MARINE SAFETY INVESTIGATION REPORT

Safety investigation into the serious injuries on board the Maltese registered container ship

SCA MUNKSUND

in position 55° 43.7’ N 015° 27.6° E

on 31 July 2016

201607/042

MARINE SAFETY INVESTIGATION REPORT NO. 17/2017

FINAL

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The objective of this safety investigation report is precautionary and seeks to avoid a repeat occurrence through an understanding of the events of 31 July 2016. Its sole purpose is confined to the promulgation of safety lessons and therefore may be misleading if used for other purposes.

The findings of the safety investigation are not binding on any party and the conclusions reached and recommendations made shall in no case create a presumption of liability (criminal and/or civil) or blame. It should be therefore noted that the content of this safety investigation report does not constitute legal advice in any way and should not be construed as such.

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Crew members SCA Munksund


Managers SCA Munksund


# GLOSSARY OF TERMS AND ABBREVIATIONS

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<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>AB</td>
<td>Able seafarer</td>
</tr>
<tr>
<td>CPP</td>
<td>Controllable pitch propeller</td>
</tr>
<tr>
<td>DNV GL</td>
<td>Det Norske Veritas Germanischer Lloyd</td>
</tr>
<tr>
<td>E</td>
<td>East</td>
</tr>
<tr>
<td>ER</td>
<td>Engine-room</td>
</tr>
<tr>
<td>ETA</td>
<td>Estimate time of arrival</td>
</tr>
<tr>
<td>gt</td>
<td>Gross tonnage</td>
</tr>
<tr>
<td>IMO</td>
<td>International Maritime Organization</td>
</tr>
<tr>
<td>kW</td>
<td>Kilowatt</td>
</tr>
<tr>
<td>LT</td>
<td>Local time</td>
</tr>
<tr>
<td>m</td>
<td>Metres</td>
</tr>
<tr>
<td>ME</td>
<td>Main engine</td>
</tr>
<tr>
<td>mm</td>
<td>Millimetre</td>
</tr>
<tr>
<td>MSIU</td>
<td>Marine Safety Investigation Unit</td>
</tr>
<tr>
<td>Mt</td>
<td>Metric tonnes</td>
</tr>
<tr>
<td>MV</td>
<td>Motor vessel</td>
</tr>
<tr>
<td>N</td>
<td>North</td>
</tr>
<tr>
<td>nm</td>
<td>Nautical mile</td>
</tr>
<tr>
<td>No.</td>
<td>Number</td>
</tr>
<tr>
<td>OS</td>
<td>Ordinary seafarer</td>
</tr>
<tr>
<td>PTO</td>
<td>Power take-off</td>
</tr>
<tr>
<td>Rpm</td>
<td>Revolutions per minute</td>
</tr>
<tr>
<td>SMS</td>
<td>Safety Management System</td>
</tr>
<tr>
<td>STCW</td>
<td>International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978</td>
</tr>
<tr>
<td>TEU</td>
<td>Twenty equivalent units</td>
</tr>
<tr>
<td>UMS</td>
<td>Unmanned machinery space</td>
</tr>
<tr>
<td>VHF</td>
<td>Very high frequency</td>
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**SUMMARY**

At about 1604\(^1\) on 31 July 2016, the chief engineer on board *SCA Munksund* was hit by flying debris following the disintegration of the flexible coupling between the power take-off from the main engine gearbox and the input to the shaft generator.

The chief engineer was seriously injured, sustaining amputation of his right hand from below the middle of his forearm. He also suffered other injuries to his face.

The vessel sought medical assistance from the Swedish Rescue Centre and the injured crew member was lifted ashore by helicopter.

The Marine Safety Investigation Unit (MSIU) found that immediately prior to the accident, the flexible coupling between the main engine gearbox power take-off and the shaft generator had been incorrectly disassembled (split), following failure of the shaft generator.

Moreover, the safety investigation revealed that the context in which the chief engineer and his subordinates were operating, was intricate enough that possible options were actually either not observed or else not deemed feasible to be considered.

The MSIU has issued four recommendations designed to ensure that risks associated with the dismantling of similar couplings are better understood.

