FINAL REPORT

FATAL INJURY ON BOARD THE BULK CARRIER CAPE INDIA AT SEA ON 28 OCTOBER 2019

MIB/MAI/CAS.073

Transport Safety Investigation Bureau
Ministry of Transport
Singapore

22 December 2020

<u>The Transport Safety Investigation Bureau of Singapore</u>

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SYNOPSIS

On 28 October 2019, at about 1600H, the Singapore registered bulk carrier, Cape India, was transiting Makassar Strait, bound for Port Walcott, Australia.

The Third Officer was alone inside the fire control station charging the air cylinders using the breathing air (BA) compressor. During this process, the air outlet filter housing (AOFH) and the pressure relief valve of the BA compressor ejected and fatally injured the Third Officer.

The Transport Safety Investigation Bureau classified the occurrence as Very Serious Marine Casualty and launched a marine safety investigation.

The pressure relief valve was found to have malfunctioned and the threaded part of the AOFH connecting the pressure relief valve was expanded as well as made of lower tensile strength material than the main body and had thinner wall.

The investigation also revealed that the BA compressor had not been included in the shipboard planned maintenance system and had not been maintained as per the maker’s recommendation. In addition, there was no job review or risk assessment and permit to work for the charging of air cylinders.

The investigation further revealed that the Third Officer was not trained to operate the BA compressor and had not followed the operating steps as recommended by the maker.

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DETAILS OF THE SHIP

Name	Cape India
IMO Number	9654804
Flag	Singapore
Classification society	Det Norske Veritas and Germanischer Lloyd (DNV GL) / American Bureau of Shipping (ABS)[1]
Ship type	Dry bulk carrier
Hull	Steel
Delivery	25 April 2014
Owners	U-Ming Marine Transport (Singapore) Pte. Ltd.
Operators / ISM[2] Managers	U-Ming Marine (Xiamen) International Ship Management Co. Ltd.
Gross tonnage	99195
Length overall	299.88m
Moulded breadth	47.50m
Moulded depth	24.70m
Summer draft	18.023m
Max speed	15.8 knots
Cargo onboard	NIL (In ballast condition)

Cape India
(*Source*: ISM Manager)

[1] DNV GL was for survey and issuance of other statutory certificates. ABS was for carrying out ISM audit and issuance of ISM related certificates.
[2] International management code for the safe operation of ships and for pollution prevention.

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1 FACTUAL INFORMATION

All times used in this report are ship's mean time (SMT) of Cape India which was eight hours ahead of the UTC (UTC + 8H), unless otherwise stated.

1.1 Sequence of events

1.1.1 On 28 October 2019, the Singapore registered bulk carrier, Cape India, was underway transiting the Makassar Strait, bound for Port Walcott, Australia at a speed of about 13 knots.

1.1.2 The Third Officer[3], after completing the assigned navigational watch on the bridge in the morning, went for rest after lunch. At about 1600H, the Third Officer went to the ship's fire control station (FCS) for the charging of spare SCBA[4] cylinders[5] which had been used in the fire and enclosed space entry and rescue drills[6] conducted on 20 October 2019[7]. The charging of these cylinders would be done using a breathing air (BA) compressor[8] installed in the FCS.

1.1.3 At about 1652H, the ship's accommodation fire alarm[9] was activated on the bridge. At about the same time, the Chief Officer[10], who was keeping the navigational watch, received a call from the Chief Engineer[11] enquiring where the location of the fire was.

1.1.4 The Chief Officer informed the Chief Engineer that the fire alarm was from the upper deck, inside the accommodation. The Chief Engineer together with an

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[3] Kept navigational watches for the periods of 0800H-1200H and 2000H-2400H at sea. Responsible for the Master for up-keeping and maintaining all life-saving appliances and fire-fighting equipment on board ship.

[4] Self-contained breathing apparatus, part of fire-fighter's outfits.

[5] There were four spare air cylinders carried on board Cape India exclusively for use in drills and were of the same type as those which were a part of the approved fire-fighting equipment (FFE) plan.

[6] As required by SOLAS Chapter III/19.3.5 and 19.3.6.

[7] As with most ships, upkeep of life saving appliances (LSA) and FFE was a part of the Third Officer's job description. Since these spare SCBA cylinders were carried exclusively for use during drills, the Third Officer did not charge them immediately after the drills, which would normally be the practice.

[8] SOLAS Chapter II-2/10.10, air compressor carried on board for refilling breathing apparatus cylinders, referred to as air cylinders in this report.

[9] The Fire Safety System Code (FSC), Chapter 8/2.5.2 (Alarm and indication), the fire alarm indication unit was installed on the navigational bridge on Cape India, which was capable to indicate where the fire occurred.

[10] Kept navigational watches for the periods of 0400H-0800H and 1600H-2000H at sea, was the head of the deck department and acted as a deputy on board when the Master was absent.

[11] The Chief Engineer was in the engine control room (ECR) at the time and noticed from the indication unit in the ECR that a fire alarm had been activated. The indication unit did not specify the location of the fire except that it was in the accommodation.

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Engine Cadet, who was also in the engine control room (ECR), proceeded to the upper deck to look for the source of the fire.

1.1.5 When they reached the upper deck, they met the Bosun near the FCS and saw the entrance door of FCS open, and smoke was wafting out from the smoke-filled space, but there was no visible flame. The Chief Engineer informed the Chief Officer to raise the general alarm (continuous ringing of the bell) and to make an announcement[12].

1.1.6 The Third Officer was found to be in seated position leaning against the wall and unconscious state inside the FCS, and severe injuries could be seen on the upper body (left arm and chest area) (see **figure 1**). The BA compressor next to the Third Officer was found to be damaged (assessed to have exploded).

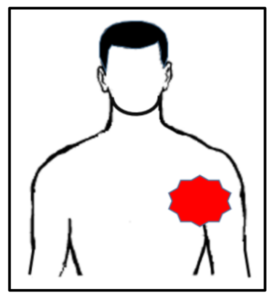

Figure 1 – Illustration of the areas of the injuries of the Third Officer

1.1.7 The Third Officer was carried out of the FCS and provided with medical care. The Third Officer briefly gained consciousness but became unconscious shortly after.

1.1.8 By about 1655H, the Master called the Company (the ISM Manager) for assistance after assessing the seriousness of injuries of the Third Officer.

1.1.9 By about 1700H, the Company linked up the Master with a doctor[13] who, upon being updated on the condition of the Third Officer, provided medical advice including sending the Third Officer for shore treatment as soon as possible.

1.1.10 The Company also initiated communication with the Maritime Rescue Coordination Centre (MRCC) in Indonesia (BASARNAS[14]) to seek for urgent

[12] As per the SMS, for emergencies not related to fire, man overboard or abandon-ship, a general alarm was to be sounded first, followed by an announcement to differentiate the type of emergency.

[13] The doctor was from the Far Eastern Memorial Hospital in Taiwan. The hospital had signed a cooperation agreement with the Company for providing medical advisory/care service to its fleet of ships at sea.

[14] Based on the ship's location, the Company contacted to the MRCC Indonesia (Badan SAR Nasional, BASARNAS) by phone and followed up with email. BASARNAS is Indonesia's national search and rescue agency.

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medical evacuation assistance. The Company also informed BASARNAS that Cape India would be diverting to Samarinda, Indonesia which was the nearest port (about 70 nautical miles from the ship's position at the time of occurrence) with an estimated time of arrival (ETA) at about 2230H on 28 October 2019.

1.1.11 However, due to the quality and the readiness of the doctor and the facility of the hospital at the port of Samarinda, BASARNAS advised the Company to instruct the Master of Cape India to proceed to Balikpapan instead (southwest of Samarinda, see **figure 2**). BASARNAS subsequently relayed the case information to the nearest Rescue Sub-coordination Centre (RSC), Balikpapan.

