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Introduction

Though claims caused by “Engine Trouble” tend to be considered as being covered by Hull & Machinery insurance, sometimes accidents caused by engine trouble do involve P&I insurance, such claims concerning harbour facilities, oil pollution and cargo but a few.

Though it is said that about 90% of the causes of marine accidents are human errors, when focusing on engine trouble, many people associate that there were numerous troubles of machinery damage caused by failure of hardware. But, when we analysed
the statistical data on engine trouble and examples of accidents reported to our Club, we found that the engine trouble was actually caused by human error.

Based on the hardware side, it seems that the cause is identified as (a) incorrect operation of machinery and (b) incorrect maintenance and inspection of machinery.

To prevent such engine trouble, we will introduce preventive measures including ERM (Engine-room Resource Management).

This time, many references from Japan Coast Guard, Japan Marine Accident Tribunal and Nippon Kaiji Kyokai (hereinafter "Class NK") were offered to us. (Since we describe these references in the back of this book, we have numbered these references as they are referred to and quoted from to the figures and others in the below description.)

Chapter 1 Occurrence Status of Engine Trouble and Trends of Accident Causes

First of all, we will look at statistical data to analyse the trends and causes of engine trouble.

Engine trouble may be due both to the mishandling of engine operation and to the poor maintenance & inspection (operator error). There are a lot of devices arranged in the engine room So, the causes of engine trouble are considered to be defects of machinery itself.
But, this consideration is not necessarily to study the cases.

1.1 Statistics of Marine Accidents (Japan Coast Guard)

1.1.1 Statistics of Marine Accidents

From Figure 1, the graph of information shows the "Current State and Countermeasures of Marine accidents" from 2009 to 2014, as published on the homepage of the Japan Coast Guard. The bar graph indicates the change of the number of accident outbreaks by year with the vertical axis. It shows about the transition in the number of accidents.
Roughly speaking, the number of annual maritime accidents lies between 2,000 and 2,500. Though we indicate the breakdown with navigational accidents (red), engine trouble (blue), other accidents (green), the number of navigational accidents account for about half of the number of annual marine accidents. The percentage of engine trouble accounts for approx. 15% of total accidents. However, the some root cause of navigational accidents includes the items caused by engine trouble, but they are not disclosed.

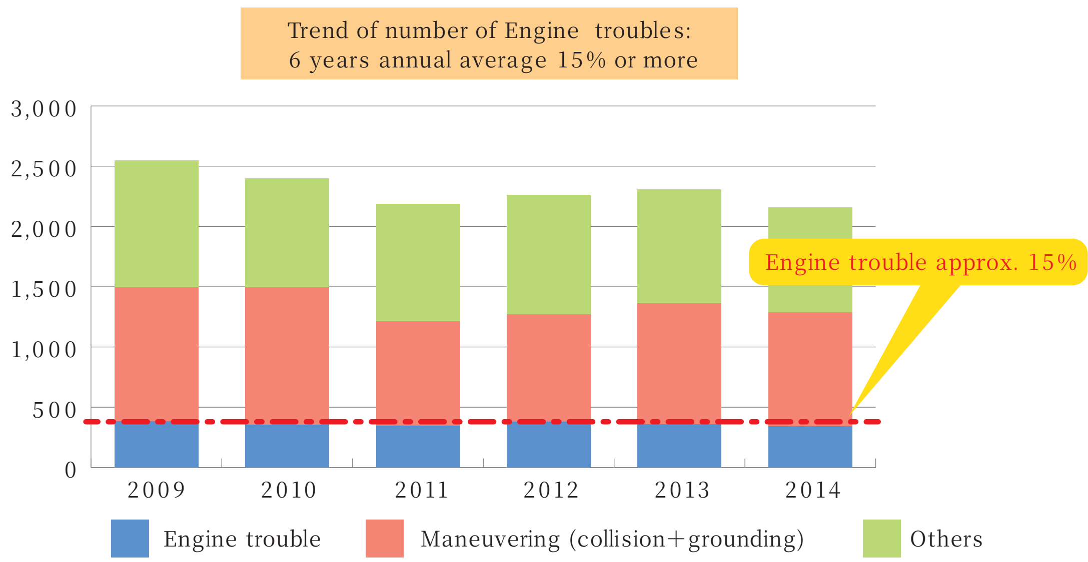

Figure 1 Trend of number of ship accident s(2009-2014)
(cargo ship, tanker, passenger ship, fishing boat, sport fishing boat, pleasure craft, others)
/ reference*1

Other accidents were caused by material and structure, irresistible forces, mishandling of flammables and combustibles material and improper securing of stowage and so on.

1.1.2 Statistics of Engine Trouble by Japan Coast Guard

Close examination of engine trouble cases shows it to be the constant trends. From Figure 2 , it shows the proportion of engine troubles each year due to operating error.

Engine operating error accounts for approx. 70% of all engine trouble. This indicates that there are numerous engine trouble incidents related to human factors. Unfortunately, the breakdown data for the engine operating error, such as careless mistakes, incorrect maintenance, a lack of understanding of systems and a lack of information sharing, are not disclosed.

Though the details are not clear, it can be said that engine trouble due to human factors happen frequently, just as they do with navigational accidents as well..

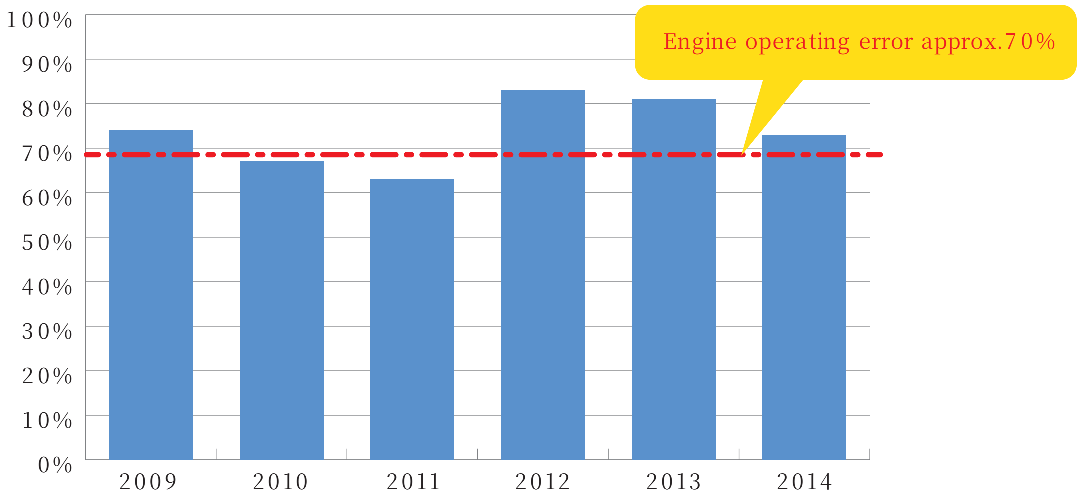

Figure 2 Ratio of human factors
(= engine operating error / engine trouble) (2009-2014) / reference *1

1.2 Statistics of Marine Accidents Inquiry (Japan Marine Accident Tribunal)

The data from the Japan Marine Accident Tribunal is confined to items which an Investigator recognizes that a marine accident resulted from an intention or negligence of marine officers and others (Act on Marine Accident Inquiry Clause 1, Article 28). However, regarding the engine trouble, the main causes is that the engineers did not conduct the basic operation as described at right. (Reference *2)

1. Failure to conduct inspections on a regular basis
2. Failure to conduct component replacement on a regular basis
3. Failure to conduct lubricating oil management properly

1.2.1 Statistics of Marine Accidents by the Japan Marine Accident Tribunal

We reviewed the "Reports of the Japan Maritime Accident Tribunal," from 2009 to 2014, as published on its homepage, and extracted engine trouble data from the list of marine accidents. From Figure 3, it shows about a percentage of their causation with the pie chart.

