Engine Accident Cases

Mitsui O.S.K. Lines

Marine Engineering Group

Marine Division

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Preface

We, in the group of Mitsui O.S.K. Lines, currently operate about 500 vessels. According to the statistics of vessel accidents in 2000 contained in data base for MOL-operated vessels (refer to the attached charts), the incidence of accidents (breakdowns which actually affected ships' schedules or those which had such a potential) was as high as 0.94 case per vessel.
Ever since 1996 when statistics were first compiled, about 40% of the accidents which occurred with vessels under our operation, are related to ships' machinery.

It is said that about 80% of accidents with ships are attributed to human error but this statistical figure is not directly applicable to engine-related damage. It is because the engine of a ship is a "man-machine system" operated with man and machinery complementing each other and, as a result, accidents of machinery always involve human beings.
The causes of engine accidents are varied, but statistics of engine damage show that structural defects, and problems with design or workmanship, largely account for such accidents. We do not encounter, with a high frequency, cases where the mishandling of equipment and instruments on the part of crew members directly contributed to accidents. There is also a tendency for similar accidents to occur on board many vessels with similar specifications.

Essentially, even if it is possible to reduce the number of failures of equipment and instruments or human errors, it is impossible to bring it to "zero". It is, therefore, important that, in order to prevent accidents, a breakdown or failure, if incurred, be averted from developing into a serious event. This means that crew members are required to recognize abnormal engine conditions as such as early as possible and stop or arrest, in the process, the flow toward degradation of the failure to a serious accident.

In order to realize that various phenomena (e.g., temperature, sound, pressure, leak, discoloration) which appear in equipment and instruments are signs which may precede subsequent accidents, experience as a professional is naturally required. However, in reality, there is a limit to the experience one engineer can have in the performance of his duties on board vessels. It is, therefore, important to sufficiently analyze accidents which have occurred on board other vessels and utilize such analyses as lessons to prevent accidents of similar kinds.

The Marine Engineering Group, Marine Division, shoulders the role to make continued efforts to investigate into causes of machinery damage and, on the basis of such investigations, determine guidelines for the operation of engines on board vessels under our operation. This time, we have put a large number of engine trouble cases in perspective in terms of the cause, countermeasure and lesson, to compile this set of “Engine Accident Cases”. We request you to take full advantage of this material for training those who embark vessels under MOL’s operation as engineers, thereby to prevent the occurrence of engine-related accidents.

Marine Engineering Group
Marine Division
Mitsui O.S.K. Lines

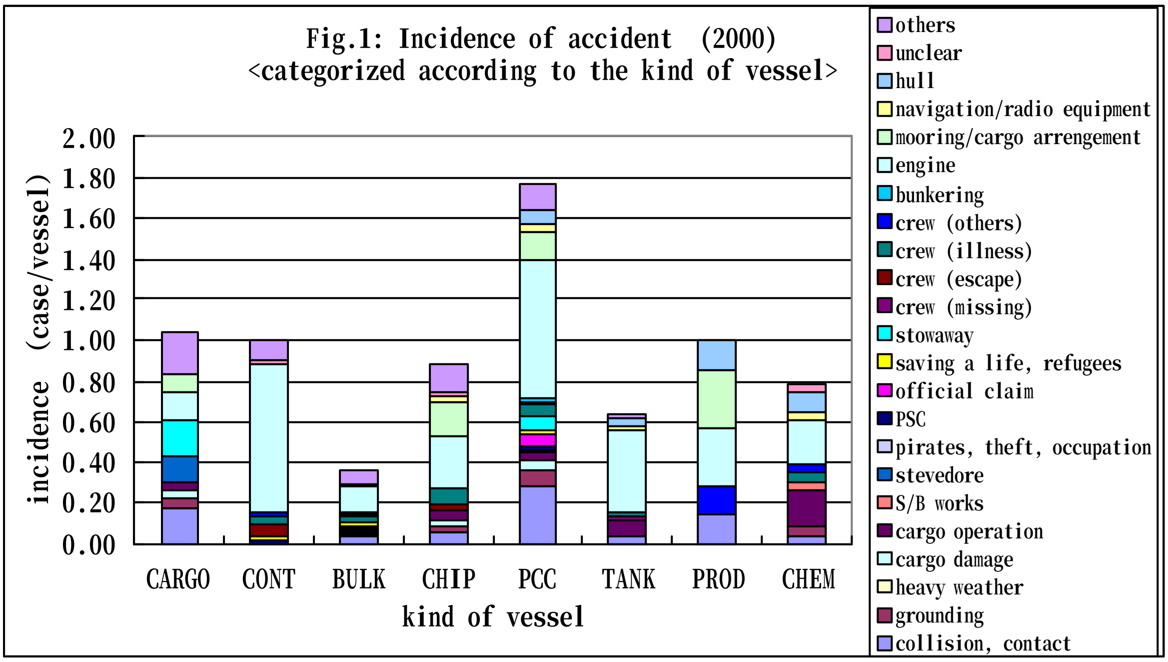


Fig.1: Incidence of accident (2000)
<categorized according to the kind of vessel>
incidence (case/vessel)
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
CARGO
CONT
BULK
CHIP
PCC
TANK
PROD
CHEM
kind of vessel
others
unclear
hull
navigation/radio equipment
mooring/cargo arrengement
engine
bunkering
crew (others)
crew (illness)
crew (escape)
crew (missing)
stowaway
saving a life, refugees
official claim
PSC
pirates, theft, occupation
stevedore
S/B works
cargo operation
cargo damage
heavy weather
grounding
collision, contact

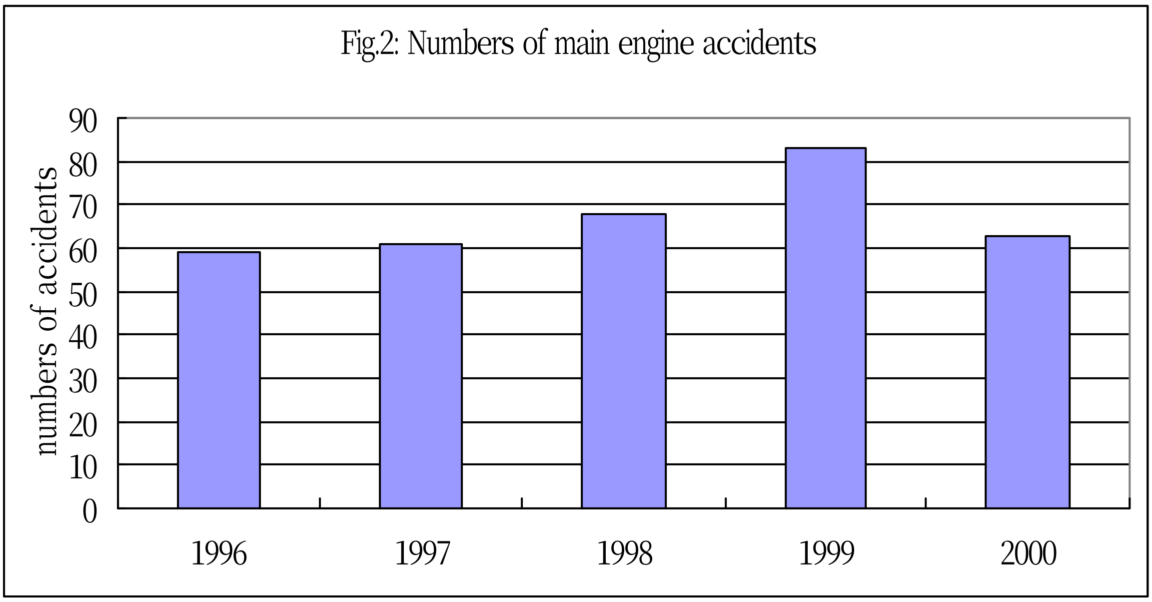


Fig.2: Numbers of main engine accidents
numbers of accidents
90
80
70
60
50
40
30
20
10
0
1996
1997
1998
1999
2000

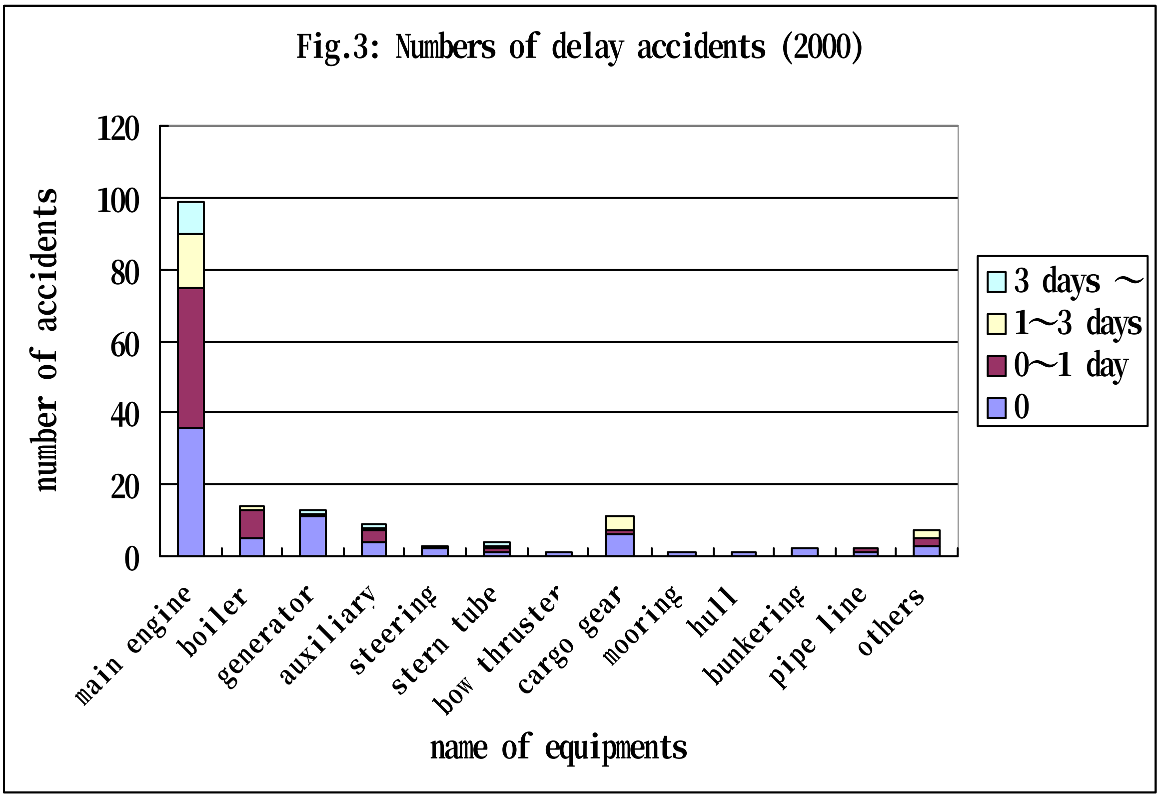


Fig.3: Numbers of delay accidents (2000)
number of accidents
120
100
80
60
40
20
0
main engine
boiler
generator
auxiliary
steering
stern tube
bow thruster
cargo gear
mooring
hull
bunkering
pipe line
others
name of equipments
3 days ～
1～3 days
0～1 day
0

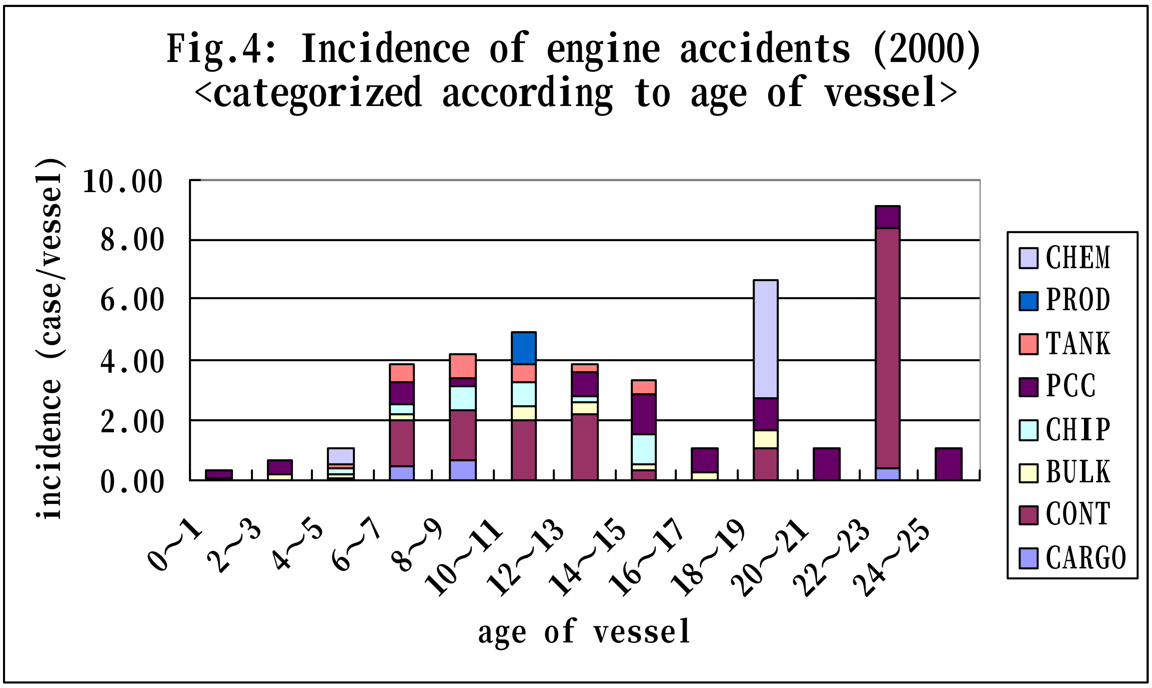


Fig.4: Incidence of engine accidents (2000)
<categorized according to age of vessel>
incidence (case/vessel)
10.00
8.00
6.00
4.00
2.00
0.00
0～1
2～3
4～5
6～7
8～9
10～11
12～13
14～15
16～17
18～19
20～21
22～23
24～25
age of vessel
CHEM
PROD
TANK
PCC
CHIP
BULK
CONT
CARGO

Fig.5: Number of engine accidents
<categorized according to age of vessel>

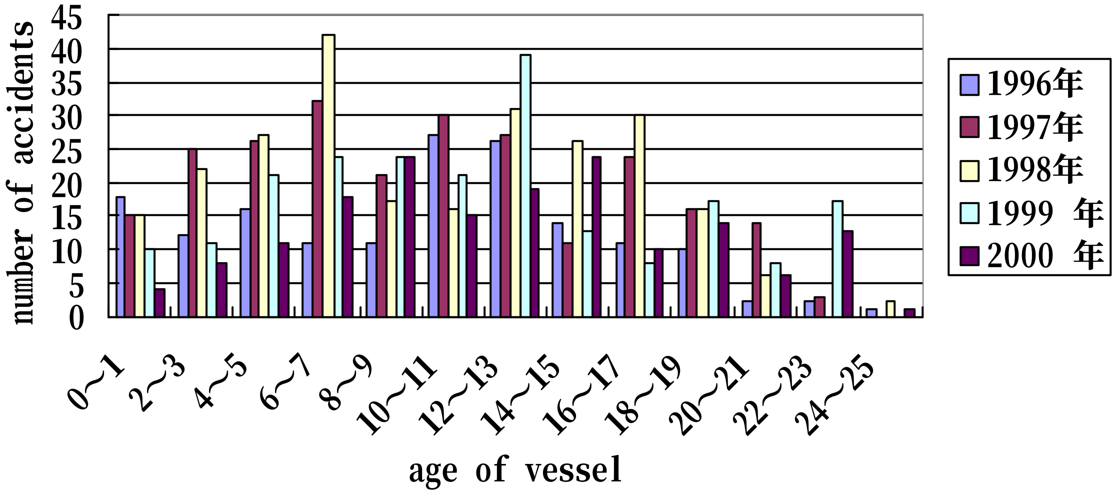
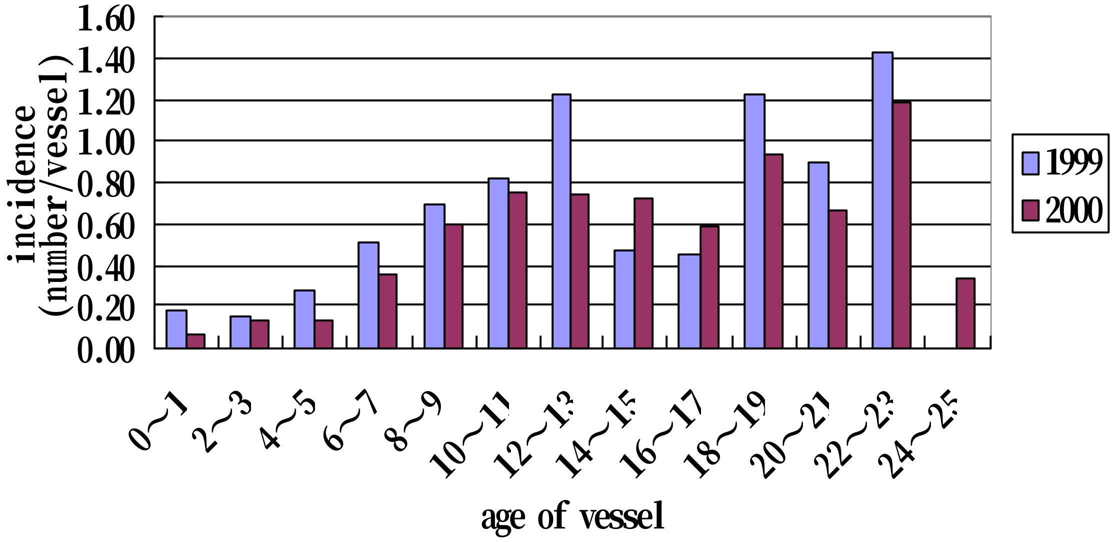


Fig.6: Incidence of engine accidents
<categorized according to age of vessel>



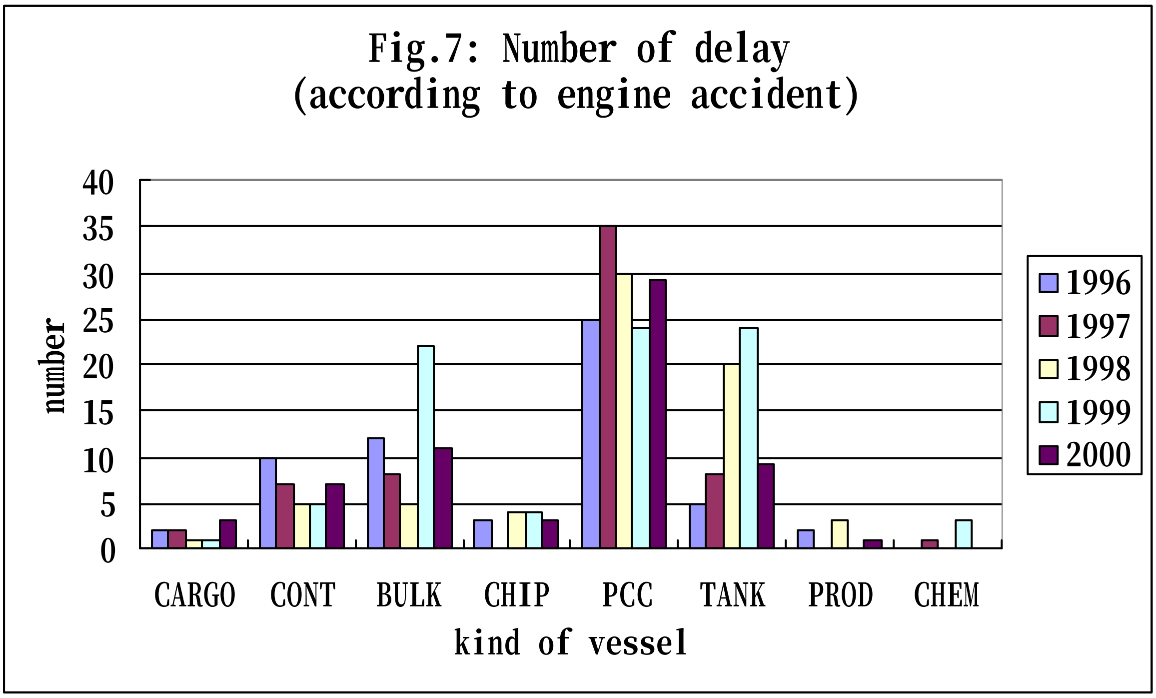


Fig.7: Number of delay
(according to engine accident)
40
35
30
25
20
15
10
5
0
number
1996
1997
1998
1999
2000
CARGO
CONT
BULK
CHIP
PCC
TANK
PROD
CHEM
kind of vessel

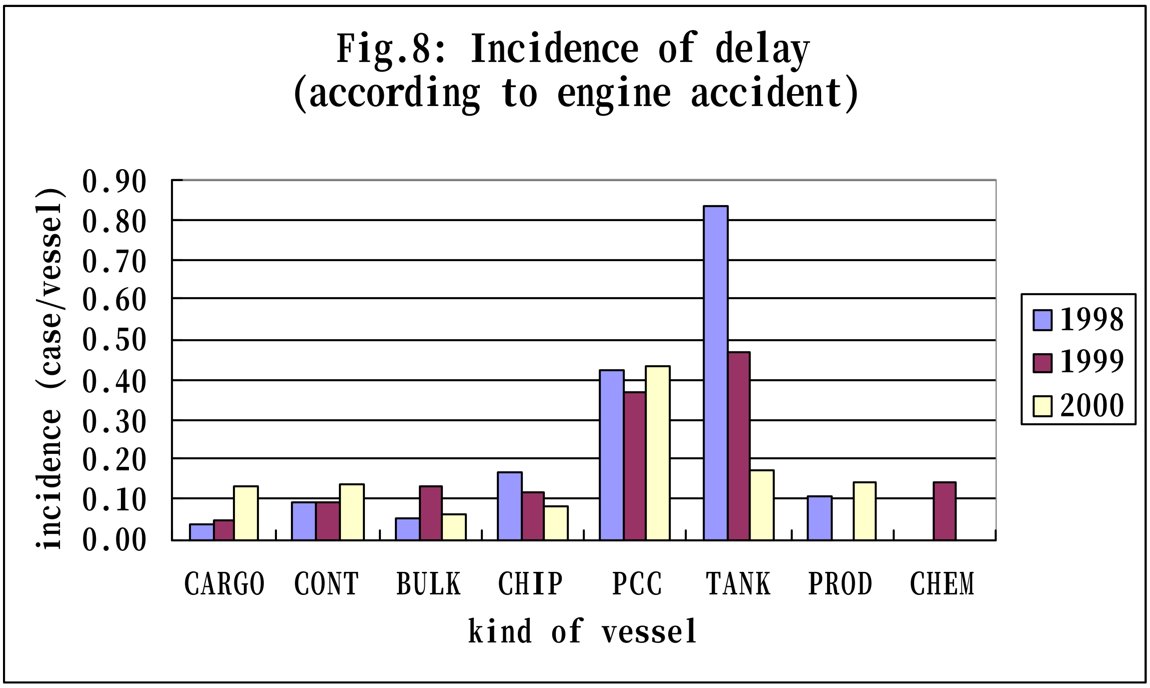


Fig.8: Incidence of delay
(according to engine accident)
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
incidence (case/vessel)
1998
1999
2000
CARGO
CONT
BULK
CHIP
PCC
TANK
PROD
CHEM
kind of vessel

Fig.9: Number of engine accidents (1998)
<according to damaged parts>

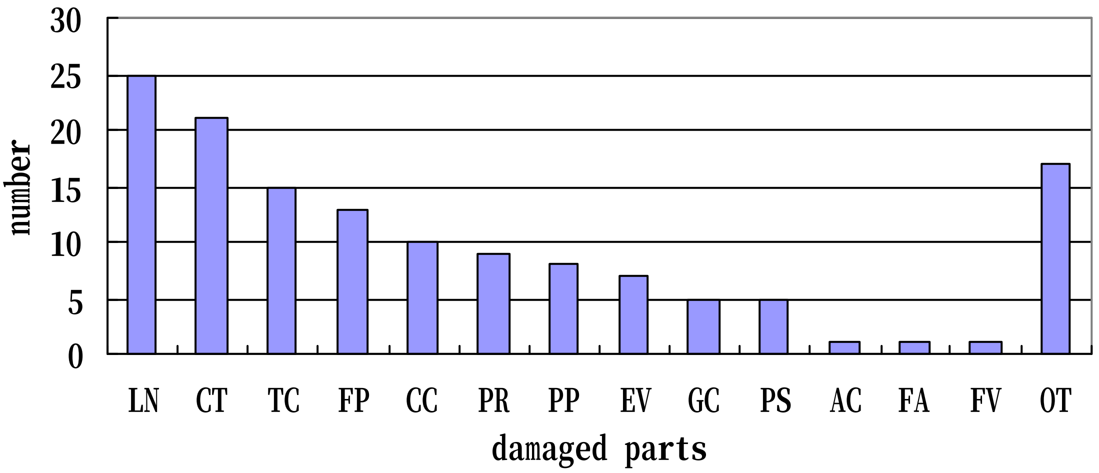
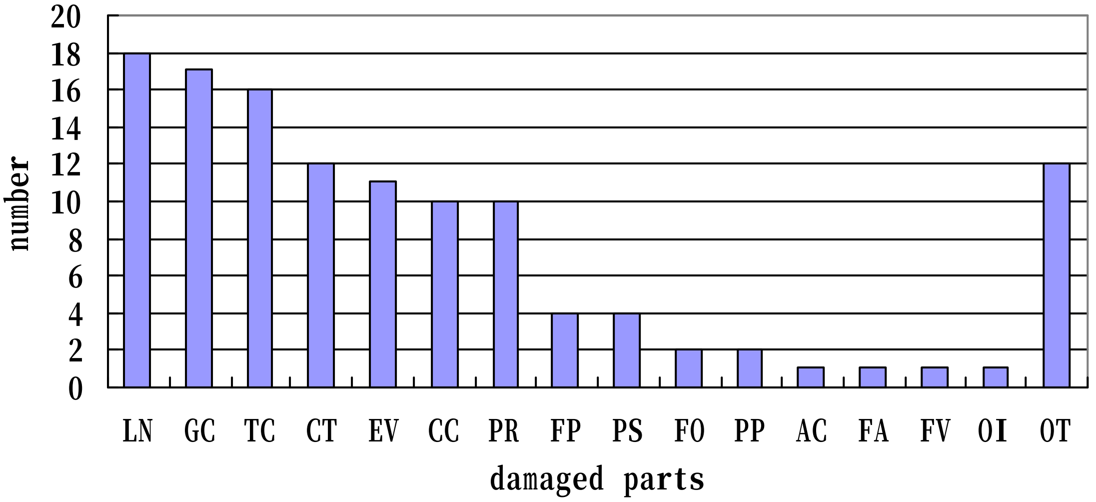
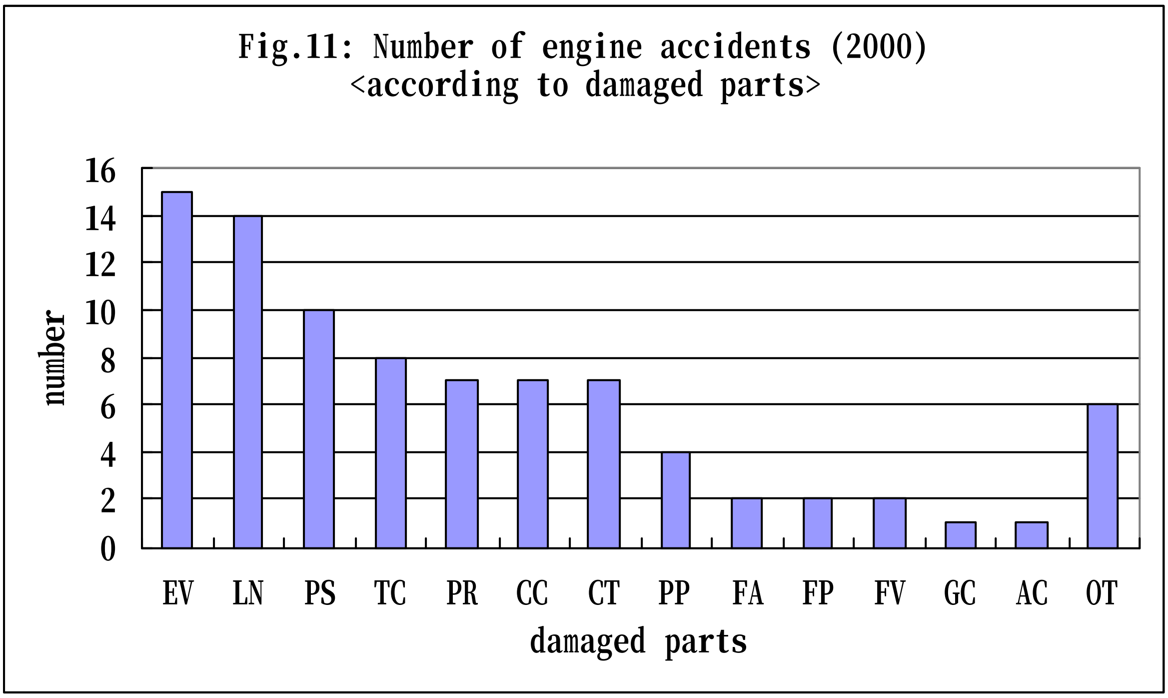


Fig.10: Number of engine accidents (1999)
<according to damaged parts>

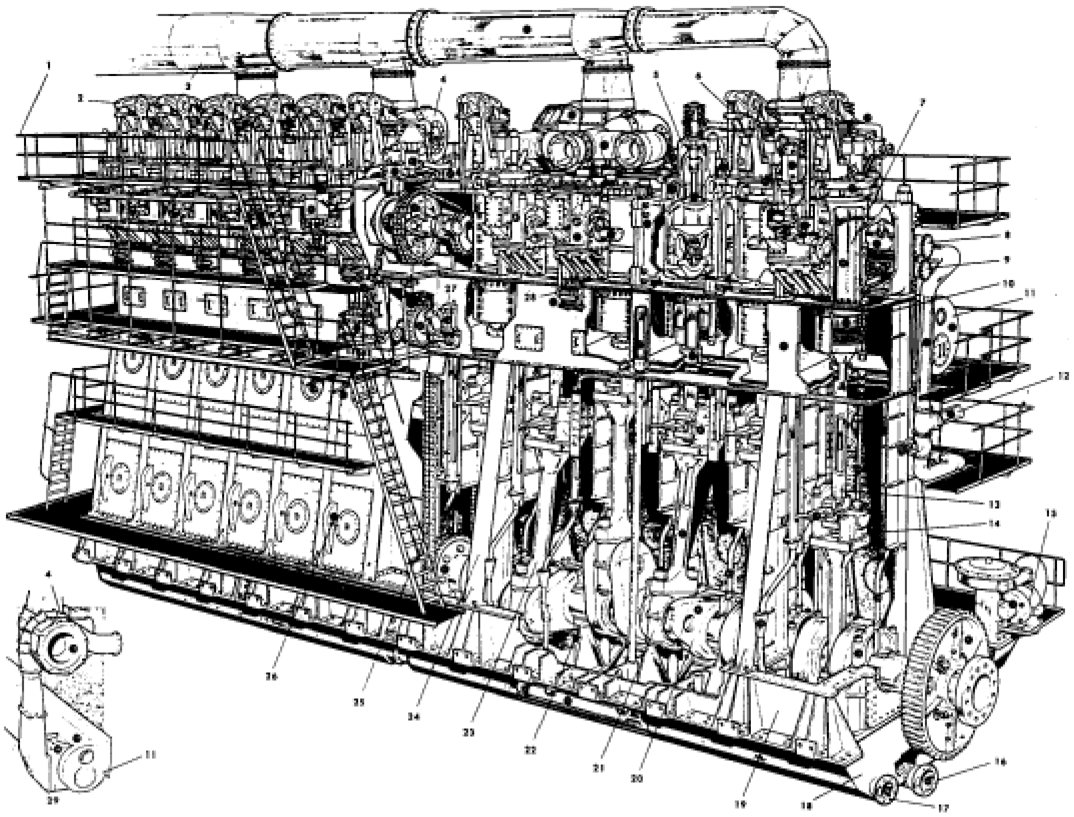




LN: Cylinder liner	GC: Bearing, shaft, cam shaft	TC: Turbo charger	CT: Control equipment
EV: Exhaust valve	CC: Cylinder cover	PR: Piston ring	FP: Fuel pump
PS: Piston	FO: Fuel	PP: Pipe line	AC: Air cooler
FA: FO Pump driving system	FV: Fuel valve	OI: Lubricator	OT: Others

Contents

1． Main engine



Engine accident cases

File No.	1 - 001				
Case name	Explosion of main engine crank case				
Device name	M/E	Damaged part	Camshaft Driving Unit	State of damage	Overheated/ Bent Shaft
Maker name	MES	Model	MAN B&W7K90MC	Total working time	Unknown
Kind of ship	Container	Date of occurrence	1997.12.06	Place of occurrence	Pacific Ocean
Cause of damage/problem	Hardware factor	Foreign object into M/E SYS. OIL ?			
	Software/human factor	Foreseeability as marine engineers			

Ⅰ. Outline of Accident

[Course of Event]

While the vessel was sailing in the North Pacific Ocean in December 1997, main engine oil mist high alarm sounded around midnight and then, main engine stopped itself just after the occurrence of explosion inside the crankcase of main engine.

Damages in and around main engine and the causes of the accident were surveyed in detail by crew and it was found that the fore side bearing for cam shaft driving chain wheel was overheated and melted, which probably caused the explosion.

An ocean going tugboat was arranged from Seattle immediately and commenced towing the vessel for, Hawaii on December 16.

[State of Damage]

(1) Fore side bearing for camshaft driving chain wheel were burnt, melted-down.

(2) Aft. side bearing for camshaft driving chain wheel showed strong touch mark due to cantilever-like support.

(3) Shaft for camshaft driving chain wheel was burnt, bent and deeply grooved.

(4) Crank case inspection doors were all bent inwardly.

(5) A-class doors in accommodation space (A, C, D and upper deck engine room entrance, central store, reefer container transformer room, No. 7 hold entrance, engine room 2nd deck) were bent.

(6) Bridge wing door was blasted off.

(7) Oil Mist Detector was broken.

(8) Some lighting and instruments, etc. were damaged.

* It was fortunate that small local fires in engine room after explosion were extinguished by crew hands at the early stage and suffered no human injury.

[Disposition]

(1) Towed ship to Honolulu by tugboat, where damaged parts were repaired.

(2) Installed thermometer for Camshaft driving wheel bearing which was a cause of explosion, and monitored and recorded bearing temperature.

(3) Cleaned LO sump tank and cleaned inside of all LO pipes.

Ⅱ. Cause of Accident / Underlying Problem

[Mechanical Factor]

The cause of these damages would be

(1) Lack of LO to the damaged cam shaft driving chain wheel bearing, or

(2) Miss-alignment of cam shaft.

The most probable cause was thought to be a lack of LO due to the incoming of some foreign substance into lubricating oil (LO) system. The substance might obstruct lubrication of the damaged bearing.

The above assumption was introduced from the facts that one of four elements of main engine LO secondary strainer was found to be partly broken (the lower end corner of gauze wire was torn) and replaced with spare at the last dry docking, and a piece of broken gauze wire (size: 4cm x 5cm) was found in the main LO pipe on this time surveythough it could not identified as the fragment of the broken element. At any rate, these facts mean that main engine was being operated with defective LO secondary strainer for some period and material might ingress into LO branch line and reach to the bearing metal clearance.

Ⅲ. Preventive Measures

[Mechanical Aspect]

(1) LO secondary strainer

Sound lubricating depends fully on the proper management of LO itself and maintenance of LO strainers. Especially, secondary strainer functioned as the last checker for main engine lubricating system and its normal working including back washing is crucial for main engine operation.

Recently, we experienced another case of engine trouble regarding LO secondary strainer on other vessel. In that case, the clogging of element from the malfunction of auto back washing stopped engine frequently.

Therefore,

(a) Each LO strainers should be overhauled periodically and be always kept in good condition.

(b) Overhaul interval should be shortening for after dry-docking.

(c) Chief engineer or first engineer must check himself the condition of strainer element elaborately and confirm whether the gauze wire is sound or not.

(d) Pressure difference between inlet and outlet of LO strainers should be observed carefully and recorded, and when it shows smaller or larger than usual, specify the reason for that.

(e) Auto back wash mechanism should be tried daily.

(2) Oil mist detector

Operation of oil mist detector should be checked daily. Adjustment of “ZERO” point and sensitivity should be done periodically.

(3) Crank case and chain case inspection

Each bearing, tightening bolts, LO piping and other working parts in crank case and chain case should be inspected periodically and carefully.

[Human/Software Aspect]

In case we found any strainer element broken, we should think of that as a very serious matter and take following procedures:

(1) Investigate the cause and the time that happened.

(2) Check if any pent of element is missing or not and if so, search all over the lub. Oil system and find out it.

(3) Check in detail the bearings, oil spray nozzle etc.

IV. Lessons

When we find any abnormality on the machinery/equipment, we should think over the consequence it might have brought about, while investigate the cause thoroughly.

Only we find any abnormality against the danger underlying can prevent accidents.

Engine Trouble Cases

File No.	1 - 002				
Case name	Damaged spare rotor bearing for main engine turbocharger				
Device name	Main engine	Damaged part	Spare part	State of damage	Fretting
Maker name		Model		Total working time	
Kind of ship		Date of occurrence		Place of occurrence	
Cause of damage/problem	Hardware factor	Vibration			
	Software/human factor	Improper storing condition			

I. Outline of accident

[Course of events]

While overhauling No. 2 turbocharger during drydock period, it was found the rotor was defective. In order to replace the rotor with a spare one, the latter was taken out from storage box upon inspection found the blower side bearing sealing was damaged.

[State of damage]

Damage of the turbocharger rotor in the bearing (sealing) portion on the blower side.

[Response measures]

It was decided to repair the damaged part during the next drydocking and the damaged rotor was restored.

When restoring the rotor, it was wrapped with hemp cloth and a lead plate, which was secured with a band.

II. Causes of accident/problems

[Hardware factors]

The storage box is a good one made of steel and the rotor was set with the shaft covered at the bearing section with a lead plate around, which was fastened with a band. Due to vibration the lead gave way gradually, making the shaft come in direct contact with the (steel) band, causing resultant damage.

[Software/human factors]

The storage box left unattended. There was no inspection of any soot.

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

Result of such an incident it is become necessary to keep a good cook on stored, we are impressed for the first time with the equipment and their condition.

While it is not necessarily known to everybody, we have experienced many cases where spare parts were not usable when in need because they had been poorly controlled. Spare parts are precious property and their unavailability in good condition may, in cases, impair ships' smooth operation. There is a need to check the condition of spare parts carefully at regular intervals.

Ⅳ. Lessons

They say that "appearance is deceiving." It holds true not only for people but also for things.

Engine accident cases

File No.	1 - 003				
Case name	DAMAGE OF M/E CAM SHAFT DRIVING GEAR				
Device name	M/E	Damaged part	Cam shaft driving mechanism	State of damage	Teeth broken
Maker name	UBE INDUSTRIES, LTD.	Model	6UEC60HA	Total working time	13 years
Kind of ship	PCC	Date of occurrence	1997.12.26	Place of occurrence	Indian sea
Cause of damage/problem	Hardware factor	Excessive vibration or poor fitting			
	Software/human factor	Insufficient check			

Ⅰ. Outline of Accident

[Course of Event]

During routine inspection in the engine room, the duty engineer found two pieces of broken bolts being used for main engine lower idler gear supporter. The engine was stopped immediately. During stopping engine, the other bolts for the supporter unit got broken and a creaking sound from the gear train was noticed. Investigation after sufficient cooling down of the engine revealed that all the cam shaft driving gear wheels (total 4 sets) were damaged. An ocean going tugboat was arranged and commenced towing the vessel for Colombo, where survey and repair were done.

[State of Damage]

(1) Lower idler gear: 5 teeth broken. Crack on some teeth at their roots. Abrasive wear
(2) Upper idler gear : abrasive wear
(3) Crankshaft gear : abrasive wear
(4) Camshaft gear : abrasive wear
(5) Supporter of lower idler gear : all bolts and taper pin broken

[Disposition]

The repair work carried out at Colombo.

(1) Renewed Crankshaft Gear and both Lower and Upper Idler Gears.
(2) Remounted shaft assembly for both Lower and Upper Idler Gears with new bolts and taper pins.
(3) Renewed thrust pads at Forward Thrust Bearing.
(4) Installed Supporter Unit and adjusted end clearances.
(5) Re-confirm the timing of the gears.
(6) Carried out alignment of all gears.

(7) Carried out the balance of works.

(8) Checked on crank shaft deflection.

Ⅱ. Cause of Accident / Underlying Problem

[Mechanical Factor]

The fixing bolt came loose in the lower idler gear shaft for some reasons, such as vibration or improper fixing. The shaft lowered with its own weight, which brought the backlash between the lower idler gear and the crankshaft gear to zero. Tooth contact is shifted from normal pitch circle to dedendum under such a condition.

This shows that twice-greater stress is applied, leading to overstress and tooth contact failure. Judging from the condition of the rupture in the teeth, fatigue crack occurred probably first, and then it developed into the fatigue breakage.

Ⅲ. Preventive Measures

[Mechanical Aspect]

Engine troubles of this kind often make the vessel dead for long time.

The masters and the chief engineers of the vessel, especially in which the same type of engine (UEC) is installed, are strongly requested to keep the adequate maintenance of main engine according to the attached manufacture's service information in order to prevent the recurrence of the similar engine troubles. Besides the manufacture's information, the following inspections are also done regularly.

(1) Visual inspection of idler gear shaft and shaft support whether steady or not.

(2) Inspect the clearance between idler gear shaft and shaft support. (every2000 – 4000 hours)
Normal value of this clearance is 0 – 0.07mm

(3) Visual inspection of the gear shaft flange and the tightening bolt whether loosening or not.
(every 2000 – 4000 hours)

[Human/Software Aspect]

It is unknown how long time has passed since the fixing bolts of the lower idler gear started to come lose, however, any sign of abnormality might be found by regular inspection of crank case.

We should bear it in our mind that regular inspection is done with specific intention in every occasion so that any slight sign of abnormality can be found.

Check list is useful for that purpose and it should be made for some groups of parts separately, i.e. one for main bearing, one for camshaft driving system etc.

And in every inspection each group is inspected in detail cyclically using this checklist.

Ⅳ. Lessons

Irrespective of gear-drive or chain-drive, camshaft driving system is crucial for the sea worthiness of the vessel. Its trouble influences her safety immediately. (That of UEC type of engine should be cared in particular because of the fragility of gear supporting system.)

Only regular and systematic inspection can make possible early discovery of sign of abnormality, though some parts reject detailed inspection physically.

Ⅴ. Reference

1.A few similar troubles relating camshaft driving system are reported recently.

(1) Semi-container ship, M/E Type：8UEC60LS (DEL. in 1992)
Lower idler gear bush was damaged and crack and pitting of this gear.
This ship was obliged to stay at port for eight days for the repair of bush.

(2) Semi-container ship , M/E Type：SULZER-6RND90(DEL. in 1977)
Upper and lower idler gears were damaged: crack on some teeth at their roots; broken bolts of M/E upper idler gear flange and deformed holes for them due to fretting; damaged cramp flange of M/E upper idler gear.
The ship was obliged to stay at port for eight days for the renewal of crank and idler gears and other necessary repair.

2.Sample Manual for Inspection of Cam Shaft Driving System

Besides the above measure, a ship manager adds the following items into manual.

(1) Visual inspection of bottom casing of gear case for foreign material – every 2- 4,000 hrs.

(2) Visual inspection of pressure face of each driving gear tooth for discoloration, pitting and crack – every 2- 4,000 hrs.

(3) Crack detection test of the pressure face of each driving gear tooth – every 8- 12,000 hrs.

(4) Magnetic particle test on the contact face and the roots of gear teeth. At least, check fillet surfaces of crankshaft gear around joining parts of each half of the gear – to be conducted 20- 30,000 hrs (docking).

(5) Measurement of backlashes between each driving gears – every 6- 8,000 hrs and 20-30,000 hrs (docking).

(6) (Proper cares to be taken while measuring backlash)

(7) Visual inspection of white metal on the thrust face of idler/intermediate gear wheel bushes – every 2- 4,000 hrs.

(8) Inspection of thrust clearance of idle gear bushes – checking of the clearance with feeler

gauge may not always be possible. For this purpose, a use of 0.5 ton hydraulic jack, to shift the gear axially, and a dial gauge will be useful – every 8- 12,000 hrs.

(9) Inspection of gear housing (yoke) fixing bolts – hammer test – every 6- 8,000 hrs.

(10) Inspection of idler/intermediate gear wheel support pin (shaft) fixed/reamer bolts –hammer test – every 8- 12,000 hrs.

(11) Inspection of crankshaft gear tightening bolts – every 20- 30,000 hrs (docking).

(12) Crack detection test of idler/intermediate gear wheel support flange weld to ‘A’

(13) frame and surrounding area – every 8- 12,000 hrs.

(14) Check of slip between crankshaft gear and crankshaft by dial gauge. Be careful in case the deflection recorded is more than 1- 2/100 mm because there is a possibility of a slip on the relation between crankshaft and crankshaft gear. As to the method of checking, as shown in the sketch, fit the dial gauge on thrust collar and turning a little the engine in ahead or astern direction – every 8- 12,000 hrs.

(15) Inspection of stern end keyway for the crankshaft and gear by magnetic particle test

(16) every 45,000 hrs (once in five years – docking).

(17) Condition of spray nozzle for lubricating oil – every 2- 4,000 hrs.

3.observation of gear tooth face

In case continuous observation of face condition of gear tooth is needed, it is recommended to take and record the stamped marking of them using carbon powder (powdered pencil lead) and adhesive tape.(Refer to the attached samples)

[Attachment]

(1) MITUBISHI SERVICE INFORMATION : DS 91-102E “Inspection manual for camshaft gears of the UEC engines”

(2) MITSUBISHI SERVICE INFORMATION : MSI-8901E “Maintenance and information of engine main parts”

(3) Samples of stamped markings of gear face

MITSUBISHI HEAVY INDUSTRIES, LTD. SERVICE INFORMATION

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YOKOHAMA BRANCH 12, NISHIKI-CHO NAKA-KU, YOKOHAMA, JAPAN TEL (045) 625-2516~8 TELEFAX (045) 625-2596

Subject : -		
Inspection manual for camshaft driving gears of the UEC engines	Clasification	DIESEL ENGINE
	Type	UEC-H,HA,L,LA,LS
	No.	DS 91-102E

Inspection and maintenance schedules for camshaft driving gears are described in instruction books. We now supplement detail procedures with the following.

	Inspection interval	2～4000hrs	6～8000hrs
1.	Inspection of the contacting conditions between each driving gear teeth.	○	
2.	Measurement of backlashes between each driving gears and inspection of thrust clearance of idle gear bushes.		○
3.	Inspection of white metal on the thrust face of idle gear bushes for spoiling off. (Visual inspection)	○	
4.	Check the slip between crankshaft gear and crankshaft by dial gauge. (Refer to Note 1.)	○	
5.	Check of gear housing fixing bolts, fixing bolts of supports for idle gear shafts and knock pins whether loosening or breakage.	○	

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YOKOHAMA BRANCH
TECHNICAL DEPARTMENT

6.	Magnetic particle inspection on the contact face and the roots of teeth. (Refer to Note 2.)	Every 12000~ 16000hrs
7.	Inspection of crankshaft gear tightening bolts whether loosening or not.	Every four years (At the inspection time for No.1 main bearing.)
8	Inspection of stern end of key way for the crankshaft and crank gear by magnetic particle inspection in detail.	

Note 1. Check extremely carefully in case the deflection of the dial gauge is more than 1～2/100 mm because there is a possibility of a slip on the relation between crankshaft and crank gear.

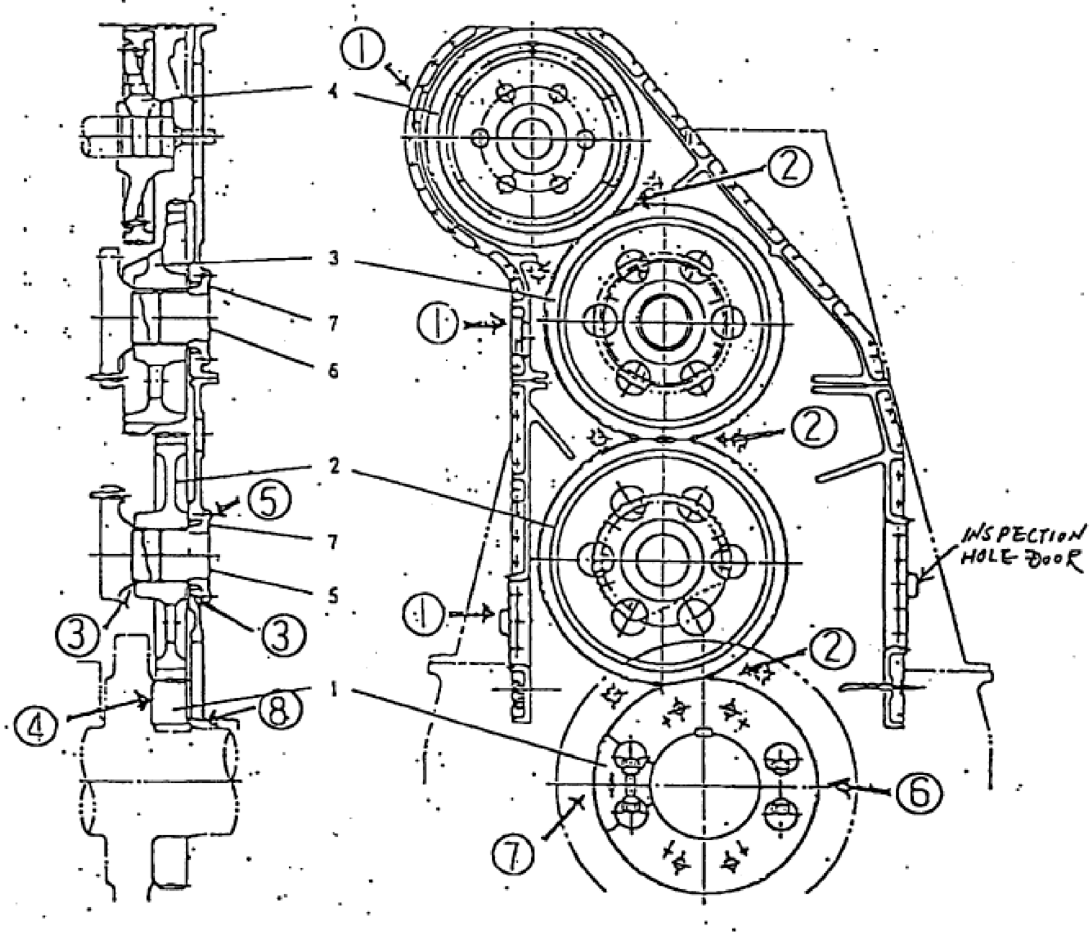
As the method of checking, fitting a dial gauge on thrust collar like shown below figure and turning a little to AH or AS.

Note 2. At least, check fillet surfaces of crankshaft gear around joining parts of each half gears.

Fig. 1 Check point of camshaft driving gear

カム軸駆動装置点検個所

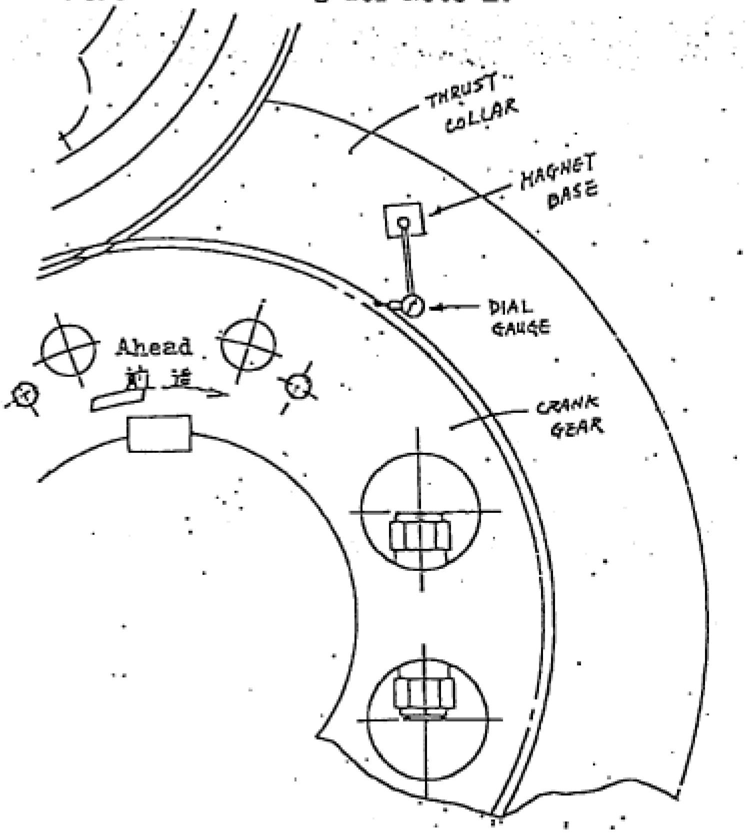
1. Crankshaft gear.
2. Idle gear(1st)
3. Idle gear(2nd)
4. Camshaft gear
5. Idle gear shaft(1st)
6. Idle gear shaft(2nd)
7. Support for idle gear shaft



Remarks : in circle & arrows show the check items described page1.

図中の○の中の数字と矢印は1頁に記述した項目No.と点検個所を示す。

Referance drawing for Note 1.



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Subject : Maintenance and Inspection of Engine Main Parts	Clasification	MITSUBISHI-SULZER Diesel Engine
	Type	RND (M), RL, RTA
	No.	MSI-8901E

In regard to the captioned matter, standard inspection intervals are shown in The Service Instruction part 055 for RND(M), and in the Maintenance Manual part 003 for RL and RTA.

In recent years, there is very rare instance in which ships enter a dock every year, consequently it seems that maintenance and inspection works of main parts which used to be carried out during docking are apt to be left over as they are.

In connection with this point also, since there appear some instances in which serious troubles have occurred recently like breakage of tension bolts, damage on balancer bearing, etc., we would request you to carry out maintenance and inspection of main parts with certainty according to the schedule as described in the above-mentioned operational instruction.

Further, for the under-mentioned parts, first of all, please take special attention so that nothing goes amiss.

HISTORY		
		KOBE SHIPYARD & ENGINE WORKS DIESEL DEPARTMENT
		MHI DIESEL SERVICE CO., LTD. KOBE BRANCH TECHNICAL SERVICE DEPARTMENT
		April, 1989

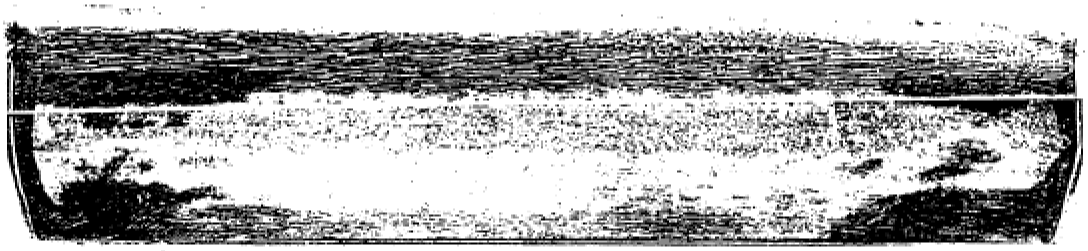
Parts	Contents of Maintenance & Inspection	Interval
Bed plate	Retightening of holding down bolt	6000～8000 hrs.
Tension bolt	Retightening of bolts : First time 2nd time and after	6000～8000 hrs. 4 years
Cam shaft driving gear	Tooth surface condition Back rush and oil clearance of bearing	3000 hrs. 6000～8000 hrs.
Cam shaft bearing	Oil clearance of bearing	6000～8000 hrs.
Fuel cam and Exhaust cam	Sliding surface (including roller)	1500 hrs.
Balancer	Tensioning of roller chain : First time 2nd time and after	500 hrs. 3000 hrs.
Piston crown	Retightening of fixing bolt Cleaning of cooling space and its corrosive condition of water cooled type	2 years 2 ～ 4 years

Note) Retighten the nut for fuel pump cam other than RTA at every 3000 hours.

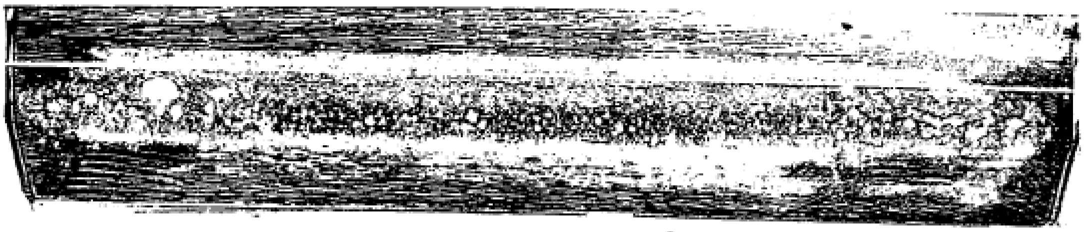
CHECKED AT STAMPED MARKINGS OF AXIAL EDGE OF GEAR TEETH
ACCORDING TO FIRING POSITION OF UNIT NO

PG 1/2

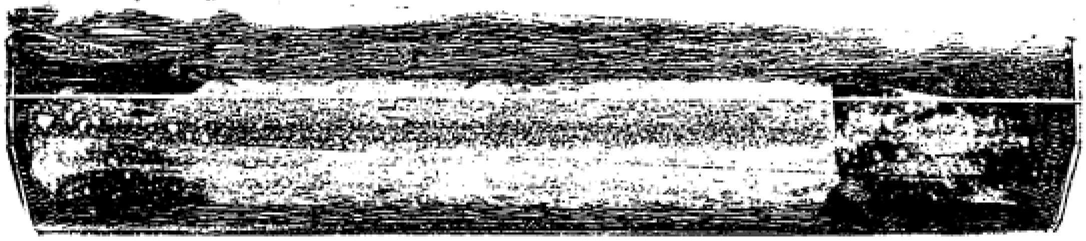
ONOMICHI DOCKYARD, 13 APR 98
RPM COUNTER = 40206290
TOTAL RUN HRS. = 97557



UNIT No 5



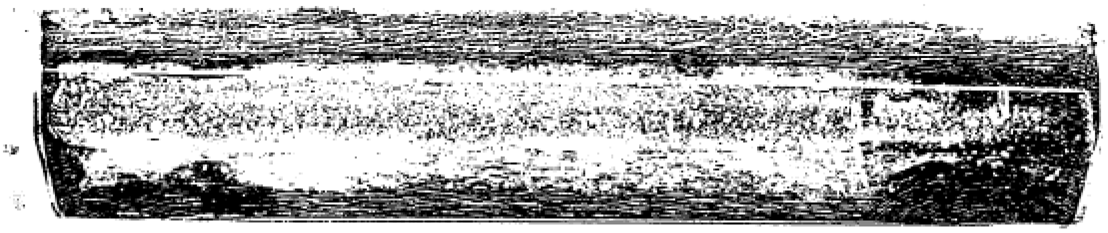
UNIT No 3



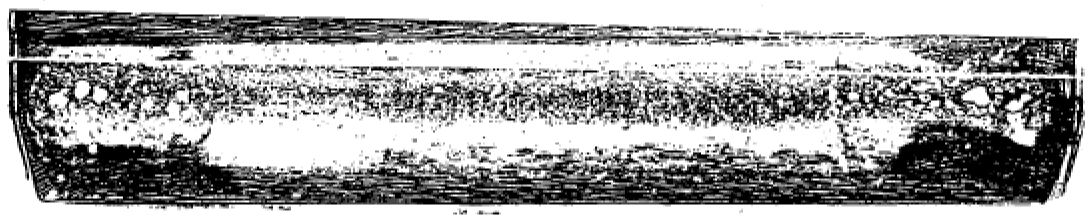
Note mark on tooth =>   A

UNIT 4 TOOTH → AFT MARKING OF 4 DOTS IS CORRECT

UNIT No. 2



UNIT No



UNIT No 1

Engine accident cases

File No.	1 - 004				
Case name	Crack of main engine cylinder liner				
Device name	M/E	Damaged part	Cylinder liner	State of damage	Heat crack
Maker name	HITACHI ZOHSEN	Model	B & W 7S80MC	Total working time	First voyage
Kind of ship	TANKER	Date of occurrence	1996.08.05	Place of occurrence	At sea
Cause of damage/problem	Hardware factor	Improper tightening of inner pipe fitting bolts			
	Software/human factor	Poor running maintenance			

I. Outline of Accident

[Course of Event]

August 4

1510 hours: Impact sounds were generated intermittently from the port side of No. 1 cylinder crankcase, when the piston cooling oil outlet temperature went up from 52 to 55ºC.

1632 hours: The engine was stopped and the crankcase was opened and checked. No abnormality was found.

1700 hours: The main engine was restarted and its speed was accelerated to sea speed.

2230 hours: Without any impact sound, the piston cooling oil outlet temperature returned to the normal value (50ºC).

2330 hours: Light impact sounds were emitted and piston cooling oil temperature rose to 52ºC.

August 5

0108 hours: Dull reports were released in the engine room while the machinery spaces were kept unattended to.

0109 hours: The scavenge chamber fire alarm and engine room fire alarm were set off, tripping the main engine to an emergency stop. At this time, cooling water was gushing out from No. 1 cylinder cooling water jacket.

0115 hours: On the basis of diagnosis of a leak of No. 1 cylinder piston cooling oil, the main lube oil pump was stopped.

[State of Damage]

(1) Cylinder liner

A vertical crack stretching approximately 1580 mm, almost 1/2 of the total length, was found starting from the upper end positioned at an angle of 30º to the port side from the aft.

(2) Cooling water jacket

A crack (1 to 2 cm wide) running through the entire length of the jacket was found almost at the same position as that of the cylinder liner's crack.

(3) Piston

It was severely burnt down, with its crown, skirt and piston rod fused together. As it was impossible to disassemble the piston, it was landed and disassembled in a shop to investigate into the cause.

The inspection revealed that the piston cooling inner pipe severed at the flange section and that the fitting bolts of the pipe fractured.

(4) Crosshead

Traces of damage in the aft port portion of the guide shoe. It is presumed to have been caused by the entry of metal fragments resulting from the breakage of the piston inner pipe.

(5) Connecting rod

A metal fragment (60, 30mm in diameter) was discovered inside the bored passage of lube oil from the crosshead bearing to crankpin bearing.

(6) Crankpin bearing

Metal fragments found their way into oil grooves of the white metal, damaging the contact surface. The crankpin was also found to have suffered thin scratch marks.

[Disposition]

The operation of No. 1 cylinder became impossible since the cooling jacket, whose spare was unavailable on board, also suffered damage.

For this reason, the piston was replaced with a fully outfitted spare, but the liner and cooling jacket were placed in position as they were. The main engine was restarted with No. 1 cylinder cut out -cooling water shut down, exhaust valves in the normal state and fuel oil cut off.

The vessel sailed for eight days at a reduced speed of 60% of the rated output while there were still leaking sounds of compression air through the cracked liner. After her cargo was discharged in Japan, the engine was repaired.

Ⅱ. Cause of Accident / Underlying Problem

[Mechanical Aspect]

The following process of the development of the accident is considered to have taken place and the accident is presumed attributable to the inadequate tightening of fitting bolts of the piston cooling inner pipe.

As the accident occurred when the vessel was still new, its cause can be traced to a mistake of a worker of the shipbuilder.

(1) The fitting bolts for the piston inner pipe worked loose and the inner pipe began dancing vertically by inertial force while the engine was in operation. The bolts came off and the vertical motion of the inner pipe increased gradually, leading to the fractures of the bolts and, finally, the inner pipe itself.
(The impact sounds released on the previous day of the accident can be attributed to the free movement of the piston inner pipe as a result of its severance.)

(2) As a result, piston cooling oil was cut off and the piston abnormally overheated as it was not cooled any more.

(3) The piston rings seized and blowby occurred. As a result of the unusual overheating, the piston itself seized against the liner, with the liner mating surface suffering scuffing and heat cracks.

(4) Abnormal combustion was caused by unburnt lube oil.

(5) Part of the heat crack in the cylinder liner progressed to a serious vertical crack as a result of the explosive force caused by the abnormal combustion.

(6) The cooling jacket which, by the heat expansion of the liner, was put in a state to embrace the liner directly, with no clearance for the 'O' ring, was destroyed at the same time as the generation of the vertical crack in the liner.

[Human/Software Aspect]

(1) The rise in piston cooling oil means a leak of combustion gas through the top ring. The normal temperature for the engine of the vessel is 50ºC. When it climbed to 52ºC, the top ring is considered to have begun to leak; and when it reached 55ºC, the cylinder is presumed to have suffered blowby at times.

However, since the accident occurred on her maiden voyage, the engine must have contained sufficient cylinder oil and, thus, it did not continuously sustain blowby.
It follows that an inspection of the scavenge space, i.e., piston rings and liner, in addition to the crankcase, when the main engine was stopped, could have prevented

such a serious accident as there must have been traces of blowby.

The peep hole of the scavenge space is very effective and if you stare through the hole for some time you may take notice of occasional blowby. In the case of a temperature rise of piston cooling oil, there is a need to make a close observation.

(2) Wasn't the delivery pressure of the lube oil pump pulsating, since the piston cooling inner pipe came off?

III. Preventive Measures

[Mechanical]

[Human/Software]

IV. Lessons

The accident is an incredible one, but as long as the engine was assembled by men, it is not always perfect even in the case of newly built vessels.