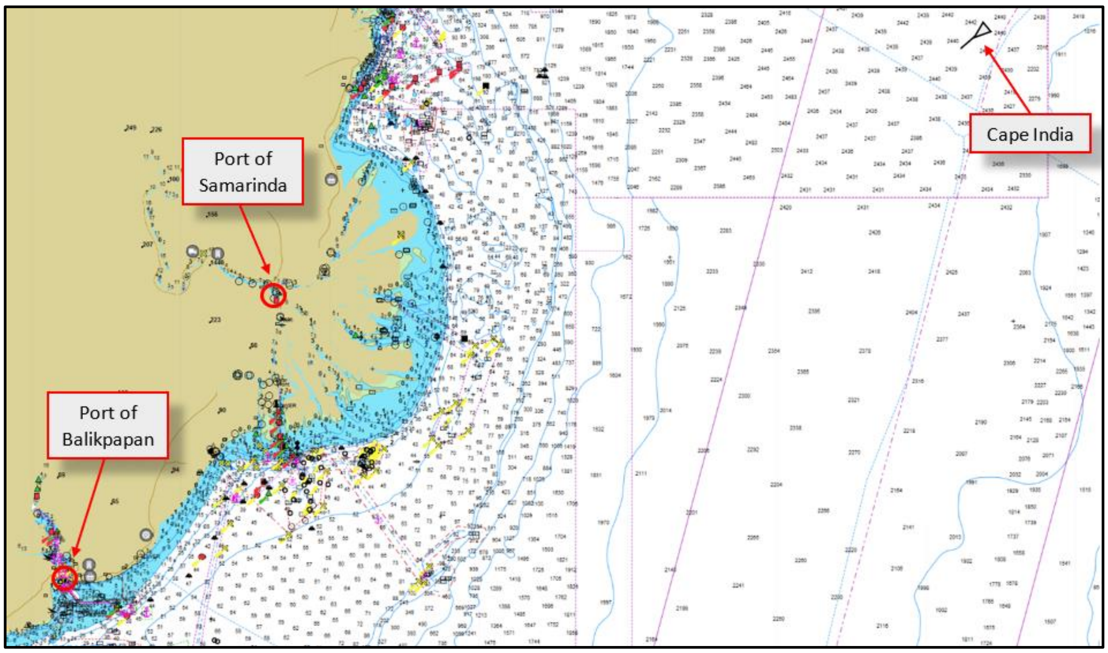

Figure 2 – Location of the ports (Samarinda and Balikpapan) and Cape India's position at 1700H in the Makassar Strait – for illustration purpose and not to scale – annotated by TSIB
(*Source*: MarineTraffic.com)

1.1.12 By about 1800H, a rendezvous position[15] was given and a rescue boat with a medical team[16] from RSC Balikpapan was arranged to intercept Cape India for subsequent transfer of the Third Officer to a hospital.

1.1.13 The Master deviated Cape India's passage and the ETA[17] to the rendezvous position, based on the fastest safe speed, was 0330H on 29 October 2019.

[15] The position was at latitude 01° 20'S and longitude 116° 52'E.

[16] As advised by BASARNAS, night flying helicopter service to airlift the injured officer was not available, rescue boat was to be used for the transfer.

[17] Estimated time of arrival was given to BASARNAS.

1.1.14 The ship's crew monitored the condition of the Third Officer by taking the temperature, pulse and blood pressure. The monitoring record for the measurements taken from 1814H to 1953H, at fifteen minutes interval, indicated that the body temperatures were fluctuating between 33.4°C and 35.1°C and eventually dropped to 34.5°C. The pulse and blood pressure were both weak during this period and became not measurable from 1953H.

1.1.15 As advised by the doctor consulted earlier, the Third Officer had been provided with an injection[18] at about 2044H. The Master was advised by the Company to concurrently contact other possible nearby medical rescue sources[19] for assistance.

1.1.16 At about 2130H, the Company proposed a revised rendezvous position[20] to BASARNAS due to navigational safety concern of the ship's draft. BASARNAS acknowledged and agreed to the revised position.

1.1.17 At about 2230H, the Master updated BASARNAS and RSC Balikpapan on the condition[21] of the Third Officer. At about 2245H, the monitoring record of the Third Officer taken from 1814H to 1953H was also sent to BASANAS and RCS Balikpapan.

1.1.18 The monitoring record taken from 2245H to 2330H, at five minutes interval, indicated that the pulse and blood pressure of the Third Officer remained not measurable.

1.1.19 At about 0200H, BASARNAS communicated with the Company requesting additional information[22] about Cape India for the evacuation of the Third Officer.

1.1.20 As requested by RSC Balikpapan, the Master started to provide the ship's position every half an hour till arrival at the revised rendezvous position. At about 0250H the ETA was updated to 0340H and provided to BASARNAS by

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18 Cardiotonic, a type of drug injection used to increase the efficiency and improve the contraction of the heart muscle, which leads to improve blood flow to all tissues of the body.

19 Including possibilities of US Navy ships (in the vicinity) to provide medical assistance. The Master's attempt to reach out to sources other than Balikpapan were unsuccessful.

20 The initial rendezvous position was within the navigational channel and the Company, in consultation with the Master had concerns regarding the ship's draft (of about 9.0m). The revised position was about five nautical miles south east of the initial rendezvous position and about six nautical miles from the port of Balikpapan at latitude 01° 21'S and longitude 116° 56.5'E.

21 Blood pressure and pulse were both weak.

22 Details such as whether the ship had a crane to lower the Third Officer to the water level by a stretcher. BASARNAS also obtained the condition of the Third Officer based on the last medical condition monitoring record taken from 2245H to 2330H.

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the Master of Cape India.

1.1.21 By about 0354H, Cape India arrived and safely anchored at a position[23] advised by Balikpapan VTS (Vessel Traffic Service). The Company informed the Master of Cape India that a guiding boat[24] would be in the vicinity to guide Cape India to coordinate with the rescue team arranged by RSC Balikpapan.

1.1.22 At about 0434H, after the vessel was brought up[25] and seeing no sign of the guiding boat, the Master sent a report to BASARNAS notifying the anchored position and that Cape India was waiting for the rescue team to arrive.

1.1.23 By about 0620H, the rescue team from RSC Balikpapan arrived. The Third Officer was secured on a stretcher and lowered onto the rescue boat using the ship's provision crane. The doctor who came with the rescue team assessed that the Third Officer had passed away[26]. Despite this assessment, the rescue team decided to take the Third Officer ashore for medical attention, with the Fourth Engineer and a Deck Cadet[27] following.

1.1.24 At about 0654H, Cape India resumed its passage to the next port of call. At about 0830H, the Master received an update from the Company that the Third Officer had been brought to the hospital and was formally certified dead.

1.2 The ship

1.2.1 Cape India was a cape size[28], gearless type of bulk carrier having nine cargo holds. At the time of occurrence, Cape India was on a return trip to Australia having discharged its cargo in China.

1.2.2 The BA compressor was installed at the FCS (at the upper deck) (see **figure 3**) for the charging of air cylinders carried on board when the pressure drops

[23] Latitude 01° 20.5'S and Longitude 116° 59.7'E, in consideration of other ships in the vicinity at the time of anchoring, which was approximately about three nautical miles away from the revised rendezvous position.

[24] This information was given by BASARNAS to the Company by telephone. There was no name or call sign of the guiding boat made known. The investigation team gathered from BASARNAS that the name of the rubber boat was "408" deployed together with an Indonesian navy ship "Lamaru".

[25] A nautical term which indicates the completion of anchoring operations. This signals that the anchor is assessed to be securely holding to the seabed.

[26] The doctor assessed that the Third Officer could have passed on seven hours ago.

[27] The Master's consideration in assigning these two persons was that their disembarkation from the vessel would not compromise the minimum safe manning requirements as well as both had a reasonably good command of English.

[28] A way of categorising of bulk carriers based on a ship's capacity, a cape sized ship is typically about 150,000 (DWT) deadweight.

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below the requirements[29].

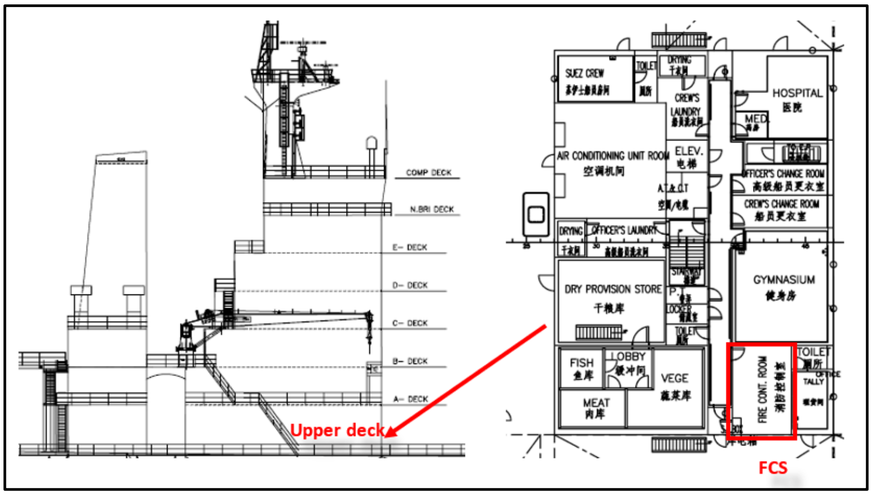

Figure 3 – Location of the FCS at the upper deck inside accommodation
(*Source*: the ISM Manager)

1.3 The crew

1.3.1 There were 21 crew of two[30] nationalities on board Cape India and all held valid STCW[31] competency certificates required for their respective positions. The working language on board was English[32].

