the charterers’ permission just in case in advance.

③ For Preventive measures, Include Lessons Learned Based on the Root Cause Analysis in the Safety Notice

- The importance of safety notices based on the lessons learned have the purpose to confirm the facts firmly, clarify causes, and prevent the recurrence of similar troubles as well as finding out the superficial direct cause. The Management Company and shipowners should also immediately issue the effective safety notice by considering following matter,

  (a) to analyse about the background of the root cause with getting support from the manufacturer.
  (b) to clarify and share the preventive measures

- The ship management company may sometimes cause crew misunderstanding that they find the person responsible when confirming the facts of trouble
  However, it is important for the company to collect the truth as much as possible with following pose

  (a) first to clarify the purpose to establish preventive measures
  (b) then to get the crew's maximum cooperation
  (c) finally to find out the root cause

(5)-3 [Measures from the view of Hardware]

① Rigid Periodic Maintenance of Generator (including equipment for emergency)

- It is basic for crew to follow the manufacturers' instruction manual and to conduct the inspection and maintenance work regularly. Moreover, manufacturers give the updated service news which is the safety guide about how to maintain or deal with equipment, based on their lessons learned. Therefore, it is also necessary for the ship management company both to make efforts to collect the updated information from the manufacturer, and to establish the regime in which shore and ship are united.
- Moreover, at this time, the emergency manual air compressor become deteriorated and then it interfered in early recovery. In order to use the emergency equipment precisely in any case as well as recovery drill described in above, crew should conduct the inspection and maintenance work of them. Its purpose is that the equipment will be operated as designed. It is also important to appropriately check spare parts, which have the risk of deteriorating. If any of spare parts are no longer supplied, you should also arrange alternative spare parts for back-up.

(5)-4 [Recommendation] Consider the Architectural Design, from the Emergency Generator to the Equipment That Can Get Power Supply

1. As the SOLAS, chapter II-1 regulation 41 1.4 indicates, the power generating equipment should have a system "to be able to start under cold conditions". Therefore, if it can supply MDO with gravity and fill the starting air reservoir by using the emergency manual air compressor, it meets the requirements surely.
2. There was the fact that all the fuel oil pipelines were switched from HFO to MDO. However, at this time, in order to restore the power, crew had to wait for the main air reservoir to be filled by the air compressor whose power was supplied by the power pack. The power pack was transported by the tug from shore.
3. Therefore, emergency manual air compressor meets minimal required specifications. However, as you understand this case, if crew forget to make its appropriate maintenance, it is vulnerable in the case of an emergency.
4. On the other hand, during that time, the power supply to the emergency power system in the ship was maintained by the normal operation of emergency generator.
5. Therefore, it is one idea that you can put the air compressor with the direct driving of the handy diesel engine, or put one that operates off another power source other than the main power, such as the power supply from the emergency generator, on emergency air reservoir.
6. Similarly, it is also the idea that you put the air compressor, which makes handy diesel engine's driving possible, or makes power supply and driving from the emergency generator possible, on the regular air reservoir.

2.2.4 Environmental Claims: Incomplete Combustion of the Boiler

(1) Outline

After the vessel arrived at the terminal, during unloading cargo operations, the black smoke with soot came out from funnel due to the boiler's defect. It had continued for 20 or 30 minutes (Figure 59). As a result, the soot scattered widely (Figure 60) and accumulated to the ocean, terminal, and some factories being located near the terminal (Figure 61, 62, and 63).

Figure 59 Black smoke

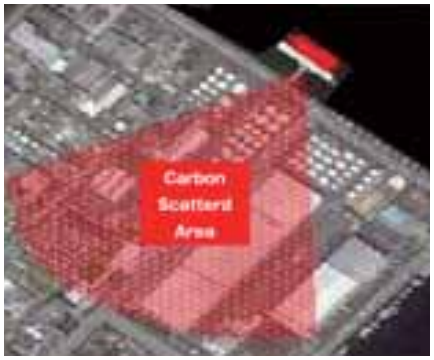


Figure 60 Scattering range of black smoke (550 m)

Figure 61 Cleaning up removed soot (inside bucket)

Figure 62 Soot on working passage of factory

Figure 63 Soot on working passage inside factory

The shipowners arranged clean-up work immediately and it took for 3 days to complete.

The terminal claimed their clean-up cost as the damage such as loss of time (including stop of factory production line) in the total sum of US$252,000 against the shipowners . Finally, this case settled at approx. US$170,000.

