

Condition assessment of *Sea Breeze* by Braemar Technical Services for MAIB

“SEA BREEZE”

Final Report

27 May, 2014



“SEA BREEZE”

At

Fowey, United Kingdom

10 to 11 April, 2014.

“SEA BREEZE”

27 May, 2014

Final Report

For
Marine Accident Investigation Branch

Acting on behalf of
Marine Accident Investigation Branch

Your ref : MAIB04/03/105
Our ref : GSS / 317088
Prepared by : XXXXXXXXXX

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1 INTRODUCTION

- 1.1 Acting on Instruction received from the Marine Accident Investigation Branch (MAIB), we attended “SEA BREEZE” (“the Vessel”), afloat at Fowey, Cornwall, between 10 and 11 April, 2014, for the purpose of carrying out a condition assessment following a reported flooding of the vessel whilst on passage.
- 1.2 Throughout our attendance, the vessel remained without electrical power, restricting normal operational testing, and limiting the extent of the inspection to visual only.

2 DOCUMENTS

- 2.1 We note that all Statutory and trading Certificates have been removed from the vessel by MAIB, hence were unavailable for inspection on board during our attendance.

3 DETAILS OF THE VESSEL

- 3.1 “SEA BREEZE” is a single compartment, general purpose bulk carrier, of 1959 gross tonnes displacement, certified to carry 2980 tonnes deadweight.
- 3.2 The vessel was built at Damen Yard, Netherlands, in 1989 under the name “MINDFUL”. Initially entered for Classification purposes with Germanischer Lloyd (GL), the Vessel has since undergone a number of name changes and also Classification Society, and at the time of the casualty was classified with Lloyds Register (LR) under the current registered name, “SEA BREEZE”.
- 3.3 Following the casualty, we understand that LR has subsequently declassified the vessel.

4 BACKGROUND DETAIL

- 4.1 “SEA BREEZE” was laden with a cargo of 2750 tonnes of #1 graded crushed limestone, and on a coastal voyage between Llanddulas to Shoreham. On 9 March, 2014 whilst ship’s staff were reportedly attempting to repair a leaking ballast pump, flooding of the machinery space occurred to the extent that the Master ordered the vessel to be abandoned whilst some 11 miles off Lizard Point, Cornwall.
- 4.2 The vessel Owners appointed Keynvor MorLift Ltd (KML) based in Exeter, to assist with salvage of the Vessel. KML subsequently attended the Vessel in conjunction with Seawide Services and initially reduced flooding using high capacity salvage

pumps. KML entered the machinery space to confirm the source of ingress, and were able to stop the ingress of water.

- 4.3 The hull was declared watertight, and KML commenced dewatering of the machinery space, transferring sea water to various empty ballast tanks. Commensurately, the vessel was towed towards Fowey Harbour where the vessel would eventually berth on 19 March 2014
- 4.4 KML remained as custodians of the vessel until 03 April, following which Brookes Bell Marine Consultants, (BB), were appointed by Owners Protection and Indemnity Insurers (P&I) to complete dewatering of the vessel in conjunction with Adler and Allen Environmental Services.
- 4.5 Dewatering of the vessel was completed on 11 April, 2014, during which approximately 770 tonnes of seawater/ slops were removed from the vessel.
- 4.6 The undersigned attended the vessel between 10 and 11 April; the following details and findings were made during survey.

5 SCOPE OF SURVEY

- 5.1 The remit of our condition survey included identifying (any) defects on board, and, commenting upon whether these were likely to have existed pre-casualty. Additionally, we were required to comment on the overall apparent condition of the vessel as found.
- 5.2 During our attendance onboard "SEA BREEZE", the survey was carried out in conjunction with the interested parties as follows: -
 - ██████████ - Brookes Bell Marine Consultants, on behalf of Owners P&I;
 - Various - Alder and Allen Environmental Services;
 - ██████████ - Braemar Technical Services, on behalf of MAIB.
- 5.3 Throughout the survey, the vessel remained without electrical power; hence the scope of our inspection remained visual with limited operational testing of equipment on board.

6 FOUND AT SURVEY

6.1 As preliminary advice, key points noted on survey are itemised below and, in our opinion, have been classified as Unseaworthy and Unsafe accordingly: -

6.1.1 The starboard side anchor windlass machinery brake system was noted damaged beyond use. It is apparent that the cause of the damage is due to insufficient maintenance. The condition as found renders the vessel unseaworthy, and was probably in the same condition as sighted, prior to the casualty.



Figure 1 Starboard windlass brake mechanism, defective.

6.1.2 The forward mezzanine deck, immediately aft' of the forward mooring deck was noted to be cracked in way of several ballast tank sounding pipes, thus allowing any water remaining on the deck to enter forward compartments. The condition as found is a contravention of Load-Line regulations and renders the vessel unseaworthy. It is probable that these cracks were present prior to the casualty.



Figure 2 Crack within main watertight deck.

6.1.3 The port side anchor hawse pipe was noted showing indication of corrosion and leakage, although the full extent of the defect could not be positively confirmed during our attendance. Such loss of watertight integrity would render the vessel unseaworthy. It is probable that the condition, as sighted, was present pre-casualty.