1.3.2 The qualification and experience of the Master, relevant officers and crew members are tabulated in table-1:

Designation onboard	Nationality	Age	Qualification[33]	Duration on board (month)	In rank service (Year)	Service in Company (Year)
Master	Chinese	55	COC[34] – Master / STCW II/2, IV/2	5.7	7.6	3.1
Chief Officer	Chinese	33	COC – Chief Mate / STCW II/2, IV/2	4.3	0.5	6.0
Third Officer	**Chinese**	**25**	**COC – Third Mate** / STCW II/1, IV/2	**5.7**	**0.9**	**3.1**

[29] FSS Code, Chapter 3/2.1.2.1 – the volume of air contained in the cylinders shall be at least 1200l or shall be capable of supplying air for at least 30mins. Typical pressure for such air cylinders is about 300bar when full.
[30] Mostly were Chinese nationals while four were Filipinos.
[31] The International Convention on Standards of Training, Certification and Watch keeping for Seafarers (or STCW), 1978 sets qualification standards for masters, officers and watch personnel on seagoing merchant ships.
[32] All crew on board were required to be able to speak in English and be able to write at an appropriate level in relation to their ranks. However, for operational efficiency, the Company allowed crew to speak in Chinese amongst the Chinese national crew. All official records and instructions on board were in English.
[33] The certified rank was stated in the Certificate of Competency (COC).
[34] COC qualified for respective seafarer met the requirements of the STCW Convention.

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Chief Engineer	Chinese	35	COC – Chief Engineer Officer / STCW III/2	4.3	1.9	9.3
Fourth Engineer	Chinese	31	COC - Fourth Engineer Officer / STCW III/1	0.3	1.4	3.6
Deck Cadet	Chinese	23	Pre-sea training certificate	3.1	0.3	0.3
Bosun	Chinese	56	Deck Rating as per STCW II/5	0.3	13.2	14.0
ASD	Filipino	23		7.5	0.8	1.8

Table-1

1.3.3 The Chief Engineer was responsible for the safe and efficient running of all mechanical and electrical machinery and equipment on board the ship. Maintenance and overhaul schedules were to be planned and programmed as per the requirements of the safety management system (SMS). The BA compressor was not identified to be in the planned maintenance system (PMS).

1.3.4 The Third Officer joined the Company in 2016 as a Deck Cadet, thereafter, serving as an Able Seafarer Deck (ASD) and was promoted to Third Officer in 2018. Cape India was the second ship serving as Third Officer.

1.3.5 The ship's training records indicated that the Third Officer had attended a safety familiarisation training[35] on the date of joining Cape India and read the fire safety training manual[36] two days later. There was no specific training for operating the BA compressor to charge the air cylinder attended by the Third Officer.

1.3.6 According to the Company, the Third Officer had experience of using BA compressor on the previous ship, but that BA compressor was of a different make and model as Cape India's.

1.3.7 The Third Officer was declared medically fit for service at sea by a medical centre[37] in China on 31 January 2019 as a part of pre-joining medical checks, which was valid for two years, without any limitation or restrictions on fitness. Hearing and eyesight of the Third Officer were tested and met the required standards[38].

[35] As per SOLAS Chapter II-2/15.2.2 (Onboard training and drills) and Chapter III/19 (Emergency training and drills).
[36] This ship specific manual is required to be developed on board as required by SOLAS Chapter II-2/15.2.3. The operation and use of fire-fighting systems and appliances including air compressor were contained in the manual.
[37] The centre was authorised by a local Maritime Safety Administration in China.
[38] STCW, A-I/9, medical standards.

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1.3.8 According to Cape India's work/rest hour records, maintained electronically, the Third Officer had 15 hours of rest on the previous day (27 October 2019), and had 108 hours of rest in the last 7-day period (21 to 27 October 2019), indicating compliance with the STCW and MLC Convention's requirements concerning the hours of work and rest[39].

1.4 BA compressor used on board

1.4.1 The BA compressor installed on Cape India had been on board since delivery of the ship in April 2014. Some ships managed by the Company also had the same make and model (see **figure 4a and 4b**), for instance, on Cape Europe[40].

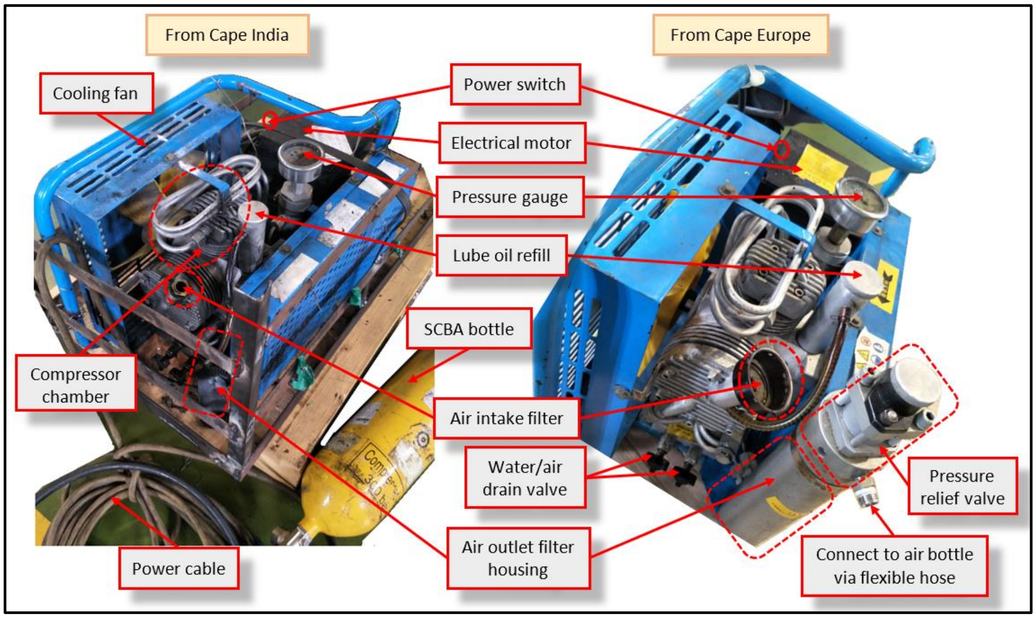

Figure 4a – View of the BA compressors from Cape India and Cape Europe

[39] STCW, Chapter VIII and MLC, Reg 2.3 with regards to rest hour - Minimum hours of rest shall not be less than i) ten hours in any 24-hour period; and ii) 77 hours in any seven-day period. Hours of rest may be divided into no more than two periods, one of which shall be at least six hours in length, and the interval between consecutive periods of rest shall not exceed 14 hours.

[40] After the occurrence, the Company arranged for another compressor of the same model from Cape Europe for comparison and test as some of the components of the BA compressor from Cape India had been damaged as a result of the explosion.

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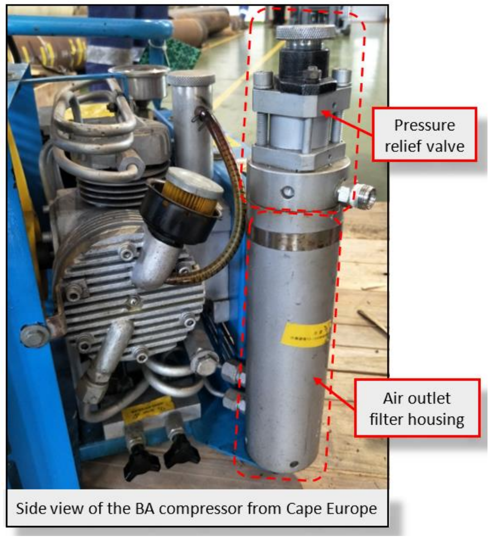

Figure 4b – Design of the air compressor with major components labelled

1.4.2 The investigation team did not receive a response from the maker of the BA compressor. According to maker's user manual[41], the BA compressor was compliant with European standards (EN12021[42]) for air quality, and could be used in breathing apparatus for fire-fighting, diving activities, etc. The main specifications of the BA compressor are tabulated in table-2.