The trouble caused by the incorrect maintenance, inspection, and operation of Main engine (red) accounts for approx. 65%, and accounts for more than half of trouble causation.

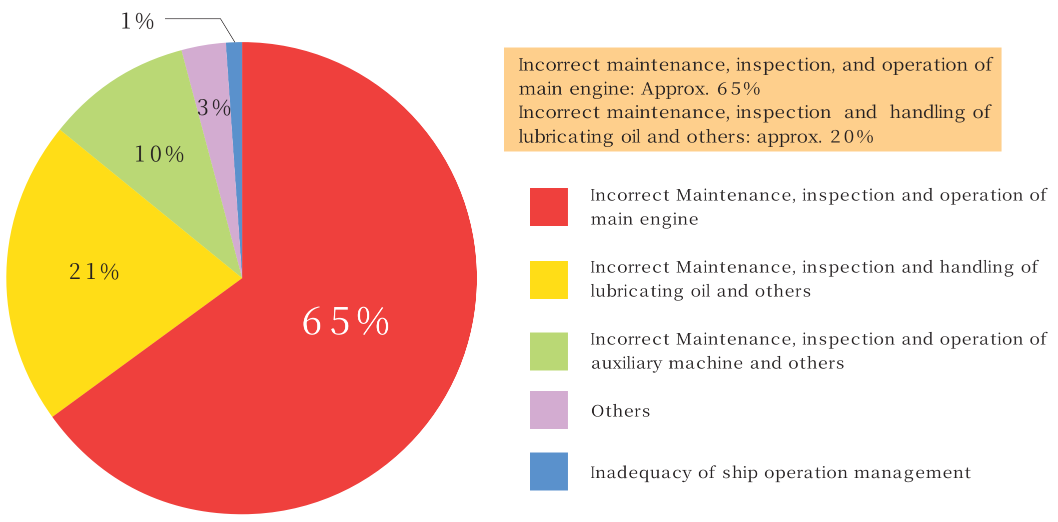

Figure 3 Cause of the maritime accident's case (only engine trouble)(2009-2014) / reference*3

1.3 Damage Statistics (Class NK)

We considered the "summary of damage" in the bulletin of Class NK, and ascertained a trend which affected ship operations. (The number of ships in the Class NK Fleet at the end of 2014 was 9,358.)

1.3.1 Damage That Affected Ship Operations

In this section, "affected ship operations" means that the ship became requiring with towing and damage leading to speed reduction (about less than 7 knots) due to the machinery damage in the engine room. From Figure 4, it shows about "Chronological transition – Number of ships which suffered damage that affected ship operations and damage occurrence rates". The bar graph indicates the change of the number by year with the right vertical axis. Likewise, the polygonal line graph indicates the change of damage occurrence rate (%) by year with the left vertical axis.

In the Long Run, the numbers of ships suffered damage has decreased, but it remains flat for recently several years.

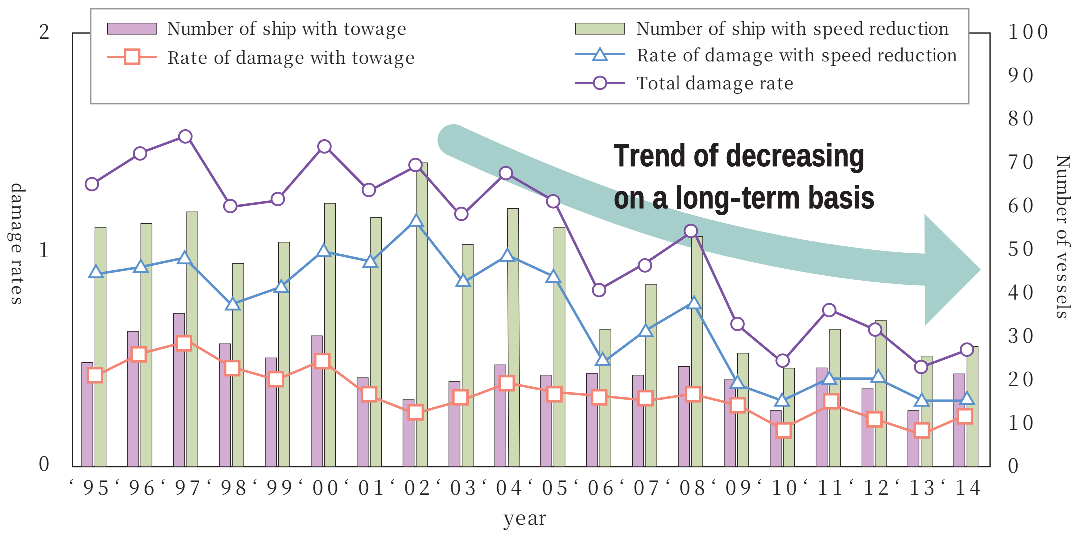

Figure 4 Year-to-year changes in number and damage rate of ships which affected shp operation due to the machinery damage in the engine room / reference *4

1.3.2 Breakdown of Machinery Damage That Affected Ship Operation

In the operation of the ship, from Figure 5, it shows about the change of percentage (%) of machinery damage by year with the vertical axis.

Approx. 80% of causes are linked to the main engine, as indicated in pink. Among them, a lot of diesel engine trouble occurred around the combustion chamber (cylinder cover, cylinder liner, piston, turbo charger and others) as well as with the crank pin and bearing.

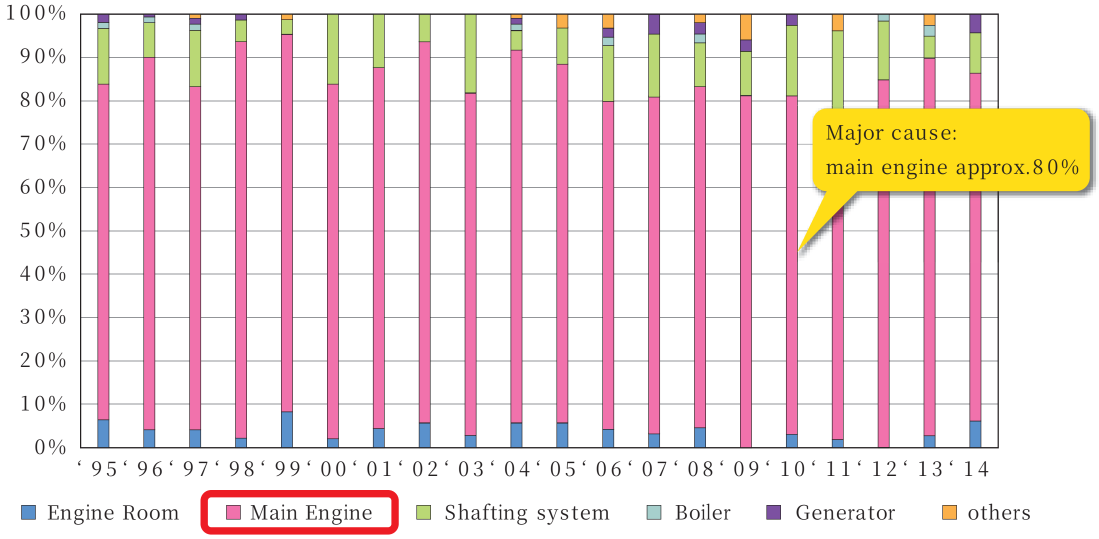

Figure 5 Percentage of machinery damage that affected ship operation /reference*4

1.3.3 Arrangement of Engine Room Machinery

From Figure 6, it shows about "Conceptual diagram of Engine room arrangement". In the case that trouble & damage occur to a main engine, a generator engine, a boiler and the shafting system in engine room, it can affect operations directly.

