Marine Safety Investigation Unit

Transport Malta

SAFETY INVESTIGATION REPORT

201905/034 REPORT NO.: 13/2020 May 2020

This safety investigation has been conducted with the assistance and cooperation of the Italian Ministry of Infrastructure and Transport.

MV *RIGA*
Fatality following entry into cargo hold in position 42° 09.6' N 016° 24.6' E
27 May 2019

SUMMARY

Following completion of loading of cargo, MV *Riga* departed from Porto Marghera, Italy, on 26 May 2019.

On the evening of 27 May, the chief engineer went up to the bridge and informed the chief officer that the water ingress alarm of the cargo hold bilge well had activated and that he intended to investigate the matter. The chief officer ordered an able seafarer to open the cargo hold access hatch to visually investigate from the deck.

The chief engineer accompanied the able seafarer and on noticing water inside the cargo hold, the former entered the cargo hold.

While on the cargo hold ladder, he fell down the access trunk. The crew members immediately prepared for the chief engineer's rescue and, on bringing him out of the cargo hold, tried to resuscitate him. However, their efforts were unsuccessful.

The MSIU has issued three recommendations to the Company designed to ensure that adequate safety measures are taken prior to entering cargo holds, and one recommendation to the flag State Administration to address the possible hazards associated with a cargo of glass cullet.

FACTUAL INFORMATION

Vessel

MV *Riga* was a 2,810 gt, single-cargo hold, general cargo vessel, built in Romania in 1997. She was owned by MV Riga LLP and managed by Powdermill Navigation Inc., Greece, since 01 August 2018. At the time of the accident, she was classed with DNV-GL.

The vessel had a length overall of 89.9 m, a moulded breadth of 13.17 m, a moulded depth of 7.15 m and a summer draught of 5.72 m, which corresponded to a summer deadweight of 4,220 metric tonnes (mt).

Propulsive power was provided by a 6-cylinder, four-stroke, single-acting, direct drive, Deutz TBD 645 L6 marine diesel engine, producing 1,200 kW of power at 600 rpm. This drove a single, right-handed, controllable-pitch propeller, through a reduction gear on the propeller shaft, which enabled *Riga* to reach an estimated speed of 11 knots.

Crew

The Minimum Safe Manning Certificate of the vessel stipulated a crew of nine, which included a chief engineer, a second engineer and an engine rating. At the time of the accident, the complement of the vessel met these requirements. The crew members were nationals of Russia and Ukraine.

The deceased chief engineer was a 58-year old Russian national. At the time of the accident, he held a Certificate of Competence issued by Russia, with STCW III/2 qualifications for a chief engineer. He had served for a total of 11 years in the rank of a chief engineer; however, this was his first assignment with the Company. He had joined *Riga* on 16 February 2019, while the vessel was in the Kiel Canal.