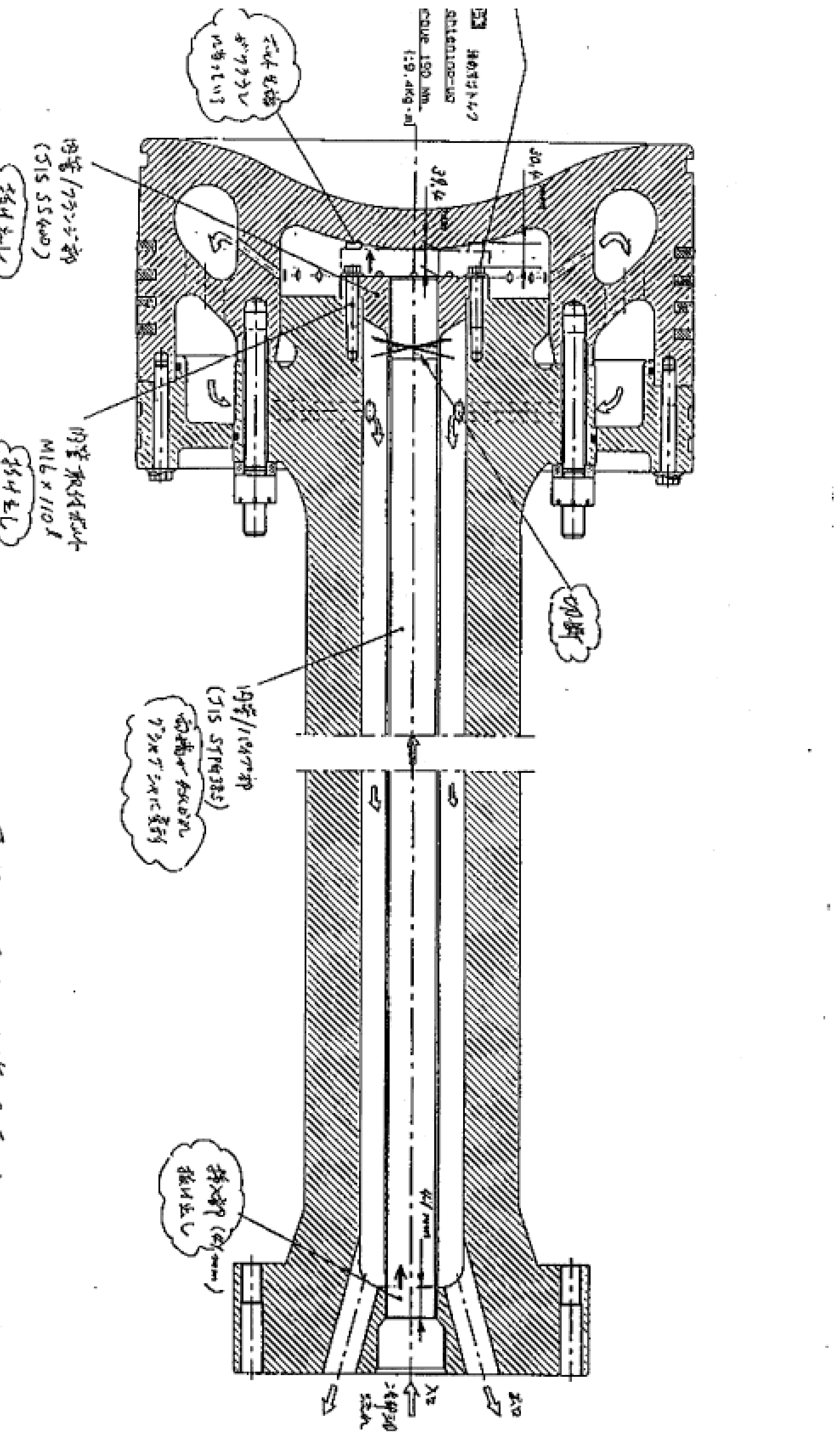


図-2, ピストン内管損傷状況

Engine accident cases

File No.	1 - 005				
Case name	Defect of main engine cylinder lubricator driving mechanism				
Device name	M/E	Damaged part	Cylinder lubricator	State of damage	Wear
Maker name	DU	Model	DU8RTA62	Total working time	2 years
Kind of ship	BULKER	Date of occurrence	1996.03.19	Place of occurrence	At sea
Cause of damage/problem	Hardware factor	Unknown			
	Software/human factor				

Ⅰ. Outline of Accident

[Course of Event]

(1) The consumption of cylinder oil was found to be less than usual according to calculations at noon on March 20.

(2) From the fact that a calculation made at 1900 hours on March 19 proved that there was no problem with oil consumption, it was thought that a defect occurred after that time.

(3) A cylinder oil non-flow alarm was not set off or main engine slowdown did not occur.

(4) The delivery pressure of the cylinder lubricator gear pump dropped from the normal 7 bars to 5 bars, resulting in the speed reduction of the driving hydraulic motor from the normal 150 rpm to 100 rpm (see the attached Fig-1).

(5) In compliance with the instructions manual, the supply of lube oil to the hydraulic motor was changed over so as to derive from the crosshead lube oil system.

[State of Damage]

(1) After stopping the main engine, the valve assembly of the gear pump was opened. No abnormality was observed with the inlet or outlet valves, but metal fragments were found in the outlet valve (see the attached Fig-2).

(2) The gear pump driving system did not show any abnormal condition.

(3) Metal fragments were observed in the vane section of the hydraulic motor, which was replaced with a spare motor (see the attached Fig-3) .

(4) In order to determine from where the metal fragments originated, the strainer on the sludge drain line coming from the main engine lube oil filter was checked, but no abnormal condition was detected. An inspection of the crankcase did not show any defect, either.

(5) After the gear pump was restored, the main engine was restarted. The pump delivery pressure maintained 5 bars and did not rotate the hydraulic motor.

(6) At this point in time, the abrasion of gears or bearing bushes of the gear pump was

presumed as the cause of the accident.

[Disposition]

The normal condition was restored by the replacement of the bearing bushes.

II. Cause of Accident / Underlying Problem

[Mechanical Factor]

Because of the excessive weardown of the bearing bushes, the gear pump failed to establish sufficient oil pressure.

[Human/Software Factor]

In RTA engines, a gear pump connected to the fuel handle, and a hydraulic motor constitute the cylinder-oil-lubricator driving system and the lube oil feed rate varies together with the change in load. It is therefore necessary to control the cylinder oil feed rate together with the main engine load at regular times.

In damage of this type, there is a possibility of the engine being operated short of lube oil for a long time, without announcing the defect by the cylinder oil non-flow alarm or main engine slowdown. The accident in question could have resulted in serious liner damage in all cylinders. Fortunately, it did not develop to such a stage thanks to the early detection of the abnormality.

III. Preventive Measures

[Mechanical]

(1) At intervals of 6,000 to 8,000 hours, at a time when regular maintenance work on cylinder lubricators is carried out, measure the clearance between pinion shaft and bearing bush.

(2) In the electronically controlled lubricating system adopted for DU-RTA engines, the feed rate of cylinder oil, heated and then pressurized by a hydraulic pump, is regulated through the control of the duration and timing of the opening of high-speed solenoid valves by a microcomputer. In this system, it is necessary to check the hydraulic pump delivery pressure and the function of the oval-gear type flow meter.

On board vessels installed with engines having the electronically controlled lubricating system, the ordinary lubricators driven by a gear pump and hydraulic pump are furnished. When the former lubricating system is in operation, the ordinary lubricators are kept out of operation as no working oil is supplied to the hydraulic motor. (In the event of a breakdown of the electronically controlled lubricating system, the lube oil feed system is automatically changed over.) It is, therefore, required to check regularly the function of the hydraulic pump and general lubricators by feeding lube oil from the crosshead system.

(3) In the engines of MAN-B&W and UEC, lubricators are mechanically driven, and the feed rate varies along with the engine speed. It is, hence, possible to check visually the function of the driving system. In MAN-B&W engines, it is also important to check the condition of the lubricator drive chain when inspecting inside the crankcase.

[Human/Software]

In addition to the regular check of cylinder oil consumption, it is necessary to grasp the condition of the lube oil system by, e.g., including, as items to be checked in the 'M0' check list, the reading of the oil pressure of the drive system and the revolution counter of the hydraulic motor.

IV. Lessons

Work behavior to perform basic matters will prevent serious accidents.

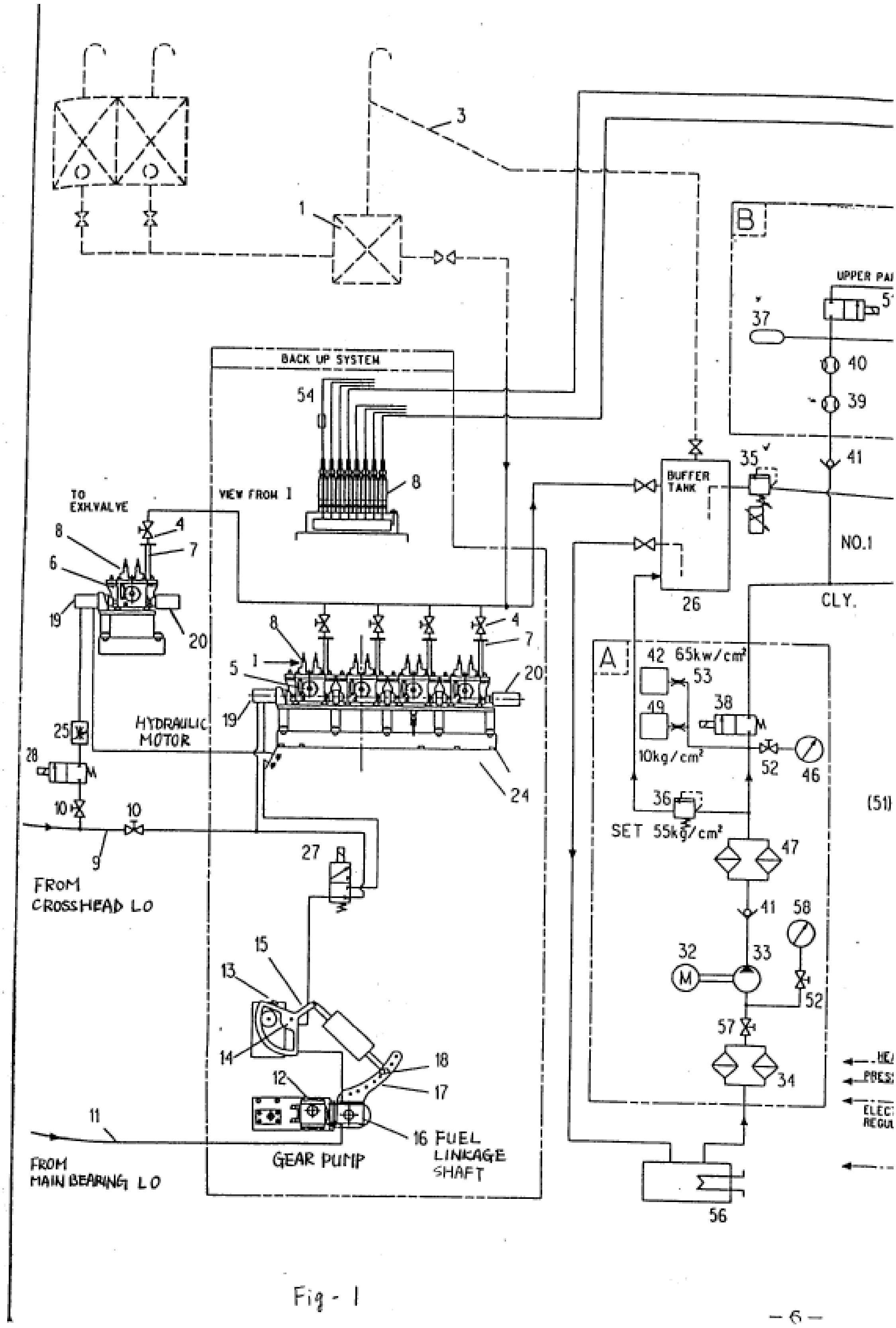
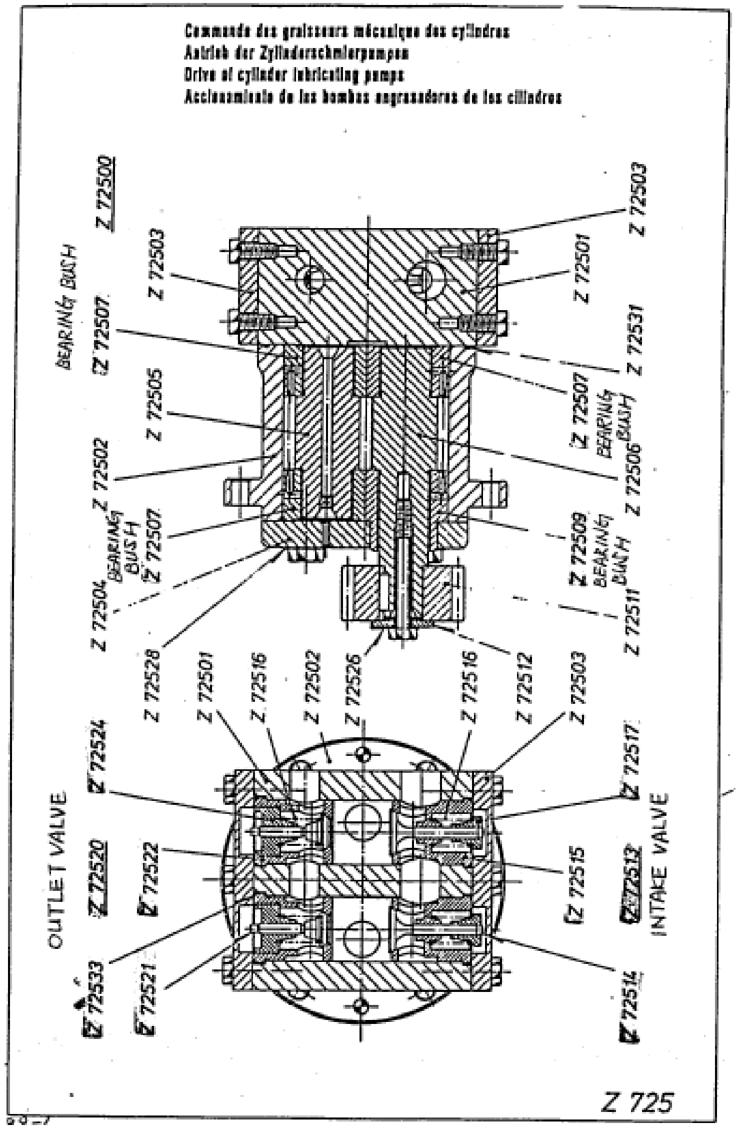

BACK UP SYSTEM
VIEW FROM I
TO EXH.VALVE
HYDRAULIC MOTOR
FROM CROSSHEAD LO
FROM MAIN BEARING LO
GEAR PUMP
16 FUEL LINKAGE SHAFT
BUFFER TANK
UPPER PA
NO.1
CLY.
65kw/cm²
10kg/cm²
SET 55kg/cm²

Fig - 1

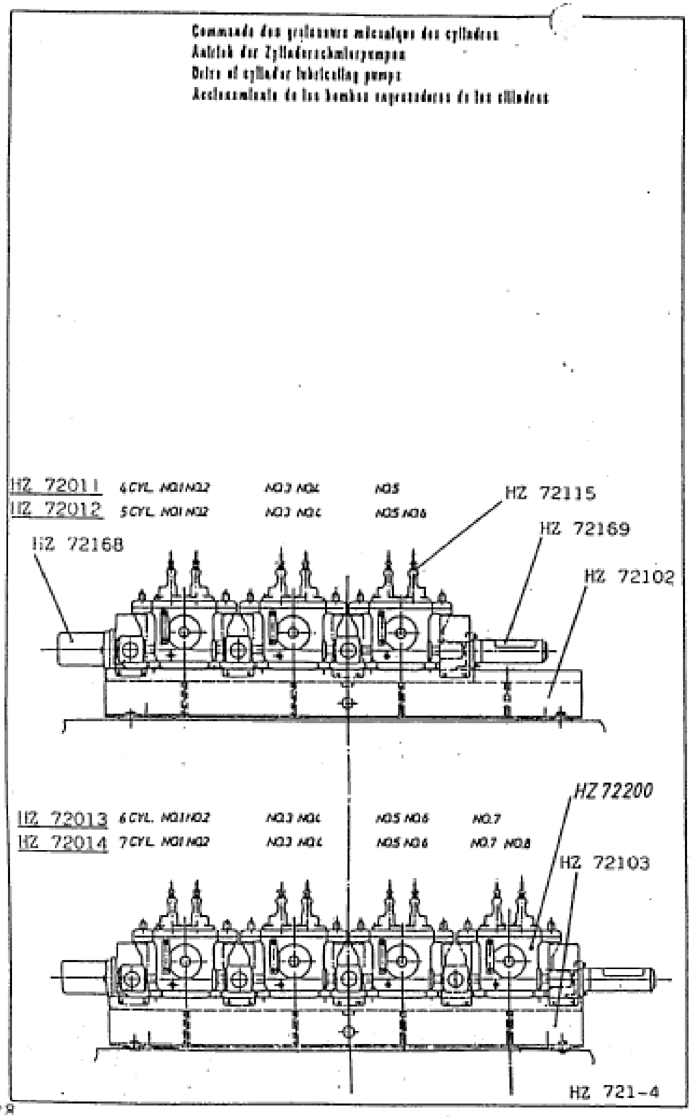


Cylinder lubricating pumps drive

Z 72500	Gear pump, complete
Z 72501	Valve body for gear pump
Z 72502	Housing for gear pump
Z 72503	Cover for valve body Z 72501
Z 72504	Cover for housing Z 72502
Z 72505	Pinion for gear pump
Z 72506	Pinion for gear pump
Z 72507	Bearing bush for gear pump
Z 72509	Bearing bush for gear pump
Z 72511	Driving wheel for gear pump
Z 72512	Washer for gear pump
Z 72513	Intake valve, complete for gear pump (Z 72514 - Z 72517)
Z 72514	Valve for intake valve
Z 72515	Valve housing for intake valve
Z 72516	Compression spring for intake and outlet valves
Z 72517	Spring guide for intake valve
Z 72520	Outlet valve, complete for gear pump (Z 72516, Z 72521 - Z 72524)
Z 72521	Valve for outlet valve
Z 72522	Valve housing for outlet valve
Z 72524	Valve guide for outlet valve

E Z 725

Fig - 2



Cylinder lubricating pumps drive

HZ 72011	Cylinder lubricating pump, complete
HZ 72012	Cylinder lubricating pump, complete
HZ 72013	Cylinder lubricating pump, complete
HZ 72014	Cylinder lubricating pump, complete
HZ 72102	Support for cylinder lubricating pump
HZ 72103	Support for cylinder lubricating pump
HZ 72115	Sight glass indicator indnctive, complete for cylinder lubricating pump
HZ 72168	Hydraulic motor for cylinder lubricating pump
HZ 72169	Revolution counter for cylinder lubricating pump.
HZ 72200	Cylinder lubricating pump

Fig -3

HZ 721-4

Engine accident cases

File No.	1 - 006				
Case name	Leakage of main engine exhaust valve operating oil				
Device name	M/E	Damaged part	Exh. valve hydraulic oil pipe	State of damage	Leaking
Maker name	MHI	Model	6UEC85LSII	Total working time	13 years
Kind of ship		Date of occurrence		Place of occurrence	At sea
Cause of damage/problem	Hardware factor				
	Software/human factor	Mishandling			

Ⅰ. Outline of Accident

[Course of Events]

The vessel sailed from the Persian Gulf, apparently with no problems following the overhauling of a main engine No. 3 cylinder piston during scheduled maintenance.

However, the sound of the exhaust valve of the No. 3 cylinder significantly increased after several days running, and checking of the trough inspection hole, located on the lower exhaust valve actuator, revealed hydraulic oil leakage inside the protection pipe. The oil was leaking from the intermediate coupling of hydraulic oil pipe. The flanges of the coupling were inadequately tightened without maintaining a proper distance between them.

[State of Damage]

[Disposition]

Re-adjusting the flange distance cleared the abnormal sound. (See Fig. 1 and 2)

Ⅱ. Cause of Accident / Underlying Problem

[Mechanical Factors]

Coupling of the exhaust valve hydraulic oil pipe flanges was incorrect in both tension and maintenance of a proper distance.

[Human/Software Factors]

No particular instructions regarding this issue are present in the manufacture's (MHI) manual.

Ⅲ. Preventative Measures

[Mechanical Aspects]

(1) When overhauling exhaust valves, special attention should be paid to the correct

alignment of the coupling flange with the end-face of the hydraulic oil pipe, and maintaining a proper distance between flanges.

(2) The coupling bolts must be tightened firmly and evenly.

(3) Leak checks should be performed after connection of hydraulic oil pipe.

[Human/Software Aspects]

We have requested MHI provide us with technical information regarding this matter.

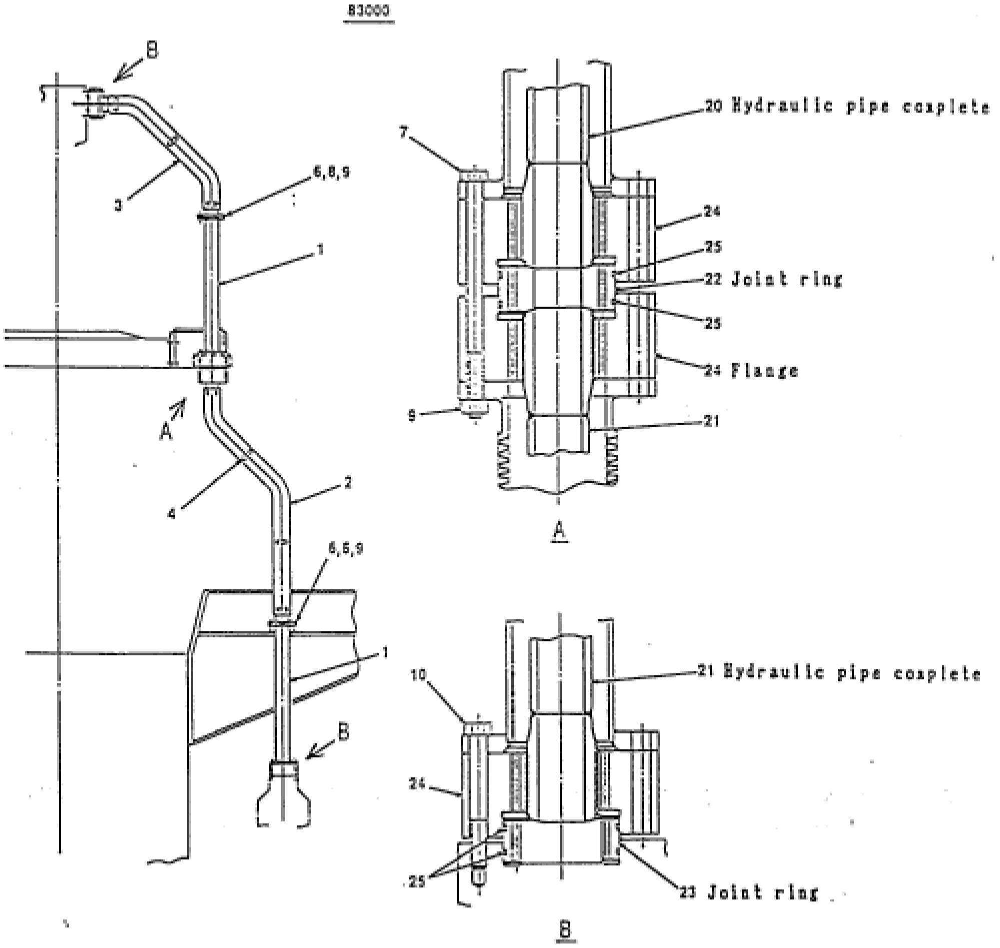
Ⅳ. Lessons

Ⅴ. Reference

Refer to the attached "UE TECHNICAL INFORMATION" (No. 0141 Rev.2) published by Kobe Diesel.

SULZER

Fig.1 PROTECTION PIPE FOR EXH. VALVE ACTUATING OIL



85LS II

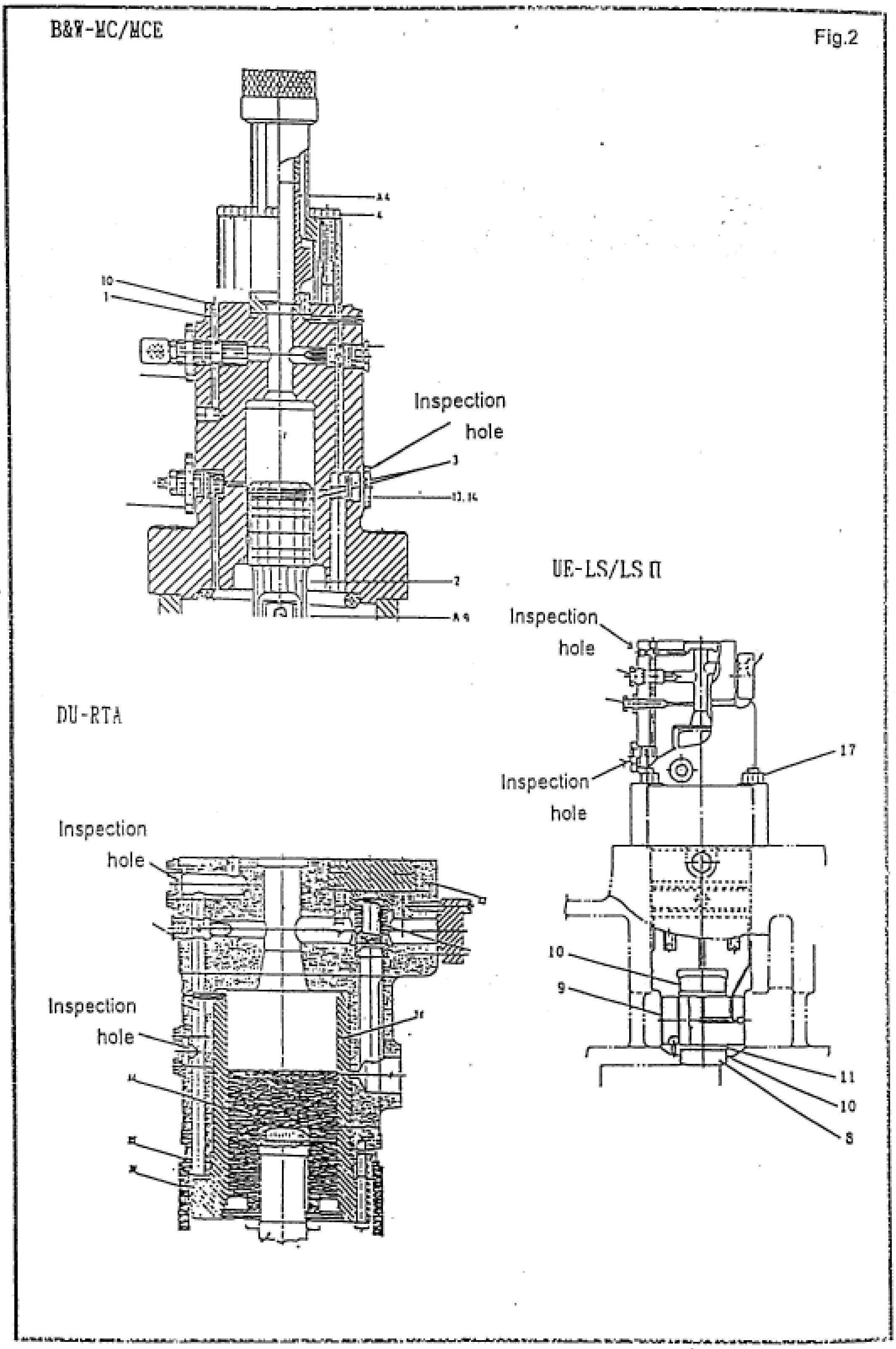

B&W-MC/MCE
Inspection
hole
3
2
UE-LS/LS II
Inspection
hole
Inspection
hole
17
10
9
11
10
8
DU-RTA
Inspection
hole
Inspection
hole

Fig.2

UE TECHNICAL INFORMATION KOBE DIESEL CO.,LTD.	NO. : 0141 Rev.2 ITEM : 531 DATE : OCT. 2ND, 1996

APPLICABLE: HYDRAULIC EXH.V.DRIVE TYPE	RE : Handling of the high pressure pipe for Exh. Valve Driving System

Recently, we have experienced the abnormal sound or the deformation (twisted) of the flexible joint for protect pipe on operation, after the Exhaust Valve maintenance in service ship.

It proved to be caused by the leakage of Driving oil into the protect pipe due to the poor fitting of Exh. V. Driving pipe .

Accordingly please pay the attention to following matters when replacement is carried.

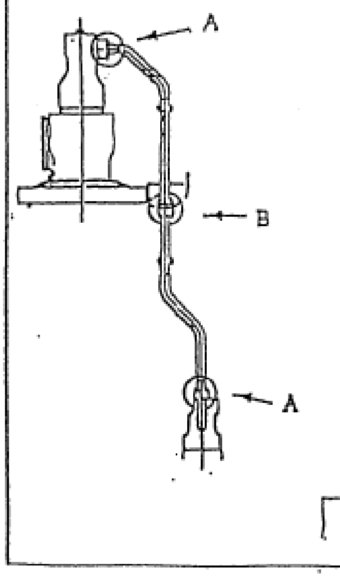
KOBE DIESEL CO. LTD. 1993. 4. 15 TOKYO SERVICE DEPT.

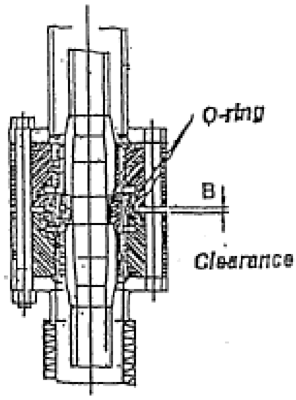
1) To be paid the attention to poor fastening and not-even fastening.

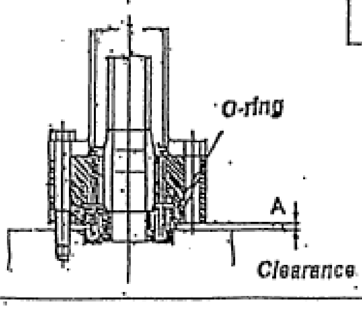
2) To be confirmed the clearance (A, B in shown as an aim) in attached table.

3) To be checked and renewed the O-ring.

4) Please take off the O-ring or clingket packing which may be installed into flange part of flexible joints.







Unit ; mm

Type	A	B
88LS II	8.0	8.0
50LS II	2.5	5.0
52LA & LS	4.0	4.0
60LA & LS	4.0	4.0

APPROVED	CHECKED	DRAWN
[illegible]	[illegible]	[illegible]

Engine accident cases

File No.	1 – 007				
Case name	Malfunction of solenoid valve for main engine emergency stop				
Device name	Main engine	Damaged part		State of damage	
Maker name	MES	Model	BMS-1500	Total working time	2 years after built
Kind of ship	Container ship	Date of occurrence		Place of occurrence	While sailing in rough seas
Cause of damage/problem	Hardware factor	Fouling inside pipes			
	Software/human factor	Inadequate inspection			

I. Outline of accident

[Course of events]

During navigation in rough seas, the main engine tripped as a result of the actuation of the main engine overspeed trip induced by racing. After resetting it, crew members made attempts to start the main engine but failed. Even attempts to start it with the local control failed to do so. Restoring operations took eight hours, including drifting for four hours.

[State of damage]

The solenoid valve 127 for an emergency stop was stuck because of dirt trapped inside the air piping system.

[Response measures]

Overhauling and cleaning of the same solenoid valve. Cleaning of the air piping system.

II. Causes of accident/problems

[Hardware factors]

When the overspeed trip was actuated first, the emergency stop solenoid valve 127 stuck, keeping air admitted to the fuel pump puncture valve.

It is reported that a considerable amount of rust and dirt was found adhering to the solenoid valve spool when it was overhauled.

[Software/human factors]

- As is evident from the air piping diagram, even if the control position is shifted to the local control, the emergency stop line is not bypassed. It follows that, while the solenoid valve for emergency stop is stuck in a state to admit air, as in this case, the emergency stop signal continues to be sent and there is a need to stop the emergency stop signal forcibly by shutting the stop valve 16 located upstream of the valve in question.

If local control to start the main engine is impossible, the list of probable causes are considerably reduced on the air piping diagram. This incident took as long as eight hours for restoration, but it would have been possible for crew members to start the engine locally within few minutes if only they fully understood the function of the control system.

- It is also required by NK rules to check the functions of all safe guards at regular intervals. If the safety device in question had been regularly checked for proper function in the past, this malfunction could have occurred at such times and, if the malfunction manifests itself during an inspection, it would not interfere with the ship's operation.

III. Measures to prevent recurrence

[Hardware aspects]

- Thorough flushing of the air piping system when it was outfitted.
- Regular checks of safe guards.

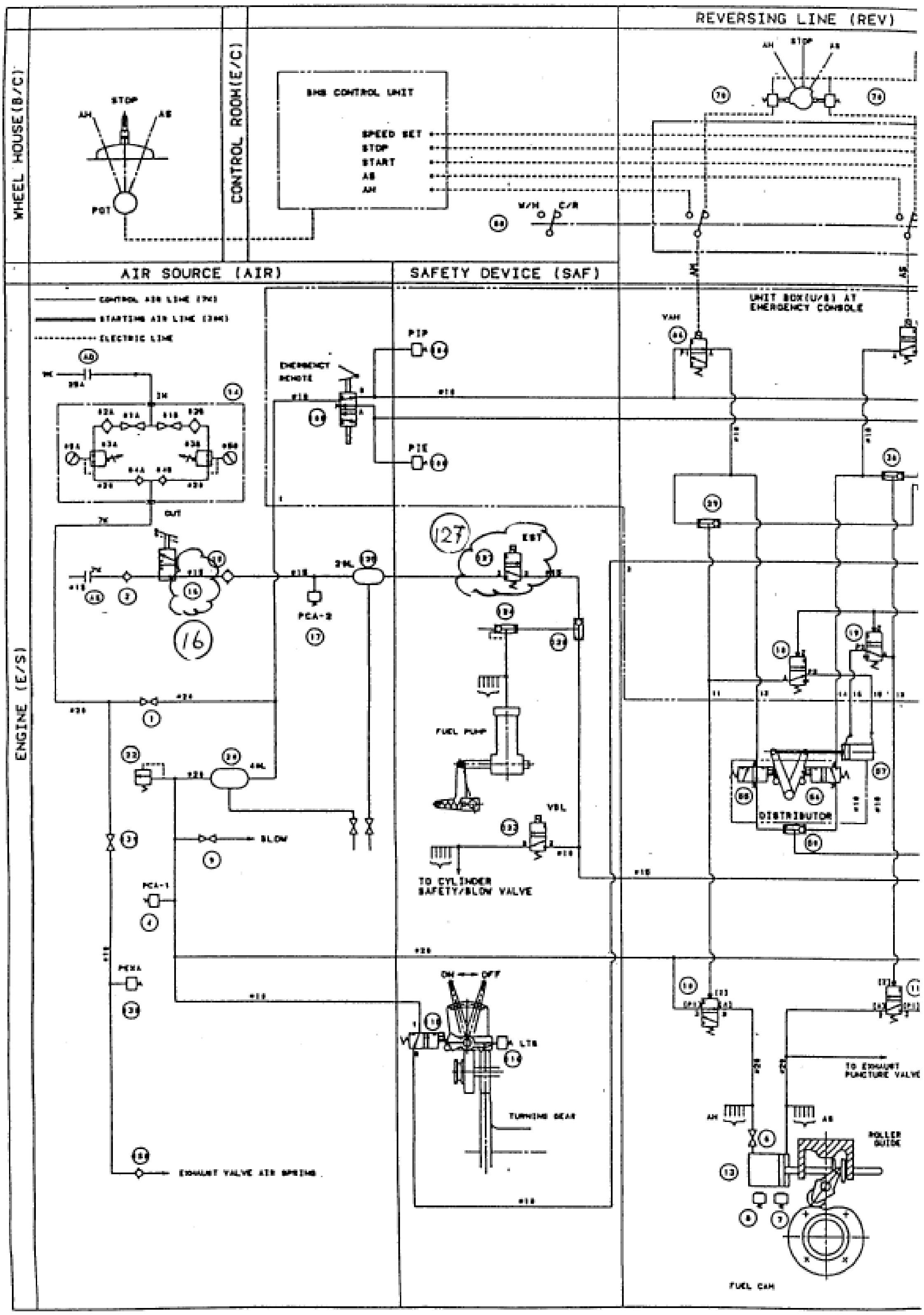
[Software/human aspects]

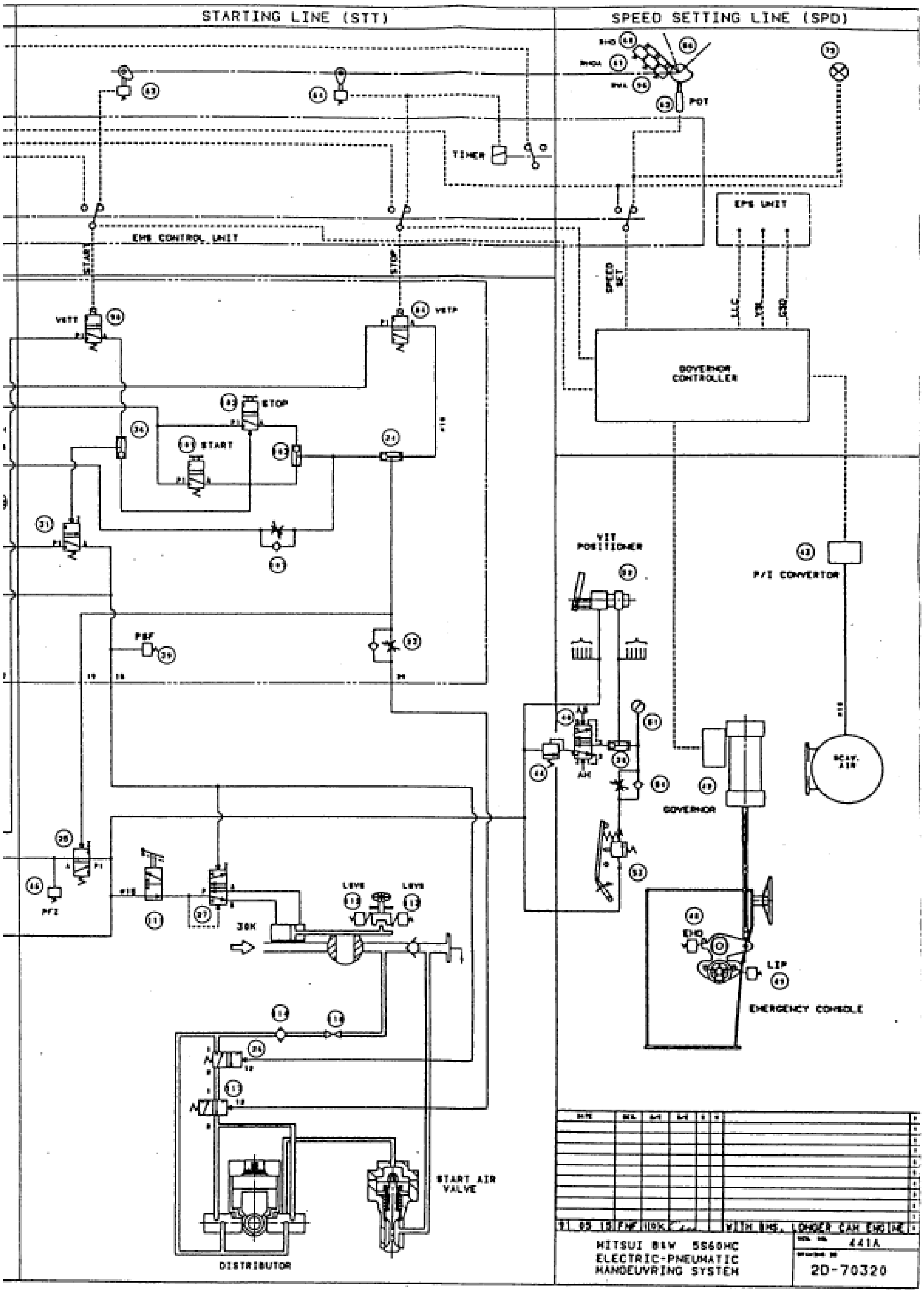
Engineers should familiarize themselves with the control system of the main engine as early as possible after boarding the vessel.

IV. Lessons

Insufficient studies at other times manifest themselves in emergencies.

Reference


WHEEL HOUSE (B/C)
CONTROL ROOM (E/C)
REVERSING LINE (REV)
STOP
AH
AS
POT
SPEED SET
START
AIR SOURCE (AIR)
SAFETY DEVICE (SAF)
ENGINE (E/S)
UNIT BOX (U/B) AT EMERGENCY CONSOLE
OUT
PCA-2
PCA-1
PIP
PIE
EST
VBL
FUEL PUMP
TO CYLINDER SAFETY/BLOW VALVE
BLOW
ON ← → OFF
LTS
TURNING GEAR
EXHAUST VALVE AIR SPRING
DISTRIBUTOR
TO EXHAUST PUNCTURE VALVE
ROLLER GUIDE
FUEL CAM
127
16


STARTING LINE (STT)
SPEED SETTING LINE (SPD)
TIMER
EMS CONTROL UNIT
START
STOP
EPS UNIT
SPEED SET
LLC
GOVERNOR CONTROLLER
VSTT
VSTP
STOP
START
VIT POSITIONER
P/I CONVERTOR
PSF
GOVERNOR
SCAV. AIR
PFZ
LIP
EMERGENCY CONSOLE
START AIR VALVE
DISTRIBUTOR
POT
WITH EMS, LONGER CAM ENGINE
MITSUI B&W 5S60MC
ELECTRIC-PNEUMATIC
MANOEUVRING SYSTEM
441A
2D-70320

Engine accident cases

File No.	1 – 008				
Case name	Damaged coupling to drive B&W main engine lubricators				
Device name	Main engine	Damaged part	Lubricator driving shaft	State of damage	Fracture
Maker name	MES	Model	B&W 7K90MC	Total working time	12 years after built
Kind of ship	Container ship	Date of occurrence		Place of occurrence	At sea
Cause of damage/problem	Hardware factor	Poor design			
	Software/human factor	Insufficient inspection			

I. Outline of accident

[Course of events]

When the vessel was sailing in the Pacific Ocean, the coupling between No. 7 lubricator and chain case slipped, unable to drive lubricators. The “Non-flow Alarm” went off, as a result, stopping the main engine.

[State of damage]

When an inspection was made shortly afterward, it was found that the lubricator cam shaft which was clamped by the coupling, was severely damaged beyond repair.

[Response measures]

The connecting part of the coupling was welded all around as provisional repairs and the vessel recovered its normal operation.

(Total time during which the engine was stopped: about 10 hours)

II. Causes of accident/problems

[Hardware factors]

(1) Insufficient gripping force between lubricator cam shaft and coupling

Structurally, the closer to the chain case, the more load is applied on the part in question, and a reduction in the grip resulted in the damage in this case.

(2) Difficulties to adjust the driving shaft centers of No. 7 lubricator and chain case and to compensate for the misalignment of the shafts

The shaft penetrating through the chain case and No. 7 lubricator cam shaft are directly connected. For operational reasons, it is difficult to align the shafts accurately upon the production of the engine.

(3) Misalignment of lubricator shaft at initial stage of engine building.

[Software/human factors]

Main engines of B&W traditionally sustain damage in the section in question and the inspection of the relevant parts is a matter naturally required for those who control such engines. Despite this, the engineers concerned neglected to do so.

III. Measures to prevent recurrence

[Hardware aspects]

(1) The model of the engine recently has undergone changes in the shape of the coupling, etc. to increase the contact area at the lubricator cam shaft end and, furthermore, the torque with which to tighten the tensioning bolts from 60 N•m to 90 N•m.

(2) The model of the engine recently has adopted a method to insert a short shaft sandwiched by a pair of couplings to give more freedom to the shaft between lubricator and chain case.

(3) By the use of a new-type jig, the shaft alignment among lubricators was checked and all couplings and driving shafts for lubricators were replaced with remodeled parts.

(4) New model engines adopt BC(Bronze Casting) products for lubricator cam shaft bearings to counter catching inside foreign matter contained in cylinder oil and to prevent seizure resulting from defects of driving shaft alignment. The BC products are effective to prevent seizure of the bearing when the shaft comes off center. Since, in the case of the vessel, the shaft alignment was normal, engineers replaced the lubricator for No. 7 cylinder only.

(5) Even with engines adopting the new devices, slight slips have been found and there is a need for regular inspection, by accurately providing a marking on the coupling. The timing of oil injection should be confirmed with the "A" mark inscribed on the cam indicator.

[Software/human aspects]

Inspect the relevant parts regularly.

IV. Lessons

If you board a vessel installed with a main engine of B&W, you must pay attention to the relevant parts.

Reference

(1) The lubricator is fixed vertically by a lubricator support and horizontally by lubricator fixing bolts. Of the 4 fixing bolts for the lubricator, the forward 2 are fixed with reamer

bolts positioned individually for each lubricator. This means that if the exchange of lubricators between those currently fitted or replacement with a spare one is inevitable, forceful driving of reamer bolts would result in misalignment. An excessive misalignment would often result in damage as in this case and, in such a case, readjustment for alignment by a service engineer should be requested soon.

(2) Mitsui B&W engines after Mark-IV inclusive, have incorporated the recurrence-preventive measures mentioned above. Hitachi, a licensee from the same licensor, has B&W engines adopting couplings of a universal joint type and, consequently, there is less concern over the problem.

Engine accident cases

File No.	1 - 009				
Case name	Contamination of main engine system oil with fuel oil				
Device name	Main engine	Damaged part	System oil	State of damage	Contami-nation with fuel oil
Maker name	MHI	Model	7RLA66	Total working time	14 years after built
Kind of ship	Semi-container ship	Date of occurrence		Place of occurrence	
Cause of damage/problem	Hardware factor	Clogged fuel pump drain pipe			
	Software/human factor	Insufficient maintenance			

I. Outline of accident

[Course of events]

Until the cause of the defect was identified, the vessel had sustained various troubles incurred intermittently, including defective discharge of sludge from the main engine lube oil purifier, malfunction of the changeover between ahead and astern engines, and clogged secondary lube oil filter.

A regular lube oil analysis showed a rise in viscosity and a reduction in flashpoint, suggesting the mixture of fuel oil.

[State of damage]

It was presumed that a total of more than 3,000 liters of FO had found its way into the lube oil.

In order to ascertain the condition of bearings, one crosshead bearing was overhauled for inspection, but it did not show any abnormality.

[Response measures]

The results of the lube oil analysis showed that it was outside of our serviceable range both in terms of viscosity and flashpoint, and the period during which the condition was maintained was so long that drain tanks and all the other devices and pipes, of the lube oil system were cleaned and the system oil was completely replaced.

II. Causes of accident/problems

[Hardware factors]

When various parts of the fuel oil system were inspected, the drain pipe for the casing of a fuel pump was found blocked. For this reason, an accumulation of FO spills from the pump found its way into the cam shaft casing through the gland which the pump spindle

penetrates.
Since the engine in question has a common system for cam shaft lube oil and system oil, the contamination with fuel oil spread entirely throughout the main engine.

[Software/human factors]
The ingress of fuel oil into system oil continued over a long period. During that period, engineers were engaged in maintenance work by withdrawing pistons and aware of a dirty crankcase. If they had suspected earlier the possibility of contamination with fuel oil, they might have not been forced to replace the entire system oil.

III. Measures to prevent recurrence

[Hardware aspects]
Usually pump casing drain pipes are guided from respective pumps to an FO drain tank via a collecting pipe, and there is no specific way to check the amount of drain other than measuring the drain tank. In order to prevent an overflow of spilled oil to the cam casing inside the pump, as well to check the amount of generated drain, it is desirable to remodel the drain pipe fitted to each pump so that drain is first received by a hopper to enable the discharge of drain to be visually observed.

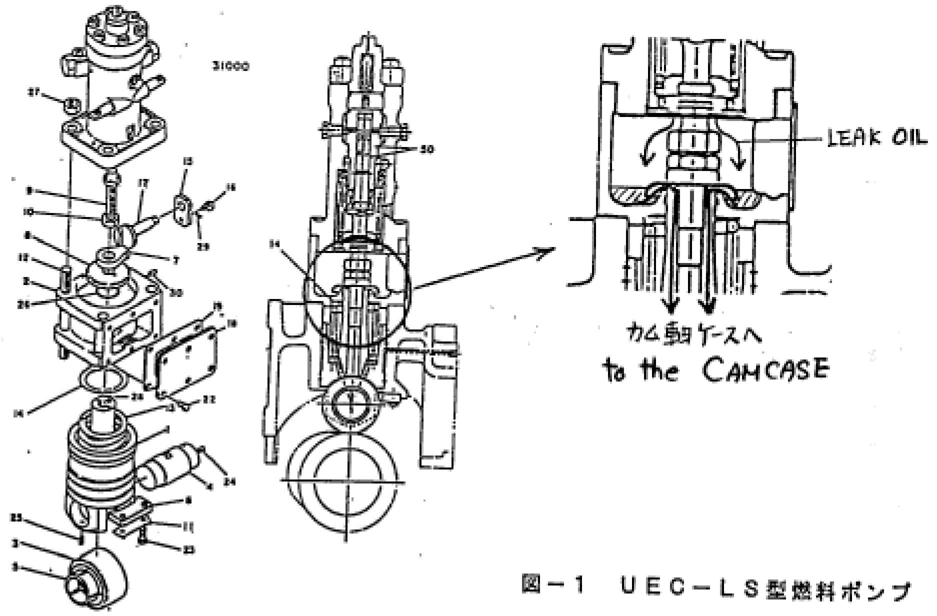
[Software/human aspects]
(1) Small bore pipes intended to handle fluids containing sludge, as in the case of fuel pump drain piping, has a high probability of getting blocked; and it is necessary to check drain pipes when inspecting fuel pumps.
(2) Check changes in the property of lube oil on the basis of regular oil analysis. In the event of contamination of lube oil with fuel oil, in particular, the flash point will remarkably drop; and if bearings get heated as a result of poor lubrication or otherwise, such lube oil may catch fire and explode inside the crankcase; it is therefore necessary to monitor the condition of lube oil at all times.
The lube oil in question was revealed, according to an analysis made by a laboratory, to have dropped to 172ºC in flashpoint against 270ºC for new oil.
(3) In addition, the amount of sludge contained in system oil will increase when contaminated with fuel oil and may show signs of contamination, such as trouble with purification and cloggage of filters. The dirty condition of the inside of the crankcase will also progress and, therefore, visual checks of lube oil at regular inspections are vital.

IV. Lessons

The regular analysis of the system oil proved effective in narrowly escaping a serious accident, such as a crankcase explosion.

Such serious accidents are often caused when some factors occur simultaneously and combine to cause serious damage.

The replacement of the entire system oil will cost a lot but it is much better in comparison with a crankcase explosion.



図－1　ＵＥＣ－ＬＳ型燃料ポンプ

Fig.1 Fuel Pump (UEC-LS type)

Engine accident cases

File No.	1 - 010				
Case name	Damaged crankshaft of medium speed engine				
Device name	Main engine	Damaged part	Crankshaft	State of damage	Burnout
Maker name	Kawasaki	Model	MAN 14V52/55	Total working time	16 years after built
Kind of ship		Date of occurrence	1998.06	Place of occurrence	During standby for departure
Cause of damage/problem	Hardware factor		Poor quality of lube oil		
	Software/human factor		Poor maintenance of lube oil		

I. Outline of accident

[Course of events]

When the engine room was in standby condition for departure, the main engine tripped as a result of a lube oil pressure drop induced by a clogged fine-mesh filter on the lube oil line. The main engine tripped again on the following day. No. 3 main bearing and journal were found burnt out. The ship's crew members attempted to replace the journal twice but in either case, the bearings came to be damaged in a short time and they abandoned repairs by themselves.

We, at our company, gave advice not to repair by crew members in view of the situation of the accident since their attempts to repair the hardened journal could possibly deteriorate the damage of the crankshaft. Despite our advice, they attempted the repair twice and deteriorated the situation.

[State of damage]

Chronologically the damage progressed as follows: At first No. 4 main bearing burnt out, followed by the burnout of No. 3 main bearing. With the progress of the burnout of No. 4 main bearing, No. 3 cylinder crankpin bearing, which is supplied with lube oil from No. 4 main bearing, burnt out. In the same token, the piston pin which is to receive lube oil from No. 3 cylinder crankpin bearing, ran short of lube oil. In this way, the piston pin bearings in both A and B banks sustained damage. As to No. 2 cylinder, which receives lube oil from No. 3 main bearing (whose damage occurred slightly later), damage was restricted to the hinge pins and piston pin bushes of the A bank, parts susceptible to poor lubrication.

[Response measures]

II. Causes of accident/problems

[Hardware factors]

This is ascribed to poor lube oil quality resulting from bad lube oil maintenance. This caused poor lubrication, leading to the damage of the bearings.

The following are factors which contributed to the deterioration of the lube oil on board the vessel and bad practices of poor lube oil control.

(1) The main engine lube oil sump tank is capable of containing 21 kiloliters, but the ordinary oil level while at sea was 9 to 10 kiloliters, an extremely small amount and, consequently, very sensitive to contamination by, e.g., blowby.

(2) The lube oil sump tank was cleaned every time the vessel was in drydock, but when the accident occurred, the drydocking interval was prolonged to 3 years as opposed to the usual 2 years and the sump tank became increasingly dirty.

(3) Approximately 200 liters of fresh oil was supplied at one time into the sump tank containing the usual level of oil and there is a possibility of the fresh oil having stirred the sludge accumulated at the bottom of the sump tank and entrained it into the lube oil system.

(4) As for the condition of the main engine before the accident, the cylinder outlet exhaust gas temperature was 470ºC or over and system oil consumption 340 liters/day, showing signs of poor combustion and a deterioration in the combustion chamber condition, evidence to the progress of the contamination of the system oil due to blowby.

(5) Defects had been pointed out in our shipboard inspections in relation to the operation of the lube oil purifier, such as an excessively low lube oil temperature at the purifier inlet, but no sings of improvement were observed.

(6) The operation of the filter differential pressure alarm switch was not checked. When it was actually tested during repairs of the engine, it gave an alarm at 2 kg/cm^2 or more, proving to be completely useless.

(7) Operation of the main engine in a considerably torque-rich region was observed before the damage.

[Software/human factors]

The causes of the accident, as mentioned above, are all related to human factors and this accident hints at the fact that the vessel neglected to maintain not only lube oil but also the engine for many years.

The following is not related to lube oil, but, for instance, the vessel has not analyzed cooling water for the main engine at all and only injected chemicals into it. It also holds true with boiler water and the reported values of analysis were all faked. The analysis kit was unusable.

To be frank, there is a suspicion that engineers of the vessel adjusted the filter differential alarm switch so that it would not function. If that is the case, they are not qualified to handle engines at all.

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

IV. Lessons

Reference

Engine Trouble Cases

File No.	1 - 011				
Case name	Damaged lube oil pump for main engine turbocharger				
Device name	Main engine	Damaged part	T/G, lube oil pump	State of damage	Fractured shaft
Maker name	IHI	Model	VTR564E-32	Total working time	Short period
Kind of ship		Date of occurrence	1999.03.25	Place of occurrence	During standby for departure
Cause of damage/problem	Hardware factor	Difference of specifications			
	Software/human factor	Good response			

I. Outline of accident

[Course of events]

The main engine turbocharger was overhauled and maintained at Hamburg and the attached lube oil pumps were replaced with larger-capacity ones both on the turbine side and blower side (pipe diameter from 12mm to 18mm). Lube oil injection was ascertained during a trial, but it became incapable to inject after leaving the berth. The vessel sailed for about 5 hours by manually lubricating with an oil syringe to reach a safe area.

[State of damage]

An overhaul, thereafter, revealed a fracture of the lube oil pump gear shaft.

[Response measures]

II. Causes of accident/problems

[Hardware factors]

The supplied lube oil pump support plate was not a correct one (for a different model), but engineers fitted it without noticing it. This caused the suction pipe inclined, making it come in contact with the thermal socket fitted to the end cover. As a result, an excessive bending moment was applied on the lube oil pump shaft, leading to a fracture of the shaft in a short time.

The change of capacity of the lube oil pumps to a larger one was made for the purpose of increasing the cooling capacity. The bearing oil temperature was confirmed to have dropped about 12ºC by the change.

[Software/human factors]

There was no problem found with the crew members in this case. If we must attempt to find fault with them, didn’t a suspicion occur as to whether the way of fitting was strange?

However, we cannot pin the blame on the crew members when we consider that the pumps were of a new type and that it was difficult to make an inquiry with the maker because the operation involved was carried out outside Japan.

Rather we would like to appreciate their efforts to prevent a serious accident. After an overhaul and maintenance of a device, engineers are naturally required to keep watching for some time its operating condition, in addition to conducting a trial.

Ⅲ. Measures to prevent recurrence

[Hardware aspects]

The manufacturer says that: The method of fitting lube oil pumps differ depending on the model of the turbocharger and there are lube oil pump support plates for both 30º-type and 15º-type on both turbine and blower sides. A 15º-type on the turbine side and 30º-type on the blower side are regular ones for the vessel. In order to prevent trouble of this kind caused by delivery of different parts, when making a requisition it is required to enter an Xi No. (turbocharger product No.) without fail. According to this entry, the maker is expected to supply regular products after having checked the fitting angles. There are cases, however, where the manufacturer delivers different products even though the entry of the Xi No. is correct as the case of the vessel shows. Engineers, therefore, are requested to check the parts before replacing.

According to the maker, such accident as the case in question, caused by the fitting of parts delivered by mistake, has occurred often and there is a need to pay attention sufficiently to the manner of placing orders shown by two letters of "IHI Service News SER-N-TC-U-043JE, SER-N-TC-U-055JE" attached hereto as reference material. (In the case in question, the Xi No. was correctly entered in the order sheet.)

[Software/human aspects]

Ⅳ. Lessons

There are often cases where serious accidents are prevented if the operation of a device is monitored according to basics.

IHI サービス ニュース service news

No. SER-N-TC-U-043JE
Date :Aug. 25, 1995
機　種：過　給　機
Machine : Turbocharger

ユーザー各位　殿

Messrs.
The customer of VTR turbocharger

VTR 564/ 564A/ 564E 形過給機用新形注油ポンプについて

Re: New model of the Gear Oil Pump for VTR564/ 564A/ 564E

表記の新形注油ポンプを、下記により適用いたしますのでご連絡申しあげます。

Gentlemen,
We would like to inform you about application of the new model of gear oil pump as follows.

記

Description

1．目　的
注油ポンプの噴射量を増加することにより，油溜内部の冷却壁面への潤滑油の接触を活発にして潤滑油温度を低下させます。過給機の運転条件にもよりますが，弊社のテスト結果によれば，通常ロードにおける ｺﾝﾌﾟﾚｯｻ側油温で，約15～20℃の低下が期待できます。

1. Object
The new model makes the temperature of lubricating oil decrease due to more active contact of lubricating oil with cooling wall of the oil sump by increasing of delivery quantity of oil.
Though the performance varies according to the condition to be tested, the new model acquired decrease of oil temperature about 10 degrees centigrade to 15 at the compressor side by our shop test.

2．対象機種
VTR 564/ 564A/ 564E 形で「ころがり軸受付き自己給油方式」の過給機

2. Machine to be applied
Machine : VTR Exhaust Gas Turbocharger
Model : VTR564/ VTR564A/ VTR564E
L.O.system : Self Lubricating oil system with ball and roller bearings.

3．従来品との相違
注油ポンプケーシング・ポンプ歯車・油吸入管などが，従来品よりも大きくなっております。
簡易的な識別方法としては，油吸入管の吸入端外径で判断できます（次ページの付図参照）。

3. The points improved for the new model from the former one
The larger ones for the principal part such as the oil pump gear, oil suction pipe and so on were adopted on the new model.
They can be simply identified by the outside diameter of the oil suction pipe (Refer to the figure of the sheet 3/3).

4．互換性
「注油ポンプ」と「支え板完備品（支えばね付き）」をセットで交換することにより従来品と互換性があります。

4. Interchangibility with the former one
The former one can be repraced Gear oil Pump and Pump Holder Complete for new ones.

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Ishikawajima-Harima Heavy Industries Co., Ltd　Mass-Produced Machinery Div.

石川島汎用機サービス株式会社　過給機統括部
shikawajima Hanyoki Service Co., Ltd　Turbocharger Control Dept.

５．適用方針
(1) 新規納入過給機の本体組込用注油ポンプ
順次 新形品に統一していきます。
(2) ｱﾌﾀｻｰﾋﾞｽ用 注油ポンプ完備品
a. 従来品・新形品のいずれでも，ご注文により納入いたします。
b. 従来品使用の過給機でも，軸受の運転温度改善効果のある新形品のご使用を推奨いたします。この場合は，新形ポンプ専用の「支え板完備品」をセットで納入いたしますので，そのむねご指示ください。（なお 支え板は，ケーシングの組付角度により異なりますので，過給機の機番（Ｘｉ番号）をお知らせください）。
c. すでに新形品を適用している過給機には新形品を納入いたしますので，ご注文の際に過給機の機番（Ｘｉ番号）をお知らせください。
(3) ｱﾌﾀｻｰﾋﾞｽ用 注油ポンプ再生工事
a. 従来品および新形品のいずれについても，再生工事は対応いたします。
b. 再生工事ご注文の際には，「従来形」または「新形」のいずれかをお知らせください（次ページの付図を参照）。

６．適用時期
平成７年当初より適用を開始しております。

以上

5. The fundamental plan for apprication
(1) The new model shall be installed on the every turbocharger to be delivered newly.

(2) Gear oil pump complete for after service
a. Both models shall be supplied.

b. It is recommended to apply the new model instaed of the former model as the effect to make oil temperature decraese more can be acquired.
In this case, a new pump holder complete shall be supplied with the new parts. Therefore, inform us your serial machine number(Xi ******) because each turbocharger has each fitting angle.

c. The new model shall be supplied for the turbocharger which adopts the new gear oil pump. So, inform us your serial machine number(Xi ******) when takes place order to us.

(3) Regeneration work of gear oil pump assembly for after service
a. Each model shall be accepted for regeneration.

b. When you give us an order for regeneration of the gear oil pump, inform us if it were the former model or the new model.

6. Date of apprication
January of 1995

石川島播磨重工業株式会社 汎用機械事業部
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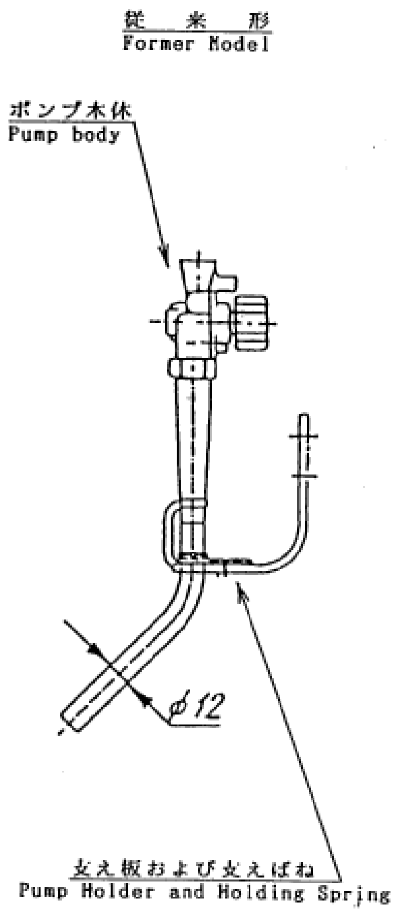
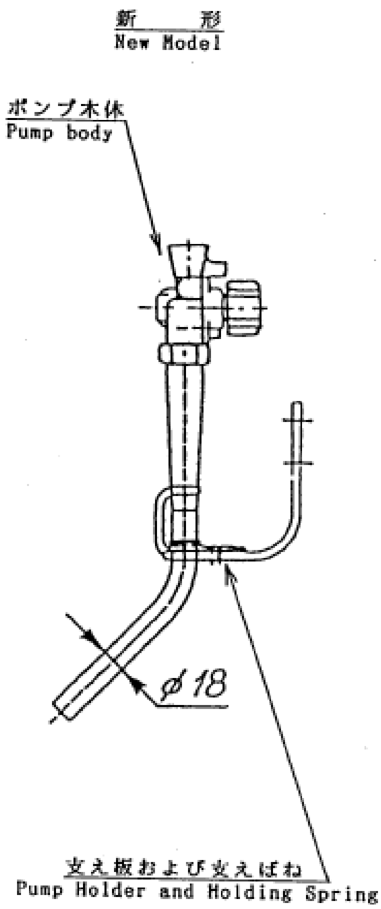
石川島汎用機サービス株式会社 過給機統括部
shikawajima Hanyoki Service Co., Ltd Turbocharger Control Dept.

Number SER-N-TC-U-043JE

VTR 564/ 564A/ 564E 形過給機用 往油ポンプの変更
Model Change of Gear Oil Pump of VTR 564/ 564A/ 564E





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過給機統括部
Turbocharger Control Dept.

IHI サービス ニュース service news

No. SER-N-TC-U-055JE
Date : Mar.14, 1997
機 種 : 過 給 機
Machine : Turbocharger
形 式
Type : VTR454/564/714

ユーザー各位 殿

IHI-ABB VTR454/564/714形過給機用
油噴射筒の変更について

平素よりIHI-ABB VTR形過給機をご愛用いただきありがとうございます。
このたび標記の過給機部品について、下記のとおり変更いたしましたのでご連絡申しあげます。

1．目的
タービン側用油噴射筒については，ABB社のTA04形軸受にも使用できるよう，油噴射穴位置 等を変更しました。
コンプレッサ側油噴射筒については，タービン側の変更に合わせて噴射穴位置を変更しました。

2．対象機種
VTR454/564/714形のころがり軸受式過給機

3．変更内容（3/3ページ付図も参照ください）
(1)タービン側用
軸受への油噴射穴の位置を小径側へ移すとともに，噴射穴部分の筒部形状を変更しました。
(2)コンプレッサ側用
軸受への油噴射穴の位置をタービン側と同様に小径側へ移しました。外観形状は変りありません。

4．適用基準および互換性
(1)タービン側用
従来形油噴射筒は，TA01/TA11 形軸受にのみ適用可能です。
新形油噴射筒は，TA01/TA11/TA04 形軸受のいずれにも適用可能です。
(2)コンプレッサ側用
従来形および新形油噴射筒は互換性があり，LA14およびLA34のどちらの軸受にも適用可能です。

5．適用時期
(1)「新規納入過給機用」
1996年後期より適用しております。

To our customers

Re: Introduction of revision of Centrifuge for IHI-ABB VTR454/564/714 turbochargers

Thank you very much for your patronage to our IHI-ABB VTR turbochargers.
We would like to introduce the revision of Centrifuge for IHI-ABB VTR454/564/714 turbochargers as follows;

1. Purpose
In accordance with the design revision by our licencer, ABB Turbo Systems Ltd., we have revised the Centrifuge as well.

2. Machine applicable
VTR 454/564/714 turbochargers equiped with Rolling contact bearings

3. Description on revision
(1)Turbine end
Revised the pitch circle diameter of nozzle holes (for oil feed) to smaller diameter, and revised its shape locally.
(2)Compressor end
Revised the pitch circle diameter of nozzle holes as well as Turbine end.
No other revision has been made.

4. Application and interchangeability
(1)Turbine end
Conventional Centrifuge can be applied for TA01/TA11 bearing.
New Centrifuge can be applied for TA01/TA11/TA04 bearing.
(2)Compressor end
Conventional Centrifuge and new Centrifuge are fully interchangeable for LA14/LA18/LA34 bearing.

5. Time for introduction of new Centrifuge
(1)for new turbochargers
We have introduced the new Centrifuges for our new turbochargers since the end of 1996.

石川島播磨重工業株式会社 汎用機械事業部
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Ishikawajima Hanyoki Service Co., Ltd Turbocharger Control Dept.

No. SER-N-TC-U-055JE

Date : Mar.14, 1997

(2)「アフタサービス品用」
過給機形式により，1997年4月頃から順次新形に統一していきますが，TA04形タービン側軸受用として「特に新形が必要」の場合は，ご注文の際に指定ください。

以上

(2)for spare parts
Although we are preparing to unify our spares to new Centrifuge from April of 1997 for each turbocharger size, in case our customers request the new Centrifuge for TA04 bearing, please let us know it. We will arrange the new ones for such request.