(2) Insurance Money

The Settlement Amount of Terminal Clam	: approx. US$ 170,000
Clean-up cost	: approx. US$ 30,000
Lawyers fees	: approx. US$ 30,000
Surveyors fees	: approx. US$ 9,600
Total	**: approx. US$ 239,600**

(3) What Happened in the Engine Room?

If the black smoke comes from the boiler to heat HFO used in the diesel generator and if it is difficult for crew to find the causes while operating the boiler, the generator's fuel oil should be changed from HFO to MDO. It is because MDO is not necessary to heat to use.
You can stop the boiler in order to find out causes of black smoke by taking time.

Check points for the black smoke are as follows.

1. Was the supply of combustion air appropriate?
2. Was the fuel's temperature appropriate?
3. Was the unburnt fuel adhered to combustion nozzle?
4. Were the type or the size of the fuel atomizing nozzle precise?

However, even if the points above are appropriate, the troubles often are occurred caused by the following.

5. If burner nozzle's bore diameter is larger than the standard and if the atomisation after fuel atomizing is not enough, it will lead to incomplete combustion.
6. If the operating position for combustion air supply control unit is not adjusted precisely, the combustion air supply will become insufficient (excessive fuel supply).

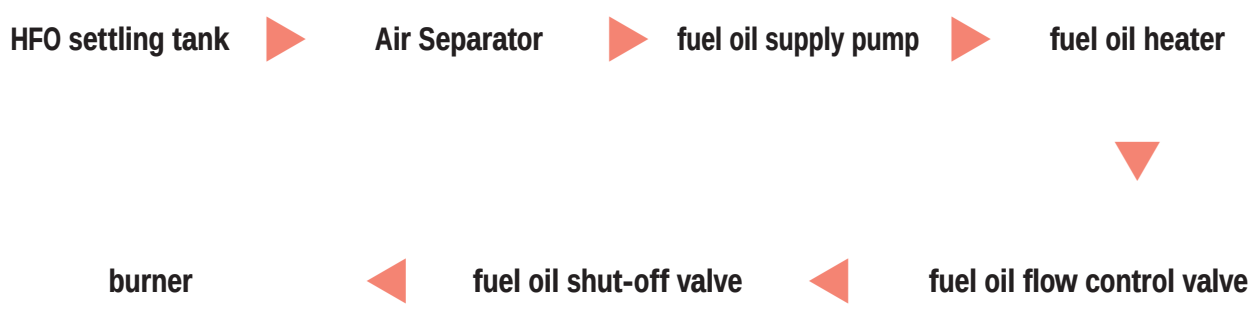
(4) Cause Analysis - - - Check Point

About hardware and safety instructions, the check points are as follows.

(4)-1 [Check from the view of Hardware]

① To understand the fuel oil supply system, please refer to
" Outline of fuel supply system for boiler "as shown in Figure 64.

During burner combustion, fuel is supplied following flow:



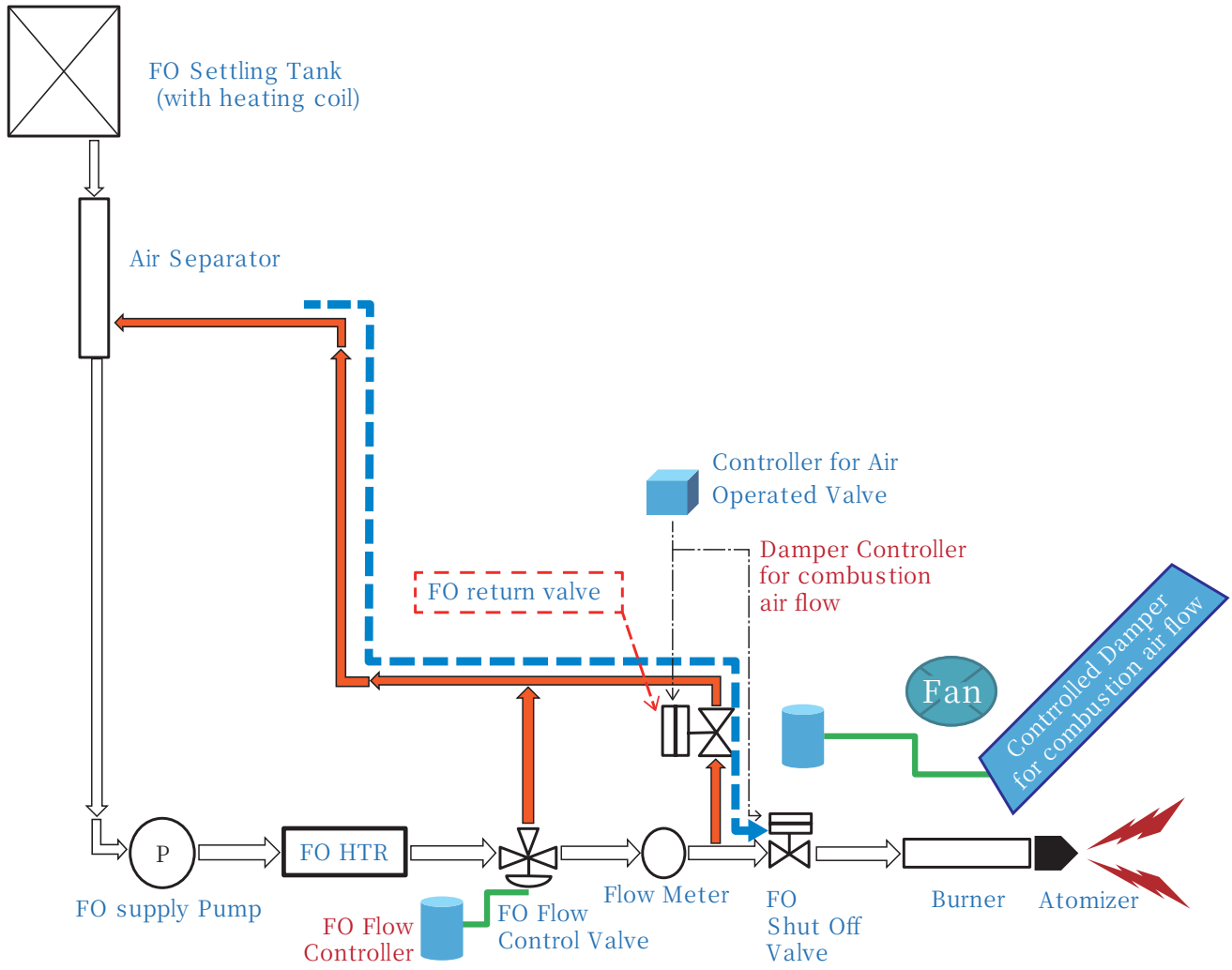


Figure 64　Outline of fuel supply system for boiler

② In front of fuel oil shut-off valve, there is the return valve driven by air cylinder, which must be closed during combustion.

However, as the O ring attached to the air cylinder was affected by the surrounding environment, it hardened and deteriorated itself.

As a result, the valve did not work properly and was still left open. Then the back pressure of the fuel oil return pipeline, which had a return valve, was 10 m, which flowed back to the combustion line. Because of this, fuel supply pressure to the burner supposedly became more excessive than the designed pressure. **Then, air and fuel became unbalanced, which caused black smoke.**

(4)-2　[Check from the view of Operation and Safety Instruction]

Because of stay at berth, they neglected to check the smoke from funnel. As a result, it became late for them to find black smoke.

The unloading cargo operations were completed and the accident occurred in the middle of the night during they were

waiting for the sunrise to departure. So, the caution against black smoke emission was not enough. Moreover, the engine department failed to the immediate response with black smoke. Thus the black smoke became one of the factors to make its emission prolonged.

Like the 2.2.3 blackout accident, it can be considered that it was not a single cause that brought about the accident, but the error chain coming from several causes.

Negative chain

(5) Preventive Measures

As for the black smoke emission, it is confirmed the above check points to be careful about hardware and operation. Taking these into consideration, the following preventive measures are recommendable.

(5)-1 [Measures from the view of Hardware]

1. It is necessary to carry out planned maintenance regularly and to establish a system of purchasing spare parts.
2. Before arriving at the port, inspect the furnace or combustion-related equipment, and make them maintenance if necessary. Afterwards, crew should do the ignition test & combustion trial.
3. The following works are needed regularly based on the manufactures' instruction,
   (a) overhaul
   (b) maintenance and inspection (including measurements).

   If it has beyond the limit of usage, it is necessary to exchange it for a new one.
4. After the maintenance of burner, it should be done ignition combustion trial. In doing the said trial, compare the current state of the operating parameter such as the temperature and pressure with that of sea trial. If crew find wide gap between them, they have to adjust it..

