Bundesstelle für Seeunfalluntersuchung
Federal Bureau of Maritime Casualty Investigation

Investigation Report 103/21

Very Serious Marine Casualty

Personnel Accident with Subsequent Loss of Life on board the Container Ship SEOUL EXPRESS at Sea between Manzanillo and Long Beach on 27 March 2021

22 September 2022

This investigation was conducted in conformity with the Law to improve safety of shipping by investigating marine casualties and other incidents (Maritime Safety Investigation Law – SUG). According to said Law, the sole objective of this investigation is to prevent future accidents. This investigation does not serve to ascertain fault, liability or claims (Article 9(2) SUG).

This report should not be used in court proceedings or proceedings of the Maritime Board. Reference is made to Article 34(4) SUG.

The German text shall prevail in the interpretation of this investigation report.

Issued by:
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Table of Acronyms Used

AB:	Able seafarer
AED:	Automated external defibrillator
AIS:	Automatic identification system
BMI:	Body mass index
GT:	Gross tonnage
DGUV:	German Social Accident Insurance
DPA:	Designated person ashore
DWD:	Germany's National Meteorological Service
EEBD:	Emergency escape breathing device
EMSA:	European Maritime Safety Agency
RA:	Risk assessment
IACS:	International Association of Classification Societies
ILO:	International Labour Organization
IMO:	International Maritime Organization
ISM (Code):	International Safety Management Code
ISO:	International Organization for Standardization
CH:	Cargo hold
MCA:	Maritime & Coastguard Agency
MariMedV:	*Maritime-Medizin-Verordnung* [German Maritime Medicine Regulations]
MLC:	Maritime Labour Convention
MRCC:	Maritime Rescue Coordination Centre
MSC:	Maritime Safety Committee
OS:	Ordinary seafarer (unskilled deckhand)
P&I:	Protection and indemnity
PA system:	Public address system
PPE:	Personal protective equipment
PPEaF:	Personal protective equipment against falls from height
PtW:	Permit to Work
SCBA:	Self-contained compressed-air-operated breathing apparatus
SeeArbG:	*Seearbeitsgesetz* [German Maritime Labour Act]
SMM:	Safety management manual
SMS:	Safety management system
SOLAS:	International Convention for the Safety of Life at Sea
STCW:	Standards of Training, Certification and Watchkeeping for Seafarers
TEU:	Twenty-foot equivalent unit
TMAS Germany:	Telemedical Maritime Assistance Service Germany
UHF:	Ultra-high frequency
UTC:	Universal Time Coordinated
VDR:	Voyage data recorder
2/O:	2nd officer (same applies to 3/O)

1 SUMMARY

At about 0800 on 27 March 2021[1], a crew member of the German-flagged container vessel SEOUL EXPRESS fell from a vertical cargo hold ladder in cargo hold no. 3 and lost his life. The casualty was carrying out the required daily inspection of dangerous goods container temperatures alone at the end of his morning watch when the accident happened. Using a handheld radio, he contacted the officer on watch upon entering and leaving each cargo hold in accordance with the standard operating procedures. Due to the absence of a report, the chief mate initiated a search and the casualty was quickly found on a cargo hold's intermediate deck. The casualty was evacuated from the cargo hold without delay after it was established that he had to be resuscitated. However, all subsequent attempts to resuscitate were unsuccessful.

It was not possible to determine the exact cause of the fall due to a lack of witnesses or other evidence. Although various underlying conditions could be ruled out as causes or contributing factors, various aspects were identified as potential contributing factors that had already been identified as such in similar accidents.

Room for improvement was found in the areas of occupational safety, shipbuilding, emergency response management, safety culture, as well as occupational safety instructions and procedural instructions. Safety recommendations were addressed to the Federal Ministries for Digital and Transport and of Labour and Social Affairs, the ship operator of the SEOUL EXPRESS, the Ship Safety and Prevention Divisions of BG Verkehr and DNV as the ship's classification society.