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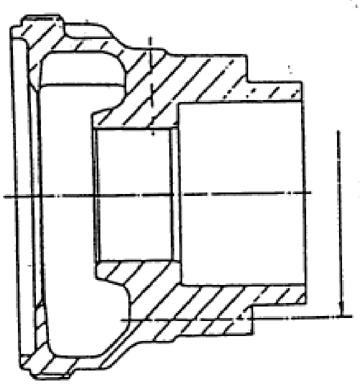
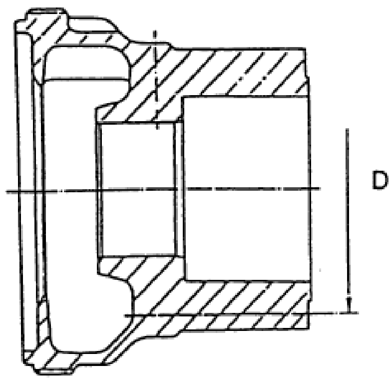
No. SER-N-TC-U-055JE

Date : Mar.14, 1997

[34150]

従来形 Prevailing design		タービン側 Turbine side	新 形 New design	
D	Code No.	Type	Code No.	D
66.0	NN449901	VTR454	NN449903	62.4
78.5	NN609901	VTR564	NN609903	75.3
106.0	NN739901	VTR714	NN739903	101.6

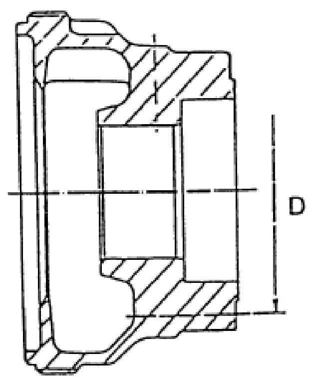


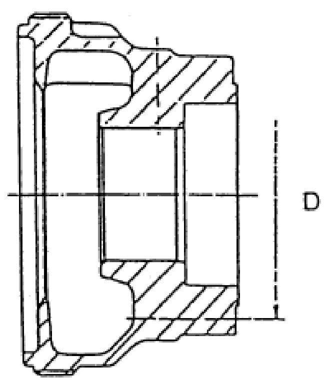


D : Pitch circle diameter of nozzle holes

[32150]

従来形 Prevailing design		コンプレッサ側 Compressor side	新 形 New design	
D	Code No.	Type	Code No.	D
66.0	NN449902	VTR454	NN449904	62.4
78.5	NN609902	VTR564	NN609904	75.3
106.0	NN739902	VTR714	NN739904	101.6

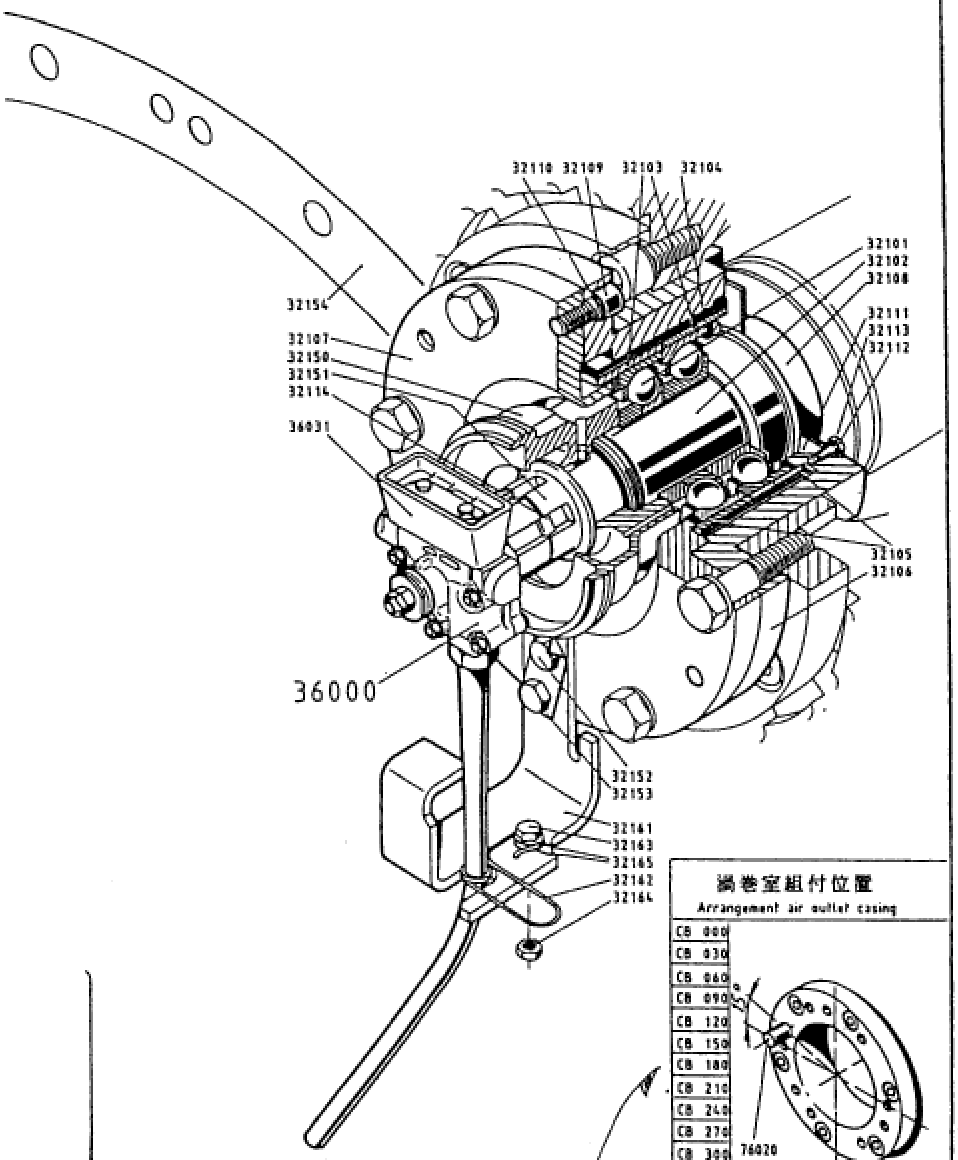




石川島播磨重工業株式会社 Ishikawajima-Harima Heavy Industries Co., Ltd
汎用機械事業部 General Machinery Div.

石川島汎用機サービス株式会社 Ishikawajima Hanyoki Service Co., Ltd
過給機統括部 Turbocharger Control Dept.

IHI	Blower Side	VTR 454/714 -03.1-001



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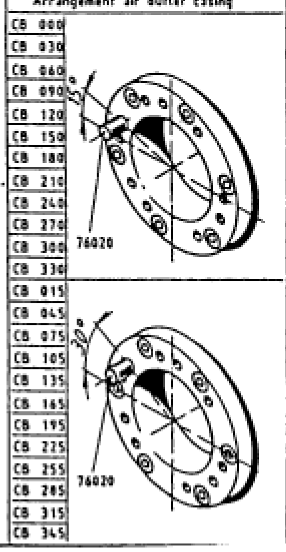
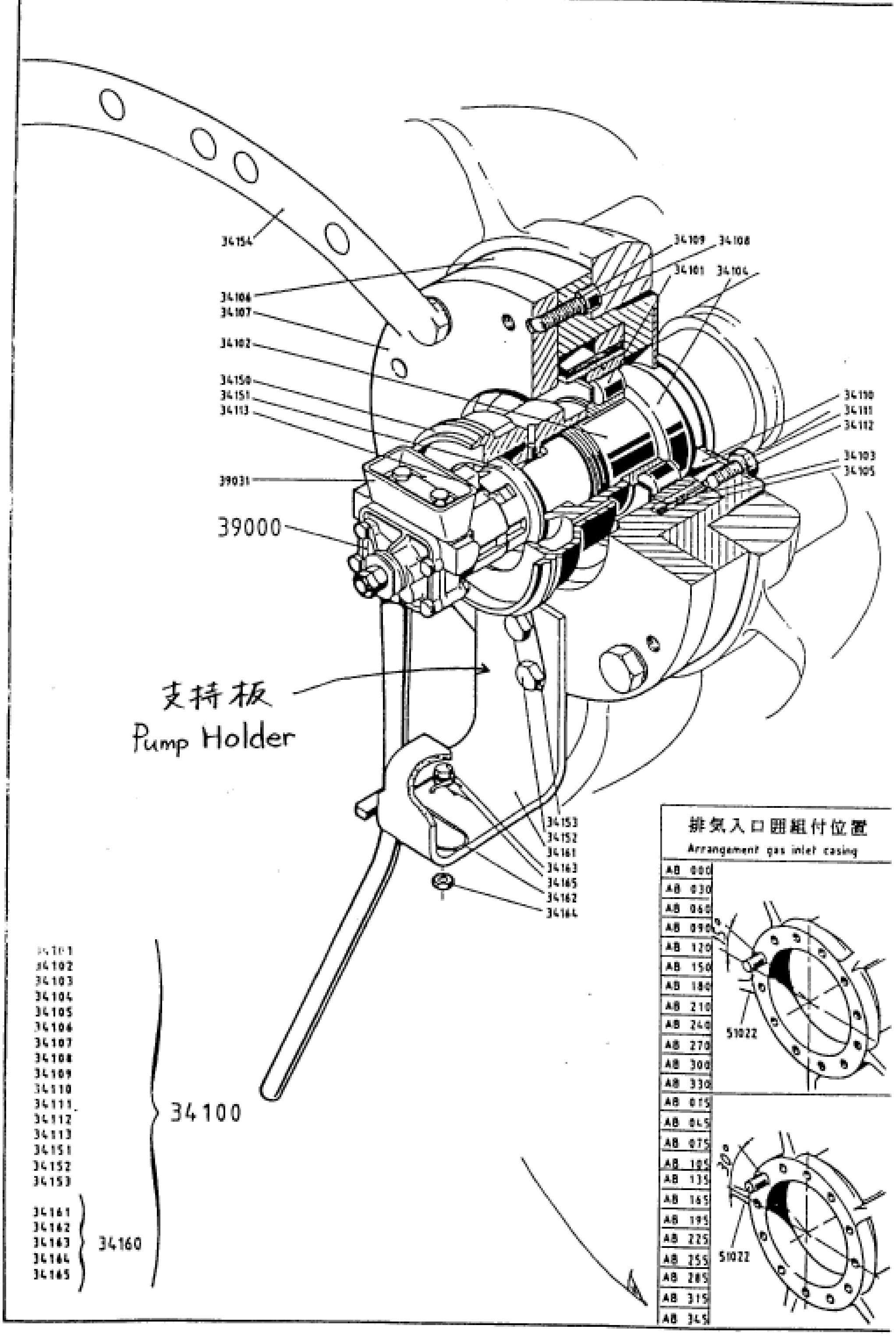
渦巻室組付位置

Arrangement air outlet casing



Bearing を取付ける
KNOCK 位置の角度
であり、L.O.ポンプ
支持板の角度ではない。

IHI	Turbine Side	VTR $\frac{454}{714}$-03.2-001



Engine Trouble Cases

File No.	1 - 012				
Case name	Main engine trouble resulting from faulty fitting of fuel valve				
Device name	Main engine	Damaged part	Fuel valves	State of damage	Poor combustion
Maker name	Mitsui B&W	Model	8LGFCA	Total working time	11 years after built
Kind of ship	PCC	Date of occurrence	1996.03.13	Place of occurrence	During standby for departure from Kanda
Cause of damage/problem	Hardware factor		Fuel valve fixing studs having worked loose		
	Software/human factor		Disregard of basics of maintenance work		

I. Outline of accident

[Course of events]

March 10

As part of measures to counter an exhaust gas temperature rise and turbocharger surge, all the plungers/barrels/suction valves of the main engine fuel pumps; and spindle guides, atomizers for Nos. 1, 2, 5 and 8 fuel valves, were replaced at Yokohama.

March 13

1600 hours Departure from Kanda.

1620 hours The chief engineer reported poor combustion in No. 8 cylinder to the master.

1710 hours The vessel anchored off Kanda. Engineers removed No. 8 fuel valve and conducted an injection test to find no abnormality. They replaced No. 8 fuel valve.

1930 hours The vessel hove up anchor. Engineers checked the condition of the engine, but no apparent change in the condition was observed.

March 14

0320 hours The vessel anchored in Beppu Bay. Engineers replaced No. 8 fuel pump.

0900 hours They tested the pump but the situation did not improve.

The following advice was received from MES Technoservice Co., Ltd.:

(1) Check the stud bolts securing the fuel valve to see whether they are loose or not.

(2) Judge of whether the fuel valve was properly fitted by comparing the position of the fuel valve flange with that of valves in other cylinders. The vessel took notice of the improper fitting of the fuel valve at this point in time.

(3) Check whether the contact surfaces of the fuel valve and the high pressure pipe were correctly set.
(4) Check for foreign material inside the high pressure fuel pipe.
(5) Since the defective fitting of the fuel valve was confirmed in (2) above, the engineers removed the valve and refitted it.
(6) Check of all fuel valves for proper fitting.

1100 hours — The engineers completed the repairs and started the engine after heaving up the anchor.

[State of damage]
Poor combustion in No. 8 cylinder.

[Response measures]
The fuel valve of No. 8 cylinder was removed; and the fitting studs were tightened and the fuel valve fitted again.

II. Causes of accident/problems

[Hardware factors]
Stud bolts for fitting the fuel valve worked loose, resulting in an improper tightening of the fuel valve to the cylinder cover. This created a gap between thrust spindle and thrust piece inside the fuel valve, leading to inability to maintain oil-tightness, which made fuel oil to circulate without fuel injection. (See Fig. 1)

[Software/human factors]
(1) Failure to check the condition of the fitting stud bolts when replacing the fuel valve
Engineers are naturally required to check how fitting studs are fitted and the condition of such parts when an operation of this kind is carried out regardless of whether the valve is a fuel valve or not. There are cases of studs having sustained fractures when the engine was in operation.
(2) Failure to read a service letter provided by the engine maker
For operating devices, engineers are required to peruse and familiarize themselves with operation manuals provided by respective makers. In the case of the incident in question, explanations contained in the relevant operation manual were insufficient without an after-sales service letter which, in view of failures occurring at times resulting from improper tightening, gave additional information. Engineers must read letters of this kind whenever they are distributed to the vessel from the managing company even

if the instrument taken up in the letter is not installed on the vessel; and when they handle the device on board a different vessel, they must recall and consult the letter.

In the case of the vessel in question, if engineers were fully aware of the service letter, even after the mistake in the initial operation, they should naturally have checked the relevant part when the main engine was first stopped. If that were the case, they could have avoided a delay of about 20 hours at anchor.

III. Measures to prevent recurrence

[Hardware aspects]

In the case of fuel valves for B&W engines, when they are closely fitted, as they are vertically compressed, in the cylinder covers by stud bolts, the relevant parts come in close contact with each other, a normal operational condition. (See Fig. 2.)

On board vessels where the seats of fuel valve fitting ports have often been lapped over a long period, it is difficult to fit them in the normal method.

For this reason, when replacing fuel valves, the following procedures are required:

(1) Check fuel valve fitting stud bolts for looseness.

(2) When having lapped a seat surface on the cylinder cover side, check with red lead how the fuel valve and seat on the cover side come in touch with each other.

(3) After replacing a fuel oil valve, measure the Pmax in the ordinary range of operation to check the condition of the fuel oil injection.

[Software/human aspects]

(1) All operations must be carried out according to basics.

(2) After-sales service letters provided by manufacturers are important and engineers must be familiar with them.

IV. Lessons

Reference

Mitsui Service Note No. 95: “Special cautions at installation of the fuel valve”

MITSUI SERVICE NOTE

MITSUI ENGINEERING & SHIPBUILDING CO., LTD.
DIESEL ENGINE DEPT.—RESEARCH GROUP.

for MITSUI—B & W engine. Special cautions at installation of the fuel valve		NO. 95	
		SECTION CHIEF	[signature]
		ASSIST CHIEF	[signature]
		STAFF	
ENGINE TYPE	K/L-GF/GFC/GFCA/GA,L-GB/GBE,L-MC/MCE	DATE	NOV.5,87

The fuel valve is necessary to be tightend to the cylinder cover in the correct direction with proper force in order to keep the good oil tightness at the passage of the high pressure fuel in the fuel valve body as well as the good gas-tightness of the fitting surface of the fuel valve with the cylinder cover so that the correct fuel injection is obtained.

Recently, since the difficulties due to improper tightening of the fuel valve have been sometimes reported, we hereby would like to explain some special cautions at installation of the fuel valve which shall be applied to the engine in your vessel.

§1 Examples of the difficulity due to improper tightening

(1) Poor functioning of the fuel valve due to deformation of each part in the fuel valve by excessive tightening.

(2) Bending damage of the thrust spindle by excessive tightening.

(3) Crack damage of the thrust piece by excessive tightening.

(4) Poor fuel injection due to unequal tightening caused by the slackening of the fitting stud bolts.

And so on.

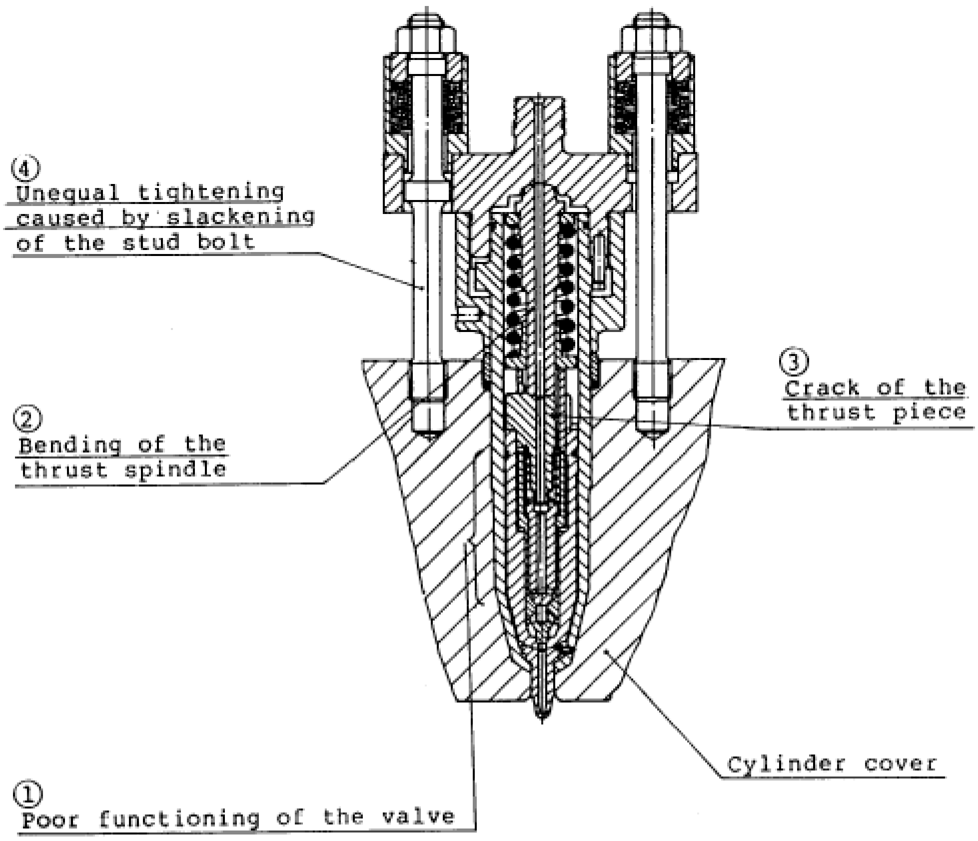


Fig.1 Sectional drawing of the fuel valve assembly

§2 Special cautions at installation of the fuel valve

1) Slackening of the stud bolts

If one of the stud bolts is slackened, the equal tightening force can not only be obtained but also, in the worst case, the fuel valve can not be tightened so that fuel can't be injected. Consequently, the stud bolts should be checked whether slackened or not. The torque of (14 ± 2) kg-m for studding the fitting bolts is applied to all engine types.

It is a real example in L67GFC type of engine that as one of the stud bolts was slackened a little as shown in the following drawing, the fuel valve could not be tightened in the cylinder cover because the foot end of the spring case contacted with the upper surface of the stud bolt collar even though the nuts for the fitting stud bolts were tightened.
Accordingly, the oil tightness in the fuel valve could not be kept in order, resulting in the trouble of no fuel injection.

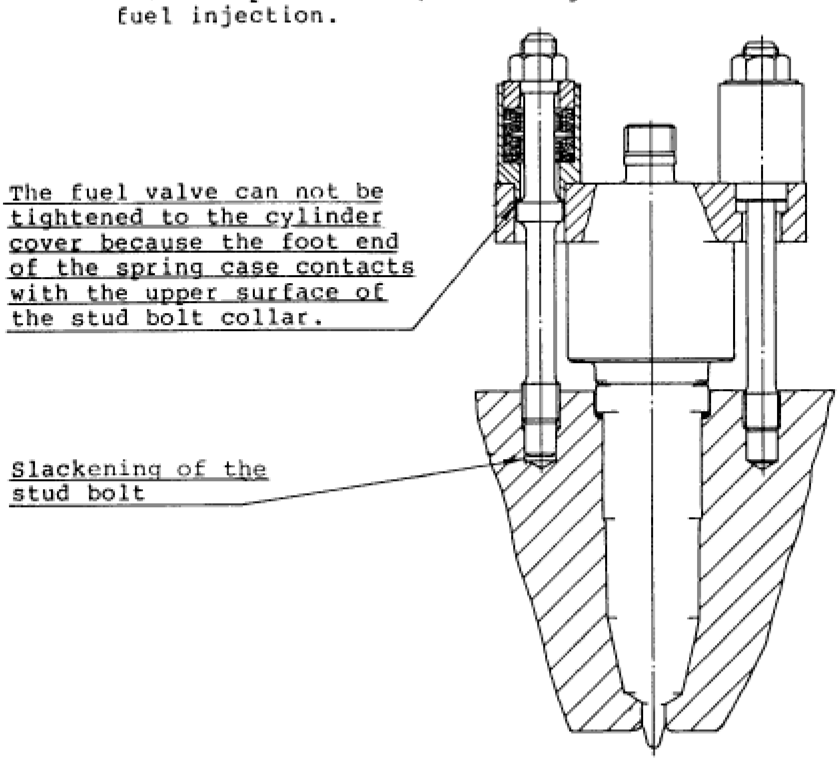


Fig.2 In case of the stud bolt slackened

2) Fitting direction of the fuel valve in the cylinder cover

The fuel valve is to be fitted by the two stud bolts in the cylinder cover, however if the fuel valve would be fitted reversely to the correct direction, the direction of the fuel injection would become reverse against the correct one and would cause a great danger.
In order to prevent from misfitting of the fuel valve, one of two stud bolts is designed with a collar on the bolt different from another bolt with no collar and also one of two bolt holes on the fuel valve flange is designed with a larger dia. than the above collar dia. different from another hole which does not allow the collar to pass through it.
Usually, at this stage, it is very clear that the fuel valve is fitted reversely, nevertheless some person do not notice and are still going to tighten the nuts of the fitting bolts by force under the above state.
Sufficient care should be paid not to do so.

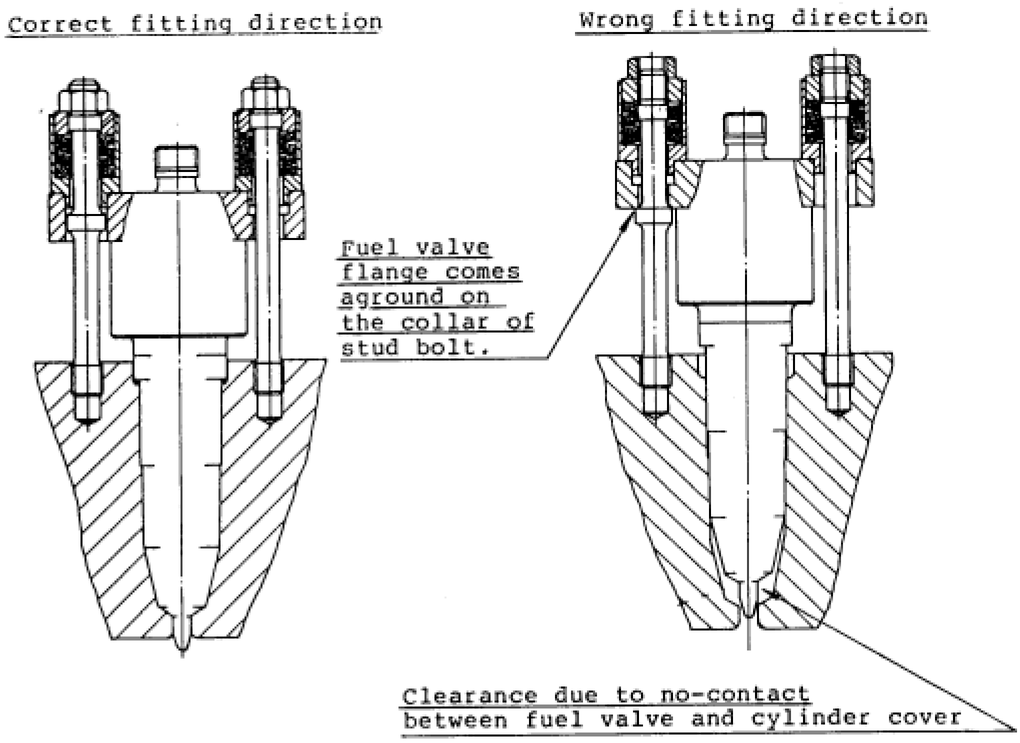
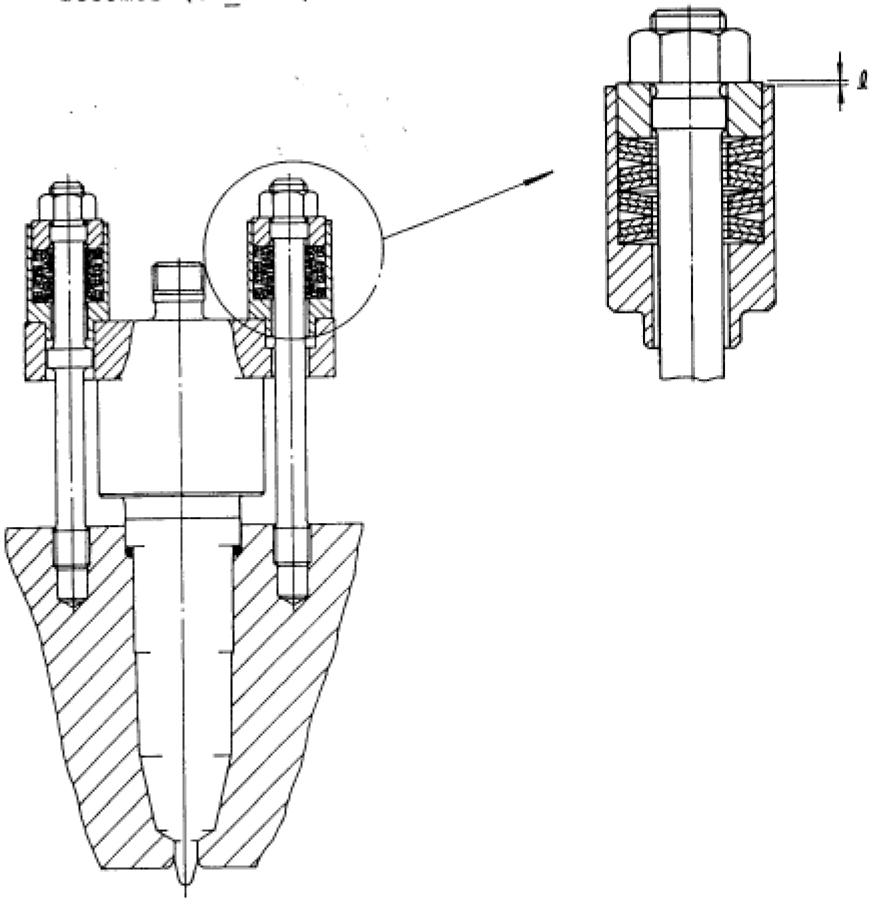


Fig.3 Fitting direction of the fuel valve

SN95
-4/6-

3) Tightening

The fuel valve body is tightened in the cylinder cover through the disk springs which are designed so that decreasing of the tightening force due to unavoidable deformation of each part or contacting each other can be minimized as far as possible.
Please tighten the nuts so that the dimension "ℓ" becomes (0 ± 0.2) mm.



Before tightening of the fuel valve ℓ = 2.4 ± 0.2 mm

After tightening of the fuel valve ℓ = 0 ± 0.2 mm

Fig.4 Tightening of the fuel valve

4) Usable time limit of the disk springs

The dimension "ℓ" before tightening the fuel valve is (2.4 ± 0.2) mm as stated before, however it will be sometimes decreased a little due to wear-down or deformation of the disk springs when they are used for long hours (about 30,000 Hrs).
As the decreasing of the dimension "ℓ" is directly connected with lowering of the tightening force, the disk springs should be renewed as the spring box complete if the dimension "ℓ" would become less than 2 mm.

Engine accident cases

File No.	1 - 013				
Case name	Bent crosshead toggle lever				
Device name	Main engine	Damaged part	Crosshead toggle lever	State of damage	Bend
Maker name		Model	7RTA62	Total working time	
Kind of ship		Date of occurrence		Place of occurrence	
Cause of damage/problem	Hardware factor	Improper maintenance procedure			
	Software/human factor	Disregard of manuals			

I. Outline of accident

[Course of events]

During an operation to reassemble a crosshead pin and its bearing metal after an overhaul for inspection, the toggle lever was bent and cracked. Crew members on board repaired it by welding after correcting the bend, but it fractured at the root section of the hinge at the center of the upper arm of the toggle lever.

The fractured upper lever was replaced with a pipe and repaired by the ship's crew members. The engine was restarted with fuel cut off to the relevant cylinder, but it tripped because of a pressure drop in the crosshead L.O. Line.

[State of damage]

An inspection thereafter revealed a fractured crosshead toggle lever and damage to the crankpin journal and its bearing metal (scratches and dents).

[Response measures]

(1) Replacement with a fully outfitted crosshead toggle lever.

(2) Honing of the crank journal by 2/100 mm to 3/100 mm after magnetic particle testing. The honing work was carried out by a repairer in Singapore.

(3) Replacement of the crankpin bearing metal.

II. Causes of accident/problems

[Hardware factors]

(1) Cross head toggle lever: Upon the overhaul, the toggle lever was removed on the crosshead side and a turning of the engine was carried out with the lever hung downard. This fact hints at the strong possibility of the toggle lever bent since it came in contact with the cross head or a fixing nut for the lower half of the connecting rod bearing.

(2) Crankpin and its bearing metal: Slag which adhered to the inside of the toggle lever

when crew members were engaged in welding for repairs, reached the crankpin bearing, causing damage to it, when the engine was put in operation.

[Software/human factors]

(1) When operating devices, engineers must thoroughly read and familiarize themselves with the operations manuals provided by the maker. If there is a modification of procedures from those contained in the original operations manual as in the case in question, after-sales service letters, though the name of such letter differs from maker to maker, are released. Letters of this kind reflect changes made as a result of defects in original procedures and, consequently, it may often lead to accidents if the original procedures, which have been modified thereafter, are followed on board vessels. Engineers must read letters of this kind whenever they are distributed to the vessel from the managing company even if the instrument taken up in the letter is not installed on the vessel; and when they handle the device on board a different vessel, they must recall and consult the letter.

(2) The upper arm fractured in an operation of the engine after repairs by welding. If lubrication is interrupted even for a short time, the bearing must be opened up. If the engineer in charge had been mindful of the seriousness of an accident of this kind, he could have prevented the entry of weld slag into the bearing and, as a result, could have saved time for restoring normally.

III. Measures to prevent recurrence

[Hardware aspects]

(1) Similar accidents have occurred in the past on board vessels managed by companies not related to us and the prevention of damage to the toggle lever in the overhaul of the crosshead bearing for inspection, is a matter which requires attention when engaged in the same operation on RTA engines. In addition, this is not restricted to the same operation, but when a chain block is used inside a crankcase as in maintenance work on a crankpin bearing, etc., it is required to take care so that the chain will not come in contact with the toggle lever.

(2) As instructed in the information provided by the maker concerning this matter, there is a need for engineers to bear in mind that, when engaged in overhauling the upper and lower bearings of a connecting rod, the toggle lever must be separated at the intermediate joint and supported on the frame side.

(3) In the event of a toggle lever deformed, the best response is to replace it with a fully outfitted part or to cut out the cylinder.

[Software/human aspects]

Perusal of, and familiarization with, service letters.

Ⅳ. Lessons

In the event of a failure, the person responsible may be inclined to handle it before it is known to others. This attitude, however, is very risky. It is important for the engineer to acknowledge a failure as such, judge the situation of the incident calmly and report it immediately.

Reference

DUQ1-042J: RTA52, 62, 72 Engines: Protection of toggle lever from unexpected damage

DIESEL UNITED-SULZER

Service Information

BULLETIN NO. DUQ1-042E

SUBJECT

DATE 18 JAN.1994

RTA52,62&72 Engines
Protection of Toggle Lever from Unexpected Damage

Preface

Some problems of toggle lever(swing-lever) which was damaged at repair or inspection-work of connecting rod bearings were reported. In order to prevent the said problems,this service news was prepared.

1. Process of damage

Prior to the replacement of bottom bearing of con-rod, the lower part of con-rod was secured on P-side of crank case by chaine-block, so as to obtain a sufficient clearance between crank-pin and bottom bearing.(Dimension "X" of attached Sketch 1) In some cases, toggle lever touched on crank case wall before obtaining the said clearances.

During the inspection work of con-rod top bearing, the toggle lever was forced to bend by the nut of stud bolts of bearing cover. This problem was caused during the turning of main engine.

2. Information

First information is to be given by this service news. The respective part of instruction manual will be revised for newly delivered engines.

3. How to prevent the said problems

3-1. Replacement or inspection of bottom bearing of con-rod.

Generally speaking, toggle lever does not need to remove from conn-rod. Because of manufacturing tolerance, however, the toggle lever touch on the wall of crank case,sometimes. If sufficient space was not provided between crank-pin and bottom end of conn-rod, it is recommended to remove toggle lever completely or to separete intermediate joint by the under mentioned manner. Lower lever is to be supported on the wall of crank case.(see attached Sketch 1.)

3-2. Replacement or inspection of top bearing of con-rod.

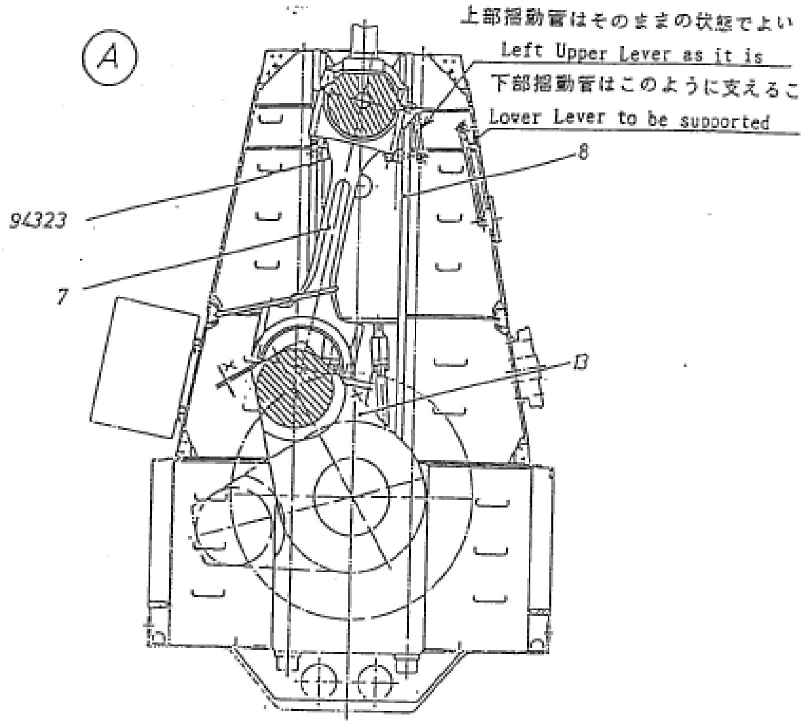
In this work, we also recommend to separate the intermediate joint of toggle lever, in addition to removing the flange from con-rod. Lower lever is to be supported on the wall of crank case as well.
(see attached Sketch 2.)
It is recommendable to remove toggle lever completely.

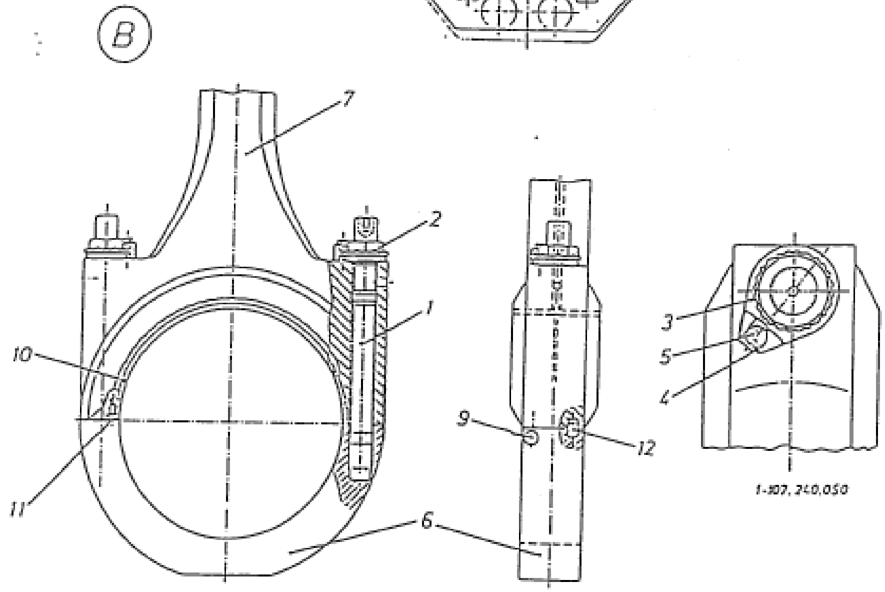
3-3. Assemblying and disassemblying of toggle lever

As shown in the Sketch 3,4 as well as Gr.360 of "Description and Operating Instructions" intermediate joint can be separated into two by removing bolts and pin. Lower lever should be secured.(see attached Sketch 3,4)

添付図 1 連接棒下部軸受点検、取換え時の揺動管

Sketch 1. Support of Toggle Lever





Gezeichnet für RTA62
DRAWN FOR RTA62

2/4 sheet

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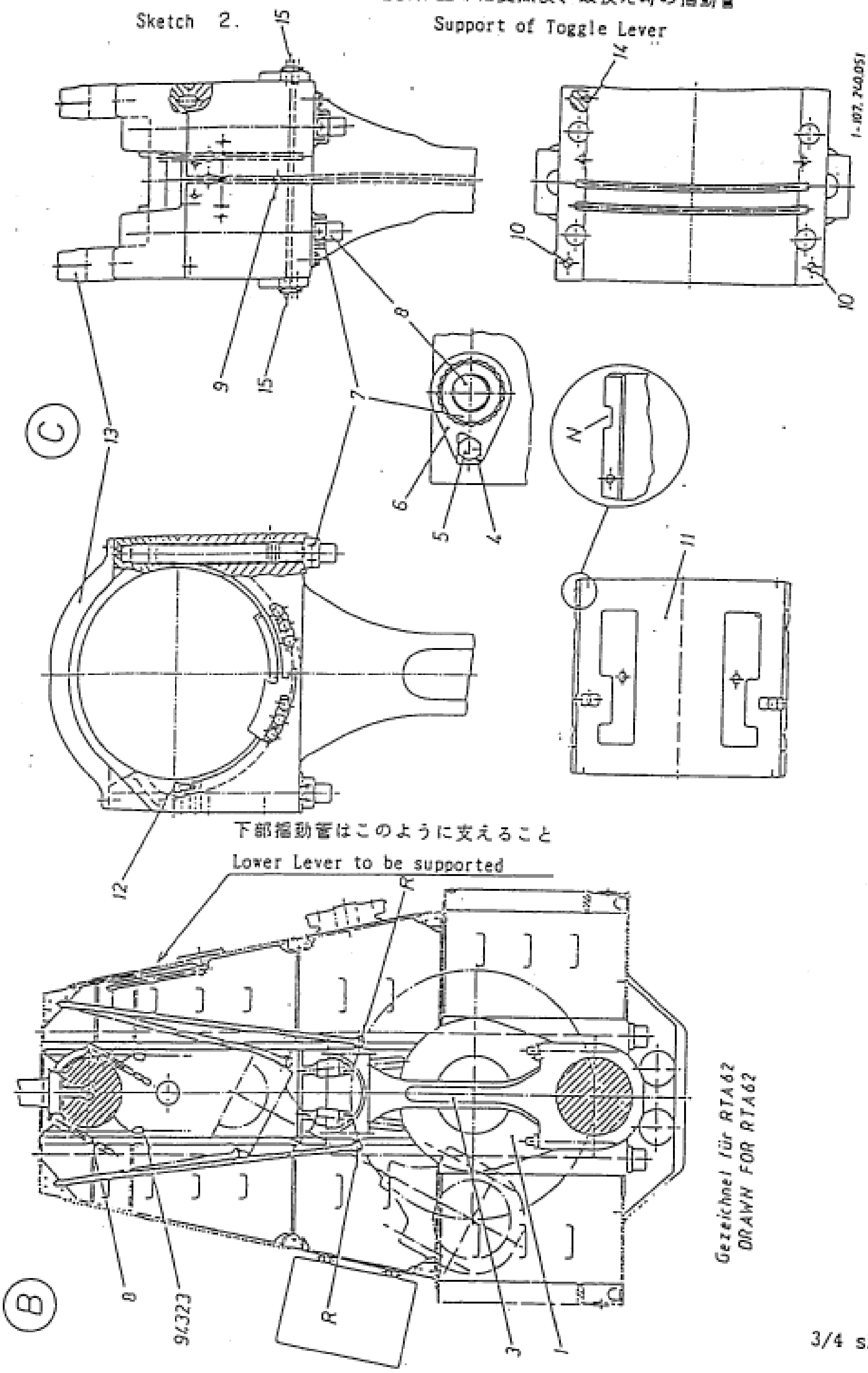
添付図 2
Sketch 2.

連接棒上部軸受点検、取換え時の揺動管
Support of Toggle Lever



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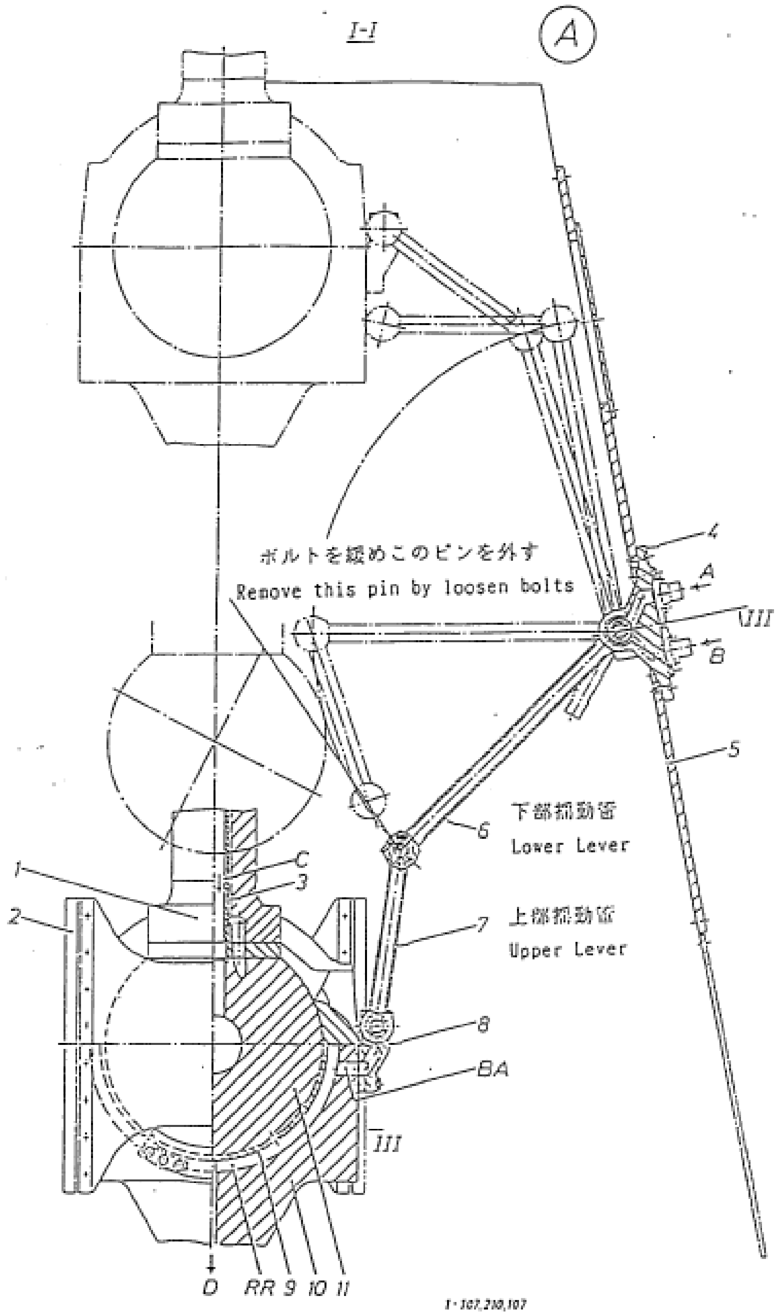
添付図 3　　下部揺動管と上部揺動管を切り離す

Sketch 3.　　Separate Lower lever and Upper lever



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DIESEL UNITED, LTD.

File No.	1 - 014				
Case name	Damage to crankpin bearings in all cylinders				
Device name	Main engine	Damaged part	Crankpin bearings	State of damage	Cracking and flaking off
Maker name	DU	Model	6RTA-52	Total working time	24,635 hours
Kind of ship	Bulker	Date of occurrence	1995.09	Place of occurrence	
Cause of damage/problem	Hardware factor	Design failure			
	Software/human factor	Nil			

I. Outline of accident

[Course of events]

When the vessel drydocked outside Japan in September 1995, after engine operation of 11,235 hours ever since the previous drydocking in March 1993, a crankpin bearing of the main engine was found to have cracked and flaked off. When, following this event, the crankpin bearings of all cylinders were overhauled and inspected, similar damage was found in all the bearings.

[State of damage]

The damage was as follows: Cracks occurred radiating from the lube oil inlet in the upper metal, causing metal to peel off. The metal sustained fretting over a wide range centering around the middle of the backing material.

[Response measures]

Renewal of crankpin bearing metals in all cylinders.

II. Causes of accident/problems

[Hardware factors]

The engine maker submitted the following view:

(1) The engine in question has, due to its compact size, a system to feed lube oil to the crankpin bearing from behind the center of the upper bearing metal via the connecting rod.

(2) For this reason, the upper bearing metal receives lube oil feed pressure on its back at all times, and is pressed toward the crankpin.

(3) The upper metal was repetitively subjected to shearing stresses, and presumably cracks radiated out from the LO inlet port, resulting in the metal flaking off.

(4) Damage caused by shearing stresses is said to occur once in 10^7 to 10^8 times.

(Approximately 19,000 hours when converted to operating time.)

[Software/human factors]

Nil

III. Measures to prevent recurrence

[Hardware aspects]

Renewal is required when the phenomenon occurs. Continued operation possible for five years.

[Software/human aspects]

IV. Lessons

Such an event may occur.

Engine Trouble Cases

File No.	1 - 015				
Case name	Trouble with main engine starting air system				
Device name	Main engine	Damaged part	Starting air system	State of damage	Failure to start
Maker name	Sumitomo Sulzer	Model	6RTA84	Total working time	9 years after built
Kind of ship	Container ship	Date of occurrence	1995.05.22	Place of occurrence	
Cause of damage/problem	Hardware factor	Miss piping arrangement			
	Software/human factor	Inattentiveness in maintenance work			

I. Outline of accident

[Course of events]

Trouble in getting the engine started occurred in succession under standby conditions for departure. The vessel experienced similar failures five or six times even after the turn of the year.

In addition, since the starting air valves became leaky and the main air control valve frequently malfunctioned as a result of its fouling and seizure. On every such occasion, the vessel overhauled and cleaned the starting air control valve but could not pinpoint the location of abnormality.

[State of damage]

[Response measures]

II. Causes of accident/problems

[Hardware factors]

A detailed inspection of the control air line made with reference to the main engine control system diagrams, revealed, in the drawing No. 53HP (three-way valve), a reverse pipe connection of the control air line (7 kg/cm^2) and starting air line. As a result of the reverse connection, the starting air pressure introduced to each cylinder becomes equal to the control air pressure, causing failures in getting the engine started.

[Software/human factors]

The case in question is a result of a mistake in pipe connection during re-assembly by the ship's hand or in drydock, but it is partly attributable to the fact that the pilot three-way valve has ports of the same size. Many of the parts employed for air control systems are similar in size while different in signal pressure, which requires special care in handling.

The basic principle for maintenance by overhauling is to restore to the original form and, for that purpose, it is vital to ensure to mark parts before the commencement of an overhaul.

III. Measures to prevent recurrence

[Hardware aspects]

The pilot valve (53HP) is of the type "GCH-37N". The main line of the relevant valve is capable of accommodating both flow directions, regular and reverse, and the valve used as a starting air control valve is employed in the reverse direction (Fig. 2).

In addition, the fitting ports are completely of the same size from the valve structure, which requires special caution.

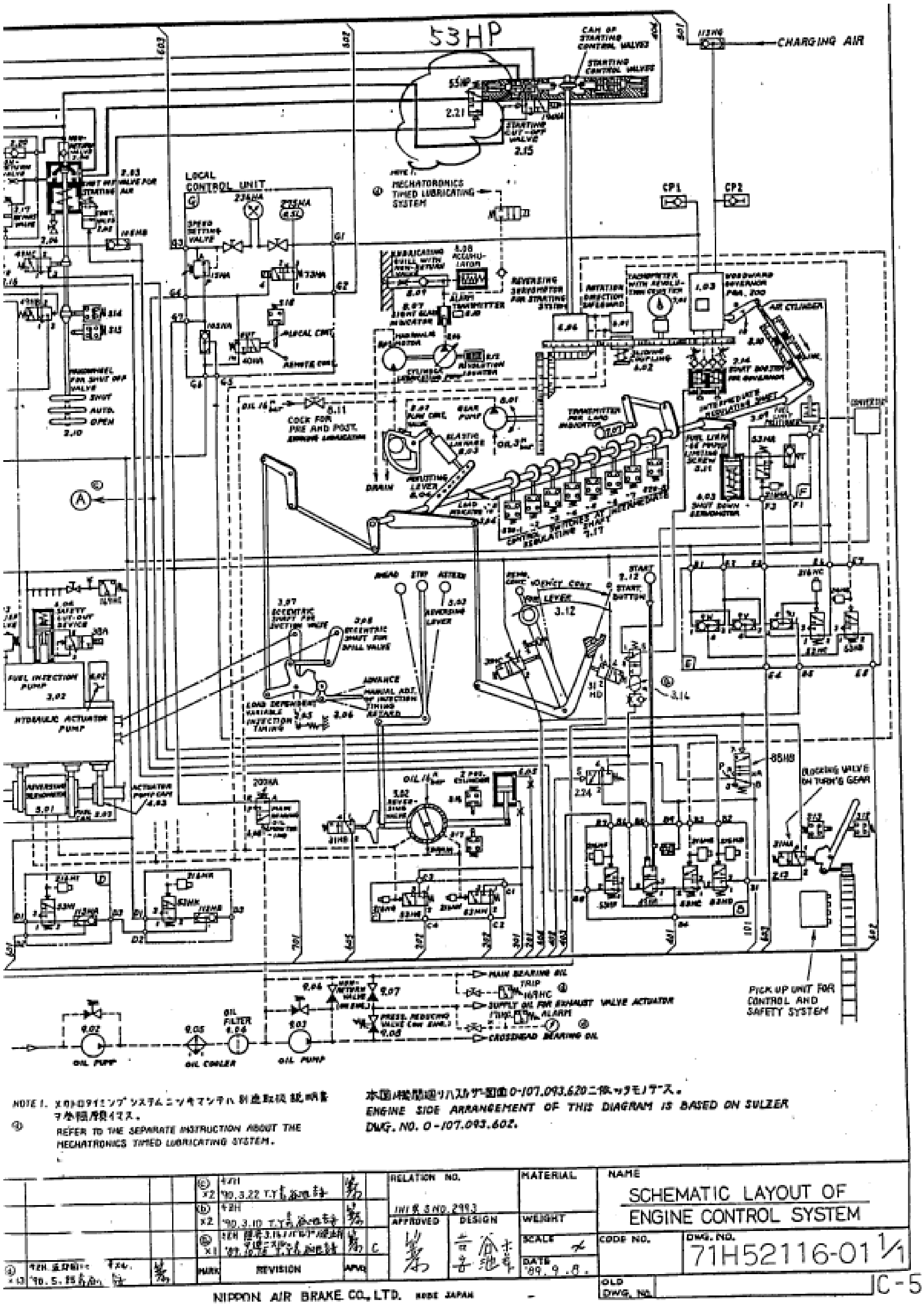
As a measure to check correct pipe fitting, an indicator is attached to the plug as shown in A of Fig. 2. The connection of the high pressure pipe to the pilot port would make the red pin to snap out to indicate a mistake in pipe connection. (The older type (prior to about 1990) does not have this indicator.)

[Software/human aspects]

In maintenance operations, it is necessary to ensure to put marks and numbers so as to make it possible to check that re-assembly work is done without a mistake.

IV. Lessons

As in this case, in a situation that shows that something is wrong but the "something" is not pinpointed, it is necessary to suspect everything, and work upwards from basic fundamentals.


53HP
CHARGING AIR
LOCAL CONTROL UNIT
MECHATRONICS TIMED LUBRICATING SYSTEM
CP1
CP2
FUEL INJECTION PUMP
HYDRAULIC ACTUATOR PUMP
OIL PUMP
OIL COOLER
OIL FILTER
MAIN BEARING OIL
SUPPLY OIL FOR EXHAUST VALVE ACTUATOR
CROSSHEAD BEARING OIL
PICK UP UNIT FOR CONTROL AND SAFETY SYSTEM
NOTE 1. REFER TO THE SEPARATE INSTRUCTION ABOUT THE MECHATRONICS TIMED LUBRICATING SYSTEM.
ENGINE SIDE ARRANGEMENT OF THIS DIAGRAM IS BASED ON SULZER DWG. NO. 0-107.093.602.
RELATION NO.
MATERIAL
NAME
SCHEMATIC LAYOUT OF ENGINE CONTROL SYSTEM
APPROVED
DESIGN
WEIGHT
SCALE
CODE NO.
DWG. NO.
71H52116-01 1/1
DATE
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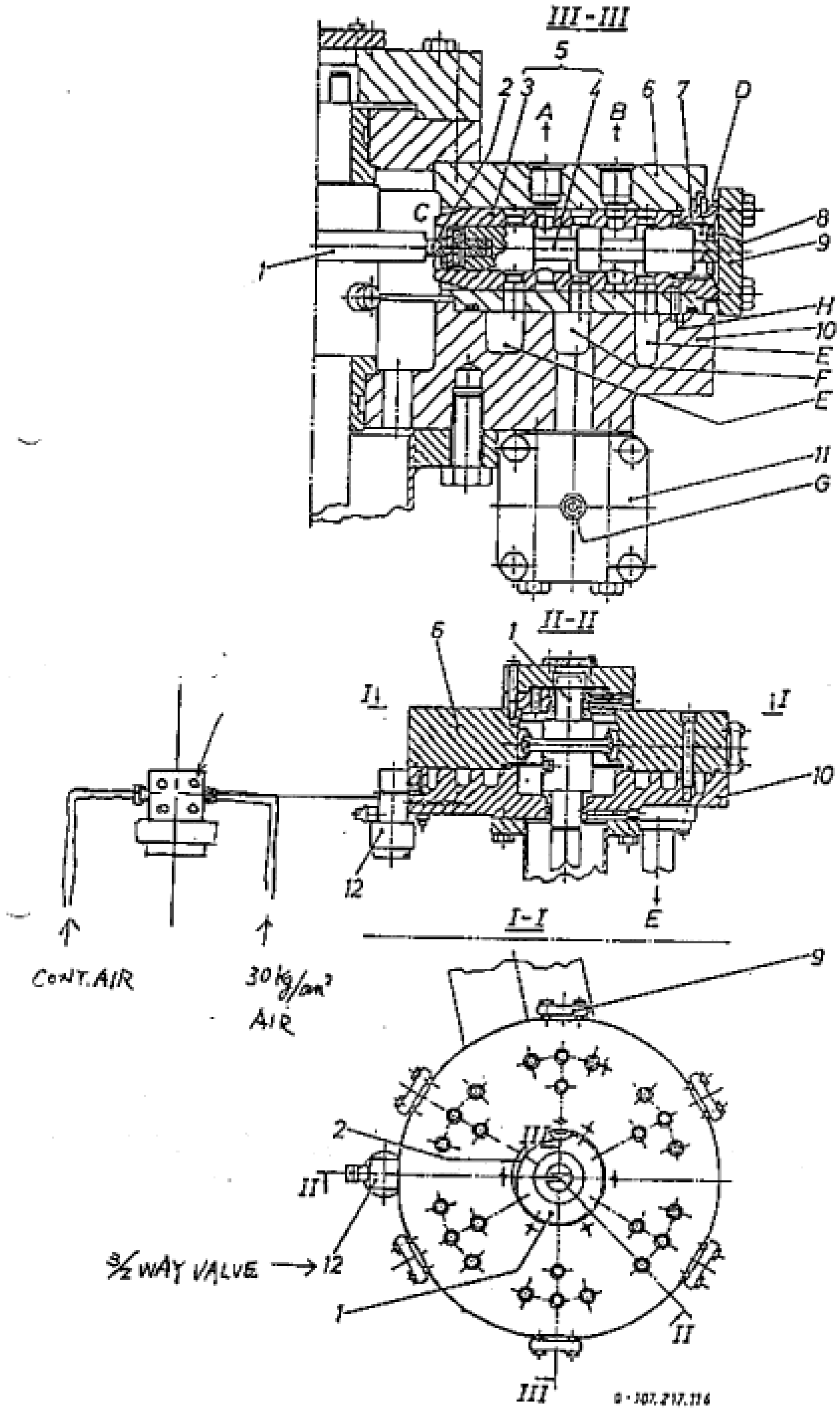
MARK
REVISION
APVD
OLD DWG. NO.
IC-5
NIPPON AIR BRAKE CO., LTD. KOBE JAPAN


III - III
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12
E
I - I
CONT. AIR
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II
12
3/2 WAY VALVE → 12
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II
III
0 - 107.217.116

Engine Trouble Cases

File No.	1 - 016				
Case name	Cracks in main engine cylinder liners				
Device name	Main engine	Damaged part	Cylinder liners	State of damage	Cracks
Maker name	Mitsubishi Ube	Model	6UEC60LA	Total working time	8 years after built
Kind of ship	Bulker	Date of occurrence		Place of occurrence	
Cause of damage/problem	Hardware factor		Contamination of cooling fresh water with cylinder oil		
	Software/human factor		Poor operational maintenance		

I. Outline of accident

[Course of events]

The vessel experienced frequent piston ring fractures and weardown of piston crown ring lands and used to pull pistons at intervals of about 2,000 hours. At the time in question when the vessel returned to a Japanese port, crew members pulled pistons from Nos. 2 and 4 cylinders and found a piston ring fracture and a cracked cylinder liner in No. 2.

[State of damage]

When service engineers of the maker inspected the main engine, they found cracks in Nos. 1, 2 and 5 cylinder liners and the seizure, fracture of piston rings and fusion of crown ring lands in Nos. 1, 2, 3 and 5 cylinders.

[Response measures]

As a result of a detailed inspection, it was decided to replace all the cylinder liners.

II. Causes of accident/problems

[Hardware factors]

As factors which induced the accident, the following three points can be enumerated:

(1) In Nos. 1 and 4 cylinders, the “O” rings for the stud for feeding cylinder oil were out of specification in terms of size and material and allowed cylinder oil to find its way into the main engine cooling fresh water.

(2) EPDM (EPT: ethylene propylene), which is not resistant to oil, was used by mistake for the seat of a butterfly valve on the main engine cooling fresh water line. As a result, the butterfly valve lacking resistance to oil sustained damage and flaked off, and such flakes blocked the cooling water passage. This caused liners to overheat and suffer heat cracks.

(3) From (1) above, the cylinder oil feed rate dropped, causing a rupture of the oil film, which, in turn, induced blowby, and resultant heat cracks.

[Software/human factors]

The fact that the pistons required withdrawal at intervals of 2,00 hours is itself a problem. Of course, such interval should be determined after comprehensively considering the maintenance condition of each part of the main engine, relations between fouled hull and design of propeller margin, and fuel oil and its treatment plant, but the problem exactly lies in the fact that the engine plant had been left in such a condition.

That is to say, the condition that cooling fresh water was contaminated with cylinder oil should have come to the notice of the engineers, through indications of fouling on the side of the cooling water space, when they were engaged in replacing exhaust valves and pulling pistons. Another opportunity to take notice of the situation is during operations for the maintenance of the quality of cooling water.

Furthermore, weren’t there any signs of it in the engine operation control, such as changes in cooling water temperature?

III. Measures to prevent recurrence

[Hardware aspects]

The material used for a butterfly valve on the main engine cooling water line is NBR (nitrile-butadiene rubber), but in this case, EPDM (ethylene-propylene-diene monomer) had been used for some time by mistake, though it is not clear since when. The cooling water outlet temperature for the main engine jacket has recently been designed by each engine maker to be controlled above 80ºC and, in the event of the use of rubber seat rings, planned inspection and replacement are required with hardening of the material in mind.

Rubber parts are difficult to identify their material according to their color, and for the purpose of identifying the material, it is usually the case that they employ color codes.

When making a requisition for, or replacing, parts, it is necessary to check the material of such parts.

[Software/human aspects]

(1) When overhauling for maintenance, never fail to inspect the cooling water side.

(2) An alert attitude, to detect any signs of change is required when the engine is in operation.

(3) It is difficult to identify the material of rubber parts according to their color, in spite of this color codes are employed for indentification.

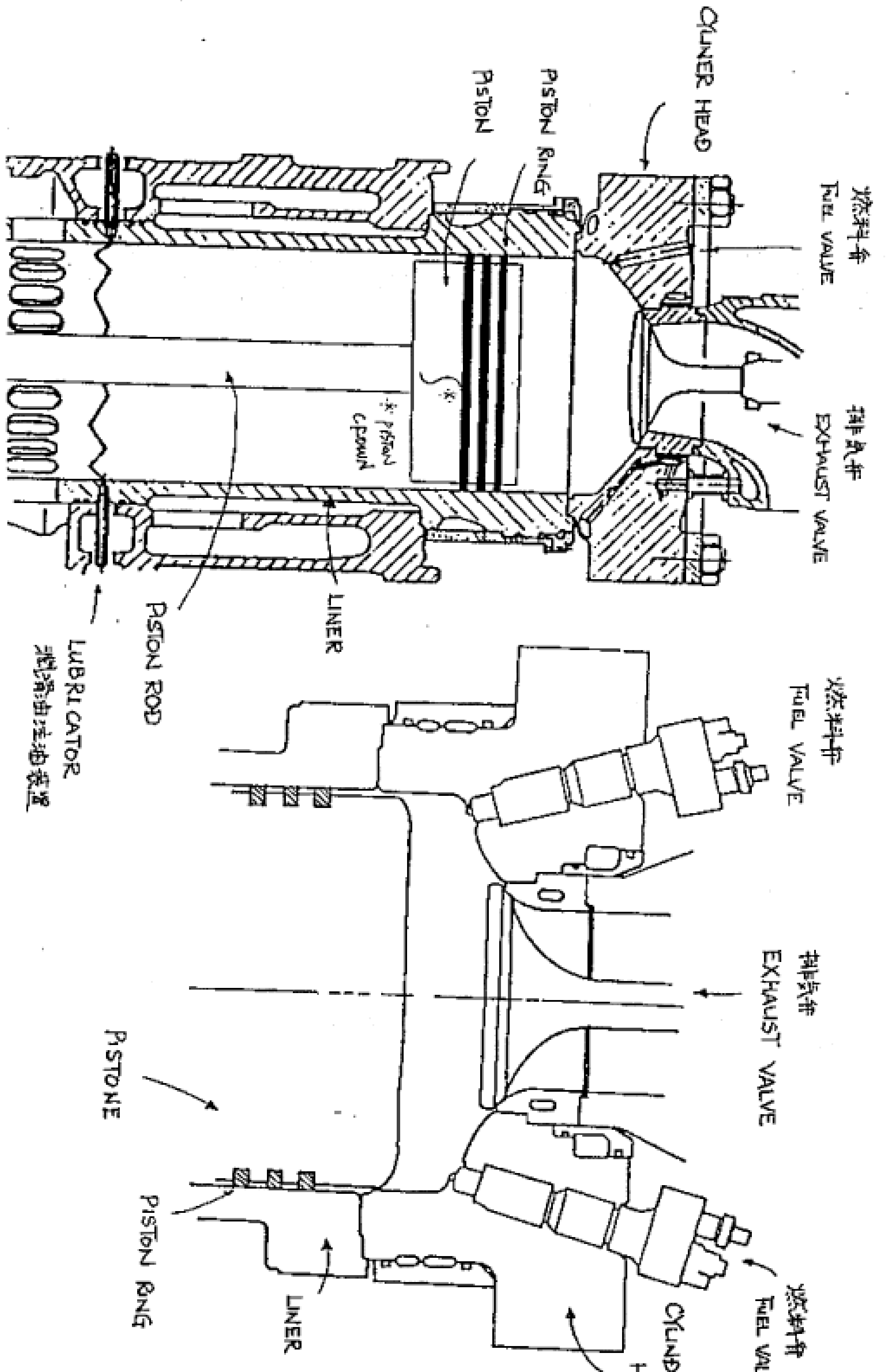
IV. Lessons

It is hard to know where the cause of a failure lies.

Reference

Example of rubber seat ring materials and a color code

Symbol	Generic name	Color code	General features	Use
NBR	Nitrile, Buna N	Blue	Oil, wear resistant	Sea water, fresh water
Hi-NBR	High nitrile	Green	Highly oil resistant	Fuel oil, lube oil
F-NBR	High tear strength nitrile	*Blue 2	High tear strength	Fresh water, sea water
EPDM	Ethylene propylene	Orange	Aging, heat resistant	Hot water, low pressure steam
CR	Neoprene	Red	Weather, ozone resistant	Air, gas
IIR	Butyl	Yellow	Acid resistant	Acid, gas
FKM	Viton, fluoric rubber	Gray	Chemical resistant	Gasoline, chemical agents
NR-C	Natural rubber for low temperature	White	Low temperature resistant	Coolant


CYLINER HEAD
PISTON RING
PISTON
FUEL VALVE
EXHAUST VALVE
PISTON CROWN
LINER
PISTON ROD
LUBRICATOR
FUEL VALVE
EXHAUST VALVE
PISTONE
PISTON RING
LINER
CYLINDER HEAD
FUEL VALVE
- 3 -

File No.	1 - 017				
Case name	Malfunction in working main engine astern				
Device name	Main engine	Damaged part	Remote control system	State of damage	Faulty control board
Maker name	MES	Model	BMS-1500	Total working time	
Kind of ship		Date of occurrence		Place of occurrence	Kaohsiung
Cause of damage/problem	Hardware factor	Faulty circuit boards			
	Software/human factor	Failure to operate locally			

I. Outline of accident

[Course of events]

(1) When under standby conditions for entering Kaohsiung, the remote control system showed "Abnormal Alarm" on the rpm pickup sensor, but, at this point in time, the normal operation of the main engine was restored by a resetting operation.

(2) When sailing out from the port, the vessel attempted to put the engine astern but failed.

(3) The control position of the main engine was shifted from BCC to ECC and to engine side but, regardless of the control position, it did not work on fuel oil though starting air was admitted.

(4) The vessel left Kaohsiung, as she was pressed in time, without being able to identify the cause of the malfunction. Unable to use astern engine, she arrived at Osaka and was engaged in berthing operations, employing more tugboats than usual.

[State of damage]

When the engine was put astern on air, each data, as was shown on the digital display of the control console, was checked in the presence of service engineers of the maker. As a result, it was confirmed that in spite of the fact that the engine was actually rotating in the astern direction, the display of the rotation still showed "Ahead".

[Response measures]

The above situation was judged to be attributable to faulty control circuit boards (RDU-1, RDU-2) of the BMS-1500 remote console, and when the two boards were replaced, the situation was rectified.