Figure 3 Port side anchor hawse pipe, leakage.

6.1.4 The starboard side anchor hawse pipe was also noted showing indication of corrosion and leakage, although the full extent of the defect could not be positively confirmed during our attendance. Such loss of watertight integrity would render the vessel unseaworthy. It is probable that the condition, as sighted, was present pre-casualty.



Figure 4 Starboard side anchor hawse pipe, leakage.

6.1.5 The forward mooring deck access hatch to the space below was noted not to be fitted with rolled edges. The as-fitted edges were partially wasted allowing certain leakage into the space. Such loss of watertight integrity would render the vessel unseaworthy. It is probable that the condition, as sighted was present pre-casualty.



Figure 5 Forward space access hatch, damage lip edge.

6.1.6 The forward space vent head was noted to have seized open, preventing the vent head from being manually closed. This condition prevents the forward space being made watertight, rendering the vessel unseaworthy. It is probable that the condition, as sighted, was present pre-casualty.



Figure 6 Forward space vent head, seized.

6.1.7 Various areas of cementing patches/ skimming were noted throughout on the forward mooring deck. Such practise generally suggests attempts to mask steel damage and/ or wastage. Precise determination would require removal of such cementing.



Figure 7 Evidence of cementing/ skimming on forward mooring deck.

6.1.8 Immediately below the above cementing patch/ skimming, under-deck, a wooden board supported by a prop was noted. This suggests the general practise of skimming over wasted/ penetrating corrosion within the main watertight deck to prevent leakage. This inappropriate repair is not Class approved and prevents the forward space being made watertight rendering the vessel unseaworthy. It is probable that the condition, as sighted, was present pre-casualty.



Figure 8 Supported wooden plate beneath forward mooring deck.

- 6.1.9 Located at the midpoint of the port side main deck, we noted an extraordinary and inappropriate temporary patch repair which is not Class approved. We are unable to confirm the purpose for such but would suggest this exists to mask steel damage/ penetrating wastage with loss of watertight integrity to the space below. In our opinion it makes the vessel unseaworthy and provides further concern to the strength and integrity of the main deck as this localised repair patch may be indicative of more widespread wastage of the deck plating. It is probable that the condition as sighted during the survey was present pre-casualty.



Figure 9 Temporary patch, port side main deck.

- 6.1.10 It was noted that the aft' mooring deck hatch giving entry to the machinery space had been removed, possibly by Salvors. The poor condition of the hatch lid fixings, hinges and securing dogs, indicates this hatch probably was not correctly attached pre-casualty.



Figure 10 Aft' mooring deck, machinery space hatch.

6.1.11 The main cargo space access hatch (aft') was sighted to be in poor condition. The hatch lid fixings, hinges and securing dogs as fitted, did not provide for efficient closing, rendering the hatch not watertight in contravention of Load Line Rules and the vessel subsequently unseaworthy.



Figure 11 Main cargo space access hatch, not watertight.

6.1.12 The starboard side chain locker access hatch was sighted as open, although the cover was not immediately available. Speculation exists that the cover was removed by Salvors to provide access to the locker, but this has not been confirmed. In its present condition, this would render the vessel unseaworthy.



Figure 12 Starboard side chain locker, access hatch cover missing.

- 6.1.13 A number of hatch cover side cleats were sighted to be defective through buckling or missing entirely, rendering the vessel unseaworthy. We cannot confirm whether these conditions were present pre-casualty but suspect they were, due to their general condition.



Figure 13 Defective hatch cover cleat.

- 6.1.14 Several hatch cover cleats were rendered inoperative due to absent/damaged snugs, rendering the vessel unseaworthy. As remedial repairs to the coatings had apparently been effected around these areas, it is probable these conditions had existed pre-casualty.



Figure 14 Defective hatch cover cleat, missing snug.

- 6.1.15 The forward mast was observed with minor deflection towards aft'. In way of the immediate area of the bend, we noted an apparent soft patch, most likely "duct tape" or similar, which may have been applied to mask corrosion or a steel perforation and painted. It is probable that this condition existed pre-casualty, and would render the vessel unseaworthy, not only for structural safety but navigation lights would be affected and out of line.



Figure 15 Temporary patch on forward mast.

- 6.1.16 The forward deck lifebuoy was notably absent from its stowage position and not apparently available on board. Whilst we cannot confirm this condition existed pre-casualty, it would however contravene SOLAS Regulations and render the vessel unsafe.



Figure 16 Absent lifebuoy.

- 6.1.17 A number of raised walkway platforms, particularly those at the forward mooring deck area were noted to be damaged, rendering the vessel unsafe. In view of the nature and extent of damage and corrosion sighted, it is probable the condition existed pre-casualty.



Figure 17 Damaged walkway.

- 6.1.18 The main engine final exhaust section was detached through corrosion and material wastage. In our opinion, this was not a recent defect. The exhaust pipe section had subsequently been temporarily secured using various types of lashing equipment. This was not reported to have been done by Salvors or a third party. Based on the degree of corrosion evident, in our opinion, we would suggest this condition had probably existed pre-casualty.