[1] Unless otherwise indicated, all times shown in this report are UTC -6 hours and correspond to ship time when the accident happened.

2 FACTUAL INFORMATION

2.1 Photograph of the Ship

Figure 1: Photograph of the SEOUL EXPRESS[2]

2.2 Ship Particulars

Name of ship:	SEOUL EXPRESS
Type of ship:	Container ship
Flag:	Germany
Port of registry:	Hamburg
IMO number:	9193305
Call sign:	DHBN
Owner (according to Equasis):	Hapag-Lloyd AG
Shipping company:	Hapag-Lloyd AG
Year built:	2000
Shipyard:	Hyundai Heavy Industries Co, Ltd., Korea
Classification society:	DNV
Length overall:	294.05 m
Breadth overall:	32.26 m
Draught (max.):	13.55 m
Gross tonnage:	54,465
Deadweight:	66,981 t
TEU:	4,890
Engine rating:	28,600 kW
Main engine:	Hyundai Heavy Industries, 7K 98 MC
(Service) Speed:	20.5 kts
Hull material:	Steel
Hull design:	Double bottom, double hull
Minimum safe manning:	17

[2] Source: Hapag-Lloyd AG.

2.3 Voyage Particulars

Port of departure:	Manzanillo, Mexico
Port of destination:	Long Beach, United States
Type of voyage:	Merchant shipping, international
Cargo information:	Containers
Manning:	25
Draught at time of accident:	D_f = 12.80 m, D_a = 12.72 m
Pilot on board:	No
Number of passengers:	None

2.4 Marine Casualty Information

Type of marine casualty:	Very serious marine casualty – crew member fell from a height in a cargo hold with subsequent loss of life
Date/time[3]:	27 March 2021, 0800
Location:	At sea abeam of the Baja California Peninsula, Exclusive Economic Zone of Mexico
Latitude/Longitude[3]:	φ 24° 55.9' N λ 113° 14.9' W
Ship operation and voyage segment:	High seas
Place on board:	Cargo hold no. 3, bay 29, 4th stringer deck
Consequences:	Death of a crew member

[3] The exact time of the accident and thus the exact position are not known. However, it is possible to narrow down the time of the accident to between 0730 and 0800. For the entry in the international and European databases for recording marine casualties (Global Integrated Shipping Information System – GISIS and European Marine Casualty Information Platform – EMCIP), 0800 is defined as the time of the accident with the ship's corresponding position.