II. Causes of accident/problems

[Hardware factors]

The maker took back the faulty boards to its plant to investigate into the cause, which has yet to be identified.

[Software/human factors]

The report given from the vessel says that even the changeover of the engine control position failed to produce the intended effect to work the engine astern. However, if the control position is changed over to local control, interlocks related to “emergency stop” will take effect but will not monitor the “wrong way”. It is, therefore, considered possible to start the engine in the reverse direction by engine side control. The failure to start the engine on this occasion is very probably ascribed to an insufficient fuel injection since the attempt to reverse the engine was made when the vessel still had headway of 7 knots. The engineers cannot be criticized one-sidedly for their failure to determine the cause when they were not allowed to take extra time because the vessel was on tight schedule, but if they had been more familiar with the main engine control system, they could have reversed the engine by local control.

III. Measures to prevent recurrence

[Hardware aspects]

The incident in question was caused by faulty control boards as a result of some trouble, but it has shown that a malfunction of a part detecting control data or receiving/sending signals may easily make the engine uncontrollable.

It is required to request the maker to improve the reliability of the engine and study how to operate in emergency situations.

[Software/human aspects]

Engineers are required to familiarize themselves with the operation of the main engine control system at the earliest opportunity after boarding a vessel.

IV. Lessons

Now that shipboard devices have come to incorporate more and more electronic parts, trouble with the main engine console may easily occur. Engineers are required at any time to respond flexibly as the situation dictates.

Engine Trouble Cases

File No.	1 - 018				
Case name	Cracks in main engine camshaft drive chain link plate				
Device name	Main engine	Damaged part	Camshaft drive chain	State of damage	Cracks
Maker name	MES	Model	B&W 9K90MC	Total working time	30,216 hours
Kind of ship		Date of occurrence	1995.01.04	Place of occurrence	Hamburg
Cause of damage/problem	Hardware factor	Improper chain tension			
	Software/human factor	Inspection in strict accordance with basics			

I. Outline of accident

[Course of events]

During an operation to check the inside of the main engine crankcase, which was conducted as a regular operation, a cracked link plate of a camshaft drive chain was discovered.

[State of damage]

(1) Of the three rows of drive chains, a crack as shown in Fig 1 was found in the forward roller link plate. The damaged plate broke apart when hammered lightly after it was removed.

(2) The surface of the roller sustained scuffing all over, suggesting a considerably heavy load imposed on it and insufficient supply of lube oil.

(3) The middle level roller guide suffered a crack almost over the entire length. (It was found in an inspection made upon arrival at a port in Japan.)

[Response measures]

(1) Crew members replaced the damaged link together with engineers from B&W and a repairing contractor. The link plates replaced are as indicated in Fig. 2; nine links were replaced in total, namely, the damaged link, its adjoining links and those links corresponding to the same position in the other chains.

(2) It was possible to remove the link plates easily by lightly hammering them.

(3) Upon returning to Japan, engineers of the chain maker and the shipbuilder inspected but found no abnormality in appearance of various parts.

(4) The middle level roller guide was replaced with a spare on hand.

II. Causes of accident/problems

[Hardware factors]

(1) The material of the damaged plate was inspected, but it did not show any signs of its

poor quality.

(2) When it is taken into account that the nut of the chain tensioning device was screwed down by one more turn during reassembly in Hamburg and that the roller guide sustained a crack, the generation of excessive stresses on the roller/plate section as a result of the whipping of the chain is presumed as a cause.

[Software/human factors]

The incident is a typical example which reminds us of the importance of regular inspections at other times. There is a need to make meaningful periodical checks and not just carry them out as a formality.

III. Measures to prevent recurrence

[Hardware aspects]

No abnormal condition was discovered in a check made by the shipbuilder/chain maker. Since the starting point of the crack was inside the part where the roller guide was inserted, which escapes detection without disassembly of the chain and, furthermore, the surface of the roller bearing also sustained scuffing, all the chains were renewed and the damaged roller guide replaced in the following drydocking after the discovery of the damage.

[Software/human aspects]

Since it seems considerably difficult to replace or re-tension chains only by consulting descriptions contained in the operations manual, there is a need to create an environment which enables such operations by ship hands on board by requesting little by little supplementary information in service news provided by the maker.

IV. Lessons

This case was an extremely lucky one; an inspection at the next port might have resulted in a serious accident.

Luck forms a part of ability??

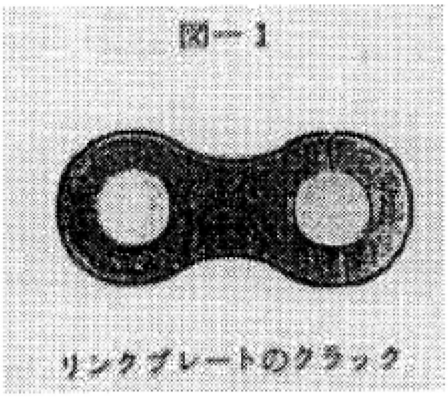


Fig. 1 Crack of the link plate

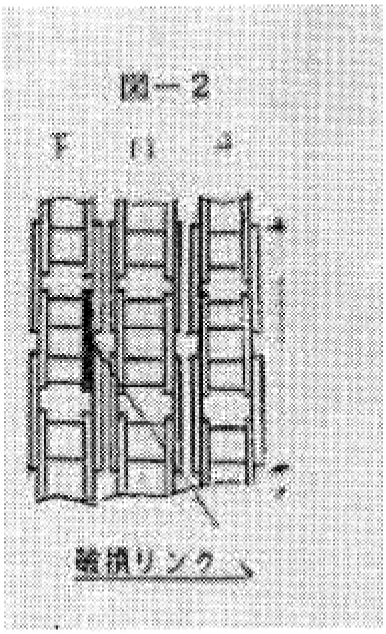


Fig.2 Damaged link

Engine Trouble Cases

File No.	1 - 019				
Case name	Engine room fire which started from abnormal combustion in main engine exhaust manifold				
Device name	Main engine	Damaged part	Various parts	State of damage	Burnout
Maker name	Akasaka Diesel Ltd.	Model	UEC45H	Total working time	
Kind of ship	Container ship	Date of occurrence		Place of occurrence	
Cause of damage/problem	Hardware factor		Scavenging air space fire resulting from poor regular maintenance		
	Software/human factor		Poor maintenance		

I. Outline of accident

[Course of events]

(1) After completing cargo work, the vessel left a port in Japan running on diesel oil.

(2) One hour after departure from the port, with the order "Full away" the vessel increased her speed after changing over fuel from Oil A to Oil C. The main engine speed abruptly climbed up (130 to 140 rpm) five minutes later, an abnormal condition. Following this situation, the engine was stopped immediately. At this point in time, a fire was detected somewhere below the exhaust manifold close to No. 4 cylinder exhaust branch. In addition, the scavenging air space fire alarm and cylinder outlet high temperature alarm were raised.

(3) The fire which originated from near No. 4 cylinder spread all over the engine room, resulting in her disability to sail under own power.

(4) Fire boats were mobilized and engaged in fighting the fire for one day and night. An investigation conducted after the fire was extinguished, revealed the engine room was completely destroyed.

[State of damage]

(1) The pistons and liners of all cylinders had traces of blowby and deep vertical grooves.

(2) The piston rings of all cylinders had seized and fractured.

(3) The "O" rings for piston crown cooling of all cylinders were hardened and a test by introducing oil revealed they were leaky.

(4) No abnormal condition was observed in fuel injection valves by an injection test.

(5) The scavenging air space of each cylinder had a large accumulation of sludge as their drain holes were clogged.

(6) The sight glass of the lube oil drain pipe for the turbocharger, installed at the lower portion of No. 4 cylinder exhaust branch, was broken and lost.

[Response measures]

The work for restoration required more than one month.

II. Causes of accident/problems

[Hardware factors]

(1) Abnormal combustion in exhaust manifold

The investigation mentioned above hints at the following possible causes:

a) A fire occurred in the scavenging air space resulting from blowby. Consequently, it accompanied incomplete scavenging, which, in turn, brought about an accumulation of a large amount of unburned fuel in the exhaust manifold.

b) Hardened "O" rings allowed piston cooling oil to leak and accumulate in the scavenging air spaces and exhaust manifold.

(2) Causes leading to engine room fire

The direct cause of the engine room fire is presumed to be as follows: As a result of a violent combustion of the unburned fuel gas trapped inside the exhaust manifold, the turbocharger overran, accompanying, as a result of its great impact, a breakage of the sight glass of the lube oil drain pipe for the turbocharger (the same sight glass was equipped at the lower portion of No. 4 cylinder exhaust branch and was confirmed broken and missing in an on-scene investigation), which allowed lube oil to flow out and catch fire when it came in contact with the exhaust manifold.

[Software/human factors]

(1) As a result of the occurrence of the fire which devastated the entire engine room and the firefighting activities which took place thereafter, the internal condition of the main engine may have changed between the outset of the fire and the time of opening it for investigation. It is, therefore, difficult to determine which of a) and b) in (1) above actually started the fire, but in either case, there is no doubt that failure to perform regular maintenance work played an important role.

(2) In this accident, a continued operation for about 20 minutes of the lube oil pump even after the occurrence of the fire and the stop of the main engine, led to the spread of fire all over the engine room.

III. Measures to prevent recurrence

[Hardware aspects]

(1) We have received a large number of reports on the occurrence of scavenging air space

fires and abnormal combustion inside exhaust manifolds, attributed to poor regular maintenance which produced foul scavenging spaces, and leaks of piston cooling oil and to poor combustion control. Special care is required for the maintenance of engines of this type.

(2) The hardening of “O” rings by blowby gas is observed and, when a piston in a cylinder where blowby has occurred is pulled for maintenance, it is, therefore, recommended that the piston crown be overhauled for inspection.

[Software/human aspects]

In the event of a fire, it is required to take care to stop pumps of unnecessary systems immediately.

IV. Lessons

You have to pay the price for poor maintenance but there is a difference in severity of this price.

Engine Trouble Cases

File No.	1 - 020				
Case name	Damaged cylinder cover tensioning hydraulic jack				
Device name	Main engine	Damaged part	Cover tensioning jack	State of damage	Hardened "O" ring
Maker name	MES	Model	B&W 7K90MC	Total working time	5 years after built
Kind of ship	Container ship	Date of occurrence	1992.06.17	Place of occurrence	Kobe
Cause of damage/problem	Hardware factor				
	Software/human factor				

I. Outline of accident

[Course of events]

(1) Crew members commenced pulling main engine pistons at Kobe on June 17, but failed to raise hydraulic pressure because of a leak of one of the jacks used for cylinder cover bolt tensioning. Although they injected grease through the air vent of the relevant hydraulic jack (three times) according to the maker's instructions manual, they abandoned the overhauling operation since the adjoining two jacks also leaked.

(2) As a result of an attempt to increase the viscosity of the hydraulic oil for the jacks by replacing it with cylinder oil at Kobe on July 6, they succeeded in raising the pressure of the hydraulic jack to 900 kg/cm^2 and unscrew nuts. Also on this occasion, two jacks leaked, but they attained pressures of 100 kg/cm^2 and 500 kg/cm^2 respectively and it was possible to unscrew with the use of a striking ring wrench.

[State of damage]

Of the 32 "O" rings used in the 16 hydraulic jacks, approximately 60% sustained cracks and all of the rings were generally hardened and in a state easy to fracture.

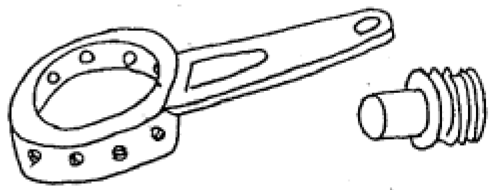
[Response measures]

(1) Replacement of the hydraulic oil of jacks with cylinder oil with a higher viscosity.

(2) If the leak of a jack is to such a degree as may allow the hydraulic pressure to attain 100 kg/cm^2, unscrew nuts with the use of a striking ring wrench. Replace O rings and backup rings of leaking jacks.

If the cover tensioning nut is round shaped (with screw holes of 8 mm in diameter), place a striking ring wrench so that its screw holes are in line with those of the nut and insert about three hexagon socket head cap screws into them and loosen the nut by striking the wrench.

The number of spare hexagon socket head cap screws (chrome-molybdenum steel) on hand is 4, but having 4 additional ones in stock is desirable for emergencies.



(3) If the leak is excessive and the jack is not capable to raise pressure at all, inject grease through the vents on both sides of the jack to raise the viscosity of the hydraulic oil; and increase the pressure of the jack and unscrew with the aid of a striking ring wrench.

(4) If even these attempts fail to raise the pressure:

a) Isolate the leaky jack from other jacks with two blank plugs and unscrew other nuts. If only one jack is leaking or leaky ones are adjoining, each other, the cylinder cover inclines, facilitating the unscrewing of nuts.

b) Sever the spherical washer for a cover tensioning nut and pull it out.

c) Heat the stud between cover and jacket and unscrew the nut. In this case, replace the stud with a spare one for safety sake.

II. Causes of accident/problems

[Hardware factors]

Poor design material of the "O" ring.

[Software/human factors]

III. Measures to prevent recurrence

[Hardware aspects]

With B&W engines, GF and other models thereafter have adopted hydraulic jacks for tightening cylinder covers, but in models, including MC, with high jacket temperatures, the O rings harden prematurely and it is necessary to replace them once every 4 years or at the time of withdrawal of pistons for the second time, as a rule of thumb. They, at Mitsui Engineering & Shipbuilding Co., have been changing the material of "O" rings from NBR to NBR-Z since about three years ago. This effort, however, is not intended to prolong their service life.

[Software/human aspects]

IV. Lessons

If you have a knowledge of such a thing, it may serve when you are in trouble.

However, this holds true ‘if there is a leak’ on the basis of your correct handling according to the instructions manual. It is out of the question if a proper pressure is not attained just because the jack is not properly bled of air or the quick joint was not correctly inserted.

Engine Trouble Cases

File No.	1 - 021				
Case name	Main engine scavenging space fire				
Device name	Main engine	Damaged part	Scavenging space	State of damage	Fire
Maker name	Mitsui B&W	Model	KL80MC	Total working time	
Kind of ship		Date of occurrence	1998.01.11	Place of occurrence	At sea
Cause of damage/problem	Hardware factor	Accumulation of drain in scavenging space			
	Software/human factor	Poor maintenance			

I. Outline of accident

[Course of events]

When the vessel was sailing after departure from Tokyo, the scavenging space fire alarm sounded immediately after the engine speed was increased from 65 to 75 rpm to avoid the barred speed range of 66 to 74 rpm. A fire occurred in the scavenging space.

[State of damage]

In an inspection after the fire was put out, there was no damage, in particular, found in any part of the engine.

[Response measures]

The fire was put out with the steam extinguishing system.

II. Causes of accident/problems

[Hardware factors]

(1) The scavenging space drain pipe of No. 9 cylinder was clogged, resulting in an accumulation of about 100 liters of drain.

(2) In the No. 9 cylinder, the piston was pulled on the previous voyage. Though the piston has not been pulled after this accident, there is no sign of leaks in the surrounding area as a result of the deterioration of "O" rings, indicating normal conditions.

(3) The scavenging space fire does not necessarily require continuous blowby as a cause and there is a possibility of its occurring even upon the speeding up of the main engine. If you peer into the scavenging space, it is evident that a large amount of sparks occur forming fire balls when the engine speed is increased. There is no shortage in the past, of fires in the scavenging space upon speed increase.

[Software/human factors]

(1) The engineers failed to take action even when there was a drain accumulation in the scavenging space.
(2) Their response action upon the occurrence of the fire was quick and proper.

III. Measures to prevent recurrence

[Hardware aspects]
The scavenging space and manifold should be cleaned every 1,500 hours.

[Software/human aspects]
Discharge drain and air through the scavenging space drain cock to prevent an accumulation of combustible matter.

IV. Lessons

There is no shortage of factors causing a fire in the engine room. If you are off guard, a fire may occur any time.
A proper response action in an emergency depends on your efforts at other times.

Engine Trouble Cases

File No.	1 - 022				
Case name	Main engine damage resulting from combustion disorder				
Device name	Main engine	Damaged part	Cylinder liners	State of damage	Cracks
Maker name	Mitsui B&W	Model	7L80MCE	Total working time	14 years after built
Kind of ship	Bulker	Date of occurrence	1999.03.01	Place of occurrence	At sea
Cause of damage/problem	Hardware factor		Defective fuel valves, fuel oil with poor quality		
	Software/human factor		Poor maintenance of fuel valves and poor management of fuel oil purification		

I. Outline of accident

[Course of events]

When the vessel was on her way to Singapore after loading cargo at Puerto de Madeira, the main engine No. 3 cylinder scavenging space set off a high temperature alarm. Since it was considered as a result of blowby, the main engine was stopped and inspected.

[State of damage]

Since the second piston ring for No. 3 cylinder fractured (3,500 hours after the previous withdrawal and maintenance of the piston), the piston was pulled and the ring replaced.

A service engineer dispatched from the maker made an inspection at a later date. The following are results of the inspection and analysis of data:

(1) No. 3 cylinder liner sustained a heat crack of 415 mm in length along the circumference on the forward starboard side at a level of 310 mm from the top end.
A close examination by the use of a magnified photograph showed scratches and low temperature corrosion.

(2) Traces of scuffing were observed here and there on the surfaces of five cylinder liners, between the cylinder oil groove and scavenging port.

(3) The weardown rate of all cylinder liners grew from 0.09 mm/1,000 hours to 0.16 mm/1,000 hours.

(4) The weardown rate of all piston rings abnormally increased from 1.0 mm/1,000 hours to 9.0 mm/1,000 hours.

(5) Breakage of piston rings were observed in all cylinders except No. 2 and, among others, almost all top rings found broken.

(6) The weardown of the top ring grooves was within the tolerance.

(7) The piston ring glands of all cylinders were excessively fouled with carbon and sludge.

(8) The wall of the scavenging manifold was coated with sludge in the form of tar.

[Response measures]

II. Causes of accident/problems

[Hardware factors]

According to results of analysis of the fuel oils used from April to September, 1998, was satisfactory. Impurities like carbon, asphaltene, vanadium and sodium, were under tolerable limits. The overall quality of the oils was not so bad, in comparison with MOL's standard values, and it seemed to be usable without any special pretreatment.

[Software/human factors]

(1) The analysis of fuel oil before and after treatment by the purifier showed that there was nearly no purification effect.

(2) An inspection of fuel valves extracted from all cylinders revealed a reduction in valve opening pressure, poor atomization and a faulty circulating function (of the auto de-aeration valves).

(3) The operation is poorly managed.

  (a) The increase in exhaust gas temperature escaped notice.

  (b) The operation in the torque rich zone escaped notice.

  (c) Other operating parameters must have changed.

  (d) A look through the cylinder liner sight holes would have provided the situation of blowby or fouled ports.

III. Measures to prevent recurrence

When it is not uncommon to encounter fuel oil of inferior quality, the proper purification of such oil on board and the maintenance of the combustion system have become indispensable to obtain a normal combustion condition.

(1) Fuel oil viscosity for purifier

To obtain an optimum purification result, feed the purifier with fuel oil after making it less viscous as far as possible.

The optimum (low) viscosity is obtained by running the purifier pre-heater at the highest temperature recommended for the fuel concerned. It is very important that, in the case of fuels above 1,500 Sec. RW/100F (i.e. 180 cSt/50ºC), the highest possible preheating temperature, 95 - 98ºC, should be maintained in the purifier.

(2) Feed rate for purifier

The purifier should be operated for 24 hours a day except during necessary cleaning and periodical maintenance. The fuel should be kept in the purifier as long as possible, by adjusting the flow rate to keep up with fuel consumption of the engine, without excessive re-circulation. The ideal ‘throughput’ is, therefore, 1.1 times normal fuel consumption. For efficient removal of water by means of a conventional purifier, the correct choice of a gravity disc is of special importance. Each purifier manual states the size of disc to be chosen in response to the specific gravity of the fuel in use. A copy of ‘Selection Nomogram of gravity disc’, attached hereto, for Mitsubishi Kakoki Model SJ 60T, shows how to select a gravity disc for a particular flow rate, separation temperature and specific gravity. Maintain a constant flow rate and ensure that the flow meter is functional.

(Refer to the operation manual and attached Nomogram.)

(3) De-sludging operation of purifier

In order to remove heavy deposits of sludge, de-sludging should be done more frequently. It should, however, be done every two hours at a minimum, depending upon the quality of the fuel.

Vessels must use a decanter, if fitted, when heavy sludge is found from the purifier.

(4) Drain quantity from HFO settling & service tanks

In order to avoid the abnormal wear of cylinder liners/piston rings, the seizure of fuel pump plungers, etc., a certain amount of drain must be removed from the bottom of tanks. Drain should be removed thrice a day - in the morning, at noon and in the evening prior to starting the machinery operation under ‘M0’ control.

Check the condition of the drained fuel and inform the Chief Engineer of the result for necessary action.

For effective separation, the ideal setting temperature for the settling tank is 60ºC and that for service tank between 85 - 90ºC.

(5) Fuel oil

Fuel oils of today are produced on the basis of a wide variety of crude oil through refinery processes.

Practical experience has shown that, because of incompatibility of different oils, certain fuels may tend to become unstable when mixed together. A mixture of incompatible fuels when stored in double bottom tanks or settling tanks, may stratify and sometimes result in rather large amounts of sludge being discharged by the purifier; in some cases the operation of the purifier is hampered. It follows that mixing different fuels should be avoided as far as practicable. However, if a problem is encountered as a result of unavoidable mixing, when a fuel tank is changed over to another, the settling & service tanks should be drained as far as possible and checked in order to take appropriate action. If a problem still persists even after the above measures are taken, the use of chemicals should be considered under advice from the office.

(6) Pre-heating of fuel oil before injection

In order to ensure correct atomization, the fuel oil must be pre-heated before injection. The necessary pre-heating temperature is dependent upon the specific viscosity of the oil in use.

Inadequate pre-heating (i.e. too high viscosity) will influence combustion, may cause increased cylinder liner wear, be detrimental for valve seats and result in too high injection pressure, leading to excessive mechanical stresses in the fuel oil system. In most installations, pre-heating is carried out by means of steam, which is controlled by a viscosity regulator. It is essential that the viscosity regulator is well maintained.

From service experience, a viscosity of up to 20 cSt after the pre-heater is allowed.

(7) Filters

Line filters can trap solid particles down to a certain size. Experience has shown that very fine screen filters tend to become clogged frequently and practically impossible to clean properly, if the cleaning interval is prolonged. Automatic back wash (secondary) filters and 'Hope' filters (including by-pass filter), where fitted, should also be opened up and cleaned at certain intervals. It is therefore essential that such frequency of cleaning and maintenance should not be unduly reduced. The primary filters in the fuel oil purification system and fuel oil service system should be cleaned twice a day, in the morning and in the evening prior to the start of machinery operations under the 'M0' control.

Any unusual condition of the filters caused by cloggage must be reported to the Chief Engineer for his necessary action.

(8) Fuel oil additives

Additives should be used after receiving instructions from the management company. Ensure that stocks of Unitor product 'Fuelcare' & 'Diselite' and Nalfleet product 'Combustion Catalyst' or 'Maxi-Mize Regular' are available at all times.

(9) Bacteria removal from diesel oil (Anti-mould additive)

Unitor product 'Fuel Oil Biocide' and Nalfleet product 'Diesel Oil Stabiliser' should be stocked on board at all times. Prior to receiving diesel oil, a dose of anti-mould additive should be poured in the relevant diesel oil tanks every time.

Remarks: Unitor product 'Fuel Oil Biocide' and Nalfleet product 'Diesel Oil Stabiliser' should be stocked on board at all times.

(10) Maintenance

In order to ensure efficient purification, the primary & secondary filters, purifier and decanter should be maintained in good working order. Reference should be made to the TOMAS-PM E/R FO/LO Pre-treatment System and the respective makers' instruction manuals.

IV. Lessons

If everything is left unattended, something will eventually break down.

Engine Trouble Cases

File No.	1 - 023				
Case name	Breakage of main engine turning gear				
Device name	Turning gear	Damaged part	Reduction gear	State of damage	Breakage
Maker name		Model		Total working time	
Kind of ship		Date of occurrence	1986.06	Place of occurrence	In standby condition for port entry
Cause of damage/problem	Hardware factor	The turning safeguard system did not work.			
	Software/human factor	Operational mistake			

I. Outline of accident

[Course of events]

When the engine room was put on standby condition for entering port, the starting air shutoff slide valve seized at 'half-open' position, prohibiting even manual operation of the valve. Since the valve was kept half open, the starting air was continuously released through the blow pipe, and the starting air reservoir pressure started dropping.

Since the pilot boat was already alongside the vessel and a forcible closure of the valve could prevent the use of the function to open it again, she completed her berthing operation safely, by handling the main air reservoir outlet valve (solenoid valve) by remote control, while maintaining the starting air pressure.

After "Finished with Engines", crew members started to change various machines for a port stay condition; and following instructions from the bridge to run the engine on air, they did so in the ahead direction after checking the indicator valves were open.

After the air run, the turning gear was found to have been engaged.

[State of damage]

(1) Three cracks were generated in the gear case.

(2) Tightening bolts for the bearing cover and the intermediate bracket fractured.

(3) The set pin hole of the intermediate bracket was partially chipped off at two locations.

(4) The motor bed plate was cracked at one location.

(5) The following damage occurred in the four-stage (final stage) reduction gear:

  (a) Slight burs in the ring gear

  (b) Traces in the distance bolt of scratches resulting from contact with a planet gear

[Response measures]

Since temporary repairs were impossible, the damaged turning gear was handled so that it might not interfere with the operation of the main engine. In addition, after confirming, by checking the main engine flywheel and its adjoining areas, that the damage would not hamper the operation of the main engine, the vessel sailed out. The turning gear was replaced with a fully outfitted spare after arrival in Japan.

II. Causes of accident/problems

[Hardware factors]

The shutoff slide valve seized at an 'open' position and the turning gear safeguard system did not function.

[Software/human factors]

(1) While running the engine on air, the turning gear was engaged.

(2) The engine was run on air without checking the turning gear engagement/ disengagement pilot lamps.

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

The damage this time occurred during work to change over to a port stay in an atmosphere of relief after the trouble of the shutoff slide valve and the crew members involved seem to have let their guard down slightly as compared with in departure from port.

In addition, this accident could not have occurred without any one of the factors enumerated above, which fact reminds us of a horror by an accidental coincidence.

The damage, however, involved a lack of the following basic matters and “strict adherence” to them could have prevented the accident:

(1) Matters which require special attention concerning the state of equipment should be known to those engaged in the operation of such equipment.

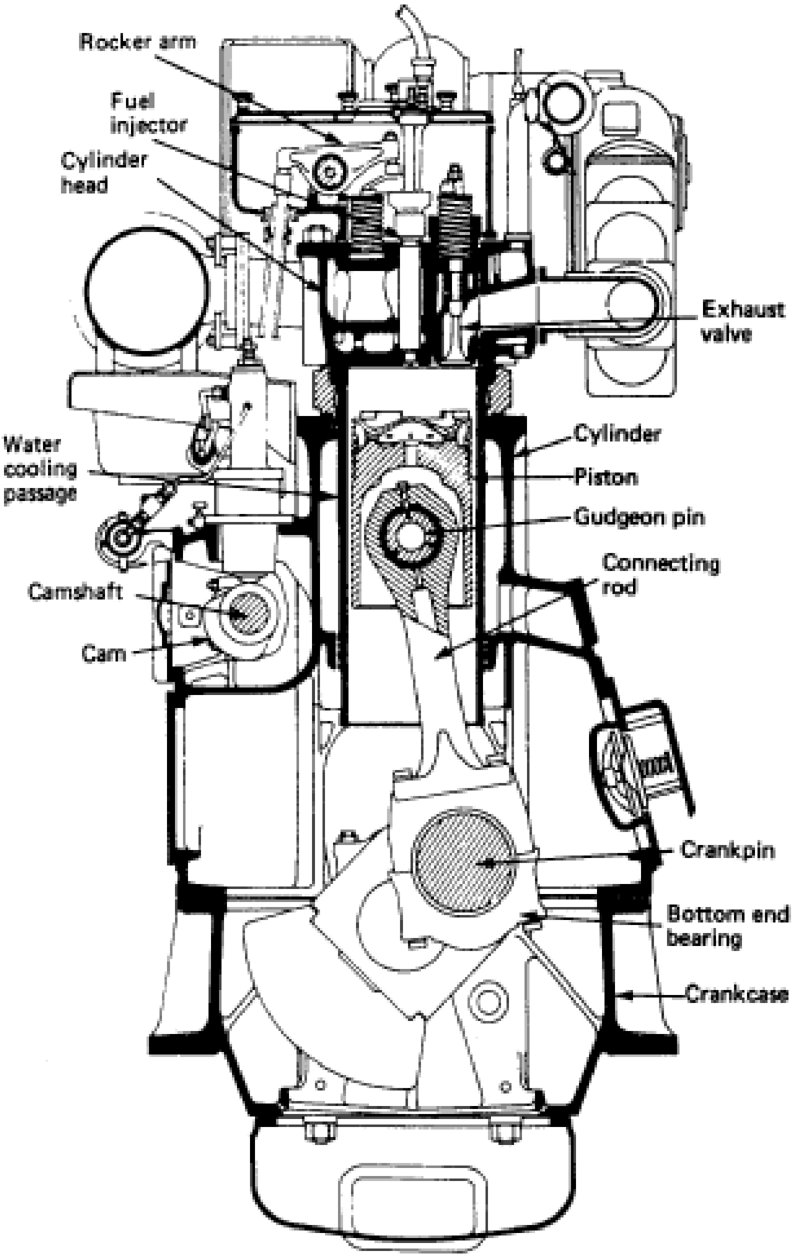
(2) The operator of a machine should give thorough feedback to the department head of the state of operation.

(3) Crew members should be thoroughly inculcated with the importance of checking safety with body action (pointing with a finger).

IV. Lessons

Take care! Failure to follow basics might lead to an accident at any time.

2. Diesel generator



Engine Trouble Cases

File No.	2 - 001				
Case name	Blackout in standby condition				
Device name	Diesel generator	Damaged part		State of damage	Operational stop
Maker name		Model		Total working time	
Kind of ship	PCC	Date of occurrence		Place of occurrence	In standby condition for port entry
Cause of damage/problem	Hardware factor	Reduction in fuel oil pressure			
	Software/human factor	Operational mistake			

I. Outline of accident

[Course of events]

No. 1 diesel generator was in operation when the engine room was under a standby condition for entering Benicia. After starting No. 2 diesel generator, a crew member opened three turns the HFO inlet valve for No. 2 D/G in an attempt to change over from DO to HFO, when a blackout occurred (No. 1 D/G tripped), forcing the vessel to deviate from her course to strand on a sand bank.

[State of damage]

The bottom paintwork was slightly scraped off.

[Response measures]

The power source was restored thereafter and the vessel refloated under her own power.

II. Causes of accident/problems

[Hardware factors]

After starting No. 2 D/G, the engineer in charge made a mistake in valve handling and opened the HFO inlet valve while the DO outlet valve was still open (the DO outlet valve had atmospheric pressure); as a result, the HFO line pressure abruptly dropped (6 to 1.5 kg/cm^2). This produced bubbles, bringing about the formation of vapor locks and blocking the supply of HFO to No. 1 D/G, which was in operation, to a halt.

The correct operations to be followed are as described below:

(1) Open the HFO outlet valve.

(2) Close the DO outlet valve.

(3) Open the HFO inlet valve.

(4) Close the DO inlet valve.

If the above-mentioned sequence is followed, the fuel oil inlet line pressure will never drop below 5.6 kg/cm^2.

However, at the time of the incident, because the operation in (3) above was done first, the HFO pressure dropped to that of the DO return line.

[Software/human factors]

(1) In a standby condition, critical equipment should be all kept in a normal running condition. In this case, the problem lies in the fact that an attempt was made to start an additional generator prime mover when the engine room was already in a standby condition.

(2) For the handling of the essential portions of the critical device, no instructions were displayed on site.

III. Measures to prevent recurrence

[Hardware aspects]

The piping arrangement was modified in the next drydocking so that even a mistake in the handling order would not cause a blackout.

[Software/human aspects]

In a standby condition, the generator engine should be handled in the following manner.

(1) Near the operating place at the side of the engine, operating instructions should be conspicuously posted.

(2) Before the engine room is put in a standby condition, the standby generator engine should be started and the necessary number of units be put, and continuously kept, in parallel operation.

(3) When the engine room is in a standby condition, engineers and engine ratings should pay attention to changes in temperature, pressure, etc. of the running engines and stand by in the engine room to address unforeseen events.

(4) Under standby condition, two generators should be running. If the load is low then one generator should run in idle condition.

IV. Lessons

When the engine room is placed in a standby condition, even an instantaneous blackout might lead to grounding like this. In a worst scenario, it might lead to a serious accident, such as a collision.

In present situation, the vessel did not sustain any substantial damage, but those concerned should think that the vessel was only lucky and that the fortune might well have turned otherwise.

Engine Trouble Cases

File No.	2 - 002				
Case name	Damaged crankshaft of generator engine				
Device name	Generator engine	Damaged part	Crankshaft, etc.	State of damage	Burnout
Maker name	Yanmar	Model	M200L-UN	Total working time	5 years after built
Kind of ship	Bulker	Date of occurrence		Place of occurrence	
Cause of damage/problem	Hardware factor	Insufficient tightening of connecting rod bolts			
	Software/human factor	Disregard of manual			

I. Outline of accident

[Course of events]

The vessel was discharging cargo, with 2 generator engines running in parallel, when No. 2 generator tripped suddenly because of low lube oil pressure.

[State of damage]

The following damage was found with No. 5 cylinder:

(1) The connecting rod bottom end bearing metal was missing;

(2) Many bearing metal fragments were found on the crank case bottom plate;

(3) Scoring marks and a dent on the crankpin, with its surface dull in color; and

(4) The connecting rod bolt head collar was deformed.

[Response measures]

II. Causes of accident/problems

[Hardware factors]

[Software/human factors]

For proper handling of engine room machinery, engineers are required to familiarize themselves with operations manuals provided by respective makers. There are cases, where the information given by instruction manual has been changed or revised from the original one, in such a case the maker issues an after-sales service information (service bulletin), to follow the improved method of maintenance.

An engineer has to follow the necessary changes made in the maintenance procedure otherwise it may often lead to accidents.

Engineers must read service bulletins whenever they are distributed to the vessel from the managing company even if the equipment is not belong to their vessel; and when they handle the equipment on board a different vessel, they can recall their memory and refer to the bulletin again.

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

IV. Lessons

Reference

File No.	2 - 003				
Case name	Water ingress into piston top space				
Device name	D/G	Damaged part	Conrod / Liner	State of damage	Bent / Fracture
Maker name		Model		Total working time	
Kind of ship	Container	Date of occurrence		Place of occurrence	S/B for departure
Cause of damage/problem	Hardware factor		Leak of intercooler warming fresh water		
	Software/human factor		Mishandling		

Ⅰ. Outline of Accident

[Course of Events]

No. 1 A/E was started from the bridge console remotely for parallel service. However, it failed to start. Investigation revealed water leakage had occurred from the air cooler/heater heating tube, and this was the cause of the failure to start. After plugging the leaking tube, the engine was started with no further checking. A few minutes later the 'LO strainer differential pressure abnormal' alarm sounded and an abnormal noise from the crankcase was heard. The engine was stopped manually.

[State of Damage]

A general investigation was made and the following damage was found:

(1) No. 5 and 6 connecting rods were bent.

(2) No. 5 and 6 cylinder liners were broken.

[Disposition]

Ⅱ. Cause of Accident / Underlying Problem

[Mechanical Factors]

The cause of the damage was the compression of water, originating from the air cooler/heater via the intake valves.

[Human/Software Factors]

(1) Except when automatically starting the S/B machine MO, it is usual to start the A/E locally. When starting locally, the procedures described in 'Ⅲ. Preventive Measures' below should be followed to prevent this type of incident occurring.

We have experienced similar cases, with varying sources of the water:

a) Rain from the funnel. Rain leaked into the cylinder, via the exhaust pipe and turbo charger (T/C), due to clogging of the exhaust drain pipe;

b) Cooling fresh water for T/C;

c) Heating fresh water for air heater; and

d) Cooling seawater for air cooler.

(2) When the water leakage from the air cooler was discovered after the initial failure to remote start the A/E, a thorough investigation of the cause should have been made.

III. Preventative Measures

[Mechanical Aspects]

[Human/Software Aspects]

The cause of this accident can be put down to insufficient checking prior to starting the engine. The following measures should be taken to avoid similar A/E troubles:

(1) No water leakage has occurred, by checking the air intake drain and T/C drain;

(2) Air blowing is done before starting;

(3) Drain valve for air intake and T/C are kept open while engine is out of service;

(4) Drain valve for air intake and T/C are adjusted daily, and water ingress is regularly checked for; and

(5) Drain pipe for exhaust drain pot is checked periodically.

IV. Lessons

Whenever problems occur when starting the engines, a thorough check of all possible causes should be made. Also, the preventative measures should be applied at all times.

V. Reference

Except for water compression of leaking cooling water, leaking water can cause contamination to fuel oil and system oil, with the following consequences:

System Oil ・・・ Emulsification of L.O.→Need to separate and purify.

Fuel Oil ・・・ Fuel oil should be completely replaced.

Engine Trouble Cases

<table>
<tr><td>File No.</td><td colspan="5">2 - 004</td></tr>
<tr><td>Case name</td><td colspan="5">Fracture of intake valve of generator engine</td></tr>
<tr><td>Device name</td><td>Generator engine</td><td>Damaged part</td><td>Intake vale</td><td>State of damage</td><td>Fracture</td></tr>
<tr><td>Maker name</td><td>Yanmar</td><td>Model</td><td>8Z280L-UX</td><td>Total working time</td><td>11,035 hours</td></tr>
<tr><td>Kind of ship</td><td>Container ship</td><td>Date of occurrence</td><td>1998.10.23</td><td>Place of occurrence</td><td></td></tr>
<tr><td rowspan="2">Cause of damage/problem</td><td colspan="2">Hardware factor</td><td colspan="3">Excessive clearance between air inlet valve stem and guide</td></tr>
<tr><td colspan="2">Software/human factor</td><td colspan="3">Disregard of manual in maintenance work</td></tr>
</table>

I. Outline of accident

[Course of events]

At 1113 hours “No. 3 D/G EXH. GAS T/C IN HIGH TEMP.” and “ROCKER ARM LO LOW PRESS.” sounded. Around the same time, an explosive sound occurred in the vicinity of the funnel. On the generator side, the generator engine was immediately stopped since cooling water was observed spewing from No. 6 cylinder cover and the rocker arm lube oil tank.

[State of damage]

(1) No. 6 cylinder

1) The rocker arm for the air intake valves fractured.
2) The T-yoke came off.
3) The exhaust valve cage was lifted up by 6 mm.
4) The push rod for the exhaust valve was bent.
5) The surface of the cam for the exhaust valve was scratched.
6) The tappet roller guide for the exhaust valve fractured and the roller distorted and was caught up.
7) Fracture of the air intake valve stem. And guide heavily scored.
8) Impact marks, and damage to, the piston crown.
9) Cylinder liner heavily scored and its upper end partially chipped off.
10) Cylinder head combustion chamber struck and damaged.

(2) No. 5 cylinder

1) Intake valve stem bent.
2) Piston crown damaged.

(3) Turbocharger

1) Nozzle ring stuck and damaged all around the peripheral area, and partially holed.
2) Rotor blades deformed all around the peripheral areas.

3) Cover ring struck and damaged all along the internal surface, resulting in an enlargement of its internal diameter.

[Response measures]

(1) No. 6 cylinder

1) The cylinder liner was renewed.
2) The piston, etc. were renewed.
3) The connecting rod was renewed.
4) The rocker arm and the Exh. Valve tappet guide were renewed.
5) The push rod was renewed, and other repairs made.

(2) Turbocharger

1) The turbine blades were renewed.
2) The nozzle ring was renewed.
3) The cover ring (diffuser) was renewed, and other repairs made.

(3) Others

The cam shaft was renewed, and other repairs made.

II. Causes of accident/problems

[Hardware factors]

Originating from the No. 6 cylinder intake valve's fracture and coming off as the direct cause, the damage expanded to No. 5 cylinder and the turbocharger as a consequence. The fracture of No. 6 cylinder intake valve is presumed to be ascribed to the following:

(1) Investigation result

1) The intake valve stem sustained scars, on the contact surface, of catching up foreign material and scuffing.
2) The gap between stem and guide expanded to 0.8 mm as compared to the maximum clearance of 0.5 mm, with the inside surface of the guide discolored.
3) From the operational need of the diesel generator, it was often used at low loads, and even kept idle for a long period, and rocker arm lubrication tends to become insufficient, promoting precipitation of carbon.

(2) Presumed causes

1) As a result of insufficient rocker arm lubricating oil, metal to metal contact between valve stem and guide, enlarging the clearance between them. When the generator engine was kept idle for a long period, carbon precipitated, making the intake valve sticky in the opened state.
2) The intake valve and piston came in contact, resulting in a bend of the root section

of the valve head. As a result, the valve came to show an abnormal tendency to seize.

3) When the intake valve was repetitively opened and closed, the T-shaped bridge came off and depressed the valve more than normal, resulting in its fracture.

[Software/human factors]

(1) When performing regular maintenance work on the cylinder cover, the engineer disregarded the standard value, found in the maker’s manual, of wear permitted for the clearance between intake valve stem and guide. That is, the gap increased to 0.8 mm as against the permissible value of 0.5 mm.

Maintenance work should never be carried out carelessly. Engineers are naturally required to take measurements of the clearance, as specified by the manual, and should always be keen to detect any signs of abnormality.

(2) The engineers were inconsiderate to the operation.

If the diesel generator tend to run at low loads from its operational necessity and, it is kept idle for an extended period, the engineers must be considerate for its operation in order to avoid potential harms from such operational necessity. Engineers should decide to change over to diesel oil before stopping the generator engine, put loads on the engine at times during an extended period of its operation, or sometimes operate the standby engine.

(3) Is there no problem with the management of the running condition?

The damage occurred at 1113 hours ship’s time, which was generally the time when crew member should have been engaged in taking parameters reading and didn’t they notice abnormal sounds beforehand? Similar incidents we have experienced in the past, abnormal sounds, including hitting sounds, have been reported during inspection rounds as a precursor of an accident.

III. Measures to prevent recurrence

[Hardware aspects]

The insufficient lubrication of rocker arms generally results in damage to tappets, but when a valve seizes, it is usually ascribed to an increased clearance between stem and guide or to combustion residues caught up in between. The contact surfaces between valve stem and guide are designed to stay without lubrication and the increase in the clearance may induce a rise in lube oil on one hand but also promote precipitation of carbon as a result of the entry of combustion gases (including unburnt gas).

When performing maintenance work on cylinder covers, ensure to adhere to the clearance recommended by the maker.

[Software/human aspects]

(1) When engaged in maintenance work, do not proceed with the operation in lockstep. Engineers are required to take measurements of the clearance, whose permissible value is specified in the manual, and should always look for any signs of abnormality.

(2) Give consideration to the operation so as to keep the best condition.

(3) During a watch or ‘M0’ check, or a job for the maintenance of the ship operation, never blindly follow fixed routine procedures but tackle jobs, ready to let no signs of change go unnoticed for the purpose of preventing accidents.

Ⅳ. Lessons

Accidents may happen any time, you should never let off. Always memorize the knocking or noise of a satisfactorily running machinery, so that any abnormal sound can easily be detected.

File No.	2 - 005				
Case name	Abnormal stop of generator engines				
Device name	Generator engine	Damaged part	Solenoid stop valve	State of damage	Leak
Maker name	Yanmar	Model	6GL-ET	Total working time	
Kind of ship		Date of occurrence	1998.01.18	Place of occurrence	While sailing in river
Cause of damage/problem	Hardware factor		Deterioration of control air system over years of use		
	Software/human factor		Poor maintenance		

I. Outline of accident

[Course of events]

A rise in control air pressure for the diesel generators activated the air pistons of the solenoid stop valves, and stopped the two diesel generators in operation, causing a blackout.

[State of damage]

The maximum pressure the solenoid stop valves for the D/G are designed to withstand (pressure at which no leak occurs in the seat section) is 30 kg/cm^2, but they leaked at a pressure of about 11 kg/cm^2.

[Response measures]

II. Causes of accident/problems

[Hardware factors]

Since the control-air-direct-acting type pressure reducing valve produced 15 kg/cm^2 against the set value of 9 kg/cm^2 as a result of a malfunction of its pilot valve. On the other hand, the solenoid stop valves for the diesel generators leaked because of their deterioration over years of use, actuating the air pistons of the engine stop valves, leading to the blackout.

[Software/human factors]

The solenoid valve has a tell-tale hole to check a leak and when a leak is confirmed here, its replacement is required. In the case of this accident, no leak came to notice before it.

III. Measures to prevent recurrence

[Hardware aspects]

(1) Yanmar

The fact that the solenoid stop valves for prime movers are normally in a stop position, accelerates the deterioration of the seat section. It follows that, with idle prime movers, there is a need to check leaks of control air from solenoid valves in the closed position by gradually increasing the inlet pressure of the following solenoid valves from 0 to 15 kg/cm^2 and removing the outlet nipples from all solenoid valves.

Solenoid stop valve

Starting air solenoid valve

Control air solenoid valve

(2) Daihatsu

There is a need to conduct a leak test on the solenoid valve for a fuel shutdown (equipped ever since 1985), which supplies control air to the stop cylinder for a fuel shut-down, provided for each fuel pump by removing the outlet nipple as in the case of Yanmar.

[Software/human aspects]

Old vessels are expected to experience malfunctioning of various parts of the control air system and crew members are required to make further efforts to inspect and maintain them regularly.

IV. Lessons

File No.	2 - 006				
Case name	Fuel oil overboard spill incident				
Device name	Generator engine	Damaged part	DO stand pipe	State of damage	Leak
Maker name		Model		Total working time	2 years after built
Kind of ship	VLCC	Date of occurrence	1998.01.06	Place of occurrence	Piloting along the US Coast
Cause of damage/problem	Hardware factor	Mistake in pipe arrangement			
	Software/human factor	Mistake in valve handling			

I. Outline of accident

[Course of events]

2100 hours on January 4 The fuel for No. 1 diesel generator was changed over from HFO to DO and the generator was stopped.

0200 hours on January 6 The second mate discovered a spill of fuel oil on the starboard deck and immediately reported to the master and the engineer on watch.

The leak originated from the stand pipe air vent for the diesel generator system. It is ascribed to a failure to shut the HFO inlet valve to No. 1 D/G. The valve was immediately shut and the leak was stopped.

[State of damage]

Since one of the scuppers in the vicinity of the leaking air vent was not plugged, 3.0 barrels (465 liters) Max., of the spilled oil, of about 1.5 barrels escaped into the sea.

[Response measures]

II. Causes of accident/problems

[Hardware factors]

(1) Defective piping arrangement which provides no other ways to keep up extra oil in the event of a leak through the HFO inlet valve.

(2) Imperfect display of the changeover of valves on the CCR display panel.

[Software/human factors]

(1) The first engineer boarded the vessel on December 22, 1997, and, at the time of the accident, he handled the valves related to the fuel oil system for the diesel generator for

the first time on board the vessel. However, for those engaged in the operation of a vessel, such thing will not serve as an excuse. Even if all crew members are replaced upon the take over of a vessel.

(2) Mistake in 'M0' checks

In spite of 'M0' checks made twice, one on January 4 and the other on 5, the crew members who did the check overlooked the mishandling of the valve. 'M0' checks are intended to inspect not only the operating conditions of various devices but also the states of the other devices kept idle or on standby. A long list of items for 'M0' checks does not make an excuse for a mistake in checking. Engineers should devise something to prevent such mistakes, by, e.g., preparing a manual for 'M0' checks.

(3) There was no instructions, which showed the operating method on site.

In the handling of valves of this kind, there is a possibility of an accident even by a different order of valve handling. Operating instructions should be displayed at site.

III. Measures to prevent recurrence

[Hardware aspects]

The vessel had a piping arrangement that allowed an extra oil, when it leaked through the IFO inlet valve, to escape only into the air vent pipe. This situation was corrected by modifying a pipe line which leads of the air vent to the overflow tank.
According to our specifications, the line is designed to lead such oil to the overflow tank or service tank or a settling tank.

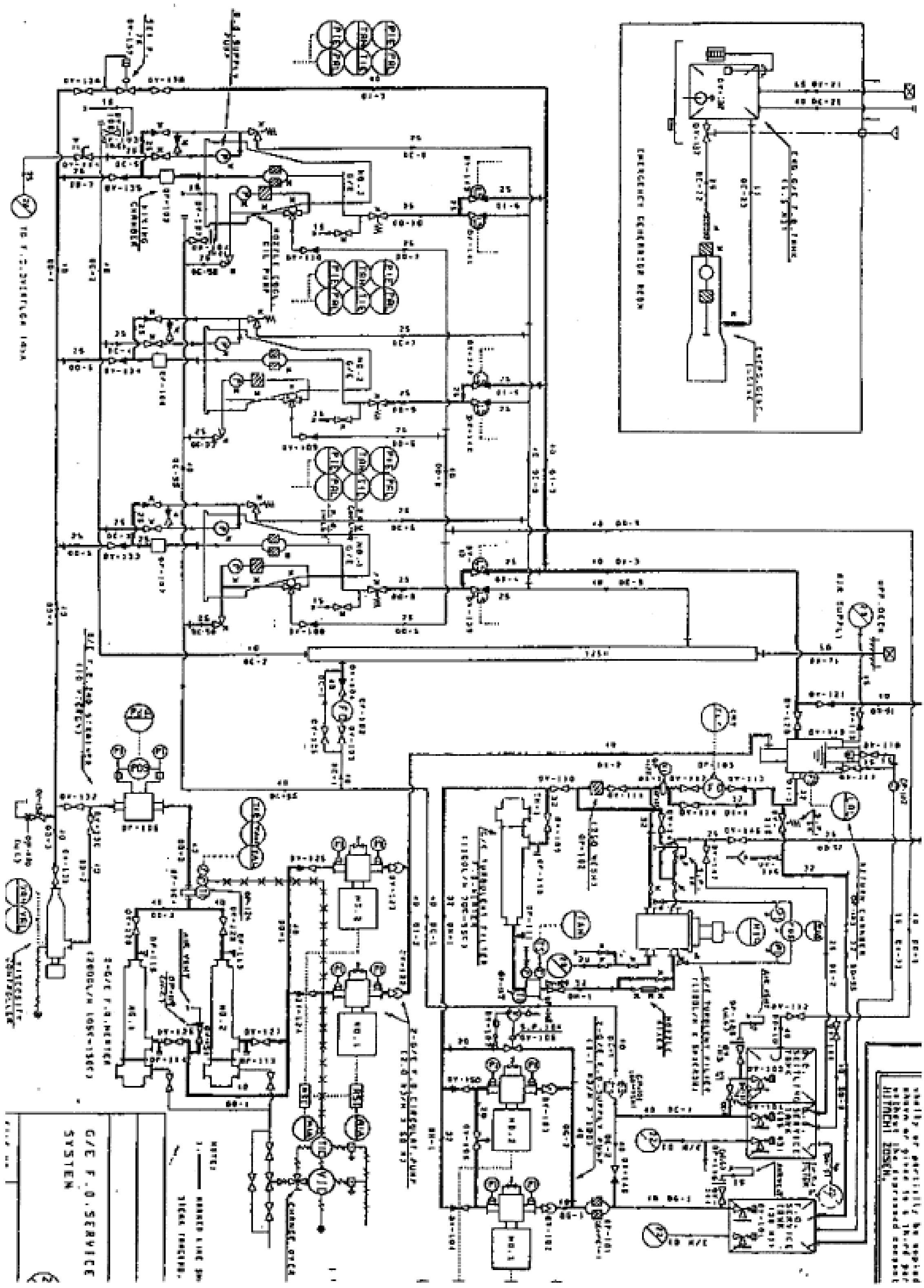
[Software/human aspects]

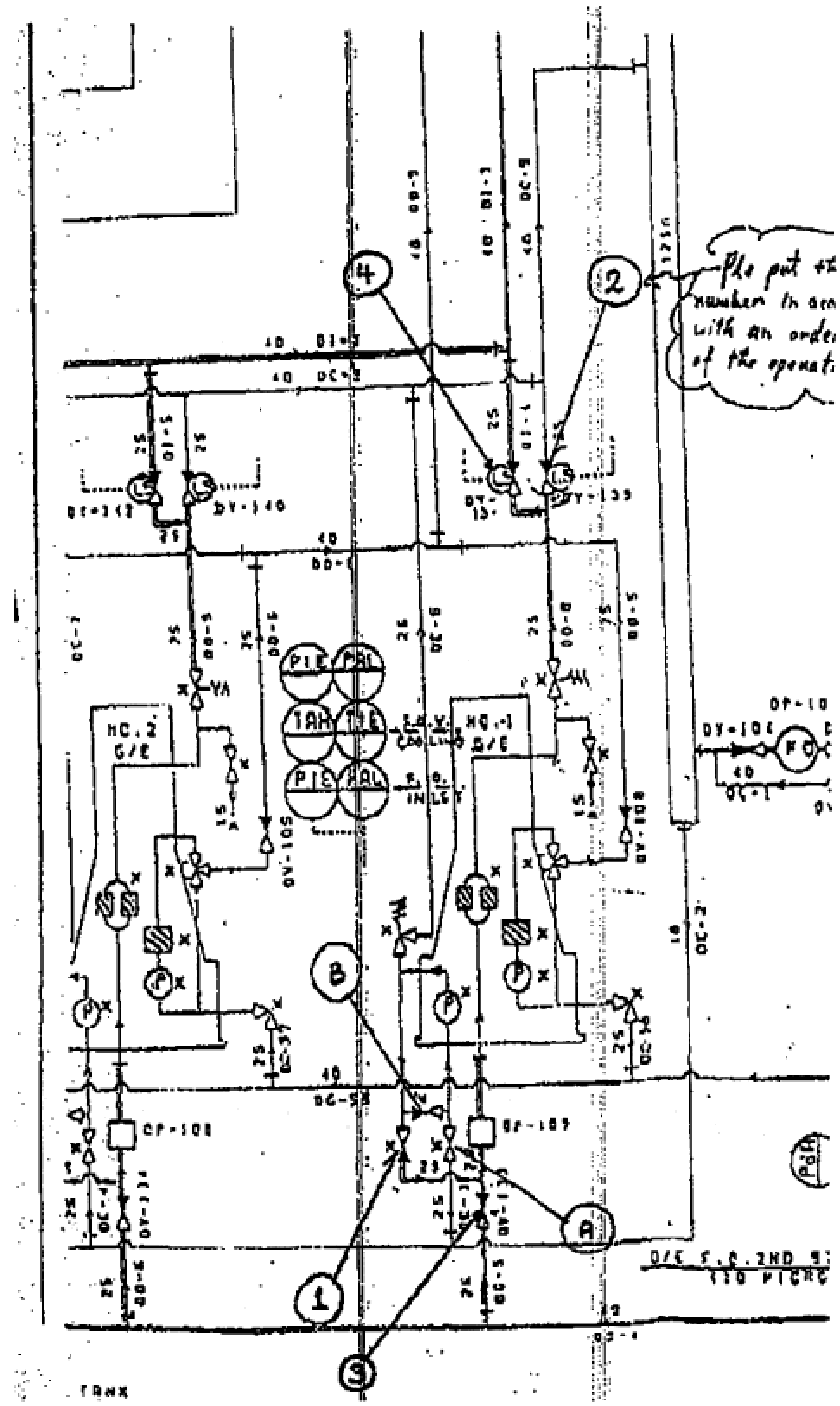
(1) In order to prevent an accident of this kind through 'M0' checks, the checklist should be reviewed.

(2) Instructions on the valve handling should be posted on site.

IV. Lessons

When the machinery spaces are periodically left unattended, engine trouble is often detected during inspection rounds before it develops into a serious accident.


G/E F.O. SERVICE SYSTEM



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Engine Trouble Cases

File No.	2 - 007				
Case name	Incident during Water Washing of D/G Turbocharger				
Device name	Generator engine	Damaged part	Connecting rod	State of damage	Bend
Maker name	Yanmer	Model	M200-L-EN	Total working time	Unknown
Kind of ship		Date of occurrence	1999.03.29	Place of occurrence	
Cause of damage/problem	Hardware factor	Water compression			
	Software/human factor	Mistake in operational procedures			

Ⅰ. Outline of Accident

[Course of Event]

The vessel used to water wash the turbine side of the turbocharger of the diesel generator engine at intervals of approximately one week. Washing should be done with no load on the prime mover, but the crew member who took load off the prime mover, before starting to do the job as routine work on March 29, pressed the “Full Auto Stop” button while maintaining the “generator engine control mode select switch” in “Auto” on the main switchboard. As a result, the prime mover automatically came to a halt seven minutes after the air circuit breaker was opened.

The engineer in charge made an attempt to restart the prime mover locally, but it made only a few turns and did not get started. Since even after the prime mover ground to a halt, wash water was still left being admitted, and found its way to cylinders through the exhaust manifold and exhaust valves, the cylinders were subjected to water compression, resulting in water leaks around No. 4 cylinder head.

[State of Damage]

After the prime mover was opened for inspection, the distortion of No. 4 cylinder connecting rod and impact marks in the lower portion of its liner were found. Fortunately, the diesel generator did not suffer any additional damage.

[Remedial Measures]

Ⅱ. Cause of Accident / Underlying Problem

[Human/Software Factor]

(1) This accident could have been prevented only if the engineer in charge had contemplated such matters as “What part of the engine is filled with water?” upon the automatic stop of the diesel generator during water washing. This type of accident is

considered avoidable only if it is sufficiently recognized that if water finds its way into a cylinder, it will bring about such a dreadful result; only if the basic principle is well understood that a liquid does not undergo compression but a pressure rise.

Lube oil mixed with water does not serve its purpose.

If, unfortunately, water has found its way into an engine, the engine should be started only after all the parts which have the possibility of the accumulation of water have been overhauled to check for water.

(2) During washing, it must be checked to ensure that drains are discharged out of the engine.

III. Preventive Measures

[Mechanical Aspect]

When the generator engine stops during a water washing operation of the turbocharger, suspend the water washing; and thereafter check the cause of the stoppage. As there is a possibility of water entering a cylinder liner or exhaust pipe, check various parts.

(a) Open each indicator valve and check for water inside the cylinder by use of the turning gear.

(b) Check whether no drain has accumulated in the casing of the turbocharger.

(c) Remove trapped drains by running the engine on air.

[Human/Software Aspect]

Nothing is more dangerous than overfamiliarity. The recent switchboard requires only a push of a button and is very easy to operate, but a mistake in the simple action of pressing a button would result in the stoppage of the machine. Operate it only after making sure that it is exactly the action you are going to take.

IV. Lessons

Accidents of this type have occurred frequently. Be aware of the danger of water compression.

V. Reference

We have another recent case related to water washing of a D/G turbocharger: Crew members washed the turbocharger without the knowledge that the drain pipe was clogged, resulting in the prime mover damaged by water compression. In this case, it was impossible to check the flow of drains since the drain pipe was not discontinued to lead to a hopper. This fact was considered to be a major contributory cause of the accident. Following this accident, the manufacturer accommodated our request and improved the drain piping to lead to a hopper. The turbocharger which sustained the damage taken up in this issue has a draining arrangement leading to a hopper.

Engine Trouble Cases

File No.	2 - 008				
Case name	Fractured T-yoke guide for diesel generator				
Device name	Diesel generator	Damaged part	T-yoke	State of damage	Fracture
Maker name	Daihatsu	Model	6DS26A	Total working time	36,271 hours
Kind of ship		Date of occurrence	1993.03.13	Place of occurrence	At sea
Cause of damage/problem	Hardware factor	Maladjustment			
	Software/human factor	Maladjustment			

I. Outline of accident

[Course of events]

While at sea, No.2 D/G T/C inlet temperature high (500ºC) alarm sounded, the engineer in charge made an inspection on site and detected an abnormal condition with the rocker arm section of No. 1 cylinder.

He immediately changed over to the standby generator engine and stopped No. 2 generator engine.

[State of damage]

(1) The T-yoke guide for No. 1 cylinder fractured at its base section where it is attached to the cylinder cover.

(2) The exhaust pipe for each cylinder was red hot and part of the insulating material was smoldering.

(3) The engineer in charge confirmed, visually and by hand touch, normal condition with No. 1 piston and liner.

[Response measures]

The fractured T-yoke guide was replaced and the tappet clearance with each cylinder was checked and adjusted.

II. Causes of accident/problems

[Hardware factors]

The failure is attributed to the maladjustment of the contacting surfaces between T-yoke guide and both exhaust valves, upon making a tappet adjustment.

Accidents of this type have frequently occurred in the past.

[Software/human factors]

Maladjustment was the cause of the trouble.

III. Measures to prevent recurrence

[Hardware aspects]

Make adjustments in the following manner:

(1) Before fitting a rocker arm, adjust the tee by operating its adjusting screw so that the T-yoke and both exhaust valves come closely in contact with each other.

On that occasion, pay special attention to the adjustment of the screw by, e.g., smearing the contact surface with bearing red. Sections marked B and C should come in contact simultaneously.

(2) Adjust the tappet clearance A.

Note: If the adjusting screw is operated to make readjustments of B and C in a warm state with the rocker arm in position, there is a large probability of the T-yoke unevenly coming in contact with both exhaust valves.

The recheck in a warm state should be restricted to the tappet clearance A.

[Software/human aspects]

IV. Lessons

In this case, all the engineers and ratings happened to stay in the engine control room when the abnormal condition occurred and, therefore, they were able to respond to the situation quickly (changed over to the standby unit in two minutes after the alarm sounded) before it could cause a serious accident; but this may happen when the machinery spaces are left unattended at night.

Engine Trouble Cases

File No.	2 - 009				
Case name	Generator engine trouble, resulting in dead ship				
Device name	Generator engine	Damaged part	Fuel pump	State of damage	Wear
Maker name	Yanmar	Model	GL-UT680	Total working time	10 years after built
Kind of ship	PCC	Date of occurrence	1991.10.28	Place of occurrence	While sailing in South China Sea
Cause of damage/problem	Hardware factor	Excessive wear of fuel oil pump			
	Software/human factor	Mistake in taking response action in emergency			

I. Outline of accident

[Course of events]

After leaving Kobe for Jeddah on October 22, the vessel was sailing in the South China Sea, avoiding the approach of Typhoon No. 23. On October 28 a blackout occurred on board the vessel at 1645 hours. The engineers made attempts to start the diesel generators in vain and used up starting air, making the vessel dead, without her ability to sail and communicate with outside.

[State of damage]

Excessive wear of the plungers and barrels of all fuel oil pumps for all generator engines and poor maintenance of all fuel valves.

[Response measures]

(1) The vessel requested its management company for assistance by a tugboat through a vessel sailing nearby since there was a bank in its vicinity and the waves were high. Around 2100 hours on October 29, a tugboat left from Singapore for the vessel.

(2) At around 2200 hours on October 30, we instructed another vessel under our charter to near the vessel to grasp the current situation of the vessel in question and convey our instructions, including bleeding air from the fuel oil system of the diesel generators. The engine department of the vessel in distress completely washed the fuel oil line up to the end of the fuel oil valves and, after waiting for the (manual) emergency air compressor to fill the auxiliary air reservoir (it took 8 hours), made attempts to start the generator engines in vain.

(3) The vessel, whose towing operation by the tugboat to Singapore was commenced around 1335 hours on October 31. Around 1900 hours on November 2 a barge loaded with a portable generator arrived and power restored. The cause was at last identified, excessive wear of plungers and barrels of the fuel pumps.

Finally at 1640 hours on November 3, she managed to start the generator engines. By the adjustment of the physical properties of the blended oil on our advice, and, make capable of sailing under her own power. After that, the vessel dropped her anchor in Singapore Eastern Anchorage around 2200 hours on the same day.

(4) One of our chief engineers flown and visited the vessel to give advice on repairs and check her seaworthiness. He confirmed that the vessel was capable of sailing with spare fuel pumps and fuel valves arranged and supplied. She sailed out for Europe around 1600 hours on the next day.

II. Causes of accident/problems

[Hardware factors]

While blended oil was being used, strainers were clogged seemingly as a result of the rough seas, stopping the diesel generators in succession. Engineers made attempts to start them after changing over to DO and cleaning lines, but failed to obtain the necessary fuel injection pressure to start them because of poor maintenance on the fuel valves and the excessive wear of the fuel pump plungers and barrels also caused by poor maintenance.

[Software/human factors]

(1) Sufficient maintenance was not performed on the generator engines. (In the case of the accident in question, maintenance on the fuel oil system.)

(2) The engineers were not aware of the fact that poor maintenance obstructed them from starting the generators.

In this case, the engineers made attempts to start generators again and again on less viscous marine diesel oil despite excessive clearances between plungers and barrels resulting from excessive wear. In addition, since blended oil was used till the stoppage of the generators, the fuel oil system was kept heated. If the engineers grasped the situation properly, they could have coped with the emergency situation by, e.g., increasing the ratio of HFO in the blended oil.

(3) Without any prospect, they made useless attempts to start, resulting in the loss of compressed air.

III. Measures to prevent recurrence

[Hardware aspects]

(1) At Singapore, the engineers replaced fuel pump plungers and barrels of Nos. 1 and 3 cylinders of No. 1 diesel generator with spare parts (used ones) on hand under instructions given by our chief engineer but it did not work well without any effect to

raise the Pmax higher than the other cylinders nor any change in the condition of the smoke, which was slightly black in color before the replacement, coming out of the funnel. It did not bring about any effect as expected since the spares used had poor performance.

(2) The vessel loaded 18 new sets of fuel pump plungers and barrels (for 3 units of diesel generator) and 12 fuel valves (for 2 units) at the port and it was decided to substitute them one by one after departure from the port since the present state was not feared to interfere with her seaworthiness.

(3) The excessive abrasion of the fuel pump plungers and barrels of diesel generators caused concerns over similar abrasion in the main engine and the dispatched chief engineer collected and checked various data. On the basis of the fact that the load index did not show any rise at the same fuel notch, he concluded that the abrasion of the fuel pumps in the main engine had not progressed so much.

[Software/human aspects]

IV. Lessons

There is nothing so miserable as dead ships. We would like to avoid such a situation by all means. Daily efforts are essential to be prepared to evade the worst scenario even in emergencies.

Engine Trouble Cases

<table>
<tr><td>File No.</td><td colspan="6">2 - 010</td></tr>
<tr><td>Case name</td><td colspan="6">Slip of generator engine fuel valve cams</td></tr>
<tr><td>Device name</td><td>Diesel generator engine</td><td>Damaged part</td><td>Fuel cams</td><td>State of damage</td><td colspan="2">Slip</td></tr>
<tr><td>Maker name</td><td>Daihatsu</td><td>Model</td><td>DLB-22</td><td>Total working time</td><td colspan="2"></td></tr>
<tr><td>Kind of ship</td><td></td><td>Date of occurrence</td><td></td><td>Place of occurrence</td><td colspan="2"></td></tr>
<tr><td rowspan="2">Cause of damage/problem</td><td colspan="2">Hardware factor</td><td colspan="4">HFO remaining inside fuel oil system when engine was kept idle</td></tr>
<tr><td colspan="2">Software/human factor</td><td colspan="4">Mishandling</td></tr>
</table>

I. Outline of accident

[Course of events]

During parallel operation, a diesel generator engine was stopped on HFO without opening the air circuit breaker.

A few hours later, the engineer in charge noticed the abnormal condition of the idle engine. He has changed over HFO to diesel oil and made an attempt to start. Engine fail to run on normal rpm because of poor combution.