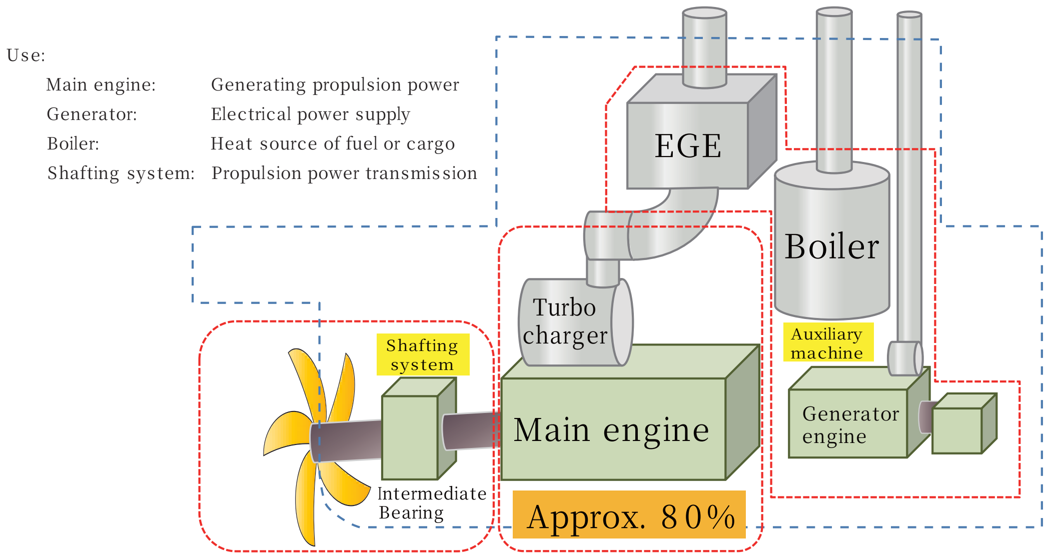

Figure 6 Conceptual diagram of Engine room arrangement

The main engine is used for the generation of propulsion power. The generator is used to supply electrical power. The boiler is used to generate a steam as a heating source of fuel or cargo. The shafting system is used for the transmission of propulsion power from the main engine to the propeller.

Therefore, it is easily understood that the main engine at the centre is a source of main propulsion power and accounts for approx. 80% of engine trouble which affected the ship operation.

1.3.4 Breakdown of Diesel Main Engine Component Parts Damage Affected Ship Operation

From Figure 7, it shows about the change of percentage (%) of Diesel Main Engine Component parts damage by year with the vertical axis. The number of turbo charger damage (red) is the most in any year, and followed the cylinder unit-related (yellow) .

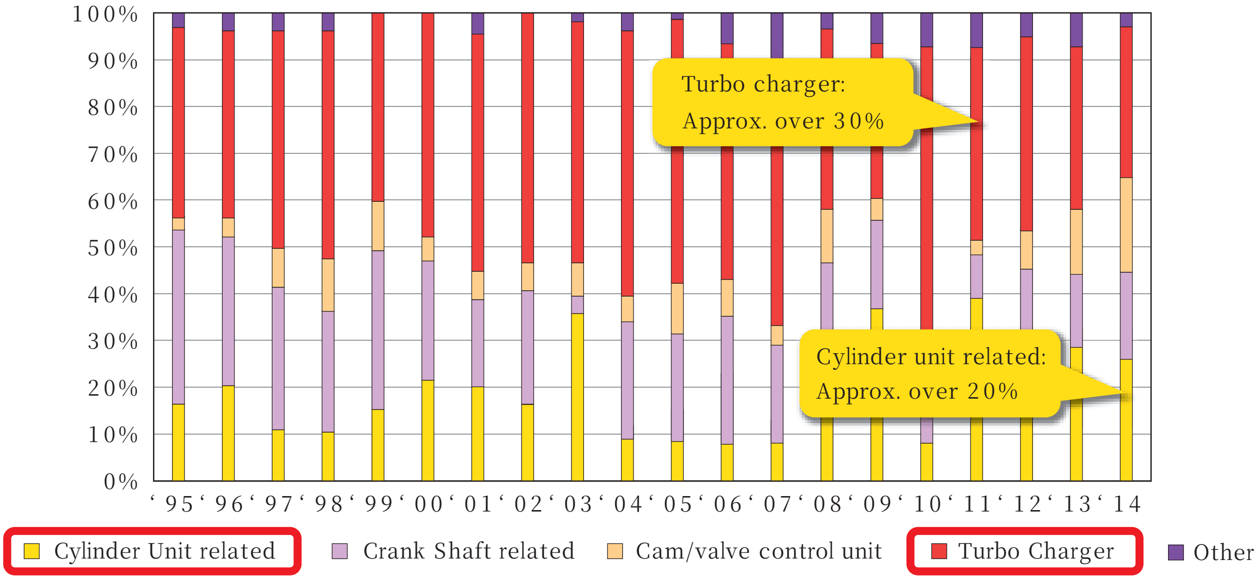

Figure 7 Percentage of parts damage of diesel main engines that affected ship operation / reference*4

1.3.5 Breakdown of Damage to Machinery and Parts (by Damage Location of Diesel Main Engine) Respectively, Which Affected Ship Operation

When we focus on damage to machinery and equipment (by damage location of diesel main engine) respectively, which affected ship operation, Figure 8 is "the percentages of individual machinery and parts (by damage location of diesel main engine) in engine room" which is based on the data from the bulletin of Class NK, No. 292, 296, 301, 304, 309 and 312 (from 2009 to 2014) . From Figure 8, it is shown that turbo charger, cylinder unit related parts and shafting system stand from 1st to 3rd place. The damage of the turbo charger and cylinder unit account for approx. 60%.