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\(^1\) All times stated herein are local (LT), as quoted in the documentary evidence.
## 1 FACTUAL INFORMATION

### 1.1 Vessel, Voyage and Marine Casualty Particulars

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td><em>SCA Munksund</em></td>
</tr>
<tr>
<td>Flag</td>
<td>Malta</td>
</tr>
<tr>
<td>Classification Society</td>
<td>DNV GL</td>
</tr>
<tr>
<td>IMO Number</td>
<td>9429223</td>
</tr>
<tr>
<td>Type</td>
<td>Container Ship</td>
</tr>
<tr>
<td>Registered Owner</td>
<td>Buss Corsar Shipping Company Ltd.</td>
</tr>
<tr>
<td>Managers</td>
<td>Buss Shipping GmbH &amp; Co. KG</td>
</tr>
<tr>
<td>Construction</td>
<td>Steel (Double bottom)</td>
</tr>
<tr>
<td>Length overall</td>
<td>157.70 m</td>
</tr>
<tr>
<td>Registered Length</td>
<td>147.60 m</td>
</tr>
<tr>
<td>Gross Tonnage</td>
<td>11746</td>
</tr>
<tr>
<td>Minimum Safe Manning</td>
<td>13</td>
</tr>
<tr>
<td>Authorised Cargo</td>
<td>Containers</td>
</tr>
<tr>
<td>Port of Departure</td>
<td>Sundsvall, Sweden</td>
</tr>
<tr>
<td>Port of Arrival</td>
<td>Europort, Rotterdam</td>
</tr>
<tr>
<td>Type of Voyage</td>
<td>Short International</td>
</tr>
<tr>
<td>Cargo Information</td>
<td>Containerised cargo (7472 mt)</td>
</tr>
<tr>
<td>Manning</td>
<td>14</td>
</tr>
<tr>
<td>Date and Time</td>
<td>31 July 2016 at 16:04</td>
</tr>
<tr>
<td>Type of Marine Casualty</td>
<td>Serious Marine Casualty</td>
</tr>
<tr>
<td>Place on Board</td>
<td>Engine-room (starboard aft side of platform deck)</td>
</tr>
<tr>
<td>Injuries/Fatalities</td>
<td>One serious injury</td>
</tr>
<tr>
<td>Damage/Environmental Impact</td>
<td>None</td>
</tr>
<tr>
<td>Ship Operation</td>
<td>Normal Service – On passage</td>
</tr>
<tr>
<td>Voyage Segment</td>
<td>Transit</td>
</tr>
<tr>
<td>External &amp; Internal Environment</td>
<td>Daylight, visibility 10 nautical mile, wind Southwesterly 10 knots, light swell (Southeasterly 0.3 m), sea temperature was 19 °C</td>
</tr>
<tr>
<td>Persons on Board</td>
<td>14</td>
</tr>
</tbody>
</table>
1.2 Description of Vessel

*SCA Munksund*, a 11746 gt container ship, was built in 2012 and is registered in Valletta, Malta. She is owned by Buss Corsar Shipping Company Ltd., managed by Buss Shipping GmbH & Co Kg, Germany and classed by DNV GL.

The vessel’s length overall is 157.70 m and her loaded draught is 8.00 m. With a corresponding deadweight of about 13050 tonnes, she is capable of carrying 1025 TEU in her cargo holds and on deck (Figure 1).

Propulsive power is provided by a 9-cylinder MAK Caterpillar 9M43C, medium speed four-stroke diesel engine, producing 9000 kW at 500 rpm, via a controllable pitch propeller (CPP). This gives the vessel a service speed of about 18.3 knots.

The Reintjes main engine (ME) driven gearbox, as well as providing 500 rpm fixed speed to the propeller shaft (and hence the CPP), provides an 1800 rpm power take-off (PTO), which in turn drives the 1360 kW AEM SE 450 L4 shaft generator. The drive train has no clutches fitted, however, a ‘Vulkan’ flexible coupling is fitted between the ME (output) and the gearbox (input), and between the gearbox PTO shaft (output) and the shaft generator (input).

1.3 Crew

*SCA Munksund*, had a crew complement of 14 from Russia, Ukraine and the Philippines, in compliance with the vessel’s Minimum Safe Manning Certificate. The crew on board at the time of the accident comprised of a master, chief mate, second and third mates, the bosun, two Able seafarers (AB), two ordinary seamen (OS), a chief engineer, one second engineer, an oiler, wiper and a cook.

All officers and ratings were duly certified with appropriate STCW qualifications for their respective ranks.