[State of damage]

When the FO pump timing was measured for the purpose of investigating into the cause of the poor combustion, slips of a great extent were found as follows:

The regular angle is 18º BTDC (before top dead center).

	Cylinder No.					
	1	2	3	4	5	6
Measurement results	ATDC 1º	ATDC 163º	ATDC 320º	ATDC 147º	ATDC 9º	BTDC 17º

[Response measures]

II. Causes of accident/problems

[Hardware factors]

The DL-type diesel engine, which exclusively runs on HFO, is designed to have fuel cams of a taper-sleeve type, as a safeguard, so that they slip when subjected to excessive load.

This means that the torque to tighten the camshaft nuts are determined so that the cams will slip when the internal pressure of the injection pump becomes about twice that under the maximum load, for the purpose of protecting fuel oil pumps, high pressure pipes, etc.

From the above, it is presumed that an excessive force was applied to fuel cams because of the presence of HFO in the high pressure pipe.

[Software/human factors]

The start/stop of a generator engine should not be left to such a crew member as may stop it before opening the air circuit breaker while it is still under load of parallel operation.

III. Measures to prevent recurrence

[Hardware aspects]

In this case, the cams slipped for their original purpose as designed by the maker. However, there are often cases where cams slip since cam nuts are not tightened with regular torque. They should be tightened according to the maker's instructions.

Torque control tightening (135 kg•m) is designated for engines of the DL-22 type. However, for the engines, a torque wrench up to only 100 kg•m is supplied. It is required, according to the maker's instructions, to tighten a cam nut up to 100 kg•m with the torque wrench and, then, turn it by 90 mm at the circumference of the cam nut.

[Software/human aspects]

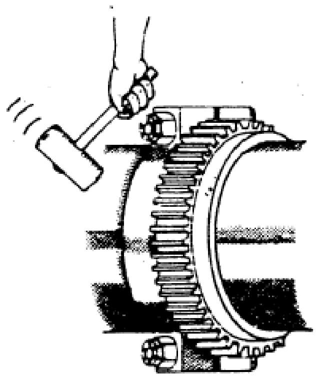
We frequently encounter damage in relation to fuel cams of generator engines. Most of such damage cases involve an insufficient changeover of fuel oil, to which operators are required to pay attention.

IV. Lessons

Historically, diesel generator engines have been operated for a long time on diesel oil and, even now most of the engines require a changeover to diesel oil before they are stopped. You should be reminded that a improper changeover from HFO to MDO will basically cause trouble.

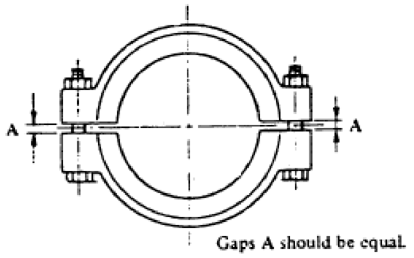
Reference

Procedures for tightening fuel cam nuts: Excerpts from operations manual for Daihatsu DL-22

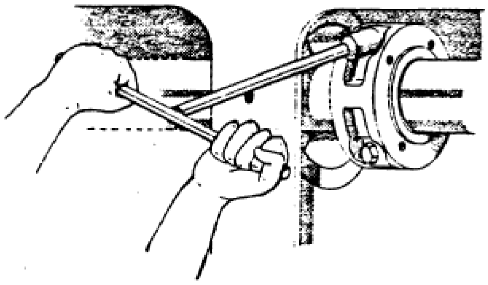


< Disassembly >

1. Disassemble gear cases at both ends of camshaft (governor gear case and rear gear case).
2. Disassemble governor drive gear.
3. Remove cam bearing (thrust bearing) at front end.
4. Disassemble camshaft drive gear.
5. Extract cam bearing lubricating bolt (which is concurrently serving as cam bearing locator).
6. After removing each tappet, move camshaft toward governor side.
7. After cam bearing comes off the engine frame, disassemble cam bearing bolt.
8. Remove cam bearing.
9. Extract camshaft toward governor side.



Crank gear installation



Extraction of camshaft

< Items to check and measure >

1. Fit-up, wear and pitting, if any, of tooth surface
2. Contact and wear on bearing and shaft
3. Loose bearing mounting bolt or gear connecting bolt
4. Gear backlash
5. Clearance between bearing and shaft.

(2) Camshaft

The camshaft of provided with a thrust bearing which serves to prevent the shaft from moving in the axial direction. If the clearance between bearing and shaft increases, breakage of the governor driving bevel gear or governor malfunction may occur. Therefore, the clearance should be checked from time to time.

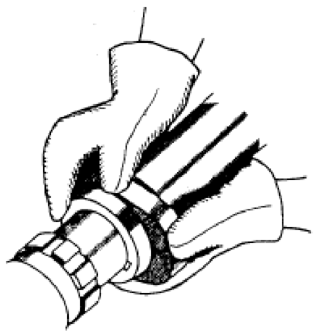
If camlift decreases due to an abraded cam, the camshaft should be pulled out to replace the cam with new one.

(3) Cam

Intake and exhaust cams are shrink-fit directly to the camshaft. Fuel cam is fixed to taper sleeve.

< Extraction and installation >

1. With camshaft firmly secured, knock cams out with a brass bar or similar soft metal piece, or draw them out with an oil jack using suitable jig.
2. Where taper sleeve fuel cam is used, detach cam, using fuel cam removing nut and take it out together with taper sleeve.
3. To make extraction and installation easier, each cam, from shaft ends to center, has a diameter 0.1mm larger than the one before. Diameter is marked on each cam.
4. Pay attention to the mark in reassembling and install each cam in the correct position.



Installation of cam

5. When installing the cams, heat them in an oil bath to approximately 150°~180°C and install them quickly in their prescribed positions. Take care not to heat over 180°C; otherwise, the cam may be changed in structure and lose strength.
6. Misalignment between cam and tappet roller should be kept to within 0.5 mm. For this purpose, it is advisable to put the position mark on the camshaft before extracting the cam.

< Items to check and measure >

1. Pitting or wear on cam surface
2. Loosely fit cam
3. Clearance between camshaft and bearing
4. Clearance between thrust bearing

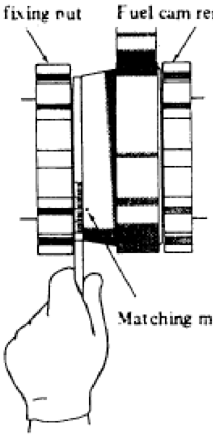
(4) Adjustment of fuel cam

Fuel cam should be adjusted when Pmax is abnormal, and only after the operator has clearly determined the true cause of the disorder; it should never be handled without reason.

The data shown on the factory operation data sheet are for operation on grade diesel fuel oil. When switching to heavy fuel oil, value of Pmax and exhaust gas temperature vary, but no adjustment is needed for Pmax unless it exceeds the prescribed limit.

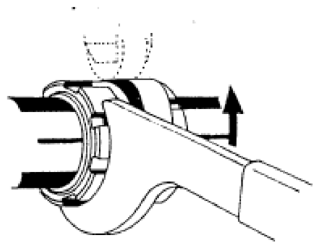
< Adjustment procedure >

1. The fuel oil cam removing nut is located at the right side, the fixing nut at the left side. Turn until matchmark at cam end position on cam removing nut side reaches about 45° downward when viewed from the front of the sight glass. In this state, the tappet roller is at the lowermost position.



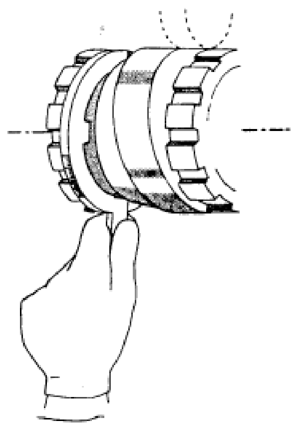
Adjustment of fuel cam

2. Loosen fixing nut. (Push wrench upward.) Note left-handed thread employed in reversing engine. (Fixing nut for reversing engine is marked with "L" on periphery.)



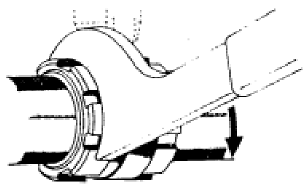
Adjustment of fuel cam
(Loosening fixing nut)

3. Turn cam removing nut (pushing wrench upward), and detach taper sleeve of cam.
4. Return removing nut, insert adjusting gauge between fixing nut and cam, and read graduation on gauge that matches cam tally mark when gauge protrusion fits in keyway on sleeve.



Setting adjusting gauge

5. Insert bar into cam shifting hole and shift cam either to advance or delay position.
6. When cam is shifted in rotation direction, maximum combustion pressure Pmax changes $3 \sim 5$ kg/cm^2 per notch on cam scale.
7. Holding cam with adjusting gauge inserted, fix cam in position tentatively by turning tightening nut.
   After confirming that cam is set temporarily in position, remove gauge and tighten nut firmly.

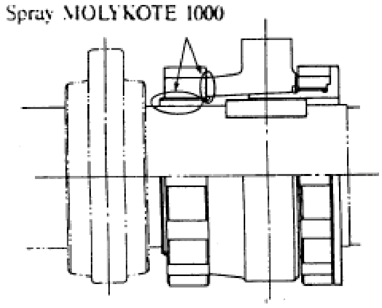


Adjustment of fuel cam
(Fixing with tightening nut)

8. Move removing nut to collar end of taper sleeve and clamp it. Never clamp it at the cam side.

< Precautions >

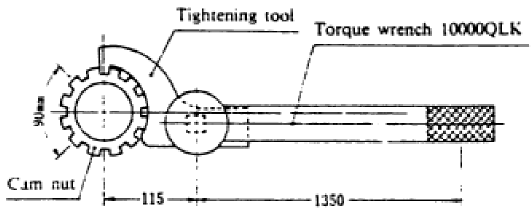
1. Deviation between the Pmax's in the cylinders should be kept within 3 kg/cm^2 while observing the requirement of the ceiling; the total pressure must not exceed the design Pmax value plus 3 kg/cm^2 in any case.
   Pmax is increased by advancing injection timing and decreased by delaying it.
2. When tightening cam-fixing nut, spray anti-seizure agent (MOLYKOTE 1000 spray type) on nut contact surface and threads. Also faithfully tighten to torque specified in Section 3 - Sheet 4.



> Note 1: Do not spray anti-seizure agent (MOLY-KOTE 1000 spray type) on tapered portion.

As the taper sleeve breaks in quickly, check it periodically in accordance with Maintenance intervals in Section 6, and tighten it further if necessary.

Note 2: Follow the procedures below when tightening fuel cam nut to the specified 135kg-m with torque wrench.



<Tightening procedures>

(1) Set torque wrench to 100kg-m as shown in the figure above, and tighten cam nut to the specified value (until sound is heard).
(2) Put tally mark on the periphery of cam nut and cam.
(3) Turn cam nut 90 mm on the periphery of cam nut, then tighten it. At this time, do not use torque wrench but pipe wrench.

> 100kg-m + 90 mm

3. Misalignment between cam and tappet roller centerline should be kept within 0.5mm.
4. In engines modified for reverse rotation, be careful of the fact that cam fixing nut is left-hand threaded.
5. In adjusting fuel injection timing, turn in direction of normal engine rotation in consideration of backlash in gears.

> Insufficient tightening of fuel cam tightening nut may cause fuel cam slippage, resulting in the ill-timed fuel injection. To avoid this, take special care to tighten nut securely to the specified torque.

Engine Trouble Cases

File No.	2 - 011				
Case name	Damage of attached cooling fresh water pump				
Device name	Generator engine	Damaged part	Cooling water pump	State of damage	Damaged bearing
Maker name	Daihatsu	Model	6DL-26	Total working time	
Kind of ship	Container ship	Date of occurrence		Place of occurrence	
Cause of damage/problem	Hardware factor	Insufficient lube oil			
	Software/human factor	Insufficient supply of lube oil			

I. Outline of accident

[Course of events]

During an inspection round throughout the machinery spaces, an abnormal condition was found with the attached cooling fresh water pump. Generator engine changed over to a standby engine.

[State of damage]

The cooling water pump and drive gears were damaged.

[Response measures]

Service engineers from the maker replaced the cooling water pump with a fully outfitted spare and three drive gears.

II. Causes of accident/problems

[Hardware factors]

Bearing failure because of insufficient lube oil for the bearing.

[Software/human factors]

Insufficient supply of lube oil to the bearing.

III. Measures to prevent recurrence

[Hardware aspects]

Lube oil for the cooling water pump for the relevant engine is supplied through an oil cup and, while oiling, the upper plug is loosened and oil is poured until it overflows the cup.

[Software/human aspects]

It is the basics to check various parts for leaks, confirm lubrication upon starting the engine, and to check for leaks and lubrication and confirm operating parameters during operation.

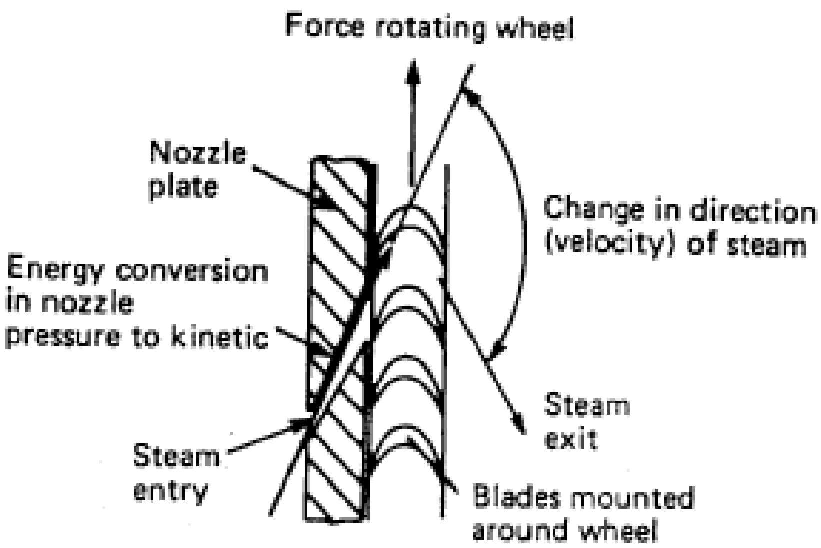
Years ago, there were many parts which required oiling by hand and, therefore, it was customary for a vessel to have a checklist for oiling. With the reduction in number of such locations, there may be cases where vessels do not have such checklists.

If you do not have a checklist in use, a checklist should be prepared containing locations require oiling and types of oil, according to the oiling interval.

IV. Lessons

Let us review the checklist once again to see whether every oiling location has been provided with oil without omission.

3. Turbine generator



Engine Trouble Cases

File No.	3 - 001				
Case name	Damaged turbine generator worm gear				
Device name	T/G	Damaged part	Worm gear	State of damage	Wear
Maker name	Nippon Kokan K.K.	Model	FEW45D-4	Total working time	14 years after built
Kind of ship	Bulker	Date of occurrence		Place of occurrence	
Cause of damage/problem	Hardware factor	Improper maintenance			
	Software/human factor	Failure to make checks			

I. Outline of accident

[Course of events]

Since an unusual sound occurred near the gear box, crew members made an inspection, when they found damage to the flexible coupling.

[State of damage]

Since it was found that the axial displacement of the reduction gear pinion shaft was excessive when the coupling was removed, the casing was opened up. The state of damage revealed was as follows:

(1) Turbine
- a) Damage of the thrust bearing
- b) Burnt forward and aft bearings, and oil deflecting ring
- c) Marks in the form of grooves on the rotor

(2) Reduction gear
- a) Displacement of the pinion shaft thrust collar by about 6 mm
- b) Impact marks on the pinion shaft

(3) Wear of the worm wheel for driving the governor and LO pump

[Response measures]

Landing and repair of the pinion shaft and rotor shaft.

II. Causes of accident/problems

[Hardware factors]

All rotating parts were dirty with oil which changed into a substance like coal tar, indicating a long period of neglect to overhaul the device for inspection. In addition, the maintenance of lube oil seems to have been improper and dirty lube oil is presumed to have caused the wear of the bearings, resulting in their damage.

[Software/human factors]

This accident apparently involves human factors as explained as follows and it seems fortunate that the damage stopped at this level of severity.

(1) This accident would naturally have been prevented if crew members had not neglected regular inspection by overhauling.

(2) Regular analysis of system oil would have indicated signs of the damage; the accident is attributed to poor lube oil maintenance.

(3) There must have been some changes, including vibrations, in the operating condition of the device.

III. Measures to prevent recurrence

[Hardware factors]

[Software/human factors]

IV. Lessons

Importance of proper management according to basics.

Engine Trouble Cases

File No.	3 - 002				
Case name	T/G prime mover damage				
Device name	T/G	Damaged part	Rotor	State of damage	Partial damage
Maker name	MHI	Model	AT34M	Total working time	
Kind of ship	VLCC	Date of occurrence	1996.10.14	Place of occurrence	During cargo discharge
Cause of damage/problem	Hardware factor	Lube oil contamination with sea water			
	Software/human factor	Insufficient inspection by overhauling; poor maintenance of lube oil.			

I. Outline of accidents

[Course of events]

It occurred while the vessel was engaged in a constant-state cargo discharge. Upon the occurrence of the accident, there was no fluctuation in the load on the boiler for the turbine generator. The vibration of the turbine in operation was 25 micro-m because of a defect (wear) of the reduction gear teeth.

When the damage occurred, the emergency shut-off valve was activated, but the valve seat was in a poor state, as a result the turbine continued turning at a rate of about 200 rpm.

The shut-off valve was soon closed in to stop the operation. Attempts were made to re-start the turbine but they were obstructed by the overcurrent trip of the electric motor.

When the bearing casing on the turbine exhaust side was inspected, it was revealed that the bearing cap was damaged and broken up into three pieces, and its use was considered impossible.

[State of damage]

First stage rotor wheel: Two moving blades and a part of the shroud ring fractured and scattered.

Fractured blades of the first stage rotor wheel in the Fir tree root section.

The sides of all moving blades came in contact, resulting in wear; and the tips of the third- and fourth-stage moving blades came in violent contact with the turbine casing.

Unusual weardown of the reduction gear tooth surfaces and scattering of the journal bearing.

Damage to the pinion journal bearing on the turbine side, etc.

[Response measures]

The following parts were replaced:

a) Turbine wheel (assembled part with blades)
b) Reduction gear (pinion, wheel)
c) Stuffing box on the turbine exhaust side, bearing support, bearing cap, bearing support cover
d) All turbine glands and labyrinth packings
e) Oil deflector on the turbine exhaust side
f) Bearing on the turbine exhaust side, pinion journal bearing, etc.

II. Causes of accident/problems

[Hardware factors]

Pitting corrosion on the tooth surfaces of the reduction gear caused by lube oil contaminated with sea water, induced vibrations, which were amplified, resulting in the fracture of the first-stage moving blades of the turbine rotor directly connected with the pinion shaft. This defect caused the run-out of the turbine rotor starting from the pinion bearing, increasing damage to various parts (particularly on the exhaust side).

[Software/human factors]

(1) Generally, if system oil is contaminated with water, water drops must become noticeable in the sight glass when its quantity reaches a level of about 0.3%.
An attitude to take notice of any slight change is necessary when crew members make inspection rounds; one oil drop or water drop on the floor may serve as a clue to defects which, if addressed at an early stage, may prevent development into serious accidents. For that purpose, cleaning at other times is required to keep the floor clear of oil or water. If water drops are not readily observable because of a dirty sight glass, such a situation itself underlies a problem which may lead to an accident at any time.
(2) Regular inspection by overhauling the gear case would have prevented the accident.

III. Measures to prevent recurrence

[Hardware factors]

[Software/human factors]

IV. Lessons

Water content in system oil must not be overlooked.

Engine Trouble Cases

File No.	3 - 003				
Case name	DAMAGE TO T/G ROTOR AS A RESULT OF OVERSPEED				
Device name	T/G	Damaged part	Turbine rotor, other	State of damage	Scatter
Maker name	Kawasaki Heavy Industries	Model	EGE MK-2A	Total working time	8 years
Kind of ship		Date of occurrence	1997.01.11	Place of occurrence	S/B for departure
Cause of damage/problem	Hardware factor		Seizure of fulcrum pin of maneuvering valve start-up lever		
	Software/human factor		Lack of expertise in operation		

Ⅰ. Outline of Accident

[Course of Event]

(1) As a preparation for routine maintenance work on the lube oil cooler, a crew member stopped No. 2 turbo-generator (T/G) by actuating the manual shutdown device of the main stop valve. After finishing the work, crew members began the start-up operation of the T/G.

(2) In this type of T/G, since sufficient hydraulic pressure cannot be obtained for driving the governor at a low speed of the directly connected lube oil pump in the initial stage of a start-up operation, the T/G is started by intentionally lifting the start-up lever (the lever is set in position by a hook) to force open the maneuvering valve (governing valve) (see the attached Fig-1) and its speed increased by gradually opening the main stop valve. This start-up lever is arranged to be automatically disconnected at a speed of about 500 rpm and, thereafter, the governor is to control the speed of the T/G.

In this case, crew members started the T/G and increased its speed to 800 rpm according to the above procedure, but the start-up lever did not get disconnected.

Five minutes later, it further increased to a range of 900 to 1000 rpm with the start-up lever still connected.

(3) After confirming that main stop valve hook for reset (see the attached FIG-2) was disconnected at around 1,000 rpm and checking the hydraulic pressure, the person in charge gradually increased the speed to slightly less than 1,800 rpm.

(4) They continued the operation in this condition. However, as the start-up lever did not come off as a result of the sluggish move of the governing valve, the crew member opened the main stop valve by 1/8 to 1/6 turn when the speed was slightly below 1,800

rpm. The T/G speed suddenly rose to 2,300 rpm.

(5) Following the sudden rise in speed, the person in charge made an attempt to shut the main stop valve. Because he felt he needed some extra effort to close the valve, he continuously pressed the manual shutdown lever of the main stop valve, but the T/G speed increased on the contrary.

(6) After leaks of steam from the short piece pipe between the main steam valve and main stop valve came to the notice of the crew members, a large amount of steam burst out through the piece flange together with a report.

(7) The person in charge stopped the T/G by shutting the main steam valve. The main stop valve suddenly began to move lightly without extra efforts to close it.

[State of Damage]

The damage described below was caused by the T/G overspeed as a result of its inability to be controlled and it proved to be a serious accident, requiring six months for its recovery.

(1) Turbine rotor:

Part of the shroud rings blown away; more than half of the blades in the final stage blown away; rotor bent; and coupling bolts fractured.

(2) Casing:

Bulges found in the final stage of both upper and lower casings; and labyrinth completely destroyed.

(3) Reduction gear casing:

Reduction gears worn down; lower half bearing support cracked; and upper half coupling bent and cracked.

II. Cause of Accident / Underlying Problem

[Mechanical Factor]

(1) First of all, the maneuvering valve start-up lever did not come off as expected at 500 rpm as a result of the seizure of the fulcrum pin of the lever.

(2) When the main stop valve handle was operated to open it, the main valve of the stop valve cracked open.

(3) A pressure difference was generated at the main stop valve by the flow of steam since the maneuvering valve was half open through the operation of the maneuvering valve start-up lever.

(4) The pressure differential generated a force 4.5 times that in normal condition, and pulled the stem of the main stop valve toward its closure.

(5) The valve stem was pulled with such an abnormal force that the person in charge felt he

needed an extra effort to operate the main stop valve handle and, as a result, the main stop valve hook for trip (see the attached FIG-2) did not come off.

(6) When the operator then pushed the manual shutdown lever, the set pin of the trip lever fractured.

(7) With the fracture of the set pin, the upper hook for trip kept staying in position, making it impossible to shut down the main stop valve.

(8) With one hook for trip caught up in position, the valve stem was pulled with a force of 1,800 kg, generating side pressure. When the operator tried to shut the main stop valve with both hands, it did not budge for this reason.

(9) The turbine was destroyed with a report as a result of its overspeed. The impact upon its destruction accidentally released the upper hook, resulting in smaller efforts required to turn the handle.

[Human/Software Factor]

The direct cause of this accident lies in the seizure of the fulcrum pin of the maneuvering valve start-up lever, which resulted in the lever's incapacity to released. It is attributed as a root cause, however, to the operator's misjudgment and lack of understanding that when the lever did not come off, he continued gathering speed without considering it an abnormal phenomenon.

III. Preventive Measures

[Human/Software]

The type of T/G found on board the vessel in question is not common. In this model, the start-up lever, which is set before the T/G is started, is automatically released as the T/G gains speed. While the probability of a similar accident is extremely low in the case of T/G manufactured by MHI and Shinko, it is a requirement for the operator to handle machines, not restricted to turbo-generators, with extreme care on the basis of a good understanding of their mechanisms.

IV. Lessons

The T/G, which is operated at high speed, often results in serious damage once an accident occurs. Without a good knowledge of its structure, it is impossible even to detect an abnormal condition in an early stage.

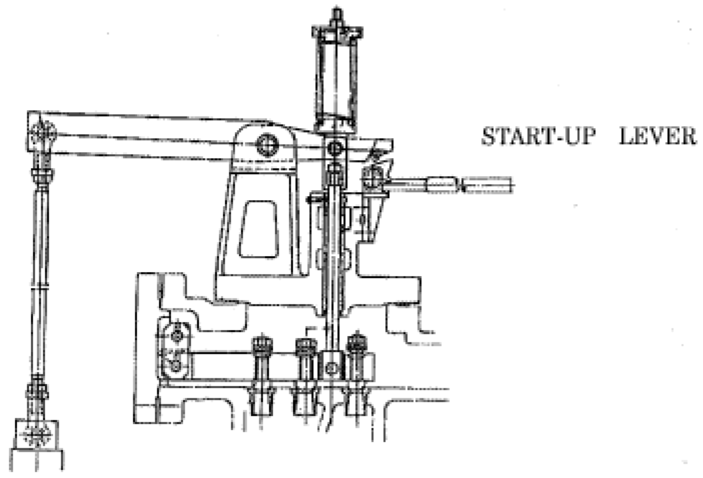


Fig-1 MANEUVERING VALVE (GOVERNING VALVE)

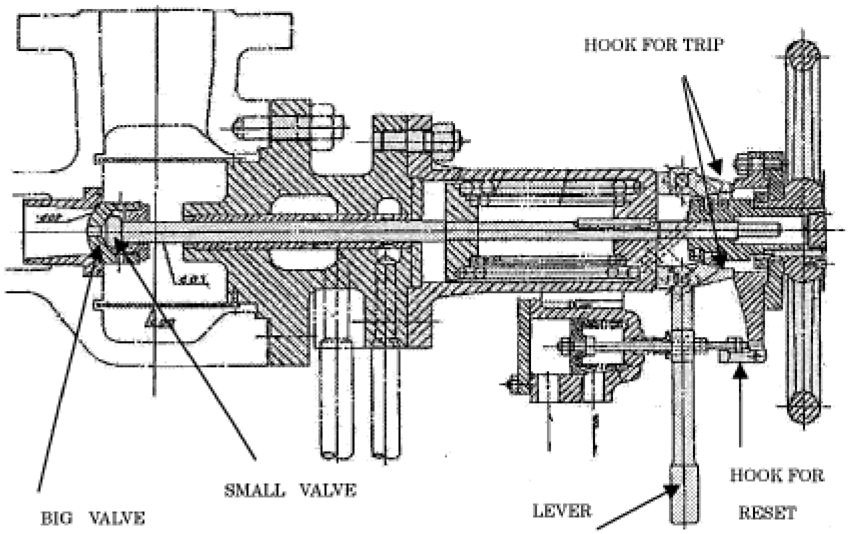
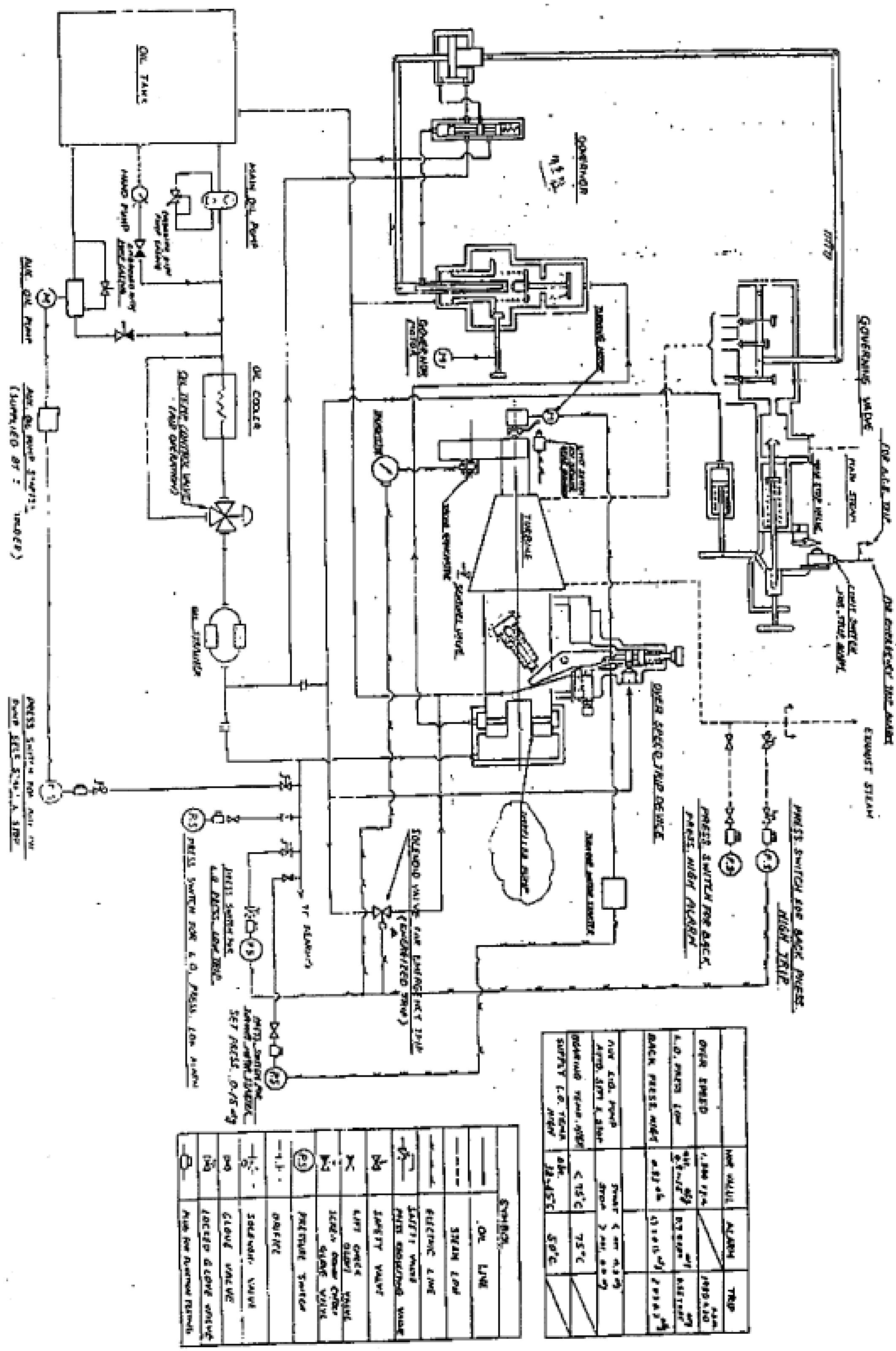


Fig-2 MAIN STOP VALVE


GOVERNING VALVE
FOR A.C.B. TRIP
FOR EMERGENCY TRIP ALARM
MAIN STEAM
EXHAUST STEAM
PRESS SWITCH FOR BACK PRESS. HIGH TRIP
PRESS. SWITCH FOR BACK PRESS. HIGH ALARM
OVER SPEED TRIP DEVICE
GOVERNOR
TURNING MOTOR
TURBINE
GOVERNOR MOTOR
TURNING MOTOR STARTER
SOLENOID VALVE FOR EMERGENCY TRIP (ENERGIZED TRIP)
TO ALARMS
MAIN OIL PUMP
OIL COOLER
OIL TEMP CONTROL VALVE (AIR OPERATION)
OIL STRAINER
OIL TANK
HAND PUMP
AUX. OIL PUMP
PRESS SWITCH FOR L.O. PRESS. LOW TRIP
PRESS SWITCH FOR L.O. PRESS. LOW ALARM
SET PRESS. 0.15
PRESS SWITCH FOR AUX OIL PUMP
NOR VALUE
ALARM
TRIP
OVER SPEED
L.O. PRESS LOW
BACK PRESS. HIGH
AUX. L.O. PUMP AUTO. START & STOP
BEARING TEMP. HIGH
< 75°C
75°C
SUPPLY L.O. TEMP HIGH
50°C
SYMBOL
OIL LINE
STEAM LINE
ELECTRIC LINE
SAFETY VALVE
PRESS REDUCING VALVE
LIFT CHECK GLOBE VALVE
SCREW DOWN CHECK GLOBE VALVE
PRESSURE SWITCH
ORIFICE
SOLENOID VALVE
GLOBE VALVE
LOCKED GLOBE VALVE

Engine Trouble Cases

File No.	3 - 004				
Case name	Damage to turbine generator by turning for excessive period				
Device name	Turbine generator	Damaged part	Bearing	State of damage	Flaking, etc.
Maker name	Shinko Industry	Model	DN12-5	Total working time	50,360 hours
Kind of ship	Container ship	Date of occurrence	1989.04.25	Place of occurrence	
Cause of damage/problem	Hardware factor		Deterioration of bearings resulting from rotation by turning gear for long time		
	Software/human factor		Insufficient understanding of operating parameters		

I. Outline of accident

[Course of events]

Around 1500 hours the HIGH TEMP ALARM sounded for bearing temperature of 75ºC.

When the alarm sounded, the turbo generator was operating under an approximately 60% load, with the lube oil inlet temperature at 40ºC and the inlet pressure at 1.8 kg/cm^2, both normal values.

Immediately, the lube oil inlet temperature was lowered to 35ºC and the priming pump was put in continuous operation to increase the lube oil inlet pressure to 2.3 kg/cm^2.

When past records were checked, this bearing showed a gradual increase in temperature from about last two years, hinting that the damage was not a sudden accident without any warning.

[State of damage]

(1) White metal in the lower bearing on the turbine coupling side sustained flaking and other damage.

(2) Renewal of coupling oil.

[Response measures]

(1) Renewal of the white metal on the turbine coupling side (check of the alignment).

(2) Injection of new coupling oil.

II. Causes of accident/problems

[Hardware factors]

The DNN- or DNM-type turbine is a direct-drive type generator turbine running at a low speed of 3,600 rpm. As a measure to improve turbine efficiency by overcoming the low speed, it employs a 12 stage-Rateau turbine and increases the pitch circle diameter (PCD) of the moving blades to a large 700 mm. As a result, the rotor weight reaches as heavy as 1,340 kg for the DMN6 type.

Reduction-geared turbines (RG63, 64, 65) are 6-stage turbines at a speed of about 10,000 rpm, with a moving blade PCD of 450 to 500 mm, and a rotor weight approximately 35% lighter as compared with DN-type turbines, allowing a prolonged turning period (24 hours; maximum to 48 hours).

[Software/human factors]

It is extremely difficult to prevent damage in a case like this where operating parameters change over a long period. It is, therefore, necessary to regularly grasp changes which occur over years in comparison with the data of shop trials and sea trials. It is common to do this in cases of main engines and diesel generators but seems rather rare with other devices. However, there are also many cases in the past where such type of management proved to be effective to prevent damage.

III. Measures to prevent recurrence

[Hardware aspects]

Carry out turning according to the following maker's instructions.

Before starting: Min. 10 min. Max. 30 min.

After stopping: Min. 15 min. Normally 30 to 40 min. Max. 60 min.

Reasons to set the turning time as mentioned above:

(1) The rotor is heavy and, therefore, the formation of an oil film between journal and white metal is inadequate when it is rotated with the turning gear.

(2) When it is rotated with the turning gear for a long time, the middle part of the bearing will generate heat, since nearly no oil is admitted, and become very hot, disrupting the oil film and resulting in the flaking of part of the white metal and in a greater load applied to it. The situation sometimes develops into scoring.

(3) When rotating at a rated speed, the rotor weight will be uniformly carried on the bearing (see Fig. 1), but when rotating with the turning gear the weight concentrates on the lowermost portion of the bearing (see Fig. 2).

[Software/human aspects]

It is necessary to grasp changes in operating parameters over the years with reference to data in shop trials and sea trials.

IV. Lessons

Fig. 1. Stress distribution at a rated speed

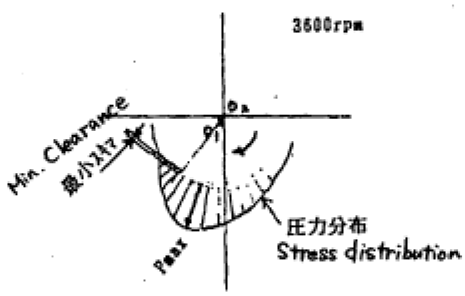
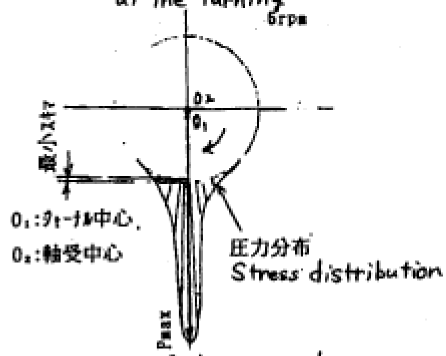


Fig. 2. Stress distribution at the turning



O_1: Center of the journal
O_2: Center of the bearing.

Engine Trouble Cases

File No.	3 - 005				
Case name	Burnt out lagging around turbine generator steam drain pipe				
Device name	Turbine generator	Damaged part	Drain pipe	State of damage	Burnout
Maker name		Model		Total working time	
Kind of ship		Date of occurrence	1982.05.14	Place of occurrence	
Cause of damage/problem	Hardware factor		Oil stain on lagging		
	Software/human factor		Poor maintenance		

I. Outline of accident

[Course of events]

Around 1300 hours smoke was found coming out from the surrounding of No. 1 turbine generator casing. The generator prime mover was changed over to the standby diesel engine immediately and No. 1 turbine was stopped. After taking the shield of the casing off, crew members started removing part of lagging in order to investigate the site of smoke, the lagging burst into flames. They put the fire out by using a carbon dioxide gas fire extinguisher placed nearby.

[State of damage]

When the remaining lagging was inspected, it proved to be almost soaked with oil up to the pipe surface. When No. 2 turbine generator was inspected, the lagging showed the same condition as in the case of No. 1 generator.

[Response measures]

The first flaming up was extinguished within a few seconds with a CO_2 gas extinguisher, since it was smoldering smoke came out thereafter, the crew members used another six portable fire extinguishers (3 CO_2 gas and 3 foam extinguishers), replaced badly stained lagging with insulating material on hand.

The leaking points of bearing oil and governor oil were all tightened further and oil pans were improved to prevent splashing of oil over the lagging.

II. Causes of accident/problems

[Hardware factors]

The inspection of the relevant part conducted after the fire was extinguished, hinted the following possibility: With oil which was penetrating little by little from the bearings and governor, the lagging of turbine casing drain pipe (15A) and the drain pipe for control (15A), began smoldering by the heat of superheated steam and went into flames as it came in contact with fresh air when the lagging was removed.

[Software/human factors]

Stains of lagging not only give the impression of poor maintenance but also have the possibility to cause an actual fire as shown by this case. It may also cause a delay in the discovery of new leaks.

It is desirable to keep lagging clean at all times.

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

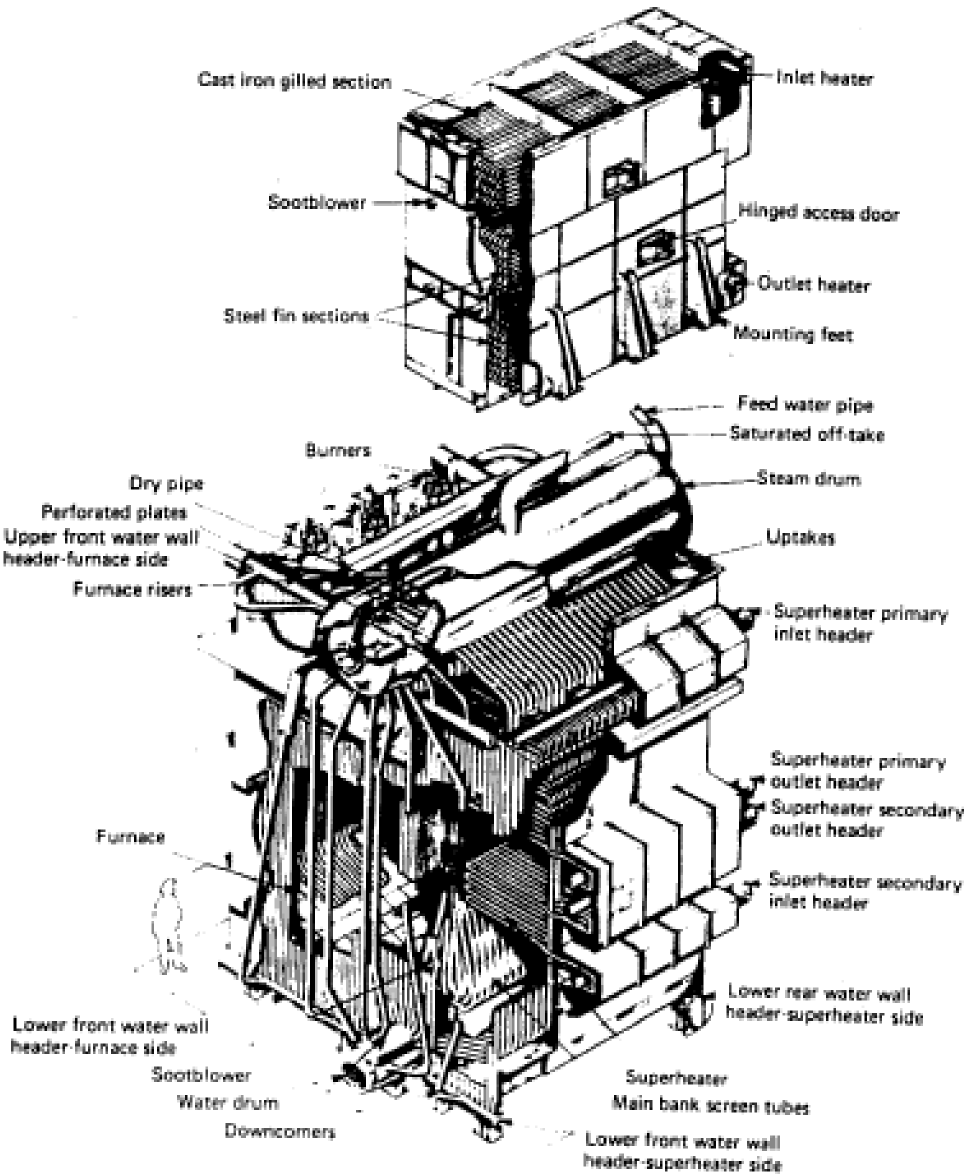
Oil stained lagging should be renewed.

IV. Lessons

In the engine room, there is always a potential danger of fire.

Looking around once again, we should perform maintenance keep in fire hazards in mind.

4. Boiler



Cast iron gilled section
Inlet heater
Sootblower
Hinged access door
Outlet heater
Steel fin sections
Mounting feet
Feed water pipe
Saturated off-take
Burners
Steam drum
Dry pipe
Perforated plates
Upper front water wall header-furnace side
Uptakes
Furnace risers
Superheater primary inlet header
Superheater primary outlet header
Superheater secondary outlet header
Furnace
Superheater secondary inlet header
Lower rear water wall header-superheater side
Lower front water wall header-furnace side
Sootblower
Superheater
Water drum
Main bank screen tubes
Downcomers
Lower front water wall header-superheater side

Engine accident cases

File No.	4 - 001				
Case name	Malfunction of auxiliary boiler rotary cup burner				
Device name	Auxiliary boiler	Damaged part	Burner	State of damage	Seizure
Maker name	Osaka Boiler	Model	Sun Flame	Total working time	3 years after built
Kind of ship	Container ship	Date of occurrence		Place of occurrence	
Cause of damage/problem	Hardware factor	Malfunction of the fuel oil regulator valve			
	Software/human factor	Poor maintenance			

I. Outline of accident

[Course of events]

While the boiler was in operation, it tripped by flame failure as a result of poor combustion. When the cause was being investigated, it was found that a large amount of fuel oil (about 1,500 liters) had accumulated inside the furnace.

[State of damage]

[Response measures]

II. Causes of accident/problems

[Hardware factors]

Inside the oil regulating valve positioned upstream of the burner, "O" rings hardened, resulting in the seizure of the spindle. (Fig. 1)

The oil regulating valve is connected to the control motor and air damper via a link mechanism. The seizure of the valve seemingly resulted in a deformation of the connecting part (Fig. 2), making the air-oil ratio out of the proper range and the excess fuel dripped into the furnace.

Although the combustion condition deteriorated, it was within the normal range of the flame detector and the operation continued, leading to the accumulation of a large amount of fuel oil in the furnace.

[Software/human factors]

This incident is almost solely attributable to human factors, including poor maintenance and insufficient checks on the operating condition. The incident was discovered before it developed into a serious accident, but the situation was so serious that it would not be surprising if a delay in its discovery would have caused a fire or explosion.

III. Measures to prevent recurrence

[Hardware aspects]

Since the portion in question is automated and frequently out of sight, it is necessary to conduct function tests and perform maintenance at regular intervals.

[Software/human aspects]

The condition inside a furnace is monitored by the flame eye only for flame failure and abnormal dripping of unburned oil can be detected by no other means but visual inspection. The check on the operating condition at all times is important.

IV. Lessons

The crew members may feel relieved at the narrow escape from a serious accident, but the accumulation of such events may lead to a serious one.

Reference information

On board a newbuilding, when employees of the shipbuilder were operating the boiler, after the sea trial, in preparation for the operation of cargo oil pumps, explosive combustion occurred inside the furnace, resulting in damage. The cause of the accident is presumed to be as follows: Unburned oil accumulated in the bottom of the furnace and evaporated as the boiler combustion chamber was warmed up. The furnace was filled with vapors and, since it was not sufficiently purged of the vapors beforehand, they caught fire from the burner flame and exploded. It was a serious accident, resulting in the boiler tube panel bent as much as 472 mm at a maximum.

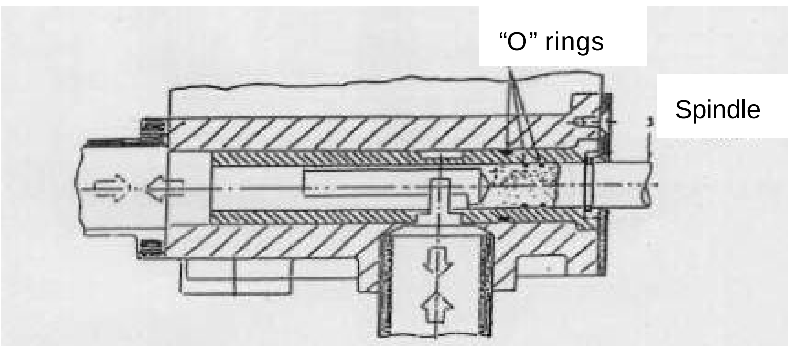


Fig.1 the oil regulating valve

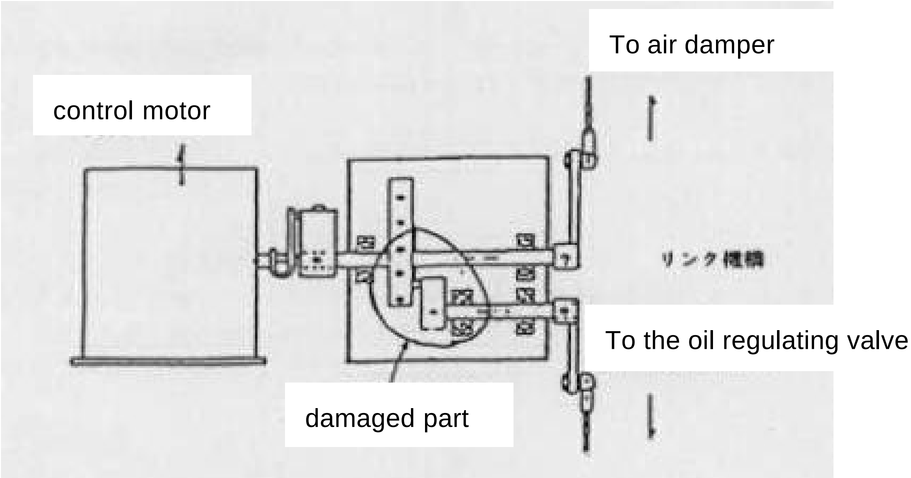


Fig.2 a link mechanism

Engine accident cases

File No.	4 - 002				
Case name	Hole of water tube boiler water wall				
Device name	Auxiliary boiler	Damaged part	Water wall	State of damage	Corrosion
Maker name	SSK	Model	SSK AMD Ⅱ	Total working time	3.5 years
Kind of ship	VLCC	Date of occurrence	1993.11.22	Place of occurrence	At sea
Cause of damage/problem	Hardware factor		Corrosion by dripping water from outside water tubes		
	Software/human factor		Insufficient check and maintenance		

Ⅰ. Outline of Accident

[Course of Event]

When making an inspection of the boiler on site before lighting off the main burner from the auxiliary burner, a water leak was found from the forward starboard casing. An inspection after removing the casing and lagging material, three tubes on the forward water wall were confirmed to be spewing water.

[State of Damage]

The third and fifth tubes (outer side) on the forward water wall were holed at a height about 50 cm above the lower header. The fourth tube was also found leaking slightly.

[Disposition]

After a changeover from the auxiliary burner to main burner, the boiler pressure was lowered to about 4 kg/cm^2 and the holes were measured to be 2 to 4 mm in diameter. They were temporarily repaired with patches.

After the vessel returned to Japan, the defective tubes were repaired by the maker by cutting off the affected parts, which were replaced and padded.

Ⅱ. Cause of Accident / Underlying Problem

[Mechanical Factor]

The smothering steam valve inside the wind box was found leaking. As a result of the leak for a long time, the lower portion of the wind box was corroded through. Water drops found their way to and ate away the water tubes from outside.

[Human/Software Factor]

The damage in question was caused as follows: The steam valve for smothering fire, which should have been kept closed at ordinary times, had been leaking for a long period and, the leak water corroded the tubes through.

III. Preventive Measures

[Mechanical]

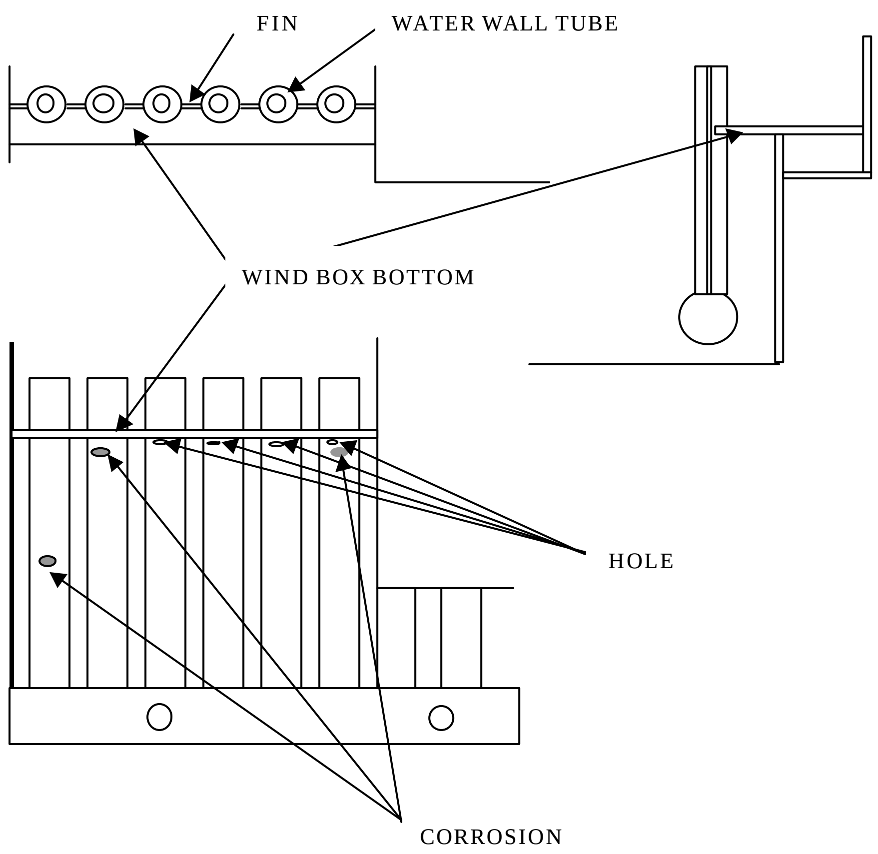
[Human/Software]

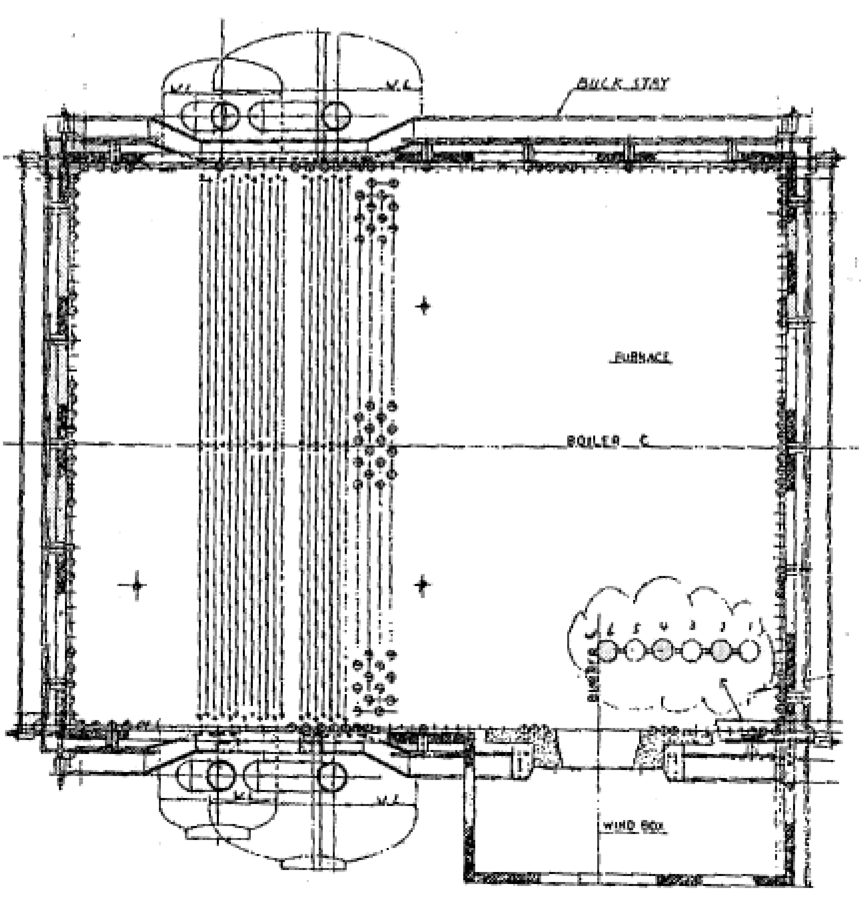
(1) We often encounter accidents arising from corrosion and erosion as a result of leaky steam valves. It is necessary to ensure that steam valves which are usually kept closed are actually in such a state.

(2) The condition inside the furnace must be checked at regular intervals.

IV. Lessons

As the proverb goes, "Constant dripping wears away the stone," bear in mind that on board vessels almost made up of steel, "drippings pierce in a short time."





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Engine accident cases

File No.	4 - 003				
Case name	Explosion of boiler combustion chamber				
Device name	Auxiliary boiler	Damaged part	Boiler casing	State of damage	Damage to boiler tubes, duct, etc.
Maker name	MES	Model	WTB-65M	Total working time	13 years
Kind of ship	VLCC	Date of occurrence	1993.12.02	Place of occurrence	During discharging cargo work
Cause of damage/problem	Hardware factor	Furnace filled with unburnt gas			
	Software/human factor	Insufficient post purge			

Ⅰ. Outline of Accident

[Course of Event]

While a tanker was being discharged at a seaberth in Japan, the oxygen content of the IGS rose as a result of a reduction in the load on the boiler. The person in charge manually reduced the air ratio, when the combustion condition became unstable.

Some time later, a flame failure occurred in the boiler. Since the combustion condition still stayed unstable after that, the person in charge kept monitoring the combustion on site. Immediately after he left the site for inspecting other machines, an explosive noise, seemingly a back fire, was issued.

[State of Damage]

One tube each on the forward and aft water walls suffered leakage; the duct for the forced draft fan system sustained cleavages, opening 50 to 80 cm at a maximum, along the four welded seams over the entire length (3.5 m); the expansion joint on the boiler gas outlet side was distorted and holed; the gas outlet casing was distorted; tubes on the forward and aft water walls bulged slightly.

[Remedial Measures]

Ⅱ. Cause of Accident / Underlying Problem

[Human/Software Factor]

In order to maintain the oxygen content of inert gas at 5% when the boiler was under a low load, the vessel coped with the situation by reducing the air feed rate. The combustion condition in the furnace, hence, was unstable as a result of an air shortage.

In such a condition, the boiler tripped. After the boiler was lighted off according to the automatic sequence, the air feed rate was abruptly increased in a poor combustion condition.

This situation presumably produced an explosive atmosphere, and resulted in an explosion.

III. Preventive Measures

[Mechanical Aspect]

The ‘IG mode’ (which automatically sets the load for proper oxygen concentration) was additionally built into the boiler control system.

[Human/Software Aspect]

(1) Before lighting off a boiler, thoroughly purge the furnace of possible gas accumulations; and check the combustion condition (residual oil on the furnace bottom) after the burner caught fire. Set all the safeguards and alarms on at all times.

(2) On board vessels with a boiler without the function of the ‘IG mode’, cope with a low load operation of the boiler by dumping steam in order to obtain inert gas of proper oxygen content. When the load on the boiler is low, there is no way other than increasing the load. A reduced flow rate of flue gas through the exhaust pipe, when the IG fan is working at an excessive capacity, results in an increase of air taken in from the upper part of the funnel, which in turn leads to a rise of oxygen concentration of the innert gas.

IV. Lessons

Boilers were manually lighted off in days gone by, and those engaged in such operations used to feel fears at a small back fire before they got used to it. Burns as a result of a back fire was not uncommon those days.

Operate boilers on the basis of a good understanding that lighting off a boiler accompanies dangers at any time.

Engine accident cases

File No.	4 - 004				
Case name	Damaged composite boiler tubes				
Device name	Auxiliary boiler	Damaged part	Smoke tubes	State of damage	Water leak
Maker name	Osaka Boiler	Model	Vertical composite type	Total working time	
Kind of ship	Bulker	Date of occurrence	1992.07.11	Place of occurrence	At sea
Cause of damage/problem	Hardware factor	Thermal distortion			
	Software/human factor	Poor response to incident			

I. Outline of accident

[Course of events]

(1) At about 0037 hours on July 11, an overflow of the cascade tank was found and a boiler water test for salinity showed 2,800 ppm.

(2) At 0050 hours on the same day, the main engine was slowed down to 90 rpm and the condenser was overhauled to conduct a pressure test. Leaks were found in three tubes and they were stopped up with plugs.

(3) During this period, the boiler was blown to replace the boiler water.

(4) Around 0500 hours, a water leak was observed from smoke tubes and, as a result of an inspection, it was found that a considerable number of smoke tubes were leaking. (Leaks from the front end fire side tubes.)

[State of damage]

The expanded tube portions were found so distorted by heat that it was impossible to insert an expander.

[Response measures]

It was decided that the repair work would be carried out in Ulsan by an agent of the maker.

II. Causes of accident/problems

[Hardware factors]

When replacing boiler water, the engine should have been stopped; almost all the boiler water was blown while the main engine was running at 90 rpm, and water was replenished resulting in expanded tube portions distorted.

The accident occurred shortly after the total renewal of all smoke tubes of the boiler at the end of March 1992.

[Software/human factors]

Thermal distortion will naturally result if all boiler water is blown and water is fed in a state where the main engine exhaust gas exceeding 300ºC continues to flow.

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

There is a need to fully understand the structure of the equipment and physical principles.

IV. Lessons

It is an unbelievable story, but it actually occurred. There is no shortage of such stories.

Engine accident cases

File No.	4 - 005				
Case name	Carryover as result of increase in salinity of boiler water				
Device name	Auxiliary boiler	Damaged part	Condenser	State of damage	Leak
Maker name	Mitsubishi	Model	MC-110A	Total working time	
Kind of ship	Container ship	Date of occurrence	1992.08.10	Place of occurrence	At sea
Cause of damage/problem	Hardware factor	Increase in salinity of boiler water			
	Software/human factor				

I. Outline of accident

[Course of events]

(1) Around 1000 hours on August 10, t was ascertained that the condenser hotwell salinometer showed 15 ppm, a value far greater than the usual 2 ppm.
The actual measurements were 250 ppm in the hotwell and 1,500 to 2,000 ppm in boiler water.
Assuming a rupture in the condenser tube, crew members started a continuous blow.

(2) Around 1715 hours on August 11, the actual measurements of salinity maintained the same level as the day before, but alarms of “T/G Governor Full Open” and “T/G Load Over Flow” went off while the turbo generator (420 kW) and two diesel generators (each 420 kW) were running in parallel, and one minute later the T/G air circuit breaker opened up as abnormal.

[State of damage]

[Response measures]

(1) Around 1820 hours, the vessel anchored at Port Said and inspected the T/G and steam pipe system but failed to find any abnormal condition; and conducted a T/G parallel running test.
When the T/G air circuit breaker load sharing equipment was set in either “Proportion” or “Over Flow” mode, the T/G air circuit breaker opened up around 400 kW and 200 kW, respectively.
After the test was completed, the T/G was stopped and a continuous blow of the boiler water was carried out.

(2) After a transit through the canal on August 12, the vessel anchored off the Port Suez at 1800 hours to repair the condenser. (Striking brass plugs to leaking pipes.)

(3) After repairs on August 13, the T/G ACB was closed and it proved to work in good

order.

II. Causes of accident/problems

[Hardware factors]

The leak of the condenser tubes caused a rise in salinity of the boiler water, resulting in carry-over, i.e., supply of moist steam mixed with drain, leading to the accident in question. (However, the proximate cause of the ACB trip was not identified but a frequency reduction is presumed to have caused it.)

In addition, the large differences between values indicated by the hotwell salinometer and those by actual measurements were ascribed, as a result of an investigation thereafter, to a mistake in connecting it to a 200V outlet as power source instead of 100V.

[Software/human factors]

This accident is a typical example which shows that, even in the case of a round boiler, which is said to be relatively resistant against carryover, the mixture of sea water might easily cause priming and furthermore, depending on the degree of the carryover, secondary damage to the T/G.

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

Generally, the contamination of boiler water with seawater from a leak of the condenser tube is said to produce actual salinity more than twice that displayed by the salinometer. It follows that it takes proper maintenance of boiler water at all times and immediate response actions in the event of seawater finding its way into boiler water.

IV. Lessons

The contamination of boiler feed water with salt requires repairs as early as practicable.

Reference

Sea water has a range of salinity from 20,000 to 30,000 ppm with electric conductance of 40,000 micro-s/cm and the boiler water of the vessel was condensed to about 1/10 of the salinity of seawater when the accident occurred.

File No.	4 - 006				
Case name	Boiler combustion with excessive vibration during operation of IGS				
Device name	Auxiliary boiler	Damaged part	Burning appliance	State of damage	Combustion with vibration
Maker name		Model		Total working time	
Kind of ship	Oil tanker	Date of occurrence	1990.05	Place of occurrence	
Cause of damage/problem	Hardware factor	Drop in oxygen content			
	Software/human factor	Operation management			

I. Outline of accident

[Course of events]

When a tanker was being discharged at night, a situation occurred in which residents in the vicinity felt the combustion vibration of the boiler although it was not felt on board the vessel.

[State of damage]

The vibration caused by combustion in the vicinity of the burner resonated in the surrounding environment.

[Response measures]

(1) Prepare a plan to discharge cargo in such a way that fluctuations in loads on the boiler are avoided at night as far as possible.

(2) Disseminate, among crew members concerned, matters which require attention on the basis of the cargo handling plan.

(3) Perform perfect maintenance work on the boiler and related auxiliary equipment.

(4) Avoid operating the boiler at a low oxygen content level and maintain an oxygen content of 4% or over even during load fluctuations. In addition, assign a person at all times so that response action may be taken manually.

(5) Install a low oxygen content alarm in the inert gas continuous recorder.

II. Causes of accident/problems

[Hardware factors]

Vibration was caused in the vicinity of the burner as a result of excessively low ratio of air to fuel.

[Software/human factors]

Even if the vibration may not have been felt at other parts of the vessel, it must have been felt on site.

Since such phenomena as the following will occur:

(1) The fire flame will vibrate;

(2) The smoke indicator will oscillate; and

(3) The oxygen content meter will oscillate;

the situation can be detected easily. Even if there is no problem with the continuous combustion of the boiler, there is no excuse for continuing such a situation as may be seen as a problem by nearby residents.

III. Measures to prevent recurrence

[Hardware aspects]

The operation of a boiler at a low oxygen level may cause not only combustion accompanying vibration but also a large-scale backfire. Pay special attention to the following boiler operation parameters:

(1) Oxygen content: 3 to 5%

(2) Smoke indicator reading: 0 to 2

(3) Air ratio set dial position: Around 1.0

[Software/human aspects]

IV. Lessons

It was lucky to receive complaints from nearby residents. If such a situation is left unattended, it will possibly lead to a serious accident.

Engine Trouble Cases

File No.	4 - 007				
Case name	Black smoke emission while in port				
Device name	Auxiliary boiler	Damaged part	Burning appliance	State of damage	Black smoke
Maker name	Osaka Boiler	Model		Total working time	
Kind of ship		Date of occurrence	1990. 06	Place of occurrence	Singapore
Cause of damage/problem	Hardware factor	Fractured pin for damper link			
	Software/human factor	Defective inspection and maintenance			

I. Outline of accident

[Course of events]

While the vessel was staying in Singapore, the flame eye detected a flame failure and shut off fuel oil. The crew member in charge made repetitive attempts to ignite the boiler without knowing the cause of the flame failure, during which the vessel emitted black smoke for about 10 minutes.

At that time, the windows of offices in the town were kept open from 1700 hours with air conditioners stopped for saving energy and the black smoke was flown away on a breeze of 4 to 5 m/sec toward the office area. Since complaints were presented from the office area, the port authority warned the vessel.

[State of damage]

The pin for the damper link mechanism for the boiler (Osaka Boiler dry-back marine cylindrical boiler/burner: Volcano) wore down and fractured, resulting in a short supply of air.

[Response measures]

II. Causes of accident/problems

[Hardware factors]

The pin had been subjected to use and vibration for many years, leading to its wear and resultant fracture.

[Software/human factors]

III. Measures to prevent recurrence

[Hardware aspects]

This type of trouble with the fracture of a pin kept out of sight is often experienced.
It should be added as one of the items contained in the pre-arrival checklist.