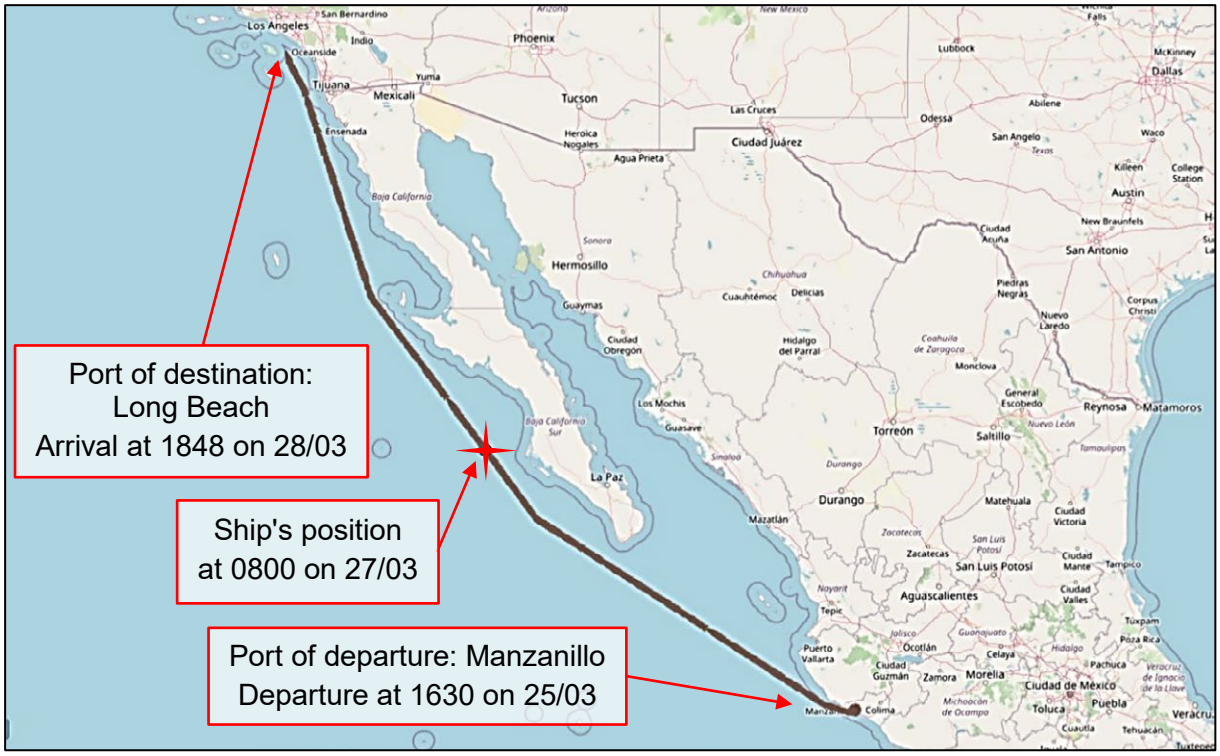

Figure 2: The SEOUL EXPRESS's Track and her Position at the Approximate Time of the Accident[4]

2.5 Shore Authority Involvement and Emergency Response

Agencies involved:	Designated Person Ashore[5], Hapag-Lloyd AG; Long Beach City Coroner Team; US Coast Guard; US Customs and Border Protection; port agency (Norton Lilly International)
Resources used:	SCBA (self-contained compressed-air-operated breathing apparatus), gas detectors, automated (semi-automatic) external defibrillator, line with snatch block and rescue sling, spineboard
Actions taken:	Evacuation from cargo hold with respiratory protection: Preliminary examination of the casualty – unresponsive, evacuation from cargo hold no. 3 to the hatch cover (Top Deck); further examination without detection of vital signs; immediate resuscitative measures – terminated after about 90 minutes with no prospect of success; determination of death and evacuation of casualty on the evening of the following day at the Long Beach anchorage by a team of coroners

[4] Source: SafeSeaNet Ecosystem GUI, OpenStreetMap; notes by the BSU.

[5] The Designated Person Ashore (DPA) acts as a link between the ship and the shipping company, monitors safety and environmental aspects on the ships and ensures that adequate resources and shore-based support are provided.

3 COURSE OF THE ACCIDENT AND INVESTIGATION

3.1 Course of the Accident and Rescue Measures

The below account of the course of the accident is based on written information provided by the ship operator (accident report, statement of facts of the master, extracts from the deck log book, email correspondence concerning the company's internal investigation) and an investigation report prepared by the Gordon & Rees Scully Mansukhani law firm investigating on behalf of the P&I club[6] of the ship operator in Long Beach. In addition, face-to-face meetings were held between the ship operator, master and chief mate of the SEOUL EXPRESS and the BSU on 11 and 23 August 2021. The information gathered from detailed eyewitness accounts and the ship's AIS data extracted from the European SafeSeaNet Ecosystem[7] complete the account of the course of the accident. An event log was not prepared during the emergency response. The times given below are taken from the master's written statement of facts, which he asserts was prepared jointly with the chief mate based on personal recollection after completion of the emergency response.

On 27 March 2021, the SEOUL EXPRESS was approximately 52 nm off the coast of Mexico en route from Manzanillo in Mexico to Long Beach in the United States. The ship was engaged in regular service between various ports in the Mediterranean, Central America and the west coast of North America.