The seriously injured chief engineer was a 54 year old Ukrainian national. He had a total of 26 years sea service, the latter 10 years in the rank of chief engineer. This was his first contract with the Company, having joined the vessel a little over two months earlier on 25 May 2016.
Figure 1: MV MSC Munksund
1.4 Environment

The weather was clear and the air temperature was 21 °C. The wind was Southwesterly, about 10 knots and the sea state was light with a 0.3 m Southeasterly swell. Visibility was good at about 10 nautical miles (nm).

1.5 Narrative

The *SCA Munksund* was engaged on a round-trip, fixed trade route, plying between St Petersburg in Russia and Europort (Rotterdam) in The Netherlands, with an additional port call in Sweden. The vessel had departed from her previous port, Sundsvall in Sweden at 1000 on 30 July 2016, laden with some 7472 tonnes of cargo with a forward draught of 7.4 m and an aft draught of 8.2 m.

Just prior to the accident, an alarm had sounded in the engine-room (ER) at 1518 on 31 July 2016, when the vessel was in position 55° 44.8’ N 015° 40.2’ E, being at that time approximately some 27 nm due South of Karlskrona (Figure 2).

![Figure 2: Vessel’s position at time of ER alarm (ME stop) and at time of accident (ME restart)](image)

The alarm was an ER fire alarm, having in turn been activated by smoke coming from the shaft generator.
1.5.1 Pre-accident events

As the smoke, which had activated the fire alarm, had been seen coming from the shaft generator, the power was immediately transferred to auxiliary generator no. 2, the shaft generator was then tripped electrically, thereafter the ME was stopped, which also mechanically coupled to the shaft generator.

The shaft generator was subsequently found to have burned exciter windings in way of the enclosed overheated aft bearing (Figure 3).

In order to continue with the vessel’s voyage, the chief engineer, having reviewed the ‘Vulkan’ coupling drawing arrangement, and in discussion with the second engineer, had made the decision to disconnect the coupling between the ME gearbox PTO and the shaft generator.

However, reportedly at about 1535 prior to commencement of any work, the chief engineer had first twice tried to contact the vessel’s technical superintendent by

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2 ‘Vulkan’ being the manufacturer of the coupling.
calling him on his mobile phone. However, unable to get a reply, the chief engineer then went ahead with his plan, having not discussed his intentions within anyone from the vessel’s technical management ashore.

The second engineer along with the oiler, followed the chief engineer’s instructions and removed the coupling guard (safety cover)\(^3\), disconnected (\(i.e.\) split) the coupling by removing 16 bolts (part # 9) and the intermediate spacer ring (part #6) which was secured by each of the 16 bolts (Figure 4).

The ME turning gear was then used to rotate the (still mounted) gearbox PTO side of the coupling to verify disconnection from the shaft generator side of the coupling, which was checked and confirmed not to rotate by both the chief engineer and the second engineer.

The vessel’s position at 1600 was 55\(^0\) 43.7’ N 015\(^0\) 27.6’ E when shortly thereafter, after refitting of the safety cover, the ME was restarted and brought up to about 250 rpm.

A while later, the wiper reported seeing from just outside the ER control room, sparks coming from the coupling. He informed the chief engineer who then, accompanied by the wiper, immediately went down to the ER, towards the coupling to investigate further without stopping the ME.

Reportedly, whilst the wiper had positioned himself about 2.1 metres fwd\(^4\) of the coupling to the starboard side of the ME gearbox on the Platform Deck, (Figure 5, position B) the chief engineer positioned himself about 1.2 m aft of the coupling, on a slightly more elevated platform (due to the three steps and hence higher up than the wiper), to the starboard side of the shaft generator itself. The relative positions of the two crew members are shown in figures 5a, 5b and 5c.

\(^3\) The terminology ‘safety cover’ is used herein to refer to the (perhaps more common) ‘coupling guard’, because it was the term used by ships’ staff on board.

\(^4\) The distances as quoted herein were subsequently obtained by measurement during the MSIU investigation, in turn based on the approximate positions as actually pointed out by witnesses.
Figure 4: Section through the Vulkan coupling with parts 6 and 9 which were removed (arrows)
Figure 5a: Relative position of the chief engineer (A) and the wiper (B)

Figure 5b: Position of the chief engineer just before the accident

Figure 5c: Position of the wiper just before the accident
1.5.2 The accident and reported injuries

The safety cover was reportedly seen to have been vibrating. Suddenly, the coupling ‘flew apart’ which in turn, catapulted the safety cover along with other debris from the disintegrated coupling towards starboard aft, precisely where the chief engineer was standing (Figure 5b). Then, it ricocheted off an overhead air compressor and ended up, along with the rest of the disintegrated coupling parts, on the port side of the platform deck.