Maker	Shanghai GOHI Compressor Co. Ltd.
Model	LYX100B
Power	2.2kW
Power driven	Electric
Speed	2800 r/Min
Number of compression stage	4
Delivery rate	100L/min (6m3/hour)
Delivery pressure	30Mpa
Type of cooling	Air cool by fan

Table-2 - BA compressor main specifications

1.4.3 The user manual (a copy of which was on board) contained the following sequential steps for charging:

[41] A black and white copy of the user manual provided to investigation team by the Company which was obtained from the maker written in Chinese language.

[42] The standard ensures the air quality produced by air compressor is suitable for air breathing purpose, either to be supplied directly to users or by charging it into cylinders. (see footnote 42, which met the requirements)

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a) keep the water/air[43] drain valves open;
b) start the air compressor by turning on the electrical power and keep it running until it is stabilised;
c) shut both water/air valves and open the air cylinder for charging. Every 10-15 minutes, user is required to open the water/air drain valves to discharge condensation accumulated in the machine;
d) shut the air cylinder valve once the air cylinder is charged to the required pressure;
e) keep both water/air drain valves open until all air pressure released from the compressor system; and
f) stop the air compressor by switching off the electrical power.

1.4.4 The user manual stated that the electrical power must be switch off in the event of an emergency during charging. The lubricating oil level was to be filled between the low (minimum) and high (maximum) level markings. If the oil was overfilled, excessive oil could enter the compressor chamber and the AOFH causing carbon deposits at the pressure relief valve [44].

1.4.5 The user manual further stated that the pressure relief valve installed on the BA compressor would auto release excessive pressure if the pre-set value was reached.

1.4.6 A safety advice contained in the user manual cautioned that the operator was to keep at least three metres away from the BA compressor while charging was in progress. The BA compressor was required to be placed at least one metre away from a wall (bulkhead on a ship) and installed at a well-ventilated area without dusty environment. On Cape India, the BA compressor had been installed next to the storage rack for spare portable fire extinguishers and was less than one metre from the nearest bulkhead.

1.4.7 The user manual had a section for troubleshooting, and extract of which is captured in table-3.

[43] The water/air drain referred to water condensation and oily particulars (if any) in the air accumulated in the air compressor system.
[44] Also referred to as a safety valve, a safety feature designed to release excessive pressure if a pre-set pressure is reached.

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Defect	Likely cause	Solution
BA compressor overheat	• Motor ran to the wrong direction • Poor cooling • Hot environment • Running overload for a long time	➢ To correct it to right direction ➢ To clean up surface dust on cooling and air cylinder units ➢ To shift the BA compressor to a cooler place ➢ Adjust the running time or to stop intermediately
Delivery volume decreased with longer charging time	• Motor belt loose or slippery • 1st stage intake/delivery valve worn • Connecting hose leaking • Intake air filter choked • Piston ring worn out • Air valve poor sealing	➢ To adjust the belt ➢ To replace the valve ➢ To check and replace the hose if leaking ➢ To replace the filter ➢ To check and replace if necessary ➢ To check and replace if necessary

Table-3 – Troubleshooting of defects extracted from the user manual

1.4.8 According to the user manual, routine maintenance required to be carried out is captured in table-4.

Items	Each recharge	Every				
		25h	30h	100h	1000h	Year
Check oil level		Δ		O		O
Driven belt condition and tension			Δ			
Air intake filter		Δ		O		O
The charging hose and connection leak check		Δ				
Pressure relief valve	Δ					◊
Check charging hose	Δ				O	

Legend:
Δ - check and clear up
O - replace
◊ - examine and calibration

Table-4 – BA compressor routine maintenance

1.4.9 The Company could not provide any records of the recommended routine maintenance as per the user manual being performed preceding the occurrence, i.e. more than five years since the ship was delivered.

1.4.10 The only annual test that was carried out was that of the air quality[45] of the BA compressor. The last air quality test was done on 18 October 2019 which documented the results of air quality parameters[46] to be within acceptable limits.

[45] SOLAS, Chapter II-2, regulation 14 (Operational readiness and maintenance) and MSC/Circ. 1432 – Guidelines for the maintenance and inspection of fire protection systems and appliances, breathing air recharging systems should be checked annually for air quality, if fitted.

[46] Six parameters were tested - no presence of objectionable odour, oxygen level at 20.9%, concentration of carbon monoxide (5 ppm), carbon dioxide (150 ppm), oil (0 mg/m3) and water vapor (15 mg/m3).

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1.5 **Post-accident information**

1.5.1 The power cable of the BA compressor was found plugged into a socket (at the "ON" position) outside the FCS at the upper deck alleyway. The door of the fire station was kept open for connecting this cable. A smoke detector (connected to the fire detection system) mounted on the ceiling at the upper deck alleyway had been activated due to the smoke wafting out of the FCS at the time of accident.

1.5.2 An inspection of the FCS by the ship's crew documented that the metal jubilee clip securing the air outlet filter housing (AOFH) was broken and found on the floor few metres away from the BA compressor. The AOFH was found near the entrance of the FCS and had broken up into many pieces. The pressure relief valve, separated from the AOFH, was lying in a damaged condition on the floor. The O-ring seal which was to prevent leaks during charging operation was missing from the thread section of the AOFH (see **figure 5**).

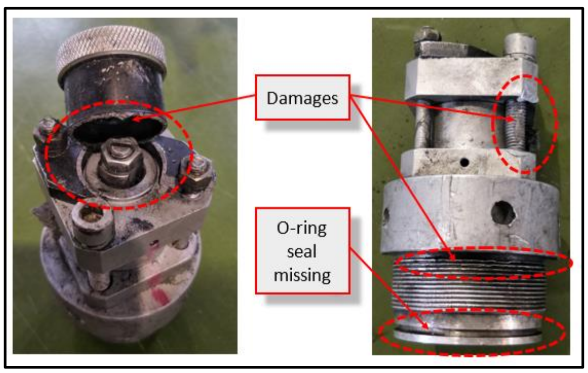

Figure 5 – Damaged pressure relief valve (annotated by TSIB)
(*Source*: the ISM Manager)

1.5.3 The opening of the AOFH, connected to the pressure relief valve, was noted to have expanded by about 2.5mm in diameter. There was no crack to the AOFH and some black oily particles and soot deposits could be seen sticking to the inner surface (see **figure 6**).

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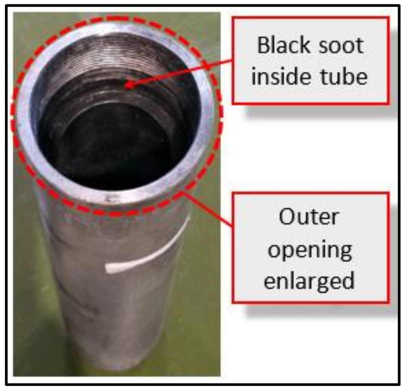

Figure 6 – Damaged AOFH (annotated by TSIB)
(*Source*: the ISM Manager)

1.5.4 The metal plate supporting the AOFH was bent downwards and cracked at the side. Both air and water drain valves were found in shut position. Soot and oily particles could also be seen all over the corner of the air compressor (see **figure 7**).

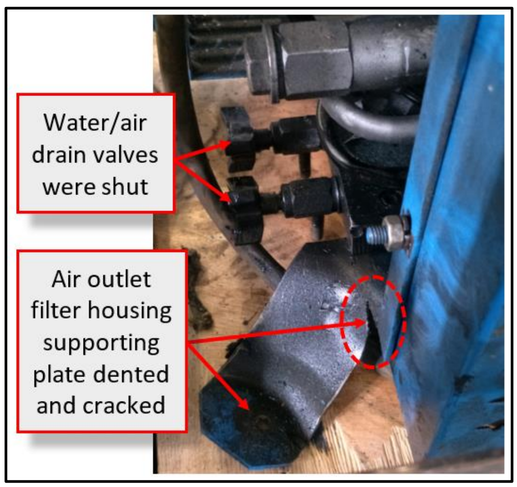

Figure 7 – View of metal supporting plate and water/air drain valves (annotated by TSIB)
(*Source*: the ISM Manager)

1.5.5 The air intake filter cartridge casing, besides the AOFH, had broken off and was found on the floor few metres away. The lubricating oil flexible pipe had also broken off (see **figure 8**).