Figure 18 Main engine final exhaust, detached.

7 CONDITION ASSESSMENT

7.1 General Condition

- 7.1.1 During the survey carried out by the undersigned, as per the scope of work given, numerous indications of ongoing neglect, both cosmetic and structural were exhibited onboard the Vessel. Considering the time of 32 days from the flooding event to the date of this survey, the level of corrosive deterioration that may be expected would be relatively minimal, therefore it is reasonable to suggest that the neglect and poor conditions sighted onboard probably commenced a significant time prior to the time of the casualty.
- 7.1.2 General coating condition throughout the vessel is poor. There are repeated examples on both the main watertight deck and mooring decks of bare, uncoated, steel with considerable corrosion evident, indicating extended periods during which protective paint coatings were not adequately maintained. The forward mooring deck is particularly poor, especially considering the apparent need for application of skimming cement to mask steel corrosion and probable loss of water tight integrity.
- 7.1.3 Deck pipe-work, including ballast tank vents and the statutory fire-main distribution system show indications of a general lack of maintenance. Typical procedures such as valve lubrication and chipping and painting appear not to have been carried out, raising questions as to the fire system integrity and the effectiveness of such a system in an emergency.
- 7.1.4 Personnel access-ways across the main cargo hatch covers, although cosmetically satisfactory, were sighted to be structurally poor. Several of the platforms had become holed due to corrosion and instead of being replaced; ships staff appear to have alternatively de-scaled the affected areas and painted over the perforated steel work. This has left sharp, open foot traps and trip hazards.
- 7.1.5 Cargo equipment was similarly noted to be in poor condition, both cosmetically and operationally. A number of side hatch cleats and/ or snugs, were found damaged or missing entirely. Of those that were present, several were found incorrectly adjusted or impossible to adjust due to excessive corrosion and solid rubber compression washers. Hatch lid stowage locks, located at the forward and after ends of the vessel, designed to hold the hatch cover segments vertically when open during cargo operations were found seized and inoperative. The nature and extent of corrosion sighted affecting these was considerable, indicating they had not been used for some time and are therefore pre-incident existing items.
- 7.1.6 A number of cracks in the main watertight deck were sighted, affecting the forward area generally. Without expert analysis including thickness testing, it is impossible to accurately determine the extent of these cracks. The corrosion visible in way of these cracks indicates they were probably formed some time prior to this flooding incident. It is notable from Port State reports issued relating to the Vessel, that localised

flooding of the forecastle spaces immediately below the cracks had been reported on several occasions, prior to the casualty. We would confirm this having noted considerable corrosion affecting the space, consistent with stagnant water remaining there for some time.

- 7.1.7 The main aft' machinery space, although clearly damaged during the casualty, appears generally satisfactory. Equipment remaining appears adequately maintained with minimal evidence of temporary patching of fluid piping systems normally associated with vessels of this type and age. Maintenance was clearly being planned as various unopened packing cases apparently containing machinery spare parts were sighted throughout the space. The overall cosmetic condition of the machinery space further suggests that the area was being maintained to an acceptable standard. However, further investigation would be required to form a definitive opinion as regard to proper machinery maintenance and operation having been carried out by the crew prior to the casualty.
- 7.1.8 The accommodation area, including public rooms, although clearly damaged following submersion, was seen to be minimally appointed, and below the current standards required by Maritime Labour Convention (MLC) Regulations. It is understood that these aspects have been officially commented upon during recent port State inspections although we cannot confirm the precise nature of such at this stage.

7.2 Casualty Damage

- 7.2.1 "SEA BREEZE", as surveyed, has suffered complete submersion by seawater of the main aft' machinery space, containing main propulsion and auxiliary machinery. Attempts were apparently made by Salvors to limit the effects of seawater to the main and auxiliary engines, but the extent of such observed during our attendance is unlikely to be sufficient to render the machinery to be commercially salvageable.
- 7.2.2 The accommodation areas of the vessel were also partially submerged by seawater, and included the galley and crew personal/ public spaces. All internal bulkheads located below the main watertight deck level, incorporating fire protection, insulation and inter-deck spaces have been damaged extensively requiring complete replacement. It is unlikely that any furnishings, insulation materials or effects remain commercially salvageable.
- 7.2.3 Electrical equipment including the main power generation equipment, machinery space distribution systems and domestic systems, including the galley and stores have been submerged by seawater and by their nature will most certainly require complete replacement prior to (any) reuse. The scope of repairs in this respect is large; costs for this alone could quite possibly exceed the commercial value of the vessel as a whole.

8 CONCLUSION

- 8.1 A number of conditions were sighted during survey which would render the vessel out of Class and unseaworthy in its present condition and probably prior to the flooding incident. Included in these is the defective anchor windlass brake which alone is sufficient to declassify the vessel. Additionally, the various main watertight deck cracks, temporary patches covering unconfirmed corrosion/ steel perforations giving rise to a loss of water tight integrity, further confirms the vessel having been unseaworthy pre-casualty.
- 8.2 The Vessel's condition as referred to at paragraph 8.1 above were probably present pre-casualty, and whilst not individually or collectively causative, could have lead to a separate casualty, potentially resulting in loss of life, vessel and cargo.