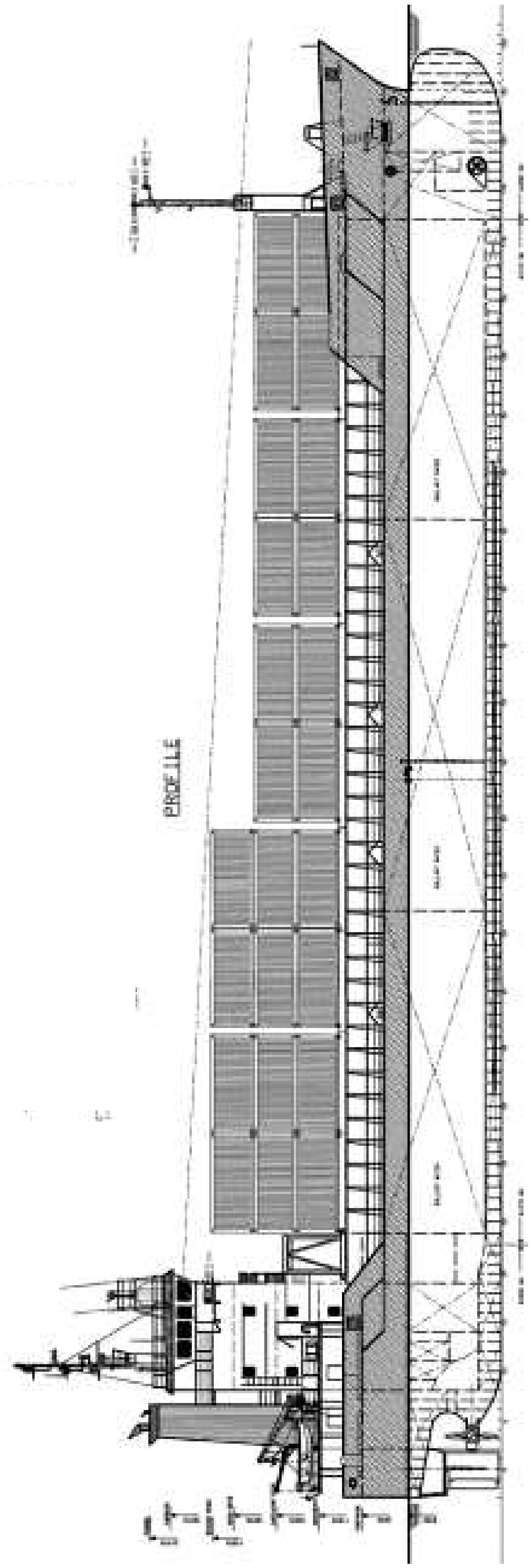

Figure 1: General Arrangement Plan - *Riga* (Scale 1:200)

The chief officer, who was keeping a bridge watch at the time of the accident, was a 55 year old Russian national. He held a Certificate of Competence issued by Russia, with STCW II/2 qualifications for a chief mate. He had served for a total of 20 years in the rank of a chief officer; 10 years of which were served in this Company. He had joined *Riga* on 11 April 2019, in the port of Ravenna, Italy.

The able seafarer, who was on deck with the chief engineer at the time of the accident, was a 54-year old Ukrainian national. He held a Certificate of Proficiency issued by Ukraine, with STCW II/5 qualifications. He had served for a total of 32 years in the rank of an able seafarer (deck), eight years of which were served in this Company. He had joined *Riga* on 28 January 2019, in Port Tellines, France.

Cargo loaded on board

At the time of the accident, the vessel was loaded with 3,926 mt of 'packaging waste glass cullet', which was loaded from an unsheltered location on the quay (Figure 2), at Porto Marghera, Italy. It was reported that the cargo, when loaded, was partly wet, as it was raining a couple of days prior to loading.

Figure 2: Area on the quay from where cargo was loaded

A report prepared by the Chemical Consultant to the port authorities of Venice indicated that this cargo originated from separate collection of municipal waste carried out by various local collection operators, on behalf of the glass recovery Consortium (Consorzio Recupero Vetro). The operators deliver the collected glass waste to the storage plant, where a 300 kg sample of the waste delivered by each operator is analysed[1].

This report also stated that further analysis was carried out on around a total of 33 samples, which formed part of the cargo to be loaded on board *Riga*, from 01 January 2019 to 16 April 2019. For further confirmation, a fraction of the waste was said to have been subjected to a chemical analysis to evaluate the possible presence of hazardous substances, such as metals, aromatic organic compounds, halogenated organic, IPA (isopropyl alcohol) and extractable metals.

The report stated that the cargo could be assumed to be similar to Glass Cullet, as described in the IMSBC Code[2], with the exception that while glass cullet "is a material already selected and composed exclusively of glass waste", the cargo was "a waste that had not yet been processed" and could be defined as Waste-Packaging Glass Cullet.

This report also contained a safety recommendation[3] and was provided to the vessel, prior to loading.

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[1] http://www.conai.org/en/regions-and-local-bodies/anci-conai-framework-agreement/glass-annex/

[2] International Maritime Solid Bulk Cargoes Code, as amended: This Code was adopted by the International Maritime Organization on 04 December 2008, after recognizing the need to provide a mandatory application of the agreed international standards for the carriage of solid bulk cargoes by sea. The code entered into force on 01 January 2011.

[3] Reference to this is made in the next section.

Cargo hazards

It was reported to the safety investigation that no safety data sheet was provided for the cargo. However, the aforementioned report, issued by the port authorities prior to loading, indicated that the cargo was free from chemical risks or possible liquefaction.

Nonetheless, this report recommended that access to the cargo hold is subjected to careful surveillance in order to verify a sufficient concentration of Oxygen, particularly after prolonged closure, as the products from which the cargo was generated may have contained foods and sugary compounds.

This report was written in Italian and no translation into any other language was found on board the vessel.

Individual schedule under the IMSBC Code

The IMSBC Code classifies this cargo under Group C. This group consists of cargoes which are neither liable to liquefy nor to possess chemical hazards.