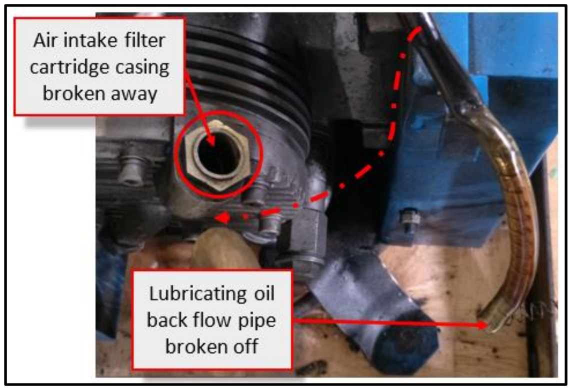

Figure 8 – View of air intake filter cartridge and lubricating oil pipe (annotated by TSIB)
(*Source*: the ISM Manager)

1.5.6 Soot and oily burnt particles could also be seen on the rubber floor mat placed below the BA compressor. Many other small pieces of debris from the BA compressor were strewn all over the places in the FCS. A pipe wrench was found on the floor. One air cylinder was connected to the BA compressor using a flexible charging hose, another three air cylinders were loosely lying on the floor (see **figure 9**).

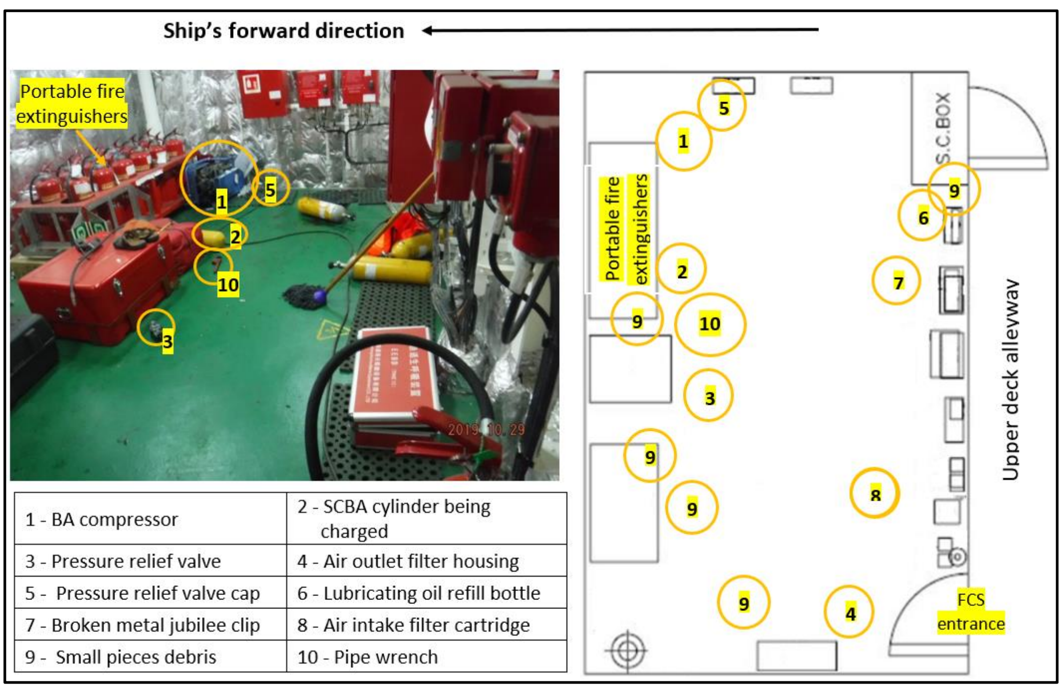

Figure 9 – View of FCS after the occurrence (relevant portions annotated by TSIB)
(*Source*: the ISM Manager)

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1.5.7 The BA compressor pressure gauge read at about 32MPa (320bar) (see **figure 10**).

Figure 10 – Pressure reading on the air compressor gauge

1.5.8 A marking on the dip stick indicated the allowable low and high level of lubricating oil to be filled in the BA compressor. The level of lubricating oil level measured after the occurrence was found to be 2cm higher than the allowable high oil level marking (see **figure 11**).

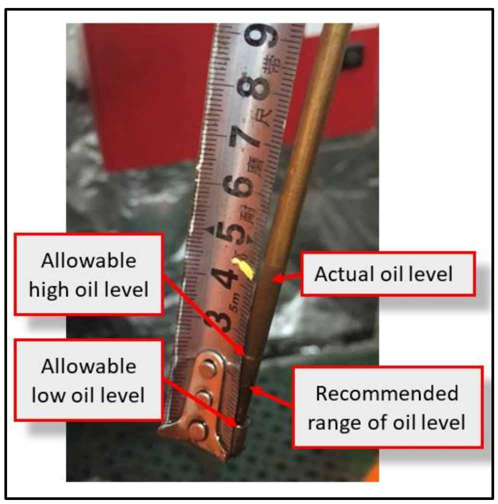

Figure 11 – Dip stick level after the occurrence
(*Source*: the ISM Manager)

1.5.9 The power switch of the BA compressor was fitted at the right rear end. To switch on/off the BA compressor, the operator would have to lean over the main body of the BA compressor to reach the right rear end. On Cape Europe, this switch was absent[47] and the power was directly controlled from the plug end at the alleyway outside the FCS (see **figure 12**).

[47] It could not be established when this switch had been removed.

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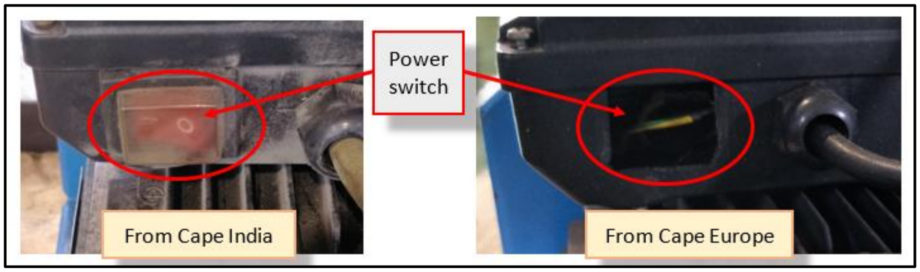

Figure 12 – Power switch on the BA compressor

1.5.10 Two sets of SCBA comprising six[48] air cylinders were carried on board. For verifying the pressure of the air cylinders, the cylinder could be connected to the SCBA and read out from the gauge (see **figure 13**).

Figure 13 – Illustration of SCBA
and pressure gauge
(*Source*: the ISM Manager)

1.5.11 According to one ASD who had assisted the Third Officer in charging an air cylinder [which had a low pressure of about 25MPa (250bar)] using the same BA compressor on 11 October 2019, the following steps were observed being adopted by the Third Officer:

a) connected the air cylinder to the BA compressor by a designated flexible hose;
b) plugged the electrical cable of the BA compressor to the power socket located at upper deck alleyway outside the FCS;
c) shut off both air/waters drain valves and opened the air cylinder valve - the air cylinder pressure on the BA compressor gauge showed 25Mpa (250bar);
d) started the BA compressor, using the switch at the rear, causing the pressure to slowly build up to 27Mpa (270bar) and the pressure did not increase anymore;

[48] It met fireman outfit carriage requirements of SOLAS.

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e) stopped the BA compressor using the switch at the rear and closed the cylinder valve;

f) released air pressure in the BA compressor system by opening the air/water drain valves (Pressure in the BA compressor gauge dropped to zero);

g) repeated the steps procedures from c) to d) thrice, to build up the pressure, and the pressure did not increase beyond 28MPa (280bar[49]);

h) The charging operation was terminated, and the FCS was cleaned up after housekeeping.