27 May, 2014


for and on behalf of
BRAEMAR Technical Services Ltd.

Paris MOU Port State Control Inspection defects

OFFICIAL-SENSITIVE

In January 2014, an inspection in Riga, Latvia identified 10 deficiencies that were required to be rectified prior to departure from port (code 17 deficiencies).

Life-saving appliances	Rescue boat inventory incomplete
Certification/Documents	Records of rest entries missing
Certification/Documents	Oil record book not properly filled
Emergency systems	Emergency lighting, batteries, switches not properly maintained
Emergency systems	Muster list incomplete
Fire safety	Personal equipment for fire safety not as required
Fire safety	Remote means of control (opening, ventilation etc) machinery spaces not as required
Safety of navigation	Other – out of date publications on board
Emergency systems	Emergency source of power not as requires
Food segregation	Not adequate

OFFICIAL-SENSITIVE

In September 2013, an inspection in Bremen, Germany identified 14 deficiencies, 12 of which were code 17.

Living and working conditions	Cleanliness of engine room insufficient
Safety of navigation	Expired charts in use
Fire safety	Emergency escape breathing devices, not as required
Radio Communications	CD containing ship MMSI assignments expired
Structural condition	Decks corrosion. Main deck and hatch covers in poor condition
Living and working conditions	Eye wash and engine first aid kit expired
Living and working conditions	Unsafe electrical appliances
Living and working conditions	Accommodation ventilation system inoperative
Certificates & Documentation	Oil record book not as required
Certificates & Documentation	Oil record book entries missing
Life saving appliances	Immersion suits not ready for use
Certificates & Documentation	Garbage record book – old edition in use
Pollution prevention	Marpol – leak on hydraulic system for hatch covers to be rectified
ISM	Not as required

Flooding and abandon ship emergency checklists

	СУДОВЫЕ ЧЕК - ЛИСТЫ Shipboard Check- Lists					35	
	Редакция Revision	01	Документ Document	2-02-ISM	Номер ИМО IMO Number	5698826	Дата корректуры Correction Date

3.9 ЗАТОПЛЕНИЕ

|| FLOODING

1.	Выполнены ли следующие действия? Have the following actions been carried out?	
2.	Объявить общесудовую тревогу. Announce general emergency alarm.	
3.	Приступить к действию в соответствии с Оперативным Планом по борьбе с водой. Start acting in accordance with the Operational water control plan.	
4.	Произвести герметизацию корпуса.. эвакуировать пострадавших Effect hermitization of the hull. evacuate casualties	
5.	Привести в полную готовность все технические средства системы живучести. Get ready all damage control technical appliances.	
6.	Определить причины поступления воды, установить характер повреждений.. Identify water intake causes, nature of damage..	
7.	Оценить опасность для судна, груза, жизни людей. Assess risks for the ship, cargo, people.	
8.	Организовать заделку пробоины. Make arrangement for stopping the leaks.	
9.	Запустить водоотливные средства. Start pumping appliances.	
10.	Предотвратить распространение воды в другие помещения. Prevent water from penetrating into other compartments.	
11.	Произвести расчеты поступления забортной воды, аварийной посадки и остойчивости. Make calculation of the sea water intake, emergency draught and stability.	
12.	Остановить судно, изменить курс, уменьшить бортовую качку и поступление воды. Stop the ship, alter course to reduce rolling and intake of water.	
13.	Определить варианты борьбы с водотечностью и приступить к их реализации. Identify method of flooding control and start its implementation.	
14.	Обесточить электрооборудование в районе водотечности с разрешения капитана. Cut off the equipment in way of leaks from power supply at the permission of the master.	
15.	При поступлении воды в количествах, поддающихся откачке судовыми водоотливными средствами: If water intake is within the capacity of the ship's pumping appliances:	
16.	* остановить движение судна; stop the ship;	
17.	* завести пластырь и заделать пробоину; stop the leaks by mats;	
18.	* выровнять крен; offset the list;	
19.	* откачать воду. pump out water.	
20.	При угрозе загрязнения моря нефтепродуктами действовать в соответствии с "Судовым планом чрезвычайных мер по борьбе с загрязнением нефтью". In case of danger of sea pollution by oil products act in accordance with "SOPEP".	
21.	Передать сообщение об аварийном случае компании Notify the Company and to Company partners concerned,	
22.	Сделать запись в судовом журнале о фактических данных инцидента. Make entries in the log book about the facts of the incident.	
23.	Если поступление больших масс воды, грозит затоплению судна: If the leaks and intake of great quantity of water threatening the ship's flooding:	
24.	* производить непрерывную откачку воды; maintain continuous pumping of water;	
25.	* следовать к месту укрытия или отмели; proceed to a shelter or shallow waters;	
26.	* обратиться за помощью к ближайшим судам или спасателям; request assistance of nearest ships or salvage vessel;	
27.	* объявить тревогу. announce emergency alarm.	