At the end of his morning watch, the later deceased first watchman of the 4-8 watch[8] (deployed at sea as a lookout, referred to below as 'watchman') began the usual inspection of the temperatures of the loaded fish meal containers at 0700 on the instructions of the chief mate, who was in charge of the navigational watch. This involved checking 11 containers in Bays[9] 10, 29 and 31 during the voyage in question. Daily temperature inspections of fish meal are required because this cargo is assigned (depending on composition) to the dangerous goods classes 4.2 and 9 according to the IMDG Code[10], which means it is a spontaneously flammable substance.[11] A contactless laser or infrared thermometer can be used for this.

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6 P&I Club: General term for maritime shipping transport insurers.

7 The SafeSeaNet Ecosystem user interface is the common web interface that provides access to the EMSA maritime applications and datasets, including SafeSeaNet, Integrated Maritime Services, Long Range Identification and Tracking, and CleanSeaNet.

8 As is common on many ships, the SEOUL EXPRESS operates a three-watch system: 0000–0400 and 1200–1600 (0–4 watch), 0400–0800 and 1600–2000 (4-8 watch) and 0800–1200 and 2000–2400 (8–12 watch).

9 Bay (reference to the length in the numerical coordinate system for the allocation of a container slot on board – see Figure 3). Bays are numbered from bow to stern. Odd numbers are used for 20-foot containers and even numbers for 40-foot containers. A bay can therefore contain 20- and 40-foot containers simultaneously. Bay 10 consists of Bays 9 and 11, for example.

10 IMDG Code: International Maritime Code for Dangerous Goods.

11 IMDG Code 2020, 3.2 Dangerous Goods List → UN 1374/2216: Stowage Code SW 24 → 7.6.2.7.2.2 Stowage requirements for fish meal in containers.

Figure 3 illustrates the bay-row-tier system used on container ships for unambiguous assignment of a container on board:

Figure 3: Diagram of Bay-Row-Tier System on Container Ships[12]

During his inspection, the watchman used a UHF[13] handheld radio to send regular reports to the officer on watch on the bridge – always upon entering and leaving each cargo hold (CH) in accordance with standard operating procedures.

At 0715, the watchman reported the entry and then shortly afterwards exit from CH1 for the inspection of the containers in Bay 10. At 0730, the chief mate was notified that the watchman was reportedly now entering CH3 in Bay 29. The four fish meal containers stowed in Bay 29 were below deck in the lowest tiers (02, 04, 06 and 08) and in Row 01 situated in the middle slightly to starboard.

Since no further report on leaving CH3 was received on the bridge and the watchman could not be contacted by radio, the chief mate informed the master before it had turned 0800. A search for the overdue crew member was then immediately initiated. The chief mate formed a search party consisting of himself, the bosun, two ABs and one unskilled deckhand (OS). At the same time, the chief mate instructed the 2nd engineer and two cadets to check the watchman's cabin.

At 0809, the search party found the access hatch to CH3 in Bay 29 open. The chief mate used a gas detector to test the atmosphere in the cargo hold and identified neither low oxygen levels nor dangerous gases. He then entered the cargo hold, climbed down to the next lower deck using the ladder beneath the access hatch and called out for the watchman. He received no answer and climbed down to the next deck. He was then able to see the missing person lying motionless on the 4th stringer deck. The chief mate decided to carry out the subsequent evacuation with respiratory protection.

Figure 4 shows the name of each deck on the SEOUL EXPRESS and the descent into the cargo hold via staggered ladders. Figure 5 shows the view from the 2nd stringer

[12] Source: SCIENCEDIRECT: *Parametric design and multi-objective optimisation of containerships*. https://www.sciencedirect.com/science/article/abs/pii/S0029801818302117 (14 July 2021); colourisation and captioning by the BSU.

[13] UHF (Ultra-high frequency): Designation for radio communications in the frequency range of about 300 MHz to 3 GHz, internally on ships using handheld radios.

deck to the 4th stringer deck beneath it where the deceased watchman was found at the foot of the vertical ladder (his helmet and gloves are also visible in the picture).