The chief engineer, who was knocked over by the impact of the flying debris\(^5\), sustained facial injuries to his nose and the complete amputation of his right hand, which was found along with his torch on the elevated platform, about one metre away to starboard (\textit{i.e.} further outboard), immediately in front of the compressor, which the debris had ricocheted off.

The second engineer, who had been in the ER control room, after being alerted of the situation by the wiper and the oiler, went down to the starboard side of the platform deck in the lower ER to check on the chief engineer, before hastily returning to the ER control room, from where he immediately stopped the ME, and informed the bridge of the accident.

1.5.3 Post-accident events

The master quickly activated the general alarm, followed by a public address announcement to inform the other crew members to proceed to the ER to afford medical assistance. The chief mate applied a tourniquet on site and bandaged the chief engineer’s right arm, prior to evacuating the casualty to the crew mess.

The chief mate then immediately requested shore medical assistance by means of VHF on Channel 16 whilst the master telephoned the Company on their emergency contact number to report the situation.

By 1630, helicopter assistance was confirmed by the Swedish Rescue Centre, who then advised an ETA of approximately 30 minutes. By 1645, the casualty had been transferred to the deck, in preparation for helicopter evacuation. The helicopter

\(^5\) Due to the speed of the accident and the only witness (the wiper) having ducked to protect himself, the MSIU was unable to positively ascertain which part(s) actually struck the chief engineer; however, it was either the safety cover itself or perhaps coupling parts carried with it. The term ‘debris’ is therefore used.
arrived on scene at 1700 and the medical team was on board by 1712. The entire helicopter evacuation was successfully completed at 1735.

After the accident (i.e. after the seriously injured chief engineer had been evacuated by helicopter), the second engineer, having removed the remaining parts of the coupling parts and cut away the remnants of the safety cover, restarted the ME at 1900 on 31 July 2016, by which time, the vessel was in position 55° 44.9’ N 015° 30.5’ E. SCA Munksund then effectively recommenced her voyage on passage to Rotterdam, via the Kiel Canal and arrived safely alongside.

1.6 Sustained Damage

Ancillary equipment in the ER did not sustain severe damages. The air compressor sustained minor impact damage, in all probability caused by flying debris. The Vulkan coupling, however, sustained a catastrophic structural failure (Figure 6).
2 ANALYSIS

2.1 Purpose

The purpose of a marine safety investigation is to determine the circumstances and safety factors of the accident as a basis for making recommendations, to prevent further marine casualties or incidents from occurring in the future.

2.2 Immediate cause of the accident

The safety investigation revealed that the chief engineer suffered serious injuries as a result of the catastrophic structural failure of the Vulkan coupling fitted between the gearbox PTO and the shaft generator.

Technical literature confirmed that any rotating equipment works when it is well aligned. With the coupling loose on the shaft generator side (albeit without rotating clearance – Figure 8 below) but still bolted down to the gearbox PTO, a situation had been created where the full weight of the coupling remained suspended from one end and unsupported at the other, creating an unavoidable deflection of the coupling body even because of its inherent flexible characteristics.

The MSIU believes that the above conditions caused a catastrophic structural failure of the coupling as a result of shaft-coupling misalignment, generating excessive and severe vibration and extreme imbalance forces when the ME was running at its operating rpm.

2.3 Fatigue

Analysis of all the ER staff’s record of hours of rest showed that during the day preceding the accident, the chief engineer had 16 hours of rest, the second engineer had 15 hours of rest, while the oiler and the wiper had 12 and 13.5 hours of rest respectively. This was typical for the vessel’s trading pattern and UMS\(^6\) routines which were applied on board. Considering that the MSIU did not have any evidence

\(^6\) Unmanned Machinery Space.
which suggested that the behaviour of the involved crew members reflected fatigue, the latter was not considered to be a contributing factor to this accident.

2.4 Limiting Factors

Review of the Vulkan coupling drawing (Figure 4) indicated that the distance between the gearbox PTO (output) shaft end and shaft generator (input) shaft ends was only 120 mm (Figure 7).