(Ф.И.О./ Name)

(должность/ position)

(дата/ date)

(подпись/ signature)

	СУДОВЫЕ ЧЕК - ЛИСТЫ					41	
	Shipboard Check- Lists						
Редакция Revision	01	Документ Document	2-02-ISM	Номер ИМО IMO Number	5698826	Дата корректуры Correction Date	18.02.2013

3.13 ОСТАВЛЕНИЕ СУДНА
|| ABANDONING SHIP

1.	Выполнены ли следующие действия? Have the following actions been carried out?	
2.	Включена авральная сигнализация General Emergency Alarm signal sounded	
3.	Команда собрана в местах сбора/посадки в спасательные средства Crew assembled at muster/survival craft stations	
4.	Установлена связь с судами и СКЦ Communication established between ship and SCC Co	
5.	Передать сообщение об аварийном случае компании и всем заинтересованным партнерам компании в соответствии с "Планом действий в аварийных ситуациях". Notify the Company and to Company partners concerned, according to "Shipboard Emergency Plan".	
6.	Включить спутниковый аварийный радиобуй "КОСПАС-SARSAT" и радиолокационный ответчик. Activate COSPAS-SARSAT epirb and SART.	
7.	Передать аварийное донесение и подать сигнал бедствия на аварийной частоте. Transmit distress message and distress alert on distress frequency.	
8.	Провести дополнительное снабжение спасательных средств одеялами, лекарствами, одеждой, пиротехникой, носимыми УКВ радиостанциями. Supply additional blankets, medicines, clothing, pirotechnical appliances, portable VHF stations to lifecraft.	
9.	Захватить карты, судовой, машинный и радио журналы, по возможности — документы и ценности. Take charts, deck, engine and radio log books as well as documents and valuable things if possible.	
10.	Доставить в спасательное средство спутниковый аварийный радиобуй "КОСПАС-SARSAT" и радиолокационный ответчик. Transfer COSPAS-SARSAT EPIRB and SART into lifecraft.	
11.	Подготовить к спуску спасательные средства с учетом реальных возможностей спуска. Prepare lifecraft for launching taking into consideration actual launching capabilities.	

 (Ф.И.О./ Name)

 (должность/ position)

 (дата/ date)

 (подпись/ signature)

Примечание: Чек-лист заполняется вахтенным помощником капитана ||| Note: Control list (check-list) is completed by Watch Mate

Report on valve from A&P Shipyard Falmouth

FINDINGS REPORT OF SEA VALVE REMOVED FROM VESSEL SEA BREEZE

VALVE WAS GIVEN TO A&P FALMOUTH TO ASSESS WORKING CONDITION, ON RECEIVING VALVE IT WAS IN AN OPEN POSITION. THE GEARBOX SPINDLE WAS THEN OPERATED BY HAND, TO DETERMINE IF VALVE WAS OPERATING CORRECTLY BY WAY OF SHUTTING VALVE. AFTER APPROXIMATELY SIX TURNS THE VALVE STOPPED CLOSING, EVEN THOUGH VALVE WAS STILL IN A PARTIALLY OPEN POSITION. THE VALVE GEARBOX COVER WAS THEN REMOVED, AND, THE SPINDLE WAS THEN OPERATED AGAIN. WITH THE GEARBOX COVER REMOVED IT WAS EVIDENT THAT THE TOP HAT THRUST BUSHES THAT SHOULD BE FITTED IN THE GEAR BOX AT EITHER END OF THE OPERATING SPINDLE WORM WHEEL WERE MISSING, THIS IN TURN ALLOWED THE SPINDLE WORM WHEEL TO THRUST BACK AND FORTH WITHIN THE GEARBOX UNTIL THE WORM WHEEL CAME INTO CONTACT WITH THE GEARBOX CASING, IN EFFECT JAMMING THE VALVE , SO AS NO FURTHER MOVEMENT WAS POSSIBLE.

THE VALVE PADDLE SPINDLE QUADRANT GEAR, WHICH, IN TURN IS OPERATED BY MEANS OF THE SPINDLE WORM WHEEL WAS THEN REMOVED, AND THE VALVE SHUT FULLY BY HAND. A PRESSURE TEST WAS THEN CARRIED OUT ON THE VALVE, THE VALVE HELD PRESSURE (IE NO LEAKAGE DETECTED) UNTIL A PRESSURE OF 3.6 BAR HAD BEEN ACHIEVED, AT THIS POINT A SMALL LEAKAGE WAS VISIBLE BETWEEN THE VALVE PADDLE, AND, THE RUBBER LINING OF THE VALVE.

ALL VALVE COMPONENTS WERE CLEANED (GREASE REMOVED FROM GEARBOX, SPINDLE WORM WHEEL, AND, PADDLE QUADRANT GEAR), ON CLOSE INSPECTION WHEN ALL PARTS HAD BEEN CLEANED, IT WAS EVIDENT THAT, A WELD REPAIR HAD BEEN CARRIED OUT ON THE PADDLE SPINDLE QUADRANT TEETH, ALSO THE SPINDLE WORM WHEEL HAD EXCESSIVE WEAR, THIS, ALONG WITH THE MISSING THRUST BUSHES, WERE SERIOUSLY AFFECTING THE OPERATION OF THE VALVE.