The potential hazards of this cargo, as identified by the IMSBC Code, are inhalation hazards and skin/eye irritation from cullet dust during handling, placement and transportation, and risks of cuts or punctures during handling and placement.

As a precaution, the Code requires that personnel working with glass cullet wear long sleeves, pants, gloves, work boots, hard hats, ear protections and eye protections. The Code also suggests that disposable masks can be worn for protection against dust inhalation.

Cargo hold

Riga was fitted with a single cargo hold (Figure 3) having a capacity of 5713 m^3. The cargo hold had a length of 62.4 m, a breadth of 11.0 m and a depth of 8.43 m.

Figure 3: Cargo hold, as seen from forward

The cargo hold could be accessed from either the forward or the aft of the hold, and both of these accesses were fitted with continuous vertical ladders (Figures 4, 5 and 6).

Figure 4: Cargo hold access hatch - aft

Figure 5: Cargo hold access hatch - aft

Figure 6: Cargo hold access ladder – aft

The access ladders were located outside the cargo space, and the forward and aft bulkheads were fitted with closable openings to enable access into the cargo hold (Figures 7 and 8).

The cargo hold was fitted with two bilge wells – one on the port side and another on the starboard side, both of which were located at the aft of the cargo hold (Figure 7). The bilge wells were fitted with suction pipes to pump out water from them via an ejector. The bilge wells were also fitted with sensors (Figure 9) which triggered an alarm if the level of any liquid inside the wells reached these sensors.

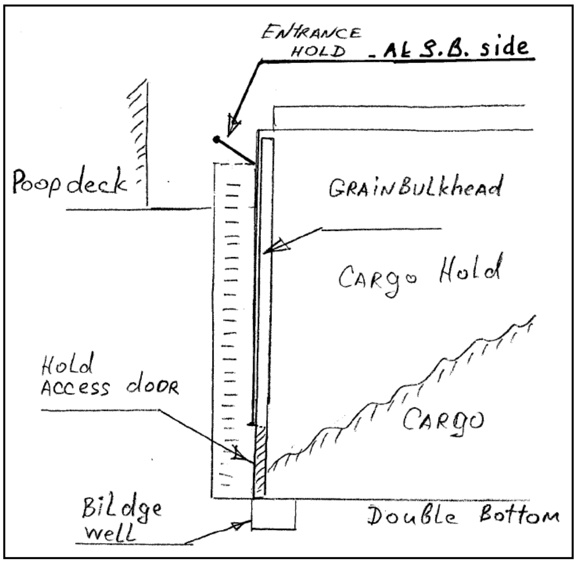

Figure 7: Rough profile sketch of the cargo hold (aft)

Figure 8: Cargo hold, as seen from aft

Figure 9: Cargo hold bilge well

Alarm panels were fitted in the engine-room, the mess room, the chief and second engineers' cabins, and on the bridge. The safety investigation tested the bilge well alarm and found the bridge alarm panel operational.

It was also reported that the cargo hold was free of defects and leaks.

Shipboard working arrangements

The vessel was certified to have a periodically unmanned engine-room. The working arrangements indicated that the engine-room would be manned by all engine-room crew members from 0800 to 1200 and from 1300 to 1700, whilst the vessel was at sea.

The bridge watchkeeping arrangements indicated that, whilst the vessel was at sea, the master was assigned the 8 to 12 watches, the chief officer kept the 4 to 8 watches, and the third officer kept the 12 to 4 watches. One deck rating each was assigned to full watches with the master and the third officer; however, a deck rating was assigned only to the chief officer's morning watch.

Narrative[4]

During the morning of 25 May 2019, *Riga* commenced loading a cargo of glass cullet, in Porto Marghera, Italy, and had completed loading in the evening of the same day. The vessel departed from Porto Marghera in the morning of 26 May and was bound for Antwerp, Belgium, to unload this cargo.

On 27 May, at around 1845, the cargo hold bilge alarm activated. At around 1900, the chief engineer went to the bridge and informed the chief officer, who was on watch, about the alarm. He requested the chief officer to check if water was present in the cargo hold, to which the chief officer replied that entering the cargo hold would be dangerous.

The chief officer then called the able seafarer over the telephone, asked him to open the cargo hold's aft access hatch cover and to visually check for the presence of water from the deck.

On reaching the main deck, the able seafarer found the chief engineer and the wiper on the deck, wearing hard hats, coveralls, gloves and safety shoes. The three of them then proceeded to the cargo hold's aft access hatch and opened it.