![Figure 7: Distance of 120 mm between the PTO and input shaft](image)

The length of the gearbox PTO drive side coupling hub alone was measured on board to be 175 mm as indicated in the Vulkan drawing.

Allowing between five to six millimetres overhang as observed and measured on board (Figure 8), the overall length of the coupling hub and the mounted flexible elastic element complete with all its various connecting parts was effectively about 300 mm.
To remove the gearbox PTO (drive) side of the coupling complete, it would have been necessary first to release the shaft generator from its foundations (after the necessary disconnection and removal of its electrical connections), and then move it far enough aft to create the necessary working clearance.
2.5 Other Options and the Exposure to Risk

Notwithstanding the limiting factors mentioned in sub-section 2.4 above, it was noted that without disturbing the shaft generator, as well as by releasing the bolts (Part 9) and removing the split intermediate ring (Part 6), the individual component parts of the coupling, including the flexible elements (Part 7) could have been disassembled. There was adequate working clearance being afforded for sequential removal of the various interconnecting bolts stage by stage, (i.e. Parts 18, 10, 7.4, 7.6 and finally Part 12), by following the replacement / dismantling procedures as described in the Vulkan manual.

After the disassembling (i.e. removal of all of the flexible element parts as described above), this would only have left the hub itself (Part 5) which could still not be removed, due to the aforementioned lack of working clearance. This would have adequately afforded a much safer emergency disconnection of the Vulkan coupling, to allow the ME to be restarted without the danger of any severe out-of-balance forces or metal to metal contact. In that case, only the coupling hub (Part 5) would have remained on the gearbox PTO shaft with a clearance of 120 mm to the disconnected shaft generator side of the coupling.

Alternatively, as an extreme emergency measure (at the cost of destroying the coupling’s flexible parts) the rubberised elastic elements could have been cut through, relatively quickly, simply by sawing through the middle of each rubberised section, hence allowing rapid access to the last set of bolts (Part 12) for then an easy and quick removal of the remaining flange connection of Part 7 from the gearbox PTO side coupling hub (Part 5).

The only remaining alternative when the shaft generator was seized or otherwise immobilised, which effectively meant the ME was immobilised, due to there being no clutch between the gearbox PTO and the shaft generator, was to hire tug assistance and tow the vessel either to a safe anchorage or port where technical assistance could have been provided.

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7 The various component parts and their respective connecting bolts can be seen in Figure 4.
All the above options, which now, with the benefit of hindsight look safer, were either not considered by the relevant crew members or else, were not thought of before the decision to remove Parts 9 and 6 was taken. The MSIU believes, however, that these potential options were not as linear as one may assume. Rather, the MSIU believes that the critical data which has been discussed in this sub-section was only possible to achieve with the benefit of hindsight.

The context in which the chief engineer and his subordinates were operating, was intricate enough that the above options were actually either not observed or else not deemed feasible to be considered. For instance, the problem which the crew members had encountered was actually related to a faulty shaft generator. Therefore, it was likely that the crew members would have never considered destroying the coupling, when the problem had originated from the shaft generator.

Even more, the analysis and understanding of the drawing at the time would have indicated that the removal of Parts 9 and 6 was all that was required to de-couple the coupling shaft generator from the gearbox PTO. Therefore, the (lengthy) sequential disassembly was most probably discarded because the understanding at the time was that the removal of Parts 9 and 6 would have sufficed to proceed with the voyage. Even more, the towing of the vessel to the nearest port, as much as being an option, was not acceptable, not to mention the costs involved and the legal implications of towing a disabled ship to safety.

The MSIU is therefore convinced that at the time, the removal of Parts 9 and 6 was seen as the safest and most cost effective option. Even if the decision to remove Parts 9 and 6 may be seen as a risky one, one has to appreciate that perception of risk is critical to risk-taking behaviour. Risks have to first be identified before they are evaluated and eventually accepted and / or rejected. Therefore, if neither the chief engineer nor any other crew member was aware that they were actually exposed to risk and / or the actual risk was not observable, then the judgement about risk (and its acceptance) would have been jeopardised.

The MSIU is of the view that the difficulty experienced by the chief engineer and the other crew members was immediate at the perception stage. Empirical studies in safety-critical domains other than the maritime, demonstrated that perceptions of
hazards (which is correlated to risk), is influenced by an array of factors, ranging from
detection to cognitive inferences.
These factors are listed below, in order of strength:

- perception of human senses;
- comparison with standards;
- perceptible events that could have been related to hazardous conditions; and
- memory recall.