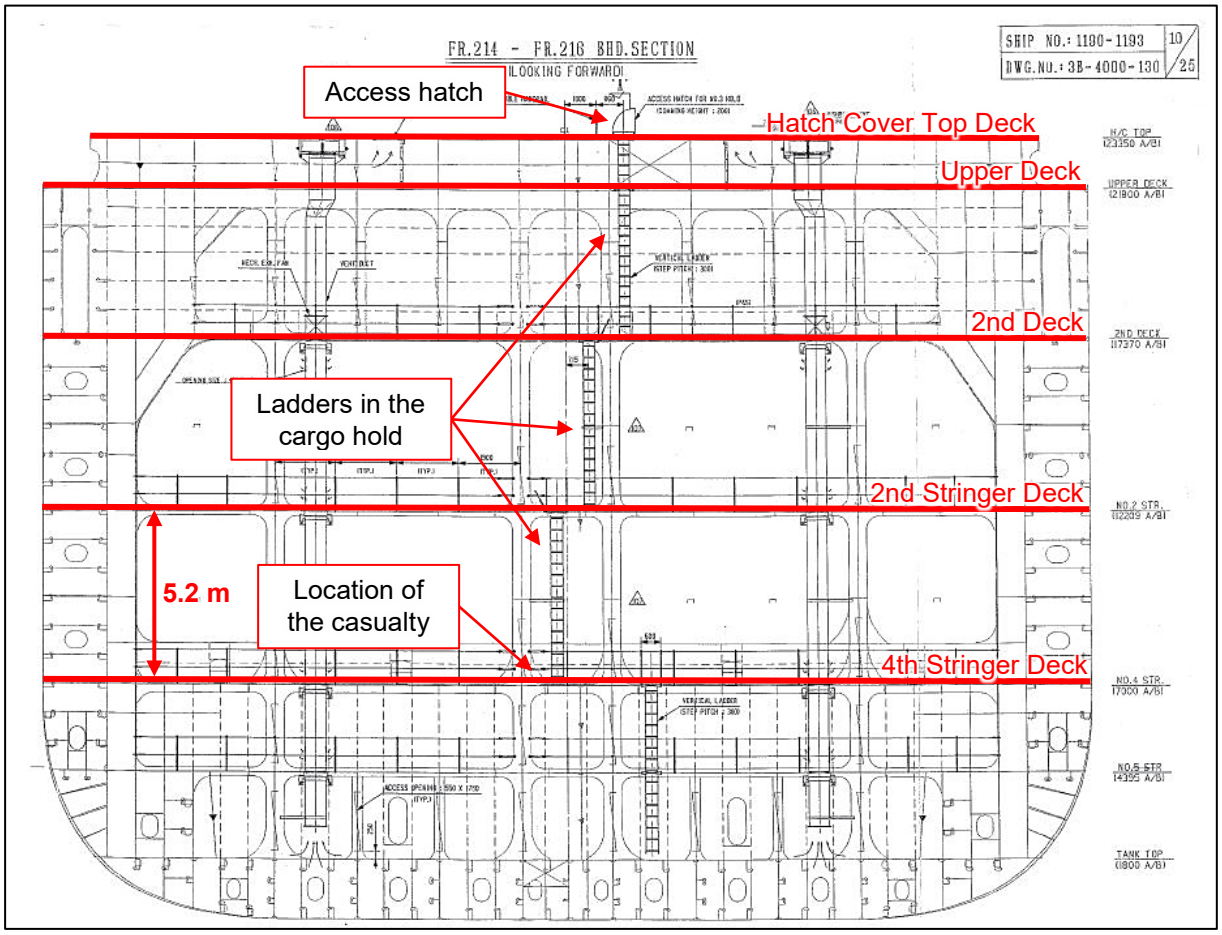

Figure 4: Cargo Hold No. 3 Ladder Support Plan[14]

[14] Source: Hapag-Lloyd AG; notes (red) by the BSU.