1.5.12 The investigation team enquired the following items relating to the BA compressor, but there were no records available on board or with the Company:

a) defects noted in the past;

b) first and subsequent dates of the tests and calibrations of the pressure relief valve;

c) first and subsequent dates of the renewal of air filter cartridge;

d) total running hours[50] of the BA compressor. According to the Company, since installation, the BA compressor had been used for about 33 operating hours. This estimation was based on half an hour charging time for two air cylinders per month typically used during the drills; and

e) first and subsequent dates of refilling of the lubricating oil.

1.6 Laboratory test

1.6.1 In order to understand the likely cause of the explosion of the BA compressor, the occurrence BA compressor and the relevant components were sent to two organisations[51] to perform detailed laboratory test and calculations, with the following main scope:

a) Proper functioning of the pressure relief valve;

b) Examination and pressure testing of the AOFH;

c) Checking the temperature readings of the air cylinder and AOFH when charging pressure was built up; and

d) Dismantling the BA compressor to check its internal condition.

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[49] The air cylinder had a maximum pressure of 300bar (30MPa). It was typically acceptable to keep the pressure within 10% below the maximum, and to top up if the pressure dropped below 270bar (27MPa).

[50] To correlate the routine maintenance as recommended in table-4.

[51] Personnel from an independent laboratory performed the test/examination for 1.6.1 (b), and personnel from another specialised air compressor company performed the test/examination for 1.6.1 (a), (c) and (d).

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1.6.2 The pressure relief valve from Cape India's BA compressor was found to have malfunctioned. Blackish particles were seen internally after the valve was dismantled. A test was carried out to verify the pressure relieve valve setting of the BA compressor on Cape Europe. The test revealed that the valve activated at 305bar (30.5MPa), and the pressure was maintained at this reading when continue running the BA compressor.

1.6.3 Additionally, a burst test of the AOFH (from Cape Europe's BA compressor) was also carried out. The test result indicated that the housing materials started to yield[52] at a pressure of about 375bar (37.5MPa) and thread area expanded rapidly till the pressure relief valve ejected from the thread locking to the AOFH.

1.6.4 Results of a further examination of the AOFH and related calculation are summarised below:

a) the thickness of the thread wall at top section of the AOFH was measured and ranges from 4.1mm to 4.5mm, which was approximately 60% thinner than the main housing tube section below the threaded part (11.5mm);
b) Microstructure examination of the AOFH further revealed that materials possessed non-homogeneous microstructure in its thickness direction, which in the opinion of the laboratory, could indicate a variation in tensile strength between different depths of tube wall due to a non-homogeneous microstructure;
c) A tensile strength test revealed that the material[53] strength at the thread area was nearly 20% lower than the inner section and 10% lower than the full section of the housing tube;
d) Above the yield point of tube materials, any further increase in the internal pressure in the housing tube would lead to a higher strain rate in the materials, which would result in a faster expansion of the tube thread section and thus a reduction of the thread engagement with pressure relief valve; and
e) As a result of reduced thickness and lower tensile strength, it was opined that the effective pressure capacity at the housing's thread section reduced to only approximately 35% of that of the main section, which in turn, would lead to a significant reduction in the safety margin of the whole air filter unit.

1.6.5 A further test on the BA compressor from Cape Europe was carried out by charging the air cylinder (used on Cape India at the time of the occurrence).

[52] Yield or Yield Point is a point at which a stress-strain curve shifts from elastic to plastic.
[53] The materials were extracted from three different locations from the housing tube, i.e. full wall section, outer 5mm layer and inner 5mm layer.

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The temperatures of the air cylinder and those in the AOFH corresponded to the pressure built up gradually inside the cylinder (see table-5).

Charging pressure (bar)	SCBA cylinder (°C)	AOFH - top (°C)	AOFH - bottom (°C)
0	31.1	32.8	32.5
100	39.8	35.8	40.1
200	43.0	36.9	41.0
250	43.1	38.1	41.0
260	43.0	37.8	43.1
270	43.0	37.9	43.0
280	44.0	37.8	44.1
290	45.0	37.6	45.1
300	45.0	37.7	45.0

Table-5
(*Source*: the specialised air compressor company)

1.6.6 The air compression chamber of the BA compressor from Cape India was also dismantled for internal checks. Its piston cylinder and piston ring were still in good condition, and there was no damage or blackish particles seen internally.

1.6.7 The laboratory test concluded that Cape India's air filter unit had expanded at the filter housing's thread section. Consequently, the pressure relief valve was ejected from the AOFH. The expansion of the AOFH was a result of internal over pressure which reached beyond the pre-set pressure relief value of 300bar (or 305bar as tested on Cape Europe) and a malfunctioning of the pressure relief valve. The O-ring seal inside the air filter unit lost the sealing ability, causing compressed air to leak into the threaded area and ejecting the pressure relief valve and AOFH from the compressor.

1.7 The Safety Management System

1.7.1 The Company managed a fleet of bulk carriers. A full-term Document of Compliance certificate was issued to the Company by ABS on 27 June 2018 based on the audit completed on the same date and it was valid until 5 June 2021. The last verification audit for this issuance was carried out on 2 August 2019.

1.7.2 A full-term Safety Management certificate was issued by ABS for Cape India on 29 June 2018, based on the audit completed on 18 April 2017 and was valid until 17 April 2022. The last intermediate verification was conducted on 19 October 2019. There was no Corrective Action Requests or Observation raised

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by the attending auditor.

1.7.3 The last Port State Control inspection was carried out on 18 June 2019, and there was no deficiency raised.

1.7.4 The Company's SMS procedures in Chinese and English languages were available in soft and hard copies on board. The Company also had a planned maintenance system (PMS) to maintain[54] and keep machinery and technical components in good condition, taking into consideration inspection/ maintenance recommended by the equipment maker.

1.7.5 According to the Company's SMS, the BA compressor was a part of the fire-fighting equipment carried on board for charging the air cylinders used for fire-fighting. The PMS did not include any maintenance of the BA compressor, other than an annual air quality test. According to the maker's instructions, a check / test / inspection was to be carried out at each charging of air cylinder or based on the running hours (see Table-4).

1.7.6 The ship's fire safety training manual[55] contained operating procedures for all shipboard fire-fighting equipment. Accordingly, a copy of the BA compressor's operating manual was inserted in the appropriate section of the fire safety training manual.

1.7.7 The risk management procedures in the Company's SMS explained that a risk assessment[56] (RA) was to cover reasonably foreseeable risks arising from any work activity on board a ship. The process of RA would require suitably experienced personnel to conduct and to take advice from area of specialist if necessary.

1.7.8 According to the SMS, a job review or re-assessment of risks was required to be conducted before the commencement of a task, unless the last job review or assessment was within one month and the same task had been carried out

[54] As required by the ISM Code Chapter 10 - The Company should establish procedures to ensure that the ship is maintained in conformity with the provisions of the relevant rules and regulations and with any additional requirements which may be established by the Company. In meeting these requirements, the Company should ensure that inspections are held at appropriate intervals, any non-conformity is reported with its possible cause, appropriate corrective action is taken, and records of these activities are maintained.

[55] The manual detailed all training on the fire safety aspects of the ship, its scope includes guidance on the use of all ship specific fire safety systems on board.

[56] RA, defined in the procedures was intended to be a careful examination of what operations could cause harm, so that decisions could be made as to whether enough precautions had been taken or whether more to be done to prevent harm. The aim was to minimize accidents and injuries on board ship.

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less than five times[57]. This was the second time that the Third Officer had operated the BA compressor in October 2019. There were no records of a risk assessment for operating the BA compressor on board in the past.

1.7.9 The Company had a permit to work system to control the relevant shipboard operations, such as hot work, working aloft, working over side, entering enclosed spaces and working on deck during heavy weather. Charging of air cylinders using the BA compressor was not identified as one of the operations requiring a permit to work.

1.8 Relevant safe working practice

1.8.1 The COSWP[58] was incorporated into the Company's SMS procedures and to be carried on board its fleet of ships.

1.8.2 Chapter 18.1 of COSWP provides some specific risks should be considered when operating a work equipment[59], such as mechanical risks like crushing, cutting or friction, etc. and non-mechanical risks like vibration, noise, electrical hazards, temperature, etc.

1.8.3 Attention was also drawn of the users for other specified hazards, such as disintegration of parts, overheating, unintended explosion of the equipment and articles or substances being ejected from the equipment.