The crew members on board *SCA Munksund* had none of these factors available until
after the accident happened and hence, their ability to assess real risk was also limited;
actually, their mental model of the situation was not rich enough to allow for a
systematic analysis. This is so because the crew members neither had previous
experience of Vulkan coupling failures nor were they receiving disconfirming cues;
until the catastrophic failure of the coupling, there were no visible conditions on
board, which would have alerted the crew members of any developing dangers.

Actually, the situation was misleading to the crew members. The ME was rotated on
the turning gear and there were no visible indications of any potential issues. Rather,
the successful turning of the ME with the turning gear not only confirmed that the
shaft generator was successfully de-coupled from the gearbox PTO, but that there
were no particular risks which should have prohibited the chief engineer from taking
the decision to start the ME.

In this respect, the crew members found themselves in a less than optimal position to
predict (or anticipate) potential developing hazards once the ME was started.
2.6 The Safety Management System (SMS)

2.6.1 Emergency manual
A review of the vessel’s SMS manuals revealed that within the Emergency Manual, various emergency plans were listed. However, none specifically addressed the unique issue of shaft generator failure due to mechanical immobilisation. Therefore, no specific guidelines were available on board for the chief engineer to refer to, except for the Manufacturer’s manual. It was deemed possible that even because of the very positive track record of these couplings, the Company did not consider a coupling failure as necessary to be addressed in the SMS Manual.

2.6.2 Risk assessment
The need for risk assessments to be undertaken was incorporated into the vessel’s SMS; adequately covered by Ship’s Order No. 045, which required a formal risk assessment to be performed for the following situations:

- unscheduled repairs; and
- seldom practiced works with expected lack of experience by performing crew members.

Contrary to the requirements of the Company’s procedures, no formal risk assessment was carried out prior to the disconnection of the Vulkan coupling. However, the chief engineer had twice tried to contact the vessel’s technical superintendent ashore by mobile telephone, which indicated that he was seeking support, but as there was no reply from the superintendent he went ahead with his plans.

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8 Not all situations from Ship’s Order No: 045 are quoted herein, only the two most relevant to the task in hand (i.e., unscheduled repairs and seldom practiced works).

9 Review of the vessel’s last three internal ISM audits revealed evidence of non-conformities in respect to lack of risk assessment in general, especially in the ER Department.

10 During the consultation period, the Company confirmed that the chief engineer had not called on the Company’s emergency number, which is on the SMS Manual and posted in all public areas on board, including the engine control room and the bridge.
It may be argued that the lack of formal risk assessment meant that the engineers concerned were unable to consider all the hazards related to this job, not least the following:

- after disconnection of the coupling, component parts still overlapped each other by 5 mm ~ 6 mm in an area where there was no running clearance by design\textsuperscript{11}, and metal to metal contact / interference was bound to occur at high speed; and
- the exceptionally large out-of-balance forces due to leaving the elastic element of the coupling still mounted on the PTO drive side of the coupling due to the inherent flexibility of the unsupported mass.

As already explained above, the better option would have been to disassemble all the flexible elastic element parts from the coupling hub, leaving only the hub mounted on the PTO drive shaft. As explained in sub-section 2.5, the statement may be made with the benefit of hindsight, which the chief engineer did not have at the time. Considering the delays involved to carry out the risk assessment, and taking into consideration that the vessel was without propulsion power and adrift, the MSIU concluded that on the basis of their understanding, both the chief engineer and the other crew members had come to the conclusion that the best option was to dismantle only the shaft generator’s side of the coupling.

It was also not excluded that after consulting the Manufacturer’s manual, the chief engineer had come to the conclusion that he had understood how the system worked and had foreseen no potential issues with the task. It was also very probable that without the support of his Company’s office, the chief engineer felt that he had to take a decision on the matter, comfortable enough that the crew members had voiced no concern on this plan.

2.6.3 Stopping the main engine
Upon the first signs of problems, \textit{i.e.}, when sparks were seen in way of the coupling and vibrations were initially felt, the crew members did not:

- stay well clear of the high speed rotating coupling; and
- first stop the drive (the ME) before investigating the cause.