On opening the hatch cover and looking inside using a torch light, they noticed water inside the cargo hold. The chief engineer then asked the wiper to go to the engine-room and prepare the bilge system to pump out the water, while he and the able seafarer remained near the access hatch.

At around 1910, the able seafarer noticed the chief engineer entering the cargo hold. On being questioned by the able seafarer, on the necessity to access the cargo hold, the chief engineer informed him that he wanted to check whether the water present inside was sea water or fresh water.

When the chief engineer was about a few metres below the entrance, the able seafarer saw him suddenly fall into the cargo hold. He called out to the chief engineer and, on not receiving a response, immediately went into the accommodation and informed the bridge via telephone.

The chief officer raised the general alarm and informed the master about the accident. The crew members prepared for rescue of the chief engineer and the third officer, wearing a self-contained breathing apparatus (SCBA) entered the cargo hold.

The third officer secured the chief engineer to a stretcher, following which, at around 1920, the chief engineer was hoisted up onto

[4] Unless specified otherwise, all times mentioned in this report are in Local Time (UTC + 2).

the deck. The crew members noted that they could neither find a pulse, nor a heartbeat, his breathing had stopped and the colour of his skin was bluish. The crew members tried to resuscitate him, while the Italian Coast Guard was informed on the accident. The vessel, around this time, was reported to be about 17 nautical miles off the port of Vieste, Italy.

At 2030, on noticing no response by the chief engineer, the crew members ceased the resuscitation efforts. The master then notified the local authorities that the chief engineer had passed away. Due to unfavourable conditions, the local authorities instructed the vessel to proceed towards the port of Manfredonia.

The following morning, at around 0300, the vessel arrived and anchored off the port of Manfredonia, Italy. At around 1235, following an investigation by medical and legal personnel of local authorities, the body was transferred from the vessel to be transferred to the local morgue.

While anchored, the vessel was inspected by the local authorities, including a shore fire team and port chemist, following which the vessel's cargo hold was ventilated. On 01 June, the vessel departed from Manfredonia anchorage.

Risk assessment and enclosed space entry permit

In accordance with the vessel's Safety Management System (SMS) Manual, risk assessments were within the remit of the master, the A standard risk assessment form, to assess the risks involved with entry into the vessel's cargo hold, was available on board. However, the chief officer had prepared a separate risk assessment for the task assigned, which was signed by the master and the chief officer. As per this risk assessment, the 'work activity being assessed' was titled as, "*Enclosed space-Cargo hold access visual check only, entry prohibited*".

This risk assessment identified three hazards associated with this task, namely: low oxygen, inhaling or absorbing by skin of toxic substances and danger of explosion [*sic.*]. The existing control measures identified for each of these hazards were the same: the use of a gas detector and a hazardous work permit. Further control measures to mitigate the risk were conducting a safety meeting on the risks associated with working in enclosed spaces and discussing the procedure to be followed in an emergency.

An enclosed space entry permit was also prepared for this task. Most of the fields in this permit, including testing of the atmosphere of the space, were marked as 'not applicable'. The fields which were marked as checked included whether the space had been thorough ventilated, the personnel were properly clothed and equipped, and whether the communication procedures were agreed upon and understood.

This permit was signed by the master and the chief officer at 1900, on the day of the accident, and the able seafarer was listed as the person authorized by this permit. The validity of the permit was indicated to be from 1900 until 2000.

Company's Drug and Alcohol Policy

The Company's Drug and Alcohol Policy, in the vessel's SMS Manual, prohibited the use / consumption of drugs and alcohol on board. However, the Policy allowed for alcohol to be kept on board, as required by the master, for the purpose of entertaining shore officials.

The master was authorized to conduct unannounced drug and alcohol tests on all or any suspected crew member. Adherence to the Company's Policy was considered to be part of the seafarers' terms of employment.

Record of hours of rest

The record of the chief engineer's hours of rest indicated that he had worked for a period of eight hours, from 0800 until 1700, prior to this occurrence. His hours of rest were found to be in compliance with the requirements of the STCW Code[5] and MLC, 2006[6].

Atmosphere testing instrument

Riga was provided with a portable gas detector (Figure 10) for the measurement of Oxygen, Hydrogen Sulphide, Carbon Monoxide and combustible gases in the lower explosive limit (LEL) range.

Figure 10: Portable gas detector on board *Riga*

A 10 m long hose had been supplied to the vessel, to enable testing of the atmosphere from outside an enclosed space. The safety investigation noted that an additional portable gas detector (Figure 11) was supplied to the vessel on 08 June 2019, after the accident, when the vessel was taking in bunkers at the port of Ceuta, Spain.