ENGINEERING MANAGER (A&P FALMOUTH) 21ST DECEMBER 2014



Report and analysis on Valve, Material Technologies Ltd

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Report on Failure of Butterfly Valve

Gearbox Ref 14/0249/PB/01/28 ex Vessel Sea Breeze

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December 18th 2014

Our Reference. MAIB E12009

Introduction

We are informed by ██████████ of MAIB that on 9th March 2014, flooding of the engine room of the vessel 'Sea Breeze' occurred as a result of mal-operation of a butterfly valve. The valve is seen in Fig. 1 of the Appendix 1 to this report.

Materials Technology Ltd (MTL) were asked to carry out an investigation on the gearbox, see, for instance, Figs 1 & 2 which was considered to be responsible for the mal-operation. The condition of the gear box actuator as delivered to MTL is shown in Fig.6 it was noted that grease seen in Fig. 4 had been removed from the worm wheel and gear by the shipyard after the incident. A general arrangement diagram of the gearbox is shown in Fig. 15.

Brief

The investigation covered the following:

- General inspection with photography of all relevant features including wear on the gear and worm-wheel
- Trial operation.
- Causes of mal-operation.
- Metallographic examination of the gear teeth to determine if they had been weld repaired and to what quality the weld had been deposited.

Procedure

Examination under stereoscopic microscopy was carried out initially followed by macro-photography.

The gearbox was then dismantled and the suspect welded teeth on the gear were removed by cold cutting. These were mounted in resin, polished on successively finer grades of carborundum, then on 6 & 1 micron diamond and finally on colloidal silica.

Examination was carried out under optical microscopy initially in the unetched condition. This sample was then etched in Marbles Reagent*.

Summary of Findings.

1. As seen in Figs 5 A & B, the spindle extension of the worm was bent out of alignment and was also loose in its bearing as a result of wear and corrosion of approximately 1mm (this has not been measured accurately since this was not required).
2. Actuation was undertaken by MTL to give an indication of the amount of slackness between the worm and the spindle gear. When fully rotated to the closed position, the spindle could then be turned through three revolutions before the spindle gear moved; this can be seen in Fig. 6. The body of the gearbox has one spacer in the spindle hole whereas from the diagram shown in fig. 15, top hat bushes should have been fitted at either end of the operating spindle worm wheel. The absence of these bearings, coupled with the wear on the spindle gear and worm wheel teeth are responsible for the out of mesh movement between the spindle gears and worm wheel.
3. Examination showed that the gearbox housing was cracked as seen in Figs 7 & 8
4. The examination of the removed gear showed that many of the teeth had been overlaid with what appears to be a manual metal arc weld deposit presumably in an attempt to correct wear/corrosion which had been present.
5. In Fig. 14, the microstructure of the gear at the teeth can be seen. This shows that the material of construction is spheroidal graphite cast iron. This material can only be welded with a very careful weld procedure. The procedure adopted was unsuitable for welding of this cast iron which is demonstrated in

Fig. 13 where brittle martensite is present between the weld and the cast iron and cracks are found.

6. The microstructure examined under optical microscopy, revealed that the weld contained, cracks, porosity and slag inclusions, see Figs. 11 & 12.

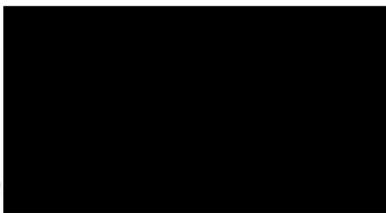
*Marbles Reagent is a copper sulphate/hydrochloric acid mixture which reveals details of the microstructure not otherwise visible.

Conclusions

The actuator gear box has been inadequately maintained. It appeared from the photograph in Fig. 4 that grease was present on initial dismantling carried out by others. This would have been sufficient to protect the internals and the spindle from corrosion but since there is evidence of corrosion, it is assumed that the grease had not always been present. The bent spindle and the cracked gearbox housing indicate that excessive load had been applied in actuating the valve at some time in the past.

Three revolutions on the spindle were necessary before the worm and gear became in sufficient contact to turn the gear. The metal loss on the mating faces of both the worm and the gear was excessive and the absence of the top hat bearings on the worm wheel meant that the gearbox would have been unfit for the duty.

The material of construction of the spindle gear is spheroidal graphite cast iron. Welding on this material can only be performed with a carefully prepared and executed weld procedure. The brittle and cracked martensite seen arrowed black in Fig.13, demonstrates that the procedure adopted was completely inadequate and the welds would ultimately have fractured at the weld interface. It is not possible to determine when the welds were deposited.



APPENDIX 1



Fig. 1 Photo from MAIB, general view of butterfly valve



Fig. 2 from MAIB, view of indicator on valve actuator



Fig. 3 MAIB photograph. Actuator gear mechanism



Fig. 4 MAIB photograph of actuator worm and gear

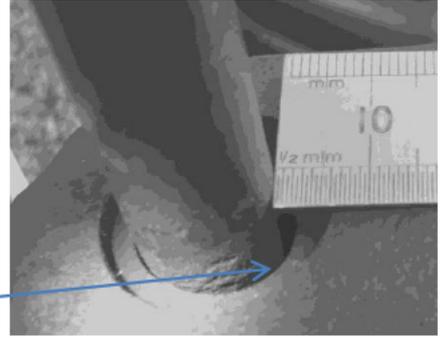


Fig. 5A & B.
Bent spindle on left and around 1mm wear and corrosion on spindle in right photograph



Fig. 6. View after spindle had been rotated three revolutions before gear wheel commenced movement.