1.8.4 Where any seafarer using the equipment or could be exposed to one or more hazards above, the Company should ensure that any significant risk to their health and safety is either prevented by the provision of appropriate equipment or protective device or where that is not practicable, to place adequate safety control measures by appropriate means.

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[57] To exempt the requirements for conducting job review or risk re-assessment before commencement of a task, the Company explained that two conditions were to be met, i.e. the last job review or risk assessment was done within one month of performing the same task and the same task had been carried out less than five times. The rationale for "less than five times" factor was because the lower the frequency of doing the task, lower were the changes to the conditions in which the task was being performed. If the same task was to be performed more frequently (five times or more), then the changes to the conditions were higher giving rise to new risks, and hence a job review or a re-assessment of risk was required.

[58] Though not a mandatory publication for carriage on Singapore registered ships, the Company's SMS had incorporated the Code of Safe Working Practices for Merchant Seafarers (COSWP) as the part of procedures for reference. The COSWP, edition 2015, published by the UK Maritime and Coastguard Agency (MCA), provides best practice guidance for improving health and safety on board ships. A copy of COSWP was on board at the time of the accident.

[59] It applies to any machinery, appliance, tool or installation provided for use at work.

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1.8.5 The COSWP further stated that equipment should be operated by competent person(s), or if operated by seafarers, to be adequately trained in the proper use of the equipment.

1.8.6 Chapter 18.2 highlighted that all work equipment is to be maintained in good repair and efficient order in accordance with the maker's instructions. This maintenance should include regular inspections by a competent person. If it is not working properly or has been subject to any treatment likely to cause damage, it should be taken out of service until it can be inspected, and any necessary repairs or maintenance undertaken.

1.8.7 Chapter 18.12 and 18.13 highlighted that any work equipment could constitute a risk to health and safety, one or more readily accessible controls must be provided to either bring it to a stop or otherwise render it safe. Additionally, one or more readily accessible emergency stop controls should be provided. An emergency stop control must be able to override any other controls.

1.9 Cause of death

1.9.1 As the body did not undergo an autopsy examination, the exact cause of death of the Third Officer could not be established. An excerpt of death certificate was issued[60] on 31 October 2020 without an indication on the cause of death.

1.10 Environmental condition

1.10.1 At the time of occurrence, Cape India's logbooks indicated that there was south-westerly moderate breeze of about 11-16 knots (Beaufort scale, force 4), the wave height was about one and half metres.

1.10.2 The outside air temperature was recorded as 32°C. The FCS was connected to the ship's central air conditioning system, the ambient temperature in the room would be lower than the outside temperature. According to the operating manual of the BA compressor, when running, the BA compressor would typically generate a noise of less than 78 dB[61].

[60] Issued by the Registry Office in Balikpapan, Indonesia.
[61] IMO Resolution A.468(XII), personnel entering spaces with noise levels greater than 85 dB(A) should be required to wear ear protectors.

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2 ANALYSIS

2.1 The failure of the BA compressor

2.1.1 The Third Officer was alone inside the FCS operating the BA compressor to charge the spare air cylinders used for drills. In the absence of a witness account, the investigation team looked into the evidence from the post-accident site and laboratory test on the BA compressor to assess the likely cause of this occurrence.

2.1.2 The initial pressure of the air cylinder to be charged was not known to anyone on board. Correlating the ASD's account during the previous charging operation on 11 October 2019, in which the pressure only reached to 28MPa, noting the pressure of the BA compressor (indicating 32MPa) after the occurrence, the investigation team deemed that the Third Officer had done something different this time, which could not be established.

2.1.3 Although the BA compressor had a pressure relief valve as a key safety feature, which was supposed to activate to release excessive air, the laboratory test revealed that this pressure relief valve had malfunctioned (discussed separately).

2.1.4 When the compressed air continued to be pushed into the AOFH, pressure started to build to a point that the O-ring seal could not hold and the air leaked into the threaded section connecting the pressure relief valve, as indicated during the laboratory tests.

2.1.5 The lower tensile strength materials (see Paragraph 1.6.4) and lower thickness of the threaded area reached its yield point and expanded, till a stage when the pressure relief valve could not be held in place by the thread and got ejected from the AOFH. The force created also caused the AOFH to break off the jubilee clip, damaged AOFH's supporting plate and flew away from its secured position.

2.1.6 Assessing the injuries sustained on the left arm and chest area of the Third Officer, it was plausible that at the time the pressure relief valve was ejected, the Third Officer was likely leaning over the BA compressor. While it could not be established why the Third Officer was leaning over the BA compressor, the following actions were likely based on the operations involving the charging of the air cylinder:

- reaching out to the power switch (at the right rear end of the BA compressor)

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for switching it off once the air cylinder was charged fully; or

- monitoring the BA charging pressure at the gauge; or
- other actions which would require Third Officer's upper body to lean across the BA compressor.

2.2 Maintenance of the BA compressor

2.2.1 There were no records of any inspection or maintenance carried out on the BA compressor, other than an air quality check. It was evident that an excessive amount of lubricating oil had been filled (about 2cm higher than the allowable high oil level marking) in the BA compressor. Correlating the carbon deposits accumulated over a period and the excessive oil, it was possible that this overfilling of lubricating oil had contributed to the failure of the pressure relief valve.

2.2.2 It was also possible that the BA compressor had been giving some problems for a while which went unnoticed. Troubleshooting these problems was likely not carried out as per the maker's manual (see table-3). For e.g. poor sealing of the air drain valve could cause a decrease in delivery volume, and subsequently a possibility of running overload for a long time resulting in overheating of the machine.

2.2.3 There were no records of any defects made known to the shipboard team / available on board, such as the inability of the air cylinder to be fully charged to the required pressure (300bar), and this remained unresolved till the occurrence.

2.2.4 The investigation team noted that there was no statutory requirement for the BA compressor to be inspected or calibrated. Considering the high pressure delivered by the BA compressor would affect the safety of the crew, as was in this case, the BA compressor should have been included in the PMS of the Company in order to maintain the reliability of the safety feature, i.e. the pressure relief valve.

2.3 Proper training in operating the BA compressor

2.3.1 According to the ASD, who had assisted the Third Officer charging an air cylinder on 11 October 2019, it was noted that the operating procedures adopted by the Third Officer were different from those recommended by the maker. The following captures the key differences in the steps:

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Maker’s recommended steps	The steps taken by the Third Officer
To keep the water/air drain valves open (to release any moisture accumulated in the system) when starting the BA compressor and to keep it running until it was stabilised.	After connecting the air cylinder to BA compressor, shut both water/air drain valves and started charging the cylinder.
To open both water/air drain to discharge condensation accumulated in the machine during operation.	This step was not performed.
To shut the air cylinder valve once it was charged to the required pressure, keep both water/air drain valves open until all air pressure released from the system, then stop the BA compressor by switching off the electrical power.	Stopped the BA compressor by switching off the electrical power and closed cylinder valve, then opened both water/air drain valves.

2.3.2 As highlighted in the COSWP, equipment should be operated by a competent person, and if operated by seafarers, they should be adequately trained in the proper use of the equipment. Though the Third Officer had past experience operating other type of BA compressor in previous ship, and had also acknowledged reading the fire safety training manual on Cape India, the incorrect operating steps indicated that the Third Officer may not have been fully conversant with the operating procedures as recommended by the maker.

2.3.3 Had the Third Officer been properly trained to use the BA equipment, he could have also recognised and reported the inability of the air cylinder to be fully charged to required pressure. It is thus extremely important to note that inadequate training and familiarisation of an equipment and operating it, could lead to adverse consequences.

2.4 The design and installation of BA compressor

2.4.1 As the investigation team did not receive a response from the maker of the BA compressor despite multiple attempts, the industry standard[62] to which the BA compressor on Cape India was constructed, could not be established. Different

[62] For example, the EU Machinery directive 2006/42/EC for machinery safety including compressor, the EU Directive 97/23/EC for pressure equipment safety standards, etc.

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makers have varying designs of BA compressors. As noted earlier, the maker had used different materials within the AOFH and with thinner thread section which contributed to this occurrence as this section expanded (enlarged) faster due to the increase in pressure.

2.4.2 The nearest source of power in use was at the upper deck alleyway. The power switch on the BA compressor was fitted at the rear end of the equipment, making it inconvenient for the user to reach it for turning it on or off, and there was no provision for any emergency stop.