\textsuperscript{11} \textit{Vide} Detail in Figure 8, which illustrates the 5 mm ~ 6 mm overlap and lack of running clearance.
The MSIU believes that at the time the wiper reported the issue to the chief engineer, there was still no understand of what was happening and why were sparks emanating from the coupling area. It was also evident that the crew members would have never suspected that the coupling would catastrophically fail within a few seconds from going in its proximity.

2.6.4 Serious injuries at sea

The aforementioned Emergency Manual, under Emergency Plans provided adequate and comprehensive guidelines for dealing with serious injuries at sea, for which the master and all ships’ staff are to be commended in following precisely the procedures set out therein. The vessel also completed the prerequisite incident reporting form as outlined in the SMS manual.

2.7 Similar Past Accidents

The MSIU was unable to identify reports into similar failures. However, a general discussion with the industry revealed that there were at least two similar accidents, which have happened in the past.

In 2010, the Swedish Club issued a circular to its members whereby a similar accident was reported\(^\text{12}\). In this reported case, the engineers had noticed a defective bearing on the shaft generator’s side. The ME had been stopped and the Vulkan coupling between the generator and the gearbox was dismounted. The multi-row elastic element was, however, retained on the secondary PTO shaft. At an engine speed of about 500 rpm, the generated forces were high enough to force the secondary PTO shaft out of the gearbox housing, damaging the bearings, housing and dear teeth.

THE FOLLOWING CONCLUSIONS AND SAFETY ACTIONS SHALL IN NO CASE CREATE A PRESUMPTION OF BLAME OR LIABILITY. NEITHER ARE THEY LISTED IN ANY ORDER OF PRIORITY.
3 CONCLUSIONS

Findings and safety factors are not listed in any order of priority.

3.1 Immediate Safety Factor

.1 The chief engineer suffered serious injuries as a result of the catastrophic structural failure of the Vulkan coupling fitted between the gearbox PTO and the shaft generator.

3.2 Latent Conditions and other Safety Factors

.1 With the coupling loose on the shaft generator side but still bolted down on the gearbox PTO, a situation had been created where the full weight of the coupling remained suspended from one end and unsupported at the other end, creating an unavoidable deflection of the coupling body even because of its inherent flexible characteristics;

.2 The operation of the Vulkan coupling only supported on one side caused a catastrophic structural failure of the coupling as a result of shaft-coupling misalignment, generating excessive and severe vibration and extreme imbalance forces when the engine was running at its operating rpm;

.3 The context in which the chief engineer and his subordinates were operating was intricate enough that possible options were actually either not observed or else not deemed feasible to be considered;

.4 The removal of Parts 9 and 6 was seen as the safest and most cost effective option;

.5 The judgement about risk (and its acceptance) had been jeopardised because neither the chief engineer nor any other crew member was aware that they were actually exposed to risk and / or the actual risk was not observable;

.6 The difficulty experienced by the chief engineer and the other crew members was immediate at the perception stage;
The crew members on board *SCA Munksund* had no disconfirming cues correlated to the detection of risk until after the accident happened and hence, their ability to assess real risk was also limited;

The situation was misleading to the crew members because the ME was rotated on the turning gear and there were no visible indications of any potential issues;

No specific guidelines in the SMS Manual were available for the chief engineer to refer to with respect to the dismantling of the Vulkan coupling.

### 3.3 Other Findings

The MSIU did not have any evidence which suggested that the behaviour of the involved crew members reflected fatigue, the latter was not considered to be a contributing factor to this accident.
4 RECOMMENDATIONS

In view of the conclusions reached and taking into consideration the safety actions taken during the course of the safety investigation,

Buss Corsar Shipping GmbH & Co. KG is recommended to:

17/2017_R1 Ensure that Company’s emergency plans within the SMS Manual are developed to address the course of action in the event of a mechanical incapacitation of the shaft generator;

17/2017_R2 Ensure that appropriate signage is displayed on the coupling guard (and other similar couplings), giving a clear warning that they should be disassembled as per Manufacturer’s instructions and the Company’s emergency plans;

Vulkan Kupplungs und Getriebebau Bernahrd Hackforth GmbH & Co. KG is recommended to:

17/2017_R3 Issue a clear warning that under no account should the coupling be run ‘split’ by only removing the bolts and spacer ring;

17/2017_R4 Issue guidance on how to best split the coupling to enable it to be run in an emergency.