The additionally supplied gas detector was capable of measuring Oxygen, Carbon Monoxide, Carbon Dioxide and hydrocarbons (combustible gases). Unlike the previously mentioned gas detector, this one was capable of measuring the volume combustible gases even if they were beyond the LEL range.

Figure 11: Additional portable gas detector supplied on board *Riga*, after the accident

Cargo hold atmosphere

Evidence indicated that the cargo hold's atmosphere was neither tested, by the crew members, following completion of loading operations nor prior to the chief engineer's entry into the hold. It was also reported that the crew members had not tested the cargo hold's atmosphere prior to conducting the rescue operations.

The Sample Analysis Report for the cargo, dated 22 May 2019, contained the following notable readings:

- Hydrocarbons ($C \leq 12$): <10 mg/kg;
- Hydrocarbons ($C > 12$): 180 mg/kg;
- Aliphatic Hydrocarbons (C5 – C8): <5 mg/kg; and
- Hydrocarbons (C10 – C40): 161 mg/kg.

The above, with the exception of the aliphatic hydrocarbons, contained the hazard statement code[7] H304, the associated hazard

5 Seafarer's Training, Certification and Watchkeeping Code, 1995 (as amended)

6 Maritime Labour Convention, 2006 (as amended)

7 A hazard statement is a phrase assigned to a hazard class and category that describes the nature of the hazards of a hazardous product. Each hazard statement has been assigned a unique code for the purposes of identification. http://www.unece.org/fileadmin/DAM/trans/danger/publi/ghs/ghs_rev08/ST-SG-AC10-30-Rev8e.pdf

statement of which indicated that it may be fatal if swallowed and enters airways.

In the morning of 31 May, while the vessel was still anchored off the port of Manfredonia, a shore fire team boarded the vessel. Following their checks of the cargo hold's atmosphere from the aft access, using their own gas detector, the following results were revealed:

- Oxygen – between 1.2% to 1.3%;
- Carbon Dioxide – 9.99%;
- Carbon Monoxide – between 40 to 60 ppm;
- Hydrogen Sulphide – 3 to 4 ppm; and
- Hydrocarbons – exceeding the lower explosive limit (LEL)[8].

Sometime later, a port chemist and other personnel boarded the vessel to confirm the cargo hold's atmosphere. These personnel used two different gas detectors for their tests, which revealed the following:

- Oxygen – oscillating around 3%;
- Carbon Dioxide – near the upper range of the instrument;
- Carbon Monoxide – about 80 ppm; and
- Hydrocarbons – fluctuating between 65% and 70% of the LEL.

Thereafter, the hatch covers and forward access were opened to ventilate the cargo hold further. Subsequent tests of the cargo hold's atmosphere indicated that the Oxygen content was rising, while the LEL was dropping.

When the vessel departed from Manfredonia anchorage, the gas measurements taken by the vessel's crew revealed the following:

- Oxygen –15%;
- Carbon Monoxide – 75 ppm;
- Hydrogen Sulphide – 4 ppm; and
- Hydrocarbons – 0.5% of the LEL.

Records from the vessel indicated that the contents of gases, within the cargo hold's atmosphere, were frequently fluctuating during the vessel's voyage. Accordingly, the cargo hold was ventilated by the crew members, to control its atmosphere.

In the morning of 15 June, after the vessel arrived at the port of Antwerp, Belgium, gas measurements were taken by an independent body, for the port authorities. These checks yielded the following results, due to which, the cargo hold was deemed unsafe for operations until the next day:

- Oxygen: 0.3%
- Hydrocarbons: 38.5% of the LEL;
- Carbon Monoxide: 0 ppm;
- Volatile Organic Compounds: 11.2 ppm;
- Sulphur Dioxide: 0.9 ppm;
- Hydrogen Cyanide: 3 ppm;
- Phosphine: 0.24 ppm;
- Hydrogen Sulphide: 0 ppm[9].

Water in the cargo hold

After the accident, from 31 May onwards, the crew members started to log the cargo hold bilge well soundings, once per day. It was revealed that water kept entering the bilge wells to levels between 50 mm and 180 mm, necessitated regular pumping out of the bilge wells.

[8] Lower explosive limit (or lower flammable limit) is the volume fraction of gas or vapour below which an explosive atmosphere does not form.