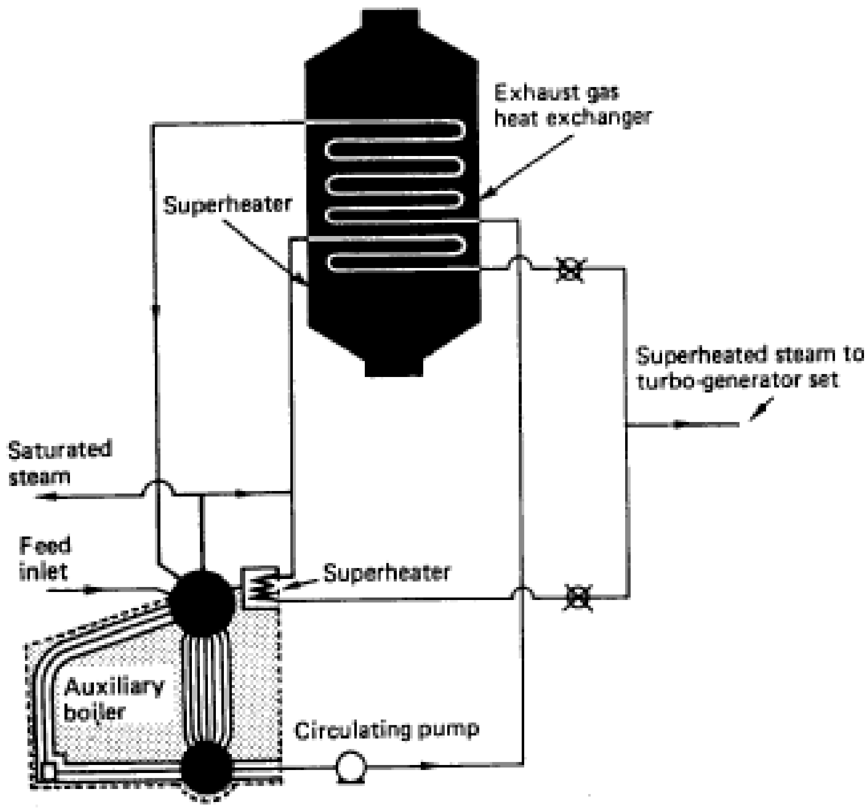
[Software/human aspects]

As for a trouble case related to black smoke emissions during a port stay, a PCC, from boiler trouble similar to the case in question, emitted soot, which fell on a large number of vehicles for export, parked in a private terminal. As a result, it was necessary to wash the cars down before loading.
In addition to the fear of causing cargo stains, black smoke emissions are strictly restricted as air pollution in some areas.
Before port entry, preparations should be made to prevent black smoke emissions with the same care as might be taken to prevent marine pollution.

IV. Lessons

The protection of the environment is also the philosophy of the MOL fleet.

5. Exhaust gas economizer



Engine Trouble Cases

File No.	5 - 001				
Case name	Soot fire of exhaust gas economizer				
Device name	Exhaust gas economizer	Damaged part	LP/HP tubes	State of damage	Overheat damage
Maker name	MHI	Model	MK-2A	Total working time	11 years
Kind of ship	PCC	Date of occurrence	1997.01.11	Place of occurrence	S /B for departure
Cause of damage/problem	Hardware factor				
	Software/human factor	Mistake in taking remedial measures			

Ⅰ. Outline of Accident

[Course of Event]

January 10

The vessel washed the exhaust gas economizer as part of shipboard operations.

January 11

0748 hours: Departure from Antwerp

2305 hours: An order was given from the bridge to gain sea speed.

2340 hours: As the EGE exhaust gas outlet temperature began to rise, the engine speed was reduced; but its high temperature alarm (225ºC) was set off. Steel balls were sprayed and the engine speed was reduced to "Dead slow ahead". The exhaust gas temperature increased further to 350ºC, with emission of a large amount of sparks.

In the engine room, crew members started two units of fresh water pumps and began spraying water by operating eight water sprayers; and in the meantime the second engineer stopped spraying steel balls.

2352 hours: The LP boiler circulating pump, unable to maintain its delivery pressure, came to a stop.

Despite continuous efforts by crew members to spray water with eight sprayers, the gas temperature went up to 450ºC, with the LP casing outside paint starting to come off. The fire showed signs of intensification and the crew members opened the four valves for water washing fitted above the preheater to spray water.

January 12

0003 hours: The bridge was informed of an emergency stop of the main engine. Efforts to cool down the EGE was started with two lines of fire hoses (sea water) and fresh water hoses on deck. At this point in time the EGE outlet gas temperature reached 658ºC.

0005 hours: The main engine was stopped.

0035 hours: The fire was put out.

[State of Damage]

(1) Preheater: 2 fins melted. (No leaks)

(2) LP evaporator tubes badly damaged. (Top & bottom sections melted)

(3) HP section: 10 tubes buckled & some tubes leaking.

(4) In addition, the inspection door burnt down.

[Remedial Measures]

All of the LP and HP tubes were removed.

Ⅱ. Cause of Accident / Underlying Problem

[Human/Software Factor]

(1) The vessel stayed in Rotterdam for six days before coming to Antwerp, where crew members water washed the EGE as excessive soot collected after a long river sailing at a reduced speed.

The vessel was constrained in time to conduct water washing sufficiently in Antwerp as shown in the "Course of events" and, she was allowed only about eight hours for the actual operation of water washing if the time consumed for cooling and preparing for, and inspecting the result of, water washing is excluded, since she was forced to shift during the stay there. When the above situation is taken into consideration, the recent soot fire is presumed to be attributed to the following:
The vessel failed to dry up the boiler sufficiently after water washing;
For this reason, the soot which had collected on the surfaces of tubes did not adequately dry up nor come off, resulting in a large amount of wet soot left inside.

As is well known, the ignition temperature of soot drops when it gets wet. Since the main engine was operated to gather sea speed, the resultant rise in the temperature of the exhaust gas led to the ignition of soot in a wet state when the hot gas passed through the EGE.

This means that the time allowed for the water washing was excessively short when consideration is given to the time required for drying the tube surface, for the soot to come off during its drying period, and for collecting the soot which fell off.

(2) The act of spraying steel balls to remove soot while soot fire was burning prompted the intensity of the fire rather than weakening it.

III. Preventive Measures

[Mechanical Aspect]

[Human/Software Aspect]

PREVENTION OF SOOT FIRE IN EXHAUST GAS ECONOMIZER

To prevent a soot fire in the exhaust gas economizer (hereinafter referred to as the EGE), you are requested to observe the following precautions and to take necessary countermeasures.

A) When Starting the Main Engine

1 When starting the main engine just after water washing of the EGE, pay close attention to its exhaust gas side and exhaust pipe line. (After water washing, the ignition temperature of remaining wet soot drops, and the soot ignites easily.)

2 To start the boiler water circulating pump before using the main engine due to avoid dry out the evaporator tubes inside, and confirming the water flow.

B) Normal steaming

1 Keep the main engine combustion in good conditions to reduce as much as possible any production of soot.

2 To produce satisfactory results of a soot blow, keep the available highest pressure when a steam or air soot blow is made.

3 Monitor the EGE for draft loss, and blow soot more often if any increase in draft loss as compared to that in a good condition is observed.

4 Never stop the boiler water circulating pump.

C) Slow steaming

1 To produce satisfactory results of the soot blow, increase the main engine load to normal load during the soot blow.

2 Soot must be blown more often than during normal steaming.

D) In port

1 To prevent a soot fire, the boiler circulating pump must be run continuously for at least 24 hours after stopping the main engine. There are cases of soot fires occurring after the main engine has been stopped for 12 hours.)

2 Fires can be triggered due to an inflow of fresh air through the manhole, so confirm before opening the manhole that the inside of the EGE has cooled to 150ºC or lower.

3 Regularly inspect the inside of the EGE, even when washing has not been carried out,

to monitor the accumulation of soot.

E) Water Washing the EGE

Water washing is the most effective method of removing soot. Carry out water washing, bearing the following in mind.

1. Water washing must be carried out periodically at suitable intervals, depending on the degree of soot accumulation or increased draft loss. The most effective approach is to carry out water washing when the draft loss rises to 1.5 to 2.0 times that under a good condition.
2. Water washing is more effective when the interior of the heating tube is still warm, after stopping the circulating pump. Ideally, the circulating pump should be kept run during the early stages of water washing.
3. Dividing water washing process into several stages with some intervals can perform water washing more effectively.
4. Soot must be completely removed. Pay special attention to the inside the EGE, where wet soot likely to accumulate. Wet soot has a low ignition temperature, and carries a high risk of triggering a soot fire.
5. Running the circulating pump after water washing tubes enable to peel off the soot. And using dry pressure air is more effectively.
   It is, however, necessary to first reduce the boiler steam pressure, because the soot of the evaporator tubes surface will reach to ignition temperature in case the boiler steam pressure is 20 kg/cm^2 or more.
6. To discharge any residual soot after water washing, blow soot as soon as possible after starting the main engine.
7. Prepare a fire fighting hose near the EGE and behind the funnel to allow rapid response to a soot-fire.

F) Way for dealing with Soot-Fires

If a soot fire occurs unfortunately, respond quickly, paying close attention to the following matters to avoid irreparable loss.

1. If a small-scale soot fire occurs, ensure that there is sufficient circulating water to cool the heating tube, while carefully monitoring the circulating pump for cavitation. Parallel operation of two pumps is preferable.
2. Choking off the oxygen supply is effective in fighting a soot fire. Arrange in advance a practical method for doing this.
3. Spray water onto the EGE casing to cool it.
4. If the heating tube in the EGE is damaged, and leakage of circulating water is observed, stop the circulating water pump. Otherwise, there is a risk of causing a

high temperature oxidation reaction of steel.

5 After the fire has been extinguished, open the manhole to confirm that the casing has sufficiently cooled. If the casing is still hot and the fire has not completely died out inside the EGE, a fresh supply of oxygen will reinvigorate the fire when the manhole is opened.

IV. Lessons

The exhaust gas economizer needs sufficient water washing, drying and collection of soot which has come off after drying, when the danger of soot fire is taken into account. With this in mind, the department head must draw up an operational plan which enables crew members to have sufficient time for the operation, including preparation and clearing work after the operation.

V. Reference

It is known that, in an atmosphere with steam remaining inside as a result of steam leakage from broken boiler tubes caused by a fire or with steam generated from water sprayed inside an economizer, iron is oxidized more rapidly than in dry air or in oxygen. If an atmosphere containing steam is created when oxidation of iron occurs at a high temperature resulting from a soot fire, the oxide film on the iron surface cracks and peels as a result of internal distortion caused by the heat generated by oxidation. This phenomenon is called “break-away oxidation” and, as far as the peeling effect of the film continues oxidation accelerates. If the temperature reaches over 700ºC, the heat generated by the high temperature oxidation of steel pipes increases rapidly and leads to the melting of the tubes.

In the recent case, it is highly possible that this phenomenon promoted the fire. However, it is also known that spraying a large amount of water at one time in the early stage of a fire is very effective for extinguishing fire.

In any case, spraying water for a soot fire depends on the situation and it is impossible to generalize the effect of water spraying.

Engine Trouble Cases

File No.	5 - 002				
Case name	Main engine operational disorder resulting from fouled exhaust gas economizer				
Device name	Exhaust gas economizer	Damaged part		State of damage	Fouling
Maker name	Osaka Boiler	Model	Fin type	Total working time	12 years after built
Kind of ship	VLCC	Date of occurrence	1999.05.23	Place of occurrence	While at sea
Cause of damage/problem	Hardware factor		Poor combustion		
	Software/human factor		Insufficient operational control		

I. Outline of accident

[Course of events]

April 20 Departure from the MSD dockyard, Singapore. The preheater was renewed and the exhaust gas economizer cleaned.

May 23 The rising tendency of the main engine exhaust gas temperature came to notice.

May 27 The main engine turbocharger inlet high temperature alarm (490ºC) sounded and to maintain of the normal engine speed at 70 rpm became difficult.

At this point in time, the vessel ascribed the exhaust gas temperature rise to the quality of the fuel oil since it coincided with the time that No. 1 FO tank was used to the bottom. Her managing company also instructed the vessel to change over the fuel tank to use.

May 29 Even after the complete changeover to fuel oil from the new tank, the running condition did not improve, and the exhaust gas temperature increased further, forcing further reduction in engine output. At this point in time, the vessel attributed the situation to the fouling of the turbocharger or fuel valve failure as a result of the use of fuel oil of poor quality, but rough seas at that time prevented the stop of the main engine to overhaul for inspection.

May 31 Although the vessel anchored temporarily on the east coast of India and overhauled the turbocharger for inspection, it was found normal.

The managing company instructed the vessel to inspect the exhaust gas economizer and spark arrester.

1530 hours: The fouling of the exhaust gas economizer was confirmed and the operation to wash it, was started.

2015 hours: The water washing operation was completed.

2200 hours: Main engine trial.

June 1 0015 hours: “Full away” was rung on the engine telegraph.

0200 hours: The recovery of operating parameters to normal was confirmed.

[State of damage]

Soot adhered to the exhaust gas economizer in a considerably wet (very sticky) condition.

[Response measures]

The exhaust gas economizer was water-washed. Approximately 60 tons of wash water was used.

II. Causes of accident/problems

[Hardware factors]

Excessively high main engine back pressure caused by the fouling of exhaust gas economizer, and a drop in the performance of the main engine accompanying it, resulted in a rise in exhaust gas temperature.

Crew members did not notice the fouling of the exhaust gas economizer earlier because the differential pressure gage for it was broken then.

According to experiments once conducted by Kobe Diesel Co., Ltd. to determine the relationship between main engine back pressure and exhaust gas temperature, the back pressure at which it is conspicuously reflected in an increase in exhaust gas temperature, is said to be 500 mmAq or over. The main engine back pressure was not measured this time, but it is thought that it probably reached a back pressure of the same level.

[Software/human factors]

It is needless to say that there lied a big problem with the fact that the exhaust gas economizer got so fouled in only a month as to set off the main engine exhaust gas high temperature alarm, restricting the operation of the vessel, but, on the other hand, there is a need to pay attention to the human factors that crew members did not rectify the broken differential pressure gage, important for the operational control of the main engine and for the maintenance of the exhaust gas economizer itself, and that it took excessive time for them to become aware of the fouling of the economizer as a cause of the exhaust gas temperature rise of the main engine.

As for the condition of the exhaust gas economizer of the vessel then, the preheater was unusable (the motor for the recirculation pump burned out). The soot blow was made six times a day.

III. Measures to prevent recurrence

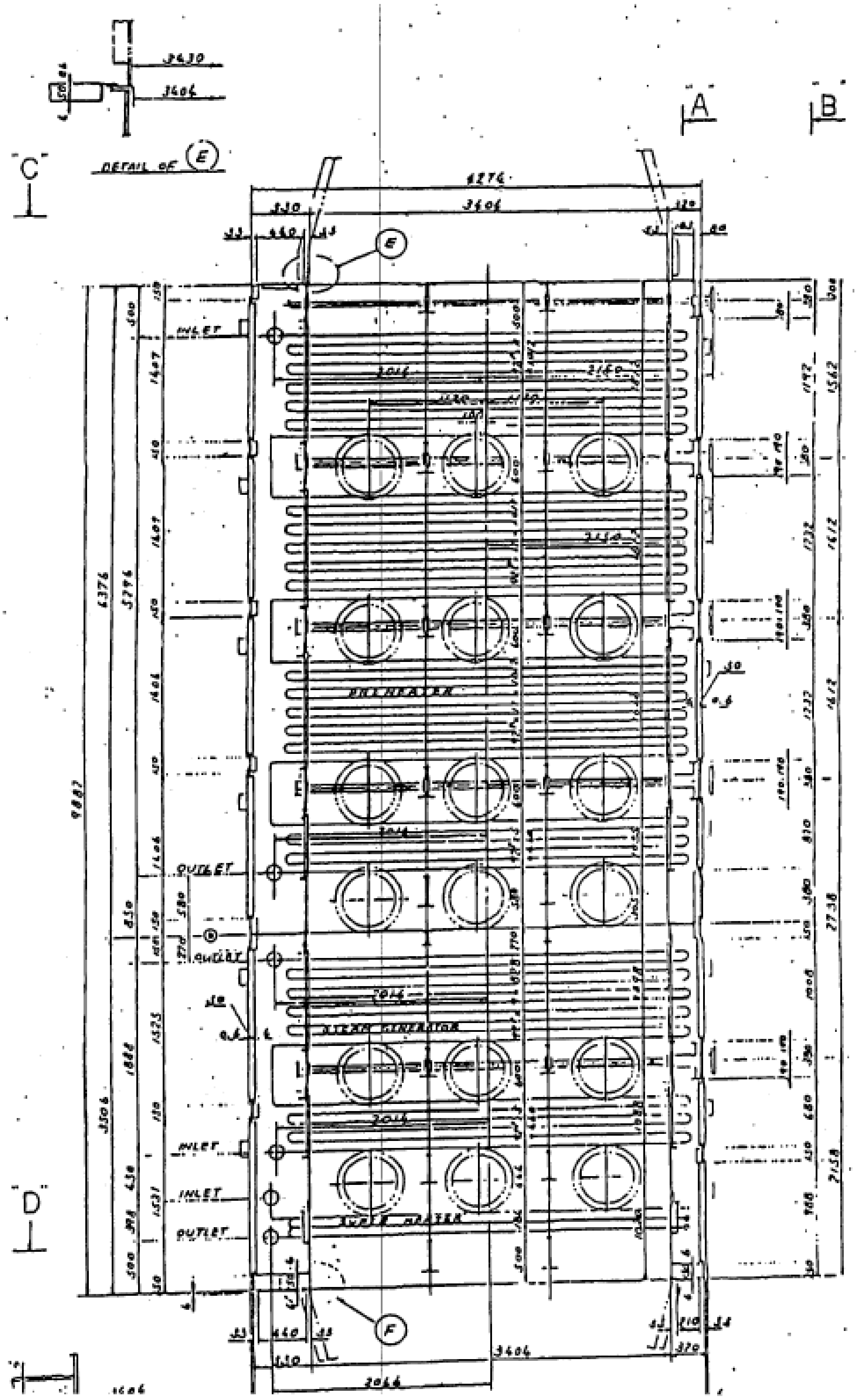
[Hardware aspects]

[Software/human aspects]

The fouling of an exhaust gas economizer can be assessed not only by differential pressures but also changes in the differential between economizer inlet and outlet temperatures and in the rate of evaporation, but reading differential pressure daily and grasping its rising tendency is most effective. There is a need to provide maintenance on the basis of trend data, not to blindly follow a customary maintenance schedule, e.g., once every certain months.

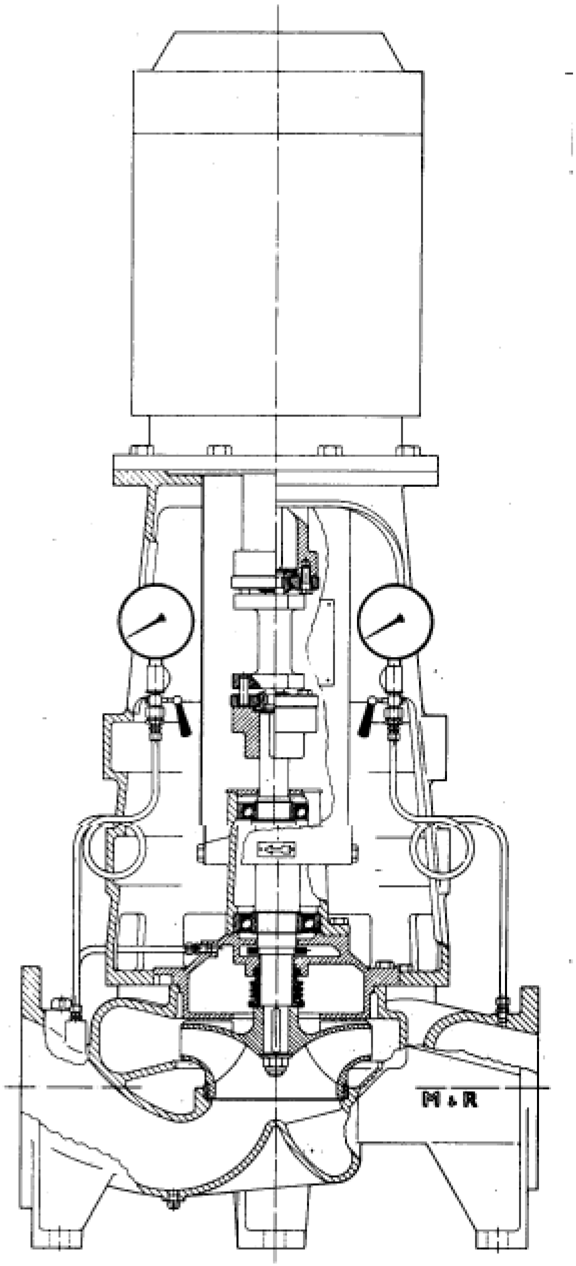
Ⅳ. Lessons

The exhaust gas economizer of a fin type may get so fouled to exceed the load limit of the main engine only in one month. There are even cases where the main engine surges in one month, depending on the turbocharger matching.



"A"
"B"
"C"
"D"
DETAIL OF (E)
INLET
OUTLET
PREHEATER
STEAM GENERATOR
3406

6. Pump



Engine Trouble Cases

File No.	6 - 001				
Case name	Failure of M/E Piston cooling pump to deliver sufficient water				
Device name	M/E piston cooling pump	Damaged part	Impeller	State of damage	Foreign matter caught up
Maker name	UBE INDUSTRIES, LTD.	Model		Total working time	7.5 years
Kind of ship	Container ship	Date of occurrence	1993.09.27	Place of occurrence	At sea
Cause of damage/problem	Hardware factor	Foreign matter caught up			
	Software/human factor	Insufficient maintenance			

I. Outline of Accident

[Course of Event]

While the vessel was sailing in rough weather, the delivery pressure of the M/E piston cooling pump dropped suddenly, triggering main engine 'Auto Slow Down'. An inspection of various parts revealed that the pump delivery pressure and electric current were showing values lower than normal, suggesting foreign matter caught up in the pump impeller, reducing its performance.

[State of Damage]

[Disposition]

Thinking that there was a possibility that foreign matter was caught up in the pump impeller, crew members started to open up the pump. However, they found it difficult and abandoned the plan since the pump was a type whose main body was installed inside a tank.

They studied how to remove the foreign matter, and decided to employ compressed air. They removed the pump outlet pipe and fitted the pump's outlet side with a flange having a coupler for air blows. They then made an air blow at a pressure of 6 kg/cm^2 in the opposite direction, which successfully removed the foreign matter caught inside the pump, recovering the pump's full capacity.

As a result of an inspection of the piston cooling tank after arrival at the next port, sludge which seemed to have caught up in the impeller was confirmed.

II. Cause of Accident / Underlying Problem

[Mechanical Factor]
Foreign matter caught up in the pump impeller reduced its performance.

[Human/Software Factor]
Failure to clean the piston cooling tank at regular intervals resulted in the accumulation of sludge inside the tank.

The incident is a typical example of poor maintenance provided by crew members.

III. Preventive Measures

[Mechanical]

[Human/Software]
Clean the piston cooling tank at regular intervals.

In light of this incident, we instructed vessels concerned to inspect piston cooling tanks, and received a report from a certain vessel that approximately 8 cans of 18 liters of oily sludge were recovered.

The internal inspection of the tank is a maintenance item likely to be overlooked and its maintenance, including the maintenance interval, is required to be reviewed.

IV. Lessons

The vessel was encountering a typhoon when the incident occurred. In rough weather, it is feared that the sludge and other residual matters which have settled down at the bottom of all tanks are agitated and sucked into pipelines.

Periodical tank cleaning is unpleasant, hard work but is very important.

With only a slight twist of fate, the incident could have led to a serious situation depriving the vessel of maneuverability.

Engine Trouble Cases

File No.	6 - 002				
Case name	Breakage of upper half casing of permanent water ballast pump				
Device name	Ballast pump	Damaged part	Upper half casing	State of damage	Breakage
Maker name	MHI Takasago	Model	BHD-45	Total working time	12 years after built
Kind of ship	VLCC	Date of occurrence	1988.01.17	Place of occurrence	Sakai
Cause of damage/problem	Hardware factor	Nil			
	Software/human factor	Defective handling			

I. Outline of accident

[Course of events]

0700 hours: The ballast pump was started to commence ballasting No. 7 P&S tanks.

0800 hours: The ballasting of No. 7 P&S tanks was completed. The ballasting operation to top off the FPT was started.

0935 hours: The FPT was topped off and the ballast pump was stopped.

0937 hours: The discharging operation of the FPT was started by gravity since excessive water was taken in the tank.

0955 hours: The sea valve for the ballast pump (BP04) was shut.
When the BP04 valve was completely shut, the ballast pump was damaged with a bump in the pump room.

[State of damage]

The delivery volute section of the upper casing was blown as a piece of 670 mm in length and 380 mm in width; and the flange section cracked over a range of about 3/4 of the circumference at the root section.

[Response measures]

(1) The entire pump was removed and landed ashore where the upper half casing was welded and annealed.

(2) After its mouth ring recess was bored, the pump was reinstalled on board and was aligned.

II. Causes of accident/problems

[Hardware factors]

When the FPT was being discharged by gravity, the valve BP04 at the downstream end was shut. The moment the valve was completely shut, the water head of the FPT and the water flow through the pipe line are presumed to have created a water hammer, causing a pressure surge, thereby damaging the pump casing. The broken surface was glittering and there was no sign of defects, such as corrosion or cracks, found inside the casing. No latent defect was detected by visual inspection.

[Software/human factors]
Mistake in valve handling order.

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]
(1) Preparation of a manual and thorough inculcation of basic operations.
(2) A pre-operation meeting should be held to eliminate operational mistakes.
(3) Engineer must note there is always a pump by pass line for gravity filling or discharging.

IV. Lessons

File No.	6 - 003				
Case name	Seizure and damage of fire & ballast pump				
Device name	Ballast pump	Damaged part	Shaft, etc.	State of damage	Burnout
Maker name	Naniwa Pump	Model	FE2V-200D	Total working time	
Kind of ship	Container ship	Date of occurrence	1988.03.10	Place of occurrence	Tokyo
Cause of damage/problem	Hardware factor	Nil			
	Software/human factor	Mishandling			

I. Outline of accident

[Course of events]

When ballast water was being discharged by remote control on the bridge ballast control console, the 'emergency stop alarm' of the fire & ballast pump appeared on the panel.

When the person in charge immediately reported to the scene, the pump was incapable of rotating with the overcurrent relay activated, and the casing temperature was extraordinarily high. Considering that it was as a result of seizure of the pump, he decided not to use it.

[State of damage]

(1) The carbon of the upper line bearing split and fell off.

(2) The upper impeller and casing burned and seized. The casing ring fused with the casing cover and partly split.

(3) The casing cover was partly cracked.

(4) The impeller shaft wore down abnormally on one side and suffered bending 2.5 mm at a maximum, suggesting that the impeller shaft was rotating with uneven contact.

(5) The stage bush burned and fused with the casing cover and shaft.

[Response measures]

The following temporary repairs were made and permanent ones were made at a later date:

(1) Although the impeller and stage bush were carefully removed from the casing cover, they were distorted.

(2) As it was difficult to remove the upper casing ring because of seizure, it was worked with drills and chisels and fixed with Devcon.

(3) The stage bush was removed and corrected.

II. Causes of accident/problems

[Hardware factors]

Nil.

[Software/human factors]

During a deballasting operation from ballast tanks, the person in charge let the pump suck air and continued its operation for a long time without establishing sufficient suction. He did not bother to check suction/delivery pressure gauges.

As a result pump was running dry.

III. Measures to prevent recurrence

[Hardware aspects]

Suction/delivery pressure gauges should be operational at valve remote control stand. The performance of any pump can be monitored only by suction/delivery pressure gauge.

[Software/human aspects]

(1) Preparation of a manual and thorough inculcation of basic operations.

(2) Review of how the watch should be kept.

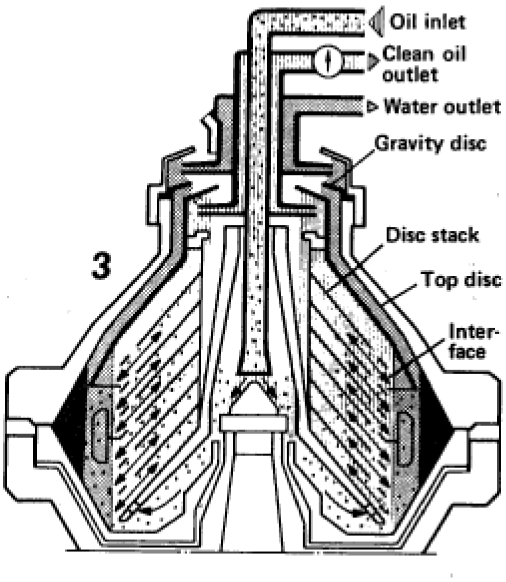
(3) Discussion between the deck and engine departments and establishment of cooperating arrangements.

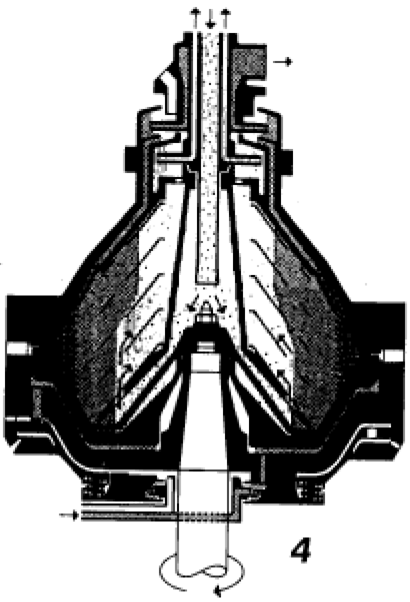
IV. Lessons

There are a large number of accidents of this type.

7. Purifier

3





4

Engine Trouble Cases

File No.	7 - 001				
Case name	Engine room fire				
Device name	Diesel oil purifier	Damaged part	Clamp nuts	State of damage	Working loose and falling off
Maker name	Mitsubishi Kakoki	Model	SJ-E	Total working time	
Kind of ship		Date of occurrence	1991.04.21	Place of occurrence	
Cause of damage/problem	Hardware factor		Defective reassembly in maintenance work		
	Software/human factor		Disregard of maker's manual		

I. Outline of accident

[Course of events]

[State of damage]

[Response measures]

II. Causes of accident/problems

[Hardware factors]

When the diesel oil purifier was reassembled, the impellers for light and heavy liquids, inlet pipe, socket set screws, clamp nuts, etc. were rather loosely tensioned and with the time of operation, clamp nuts worked loose and came off, damaging the liquid inlet pipe and distributor; furthermore, the upper and lower hood portions came in contact with the liquid inlet pipe, causing abnormal heat and, as a result, igniting the admitted oil, leading to an engine room fire.

[Software/human factors]

When handling equipment and instruments, engineers are required to read and familiarize themselves with operations manuals provided by the relevant maker. In addition, sometimes the original manuals may undergo changes as in this case and, in such cases, after-sales service letters are issued by relevant makers, though such letters may be called by a different name.

These letters are issued almost always as inconveniences have been experienced and it follows, therefore, that observance of the original operations manuals may possibly lead to accidents.

Engineers must read letters of this kind whenever they are distributed to the vessel from the managing company even if the instrument taken up in the letter is not installed on the vessel; and when they handle the device on board a different vessel, they must recall and consult the letter.

III. Measures to prevent recurrence

[Hardware aspects]

Precautions in tightening clamp nuts for Mitsubishi Kakoki SJ-E series purifiers were communicated to vessels installed with such purifiers in an operating maintenance guide issued in June 1989. We distribute again Service Information No. 069 “Method to tighten clamp nuts”, which you are requested to disseminate among engineers concerned.

[Software/human aspects]

IV. Lessons

Accidents related to purifiers are prone to become disastrous ones involving a fire or personal injuries. Engineers engaged in the operations mentioned here consider them as routine operations due to their frequency and they tend to carry them out lightly. They should conduct such operations very diligently in spite of the operation being a very frequent one.

INFORMATION
of
MITSUBISHI SEPARATOR

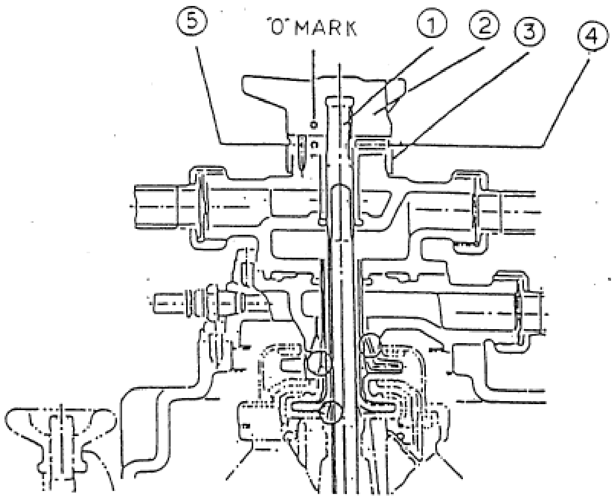
Service Inf. No.069

How to Fasten Clamp Nut

Model : SJ-10 ～ SJ-60

Construction

The upper part of SJ-E Series is as shown in the following drawing.
The Heavy Liquid Impeller and Light Liquid Impeller are incorporated into Inlet Pipe and each tapered part (marked ◯) is fixed at the prescribed position by fastening the Clamp Nut.



1. The following troubles may occur when purifier is operated under the condition of insufficient fastening of Clamp Nut:
   a) Each Impellers contacts the Heavy Liquid Chamber or Light Liquid Chamber.
   b) Each Impellers turns by the liquid dynamic pressure and each tapered part abrades.
   c) In some case, the Inlet Pipe descends and contacts the Distributor.

   As the failures mentioned in the above will cause excessive vibration, expansion of parts damages and the generation of heated part, certainly perform the fastening of Clamp Nut in accordance with the undermentioned procedures:

2. Assembly Procedures
   a) Incorporate the Frame Cover.
   b) Incorporate the Lock Ring③ into the Inlet Pipe①. At this time, pay attention and screw in slightly the Socket Head Screw④ of Lock Ring into the groove of Inlet Pipe.
      Further, while turning the Inlet Pipe and adapting the hole made on the Lock Ring to the fixed Knock Pin ⑤, push in the Lock Ring.
   c) Install a Clamp Nut and fasten it by hand to the last.
      Normally speaking, in case there is no abnormality of threaded part, no abrasion of tapered part, no dust attached to tapered part, fastening can be performed by hand until the tally marks of Clamp Nut and Lock Ring are located at the dimentional position of the following table 1.

Table 1

Model	Dist. of 2 marks(mm)
SJ-10P/T～SJ-11P/T	10 ～ 12
SJ-25P/T～SJ-30P/T	11 ～ 13
SJ-40P/T～SJ-60P/T	13 ～ 15

* Dimension in the Table 1 is the distance between 2 marks which was manufactured at our company. The distance should be differed by renewal, abrasion or corrosion of the related parts.

d) Fasten the Clamp Nut with a hammer up to coinside the tally mark of Clamp Nut with the tally mark of Lock Ring.

e) Fasten fully the Socket Head Screw ④ until it contacts the Inlet Pipe.

3. Caution

a) After completely fasten up the Clamp Nut with a hammer, perform the fastening of Socket Head Screw ④.
If the Socket Head Screw is fixed to the Inlet Pipe first, even if the Clamp Nut is fastened, it will become impossible to fasten to the prescribed position and a damage will happen.

b) With the lapse of time of use, if the corrosion and abrasion occur on each part of the Heavy Liquid Impeller and Light Liquid Impeller, though the tally mark of Clamp Nut become apt to advance in the direction of screwing, and even if the tally mark of Clamp Nut advances 90 degrees than the tally marks of Lock Ring, there will be no problem in use.
However, in case the tally mark of Clamp Nut exceeds 90 degrees, be sure to exchange the defective parts with a new one.

c) In case the exchange of parts such as the Inlet Pipe, Heavy liquid Impeller, Light Liquid Impeller and etc. was conducted, as the fitting of each tapered part will change, the position of tally mark of Clamp Nut will also change. Therefore, stamp the new tally mark with a die in accondance with the point of the abovementioned Section 2 (Assmble Procedures).

d) When new mark is stamped, fasten up the Clamp Nut up to the dimension of Table 1 from the condition of section 2-c) with the hammer. After that, stamp "O" mark on the Lock Ring at the same position of Clamp Nut.
If a torque wrench is used to fasten the Clamp Nut, following torque should be used.

SJ-10P/T ~ SJ-11P/T : 700 Kgf-cm
SJ-15P/T ~ SJ-60P/T : 1,000 Kgf-cm

Engine Trouble Cases

File No.	7 - 002				
Case name	Generation of fuel oil purifier vibration				
Device name	Fuel oil purifier	Damaged part	Vertical shaft system	State of damage	Wear/breakage
Maker name	Mitsubishi Kakoki	Model	SJ-4000	Total working time	
Kind of ship		Date of occurrence	1989.04.20	Place of occurrence	At sea
Cause of damage/problem	Hardware factor	Mistake in reassembling a bearing			
	Software/human factor	Operational mistake			

I. Outline of accident

[Course of events]

Since around April 20 at sea, No. 1 purifier (during continuous bypass purification of diesel oil) started to vibrate increasingly. Furthermore, unusual sounds were sometimes observed on the 22nd same month during a stay at Sakaide and it was stopped for an overhaul, which revealed damage.

[State of damage]

(1) Breakage of the ball bearing;
(2) Fracture of the spring pin;
(3) Abnormal abrasion of the spiral gear;
(4) Abrasion of the bearing case, spring seat, ball race and slight marks of contact; and
(5) Lowering of the standard height after reassembly of the vertical shaft.

[Response measures]

(1) Inspection of the vertical and horizontal shafts and renewal of the vertical shaft bearing.
(2) Renewal of the lower bearing set screw with an oversized one and insertion of a knock pin.
(3) Correcting the tooth surfaces of the spiral gear and machining the spring seat.
(4) Restoration after rectifying the standard height of the vertical shaft.
(5) Taking remedial measures after overhauling each purifier for inspection.
   a) No. 2 fuel oil purifier
      Since the lower vertical shaft bearing and the ball bearing were placed in opposite locations, they were replaced in normal locations.
   b) Lube oil purifier
      Renewal of the ball bearing since it was fitted upside down.

II. Causes of accident/problems

[Hardware factors]

Since the ball bearing for the vertical shaft was reassembled upside down by mistake, the bearing was broken under thrust force. As a result, the vertical shaft sank, causing an imbalance, which seemingly induced abnormal vibrations.

[Software/human factors]

Disregard of the relevant operations manual.

III. Measures to prevent recurrence

[Hardware aspects]

One of the precautions in reassembly of the ball bearing of the vertical shaft is to set it with the portion inscribed with a number down, as described in the operations manual for Mitsubishi Kakoki's Self-jector.

The manufacturer says that, since the former instructions manual (with a green cover) before March 1979 had an attached drawing showing the assembly upside down, the company disseminated the fact among vessels by distributing stickers for correction. Vessels equipped with the relevant purifier are requested to check again whether the operations manual has a correctly revised drawing.

[Software/human aspects]

Engineers are required to read instructions manuals carefully before starting to perform maintenance and reassemble by consulting drawings.

IV. Lessons

It is expected that equipment, if reassembled in a wrong manner, will break down.

File No.	7 - 003				
Case name	Damaged fuel oil purifier vertical shaft bearing				
Device name	Fuel oil purifier	Damaged part	Vertical shaft bearing	State of damage	Breakage induced by weardown
Maker name	Mitsubishi Kakoki	Model	SJ3000	Total working time	
Kind of ship		Date of occurrence		Place of occurrence	
Cause of damage/problem	Hardware factor	Deterioration over years of use			
	Software/human factor	Poor maintenance			

I. Outline of accident

[Course of events]

No. 2 fuel oil purifier unusually discharged fuel oil to the heavy liquid side, with a louder rotating sound and excessive vibration. Same stopped and changed over to No. 1.

[State of damage]

The vertical shaft was dancing, with only a half of the balls for the upper bearing remaining. In addition, the bowl was displaced considerably below the normal level, the impeller of the inlet tube chipped off, its cover worn down and the sealing water distributor placed under excessive stress.

[Response measures]

(1) Vertical shaft: The upper and lower bearings were renewed and 'O' rings were renewed with spares.

(2) Sealing water distributor: 'O' rings were renewed.

(3) Bowl: The scratched inlet tube was repaired and the light liquid impeller replaced.

II. Causes of accident/problems

[Hardware factors]

The bearing for the vertical shaft should be replaced at an interval of 8,000 hours, but the bearing in question was used for a period far greater than that.

[Software/human factors]

The damage was caused by failing to observe the maintenance standard recommended in the maker's operating manual.

The purifier of the SJ type will always fall in various types of trouble with bearings, etc. if the suggested maintenance standards are not followed.

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

Regular maintenance work should be carried out in accordance with the maker's operations manual.

IV. Lessons

Any machine, if specified maintenance is not carried out, will eventually break down.

File No.	7 - 004				
Case name	Water contamination of M/E System oil				
Device name	LO purifier	Damaged part	M/E System Oil	State of damage	Contamination of water
Maker name	Alfa-laval	Model	MOPX	Total working time	
Kind of ship		Date of occurrence		Place of occurrence	
Cause of damage/problem	Hardware factor	Mis-installing of packing			
	Software/human factor	Disregard of instruction manual			

Ⅰ. Outline of Accident

[Course of Events]

Whilst checking the on board M/E system oil, it was found that the water content had increased significantly. Investigation revealed that during the discharging process the valve cylinder had not opened due to faulty assembling of the LO purifier. This led to replacement water and seal water entering the M/E system oil.

[State of Damage]

[Disposition]

Ⅱ. Cause of Accident / Underlying Problem

[Mechanical Factor]

Due to incorrect sitting of the rubber packing used to seal the operational water in the assembling purifier, the valve cylinder did not correctly open during the discharge process.

[Human/Software Factor]

(1) Carelessness in installation of rubber packing.

(2) No running test done after the purifier was assembled.

Ⅲ. Preventive Measures

[Mechanical]

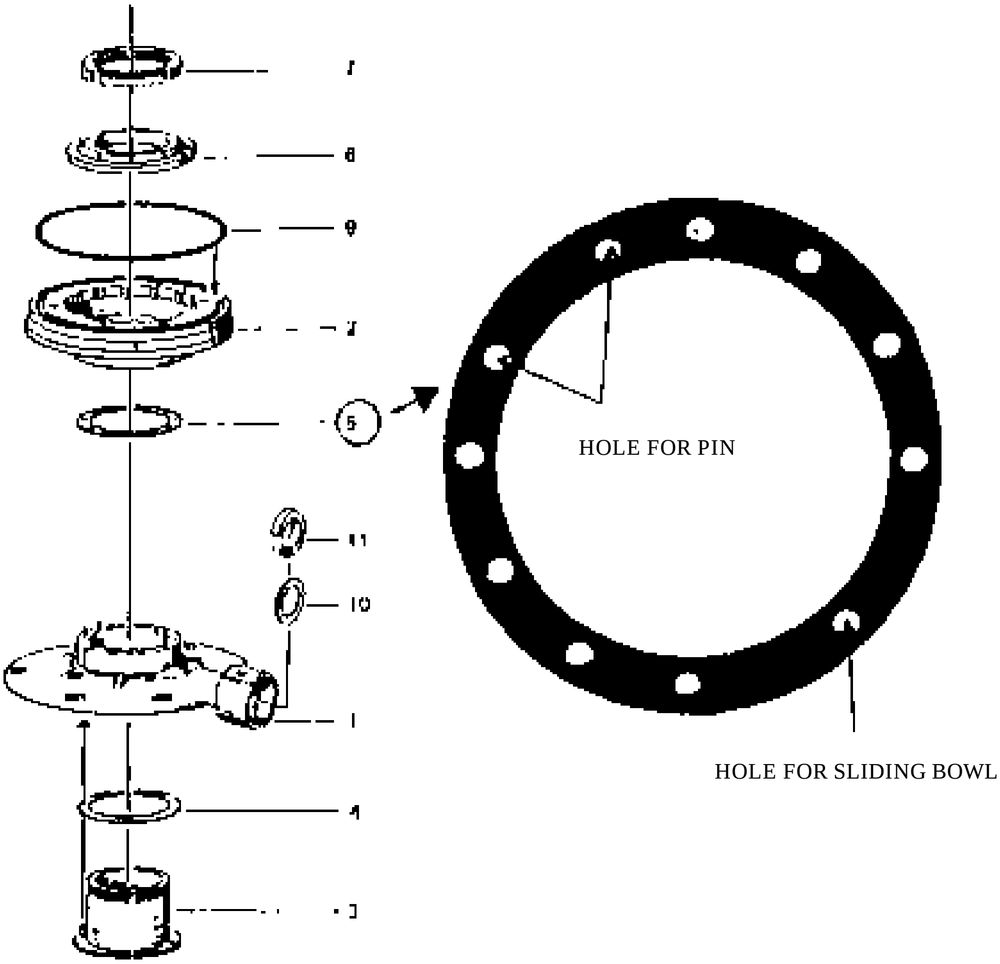
The rubber packing is fixed using a set pin. However, it can be set to the wrong position, as happened in this case. A similar problem has occurred previously on another vessel. An operation test of sludge discharge must be done after assembling the purifier, and periodic checks should be made to ensure continued normal running.

[Human/Software]

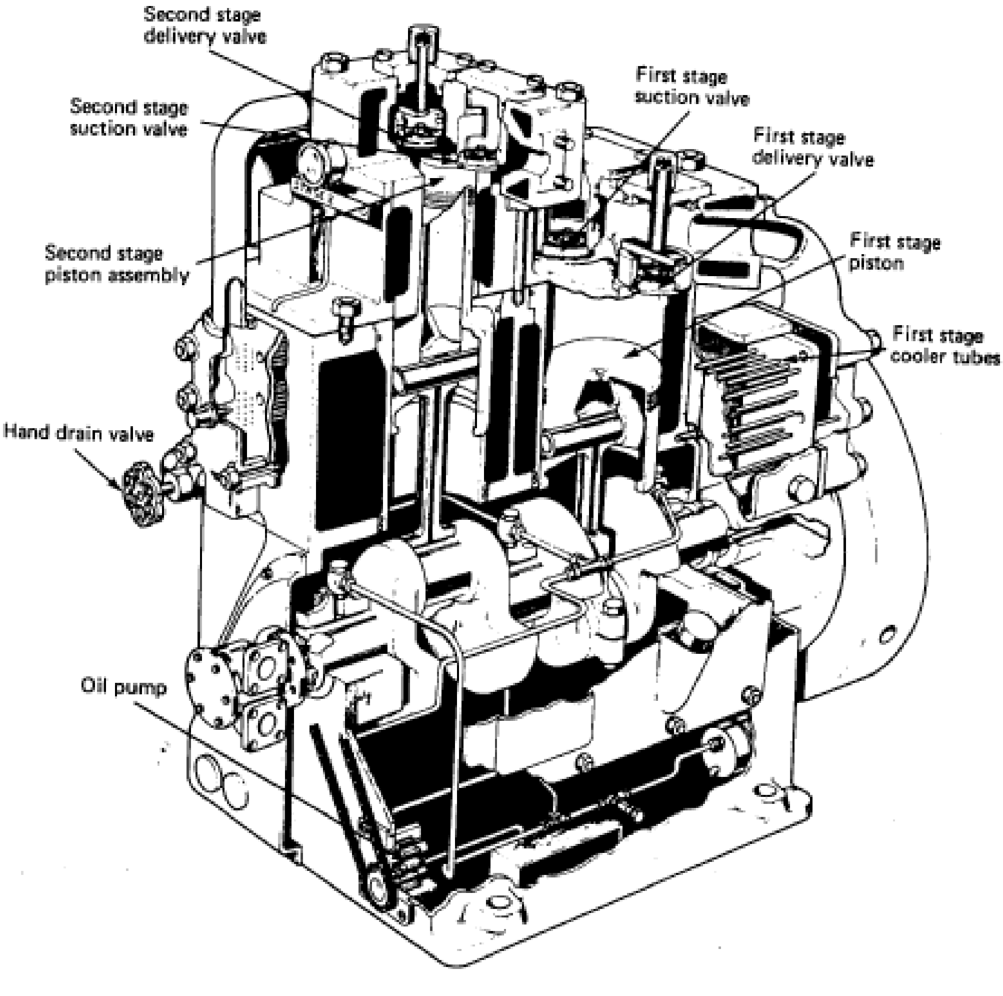
Care should always be taken to fully understand and follow the assembling instructions for the purifier, and simply relying on past experience should be avoided.

IV. Lessons

It is important that running tests are conducted after maintenance or replacement work.



8. Air compressor



Engine accident cases

File No.	8 - 001				
Case name	Damage to TANABE air compressor				
Device name	Air compressor	Damaged part	Piston, etc.	State of damage	Buckling, etc.
Maker name	Tanabe Pneumatic	Model	H237	Total working time	3,837 hours
Kind of ship		Date of occurrence	1992.12.20	Place of occurrence	
Cause of damage/problem	Hardware factor		Nut for low pressure union valve set bolt working loose and coming off		
	Software/human factor		Valve clamping nut left inadvertently left unfit		

I. Outline of accident

[Course of events]

0326 hours on December 20: When the vessel was sailing under 'M0' control, No. 2 auxiliary air compressor tripped as a result of "LO low pressure". (617 hours after the previous maintenance).

1713 hours on December 21 (next day): No. 1 auxiliary air compressor tripped from the same cause. (864 hours after the previous maintenance).

[State of damage]

The following damage was observed in the forward cylinder in No. 2 auxiliary air compressor:

(1) Total loss of the low pressure Suc./Del. Valve;

(2) Piston head hit all over and ring grooves crushed by pressure;

(3) Fracture of the connecting rod; and

(4) Lower part of the cylinder chipped off at two locations.

[Response measures]

The damage state of No. 1 auxiliary air compressor was similar to that of No. 2; and the intact piston together with the cylinder and connecting rod of No. 1 were used to replace the damaged parts of No. 2 in order to make it serviceable.

II. Causes of accident/problems

[Hardware factors]

The accident is attributed to the fact that the nut for the low pressure Suc./Del. Valve set bolt worked loose and, finally, came off.

Although it was not known in the initial investigation, another one conducted at a later date revealed that the valve clamping nut for the purpose of preventing the tightening nut of the set bolt from coming loose, was not fitted.

[Software/human factors]

(1) Crew members involved in the previous maintenance work inadvertently failed to fit the valve clamping nut; they did not wonder, “Won’t the tensioning nut work loose without a valve clamping nut?”

(2) After the occurrence of damage to No. 2 compressor, they did not think, “Is No. 1 compressor free from the same trouble?”

III. Measures to prevent recurrence

[Hardware aspects]

The nut for the low pressure Suc./Del. Valve set bolt shall be properly fitted with a valve clamping nut to prevent it from coming loose.

[Software/human aspects]

(1) In a restoring operation after an overhaul, assemble carefully by referring to the operations manual and drawings.

(2) Unfortunately, if damage has occurred, ensure to identify the cause to prevent a recurrence of the same trouble.

IV. Lessons

No wonder that No. 1 compressor was damaged in succession to No. 2 on board the vessel.

“Similar accidents occur in succession”

“What happened twice will happen three times.”

Take care.

Engine accident cases

File No.	8 - 002				
Case name	Damage to air compressor				
Device name	Air compressor	Damaged part	Piston, etc.	State of damage	Fracture, etc.
Maker name	Tanabe	Model	H-373	Total working time	291/329 hours
Kind of ship	Container ship	Date of occurrence	1991.10.28	Place of occurrence	In standby condition for entering Kaohsiung
Cause of damage/problem	Hardware factor	Drain backflow to high pressure suction side			
	Software/human factor	Insufficient investigation to identify causes of damage			

I. Outline of accident

[Course of events]

(1) On October 28, 1991, when the engine room was put on standby to enter Kaohsiung, No. 1 main air compressor came to a halt in an abnormal condition. An investigation revealed a fracture of No. 2 cylinder connecting rod.

(2) On February 25, 1992, after the above damage was restored, the same compressor stopped in an unusual situation when the vessel was on standby for departure from Tokyo. No. 1 cylinder piston fractured in the skirt below the piston pin and seized all around the sliding surface.

[State of damage]

[Response measures]

The drain line was rearranged.

II. Causes of accident/problems

[Hardware factors]

Since, upon the occurrence of the trouble in October, the piston also seized and the cylinder oil nozzle was clogged, it was attributed to insufficient oiling. However, when the piston fractured, the oil nozzle was normal, following which a further investigation was made and the following facts were found:

The drain piping system of the vessel, which was shared by all compressors, led directly to the waste oil tank. For this reason, the remnant pressure inside the piping system tended to be released less easily. As a result, the drain generated by the auxiliary air compressors, which are usually used, flowed back through the automatic drain trap which is fitted to the intercooler drain pipe for No. 1 main air compressor and located closer to auxiliary compressors, to the high pressure suction side and accumulated there. This presumably caused the cylinder liner, high pressure suction valve, etc. to rust and run short of oil films during operation, resulting in the damage this time.

[Software/human factors]
The initial investigation was insufficient to identify the true cause of the damage.

Ⅲ. Measures to prevent recurrence

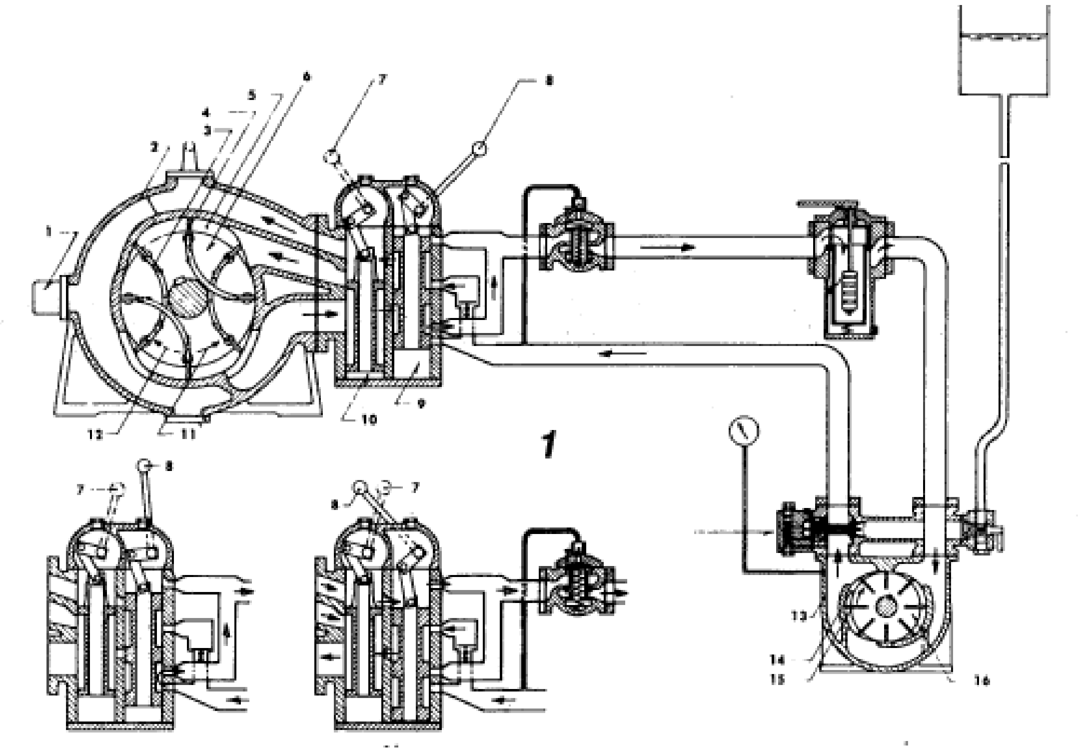
[Hardware aspects]
Concerning newbuildings from now on, we have decided to request each shipbuilder to give sufficient consideration to the piping to handle drains.

[Software/human aspects]
We have disseminated information on this case among the vessels concerned.

Ⅳ. Lessons

Such an accident may occur and a thorough investigation must be made to identify causes to the satisfaction of the person in charge.

9. Deck machinery



File No.	9 - 001				
Case name	Removal and falling of steering gear ram pine bush				
Device name	Steering Gear	Damaged part	Ram Pine Bush	State of damage	Removal/Falling
Maker name	MHI DFT-400	Model		Total working time	2 years
Kind of ship	Tanker	Date of occurrence	1997	Place of occurrence	At sea
Cause of damage/problem	Hardware factor	Excessive vibration or poor fitting			
	Software/human factor	Insufficient che			

Ⅰ. Outline of Accident

[Course of Events]

On a 2 (two) year old crude oil tanker, the 2nd engineer made his rounds for the MO check and found that the RAM-PIN BUSH had dropped out of the steering gear.

[State of Damage]

The ram-pin bush had fallen out.

[Action]

Repair work was carried out by the ship’s hands and completed in 1½ hours.

Ⅱ. Cause of Accident / Underlying Problem

[Mechanical Factors]

The bolt for the lower cover plate was loose because of poor tightening and vibration. This resulted in the anti-loosening wire becoming torn leading to loosening of the bolts, which eventually dropped out. Finally, the ram-pin bush dropped out (see figure below).

Also, the size (diameter) of the anti-loosening wire for the lower cover plate bolts was incorrect (smaller).

[Human/Software Factors]

The MO check spotted the damage before a serious incident occurred

III. Preventive Measures

[Mechanical Aspects]

a) The bolt (material: SCM435) should be tightened by a torque of 16 – 17 kgf-m.

b) Wire 2.0 mm in diameter should be used.

c) The condition of the bolts, wire, ram-pin, and bush should be checked daily.

[Human/Software Aspects]

To regularly carry out thorough MO checks.

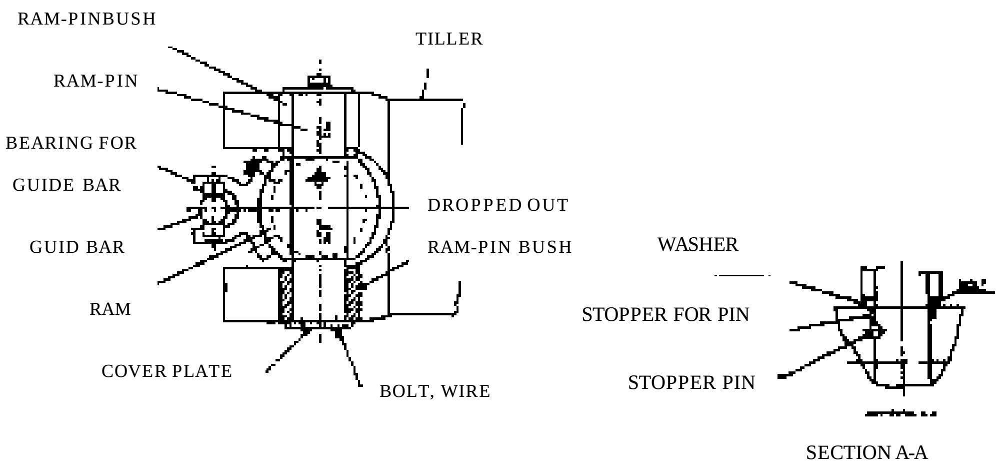
IV. Lessons

Carrying out M0 checks can prevent an accident of this type.

V. Reference

There was a similar case on another vessel that lost the ability to steer.

In this incident, DFT-type steering gear was installed on the container vessel. The bolts that connected the washer to the ram were loose, resulting in an upward force being applied to the RAM-PIN. This led to the bolts for the lower cover plate breaking, the RAM-PIN BUSH falling out, and the RAM-PIN being drawn out upwards. Finally, the vessel lost its steering ability.



Engine accident cases

File No.	9 - 002				
Case name	Fatal burns by steam				
Device name	Sliding type sleeve for on-deck steam pipe	Damaged part	Sleeve	State of damage	Dislocation
Maker name	TAIYO	Model		Total working time	20 years
Kind of ship	BULKER	Date of occurrence		Place of occurrence	At Dock
Cause of damage/problem	Hardware factor	Removal of fixing clamp			
	Software/human factor	Disregard of basic principle of work			

Ⅰ. Outline of Accident

[Course of Event]

In drydock, when a dock worker removed a clamp for fixing an on-deck steam pipe, the pipe came off the sleeve, showering a large amount of steam onto the worker to death.

Ⅱ. Cause of Accident / Underlying Problem

[Mechanical Factor]

The on-deck steam piping was made of a copper alloy and fitted with a U-bend to absorb expansion/shrinkage; and a sleeve type expansion joint was fitted in the middle of the U-bend.

Unfortunately, the steam piping system was in use. It therefore follows that when the worker took off the fixing clamp near the sleeve joint, the pipe came off the sleeve like a spring in no time at all.

[Human/Software Factor]

It is because the worker worked on a pipe line with steam flowing inside.

Ⅲ. Preventive Measures

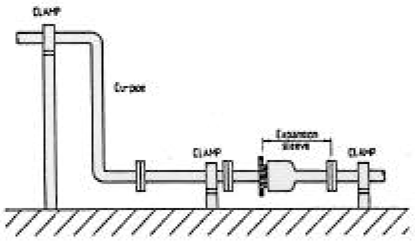
[Human/Software Aspect]

Never carry out maintenance work on steam pipes or joints still with pressure.

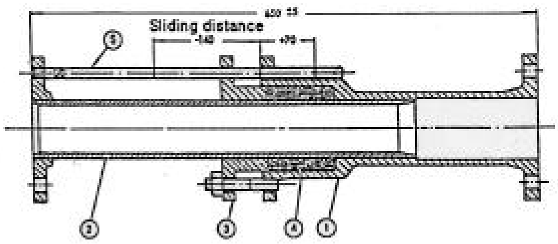
Nearly no sleeve type expansion joints are of a rupture-free structure and, for this reason, it is currently necessary to secure them properly to keep them in position.

Ⅳ. Lessons

Before starting operations, hold a sufficient conference to ensure work safety.



Steam Pipe Line on Deck



Sleeve Expansion Box (Bronze)

① Expansion box housing
② Expansion box sliding tube
③ Packing gland
④ Packing
⑤ Position indicator

Engine accident cases

File No.	9 - 003				
Case name	Damage of windlass pinion gear bushes				
Device name	Windlass	Damaged part	Pinion gear bushes	State of damage	Wear down
Maker name	Yutani Heavy Industries Co., Ltd.	Model		Total working time	7 years
Kind of ship	VLCC	Date of occurrence	1993.08.18	Place of occurrence	S/B for mooring
Cause of damage/problem	Hardware factor	Insufficient greasing			
	Software/human factor	Insufficient maintenance			

Ⅰ. Outline of Accident

[Course of Event]

During a mooring operation, the bush for the starboard windlass pinion gear was found having bulged at the end of the coupling, with many cracks on the surface.

When the windlass shaft was rotated for inspection without load, with the pinion gears disengaged, it was discovered that there were some bushes rotating together with the shaft.

[State of Damage]

Since the shaft and the bushes seized as a result of overheating, the pinion gear and bushes were slipping.

[Disposition]

New bushes for the pinion gears were manufactured and loaded on board the vessel. Two service engineers from the shipyard stayed on board during a leg from Japan to Singapore to replace the bushes of the windlasses on both sides.

(1) Each surface of the pinion gear where it came in contact with the bush was rough because of corrosion near the coupling end. It was corrected with hand tools since the work prohibited the use of a lathe. The shaft was also rectified in the same manner.

(2) The (oversized) bush for the pinion gear was worked on by use of the lathe of the vessel, with an allowance for shrinkage fit of 5/100 to 10/100 mm.

(3) Each bush which had been kept cold in a refrigerator was struck into each pinion gear which was heated.

(4) The bushes were provided with set bolts to prevent them from rotating.

Ⅱ. Cause of Accident / Underlying Problem

[Mechanical Factor]

An inspection after an overhaul revealed that the bushes at the coupling ends of respective windlasses ran short of grease, suggesting that the bushes seized by overheating as a result of insufficient application of grease.

[Human/Software Factor]

This incident is a typical case of damage to equipment which arose from insufficient provision of grease.

Mooring facilities on deck are placed in an environment likely to lead to a lubricant shortage and rusting; and, in addition, various parts are subjected to heavy loads and, therefore, a shortage of lubricant in the mating surface of a bush and the like, is thought to result in immediate seizure.

Ⅲ. Preventive Measures

[Human/Software]

(1) Every time on-deck machines are operated, ensure to check their operating conditions.

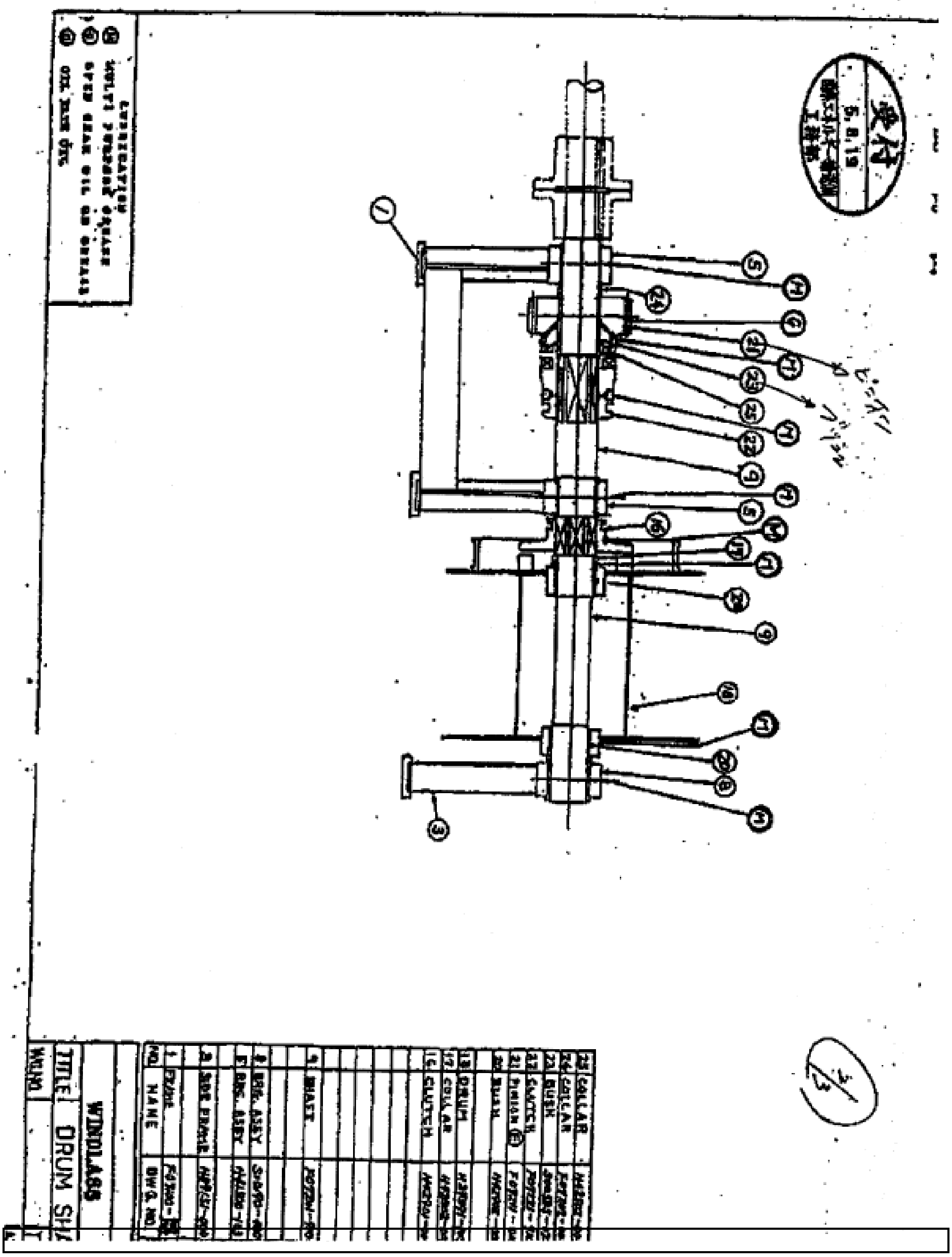
(2) When applying grease and other lubricants, ensure that the lubricant has reached the far end of the intended part.