Figure 5: View of the 4th Stringer Deck in Cargo Hold No. 3 from Above; Scene of the Accident[15]

At 0817, the chief mate and an AB entered CH3 wearing respiratory protection and reached the casualty on the 4th stringer deck two minutes later. The latter was lying chest down with his head face down and turned slightly to the left, his arms resting against his torso and his legs outstretched. He had a bleeding wound on the back of his head and was unresponsive. The chief mate tried in vain to find a pulse on both the neck and wrist.

The unconscious casualty was secured at the scene with a rescue sling at 0826 and evacuated to the hatch cover (top deck), where he was placed on a spineboard[16], at 0834. A rope and snatch block system suspended between containers on the top deck was used for the evacuation. A more detailed examination and first aid were carried out on the top deck but the casualty continued to display no vital signs. Cardiopulmonary resuscitation was started directly in the transverse corridor next to the access hatch at 0838 and an AED was used to resuscitate the watchman. Since there was no ventricular fibrillation and no discernible heartbeat, the AED did not deliver a shock. The casualty displayed no vital signs.

At 0900, the unconscious watchman was carried to the ship's hospital on the spineboard in accordance with the master's instructions, where resuscitation was continued and another unsuccessful attempt was made to revive the watchman using a defibrillator (the defibrillator did not deliver a shock).

[15] Source: Hapag-Lloyd AG.
[16] Device made of hard plastic on which a person with a potential spinal injury can be held in place for rescue by means of a belt system and then transported.

At 0955, the ship's command informed the DPA of the shipping company, Hapag-Lloyd, about the accident.

The resuscitative measures were discontinued at 1010 for lack of any prospect of success.

On the evening of the following day (28 March 2021), the SEOUL EXPRESS reached the anchorage of Long Beach (Outer Harbour Anchorage) and made fast there at 1948 local time (UTC -7 h).

At 2200 local time, three coroners from the Long Beach City Coroner Team boarded to examine the deceased and took him ashore an hour later.

3.2 Investigation

The shipping company, Hapag-Lloyd, notified the BSU on 29 March 2021 of the occupational accident with subsequent loss of life on board the SEOUL EXPRESS off the coast of Mexico. The ship is engaged in the Mediterranean Pacific Service and sails between Vancouver in Canada and Livorno in Italy regularly. A round trip takes about three and a half months and usually involves calling at 13 ports in nine countries.

Due to the global COVID-19 pandemic and associated travel restrictions, the BSU was unable to carry out a timely survey of the ship and personal interviews with the crew members. The BSU inspected the scene of the accident on board and other circumstances relevant to the investigation in the port of Valencia on 19 October 2021. At that time, no crew members were on board who also belonged to the crew of the SEOUL EXPRESS on the day of the accident, however.

Data on the voyage data recorder (VDR) at the time of the accident were not backed up on board, meaning that neither ship data recorded on board nor audio recordings from the bridge are available for analysis. Accordingly, the investigation is based on

- the written information provided by the ship operator (see Chapter 3.1);
- the outcome of several face-to-face interviews between the BSU's investigators and
  - the ship operator on 11 August 2021 and 27 January 2022 (video conference);
  - the master and the chief mate of the SEOUL EXPRESS on 23 August 2021;
  - the Ship Safety Division (Maritime Medical Service) and the Prevention Department of BG Verkehr (video conferences), as well as
  - the classification society DNV (video conference).
- the findings made during the BSU's survey on board on 19 October 2021, and

- the ship's AIS data at the time of the accident extracted from the European SafeSeaNet Ecosystem.

Since the deceased watchman was alone when he went on his daily rounds to check the temperature of the dangerous goods containers (in accordance with usual practice on board), no witnesses observed the accident directly. Furthermore, there are no image recordings or similar because the scene of the accident was not under camera surveillance.
Several factors that might have had an impact on the accident and its consequences had already been identified in the early stages of the investigation and were therefore investigated in greater detail. These include:

- general hazards during work aloft;
- implementation of occupational safety on board;
- the ship's basic structural conditions (ladders in cargo holds with a risk of falling from a height);
- the health and therefore the fitness for service at sea of the casualty;
- the emergency response management of the crew, and
- the safety culture on board as well as within the company and the implementation of ISM[17] requirements.