Fig. 7 General view of actuator and body, note crack, arrowed



Fig. 8. View of crack in body see Fig 6 for location.



Fig. 9 Damage and weld repair on gear wheel teeth



Fig. 10. Weld repair on gear wheel teeth, also note corrosion on body of gear

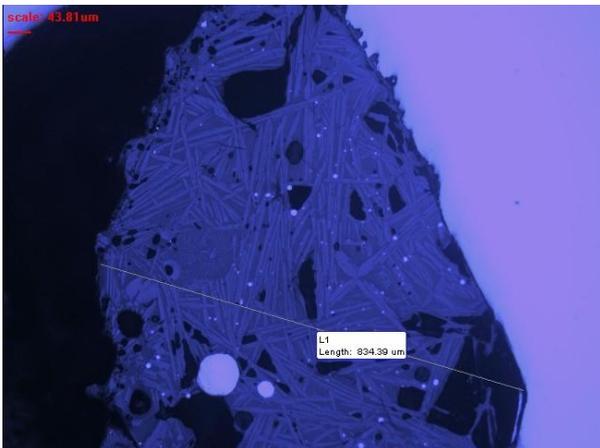


Fig. 11 Slag inclusion in weld
100x mag.

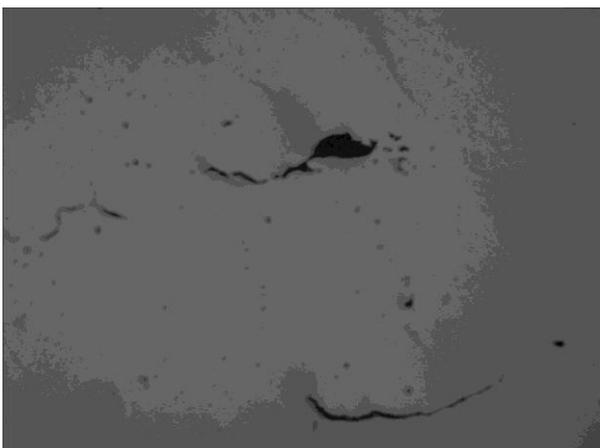


Fig. 12 cracks in weld. 100x magnification

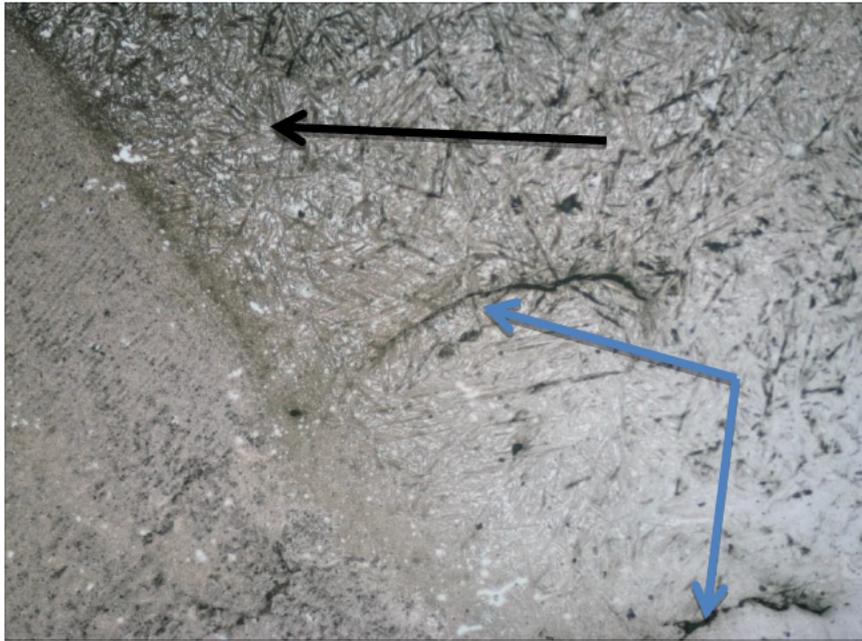


Fig. 13.
Microstructure at
weld, parent metal
interface showing
brittle martensite
and cracks, arrowed
blue. Photograph
taken at 100x
magnification