[9] The concentrations of Sulphur Dioxide, Hydrogen Cyanide, Phosphine and Hydrogen Sulphide were stated to be unsure due to high Methane concentration.

ANALYSIS

Aim

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

Cooperation

During the course of this safety investigation, MSIU received all the necessary assistance and cooperation from the Italian Ministry of Infrastructure and Transport.

Immediate cause of death[10]

An autopsy and toxicology tests were conducted in Italy. The findings of the autopsy were interpreted in the light of the circumstantial data and data provided by the harbour authorities of Manfredonia. The autopsy report attributed the death of the chief engineer to acute asphyxia which resulted from a high concentration of Carbon Dioxide.

A change in the potential of Carbon Dioxide (pCO_2) in the body is readily recorded by chemoreceptors within the Central Nervous System, as Carbon Dioxide can diffuse through the blood-brain barrier into the cerebrospinal fluid. A change in the pCO_2 causes a chemoreceptor reflex to correct the increase in the CO_2 concentration which would result in the consequent lowering of the blood pH (potential of Hydrogen).

This is a highly sensitive mechanism, and it is possible that it could either malfunction or be over-stimulated. In both cases, the result would be a sudden build-up of CO_2 and the consequent steep drop in blood pH, which is capable of inducing hypercapnia (*i.e.*, excess CO_2 in the blood) and cardiac arrhythmia.

At high concentrations, Carbon Dioxide can cause a state of sudden unconsciousness which could result in an almost immediate respiratory arrest, and concentrations exceeding 10% may be lethal. In the case of *Riga*, the first gas measurements of the cargo hold, taken by the shore fire team in the morning of 31 May, revealed a CO_2 concentration of 9.99%.

In cases of asphyxiation due to CO_2, it is not possible to obtain a reliable estimate of the concentration of CO_2 based on blood sample tests, as the gas itself is a physiological product which accumulates in the blood after death.

Fatigue and consumption of drugs/alcohol

As mentioned earlier in this safety investigation report, the chief engineer's records of rest hours were found to be in compliance with the applicable regulations. However, the quality of his rest could not be ascertained, due to unavailability of substantial evidence. Therefore, fatigue could not be completely ruled out as a contributory factor to this occurrence.

The toxicological report also revealed a blood alcohol content of 1.6 gl^{-1} (0.16%) of ethyl alcohol.[11] It came to the attention of the safety investigation that no alcohol test was conducted during any leg of the vessel's voyage from Porto Marghera to Antwerp.

The toxicological report did not reveal the presence of any narcotics and / or medications. Therefore, drugs were ruled out from being a contributory factor to this occurrence.

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[10] Sources of reference: Autopsy and Toxicological Report forwarded by the Italian Ministry of Infrastructure and Transport, and https://www.ncbi.nlm.nih.gov/books/NBK482456/

[11] The maximum limit of Blood Alcohol Contents, prescribed in the STCW Code for seafarers performing safety, security and marine environmental duties, is 0.5 gl^{-1}.

Cause of the fall
Although not precisely known, the safety investigation hypothesized that the deceased chief engineer was overcome by the high concentration of gases as well as the depleted Oxygen in the cargo hold, which led to his fall from the cargo hold access ladder.

It was not excluded that the concentration of alcohol in the deceased chief engineer's blood, by itself, interfered with his motor skills and/or his cognitive ability to promote a physical response to the feeling of asphyxia.

Cargo hold atmosphere
The Sample Analysis Report of the cargo indicated that the readings of all elements and compounds were within the prescribed cut-off values[12]. The Report issued by the port authorities, prior to the loading of the cargo, therefore indicated that the cargo was free from chemical risks.

However, as was mentioned earlier in this safety investigation report, the same Report issued by the port authorities also recommended that caution was to be exercised prior to entering the cargo hold, especially after prolonged closure of the cargo hold.

Following the accident, the MSIU requested for samples of water from the cargo hold bilge wells to be delivered to the Unit. The same were couriered following completion of cargo unloading at Antwerp. Upon receipt, the samples were sent by the MSIU to a laboratory for analyses. Even though the bilge water was reported to have been regularly pumped out, during the vessel's voyage from Manfredonia to Antwerp, the laboratory analyses revealed a concentration of 4 ppm of Hydrogen Sulphide in the samples.

The gases in the cargo hold were neither measured prior to cargo loading nor after the completion of loading. Due to this the safety investigation could not ascertain whether there were gases already present in the cargo hold prior to cargo loading.