2.4.3 Having an electrical power switch located at the rear end would create hazards to the user in having to lean over a running compressor to reach the switch. It could not be established whether the switch on Cape Europe had been removed for safety reasons. The investigation team opined that even if the switch was removed, it should have been replaced with an alternative arrangement for use in an emergency, as recommended in the COSWP.

2.4.4 The safety advice cautioning the operator to keep at least three metres away from the BA compressor while charging was in progress, was possibly intended to help to protect the operator. However, staying away from the BA compressor may not be practicable especially when the operator may be required to monitor the charging progress. Thus, the investigation team held the view that in an emergency, the user may have to run out of the FCS to switch off the BA compressor. The design, type and location of the power switch and emergency switch should thus be reviewed.

2.4.5 Any equipment installed on board ships should be safe for use, to protect the safety[63] of the users who are operating it. It was thus important for the Company to ensure that the BA compressor was placed in a suitable location, such as at least one metre from any bulkhead/wall and free from other stores, and the spare fire extinguishers as in this case, for better dissipation of heat.

2.5 The Company's SMS procedures

2.5.1 The Chief Engineer was responsible as per the SMS for the maintenance and overhaul schedules of all mechanical and electrical machinery and equipment to be planned and programmed into the PMS on board. However, the BA compressor had not been identified as a part of the PMS. As a result, the recommended maintenance schedules as stated in the maker's manual had

[63] ISM Code Element 1.2.2.2 - The objectives of the Safety Management System are to assess all identified risks to its ships, personnel and environment and establish appropriate safeguards.

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been left unattended, which could have detected problems with the pressure relief valve. On the same note, a detailed and regular inspection of the BA compressor would have likely detected the overfilled lubricating oil at an early stage and thus avoided accumulation of carbon deposits.

2.5.2 Consequently, the responsibility of maintaining this equipment was unaccountable even though the Third Officer was required to maintain and upkeep the fire-fighting systems as per the Company's SMS procedures. It was likely that the Third Officer considered this equipment to only be operated and there was no ownership of maintaining it, which was likely due to the lack of clarity on how it was to be maintained and by who.

2.5.3 According to the SMS, a job review or re-assessment of risks was required to be conducted before commencement of a task, unless the last job review or assessment was within one month and the same task were to be carried out less than five times. However, the charging of the air cylinder with the BA compressor had not been specified as a task that required a job review or risk assessment.

2.5.4 Considering the high pressure and heat generated during the charging of air cylinder, by conducting a risk assessment before the operation commencement would have helped to identify likely risks involved and could have had introduced safety control measures in place as recommended in the COSWP.

2.5.5 Similarly, the Company's permit to work system did not cover the air cylinder charging operation using the BA compressor, and it was left to the person in-charge of the operation for using their knowledge and experience, to operate as and when it was required.

2.5.6 As the charging of air cylinders using the BA compressor involved the hazard of high pressure which posed a high risk to personnel, a permit to work containing a checklist would be desirable as an additional safety barrier. This would allow the senior management on board to counter check and ensure the equipment could be safely operated before granting the permit. Thus, there is merit for the Company's SMS to ensure that job review and risk assessment are carried out and review the permit to work criteria for charging of air cylinders using the BA compressor.

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2.6 Coordination on rescue efforts

2.6.1 Though the revised rendezvous point for Cape India was communicated regularly between the various stakeholders, after Cape India had anchored there was an overall delay of nearly two and half hours (0354H – 0620H) when the rescue boat met up with Cape India. The following factors likely contributed to this delay:

a) The identification (name or call sign) of the guiding boat was not made known to the Master of Cape India and hence the Master was unable to communicate with the boat directly. Similarly, there was no call made via VHF radio to Cape India from the guiding boat if indeed it was waiting in the vicinity;

b) The new position (anchored position) was only conveyed to BASARNAS and RSC Balikpapan by the Master of Cape India after the vessel was brought up, that is, about half an hour after the vessel arrived at the location.

c) The RSC Balikpapan did not enquire the ship's status when the given ETA had passed, and the rescue team was likely not standing by at the revised rendezvous position.

2.6.2 Regardless of the medical assessment that the Third Officer had likely passed away a few hours earlier, it is worthwhile to take into consideration the critical at time in such situations and effective coordination was extremely important between the various stakeholders such as the ship, VTS and the MRCC.

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3 CONCLUSIONS

From the information gathered, the following findings, which should not be read as apportioning blame or determining liability to any particular organisation or individual, are made.

3.1 The Third Officer was alone inside the fire control station charging the air cylinders using the breathing air (BA) compressor when he was injured likely by the ejected pressure relief valve and the AOFH.

3.2 The pressure relief valve of the BA compressor had malfunctioned, likely caused by the excessive amount of lubricating oil, and allowed pressure to continue building up in the AOFH.

3.3 When pressure build-up in the AOFH, the air leaked into the threaded section of the AOFH and expanded the threaded section which was made of thinner and lower tensile strength material.

3.4 The expanded threaded section caused the pressure relief valve to be ejected out of the AOFH. The force created had also caused the AOFH to break off from its secured position.

3.5 The Third Officer was probably leaning across the BA compressor when the pressure relief valve and AOFH ejected from the BA compressor which could have severely injuring the Third Officer's left arm and chest.

3.6 The routine maintenance of the BA compressor including the examination and calibration of the pressure relief valve were not incorporated into the shipboard PMS as per the maker's recommendation.

3.7 The Third Officer had not received proper training to operate the BA compressor for charging the air cylinders resulting in not fully conversant with the operating steps of the BA compressor.

3.8 The Company's SMS procedures on risk assessment did not consider the risks associated with operating a high-pressure equipment and did not require a permit to work for operating the BA compressor. Hence, there was no job review or risk assessment required for the charging of the air cylinders using the BA compressor on board Cape India.

3.9 The BA compressor was installed in a location less than one metre away from the bulkhead which was not as per the recommendation of the maker.

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3.10 The design of the electrical power switch location at the rear end for the BA compressor would create safety hazard for the user to turn off the power. There was also no other emergency stop switch fitted for easy access.

3.11 There was a delay of about two and half hours between the arrivals of the ship and the rescue party at the rendezvous position, there is room for improvement among the stakeholders in ensuring timely arrival of the rescue party.

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4 SAFETY ACTIONS

During the course of the investigation and through discussions with the investigation team, the following safety actions were initiated by the relevant stakeholders.

4.1 Actions taken by the Company

4.1.1 After the occurrence, the Company had suspended all charging of air cylinders using the same model of BA compressor in its fleet of ships. Instead, they had placed spare charged air cylinders, i.e. to dispense the need for a BA compressor as permitted within SOLAS as an interim safety measure.

4.1.2 Learning from the occurrence, the Company's SMS procedures had been reviewed and amended in the following areas:

a) all BA compressors in use on its fleet of ships, the scheduled maintenance as recommended by maker are to be incorporated into the ship's PMS, which should be planned by ship's Chief Engineer in consultation with ship's Master, and to ensure it would be carried out timely as planned;

b) Each charging operation using BA compressor, a permit to work must be obtained from the ship's Master and the Chief Engineer. Risk assessment is required to be carried out;

c) Both the Third Officer and Fourth Engineer are designated officers to be present to carry out charging operations. If one of them is not available, an alternate experienced person should be approved by the Master and the Chief Engineer;

d) Additionally, the charging of air cylinder using the BA compressor has been classified as a special operation. A list of procedures and precautions are developed in accordance with the maker's recommendations.

e) To arrange for BA compressor maker to provide training to persons designated for operating the BA compressor on board.

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5 SAFETY RECOMMENDATIONS

A safety recommendation is for the purpose of preventive action and shall in no case create a presumption of blame or liability.

5.1 The Company (the ISM Managers)

5.1.1 To ensure that BA compressor of safety standard approved by competent authority is used on board its fleet of ships. **[TSIB-RM-2020-045]**

5.1.2 To ensure that BA compressor is installed in accordance to the recommendations by the maker. **[TSIB-RM-2020-046]**

5.2 The MRCC Indonesia (who provided medical evacuation coordination service from Cape India)

5.2.1 To review its operation procedures to improve the coordination between the incident ship requiring urgent medical evacuation assistance and parties ashore, such as local Rescue Sub-coordination Centre, Vessel Traffic Service, whenever applicable. **[TSIB-RM-2020-047]**

- **End of Report** -

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