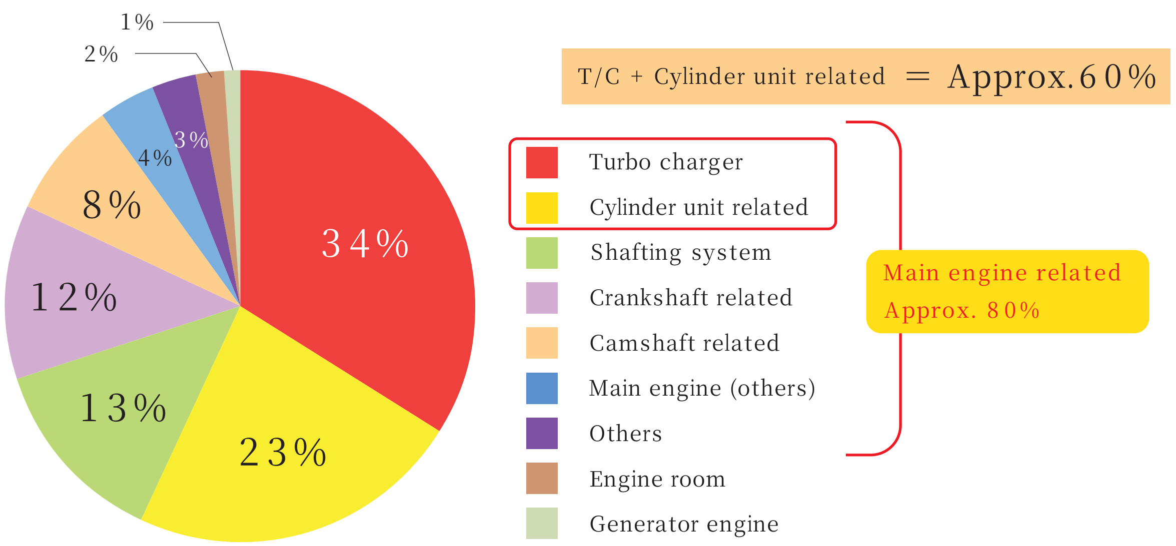

Figure 8 Individual part percentage of equipment & main engine (damage that affected ship operation) (2009 - 2014) / reference*6

1.3.6 Engine Trouble of Coastal Cargo Ships in Japan

When we analysed (1) engine trouble judged by Marine Accidents Enquiry Agency from 2000 to 2002 and (2) its trends, from Figure9, it is shown that the troubles with the turbo charger and cylinder unit related (cylinder and piston related) accounts for approx. 70% of all engine trouble.

This is a similar trend to data from "summary of damage" in the bulletin of Class NK, as indicated in Figure 8.

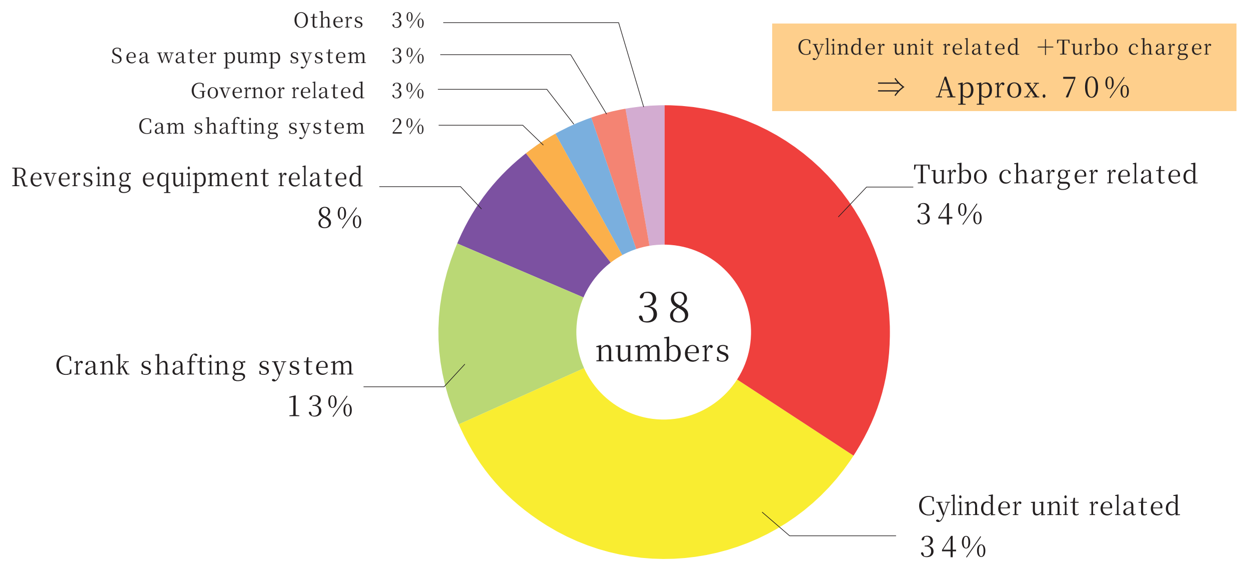

Figure 9 Situation of damage part for coastal cargo ships Refernce *5

1.3.7 Breakdown of Damage to Machinery and Parts (by Damage Location of Diesel Main Engine) Respectively, Which Required Towing

In relation to damage requiring towing, we indicate the percentage of damage to machinery and equipment (by damage location of diesel main engine) respectively in Figure 10, based on the data in said 1.3.5 from "summary of damage" in the bulletin of Class NK .

The damage of cylinder unit related parts and shafting arrangement are the biggest proportion, and accounts for approx. 50%.

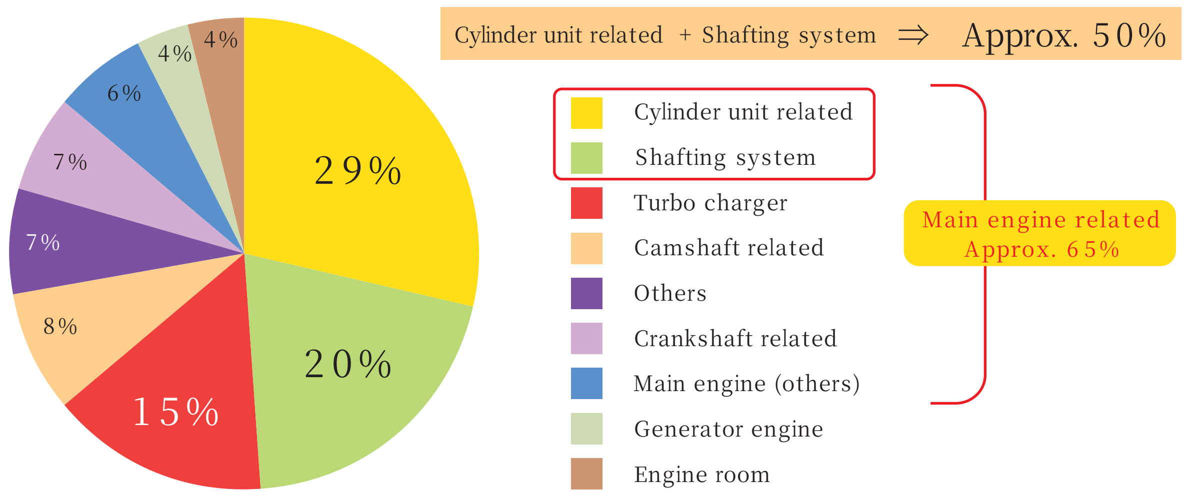

Figure 10 Percentage of machinery damage and parts damage of diesel main engines that required towing (2009-2014) / reference*6

1.3.8 Breakdown of Damage to Machinery and Parts (by Damage Location of Diesel Main Engines) Respectively, Which Leaded to Speed Reduction

In relation to damages leading to speed reduction, we indicate the percentage of damage to machinery and parts (by damage location of diesel main engines) respectively Figure 11, based on the data in said 1.3.5 from "summary of damage" in bulletin of Class NK.