(3) Apply a necessary amount of lubricants at proper intervals.

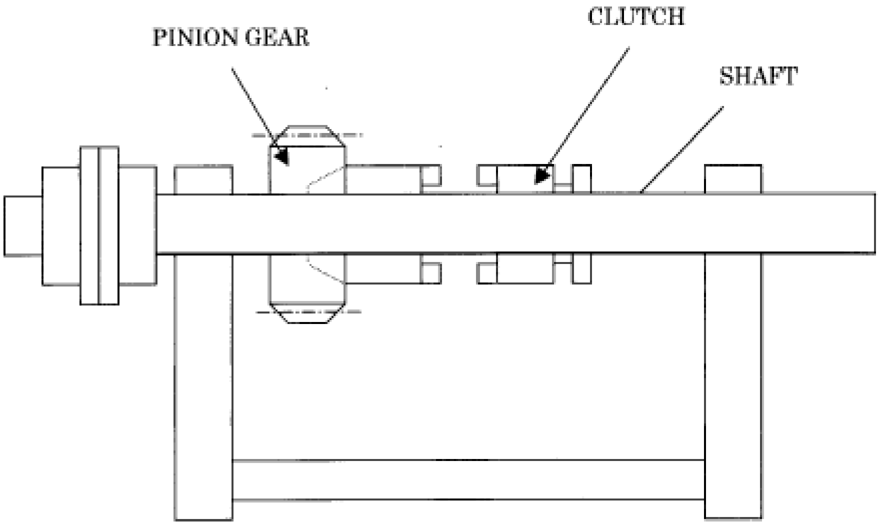
(4) Review lubricant application locations and ensure that no location has been omitted.

Ⅳ. Lessons

Repair work on hull machinery often proves to be major work as in this case. Furthermore, when such work is carried out at sea, it is required to set up sheer legs or prepare a post because there is no proper place to hang a chain block from. You must pay attention to maintenance of deck machine because it is possible that the damage by such a insufficient maintenance is occurred on the deck.



LUBRICATION
MULTI PURPOSE GREASE
OPEN GEAR OIL OR GREASE
OIL BATH ETC.
5.8.19
25 COLLAR
24 COLLAR
23 BUSH
22 CLUTCH
21 PINION
20 BUSH
18 DRUM
17 COLLAR
16 CLUTCH
9 SHAFT
8 BRG. ASSY
5 BRG. ASSY
3 SIDE FRAME
1 FRAME
NO. NAME DWG. NO.
WINDLASS
TITLE DRUM SH



WINDLASS PINION GEAR, SHAFT, CLUTCH

Engine accident cases

File No.	9 - 004				
Case name	Mooring winch shaft put off center, resulting from distortion of support brackets				
Device name	Mooring winch	Damaged part	Support brackets	State of damage	Distortion by wastage
Maker name	Fukushima, Ltd.	Model	MW 15Tx15m	Total working time	21 years after built
Kind of ship		Date of occurrence	1993.06.17	Place of occurrence	While berthing alongside in Keelung
Cause of damage/problem	Hardware factor	Corrosion and reduction in thickness through years of use			
	Software/human factor	Improper inspection and maintenance			

I. Outline of accident

[Course of events]

When a mooring winch was operated to heave in a hawser, the brackets of the winch (support leg) distorted inward, displacing the wheel shaft bearing section about 50 mm downward.

[State of damage]

[Response measures]

The distorted bracket leg was corrected by using a hydraulic jack and strengthened with steel plates (12 mm).

The bracket wall section, which was excessively corroded, was removed and strengthened with five angle bars.

When other winches were also checked, the bracket wall of each one was found extremely corroded and was strengthened with angle bars.

II. Causes of accident/problems

[Hardware factors]

The steel members forming the bracket leg and wall section grew thinner, losing its strength to support the bearing section.

When the hawser was hauled in, the bracket wall broke down because of the tensile load on the hawser, deforming the bracket leg and, as a result, displacing the shaft at the bearing section off center.

[Software/human factors]

This incident is a case attributed to corrosion, typically to old vessels, and can be said to be a damage case which occurred at a place likely to be neglected in usual inspection and maintenance.

The allowable reduction in thickness of a structural member by corrosion is 10 to 20% of the original thickness, depending on the part of the member, and there is a need to strengthen it, as necessary.

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

Machinery, such as mooring winches, installed on deck are in an environment particularly conducive to corrosion and are subjected to significant forces; and it, therefore, follows that on board old vessels, such machinery requires checks for soundness in terms of strength, in addition to general maintenance.

IV. Lessons

Even in the case of old vessels, the functions of each device are required to be the same as on board new vessels. The strength of a machine should also be such that it enables the device to perform its functions.

Old vessels naturally undergo deterioration through years of use but they must maintain the functions of their respective facilities.

Engine accident cases

File No.	9 - 005				
Case name	Fall of lifeboat during drill				
Device name	Lifeboat	Damaged part	Winch brake	State of damage	Fracture resulting from corrosion
Maker name	Tsuji Sangyo	Model	OAP-H	Total working time	10 years after built
Kind of ship		Date of occurrence		Place of occurrence	At sea
Cause of damage/problem	Hardware factor	Deterioration of "O" ring			
	Software/human factor	Poor inspection and maintenance			

I. Outline of accident

[Course of events]

(1) During a lifeboat drill at sea, the brake of a boat winch became ineffective shortly after the boat began to be lowered and, as a result, the boat fell down into the sea.

(2) The main engine was immediately stopped, but because of the ship's head way the boat was dragged, with the boat falls having run out to their end on the drum. This caused the cradle of the boat davit to bend, disabling the davit to hoist up the boat. For this reason, the boat was recovered by using a cargo winch installed in the midship section of the vessel.

Fortunately, the accident did not involve any personal injury since no one was in the boat when it occurred.

[State of damage]

[Response measures]

II. Causes of accident/problems

[Hardware factors]

A large amount of water was detected inside the gear case attached to the air motor. On the basis of this fact, it can be presumed that the "O" ring provided in the section of the gear case for attaching the air motor deteriorated, allowing rain water to enter inside and to cause a fracture of the brake band of the hand brake, which finally resulted in the accident in question.

[Software/human factors]

III. Measures to prevent recurrence

[Hardware aspects]

There is no need to highlight the importance of regular efforts to check lube oil inside the gear case and inspect the gear and brake sections on board vessels equipped with davits of the same type. In view of the seriousness of an accident of this kind, it is essential to regularly inspect and maintain davits of other types at all times.

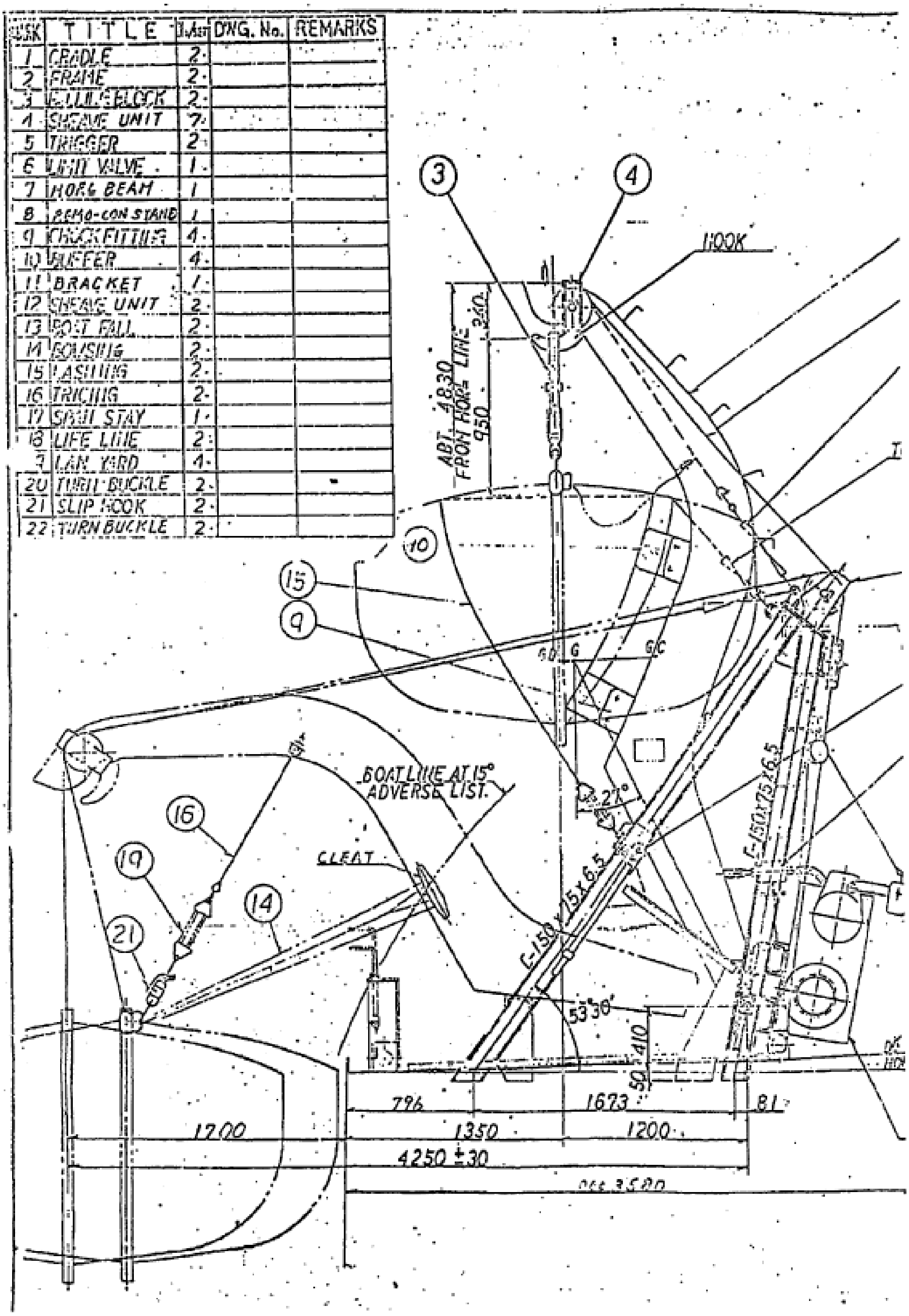
[Software/human aspects]

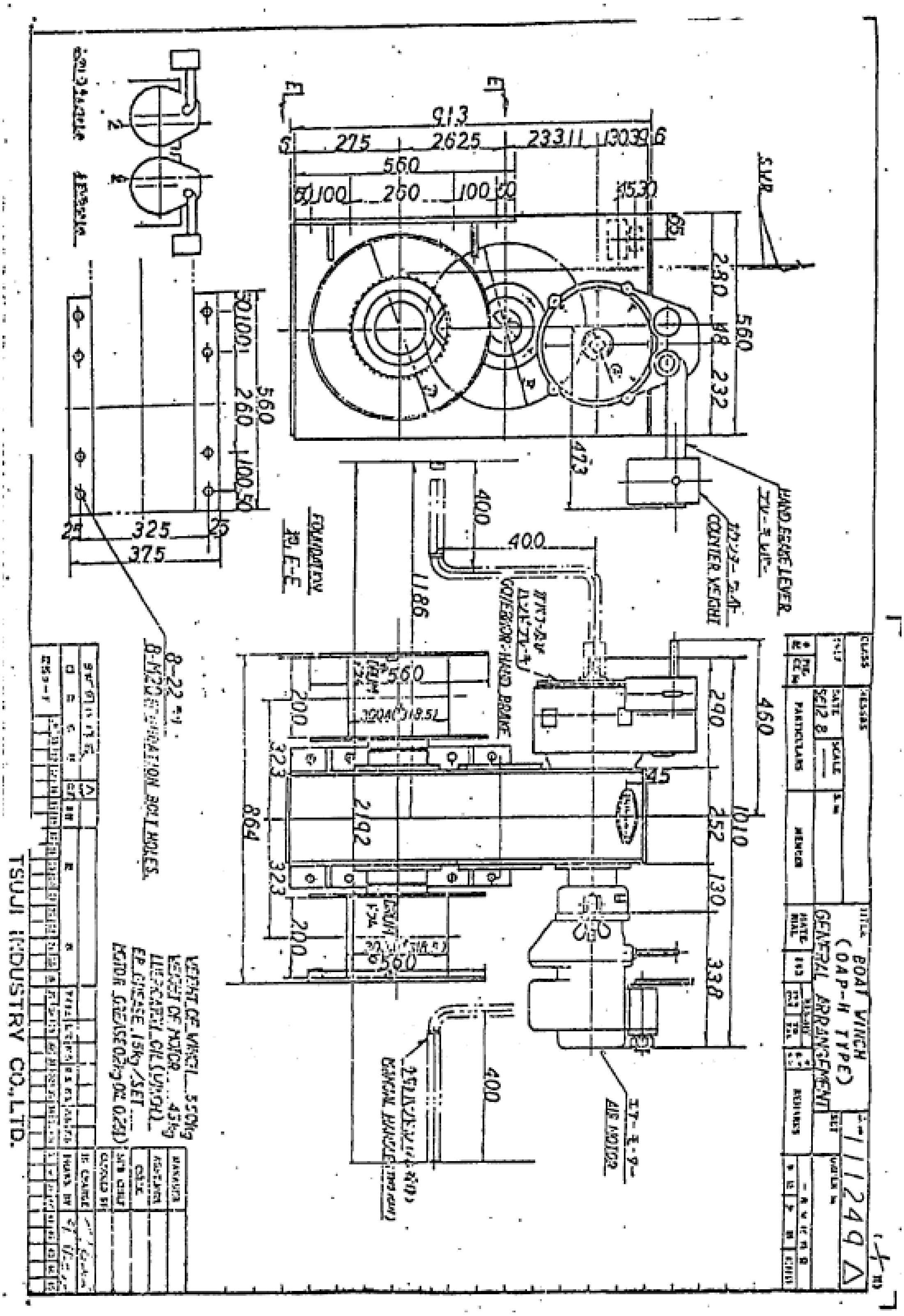
With the fact in mind that devices installed on deck are liable to undergo ingress of water, regular inspection must be carried out.

IV. Lessons

Inspect devices before use. This is a basic matter.

MARK	TITLE	Q'TY	DWG. No.	REMARKS
1	CRADLE	2		
2	FRAME	2		
3	[illegible] BLOCK	2		
4	SHEAVE UNIT	2		
5	TRIGGER	2		
6	LIMIT VALVE	1		
7	HORI. BEAM	1		
8	REMO-CON STAND	1		
9	CHOCK FITTING	4		
10	BUFFER	4		
11	BRACKET	1		
12	SHEAVE UNIT	2		
13	BOAT FALL	2		
14	BOWSING	2		
15	LASHING	2		
16	TRICING	2		
17	SPAN STAY	1		
18	LIFE LINE	2		
19	LAN YARD	4		
20	TURN BUCKLE	2		
21	SLIP HOOK	2		
22	TURN BUCKLE	2		




BOAT WINCH
(OAP-H TYPE)
GENERAL ARRANGEMENT
TSUJI INDUSTRY CO.,LTD.

File No.	9 - 006				
Case name	Failure of steam windlass to heave up anchor				
Device name	Windlass	Damaged part		State of damage	
Maker name	Tokyo Kikai	Model	Horizontal sliding type	Total working time	
Kind of ship	VLCC	Date of occurrence	1987.06.10	Place of occurrence	Outside Mina al Fahal
Cause of damage/problem	Hardware factor	Loosened slide valve adjusting rod lock			
	Software/human factor	Poor maintenance			

I. Outline of accident

[Course of events]

No. 1 windlass started to heave up the anchor, it became unstable and stopped soon. Attempts were made to operate it under no load, but its operation remained unstable.

[State of damage]

The operation to heave up the anchor was suspended and various parts inspected. The inspection results suggested the malfunction of the slide valve. When the gear case sight hole and cylinder cover of the slide valve were opened up, it was found that the slide valve rod on the port side had worked loose and that there was excessive play between the port and starboard slide valves and the rod connecting section.

[Response measures]

(1) As a first-aid measure, only the stroke of the slide valve on the port side was adjusted to raise the anchor.

(2) After departure from the port, a piece was made and inserted to the worn out section of the boss of the slide valve and the strokes of the port and starboard slide valves were adjusted.

(3) When No. 2 windlass was also inspected, the wear of the boss section was found in the same way as No. 1, but the slide valve rod was not loose.

II. Causes of accident/problems

[Hardware factors]

The failure to raise the anchor is the fact that the adjusting rod lock nut for the port side slide valve worked loose, resulting in change of the stroke, which hampered smooth reciprocating movement.

The loosened lock nut is possibly attributed to its insufficient tightening or vibration; and the abnormal weardown of the slide valve boss to deterioration over years of use.

[Software/human factors]
Lack of regular inspection and maintenance.

III. Measures to prevent recurrence

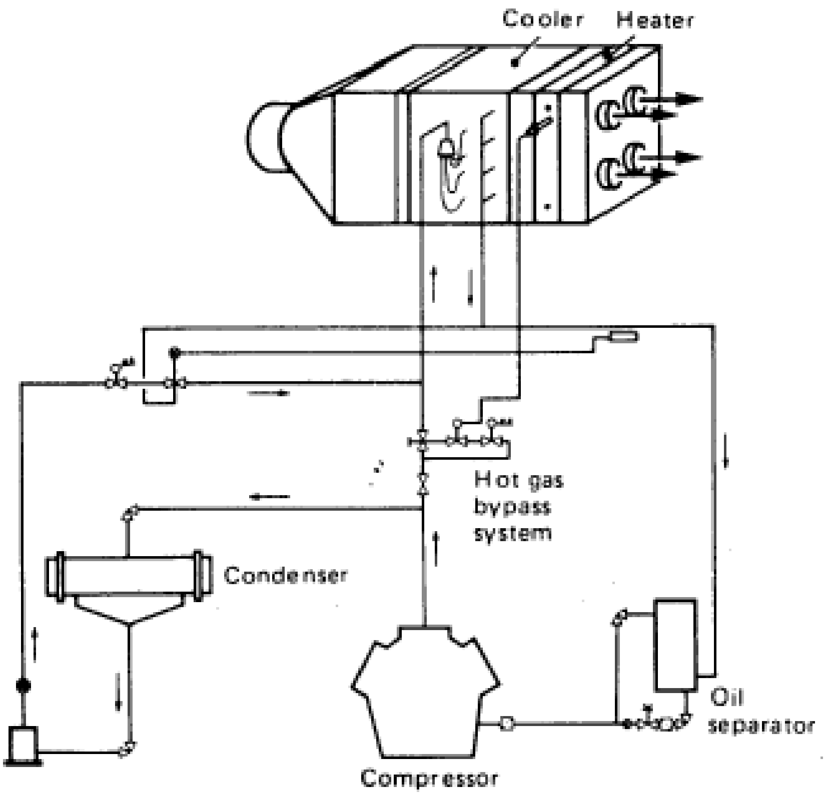
[Hardware aspects]

[Software/human aspects]
Inspection and maintenance work should be regularly performed.

IV. Lessons

The trouble of a windlass will immediately lead to the obstruction of the ship's operation. It is a critical device.

10. Fan



Cooler
Heater
Hot gas
bypass
system
Condenser
Oil
separator
Compressor

File No.	10 - 001				
Case name	Burnout of central unit fan motor				
Device name	Unit fan motor	Damaged part	Stator coil	State of damage	Burnout
Maker name	Taiyo Electric Co., Ltd.	Model	IT-180M	Total working time	
Kind of ship	VLCC	Date of occurrence	1987.06.12	Place of occurrence	On standby for entering Sharjah
Cause of damage/problem	Hardware factor	Entry of water into motor			
	Software/human factor	Incapacity to discharge drain from bottom of unit			

I. Outline of accident

[Course of events]

When the vessel was under a standby condition to enter the port, the refrigerating machine for the air conditioner tripped. An inspection revealed that the non fuse circuit breaker for the accommodation fan on the main switchboard was OFF, showing that it was actuated by an interlock with a stop of the central unit fan.

[State of damage]

(1) The insulation resistance of the stator dropped to 0.2 M ohm, but no trace of burnout was observed on the outer surface. It was cleaned with a cleaning agent and dried to recover its resistance up to 70 M ohm, but when it was operated again, the NFB was turned OFF. It is considered to have burned out internally.

(2) Water found its way into the motor, showing rust.

(3) Deterioration of the ball bearing.

[Response measures]

The damper for the central unit, which connects air ducts on both sides, was opened and cold draft was sent to both sides for air conditioning by use of one unit of fan, with the interlock with the broken fan bypassed.

II. Causes of accident/problems

[Hardware factors]

The thermotanks of the central unit in question had two drain pipelines, respectively. Inspection revealed that plugs for draining the pipes were removed but U-shape seal pipe (40A) was clogged, resulting accumulation of water such a level as the tip of the sirroco fan started splashing. As a result, water entered inside the motor through the motor shaft penetrated the bearing cover.

[Software/human factors]

The trouble occurred since the clogged drain pipe was left unattended.

It is often the case that the drains of the unit cooler get choked as a result of an accumulation of rust. It must be ensured daily that drains are clear.

III. Measures to prevent recurrence

[Hardware aspects]

A vinyl hose for draining was fitted between the unit and the U-shaped seal pipe to make the discharge of drain easily noticeable.

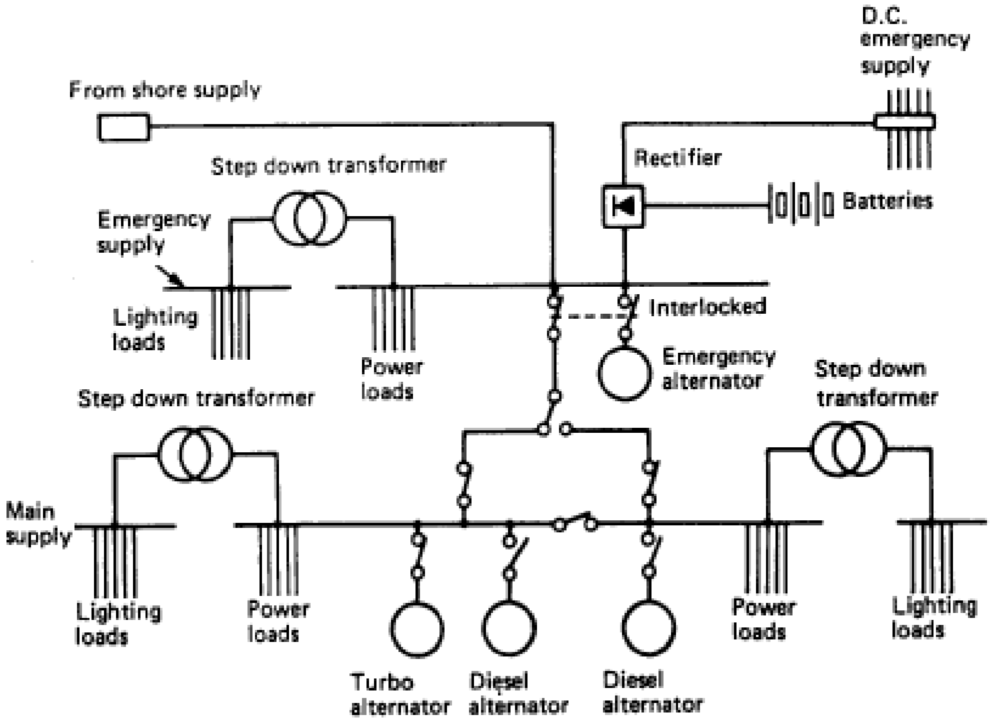
[Software/human aspects]

A check should be made to confirm no rust is accumulated inside the unit.

IV. Lessons

This type of trouble has often occurred.

11. Electrical equipment



Engine Trouble Cases

File No.	11 - 001				
Case name	Damage to generator engine caused by megger test				
Device name	Generator engine	Damaged part	Crankshaft, etc.	State of damage	Cracks
Maker name	Yanmar	Model	T240L-ST	Total working time	5 years after built
Kind of ship		Date of occurrence		Place of occurrence	
Cause of damage/problem	Hardware factor	Malfunction of plunger shaft for fuel rack			
	Software/human factor	Disregard of operational basics			

I. Outline of accident

[Course of events]

A crew member disconnected one of the electric wire cables of No. 3 generator engine control circuit in order to check the 24V battery line for grounding, when No. 3 D/G started by itself suddenly and kept running at a maximum fuel feed rate. The engine became uncontrollable and was stopped finally after closing fuel valves.

[State of damage]

(1) No. 2, 3, 4, 6 and 7 main bearings were damaged;

(2) No. 2, 3, 4 and 5 crank pin bearings were damaged; and

(3) The main bearing journal was cracked.

[Response measures]

II. Causes of accident/problems

[Hardware factors]

The accident is attributed, as a proximate cause, to the seizure of the fuel oil injection pump rack, but the underlying cause lies in the inadequate procedures followed by the crew member in the electrical work.

[Software/human factors]

The line in question should have been isolated before disconnecting.

The fuel handle lever should have been set in the stop position and the starting air valve securely closed.

The vessel experienced the same trouble with No. 3 D/G before and proper measures should have been taken at the occurrence of the first trouble.

When taking into consideration the fact that the vessel experienced a similar accident before, we wonder why wasn't the lesson learned and the fault rectified before it was put in use? From among a large number of similar minor incidents, serious accidents develop only when they are, unfortunately, combined with other factors. This tells us that it is vital to take measures as far as possible to prevent a recurrence of even minor incidents.

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

IV. Lessons

File No.	11 - 002				
Case name	Accident involving death during maintenance work on elevator				
Device name	Elevator	Damaged part		State of damage	
Maker name		Model		Total working time	
Kind of ship	Bulker	Date of occurrence	1999.09.04	Place of occurrence	At sea
Cause of damage/problem	Hardware factor				
	Software/human factor	Disregard of basic operations in maintenance			

I. Outline of accident

[Course of events]

At 1320 hours on September 4, the third engineer, who was in charge of elevator maintenance, was performing regular inspection and maintenance work on the elevator together with a wiper.

The elevator suddenly moved up from the third floor when the third engineer was in the elevator trunk and, as a result, he was caught between the cage and the second deck floor entrance step. He was found severely injured with a very weak pulse and respiration.

He was treated on board according to radio medical advice from a shore medical center. The vessel deviated from her original course and arrived at the nearest port at 2240 hours the same day. The doctor declared him dead.

[State of damage]

[Response measures]

II. Causes of accident/problems

[Hardware factors]

[Software/human factors]

The third engineer was briefed beforehand by the first engineer on the procedures of elevator maintenance in accordance with the maker's operating manual. At a meeting held on the morning prior to the work, each procedure such as the way to go up to the top of the elevator, the way of manual operation, was confirmed again. In addition, the third engineer was specifically instructed by the first engineer in the maintenance procedures on site. The first engineer considered the third engineer sufficiently mastered the maintenance procedures and might do the job well by himself. He left the remaining job to him.

But contrary to the first engineer's expectation, he did it in the utterly different way to reach the top of the elevator cage. After posting warning plates saying, "DON'T USE", at the elevator entrance on every floor, he and a wiper brought the elevator to the engine room third floor. The third engineer ordered the wiper to stay in the elevator at the third floor while he opened the second floor elevator outer door with a special tool. He went down into the elevator trunk in order to reach the elevator cage top, just when the elevator started moving. Immediately after that, the wiper then pushed the "emergency stop switch", but the third engineer, who was caught between the cage and the second floor ladder, was later removed from there and found almost dying.

The reason elevator started suddenly is not identified though it is apparent that he did not act properly according to the manual. In the manual, it is described clearly that one must go up to the cage top through the emergency escape door after actuating the "emergency stop switch".

This accident could have been avoided if the third engineer had thoroughly read the relevant manual and understood why such procedures should be followed. Only if he had understood the sequence of the electric circuit, this could have been prevented.

In order to go to the elevator cage top safely and make ready for maintenance, he should have observed the following procedures:

(1) Push the "emergency stop button" first;
(2) Go up to the cage top through the emergency escape door;
(3) Changeover the "Manual-Auto" switch on the cage top to "Manual";
(4) Reset the "emergency stop button".

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

For the purpose of preventing similar accidents involving personal injury in elevator maintenance work, you are requested to ensure that the necessary safety measures are taken as follows:

(1) Provide crew detailed and adequate information regarding the machinery when inspection/maintenance is planned, and let them fully understand each procedure;
(2) Hold a prior meeting and ensure:
    a) To inform the bridge and all crew members clearly that the use of the elevator is banned during maintenance work;
    b) To wear necessary protective equipment;

c) To keep communications during the work;

d) To follow inspection/maintenance procedures;

(3) Make sure that the maintenance team comprises of more than one person;

(4) Make and prepare the checklist for not only inspection check point for changeover procedure of "Auto-Manual" operations before and after inspection;

(5) Announce and post a warning notice of "Maintenance in progress – Don't use" at every elevator entrance so that no one may use inadvertently;

(6) Cancel the "Home Landing" function beforehand;

(7) For access to the operation panel on the cage top for maintenance:

a) Push the emergency stop button;

b) Go up to the cage top from the inside of the cage through the emergency escape door;

c) Turn the "Auto-Manual" changeover switch to "Manual";

d) Reset the emergency stop button.

Ⅳ. Lessons

Engineers should be timid in a sense. They are required to consider all possibilities and be timid (cautious) about everything, always thinking, "Does this lead to a dangerous situation?" This applies to engine operations, which may result in accidents involving personal injuries.

Engine Trouble Cases

File No.	11 - 003				
Case name	Damage to emergency switchboard				
Device name	Emergency switch board	Damaged part	Entire switchboard	State of damage	Inundation
Maker name		Model		Total working time	7.6 years after built
Kind of ship	Woodchip carrier	Date of occurrence	1998.07.07	Place of occurrence	At sea
Cause of damage/problem	Hardware factor	Inundation			
	Software/human factor	Insufficient preparation for rough weather			

I. Outline of accident

[Course of events]

The vessel encountered rough seas en route to Durban. Sea water found its way into the emergency generator engine room located on the port side of the mooring deck below the aft upper deck. The emergency switchboard and transformer installed inside the room lost their functions, as they got drenched, disabling electric supply to such instruments as gyro compass, radar sets and GPS receiver. Their power was supplied through the switchboard.

[State of damage]

When the emergency generator room was inspected, the room was flooded with water of 5 to 10 cm, with sparks observed from the transformer.

[Response measures]

(1) Crew members discharged the water found inside and made attempts to dry up the wet equipment but failed completely to restore the grounded condition.

(2) They improvised emergency wiring from the light distributor for such equipment as GPS and NAVTEX receivers; and the operation of the main engine was continued by local control.

(3) On July 9, a contractor, dispatched to the vessel at Durban, removed the relevant wetted parts and, after washing and drying them, they temporarily restored the equipment. Power supply through the emergency switchboard became possible, but the closing of the air circuit breaker was only possible by manual operation.

(4) The equipment was permanently repaired at Nagoya on August 4.

II. Causes of accident/problems

[Hardware factors]

The layout of the relevant equipment and the structure of the air vent are as the attached figures show.
The emergency generator room of the vessel is equipped with a Venetian-type opening for ventilation, looking out to the sea, and the latter was fitted with a shield plate on its other side facing the inside of the room to protect such equipment as transformer and emergency switch board against direct splashes of seawater. The shield plate is fitted on the cargo hold bulkhead in the forward part of the emergency generator room and the frame is penetrated with a scallop hole (hole made for the convenience of welding such penetrating portions; such holes may sometimes be left as they are for their use as drain holes but they are generally closed thereafter) left open.
A drain hole is provided in the lower portion of the shield plate box and drains a small amount of water coming in, but it cannot handle a large amount of water coming in at one time and such water finds its way into the room through the scallop hole.
In addition, the emergency generator room is provided, as a draining device, with only a drain plug of 16A in the port aft part and, the switchboard and transformer seem to have got wet by the motion of the seawater which found its way into the emergency generator room (5 to 10 cm deep).

[Software/human factors]
This accident is attributed to a mistake by the shipbuilder of neglecting to close the scallop, which is a rare case, but when the importance of the emergency switch board and the power supplying system is taken into consideration, it is vital to check and address locations, including scallop holes, which have a potential of ingress of seawater.
Since the vessel was already 7.6 years old when the accident occurred, it is suspected that there were cases of slight seawater ingress in the past. If investigations had been made to identify causes from such slight signs, we consider that the recent accident could have possibly been prevented beforehand.

III. Measures to prevent recurrence

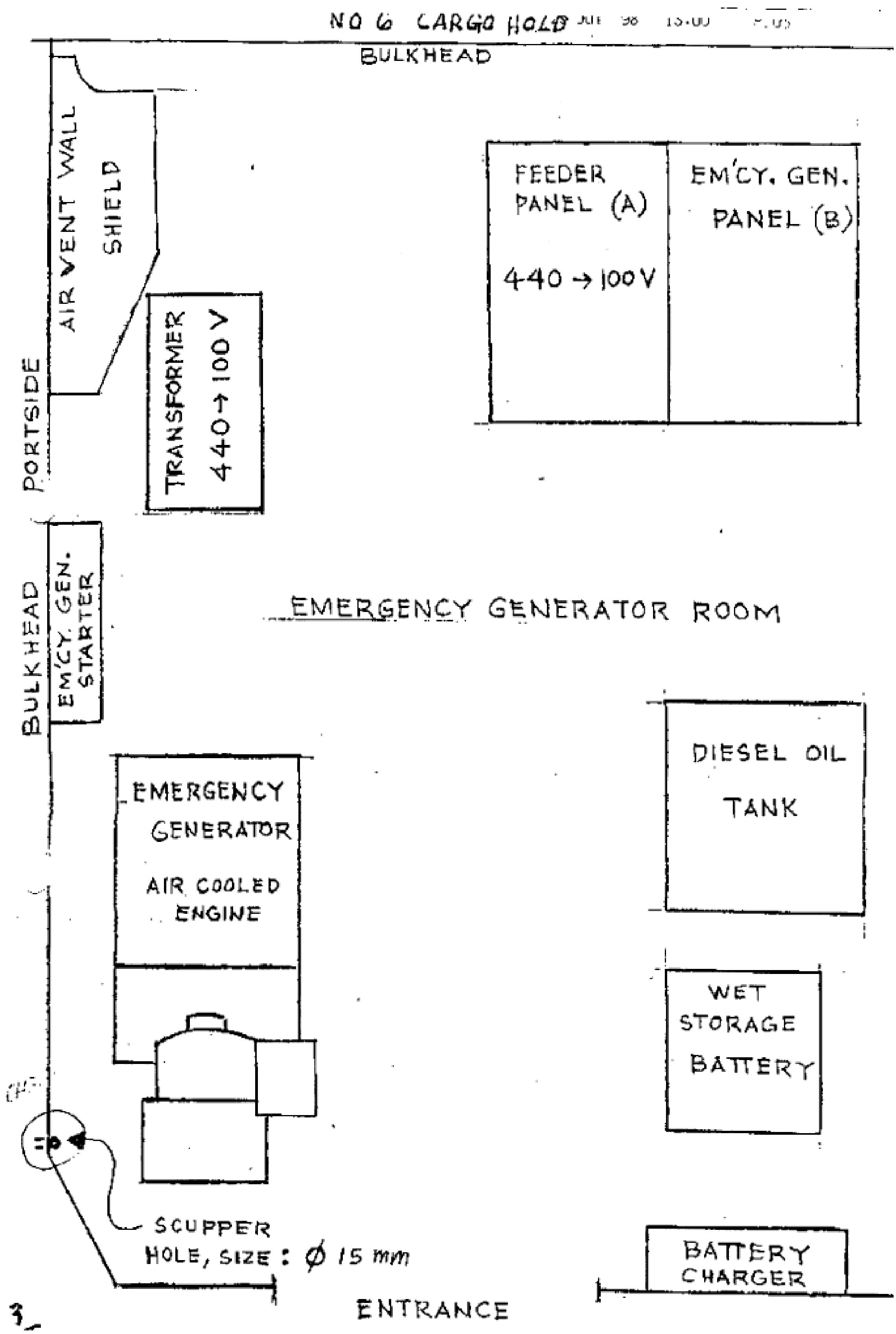
[Hardware aspects]
(1) A sliding-type shield cover was fitted to the wall venetian from outside.
(2) Another drain hole was provided in the lower portion of the wall venetian.
(3) A thin plate was welded to cover the scallop hole.

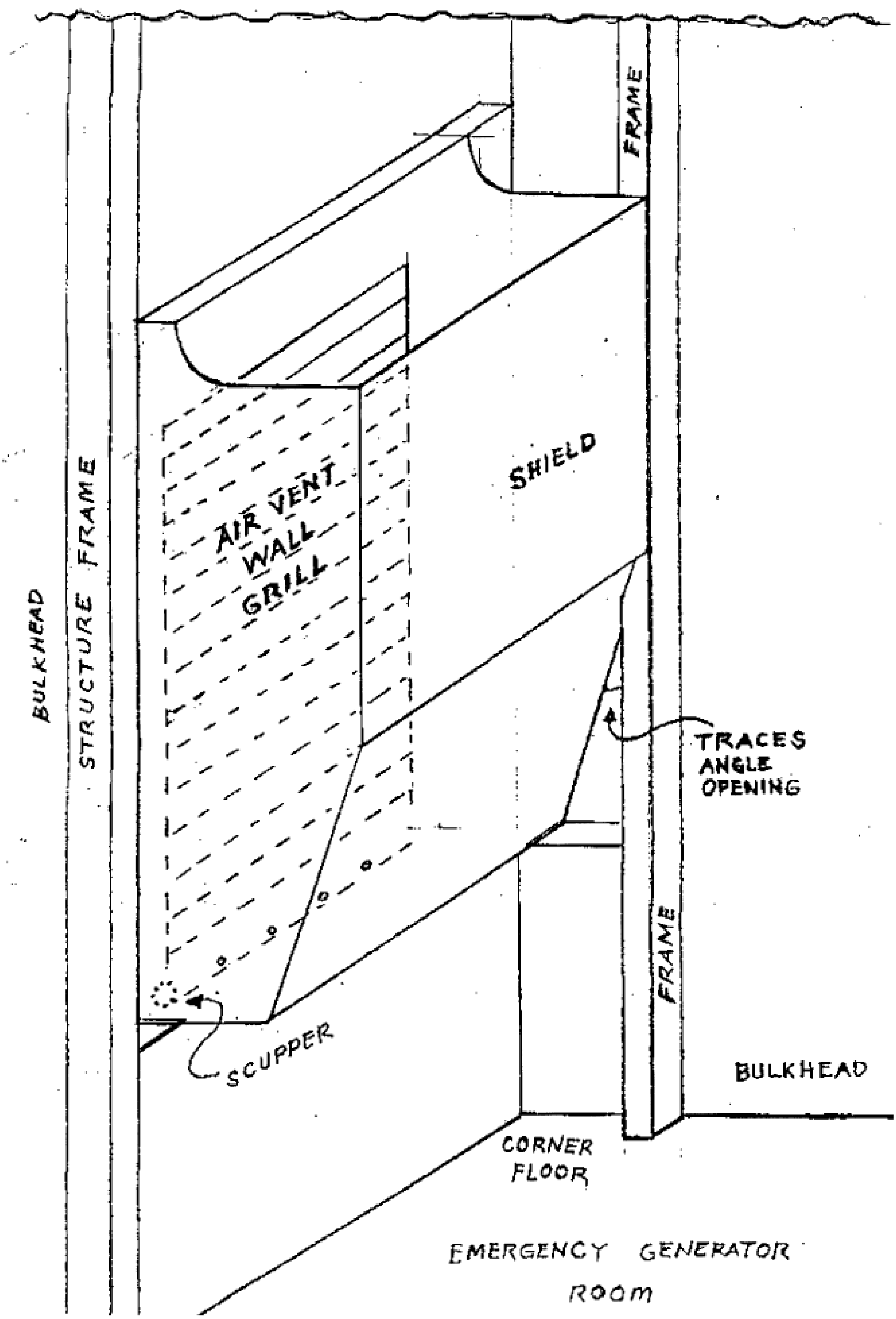
[Software/human aspects]
When making preparation for rough weather, you are required to take measures so that

such measures are adequate to prevent possible damage from heavy seas but they do not interfere with the functions of the devices affected. As to the emergency generator room, it is a difficult job to meet the dual purpose of supplying air to the engine and preventing the ingress of sea water at the same time. There is a need to devise a method based on the special circumstances of each vessel.

IV. Lessons

Ventilation for the emergency generator engine room requires special consideration.


NO 6 CARGO HOLD
BULKHEAD
AIR VENT WALL
SHIELD
PORTSIDE
BULKHEAD
TRANSFORMER
440→100 V
FEEDER
PANEL (A)
440 → 100V
EM'CY. GEN.
PANEL (B)
EM'CY. GEN.
STARTER
EMERGENCY GENERATOR ROOM
EMERGENCY
GENERATOR
AIR COOLED
ENGINE
DIESEL OIL
TANK
WET
STORAGE
BATTERY
SCUPPER
HOLE, SIZE : ∅ 15 mm
BATTERY
CHARGER
ENTRANCE


FRAME
BULKHEAD
STRUCTURE FRAME
AIR VENT WALL GRILL
SHIELD
TRACES ANGLE OPENING
SCUPPER
FRAME
BULKHEAD
CORNER FLOOR
EMERGENCY GENERATOR ROOM

Engine Trouble Cases

File No.	11 - 004				
Case name	Damaged tachogenerator for main engine control console				
Device name	Control console	Damaged part	Tachogene-rator	State of damage	Insufficient output
Maker name	Sanyo Denki Co.	Model	GTY	Total working time	30,000 hours
Kind of ship	Container ship	Date of occurrence	1987.01.02	Place of occurrence	Under 'M0' control at sea
Cause of damage/problem	Hardware factor	Deterioration of bearing over years of use			
	Software/human factor	Poor maintenance			

I. Outline of accident

[Course of events]

From around December 27, 1986, a slight vibration of the tachometer came to the notice of the operator. When he was paying attention to the BMS (bridge maneuvering system) tachometer, the starboard engine repeated starts and stops while sounding the start failure alarm. Since regardless of the revolution, the BMS tachometer showed '0', suggesting damage to the tachogenerator, the operator changed over from the 'Master Bridge' mode to the 'Individual' mode.

[State of damage]

[Response measures]

(1) The tachometer in front of the handle was provisionally set close to the BMS to show the actual revolution on the BMS side.

(2) The control mode was changed over to 'Master Bridge Control' to enter Tacoma, placing the revolution detecting switch of the BMS to 'Test' and manually sending pseudo signals of rpm.

(3) The damage extended to the brush holder and the bearing support, a situation where it was impossible to repair the tachometer only by replacing some parts. Since, fortunately, a spare stator section was on board, the commutator in use was machined and fitted in position. The tachometer was found usable after it was checked that the commutator generated a voltage in response to its rpm when it was rotated with a lathe.

(4) However, it did not develop the regular voltage and it was replaced with a fully outfitted one supplied in Japan.

II. Causes of accident/problems

[Hardware factors]

Deterioration of the bearing for the direct current generator over years of use.

[Software/human factors]
Poor maintenance.

III. Measures to prevent recurrence

[Hardware aspects]
Regular maintenance should be provided.

[Software/human aspects]
Vessels have many machines and devices which require maintenance, or rather, you should think that all the shipboard machinery needs some sort of maintenance. It is vital to review everything once again and newly prepare a maintenance plan.

IV. Lessons

Poor maintenance of a trivial thing might lead to the impediment of the operation of your vessel.

Engine Trouble Cases

File No.	11 - 005				
Case name	Flooding of bow thruster room				
Device name	Bowthruster	Damaged part	Blade angle followup transmitter	State of damage	Inundation
Maker name	MHI Yokohama	Model	SP-1200/AS	Total working time	
Kind of ship	Container ship	Date of occurrence	1988.03.30	Place of occurrence	On standby for sailing out from Bremen
Cause of damage/problem	Hardware factor	Holed air vent pipe for ballast tank			
	Software/human factor	Poor maintenance			

I. Outline of accident

[Course of events]

Upon departure from Bremen the bowthruster did not start. Upon inspection, it was found that the void space below the bed on which the driving electric motor was mounted was flooded. An operation to discharge the space was immediately started and it was found that following were submerged, the extension shaft below the electric motor coupling, watertight packing bearing, flexible coupling, blade angle followup transmitter and wiring cables.

[State of damage]

Inspection revealed after discharging water, defective insulation of the blade angle followup transmitter containing a synchrometer, potentiometer, and micro switch.

[Response measures]

The inundated section was washed with fresh water and the following operations were carried out:

(1) Three extension shaft bearings were overhauled and greased up.
(2) The blade angle followup transmitter was opened up, electric parts replaced and adjusted.
(3) The tips of the wiring cables were treated with hot water to remove salinity and then dried up.
(4) Three lighting appliances in the void space were removed and dried.
(5) The insulation resistances of the driving electric motor, space heater for it, etc. regained 100M ohm.
(6) Operation tests with and without load.

II. Causes of accident/problems

[Hardware factors]

For trim adjustment, the forepeak reserve tank was completely filled up with water. The air vent pipe for the tank was corroded and holed (30 x 100 mm) at a welded joint located in the bowthruster room (on the starboard side), allowed water to flood the room.

[Software/human factors]

The air vent pipe for the forepeak reserve tank was left unchecked for corrosion.

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

Similar accidents resulting from holed air vent pipes, sounding pipes, etc. have often occurred. There is a need to pay attention.

IV. Lessons

This case involved a water leakage in a void space, but we have experienced a considerable number of incidents because of holed tank air vent pipes, sounding pipes, etc. running through ballast tanks.

Engine Trouble Cases

File No.	11 - 006				
Case name	Burnt out lube oil purifier driving motor				
Device name	Purifier	Damaged part	Driving motor	State of damage	Burnout
Maker name	Taiyo Electric Co.	Model	1F-132M	Total working time	4 years after built
Kind of ship		Date of occurrence	1982.12.27	Place of occurrence	At sea
Cause of damage/problem	Hardware factor		Vibration		
	Software/human factor		Poor operation control		

I. Outline of accident

[Course of events]

When at sea, the nonfuse circuit breaker for the lube oil purifier on the group starter panel tripped without warning. When the person in charge reported to the scene, he found that a bad odor of burnt insulation varnish was being emitted from around No. 2 lube oil purifier.

[State of damage]

A megger test of the resistance of the motor revealed a burnout of the stator coil.

[Response measures]

The motor was replaced with a spare one. The burnt out motor was landed and repaired by rewinding the coil.

II. Causes of accident/problems

[Hardware factors]

Since the area in the vicinity of the lube oil purifier was subjected to heavy vibration and the damage is ascribed, despite only 4 years after the ship's construction, to deterioration over years of use.

[Software/human factors]

Insufficient check during inspection rounds.

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

As for motors, the following matters must be checked on an inspection tour.

(1) Value indicated by the ammeter and the swing of the pointer.

(2) Check for overheating of the bearings and stator by touch.

Thermometers should be attached to those which are hot at all times.

(3) Check for the motor for vibration by touch.

(4) Sound generated by the motor. At least check for abnormal sound once a week, the sound of the bearing should be checked with a listening rod.

If, any abnormality noticed, overhaul motor, then replace ball bearing is soaked in kerosene to remove grease, and rotated slowly by hand to check its condition, its deterioration will always become evident. Conversely, careful monitoring would prevent the burnout of motors.

IV. Lessons

We have experienced in the past many burnouts of motors for the lube oil purifier, Hope System, main engine auxiliary blower, etc.

File No.	11 - 007				
Case name	Burnout of nonfuse circuit breaker resulting from water leaking from holed seawater pipe above main switchboard				
Device name	Main switch board	Damaged part	Nonfuse circuit breaker	State of damage	Burnout
Maker name		Model		Total working time	
Kind of ship		Date of occurrence	1987.03	Place of occurrence	While at sea
Cause of damage/problem	Hardware factor	Entry of water resulting from holed seawater pipe			
	Software/human factor	Insufficient measures to cope with accidental damage			

I. Outline of accident

[Course of events]

At sea a reverberating sound occurred at 1135 hours in the vicinity of the main switchboard without any warning. The low insulation alarm for the MSB 440V bus bar went off.

[State of damage]

Inspection thereafter revealed that sea water dripped into the center feeder panel from above and that the connector (of Bakelite) of a severely wetted nonfuse breaker burned out.

[Response measures]

The switchboard was immediately drained, wiped and dried up, and its resistance was raised to 5MΩ in about four hours.

II. Causes of accident/problems

[Hardware factors]

Seawater pipe for the package air conditioner for the cargo control room was passing above the main switch board. One of them had a pin hole leaking water, which found its way into the switchboard through gaps of its casing and bolt holes.

[Software/human factors]

It is improper to arrange seawater pipes immediately above such a critical device a switchboard and, if there is no other option, some protective measures should be taken.

Crew members burdened with the responsibility to operate a vessel already built are requested to grasp the current situation of facilities and take protective measures to prevent such defective situations, if any, from causing damage.

In the present condition, the provision of a drain pan, had been taken to prevent damage expected to be caused by seawater in the event of the pipe failure, …

In this case, seawater leaked through a pin hole, but there is also a possibility of water dripping as a result of condensation on a cold pipe.

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

IV. Lessons

When making rounds throughout the machinery spaces, it is necessary not only to inspect the running conditions but also to think such things as what would happen in the event of a breakage of a pipe.

Engine Trouble Cases

File No.	11 - 008				
Case name	Blackout trouble due to damage of MSB Bus bar				
Device name	MSB	Damaged part	BUS BAR	State of damage	Peeled silver Plate
Maker name		Model		Total working time	13 years
Kind of ship	VLCC	Date of occurrence		Place of occurrence	At sea
Cause of damage/problem	Hardware factor	Excessive vibration or poor fitting			
	Software/human factor	Insufficient checks			

Ⅰ. Outline of Accident

[Course of Events]

While the vessel was at sea, a piece of peeled silver plating fell off the bus bar of the Main Switchboard and bridged the bus bar and inside of the side panel, causing a short-circuit. (Please refer to attached sheet Fig.-1: 'Outline of Earth Inside the Main switchboard'). At the time the trouble occurred, the PTG (Power Turbine Generator) and one set of DG (Diesel Generator) were running in parallel. The inter-phase short-circuit caused a blackout. The peeled piece of silver plating was found and immediately removed, and the main electric supply was restored without any further problems.

[State of Damage]

[Disposition]

Ⅱ. Cause of Accident / Underlying Problem

[Mechanical Factor]

Leaking gas from the PTG exhaust gas line had accelerated Sulfuric acid corrosion of the silver plating covering the surface of the bus bar. Corrosion took place deep within the plating, rapidly progressing to the copper bar material. Eventually the silver plating peeled off and a piece of the peeled silver fell down.

Silver plating is very susceptible to corrosive atmospheres and ultraviolet rays. Sulfur dioxide gas present in the air creates a silver sulfide film on the surface of silver plating, darkening the colour of the plating. This occurs naturally, although the degree is depends on local conditions and period of exposure. However, when the content of corrosive gas is higher than normal, as in this case, corrosion is accelerated, with a corresponding increase in the potential for trouble.

Corrosive gas is brought into the engine room in the following manner:

(1) Leaks from a damaged/loosened flange, or expansion of main/aux joint. Engine or Boiler exhaust piping, etc;

(2) Admission of exhaust gases and/or vapor of cargo oil through the ventilator into the engine room.

[Human/Software Factors]

III. Preventive Measures

[Mechanical Aspect]

Corrosive gas itself, or even the atmosphere in the engine room which contains a certain amount of corrosive gas, will cause severe damage to not only the main switchboard, but also to the generator, the blower impeller of the turbo charger, the inter-cooler, etc. Therefore, when any gas leak are found, equipment causing the problem must be stopped immediately and repaired.

In this incident, as well as repairing the gas leak, the bus bar was re-coated, following the complete removal of the peeled plating.

General inspection of the main switchboard, including the coating of the bus bar, should be carried out at regular intervals, such as when dry-docking.

[Human/Software Aspect]

The masters are requested to prevent future similar trouble and ensure that regular inspection and maintenance of emergency machinery/equipment takes place to ensure optimum condition of the equipment is maintained at all times.

IV. Lessons

V. Reference

(1) Blackout trouble on a VLCC (not under MOL operation)with same type of engine and electric power plant as the vessel above was reported recently. While passing through narrow water the vessel, with a cargo of 700,000 barrels of crude oil, suffered a blackout due to a burnt main electric feeder panel.

The emergency generator failed to cut in with emergency electric power due to a defective starting air motor. As a result, the vessel drifted for quite a long period of time without any power. Obviously, a situation where a vessel is carrying a dangerous cargo, and drifting with no power, can easily lead to a major disaster.

(2) Importance of Emergency Generator

When equipment and machinery lose their functional capability, the integrity and safety of the vessel is jeopardized. Therefore, it is essential stand-by machinery on board, including the emergency generator, should be kept in a good condition at all times. This requires the carrying out of periodical inspection and maintenance work. This greatly reduces the risk of a very serious situation developing, should running equipment fail.

It is perhaps worthwhile reiterating the maintenance procedures and areas of concern for the Emergency Generator, possibly the most critical item amongst the stand-by equipment:

(a) Starting tests should be conducted at least once a week. Periodical manual turning of rotor and lubrication is also advisable. Care should be taken to ensure that the AUTO-MANUAL changeover switch is set at the “AUTO” position after completion of testing or turning.

(b) System oil and cooling fresh water are controlled in the same way as for the diesel generator. The proper quantity of antifreeze solution is added to the cooling fresh water at the appropriate time.

(c) Fuel oil tank should always be kept full. There is a possibility that in the event of an emergency, access to the engine room and/or pumping fuel to the tank may become impossible

(d) Regarding the air dampers of the Emergency Generator Room, both the inlet and outlet/exhaust fan should always be kept open. However, checks should be made that they can be easily closed when necessary.

(e) It is important to check for proper drainage from the air intake duct. It must be confirmed that there is no danger of rain or seawater ingress affecting the electric panel or generator.

(f) The drain valve of the exhaust gas pipe must be kept open and clog free. Countermeasures should be taken where necessary e.g. cover sheet to shield against incoming rain from the funnel.

(g) Regarding the starting system of the primary engine:

①Where the electric starter motor is employed, each battery is changed over daily. Attention should be paid to the prevention of over-discharge of battery and the battery’s lifetime.

②If the air starter motor is employed, care should be taken that:

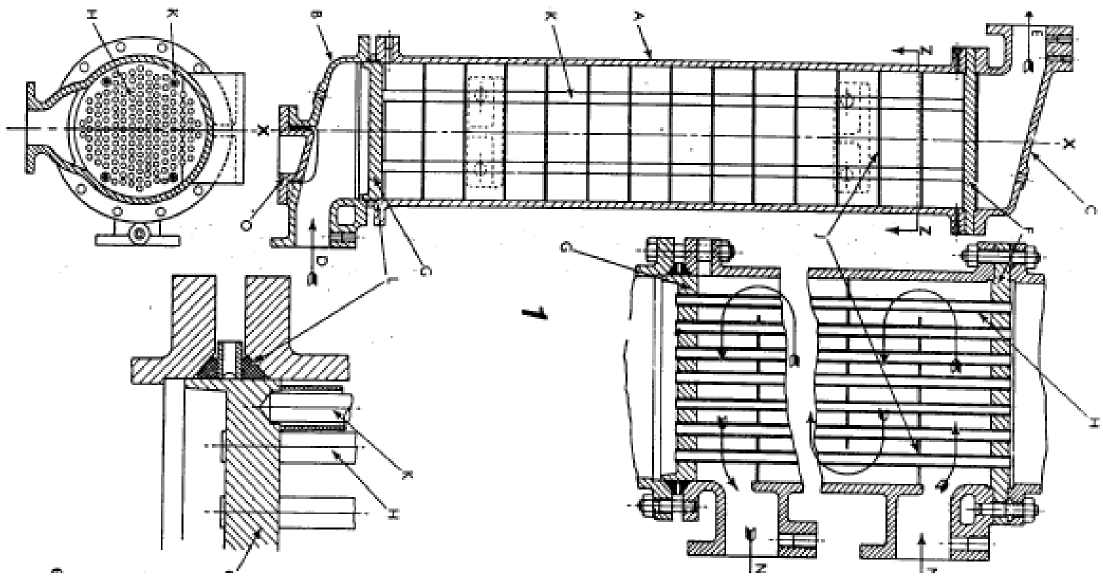
- the motor vanes are properly lubricated.
- the emergency air reservoir is always fully charged.
- the emergency air compressor is regularly tested for its capability to charge

the reservoir from empty to full. In rare cases, incapability of the solenoid valve due to the deterioration of the emergency battery has been reported.

- the maintenance-free battery is checked The voltage of each cell during floating charge is required to be 2.23±0.1V. If the measured voltage of the cell is lower than that value, the battery must be renewed.

(g) Condition and tension of radiator fan driving belt is inspected regularly. Filter cartridge for fuel oil or lubricating oil is cleaned or renewed regularly.

12. Heat exchanger



Engine Trouble Cases

File No.	12 - 001				
Case name	Main lube oil cooler tube leak				
Device name	Main lube oil cooler	Damaged part	Tube	State of damage	Fracture
Maker name	Setouchi Kogyo Co.	Model	Shell tube	Total working time	4 months after built
Kind of ship	Container ship	Date of occurrence	1995.08.24	Place of occurrence	Hamburg
Cause of damage/problem	Hardware factor		Defective design		
	Software/human factor		Insufficient awareness of marine pollution prevention		

I. Outline of accident

[Course of events]

(1) At 2035 hours on August 23: Departure from Hamburg for Southampton.
While crew members were engaged in preparatory operations for departure from Hamburg, a longshoreman discovered seemingly floating oil around her. Before departure, reported the fact to the local authorities. They underwent an onboard inspection. As it was raining then, the inspectors regarded the oil as a kind of fat flowing down from the wharf and dismissed the vessel without any punishment.

(2) Crew members watched the wake of the vessel for oil as she was going down the river (at night) after sailing out from Hamburg, but no abnormal situation came to their notice.

(3) At 2300 hours, about three hours after her departure, the low level alarm of the main engine lube oil sump tank sounded. With the possibility of leaking lube oil cooler tubes in mind, the engineer on watch put the main engine cooling water pumps in parallel operation to raise the pressure on the seawater side as a measure to prevent the outflow of lube oil. In such a condition, the vessel continued her voyage down the river.

(4) After the disembarkation of the Elbe river pilot at 0345 hours, the vessel commenced her voyage toward Southampton by increasing her engine speed to around 77 rpm in order to maintain her schedule.

(5) At 0700 hours, about three hours after the rise of the engine speed, the lube oil sump tank low level alarm sounded again.

(6) At 1000 hours when a sample of water was taken through the air vent pipe on the seawater side of the cooler, contamination by oil was recognized, indicating an abnormal condition of the main lube oil cooler.

[State of damage]

The number of tubes recognized to be leaking was four and, later it was revealed that, they fractured at baffle plates.

[Response measures]

(1) After confirming the occurrence of the damage, crew members overhauled and inspected the main lube oil cooler, while the vessel was drifting north of the Dover Strait, and found four tubes were leaking. They plugged 19 tubes, including neighboring ones, with wooden plugs.

(2) After arrival at Southampton, the vessel underwent an inspection by a shipyard engineer and a survey by NK to obtain a certificate of seaworthiness.

(3) The vessel informed port authorities, according to the oil pollution manual that there was a possibility of oil leak. Following that, inspectors came on board, checked the situation of the vessel, and interviewed the relevant personnel. They granted the vessel sailing permission since there was nothing to cause trouble.

(4) When she called at Singapore, the vessel underwent an eddy current testing of 160 tubes, 20 tubes were found to be reduced in thickness. Of them, 6 were replaced and 14 were plugged with wooden plugs.

(5) Following that, also when the vessel called at Kobe, all the tubes were put through an eddy current testing, which revealed a reduction in thickness in 12 tubes; and 15 tubes were replaced and 65 tubes, into which steel bars were inserted, were stopped up with brass plugs. The purpose of the insertion of steel bars was to change the natural frequency of the tubes by altering the weight of each tube.

II. Causes of accident/problems

[Hardware factors]

From the fact that the damaged portions were mostly found in tubes in the lube oil inlet section of the cooler and that the design calculations showed that the dynamic pressure at the inlet section of the cooler, created by the flow speed of lube oil, overwhelmingly exceeded TEMA's design standard, it is presumed that tubes were deformed by the dynamic pressure of lube oil and were repeatedly forced to come in contact with baffle plates. This caused the wear and eventual fracture of the tubes.

Furthermore, the asymmetrical arrangement of the tubes on the lube oil inlet and outlet pipes made the flow of lube oil inside the cooler asymmetrical, causing damage mostly in tubes on the baffle plates on one side.

[Software/human factors]

Since the vessel was a newly built, crew members were burdened with excessive work and were not in a situation which would allow them to take into consideration a leak of a cooler. However, under the recent stringent atmosphere against marine pollution, it is hoped that the identification of the oil leak should have been made in a slightly earlier stage. When entering European waters, for example, it is desirable to check sea water from all coolers for contamination with oil by taking samples through their air vent pipes.

III. Measures to prevent recurrence

[Hardware aspects]

Various measures were taken from the aspect of piping design.

[Software/human aspects]

IV. Lessons

You cannot let your guard down at all only because your vessel is new.

Engine Trouble Cases

File No.	12 - 002				
Case name	Marine pollution from holed lube oil cooler tubes for the main engine				
Device name	Main engine lube oil cooler	Damaged part	Cooler tubes	State of damage	Deposit attack
Maker name		Model	Shell tube type	Total working time	3 years after built
Kind of ship	PCC	Date of occurrence		Place of occurrence	Port Hueneme
Cause of damage/problem	Hardware factor		Improper adjustment of concentration of chemical agent for MGPS		
	Software/human factor		Improper overhaul and inspection, insufficient measures to cope with marine pollution		

I. Outline of accident

[Course of events]

Upon arrival at the port, oil was found floating on the sea surface in the harbor and an investigation thereafter suggested that it originated from four cooler tubes of the main engine lube oil cooler.

Approximately 1500 liters of lube oil is thought to have leaked out over a period of about 6 days from a further inspection.

[State of damage]

[Response measures]

When the vessel returned to Japan the vessel went though an inspection and measurement of the thickness of the tubes by the maker. On the basis of the result, 12 tubes with reduced thickness, in addition to the 4 leaky ones, were replaced.

II. Causes of accident/problems

[Hardware factors]

The holes of the tubes are attributed to deposit attack.

[Software/human factors]

(1) Since as much as 1500 liters of lube oil spilled out over a period of about 6 days, though little by little, it should not have escaped notice under a stricter daily operational management.

(2) Before port entry, the check of sea water must be made for oil films from the vent cock, but the engineer in charge failed to do so.

(3) As this case was pointed out by the USCG, it is very much concern that crew members did not notice anything even when they were awaiting the port entry, suggesting how low is their conscious of the need for marine pollution prevention.

III. Measures to prevent recurrence

[Hardware aspects]

The MGPS on board the vessel is a type which requires chemical injection and a biannual overhaul of the main lube oil cooler.

An inspection is made through the sight hole, as appropriate, and the chemical dosage is adjusted.

[Software/human aspects]

Measures for the prevention of marine pollution should be planned and actually implemented.

IV. Lessons

Minor marine pollution incidents of this kind have frequently occurred. There is a need to have consciousness that lube oil coolers have a possibility of leaking oil at any time, causing marine pollution.

File No.	12 - 003				
Case name	Holed evaporator pipes for fresh water generator				
Device name	Fresh water generator	Damaged part	Evaporator pipe	State of damage	Erosion resulting in holes
Maker name	Sasakura	Model	AFGU-S52	Total working time	15,000 hours
Kind of ship	Container ship	Date of occurrence	1986.01	Place of occurrence	While at sea
Cause of damage/problem	Hardware factor	Overloading			
	Software/human factor	Improper handling			

I. Outline of accident

[Course of events]

From January 1986 the water level of the main engine fresh water expansion tank started dropping gradually. Upon inspection of various parts, six of the evaporator pipes for the fresh water generator were found to be holed.

[State of damage]

According to the results of an inspection by overhauling it in a drydock, almost all pipes other than the six with holes, also sustained damage.

[Response measures]

As a first-aid measure for the time being, the holed pipes were all stopped up with plugs and, at a later date, all evaporator pipes were renewed in a drydock.

II. Causes of accident/problems

[Hardware factors]

According to the results of inspection by overhauling it in a drydock, almost all pipes other than the six with holes also sustained damage, though with differences in severity, inside the pipes on the seawater side. As a result of a microscopic investigation (with a borescope) made by an independent laboratory at the request of the manufacturer, the damage inside the heating tubes was found to be caused by erosion from such aspects as the shape of the pitting and a lack of corrosion factors.

It is presumed that, for the following reasons, instant evaporation occurred partially by the provision of a heat source under a high degree of vacuum:

(1) This fresh water generator was designed for conditions of a jacket water temperature of 65ºC and sea water temperature of 30ºC, but the jacket water temperature is higher than 80ºC on board the vessel and, therefore, the water generator had an extremely

great margin.

(2) The eroded portions are found in the bottom sections of the heating tubes, where liquid and gas phases are mixed, that is, the phase changes.

(3) The severely eroded portions were located in the peripheral areas of the heater shell and jacket cooling water flows more in peripheral areas with less resistance.

[Software/human factors]

Water was generated more than the rated quantity, that is, the generator was overloaded. It can be said that there were portions subjected to a load more than the design value and that such portions sustained damage.

Keeping operating parameters within the design criteria will automatically lead to uniform evaporation, eliminating overloaded portions.

Currently the jacket water has risen in temperature and it is easy to produce fresh water more than the rated quantity if seawater temperature is low. It follows that special care should be taken to adhere to water generation within the rating.

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

The following require attention in order to restrict explosive evaporation and keep a more uniform evaporating condition.

(1) In the event of a fresh water generator with a large margin, increase the feedwater rate by raising the feedwater pressure.

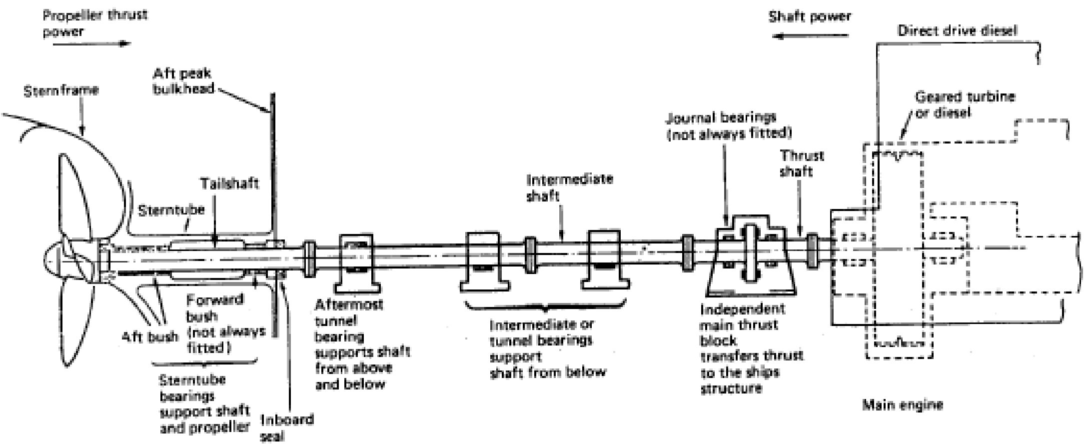
(2) Maintain the vacuum inside the water generator as low as possible.

(3) Regulate the valve position for jacket water to keep water generation within the rating.

IV. Lessons

Even fresh water generators may sustain damage if overloaded.