In this context, reference is also made to the BSU's Investigation Report 452/19 published on 15 September 2021 concerning a fatal occupational accident following a fall in a cargo hold of another Hapag-Lloyd vessel in December 2019. Some aspects of the investigation also apply to the present case, in particular on the topics of ship manning, medical training of crew members, cranable rescue stretcher – spineboard comparison and support for seafarers following traumatic events. Accordingly, these will either not be revisited in this investigation report or mentioned only in passing in the interest of completeness.

This report first analyses a number of third-party reports (including from the law firm investigating locally), evidence such as photographs of the scene of the accident, an official weather report from the Germany's National Meteorological Service (DWD) and the results of the interviews on 11 and 23 August 2021. Moreover, other comparable accidents are considered and possible similarities derived on the basis of investigation reports already published. Furthermore, those measures taken on the ships concerned in response to the respective accident that the ship operator assessed as being effective and economical are also investigated.

[17] ISM Code: International Management Code for the Safe Operation of Ships and for Pollution Prevention.

3.2.1 Presentation of the Initial Findings

3.2.1.1 Weather Conditions and Ship Movement

The investigators began by considering whether the weather conditions could have contributed to the accident directly or indirectly during the days and hours leading up to it.

The entries in the deck log book indicated that a northerly wind of 5 Bft prevailed at the time of the accident (fresh wind, 17–21 kts or 8–11 m/s). It was estimated that the strength of the wind sea stood at 4 (moderately agitated sea, wave height 2–4 m). Figures relating to the observation of swell were not entered. According to the entries, visibility was more than 18 nm. The shipping company's marine casualty accident report stated that the wave height was 2 m at the time of the accident.

On the day of the accident, dawn started on board at about 0705 and sunrise was at about 0730.[18]

The master's statement of facts supplements the deck log book with information on air temperature (15.3 °C) and the air pressure (1,017.2 mbar, moderately rising). The sky was reportedly cloudy.

An official report requested from the DWD on the wind, swell and weather conditions off the west coast of Mexico on 26 and 27 March 2021 confirms this information. The US National Oceanic and Atmospheric Administration recorded a significant wave height[19] of almost 2 m at the position in question when the accident happened.

According to the submitted stability calculations of the ship's command, the SEOUL EXPRESS had a GM_{corr}[20] of 0.60 m with a required GM_{min}[21] of 0.39 m on the day of the accident. This produces a calculated roll period of about 26 seconds. Therefore, the SEOUL EXPRESS's rolling behaviour can be categorised as rather 'soft'.

Due to the weather conditions described above and the soft rolling behaviour of the ship, the BSU sees no evidence of significant vessel movement at the time of the accident. Furthermore, there is no evidence to suggest that it was damp or wet in the cargo hold at the time of the accident.

[18] Source: https://www.sonnenverlauf.de/#/24.8167,-113.1517,3/2021.03.27/06:30/1/0 (30 July 2021) and the NauticTools freeware with the ship's position at sunrise calculated using the deck log book.

[19] Mean height of the higher third of all waves occurring (statistically, 1.6 times the wave height can be expected about every 100 waves and 1.9 times the wave height about every 1,000 waves).

[20] GM_{corr}: Metacentric height GM (distance from the centre of gravity G to the metacentre M) corrected for conditions of liquid transfer.

[21] GM_{min}: Required metacentric height to meet all the criteria for ship stability with the current draught of the ship according to the International Code on Intact Stability, 2008 (IS Code).

3.2.1.2 Competence, Duties and Working Hours of the Watchman

The deceased watchman was a 43-year-old Philippine national. He had 21 years of professional experience at sea, which included almost 15 years with Hapag-Lloyd and 14 years as an AB. He had been on board the SEOUL EXPRESS for just over seven months when the accident happened.