Damage to turbo charger and cylinder unit related parts are superiority and totals to a little less than approx. 70%.

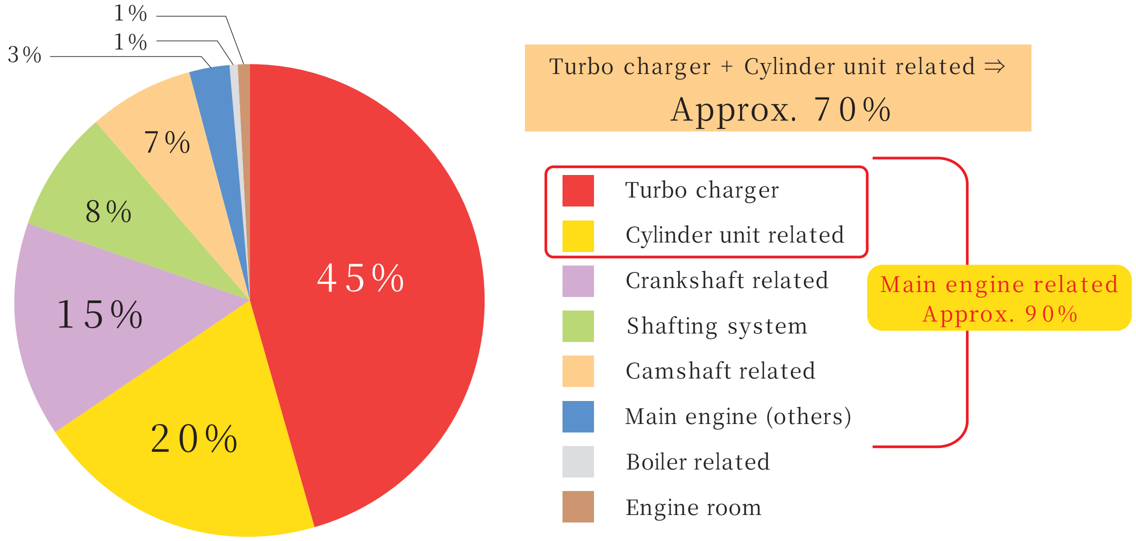

Figure 11 Percentage of machinery damage and parts damage of diesel main engines that lead ed to speed reduction (2009-2014) / reference*6

1. 4 Summary of Statistics

Analysis of above statistical data shows the following summary.

(1) According to the Japan Coast Guard statistics, human error accounts for approx. 70% of the causes of engine troubles.

(2) According to the Japan Marine Accident Tribunal, incorrect maintenance, inspection and operation of the main engine account for approx. 70% of engine trouble cases.

(3) According to Class NK about the damage which affected ship operation, the main engine damages account for the majority. On the other hand, as for the parts (by damage location of diesel main engine), the damages of the turbo charger and cylinder unit-related parts (cylinder and piston-related) account for approx. 60%.

(4)According to the Marine Accidents Enquiry Agency, though this is based on analytical information of all engine trouble affected coastal cargo ships operation about 10 years ago, the damages of the turbo charger and cylinder unit-related parts (cylinder and piston-related) account for approx.70% of all engine trouble. This shows a similar trend to the Class NK.

Based on above, as with navigational accidents, majority of engine trouble is also caused by human factors, and about damages which affected ship operation, the damages of turbo charger and cylinder unit related parts (cylinder and piston-related) predominate.

Therefore, we believe we must bear these facts in mind.

1.5 Details of Damaged Parts (Class NK)

1.5.1 Damage to Turbo Charger (End of Book: Reference Information (2)- ① Turbo Charger)

(1) Features of Damage

From Figure7, about the category of the main engine damage which affected ship operation, damage related to turbocharger were maximum every year.
The most common causes of damage are following three:

1. Explosion / over-run
2. Vibration / Abnormal noise
3. Damage of the rotor shaft and bearing due to the shortage of lubricating oil.

Figure 12 Damaged turbine blade, T/C explosion damage leaded to speed reduction in fiscal year 2011 / reference*10

The picture on the right shows the case when an explosion causes damage which leads to a speed reduction. The turbine blade on the driving side in turbo charger was damaged.
As for the causes of damage, they are considered as follows; (Reference *7, *8)

1. The use of low quality fuel,
2. The poor atomization of the fuel injection valve,
3. The dirty scavenging chamber
4. The contamination of the combustion chamber and exhaust system of the main engine due to incorrect maintenance,
5. The problem with the exhaust gas temperature of the turbo charger inlet,
6. The incorrect maintenance and servicing leading to damage to main engine, and so on.

As for the preventive measures, Class NK recommends as follows; (Reference *8, *9)

1. To collect the most updated service news based on the lesson learned issued by the engine and turbo-charger manufacturer,
2. To implement the proper maintenance and service to be carefully adhered to in accordance with the manufacturer's instruction manual and above information, and so on.

We included pictures of the damaged turbo charger in photographs ④ -1, so please refer them.

(2) Explosion Damage to the Turbo Charger/the Number of Over-run Cases

From Figure 13, it shows about "the number of damaged turbo chargers (2009-2014)". There seems to be a decreasing trend of incidents, however it is clear that there was not one year when the number of these troubles achieved zero.

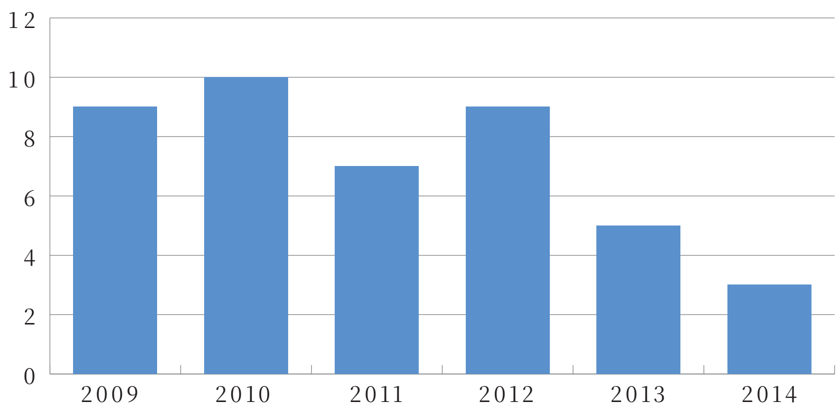

Figure 13 Number of damaged turbo chargers caused by explosion or over run / reference *7

(3) Parts Damaged by the Explosion or the Over-run of the Turbo Charger

From Figure 14, it shows about the influence and impact of the explosion or the over-run.

And also, we explain what the phenomenon occurs in order from a to c below after the explosion or the over-run.

a To damaged turbine blades, nozzle rings, and casing and others (or damage to other parts by contact with fragments of damaged turbine blades or others)

b When the turbo charger rotor rotates at abnormal speed it can lead to failure of the rotor shaft and or journal/thrust bearings.causing abnormal wear and leading to heat damage and / or scratches.

c To occur a slight gap of alignment in the rotation of a shaft due to a damaged bearing, and to occur scratches on both compressor wheel side and casing sides when the compres-sor comes into contact with a casing.