13. Propelling system



Engine Trouble Cases

File No.	13 - 001				
Case name	Damage to stern tube bearing				
Device name	Stern tube	Damaged part	Bearing	State of damage	Damage
Maker name	SHI SUL	Model	7RND76M	Total working time	11 years after built
Kind of ship	PCC	Date of occurrence	1992.06.17	Place of occurrence	
Cause of damage/problem	Hardware factor	Entangling of fishing net			
	Software/human factor	Poor maintenance of lube oil			

I. Outline of accident

[Course of events]

(1) While the contamination of lube oil with seawater was observed ever since April 1992, the condition remained unchanged for some time without further deterioration. Since around May, the amount of sea water finding its way into lube oil increased (50 to 60 liters/day) and, on her leg from Bremerhaven to Baltimore, small fragments of white metal were detected in the suction strainer for the stern tube lube oil pump and in the sump tank. Thereafter, the relevant crew members managed to minimize oil spills through such attempts as the replacement of the lube oil with Vickers Hyddrox Oil, a highly viscous oil and the adjustment of the gravity tank, and entered the shipyard of MHI in Yokohama on June 7 after calling at Los Angeles and San Francisco.

(2) As a result of an overhaul of the same section made immediately after entering the drydock, no abnormal condition was observed with the net guard, but a small amount of fragments of fishing net was found inside it and in the sealing equipment on the aft end, together with slight damage to the seal ring.

[State of damage]

(1) The metal on the aft end sustained a partial loss of the white metal (4 mm thick) and the forward metal was slightly scraped in the circumferential direction because of the entry of fused metal fragments. The weardown reached as much as 1.2 mm.

(2) The propeller shaft suffered scuffing in the circumferential direction on its surface where it is immersed inside the oil bath; and the mating surfaces of the bearing sustained a large number of corrosion pits in the form of a pockmark. Both parts caught up metal fragments. In addition, corrosion was observed in the bearing on the aft end because of admission of seawater.

[Response measures]

(1) The bearing on the aft end was renewed and that on the forward end was placed in continuous operation after the metal surface was rectified.
(2) As for the propeller shaft, white metal fragments imbedded on the surface were removed, and the surface was smoothed.
(3) Wiping and flushing of the lube oil system, including the inside of the stern tube and the lube oil tank, and cleaning by circulation.
(4) The stern tube sealing system was changed over from a product of Eagle Industry Co., Ltd. to that of Dover Japan Inc.

II. Causes of accident/problems

[Hardware factors]

Admission of seawater as a result of the entanglement of fishing net in the stern tube sealing system.

[Software/human factors]

The engineer in charge failed to take appropriate actions as the circumstances dictated, such as the proper maintenance of lube oil and a changeover to the emergency seal, in response to the entry of sea water caused by the entanglement of fishing net in the stern tube sealing system. The deterioration of lube oil in quality as a result of the admission of seawater to the oil bath for a long time, in combination with the defect of the propeller shaft ascribed to damage sustained before that, caused damage to the bearing metal.

The damage was ascertained through the detection of small metal fragments in the suction strainer to the stern tube lube oil pump, but, at this point in time, the damage had already reached a serious stage.

On board the vessel, because of damage to metals on both forward and aft ends, the sealing system and the same metals were renewed in the previous drydocking (two years before), too. An investigation conducted after the discovery of the damage, suggests that no record was entered about the contamination of the lube oil for the stern tube with water, despite the possible commencement in January of the contamination as indicated from the state of the damage, and that probably no remedial measures were taken until after the discovery of metal fragments.

In the past there was a case where, after the detection of a leaky stern tube seal system on board another vessel, the bearing of the same did sustain no damage although an analysis of the lube oil in the sump tank showed a ratio of seawater to lube oil of 50%. This damage could have been prevented from deteriorating to such a severity only if the engineer in charge had inspected stern tube lube oil for water content by regularly sampling the oil through the drain cock, checked its oil level and performed basic operating control.

Ⅲ. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

Observe the practice of making regular inspections of stern tube lube oil for water content by sampling through the drain cock, checking its oil level and performing basic operational control.

Ⅳ. Lessons

Lube oil will emulsify with only a small percentage of water. It is quite natural for bearing metal to sustain damage in time if emulsified lube oil is left unaddressed.

File No.	13 - 002				
Case name	Hawser caught up by propeller				
Device name	Controll-able pitch propeller	Damaged part	Rope guard	State of damage	Entangle-ment of hawser
Maker name	MHI Yokohama	Model	94XF/4	Total working time	6,008 hours
Kind of ship	Module plant carrier	Date of occurrence	1985.12.02	Place of occurrence	Shuaiba
Cause of damage/problem	Hardware factor	Nil			
	Software/human factor	Operational mistake			

I. Outline of accident

[Course of events]

During mooring operation at provision jetty in Shuaiba, a heaving line and a hawser were caught by a propeller and the following damage occurred.

[State of damage]

(1) The propeller shaft end and the boss were entangled with hawser (about 40 m) and a heaving line (about 17 m); the ropes were also pressed into the guard ring.

(2) The rope guard fitting bolts (20), which were severed by the rotation of the cover, all came off. Two of the four plugs of the rope guard also fell off.

(3) The rope guard is presumed to have rotated several times since it had circumferential scratches on its internal surface caused by contact with the propeller shaft flange and its tensioning bolt holes expanded in the rotating direction of the propeller. The rope guard was displaced about 16 mm forward, with the “O” ring partly pressed out.

(4) Two sets of wires to fit to prevent the rotation of tightening bolts of the simplex seal liner were severed.

(5) Two of the four plugs for the simplex cover ring were set loose.

[Response measures]

Divers were employed on the day following the incident (December 3) to grasp the state of damage and remove the entangled rope and messenger rope. After the completion of cargo work, repairs were made afloat from December 14 to 16 by local repairers and engineers dispatched from the maker, with her stern raised above water. The propeller was restored and put through an inspection by an NK surveyor.

II. Causes of accident/problems

[Hardware factors]

(1) The vessel is driven by two propellers which protrude outboard from the sides.

(2) The propellers are controllable and the engine rotates at all times.

[Software/human factors]

(1) Since it was a makeshift jetty, no expert linesmen were available.

(2) The mooring operation was not carried out smoothly.

III. Measures to prevent recurrence

[Hardware aspects]

There is some room for improvement in terms of the structure of the guard ring.

[Software/human aspects]

There is a need to carry out mooring operations more carefully.

IV. Lessons

Once propellers are entangled with ropes, it is troublesome afterwards.

Engine Trouble Cases

File No.	13 - 003				
Case name	Damage of intermediate shaft bearing				
Device name	Intermediate Shaft /Bearing Mechanical Lubrication	Damaged part	Shaft/Bearing	State of damage	Overheat
Maker name	JAPAN DOVER	Model		Total working time	3 years
Kind of ship	LPG	Date of occurrence	1993.06.27	Place of occurrence	Proceeding PG
Cause of damage/problem	Hardware factor	Insufficient LO supply			
	Software/human factor	Misoperation			

Ⅰ. Outline of Accident

[Course of Event]

An LPG carrier, laden with a full cargo of LPG from Ras Tanura, was sailing toward Japan after clearing out of the Hormuz Strait. The vessel was under the ‘M0’ operating arrangement and an inspection round in the morning found an abnormal overheating of the intermediate shaft bearing.

When the intermediate lube oil valve was checked to see how lube oil was being admitted to the bearing, it was revealed that the valve had been closed. The valve was immediately opened, but the lube oil caught fire when it reached the bearing. Crew members immediately attempted to extinguish it by using portable extinguishers and pouring water, while stopping the main engine. They cooled down the bearing gradually by rotating the shaft with the turning device.

[State of Damage]

An inspection thereafter found that the vessel was so damaged that she was not able to sail under her own power. The vessel was towed to off Dubai by a tugboat and cast her anchor there.

(1) Melting of the upper and lower metals; cracking of the lower bearing backing metal; fracture of upper metal set bolts.

(2) The shaft journal, with scattered metal deposits and heat cracks, sustained considerable scratches and the oil deflectors flanking the bearing were burned out.

(3) The upper half of the bearing was overhauled and the deflection of the shaft was measured. A bend of 140/100 mm was observed in the vertical direction. As for the paintwork of the bearing support, only blisters were observed. The value of the

temperature rise is unknown.

[Disposition]

In an effort to revive her ability to sail under her own power, we sent engineers of MHI, the builder of the vessel, and other experts to repair the shaft, including the removal of cracks in the intermediate shaft journal.

(1) Removal of cracks in intermediate shaft journal
   a) All the cracks in the circumferential directions of the shaft were removed and such surfaces were sufficiently smoothed out.
   b) Since it was apparent that cracks in the axial direction would not be removed completely even by machining to a depth of 45 mm, parties concerned discussed and responded to the situation by providing stop holes (it was considered that cracks in the axial direction might not progress further).

(2) Machining of intermediate shaft journal
   The shaft was machined to 503.15 mm against its original diameter 505 mm and the irregular journal surface and minute cracks were smoothed out.

(3) In addition, upper and lower metals were prepared and substituted for the damaged ones.

(4) Trial and adjustments

After the above work was done, NK issued a sailing permit under the following conditions:

(1) Output restriction:
   On the basis of a strength calculation as a result of the reduction in effective diameter, the upper limit is set approximately at 50%.

(2) Valid period of the permit:
   A period till the vessel completes discharging cargo in Japan and enters a dockyard after gas-freeing (end of August).

(3) Sailing condition:
   The machinery spaces may not be left unattended to, that is the ‘M0’ operation arrangement is not allowed.

Ⅱ. Cause of Accident / Underlying Problem

[Mechanical Factor]

The intermediate valve branching off from the lube oil main pipe for the main engine gradually closed because of vibrations and this caused a shortage of lube oil supply to the intermediate shaft bearing, which resulted in its melting by overheating.

[Human/Software Factor]

The change in the open and closed valve position is unavoidable under the influence of vibrations in locations subjected to vibrations, such as places around shafting and generator engines. It is desirable for such valves to be fitted with a stopper fixing the position of the valve spindle. Without such a stopper, it is a common practice to lash a valve with a rope or wire. It is to our great regret that crew members had taken no heed of such possibility until the occurrence of the accident for three years since her building.

III. Preventive Measures

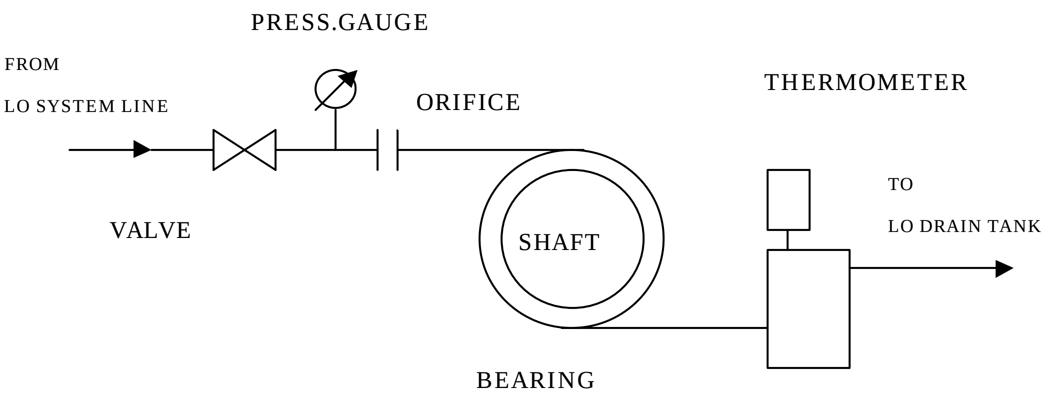
[Human/Software]

(1) With regard to facilities with a forced lubricating system, check the condition of lubrication and take measures to fix the open and closed position of the intermediate valve.

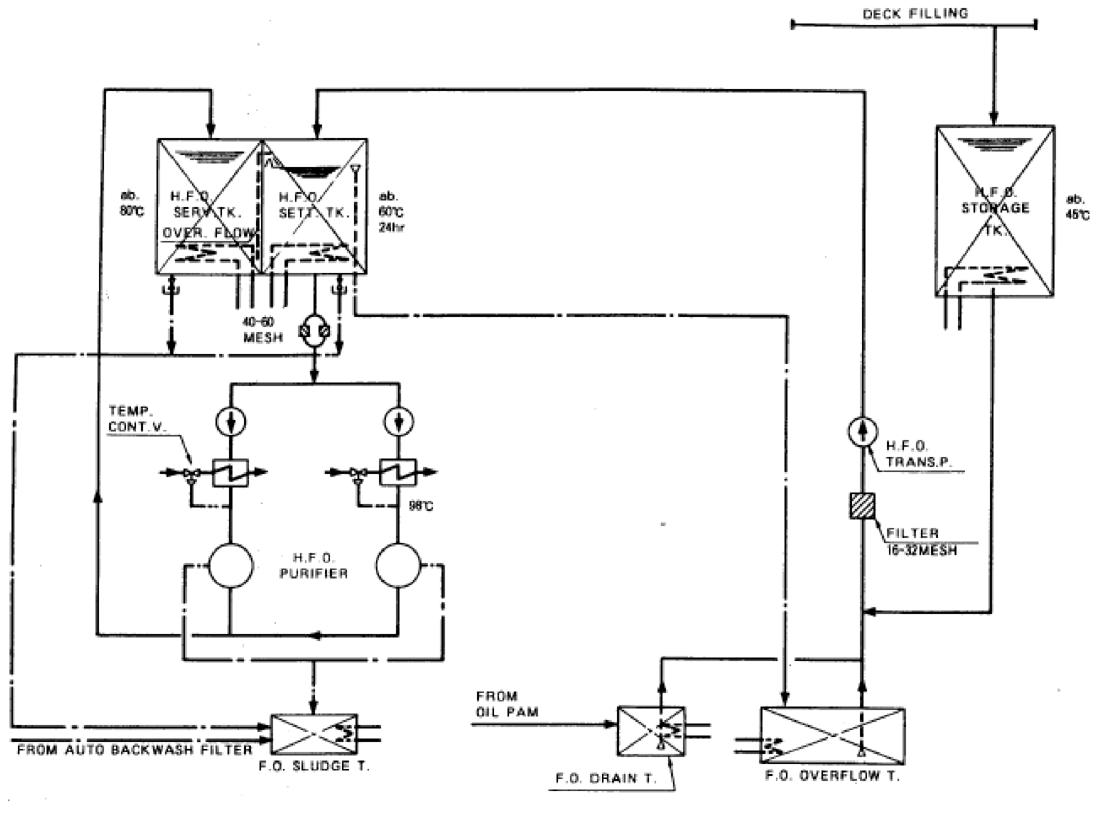
(2) As for the oil feed rate, feed oil at a maximum rate at which no oil leaks from both ends of the bearing, after having checked the good condition of the inlet orifice and the performance of the shaft oil seal.

IV. Lessons

There are cases that a serious accident like this takes place even if an alarm does not go off during the engine operation with the machinery spaces unattended. Assuming every possible situation, engineers must take due measures to counter it.



14. Bunkering



Engine Trouble Cases

File No.	14 - 001				
Case name	Mixed loading of lube oil				
Device name	Lube oil tanks	Damaged part		State of damage	Mixed loading
Maker name		Model		Total working time	6 years after built
Kind of ship	Woodchip carrier	Date of occurrence		Place of occurrence	Iwakuni
Cause of damage/problem	Hardware factor				
	Software/human factor	Disregard of basics for lube oil replenishing operations			

I. Outline of accident

[Course of events]

(1) With a plan to supply lube oil after arrival, the vessel arrived at the port with the following tank conditions.

Tank name	Remaining on board
No. 1 cylinder oil tank	1,500 liters
Main engine system oil tank	2,200 liters
Generator engine system oil tank	2,000 liters

(2) Crew members connected hoses with both cylinder oil supply system and system oil supply system and started the supplying operation at the same time.

(3) They checked the tank levels after completing the operation and became aware of an unusual condition.

[State of damage]

The tank condition of each tank after the replenishment was as follows:

Tank name	On hand (liters)	Supply (mixed oil kinds) (liters)	Total (liters)
No. 1 cylinder oil tank	1,500	2,400 (M/E, D/G sys. oil)	3,900
Main engine system oil tank	2,200	3,600 (M/E cyl. oil)	5,800
Generator engine system oil tank	2,000	1,300 (M/E cyl. oil)	3,300
		Sum total of mixed oil	13,000

[Response measures]

Adjusted oil (85TBN, 60SAE) was added to the mixed oil for use as cylinder oil after adjusting its viscosity (40) to 220 cSt.

II. Causes of accident/problems

[Hardware factors]

Since the flanges with names of lube oil types inscribed on them were restored in a wrong way after the previous replenishment, the crew members engaged in the replenishing operation made a mistake in connecting the hoses.

[Software/human factors]

In addition to the proximate cause, the following problems contributed to the incident:

(1) No meeting was held before the lube oil replenishing operation to check the procedures for the oil transfer.

(2) No proper assignment of crew members was made to the job.

(3) The relevant crew members checked the tank levels upon the commencement of the replenishing operation, and checked the increase in oil level in tanks being loaded but failed to check changes in oil level in other tanks.

(4) The supply of two different types of oil was started at the same time.

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

The tank names should be marked on the respective intake pipes or on the bulwark nearby.

IV. Lessons

Failure to follow basic procedures will lead to a pitfall when least expected.

Engine Trouble Cases

File No.	14 - 002				
Case name	Supply of fuel oil of poor quality				
Device name		Damaged part		State of damage	
Maker name		Model		Total working time	13 years after built
Kind of ship	PCC	Date of occurrence	1996.05.07	Place of occurrence	Ulsan
Cause of damage/problem	Hardware factor	Catalytic fines			
	Software/human factor	Failure to receive oil samples			

I. Outline of accident

[Course of events]

(1) MOL Technology Research Center analyzed a sample of the oil (830 MT of IF-280) supplied at Ulsan and revealed the content of (Al + Si) at a level of 141 mg/kg (ppm). Even an observation by a microscope showed a large number of particles of 20 to 30 micro-m. This value exceeds MOL's recommendation (30 ppm) and the reference value of ISO 8217 (80 ppm) by far, and is considered to directly lead to interference with vessel operation and, therefore, unsuitable for use.

(2) When samples were taken from all fuel tanks of the vessel and analyzed by the above laboratory, all samples showed abnormal values of 65 to 147 ppm.

(3) It was found that the vessel did not have a retained sample of the bunker oil and only the supplier retained one (no engineer attended the sampling on site) and the sample showed 1 ppm of Al and Si according to an analysis by SGS, South Korea.

(4) It was decided to discharge the relevant bunker and intended to have the supplier to do the job, but the supplier refused to do so on the excuse of the outcome of the retained sample analysis. An attempt was made through another trading company to discharge it in South Korea, but it was not possible, either, because of its tax law.

(5) Since the oil sample retained by the supplier was not credible, oil samples were taken from all tanks in the presence of an independent surveyor with approval from the trading house in between. The result of an analysis of the samples made by DNVPS showed high values of 137 to 156 ppm for all tanks.

(6) The vessel took in bunker oil necessary to reach Singapore at Inchon and discharged the poor quality bunker at Singapore.

[State of damage]

[Response measures]

II. Causes of accident/problems

[Hardware factors]

The vessel did not retain oil samples properly.

[Software/human factors]

Whether it is possible or not to prove the inferior quality of supplied bunker oil depends solely on the analysis results of oil samples retained by both supplier and vessel. In the case in question, without awareness of the importance of an oil sample to be retained, the chief engineer of the vessel signed an oil sample without any knowledge of where it came from, furthermore, he did not receive oil samples for the vessel.

As a result, although the analysis made by our laboratory of samples taken upon bunkering and thereafter, and the analysis made by DNVPS of other oil samples taken from respective tanks evidently showed that the bunker was of a poor quality, we were forced to accept the supplier's argument that there was no problem with the bunker.

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

The incident was a case which served to remind us of the importance of sampling.

The following is important in sample taking: Samples are taken in the presence of a crew member of the vessel, seals are confirmed (the seal numbers are recorded) and the supplier and the chief engineer sign and mutually retain them.

If no crew member attended sampling and a sample is not known as to where it came from, the chief engineer should annotate "Receipt Only" somewhere in the receipt delivered after bunkering or report to our Fuel Section.

IV. Lessons

When the vessel is engaged in bunkering operations, the ship's obligation is not discharged only by carrying out the bunkering operation safely and the chief engineer should be aware of the fact that he is a person burdened to execute a purchase contract. In the case taken up here, there was a problem with the performance of the contract and the buyer was, therefore, forced to dispose of the bunker oil of inferior quality and to load bunker oil again at the buyer's expense when the discharge of the bunker oil should have been done all by the supplier as a seller.

Engine Trouble Cases

File No.	14 - 003				
Case name	Marine pollution upon taking on lube oil				
Device name	Lube oil	Damaged part		State of damage	
Maker name		Model		Total working time	
Kind of ship		Date of occurrence		Place of occurrence	
Cause of damage/problem	Hardware factor				
	Software/human factor	Disregard of basics upon taking on lube oil			

I. Outline of accident

[Course of events]

(1) For the supply of lube oil, the chief engineer was stationed at the intake manifold and the first engineer in the engine room. While keeping communications over walkietalkies, they supplied lube oil in the following order: cylinder oil → diesel generator system oil → main engine system oil.

(2) After some time 4,000 liters of main engine system oil was completed, the first engineer checked the relevant tank level and found that only 3,000 liters recieved, an abnormal situation.

(3) Inspection revealed that lube oil spilled from the bunker line on the other side of the vessel. It was noticed that the blank flange was not tightened.

[State of damage]

After recovering spilt oil, oil measurements were taken, and concluded that about 150 liters of oil spilt overboard.

[Response measures]

II. Causes of accident/problems

[Hardware factors]

(1) The blank flange on the other manifold was not completely bolted up.

(2) The upper deck scuppers were plugged incompletely.

[Software/human factors]

(1) Personnel were not stationed in accordance with the bunkering manual on board.

(2) The operational procedures were not sufficiently checked.

(3) The line alignment was not checked according to the oil pollution prevention manual,

without adequate posting of personnel as lookouts or preparation of oil pollution equipment and materials.

(4) No inspection rounds were made during the oil replenishing operation, on the basis of the oil pollution prevention manual.

(5) No check of the situation of the replenishing operation was made upon the changeover of lube oil from one type to another.

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

As enumerated above as contributing factors, this incident can be said to be completely due to human error. Such factors as the supply of a small amount of lube oil and the direct involvement in the operation of the chief and first engineers, seemingly made them lower their guard, as shown by their failure to assign a proper number of persons.

They are required to recognize that operating manuals are prepared not only to show operating procedures but also to prevent possible emergency situation.

IV. Lessons

Failing to follow basics in any event may result in an accident.

Engine Trouble Cases

File No.	14 - 004				
Case name	Water pollution due to oil spill				
Device name	FO tank	Damaged part		State of damage	
Maker name		Model		Total working time	
Kind of ship	PCC	Date of occurrence	1998.09.18	Place of occurrence	YOKOHAMA
Cause of damage/problem	Hardware factor				
	Software/human factor	Misoperation			

Ⅰ. Outline of Accident

[Course of Events]

The vessel started bunkering after the completion of cargo work at a Wharf in Yokohama. The bunkering operation was carried out at a rate of about 200 MT/hour, with the intake valves for No. 1 (P) & (S) FO tanks fully open, and that for No. 3 (C) tank used for adjusting pressure.

The third Engineer was engaged in valve operations in the machinery space, under the supervision of the Chief Engineer, and two oilers were employed in taking ullages of No. 1 (P) & (S) FO tanks, under the direction of the Forth Engineer.

No. 1 (P) & (S) FO tanks, both with a capacity of 70 m^3, each contained 40 m3 of FO and it was planned for them to receive oil up to 87% of their capacity (61 m3 each). No. 3(C) FO tank was to receive 110m^3.

Thirty minutes after the commencement of the replenishing operation, almost at the same time as the oiler reported the measured valves of No. 1(P) & (S) tanks, No. 1 (P) FO tank overflowed through its sounding pipe.

[State of Damage]

No. 1 (P) FO tank overflowed through its sounding pipe resulting in a spill of about 250 liters on board and about 50 liters overboard.

[Disposition]

Ⅱ. Cause of Accident / Underlying Problem

[Mechanical Factor]

[Human/Software Factor]

(1) The intake valves for the tanks with smaller ullage spaces were kept fully open,

without regard to the excessively high loading rate, and the intake pressure was controlled by the adjustment of a tank with a larger ullage space.

(2) Ullages of No. 1(P) & (S) FO tanks were taken only twice before the occurrence of the oil spill.

(3) When the ullage was taken for the second time, the sounding pipe was soiled, making the reading of the ullage less reliable.

(4) Despite the situation as described above, the Chief Engineer did not attempt to reduce the filling rate.

III. Preventive Measures

[Mechanical Aspect]

[Human/Software Aspect]

(1) Preparation of bunkering plan

Before bunkering operations, it is required to prepare a bunkering plan and inform all personnel involved in the bunkering operation of its procedures. The plan must take into account the following:

(a) Prepare a bunkering schedule on the basis of a pumping rate within the capacity of the facilities on board.

(b) Determine the oil quantity to be received by each tank, taking into consideration such matters as the total volume of the tank, heating condition, structure of the air vent pipe, and installation of overflow piping. Limit receiving oil up to 90% of the tank capacity, as a rule.

(c) Clearly assign duties to the staff members to be engaged in the operation.

(2) Preparation for bunkering

Before bunkering, ensure the following preparations are made and confirmed by both the Chief Engineer and engineer in charge:

(a) The receiving tanks have sufficient ullage to receive the planned quantity of oil;

(b) The valves, piping arrangements, and tanks necessary for receiving oil are in a satisfactory condition for trouble-free bunkering operation;

(c) All air vent pipes for FO tanks are functioning properly;

(d) The means of communication between bunker manifold and bunker station are functioning properly.

(e) The coamings for the air vent are properly plugged;

(f) The deck scuppers are securely plugged;

(g) Equipment and materials for oil removal are placed ready for use beforehand;

(h) The correct valves are opened (ensure unnecessary valves are closed);

(i) The bunkering procedure manual and bunkering plan are displayed in the vicinity of the bunker manifold and bunker station; and

(j) If remote control valves or alarms are installed, they are checked for correct functioning.

(3) Meeting before bunkering.

Before bunkering, hold a meeting on the bunkering operation with the supplier (shore or barge) and confirm the following matters:

(a) Means of communication between ship and supplier;

(b) Acceptable transfer rate and upper limit of the manifold pressure;

(c) Quantity of oil to be supplied and order of bunkering;

(d) Response at critical stages of the bunkering operation, such as the commencement, topping off of each tank, and final drainage of the relevant lines by air; and

(e) Response in emergencies.

(4) During bunkering operations.

Check the following matters while bunkering:

(a) Convey the pumping order to the supplier only after the Chief Engineer has confirmed that all preparations have been completed.

(b) After the commencement of bunkering, maintain the minimum transfer rate for a while, during which checks should be made to see that:

① The oil is flowing into the correct tanks;

② There is no change in the quantity of oil contained in other tanks;

③ The bunker hose is properly secured and supported.

(c) Take ullages and make rounds on the deck at regular intervals according to the bunkering plan.

(d) When topping off a tank, never close its intake valve before opening that of the next tank to receive oil, in order to avoid excessive pressure rise.

(e) When topping off a tank, adjust the flow rate to other tanks so that utmost attention may be paid to the tank to be topped off.

(f) Check to see that there is no increase in oil level of tanks that have already been topped off.

(g) Keep close contact with the supplier.

(h) Before topping off the final tank, reduce the pumping rate step by step.

(i) Before starting to drain the relevant pipeline, check to see that the tank planned to receive the drain in the pipeline has sufficient ullage.

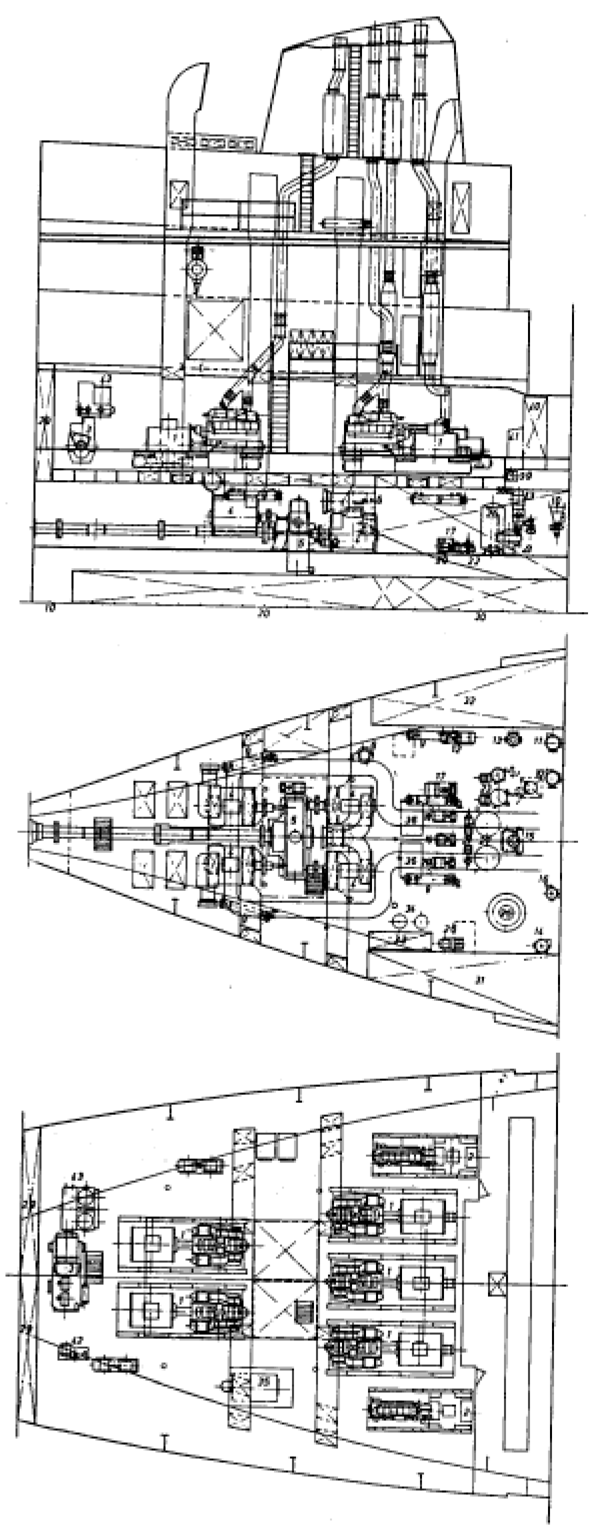
(j) When draining the relevant lines, cap the sounding pipes.

IV. Lessons

Bunkering works should be done with the utmost care in the works of the engine department, as any mistake can lead to serious consequences. For any important actions, a check by the Chief engineer is required in addition to the person in charge.

And in addition to onboard work, careful attention should be paid to the supplier's facilities (land facility, barge) and actions. Communication lines for urgent communication should always be established.

15. Tank



Engine Trouble Cases

File No.	15 - 001				
Case name	Damage to main engine crankcase drain pipe				
Device name	Main engine sump tank	Damaged part	Crankcase drain pipe	State of damage	Crack
Maker name	Ube	Model	UEC60LA	Total working time	11 years after built
Kind of ship	Bulker	Date of occurrence	1998.07.12	Place of occurrence	At sea
Cause of damage/problem	Hardware factor		Deterioration through years of use by vibration and corrosion		
	Software/human factor		Poor ‘M0’ check and watchkeeping		

I. Outline of accident

[Course of events]

On July 12, 1998, an increase in the level of the main engine lube oil sump tank was noticed.

On July 14, the “main engine lube oil pressure drop alarm” went off. The main engine was stopped and various parts were inspected. When the purifier was checked, water gray in color was detected from the drain pipe, convincing crew members of lube oil contamination with water.

[State of damage]

A hole caused by corrosion was found in the drain pipe in the lower part of the crankcase leading to the lube oil sump tank, together with a crack in the same pipe at a portion where it is welded to the sump tank. Bilge water which flooded the place found its way into the main engine sump tank through the crack and hole and ultimately mixed into the system oil.

It seems that 1.5 m^3 of bilge water mixed into 15 m^3 of system oil.

[Response measures]

Replacement of the system oil with new oil.

II. Causes of accident/problems

[Hardware factors]

While the vessel is in her eleventh year of service, the drain pipe below the crankcase had been left unchecked and the crack is considered to have been caused by deterioration through years of use and poor welding quality or corrosion induced by vibration.

[Software/human factors]

(1) The oil level increase of the sump tank came to notice on July 12 and the main engine

lube oil pressure drop alarm sounded on July 14. Only after that crew members started to check various parts, but did they investigate the cause of the rise in level before the alarm went off?

If there is a change in tank level during 'M0' checks and engineering watches while under way, it is a must to investigate possible damage to or flaws in equipment. Crew members are required to know that it is the fundamental method to prevent accidents. You may leave a notable change unaddressed without being convinced as to what has caused such a situation, only when you can satisfy yourself that nothing problematic will occur in the worst scenario as far as you can imagine.

It would not be surprising this accident had unfortunately developed into a serious one, including damage to the bearings.

(2) Generally, if water finds its way into system oil, the water content will manifest itself as water drops in the sight glass at a level of about 0.3% of oil.

An attitude to take notice of any slight change is necessary when crew members make inspection rounds; one oil drop or water drop on the floor may serve as a clue to defects which, if addressed at an early stage, may prevent development into serious accidents. For that purpose, cleaning at other times is required to keep the floor off oil or water. If water drops are not readily observable because of a dirty sight glass, such a situation itself underlies a problem which may lead to an accident at any time.

(3) As one of our standard features, main engines and diesel generators are surrounded by coamings. Setting aside whether it was the case on board the vessel or not, it is a problem that the tank top was flooded with a large amount of bilge water and that as much as 1.5 m^3 of water found its way through the cracks. The bilges must be maintained so that water does not overflow the bilge wells. In such a state, if bilge water is not found on the tank top, it is easy to locate a hole in a pipe, or other abnormal conditions.

(4) The creation of cracks is beyond control of crew members, if they were caused by improper welding or induced by vibrations, but the engine pit bilge generally must be kept dry and if there is a pool of bilge water in it, it must be stripped and its cause investigated.

III. Measures to prevent recurrence

[Hardware aspect]

[Software/human aspects]

Ⅳ. Lessons

The operational management according to basics often prevents serious accidents.

File No.	15 - 002				
Case name	Flow of FO into duct keel				
Device name	No. 1 FO tank	Damaged part	Dresser joint	State of damage	Leak
Maker name	Taiyo	Model	150F-1	Total working time	10 years after built
Kind of ship	PCC	Date of occurrence		Place of occurrence	Inchon
Cause of damage/problem	Hardware factor	Deterioration through years of use			
	Software/human factor	Insufficient inspection			

I. Outline of accident

[Course of events]

(1) Upon arrival at Inchon, a shortage of remaining oil by 20 M/T in No. 1 P and S tanks became evident. (Both tanks, which were made “common”, were in use.)

(2) The vessel took in fuel oil at Inchon and four days after her departure it was noticed that 300 M/T of oil was missing.

(3) Soundings proved that fuel oil flowed into the duct keel.

[State of damage]

[Response measures]

The bilge piping for the duct keel was provisionally arranged to connect to the FO transfer system and the oil in the duct keel was transferred to the settling tank every day by use of the auxiliary transfer pump.

II. Causes of accident/problems

[Hardware factors]

The transfer line from No. 1 P and S FO tanks has dresser couplings at four locations inside the duct keel of the vessel and of those:

(1) The coupling closest to the engine room had its bolts out of place; and

(2) Two other couplings were detected to be leaking oil through the rubber gaskets.

[Software/human factors]

The preventive measures as enumerated below should naturally have been taken and the failure to do so is a problem.

III. Measures to prevent recurrence

[Hardware aspects]

(1) Take soundings of the duct keel every day.

(2) Check the leakproof condition of the dresser couplings once every year.

(3) Inspect the pipes visually once every six months.

(4) Pressure test FO piping once every six months.

(5) Replace the rubber gaskets every five years.

(6) Keep the FO tanks closed when they are not in use.

[Software/human aspects]

Soundings are supposed to be taken every day, but, in some cases, while daily entries are made in the sounding note, soundings are not actually taken.

IV. Lessons

The ship's hull must be inspected at every nook and cranny against a checklist at regular intervals.

File No.	15 - 003				
Case name	Shipboard MARPOL inspection in Germany				
Device name	Waste oil tanks	Damaged part		State of damage	
Maker name		Model		Total working time	11 years after built
Kind of ship	PCC	Date of occurrence		Place of occurrence	Emden
Cause of damage/problem	Hardware factor				
	Software/human factor	Improper entry in oil record book			

I. Outline of accident

[Course of events]

(1) Response action taken on board on a daily basis in relation to entries in the oil record book

a) On every occasion when disposal was made, entries were made and the signature of the master as well as that of the first engineer set.

b) The quantity of oily residues in each tank was recorded every week instead of one voyage.

c) The operating time of the incinerator, quantity of disposal, names of tanks handled were entered; and as to the quantity of disposal, care was exercised not to exceed the capacity certified in the IOPP certificate.

d) Entries of the maintenance of the bilge separator, 15 ppm alarm test and the like were made with the use of the symbol “I”.

e) The time used for shifting waste oil was recorded.

(2) Matters carried out before entering European ports

a) Maintenance of the incinerator

b) Maintenance of the bilge separator

c) Inspection of the bilge overboard discharge pipe

d) Cleaning of the inside of the engine room

[State of damage]

[Response measures]

A matter was pointed out only.

II. Causes of accident/problems

[Hardware factors]

[Software/human factors]

The vessel entered the quantity of oily residues in each tank, collectively in C-11 once every week. Authorities pointed out the need to make entries separately in C11-1 and -2.

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

(1) Engineers are supposed to enter, in C11-1 and -2 of the oil record book, the quantity of oil residues remaining in each tank. However, the way each vessel makes entries is not unified, resulting from different interpretations and, consequently, authorities often highlight improper entries in Europe.

Accordingly, you are requested to observe the following manner when making entries from now on:

a) Entries shall be made separately in C-11-1 and -2 at intervals of one week regardless of whether at sea or in port.

b) Upon the completion of an ocean passage, entries shall be made so that they represent the situation upon arrival at the port.

(2) In Germany authorities check the consumption of FO and the amount of disposed waste oil (including sludge) in comparison with each other. Vessels may respond to shipboard inspections by authorities smoothly if they have already calculated the sum total before entering a port, particularly in Germany,

a) When the oil record book has no extra space for entries, the sum total of fuel oil consumption and that of waste oil disposed (both incinerated and landed) during the period of the record book was in use; and

b) The sum total of fuel oil consumption and that of waste oil disposed (both incinerated and landed) in the oil record book now in use from the date of the use of the record book till the date of arrival in Germany.

IV. Lessons

In relation to MARPOL Convention, no problem will be pointed up, in particular, only if all operations are carried out according to the regulation and the oil record book is properly entered.

However, concerning environmental pollution, some ports have their own rules and, therefore, vessels are required to thoroughly consult our circulars in advance to prepare for a port call.

File No.	15 - 004				
Case name	Damage to shell plating of FO tank resulting from heavy weather				
Device name	No. 3 FO tank	Damaged part	Shell plating	State of damage	Cracks
Maker name	MHI	Model		Total working time	10 years after built
Kind of ship	Container ship	Date of occurrence	1996.02.15	Place of occurrence	At sea
Cause of damage/problem	Hardware factor		Defective welding		
	Software/human factor		Main engine operation and hull resistance in heavy weather		

I. Outline of accident

[Course of events]

February 15

0930 hours A large amount of sea water was found discharging from the FO purifier water outlet.

A rise of the level gage was observed in No. 3 FO tank (P). No unusual situation was detected in other related tanks.

1140 hours The oil level in the sounding pipe of No. 3 FO tank (P) stopped rising only when the level reached the value of the ship's draft.

It was judged that the shell plating sustained some damage.

2100 hours The First Regional Maritime Safety Headquarters was notified.

February 16

0630 hours Damage was discovered in the port side shell plating of the boatswain's store.

Five forecastle frames were damaged, of those, three were buckled.

1150 hours The vessel stopped in calm waters and inspected the extent of damage in the above shell plating but failed to locate the exact location of the craks.

February 17

1000 hours It was decided to carry out a survey by divers and make temporary repairs in Sagami Bay in order to avoid oil spills in Tokyo Bay.

1100 hours The vessel notified the Third Regional Maritime Safety Headquarters, which instructed the vessel to stop before entering Sagami Bay to check for oil leaks and start operations in the same bay at 0900 hours.

[State of damage]

The crack extended over a length of 3.18 m down from a position 2 m below the water line.

[Response measures]

(1) Measures to prevent FO spills overboard

a) As a precautionary measure to prevent a leak of FO overboard, before arrival off O Shima Island, the forward overflow pipe (one of the two pipes (located forward and aft)) for No. 3 FO tank (P), running through No. 3 heel tank (P) situated above the FO tank, was severed inside the heel tank and the vessel was listed to port by 10º to displace about 120 m^3 of FO with seawater and force it into No. 3 heel tank (P), thereafter filling No. 3 FO tank with seawater.

b) The vessel stopped off O Shima with a list of 10º to Port to confirm no leakage of FO into the sea. She entered Sagami Bay accompanied by a guardboat and underwent a provisional repair of the cracked portion by divers.

Provisional repairing method: They stuffed into the cracked portion something like rubber insulation tape and applied watertight putty (putty for application to home bath tubs).

c) After discharging cargo, the vessel entered drydock of IHI, Yokohama, and underwent permanent repairs on the shell plating.

(2) Disposal of remaining water

a) No. 3 FO (P & S) tanks containing 675 m^3 of oily water were discharged into a barge at Ohi No. 4 berth by using the ship's FO transfer pump and FO supply line.

b) As for the oily water left in No. 3 heel tank (P), 130 m^3, while being heated with steam introduced through a hose from the general service steam line of the engine room, was first shifted to No. 3 FO tank (S) by using a portable pump and the remaining 10 m^3 manually recovered; and cleaning was conducted.

II. Causes of accident/problems

[Hardware factors]

The investigation result of the cracked portion described below, indicates that the creation of the crack is attributed to the following: the stress greater than usual the vessel sustained when she encountered heavy weather, caused and enlarged a crack which started from a part of defective welding, including incomplete fusion.

The incomplete fusion assumed to have been mainly caused by the low level of the welder's skills.

Result of investigation of crack in shell plating:

(1) The portion which suffered a crack corresponds to plates replaced by Mitsubishi, Nagasaki, in 1991 and by MSE in 1994.

(2) The radiographic test conducted at IHI this time revealed a defect (cavity) in the weld carried out by MSE.
(3) The broken section shows a cavity, which is considered to be an example of catastrophically incomplete fusion.
(4) The welding is assumed to have been done manually with upward manual welding in the vertical position.

[Software/human factors]

When the damage was incurred, the vessel was sailing in waters East of the Kuril Islands in heavy weather.

The vessel is installed with a propulsion generator motor, but when the engine enters a torque-rich region in rough seas and the engine speed is reduced to avoid the situation, the propulsion generator motor must be isolated. However, the additional system was isolated, the operation of the main engine itself became further torque-rich.

For this reason, the vessel was put in a situation where she was forced to maintain her engine speed even though the hull was overstrained and the main engine overloaded.

The chief and other engineers are always taking pains with the management of engine operation. This case of accident gives a lesson that, in heavy seas, they are required to manage the engine operation by also giving consideration to the hull strength in close consultation with the master.

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

IV. Lessons

In heavy weather, if the main engine were operated beyond its operating limit, it could result in damage to the hull.

Engine Trouble Cases

File No.	15 - 005				
Case name	Marine pollution caused by waste oil				
Device name	Bilge system	Damaged part	Three-way valve	State of damage	Seizure
Maker name		Model		Total working time	4 years after built
Kind of ship	Woodchip carrier	Date of occurrence	1994.04.19	Place of occurrence	Iwakuni
Cause of damage/problem	Hardware factor		Seizure of three-way valve for bilge overboard discharge pipe		
	Software/human factor		Improper handling		

I. Outline of accident

[Course of events]

April 12

0800 hours Oil globs were found floating around the port stern. Steps to recover them were immediately initiated.

0850 hours The Iwakuni Maritime Safety Station was notified.

1000 hours Maritime safety officers came on board and checked the scene of the pollution and started to interview crew members.

1050 hours An inspection to locate the leaking point was started by divers. A leak was confirmed from a bilge overboard discharge port situated at a point about 10 m forward from the right aft to the port side and about 5 m below the water line. An inspection of the relevant valves and pipes was commenced by the ship's crew.

[State of damage]

[Response measures]

II. Causes of accident/problems

[Hardware factors]

The vessel was engaged, during the port stay, in an operation to shift waste oil from the fuel oil/lube oil sludge tanks, but on that occasion the following events happened simultaneously to cause the inadvertent discharge overboard.

(1) The waste oil in the fuel oil/lube oil sludge tanks is originally supposed to be transferred to

the waste oil settling tank with the sludge pump, but instead it was shifted to the bilge tank by means of the bilge pump on this occasion.

(2) The three-way valve, downstream of the bilge separator, on the overboard discharge line, to change over between bilge tank and overboard discharge, was seized and, furthermore, the non-return valve at the bilge tank inlet was slightly sticking, both of which contributed to a partial outflow of the waste oil to the sea, not the bilge tank.

(3) The overboard discharge valve was kept locked but was not placed completely in the closed position, resulting in the oil finding its way into the sea.

[Software/human factors]

(1) The closure of the overboard discharge valve should be checked by the person in charge under his responsibility and it is his mistake to have locked the valve in a slightly opened state.

(2) The mis-operation to shift waste oil from fuel oil/lube oil sludge tanks to bilge tank with the bilge pump is attributable to the defect of the relevant manual.

III. Measures to prevent recurrence

[Hardware aspects]

(1) A check valve was newly installed between transfer line to the bilge tank and three-way valve, to prevent a leak to the overboard discharge line even in the event of the seizure of the three-way valve.

(2) A valve was established in addition to the existing overboard discharge valve to incorporate a double-shut arrangement.

(3) A water (oil) detecting valve was newly provided on the overboard discharge line. It is kept open while in port to check the line for leaks of water (oil).

[Software/human aspects]

A manual for the handling of bilge water and waste oil was prepared to keep them thoroughly under control.

IV. Lessons

Marine pollution proves disastrous once it is incurred. Crew members are required to act prudently. They cannot be over careful in preventing marine pollution.

File No.	15 - 006				
Case name	Main engine lube oil outflow into engine room				
Device name		Damaged part		State of damage	
Maker name		Model	EGE MK-2A	Total working time	
Kind of ship		Date of occurrence		Place of occurrence	During shift to KHARG
Cause of damage/problem	Hardware factor	Seizure of swing check valve			
	Software/human factor	Careless handling			

Ⅰ. Outline of Accident

[Course of Event]

Lube oil was found flowing out of the D/G lube oil settling tank overflow pipe on the second deck in the machinery space. On that day, only the lube oil purifier for the main engine was in operation. The purifier was immediately stopped and an inspection was made for causes.

[State of Damage]

The measurements of quantities in respective tanks were as follows: Main engine lube oil sump tank - reduction by 6,100 L; D/G lube oil settling tank - increase by 2,300 L; lube oil drain tank - increase by 600 L; waste oil tank - increase by 3,000 L; outflow onto the deck - approximately 200 L.

[Remedial Measures]

After 2,000 L of lube oil were recovered from the D/G lube oil settling tank to the main engine lube oil sump tank, the quantity of lube oil which flowed out proved to be 4,100 L.

Ⅱ. Cause of Accident / Underlying Problem

[Mechanical Factor]

As a result of a seizure of the swing check valve on the side of No. 1 lube oil purifier deaerater, lube oil reached the air vent header through the deaerater vent pipe; and part of the lube oil backflowed to the D/G lube oil settling tank air vent located at the lowest level of the header and the other part flowed to the waste oil tank through the drain line.

After the D/G lube oil settling tank was filled up, the lube oil which flowed from the overflow pipe dropped inside the coaming surrounding the tank and, from there, to lube oil drain tank. Some of the oil overflowed the coaming onto the floor plating.

On that day 2,000 L of lube oil had been supplied to the main engine lube oil sump tank. The same lube oil line is so structured to be used as a lube oil feed line and lube oil purifier line. The swing check valve is installed on the purifier line and so arranged to prevent a backflow upon lube oil feeding. An overhaul of the check valve revealed that this check valve had seized in the closed position when it had been subjected to back pressure upon the supply of lube oil.

[Human/Software Factor]
All check valves are susceptible to seizure or jamming in a half closed position. In the case of a check valve used to partition commonly shared piping, it is required to ensure, after having operated the valve, that the liquid inside actually flows in an intended direction.

In this case, only a touch of the pipe downstream of the check valve or monitoring of the main engine sump tank level could have sufficed to take notice of the abnormal situation before the occurrence of the accident.

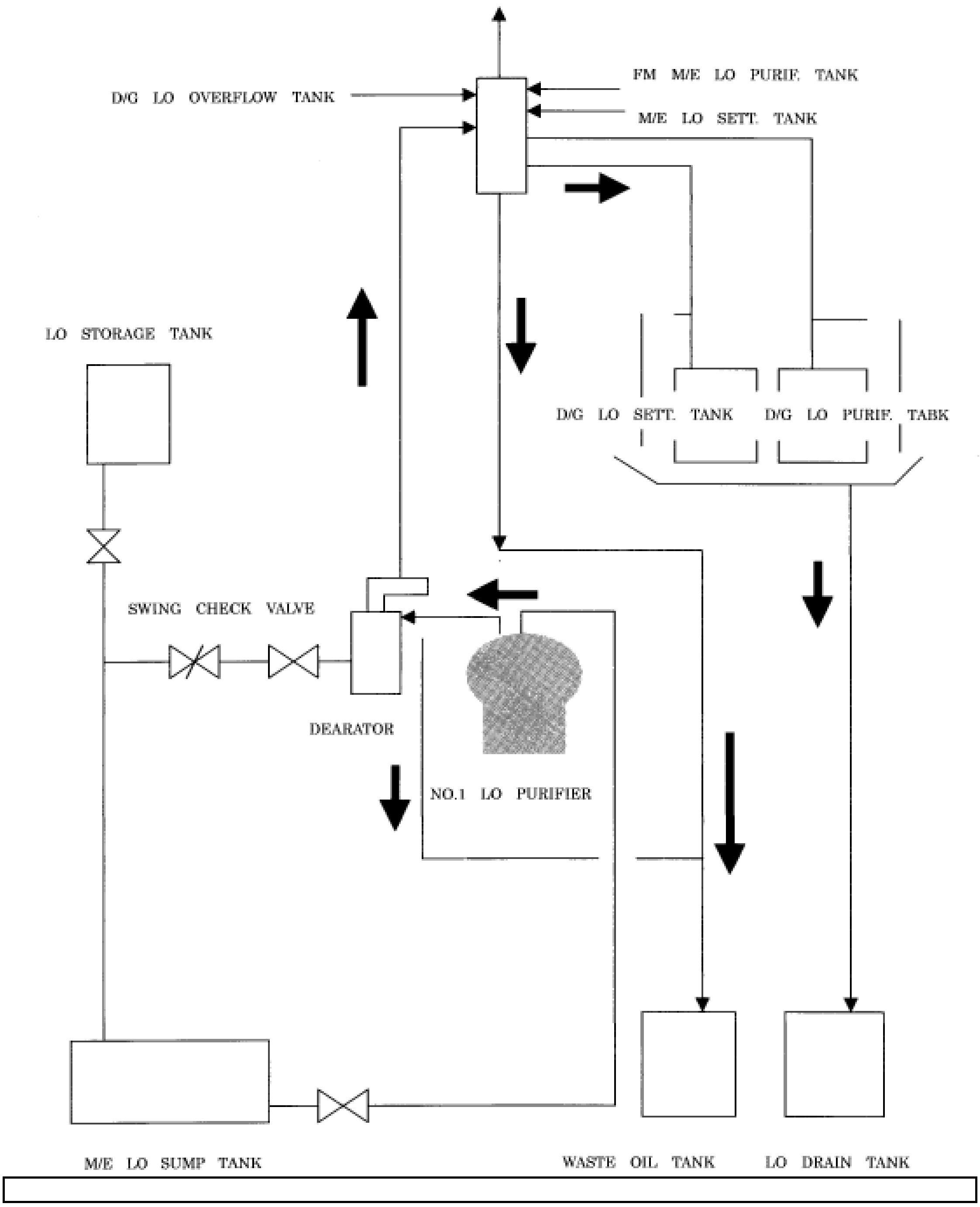
III. Preventive Measures

[Mechanical Aspect]
The swing check valve was replaced with a globe check valve so that it would be manually handled.

[Human/Software Aspect]
The operation method has been changed so that, upon the supply of new lube oil, lube oil purification is suspended once with the check valve shut and that, after the finish of the supply, the check valve is opened and purification is resumed.

IV. Lessons

When a machine is operated, it is basically required to check its operating condition.



FM M/E LO PURIF. TANK
D/G LO OVERFLOW TANK
M/E LO SETT. TANK
LO STORAGE TANK
D/G LO SETT. TANK
D/G LO PURIF. TABK
SWING CHECK VALVE
DEARATOR
NO.1 LO PURIFIER
M/E LO SUMP TANK
WASTE OIL TANK
LO DRAIN TANK

Engine accident cases

File No.	15 - 007				
Case name	Lube oil finding its way into sea while it was being shifted				
Device name	D/G lube oil	Damaged part		State of damage	Marine pollution
Maker name		Model		Total working time	
Kind of ship	Container ship	Date of occurrence	1992.07.11	Place of occurrence	Southamp-ton
Cause of damage/problem	Hardware factor		Tank overflow		
	Software/human factor		Carelessness during operation		

I. Outline of accident

[Course of events]

(1) After arrival at Southampton, it came to the notice of a crew member who was making an inspection round throughout the engine room around 1400 hours that the oil quantity in the D/G lube oil overflow tank (whose capacity is 3 m^3) had dropped to a level which required replenishment (1400 liters) and he started at 1425 hours the operation to fill the tank with new oil by opening the D/G lube oil storage tank outlet valve.
Thinking that the topping off operation by gravity would take a long time, he shut the outlet valve of the D/G lube oil settling tank (used for de-aeration of purified oil) in an attempt to reduce the time.

(2) Although he was at first monitoring the levels of the D/G lube oil storage tank and D/G lube oil settling tank, he started to wipe off the diesel generator situated in front of both tanks on the same floor since it seemed to take some time.

(3) At 1510 hours he noticed the D/G L.O. Settling tank was filled up, and he immediately opened the outlet valve of the D/G lube oil settling tank and closed that of the D/G lube oil storage tank.
When he made an inspection on deck, he found lube oil overflowing the D/G lube oil settling tank through its vent pipe on the starboard upper deck and finding its way to the sea via the sunken deck of the stern.

[State of damage]

According to calculations on the basis of the quantities of oil remaining in the engine room, that recovered on deck and that collected from overboard by use of the ship's oil absorbents, it is presumed that about 910 liters of lube oil flowed overboard.

[Response measures]

Crew members started to remove oil immediately after the discovery of the spillage, and notified parties concerned, including the ship's agent and the harbour master.

1610 hours Two marine officers (representatives of the harbour master) came on board and checked the site; they took samples of the oil in the D/G settling tank and spilled oil.

1745 hours The oil spill service center designated by the harbour master started to recover oil and completed collecting most of the spilled oil at 2115 hours.

1840 hours A local surveyor for the P&I club (UK) came on board the vessel and held interviews concerning the situation and took photographs.

2130 hours Since the completion of recovery of the spilled oil was in sight, the vessel notified the harbour master to that effect. The vessel was granted a clearance for departure at 1000 hours next morning (July 12) by submitting a letter of undertaking jointly endorsed by us and the ship's agent.

July 12 (next day)

0945 hours Upon departure from the port, when the vessel was pulled about 10 m off the wharf, crew members inspected the situation of pollution by the spilled oil in the presence of the harbour master, and noticed a small amount of oil (2 to 3 m^2) on a berth fender about the water level, which oil was recovered by a boat standing by. After checking that there was no more problem, the vessel sailed out.

II. Causes of accident/problems

[Hardware factors]

[Software/human factors]

(1) Even during an oil transfer operation, the crew member was engaged in another job; no arrangement was made to post another person, resulting in a lax monitoring of the subject operation.

(2) Taking the operation (transfer of oil) lightly, he did not have any prior discussions over the operation.

(Although the oil level of the D/G lube oil overflow tank dropped to a level of 1,400 liters (against the tank capacity of 3 m^3), which normally requires topping up, there was no need to carry out the operation during her port stay since there was some time before the oil level reached the alarm point of 700 liters.)

(3) The person engaged in the operation closed the outlet valve of the D/G lube oil settling tank in an effort to reduce the time required to top up the tank, but, as a result of his misjudgment on (wrong impression of) the piping system and inability to predict the

outcome of his action, things turned out in the worst scenario where purified oil from the purifier overflowed through the air vent pipe.

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

(1) In relation to operations liable to cause marine pollution, including not only the supply and transfer of fuel oil but also oil transfer between tanks inside the engine room, operations shall be carried out, regardless of the kind of oil, under the direction of the chief engineer and department head (including reporting to them) on the basis of the provisions for the control of fuel oil and lube oil as specified by the work regulations.

[Examples of work regulations]

1) The chief engineer shall exercise, and be responsible for, proper control over fuel oil and lube oil in their replenishment and use.
2) Before the supply of fuel oil and lube oil, the chief engineer shall check bunkering plans, related facilities and oil spill prevention measures by himself and thoroughly inculcate the oil spill prevention measures in those to be engaged in the operation.
3) Due care shall be taken in the transfer and disposal of fuel oil, lube oil and bilge water and the transfer of fuel oil, in particular, shall be done under the direct command of the chief engineer, with close communication kept with the deck department.
4) The control and spill prevention of fuel oil and lube oil shall be done under the direct command and supervision of the chief engineer.

(2) Regardless of the kind of oil, whether fuel oil, lube oil, waste oil, or oily bilge water, transfer procedures containing operational sequence and related piping diagrams shall be prepared and posted at appropriate locations and, furthermore, warning plates be displayed as necessary.

(3) Full discussions shall be held among parties concerned, on the basis of operating plans and documented operational procedures, before the commencement of operations. Operations to shift oil between tanks during a short port stay or at nighttime shall be avoided as far as practicable, except operations to supply fuel oil and lube oil.

(4) In the preparatory operation, checks shall be made against the checklist and the on-site person in charge shall check the “open/closed” state of each valve by touching it by hand.

(5) During operations, the person assigned to such a station shall be exclusively engaged

in the monitoring work without being distracted by other operations. During bunkering operations, in particular, he shall not be engaged in other operations related to fuel oil.

(6) All the scuppers shall be completely stopped up with wooden plugs, cement, sand bags, or otherwise, during bunkering or shifting operations.

IV. Lessons

Once an oil spill incident occurs, the vessel will be held liable in any case regardless of whether there is negligence or not on her part.

Specific precautions during bunkering or shifting operations have been given since before such as: "Never leave the assigned post," "Never carry out other jobs simultaneously."

Such instructions have recently been neglected and the accident taken up here seems to have occurred since the basic procedures were disregarded.

It is essential that all personnel be inculcated in these basic matters concerning various operations and that they endeavor to prevent accidents.

File No.	15 - 008				
Case name	Boiler ignition failure resulting from contamination of DO service tank with HFO				
Device name	DO service tank	Damaged part		State of damage	Contamina-tion with HFO
Maker name		Model		Total working time	Half year after built
Kind of ship	Oil tanker	Date of occurrence	1992.06	Place of occurrence	
Cause of damage/problem	Hardware factor	Nil			
	Software/human factor	Fuel change over upon stopping generator engine			

I. Outline of accident

[Course of events]

(1) From around half a year after the vessel was built, it was often the case that the main and auxiliary burners of the auxiliary boiler failed to ignite. In the case of the pilot burner, in particular, the combustion condition became unstable after its ignition, i.e., the burner gets ignited only till the igniter was on, and did not continue burning thereafter.

(2) The engineer in charge made various attempts, such as maintenance of the burner and adjustment of the temperatures and pressures, but the situation did not improve. For the purpose of identifying its cause, he established a makeshift tank and separated it from the existing DO service line, thereby to supply diesel oil of good quality. This measure actually worked and drastically reduced ignition failures.

[State of damage]

A large amount of HFO found its way into the DO service tank, deteriorating the quality of diesel oil.

[Response measures]

II. Causes of accident/problems

[Hardware factors]

Upon stopping generator engines, crew members used to change over from HFO to DO almost at the same time and the HFO remaining inside the line of generator engine flowed back to DO through return line. This practice over a long period allowed HFO to find its way to the DO service tank, increasing the viscosity of DO.

[Software/human factors]

The changeover of inlet and outlet upon the changeover from HFO to DO will naturally admit HFO remaining in the generator engine into the DO line.

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

(1) Procedures for changing over HFO/DO for generator engines

  (a) When changing over from HFO to DO upon stopping an engine, never change over the engine outlet valve (return valve) immediately after the changeover of the inlet valve but continue running the engine as it is with the HFO return valve open for some time and change over to DO after the system is completely filled with DO to the outlet valve.

  (b) In the case of a remote automatic changeover system with a three-way valve, set the timing, as far as possible, to correspond to the actual replacement with DO.

(2) Bear the following in mind on board vessels without the installation of a DO settling tank:

  (a) Recently, generator engines have come to run exclusively on HFO, in addition to propulsion engines running only on HFO, bringing about a drastic decrease in DO consumption. For this reason, DO settling tanks are not found on board many ships and DO service tanks have become smaller in capacity as compared with those on board traditional vessels. It follows that, in the event of the operation of a boiler being hampered by more viscous DO as a result of its contamination with HFO, it has become more difficult to take immediate response action because of the lack of redundancy of the system.

  (b) DO, therefore, must be maintained in good condition at all times. Check locations where there is a possibility of contaminating DO tanks with HFO on every such occasion, and overhaul the three-way valve for the return of HFO, if necessary. There is a need to give consideration to emergency needs to use DO of good quality or kerosene for a boiler.

IV. Lessons

You should never do any operation mechanically but should, think before taking such action, what result will follow.

File No.	15 - 009				
Case name	Generation of bacteria which reduced inhibiting effects for generator engine cooling water system				
Device name	Cooling water system	Damaged part	D/G cooling water system	State of damage	No corrosion protective effect
Maker name		Model		Total working time	
Kind of ship		Date of occurrence	1991.04	Place of occurrence	
Cause of damage/problem	Hardware factor	Generation of nitrobacter			
	Software/human factor	Nil			

I. Outline of accident

[Course of events]

Around leaving a drydock, despite sufficient, additional injection of a chemical agent for the generator engine cooling water system (the system is independent from that for the main engine), the corrosion protective chemical content dropped and the maker made an analysis.

[State of damage]

The maker's analysis results showed that a nitrite, the main component of the inhibitor, had changed to a nitrate without any inhibiting effects, and that electric conductivity increased remarkably.

[Response measures]

The cooling water was entirely exchanged and a bactericide and an inhibitor were injected.

II. Causes of accident/problems

[Hardware factors]

Nitrite, which is the main component of the inhibiting agent, is subject to oxidation or reduction and it transforms itself to nitric acid ion when oxidized and to ammonium when reduced. The following analysis results of the ship's cooling water hinted at a high probability of the generation of bacteria which convert a nitrite to nitric acid.

(1) The cooling water of the vessel became below 58ºC (the bacteria reproduce below 58ºC);

(2) There was no red rust found in the water system, almost ruling out the possibility of the decomposition of the nitrite by rusting;

(3) Since the ammonium content in the cooling water was low, showing no increase in pH, no reduction occurred; and

(4) The density of the nitrite sharply dropped.

[Software/human factors]

It makes a big difference if you have technical knowledge.

Even if you do not have technical knowledge, you have to report whenever you feel strange and obtain information.

III. Measures to prevent recurrence

[Hardware aspects]

[Software/human aspects]

IV. Lessons

Nitrobacter which is one of the nitrifying bacteria:

If nitrobacter grows in cooling water, the nitrite content is said to drop sharply and become zero in several days. The following information is known about nitrobacter:

(1) Characteristics
  (a) Relationship with oxygen
    Nitrobacter nitrifies only in aerobic conditions.
  (b) Relationship with temperature
    Its optimal temperature for growing and oxidation ranges from 25 to 30ºC. It dies if it is left at a temperature from 56 to 58ºC for 10 minutes.
  (c) Relationship with pH
    The most suitable pH for growth is 8.0 to 9.3.

(2) Necessary nutrition sources
  (a) Energy sources and nitrogen sources
  (b) Carbon sources

(3) Phenomena when generated
  (a) The exchange of water only will not prevent the drop of nitrite content caused by nitrobacter.
    Nitrobacter not only lives in circulating water but also adheres to pipe walls, etc.
  (b) The speed of nitrite reduction is extremely high.
    Once the nitrite content begins dropping, it becomes zero in a few days.

File No.	15 - 010				
Case name	Spurts of oil from waste oil tank				
Device name	Waste oil tank	Damaged part		State of damage	Water pollution
Maker name	UBE INDUSTRIES, LTD.	Model		Total working time	
Kind of ship	Container	Date of occurrence	1993.09.27	Place of occurrence	HAMBURG
Cause of damage/problem	Hardware factor	Clogged drain pipe of vent line drain separator			
	Software/human factor	Mishandling			

Ⅰ. Outline of Accident

[Course of Events]

During port cargo operations, a duty officer noticed oil film on the sea surface of the vessel's starboard side. Also, oil mist was flowing from the waste oil settling tank air vent pipe in the funnel. At that time, the engine department was moving the contents of the oily sludge tanks to the waste oil settling tank. The parties concerned investigated the pollution and came to an understanding of no penalty on this occasion, excepting a bond as security for covering anticipated cleanup costs.

[State of Damage]

Regarding the pollution, it is estimated that the quantity of spilled oil was 2-3 litres, and the extent of pollution by oil film about 400-500m^2.

[Disposition]

The Master immediately informed the Oil Spill Decontamination Station, and arranged the necessary steps to contain and rectify the problem. He then, through the Agents, reported the events to the Water Police and P&I inspector.

Ⅱ. Cause of Accident / Underlying Problem

[Mechanical Factor]

The waste oil settling tank had been filled to 60% of its capacity with heated waste oil. The incident occurred soon after the shifting of waste oil from the sludge tanks to the waste oil settling tank.

A ship investigation revealed that the drainpipes of the drain separator in the heating vapor vent line were clogged.

Probable sequence of events:

a) Water content in the shifted waste oil evaporated rapidly due to the latent heat of the remaining waste oil in the waste oil settling tank.
b) This explosive oily mist spouted from the vent pipe, together with accumulated oil in the drain separator.

[Human/Software Factor]

①Sending cooled sludge oil to the tank, when the tank temperature had risen to more than 100℃.

②Heating the waste oil tank to a temperature exceeding 100℃ after arrival in port.

③Changing the oil whilst in port.

III. Preventive Measures

[Mechanical Aspects]

a) Stop the heating of waste oil tanks, including waste oil settling and service tanks, prior to entering port;
b) Do not run the waste oil incinerator during stay in port;
c) Do not shift waste oil settling or service tank during stay in port; and
d) Periodically check for clogging of pipes from drain separators and oil mist box.

[Human/Software Aspect]

Take all necessary precautions to prevent marine pollution.

IV. Lessons

It is important we recognize that marine pollution prevention must always remain a top priority, and that this incident was entirely avoidable. In the port, we must be especially vigilant in preventing environmental pollution, and take especial care with work that involves a danger of environmental pollution.

The drainpipe should have been cleaned periodically as it was susceptible to choking. Dirty sides to air vent pipes are a good indication that the drainpipe has become clogged with sludge. Action to unclog the drainpipe should be taken immediately.