Nonetheless, although the cargo hold was ventilated prior to the vessel's departure from Manfredonia, due to which the Oxygen content increased while the LEL dropped, the safety investigation noted that there was a low concentration of Oxygen and a high concentration of toxic and flammable gases within the cargo hold, throughout the vessel's voyage and even after the vessel arrived at Antwerp.

Taking the above into consideration, and also that the cargo hold was reported to have been free of defects, the safety investigation hypothesized that the depletion of Oxygen and the build up of toxic and flammable gases were caused by the cargo's inherent properties, in conjunction with the cargo hold being an enclosed space.

Water in the cargo hold
It was reported that, following the vessel's departure from the port of Antwerp, there was no further entry of water into the vessel's cargo hold bilges.

As stated earlier in this safety investigation report, the cargo was partly wet at the time of loading. Therefore, the safety investigation is of the opinion that the water had emanated from the cargo itself.

In addition, due to a drop in air temperature, during the course of the vessel's voyage from Manfredonia to Antwerp, condensation would, most probably, have caused more water to enter the bilges. This may, in the opinion of the safety investigation, explain why the soundings of the cargo hold bilges kept increasing, even though the bilges were being regularly pumped out.

[12] Reference: http://www.unece.org/fileadmin/DAM/trans/danger/publi/ghs/ghs_rev08/ST-SG-AC10-30-Rev8e.pdf

Testing of the cargo hold atmosphere

As mentioned earlier in this safety investigation report, the cargo hold's atmosphere was not tested by the crew members, even though one of the control measures listed in the risk assessment was the use of a gas detector. The first evidence of atmosphere testing of the cargo hold was the checks carried out by the shore fire team, in the morning of 31 May.

Evidence indicated that, in the evening of 31 May, the master had requested the port chemist to guide the crew members on the correct use of the on-board gas detector. This led the safety investigation to believe that the crew members were not necessarily familiar with the use of the gas detector and consequently, they were unable to measure the cargo hold's atmosphere at any time before or after the occurrence.

Cargo hazards

The report issued by the port authorities, prior to loading, indicated that the products from which the cargo was generated may have contained foods and sugary compounds, due to which caution was recommended to be exercised prior to entry into the cargo hold. However, this report was documented only in Italian.

During the course of the safety investigation, it came to light that neither were any of the crew members aware of the hazards of the cargo, prior to loading, nor was any evidence found which would indicate that they had understood the recommendations contained in the port authorities' report.

As mentioned earlier in this safety investigation report, the individual schedule for glass cullet, as listed in the IMSBC Code, does not indicate that this cargo could possess hazardous properties. However, the Code also states that the properties attributed to the cargoes are given only for guidance.

The IMSBC Code states that prior to loading any solid bulk cargo, it is essential to obtain current valid information from the shipper on the physical and chemical properties of the cargo and that the shipper shall provide appropriate information about the cargo to be shipped.

Taking into account that a cargo of glass cullet would often be generated from glass products which may have contained foods, beverages, medicines, oils, perfumes, *etc*., the safety investigation is of the view that remnants of the contents of glass products could result in the depletion of Oxygen and/or the evolution of toxic/flammable gases, either by reaction with traces of contents of other glass products, or by decomposition. The effects of such depletion/evolution of gases could be even more pronounced in an enclosed space, such as a vessel's cargo hold.

The above gave an indication to the safety investigation that corporeal barriers, in the form of the port authorities' report and the IMSBC Code, were ineffective. The IMSBC Code, while stating that adequate and up-to-date information is to be obtained from the shipper, largely indicated that the cargo was not hazardous. The port authorities' Report proved to be ineffective as it was, most probably, not understood by the crew members.

Acceptance of risk

Irrespective of whether the recommendations contained in the report issued by the port authorities, prior to loading, were understood by all crew members or not, the cargo hold was still an enclosed space.

Although there was no evidence available, which indicated that the chief engineer was involved in the preparation of the risk assessment and/or the enclosed space entry permit, warning signs were posted on the cargo hold access cover (Figure 4). In addition, the able seafarer, who solely was assigned the task of visually inspecting the cargo hold from the deck, questioned the chief engineer on his reason for entering the cargo hold.

Reportedly, the chief engineer intended to check whether the water that was in the cargo hold was fresh water or sea water. The safety investigation hypothesized that the chief engineer was, most probably, concerned of sea water ingress into the cargo hold.