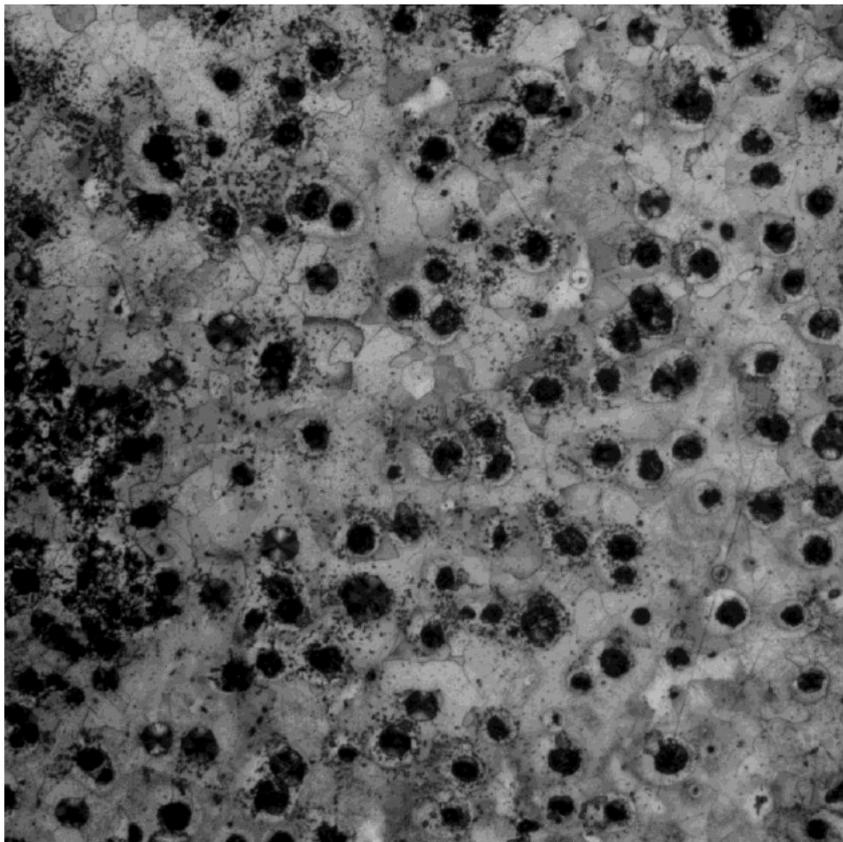
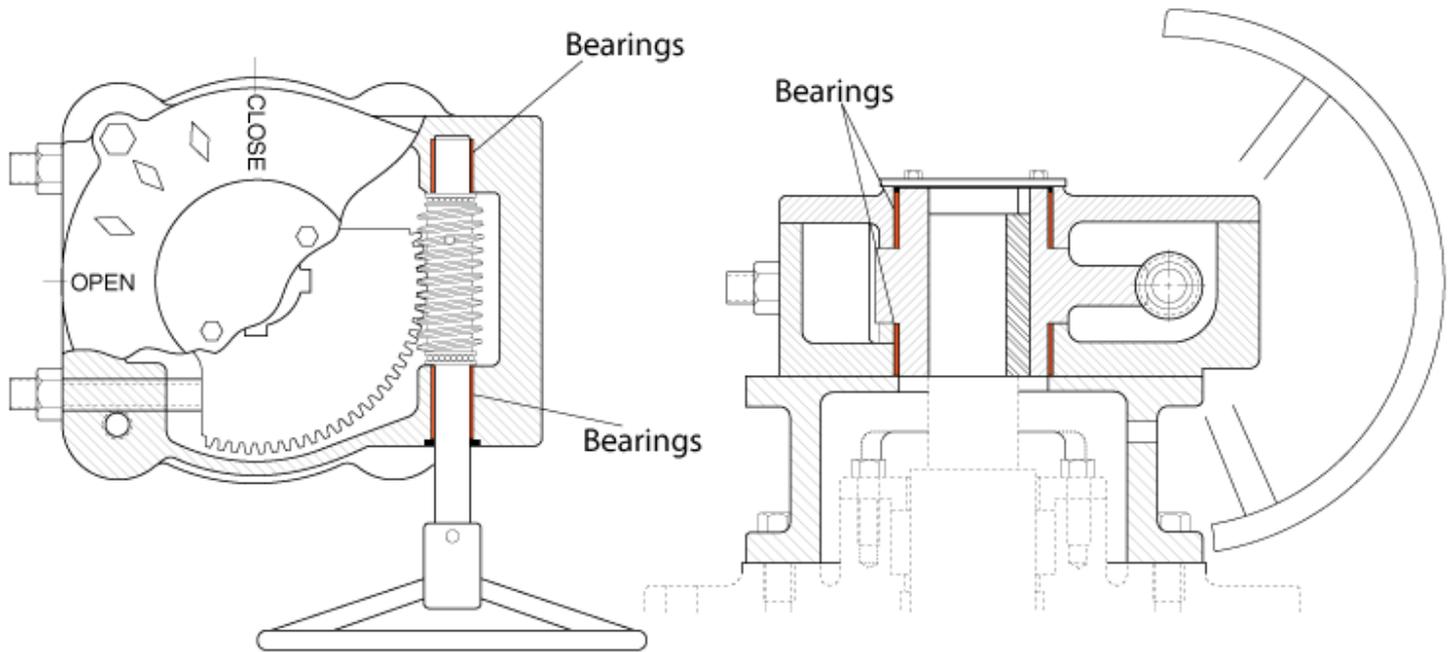


Fig. 14. Spheroidal
graphite cast iron
microstructure of the
teeth on the gear.
100x magnification

Bronze Radial Bearings



**Fig. 15 General arrangement of Actuator,
Diagram supplied by MAIB**