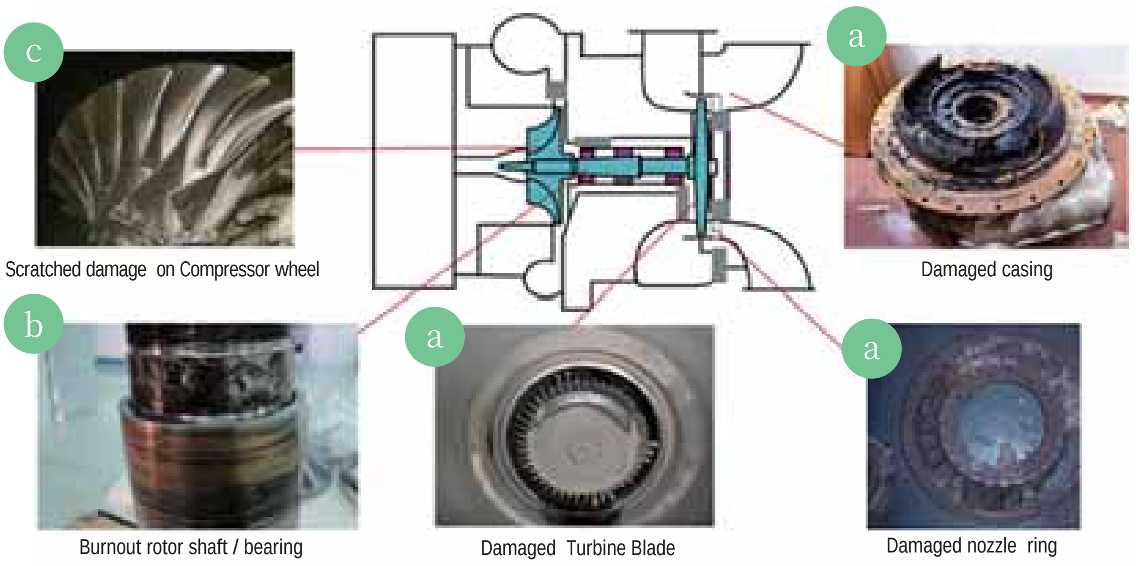

Figure 14 Damaged parts caused by explosion or over run /reference*7

If the explosion of the turbo charger is larger, both the damage will affect the turbo charger and the fire will be broken out in the engine room as the worst scenario.

(4) What causes an Explosion/Over-run?

We will introduce the features and mechanism of the explosion or over-run, as follows:

① Features

If there is the sediment of oil content of unburnt fuel / lubricating oil in the exhaust pipe or manifold connected from the main engine to the turbo charger, and then it ignites them by some reason, the explosive combustion will occur. As a result of this, the turbo charger over-speeds, or the turbo charger itself explodes. As describing in above (3), it causes the significant damage in any parts of turbo charger.

② Mechanism

From Figure 15, it is shown what the mechanism of an explosion or over-run occur in order from a to f after breaking out of fire in scavenging air box.

- a Even if drawing out pistons is done, if the piston and piston ring without their proper measurement and maintenance continue to be used, the blow-by might be occurred.
- b As a consequence, the combustion gas blows through the piston ring and reaches the scavenging air box. At the time, if the inside of the scavenging air box has oil sediment residue therein and the oil sediment is lit, a fire will occur. (Figure 16). At the same time, air from the scavenging air box is sent into the combustion chamber with air containing CO_2 because of this fire.
- c Accordingly, combustion with a lack of oxygen (due to incomplete combustion) occurs in the combustion chamber,
- d That is to say, unburnt fuel goes into the exhaust pipe, manifold or turbo charger (turbine side) and then accumulates there.
- e Next, when the fuel accumulates to a certain extent, firing or explosive combustion will occur.
- f This causes the turbo charger to over- run.

In addition to this, the broken hole of the piston crown, poor atomization of the fuel injection valve, or long-term slow steaming might cause of this.

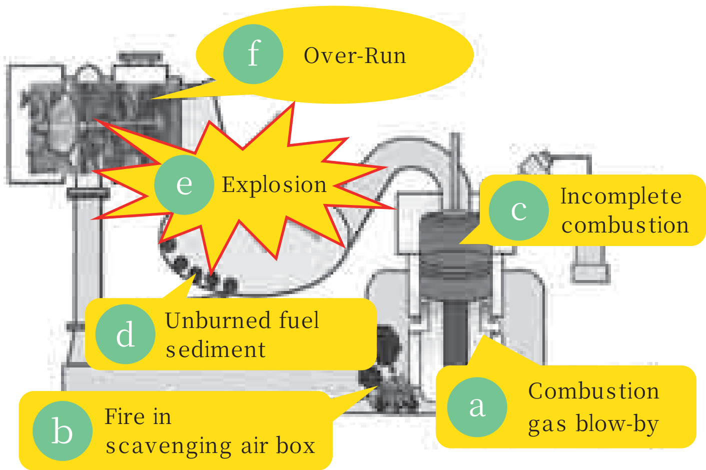

Figure 15 Mechanism of explosion/over-run of turbo chargers due to fire in scavenging air box /reference*7

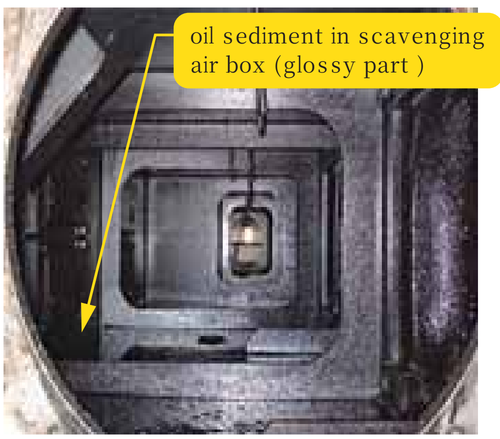

Figure 16 State of oil sediment in scavenging air box / reference *7

③ Case of Explosion/Over-run

We will introduce the case of explosion or over-run leading to speed reduction. During the operation of one ship, the exhaust manifold of the main engine suddenly exploded. The ship emergently navigated to an anchorage. At the anchorage, the turbo charger was locked as an emergency measure. And then the ship arrived at the

- Turbine blade: damaged (Figure 17)
- Journal bearing: burnout
- Labyrinth: damaged
- Nozzle ring: deformed (Figure 18)
- Thrust bearing: peeled off white metal (Figure 19)

port of destination by slow steaming. After this, the above damage was found.
As we mentioned the mechanism of explosion and over-run, described in above (4)- ② , a fire occurred in the scavenging air box and the fuel burned incompletely in the combustion chamber. As a result of this, unburnt fuel accumulated in the exhaust manifold and exploded.

Figure 17 Damaged turbine blade / reference*7

Figure 18 Excessively deformed nozzle ring / reference*7

As for the preventive measures, the problems of "Retention of oil in the manifold or scavenging air box" or "Blow-by occurrences" in (4) - ② , may be prevented by, for example, removing unburnt fuel or lubricating oil and ensuring proper maintenance. That is to say, it is important that the basic actions of inspection, maintenance and cleaning are carried out rigorously and routinely.
We list detailed work actions below.