In the view of the safety investigation, this concern led the chief engineer to ignore the warnings and accept the risks involved with entering the enclosed cargo hold. While the safety investigation had no means to confirm the motivating factors behind the urgency shown by the chief engineer, the influence of alcohol on his analysis of the situation and risk acceptance, and subsequent actions, could not be excluded.

Other findings

The existing control measures in the risk assessment included the use of a gas detector, while the space for logging of pre-entry atmosphere checks in the enclosed space entry permit were struck off and marked as 'not applicable'. The safety investigation is of the view that this contradiction was indicative of an uncertainty in procedures to be followed, although the vessel's SMS manual contained such procedures.

CONCLUSIONS

1. The death of the chief engineer was attributed to acute asphyxia, caused by a high concentration of Carbon Dioxide in the cargo hold.
2. It is likely that the chief engineer fell into the cargo hold after he was overcome by the high concentration of gases and the depleted Oxygen.
3. The safety investigation did not exclude the possibility that the high blood alcohol content ($1.6 gl^{-1}$), found during the toxicology of the deceased chief engineer, contributed to his fall into the cargo hold.
4. The atmosphere of the cargo hold was not measured by the crew members, prior to the Chief Engineer's entry into the hold.
5. Evidence suggested that the crew members were not familiar with the use of the vessel's gas detector.
6. The depletion of Oxygen and the build up of toxic and flammable gases, in the cargo hold, were most likely the result of the cargo's inherent properties as well as the cargo hold being an enclosed space.
7. The cargo was classified under Group C of the IMSBC Code *i.e.*, it was neither liable to liquefy nor possess chemical hazards. However, the report issued by the port authorities, at the port of loading, recommended caution to be exercised before entering the cargo hold.
8. It appeared that the crew members were not aware of the hazards of the cargo and the safety recommendations issued at the port of loading.
9. Fatigue was not completely excluded as a contributory factor to the occurrence.
10. It was hypothesized that the water in the cargo hold's bilges had emanated from the cargo itself.

SAFETY ACTIONS TAKEN DURING THE COURSE OF THE SAFETY INVESTIGATION[13]

Following the accident, the Company conducted an internal investigation and analysis to identify the cause of the accident and other contributory factors. The following measures were taken by the Company to prevent recurrence of such accidents:

1. The crew members were briefed on the SMS procedures relating to work safety and enclosed space entry;

2. Training and instructions were provided to the crew members on enclosed space entry and rescue;

3. A circular emphasizing the SMS procedures and guidelines on enclosed space entry and rescue procedures, was promulgated within the Company's fleet of vessels.

RECOMMENDATIONS

The Company is recommended to:

13/2020_R1 review its procedures to ensure that all shipboard officers are trained in the correct use of the gas detectors provided on board.

13/2020_R2 review its procedures to ensure that all cargo-related safety documentation is provided on board in the English language, or with a translation into the English language.

13/2020_R3 review its procedures to further enhance compliance of the Company's Drug and Alcohol Policy.

The flag State Administration is recommended to:

13/2020_R4 issue an Information Notice to advise all its stakeholders on the possible hazards involved in the carriage of glass cullet, taking into account that the cargo may, in certain cases, have not been processed.

[13] **Safety actions and recommendations shall not create a presumption of blame and / or liability.**

SHIP PARTICULARS

Vessel Name:	*Riga*
Flag:	Malta
Classification Society:	Det Norske Veritas – Germanischer Lloyd
IMO Number:	9141376
Type:	General Cargo
Registered Owner:	MV Riga LLP
Managers:	Powdermill Navigation Inc.
Construction:	Steel
Length Overall:	89.90 m
Registered Length:	84.99
Gross Tonnage:	2,810
Minimum Safe Manning:	9
Authorised Cargo:	General cargo

VOYAGE PARTICULARS

Port of Departure:	Port Marghera, Italy
Port of Arrival:	Antwerp, Belgium
Type of Voyage:	International
Cargo Information:	Glass cullet in bulk – 3,926 MT
Manning:	9

MARINE OCCURRENCE INFORMATION

Date and Time:	27 May 2019 at 1915 LT
Classification of Occurrence:	Very Serious Marine Casualty
Location of Occurrence:	42° 09.6’ N 016° 24.6’ E
Place on Board	Cargo hold
Injuries / Fatalities:	One fatality
Damage / Environmental Impact:	None
Ship Operation:	In passage
Voyage Segment:	Transit
External & Internal Environment:	Weather: Clear. Visibility: 8 to 10 nm. Wind: Beaufort Force 3. Sea State: Slight. Swell: 1 m.
Persons on board:	9