(5)-2 [Measures from the view of Operation and Safety Instructions]

1. During staying alongside the terminal in port, both the watch person of the engine control room (ECR) and the watch person of the bridge should check and monitor the state of smoke emission coming from the funnel, and share information with each other.

   Reference: In the terminal or the place where harbour regulations are strict, the ship equips CCTV for monitoring the smoke from ECR.
2. It is necessary for crew to carry out the drill how to react immediately under following circumstances. For example, switching fuel oil for the generator engine from HFO to MDO where heating is unnecessary, and stopping the boiler, etc.. Of course, it may not be able to stop the boiler from time to time, due to loading the cargo heating is necessary. It is important to carry out the maintenance based on a long-term plan.

   The securing maintenance time is difficult in busy and limited operation period. So, it is important that ship and shore-side work together in such a way that the ship management department reports necessary information to the operations department. Its purpose is to arrange the system to secure the necessary time for maintenance to implement proper scheduled maintenance for accident prevention.

2.2.5 Summary

We have summarised the 4 cases above as follows.

1

Cargo Claims (Cargo Shortage)	
Direct Cause	**Root Cause**
Boiler trouble	Insufficient management of maintenance
Lack of attention to water treatment, furnace cleaning, safety interlock, and etc.	

2

Harbour Facilities Claims (Damage to Submarine Cable)	
Direct Cause	**Root Cause**
Main engine start failure	The procedure of switching the main engine fuel oil is inappropriate
Things such as understanding the system, setting the temperature, switching timing, and the assumption of mixed fuel's viscosity are not carried out.	

3

Cargo Claims	
Direct Cause	**Root Cause**
Unable to re-start generators (blackout)	Operation, shipboard education and maintenance are not enough
Things such as cause removal, following instructions, blackout recovery drill, and periodic maintenance (including emergency equipment) are not carried out.	

4

Environmental Claims	
Direct Cause	**Root Cause**
Incomplete combustion of the boiler	Maintenance (the deterioration of the O ring), shipboard education, and the system of watch are not enough
Things such as the management of combustion equipment, emergency response, cooperation with other department, and monitoring environment are not carried out.	

There was trouble with O ring relating the boiler combustion fuel oil system, ④ Environmental Damages. Except for this, we found that the cause of the trouble was such as insufficient understanding of system, incorrect maintenance, inadequate emergency response, incorrect operation, and breach of work instructions.

Finally, when the ship face the engine trouble, we confirmed that the crew could not sufficiently operate and handle the engine systems due to lack of human's knowledge or lack of awareness and consideration toward behaviour.

2.2.6 [Reference] Out of P & I Insurance Coverage

Figure 65 Magic Pipe / reference*16

Next, we will introduce the case not covered by P & I insurance, which is illegal actions related to intentional environmental pollution.

(1) To our great surprise, the violations of law related to bilge discharging occur frequently and never ceased, shown on the website of United States Department of Justice.

(2) Our club also published the part of those in our P&I News No.735 and No. 754 in 2015.
The main charges are as follows.

1. A lot of oil-water-mixed bilge was illegally discharged to the sea.
2. Misstatement on Oil Record Book
3. Engineers plotted together, and for example as shown in Figure 65 they illegally install special pipes made in the vessel on bilge overboard line; they illegally put it between bilge pump and overboard valve, by-passing bilge separator, and discharged the bilge overboard.
4. During USCG inspection, they removed and hide the illegal pipeline, and evaded the inspection.

(3) About the case that the bilge was discharged to sea in March 2015, by-passing the oily water separator, the shipowners and the crew were gotten the ruling they should pay US$1.5 million as a fine and should not be done their own business in the US for the next five years In March 2016,.

(4) As we will be imposed to pay a severe fine for intentional oil discharge in the US, we should both comply with the relevant regulations and understand them.

As the article 31, 2(5) of our Rules of Association says, "there shall be no recover from the Association of a fine or other penalty imposed for an infringement of International Convention for the Prevention of Pollution from Ships, 1973, as modified or amended by the Protocol of 1978 (MARPOL) where the ship's oily water separator or the other pollution prevention device has not been used or used incorrectly".

As you understand very well, where we affect the environmental damage, it will take enormous cost and time to recover.
We should realise the importance of environmental protection for both the vessel and the shore, and keep the spirit of environmental protection strictly. Its purpose is that we will not pollute the environment.