Figure 19 Thrust bearing with metal peeled off / reference*7

- To inspect and clean the exhaust pipe, manifold or turbo charger properly for preventing an explosion of the exhaust manifold.
- To inspect and clean the scavenging air box (including drain pipes) properly for preventing a fire in the scavenging air box.
- To inspect and make a maintenance (weakened and declined amount measurement) of the piston ring or piston crown regularly for preventing blow-by.
- To inspect and make a maintenance of fuel injection valves regularly for good combustion.

(5) Vibration/Abnormal Noise

① Causes and Prevention Measures

We will introduce the case of the Vibrations & abnormal noises. (Reference *7) Then, they can lead to bearing damage.
As for the Vibrations & abnormal noises, they result from an imbalance in turbine blade rotation caused by the carbon

deposit adherence on the blade. Then the carbon deposit comes from the incomplete combustion

As for the preventive measures, to clean the turbine blade regularly could prevent such damage. Basically, it is important for crew to make a maintenance in accordance with the intervals recommended by the engine manufacturer. However, the dirtiness of combustion gas are largely influenced by the fuel oil quality and the running environment which is the main engine load or navigation sea area. Therefore, firstly it is necessary to predict any sign of abnormality by carefully monitoring the operational parameters (temperature, pressure, etc.) of the diesel main engine and the operational parameters (RPM, outlet temperature, discolouration of T/C lubrication oil, etc.) of the turbo charger. Then, it is important for crew to make the proper maintenance based on the above prediction.

② Case of damage by vibration / abnormal noise

Here is an example of damage due to vibration & abnormal noise. During the ship navigation, vibration & abnormal noise occurred in the turbo charger, and the performance of the main engine declined.

Judging from circumstance, it was impossible for the ship to self-propell. The detailed investigation was conducted after the ship was towed into the port. It was found that there was significant adhesion of carbon on the turbine blade and the nozzle ring, (Figure 20 and 21).

Following several tasks were carried out,

1. To clean stained items and to replace damaged components such as bearings and sealing and etc. (Figure 22 and 23), and
2. To make a maintenance work of the diesel main engine (air cooler, piston ring replacement and others).

As for the causes of damage, the causes were related to dirty deposit due to incomplete combustion in diesel main engine and a lack of regular cleaning.

As for the preventive measures, as mentioned above, the measures were “to conduct proper inspection and maintenance” only based on referring to good engineering practices on a day-to-day basis.

Figure 20　Carbon adhering excessively on turbine blade / reference *7

Figure 21　Carbon adhering excessively on nozzle ring / reference*7

Figure 22　Scratches in rotor shaft / reference*7

Figure 23　Slipping out of lub. oil hole on bearing / reference*7

1.5.2 Burnout of the Rotor Shaft and Bearing Due to shortage of lubricating oil.

(1) Features and Causes

We will introduce the features and causes of the burnouts of the rotor shaft and bearing due to shortage of lubricating oil. (Reference *7)

It is estimated that most of the burnouts of the rotor shaft and bearing were due to shortage of lubricating oil. Specifically, the causes are considered to the following three listed.

1. Deterioration of lubricating oil itself (contaminated with the water and others)
2. Blockage of the oil hole on the bearing
3. Flow shortage of lubricating oil due to malfunction of lubricating oil pump.

(2) Case of Burnout Roter Shaft and Bearing (Figure 24, Reference *4)

We will introduce the case of damage, leading to speed reduction, that is the burnouts in the rotor shaft and bearing due to a shortage of lubricating oil. (Figure 24 and Reference *4)

During ship navigation, abnormal noise & vibrations occurred in turbo charger of the diesel main engine. After the turbo charger was overhauled for the investigation, it is confirmed that there were the burnout bearing and the contact scratches on between compressor wheel and casing. The damaged parts were replaced and renewed.

As for the cause, the root cause was to postpone the periodic inspection of L.O. pump because of the tight work and navigation schedule on board. As the result of this, the lubrication of bearings became the inadequate, and the burnout (heat damage) of the bearings occurred. It is assumed that the resulting imbalance of the shaft led to the compressor wheel and casing contacting each other.

Figure 24 Scratches on compressor wheel, lubricating oil shortage damage leading to speed reduction in fiscal year 2014, reference*4

As for the preventive measures, the cause of this damage was lack of time for scheduled maintenance, and so the measures are to establish and implement maintenance plans on the basis of the manufacturers' instruction manual.

Moreover, if the ship side try to manage the maintenance work within keeping the normal ship operational schedule strictly, it is difficult and limited for crew to accomplish the required maintenance items. Therefore, we recommend the ship management department and the ship operations department to conduct the close meetings together, and coordinate and ensure the necessary schedule for proper maintenance work.

1.5.3 Damage to Cylinder Unit Related Parts

(1) Features of Damage

From Figure 7, the cylinder unit-related damages are the second most common. (Reference *4)
These can lead to the damage not only to the cylinder unit-related parts (the combustion chamber components) but also to the turbo charger.

As for the cause of damage, the cause may be the use of low quality fuel oil, poor maintenance, and so on. As for the preventive measure, especially when you found that the using fuel is the low quality fuel oil, we recommend the following necessary preventive measures;

1. To carry out the fuel pre-treatment rigorously,
2. To reduce the operating load of the diesel main engine,
3. To dilute the low quality fuel by mixing light quality oil and to improve it
4. To use the fuel additives and so on.

(2) Case of Low Quality Fuel (Figure 25, Reference *10)

We will introduce the case of using low quality fuel leading to damage requiring the towing. During the ship navigation, a number of abnormalities occurred and eventually the main engine failed to start. The ship was required with towing to the nearest port.
As a result of emergency repairs to the main engine, the fuel injection pump and fuel injection valve were opened up, and renewed as necessary., and 300 Mt of new fuel was bunkered and the ship operation restarted. After arriving at the repairing site, the excessive wornout was found on No. 1, 2 & 4 of the piston crown and piston ring, and so these were replaced with a reconditioned one.

Figure 25 Wornout plunger, low grade fuel damage requiring towing in fiscal year 2011 / reference*10

(3) Example of Incorrect Maintenance and Cleaning (Figure 26, Reference *11)

We will introduce the case of incorrect maintenance and cleaning leading to damage requiring the towing

① First Trouble

During the ship navigation, the temperature of lubricating oil in the main engine became high, and the main engine stopped automatically. A broken hole was found at the top of No.6 piston crown, and this piston crown was replaced with a spare one.

② Second Trouble

After the first trouble, a knocking sound occurred when the rpm of main engine was increased to the normal engine rpm. Again, the main engine was stopped for investigation.

Damage was found to No.6 crankpin and the same bearing, so the ship sailed to a repairing site, where the No.6 cylinder was taken out of the main engine and the cylinder was cut off. At the repairing site, Damage on the No.6 crankpin and a misalignment were found. And the crankpin was shaved off by 2 mm to achieve proper alignment. The size of the No. 6 crankpin bearing was also adjusted by re-metalling it.

Furthermore, significant damage (cracks) was found in No. 6 on a crosshead pin and the bearing. The cross head pin was ground off smoothly and the bearing was replaced. During the repairs, pieces of cloth were then found in the oil feed pipe for No.6 cross head pin and crank case bottom.

The oil dirty lubricating oil from the main engine was transferred to a waste oil tank. In addition the sump tank, oil pan and all filters inlet side were all cleaned. 10,000 litres of new lubricating oil was supplied.

Figure 26　Hole in piston crown, damage from poor maintenance and repair mistake , requiring towing in fiscal year 2009 / reference*11

③ Causes and Preventive Measures

As for the cause of damage, in this case of the main engine, there are double defects that one is the incorrect scheduled maintenance and the other is an incorrect procedure during the repairing of damage and restoring work.
The first trouble was cracks being caused to the top of a piston due to a incorrect inspection of a piston crown. As for the preventive measures, it is necessary to implement the scheduled maintenance of a piston crown based on the manufacturer instruction manual. If necessary, please replace the drawn-out piston crown with a reconditioned spare or a new one after examining whether the drawn-out piston permits the limitation to use continuously during overhauling.

The second trouble was that the bearing was damaged as a result of a shortage of lubricating oil due to a blockage by pieces of cloth in the system. Those involved in the repairing of the above first trouble forgot to collect used cloth. As a preventive measure, senior engineers should not rely on those less experienced colleagues, and it is necessary that senior engineers such as the Chief engineer (described as C/E below) and first engineer (described as 1/E below) double check the their work, especially at the following work a),b),and c),

- (a) Not to leave residues
- (b) To clean contact area when assembling
- (c) To preserve the manufacturer instruction manual and your own work instructions for assembling, fastening torque, technique of fastening and other special cautions.

(4) High Risk Damages which May Lead to the Turbo Charger Damage (Figure27, Reference *10)

We will introduce the case of high risk leading to turbo charger damage which results speed reductions.
During the navigation, alarms indicating scavenging trunk fires in several cylinders were emitted. Then temperatures of exhaust gas, scavenging and cooling water was found to be abnormally high. Many broken piston rings were found in the scavenging trunk (Blow-by).
The rpm of diesel main engine could not be able to maintain the engine speed necessary for operation and could not be raised due to the compression drop and high temperature, so the ship sailed at low speed (30 - 50 rpm).
After anchoring, the necessary temporary repairs were conducted as follows;.

- Cracks found at the internal top of all cylinder liners of the diesel main engine.
  Treatment : No.1 cylinder liner was renewed
- Top ring groove of No.1 piston was missing
  Treatment : No.1 piston crown was renewed

Figure 27 Liner with crack, fire in scavenging air box ,leading to speed reduction in fiscal year 2011 / reference*10

A damaged (peeled off) white metal of No.1 cross head pin bearing was found, and this permanent repair was recommended by the classification society.
Several days later, the following repairs to the main engine were conducted.

- Renewing of all piston rings of No.2, 4, 5, 6 cylinder
- Renewing of all cylinder liner
- Renewing of No.1 cross head bearing

As for the preventive measures, this case concerns a scavenging air box fire by blow-by explained in "What causes an Explosion/Over-run?" in 1.5.1.(4), the measures are as follows;

- To implement the proper scheduled maintenance of pistons based on the manufacturer instruction manual
- To inspect and clean the scavenging air box and the exhaust gas manifold regularly for removing oil accumulation.

1.5.4 Damage to Shafting System: Intermediate Bearing (End of Book: Reference Information (2)- ② Intermediate bearing)

(1) Features of Damage

In damage of the shafting system, it may be difficult for crew to prevent breakage, however there might be the preventive measure against damage to the intermediate bearing.
We will introduce that the features of damage to intermediate bearing are cracks of shaft and wearing / peel-off / burn-out of bearing, as discussed below.

(2) Case of Damage to Intermediate Bearing Reference *10

We will introduce the case of Damage to Intermediate Bearing leading to speed reductions. During ship navigation, when C/E conducted regular inspection, C/E found that an intermediate shaft bearing had overheated. So he decreased engine speed.The situation were as follows.

1. Liquid level of lubricating oil in the Plummer block of intermediate bearing was low in level.
2. The temperature of lubricating oil was higher than 100 ℃
3. The temperature of the upper cover was 132℃

The following temporary measures were conducted.

1. 10 litres of lubricating oil were replenished.
2. To increase feeding of cooling sea water to the bearing, the by-pass valve of cooling sea water intake of the stern tube lubricating oil cooler was opened.

The Further inspection was held after arrival in port, the burn-out, wear, and peel-off of metal, as indicated in Figure 28, were found.
As for the cause of damage, the cause was considered to be a shortage of cooling sea water and the shortage and degradation of lubricating oil.
As for the temporary measures, it is to re-metal the damaged intermediate bearing.

Figure 28 Burnout intermediate shaft bearing metal, damage leading to speed reduction in fiscal year 2011 / reference*10

(3) Preventive Measure

As for the preventive measures, the measures is as follows;

1. To monitor rigorously the operating parameters around the bearing, such as the temperature of the bearing and the quantity, flow volume, leakage of lubricating oil and the operating status of cooling systems,
2. To predict early malfunctions of cooling systems,
3. Then, to conduct an adjustment of quantity of cooling water and proper maintenance and so on.

1.6 Summary of Damaged Parts and Overview

The summary on the damaged part is as follows.

1

The number of damage involving the turbo charger is the most common, and the major types of damages are the following three.

① Explosion/Over-run

② Vibration/Abnormal noise

③ Damage to the rotor shaft and bearing due to the shortage of lubricating oil

Each of these looks different, however the common preventive measures are how to manage the incorrect maintenance. So, these damages could be prevented by learning, understanding and following the manufacturer instruction manual and by familiarising and implementing the proper maintenance in accordance with them.

2

The cylinder unit-related damage is the second most common. There is a high risk that damage to components in combustion chamber and damage to turbo charger will occur. The causes include the use of low quality fuel, and incorrect maintenance.
To rectify this, it is necessary for crew to conduct the severe fuel management and the continuous proper maintenance rigorously.

3

The third most common damage is to the shafting system, it is specially relating to the bearing damage caused by the shortage of lubricating oil and incorrect maintenance of cooling system in troubles. The preventive measures include the ensuring proper operational management and the proper maintenance rigorously.

When comprehensively analysing statistical data on engine trouble damage that affected ship operation, the causes include maintenance management often. In other words, the causes are human in nature. That is to say, it is important for crew to conduct maintenance and inspection systematically and regularly and to arrange a management system which is capable of comprehending the operating status of an engine so that the device and system can operate properly on the basis of rule and principle of science and technology. In addition to above, it is important for your ship to review your ISM procedures and the planned maintenance system (PMS) if it is practicable for your crew. If necessary, you need to update them.

On the other hand, loss prevention measures on board are considered to be limited. It is important for the ship management department to improve measures to control problems by understanding the features of damage in several cases and then collecting the most updated service news, in order to add to the existing manufacturer's instruction manual. Their considered measures must instruct to the ship and then finally preventive measures for implementing engine operation and daily inspection and maintenance properly can be developed

Of course, since securing maintenance time is difficult in busy and limited operation period, 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 and to arrange the system to secure the time necessary for maintenance to implement proper scheduled maintenance for prevention of accidents. The information introduced above is open to the public, however there are many important messages in these public information. We would ask that you continue to pay attention to all these public information discussed in this chapter.