Both the experts of the law firm investigating locally in Long Beach and the BSU were told that the casualty was reportedly popular, respected and trusted among the crew members on board. He had a generally friendly, balanced and diligent nature. There had been no signs of conflict between the crew and the deceased on board. As far as was known, the deceased had not suffered any illnesses, had not taken any medication, had not shown any signs of depression and there was reportedly no knowledge of any corresponding history. Moreover, the ship operator, the master and the chief mate stated that the deceased had not shown any unusual behaviour and had carried out his duties to his usual high professional standard during the days and hours leading up to the accident.

According to information from the shipping company, the watchman held the following certificates and qualifications:

- basic security training (STCW[22] Regulation VI/1);
- security awareness training and training for people with specific security tasks (STCW Regulation VI/6, points 4 and 6);
- navigation of survival craft and rescue boats (STCW Regulation VI/2.1);
- navigational watch proficiency (STCW Regulation II/4), and
- AB (STCW Regulation II/5).

According to the casualty's job description, his duties included assisting the officer on watch in relation to the safe operation of the ship, maintenance and repair works on deck, security duties (e.g. gangway watch), steering the ship, carrying out rounds of the ship to monitor general safety on board, as well as ensuring that PPE, deck equipment and other materials were handled properly.

In accordance with the company's internal requirements, the casualty had been fully briefed on his duties, security and safety aspects on board, as well as relevant requirements of the employer at the beginning of his engagement on board the SEOUL EXPRESS in August 2020. This included instructions for (potentially) dangerous works such as entering a cargo hold for which a PtW is required, as well as the use of appropriate PPE.

The watchman's daily working hours amounted to ten hours. He had been assigned to the 4-8 watch as first watchman since 14 March 2021 and in addition to his watch was also tasked with maintenance works on deck for two hours in the mornings after his watch ended at 0800 and a breakfast break. Prior to the occupational accident at between 0730 and 0800, the watchman had therefore been on watch since 0400 and

[22] STCW Convention: International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, UN Convention.

on a rest period of about eight hours from 2000 on the previous day. The ship operator's summary of activities carried out in the four days preceding the accident contained no indications of fatigue on the part of the casualty. All requirements of the MLC, the STCW Code and the SeeArbG regarding maximum working hours and minimum rest periods to be observed were complied with.

3.2.1.3 Manning and Competence of the Crew

According to the crew list at the time of the accident and the minimum safe manning certificate (issued on 25 June 2020; minimum safe manning: 17), the SEOUL EXPRESS was more than adequately manned with 25 crew members possessing all qualifications required according to the STCW.

Due to his qualifications (AB), the casualty was qualified to the highest possible standard under international law at the support level and beyond the requirements of the minimum safe manning certificate (see 3.2.1.2). The only mandatory requirements were the basic safety training and navigational watch proficiency – not the AB training, however.
With regard to the manning of the ship, reference is also made to BSU Investigation Report 452/19, as the requirements of the minimum safe manning certificate (rank, number, required certificates of competency according to the STCW) of the SEOUL EXPRESS are the same as those of the SAJIR's certificate.

3.2.1.4 Lawyer's Report

On 6 April 2021, the California-based Gordon & Rees Scully Mansukhani law firm, which was investigating on behalf of the P&I club, sent its investigation report to the shipping company, which in turn sent it to the BSU.

The report states that the ship was adequately manned, fully operational and seaworthy.

The scene of the accident was reportedly carefully examined and nothing out of the ordinary was found during the inspection of the ship. The report confirms that lighting conditions were good and the deck above the location of the watchman's body was level and not slippery. Moreover, it stated that both the deck and the ladder leading to the 4th stringer deck were reportedly somewhat rusty. The experts reported that they had no problems using the ladder.

Furthermore, despite a careful examination of the ladder, walls, ceilings and permanently installed lights in the accident area, they were unable to identify the object that caused the wound to the back of the deceased's head. According to the autopsy report (see Chapter 3.2.1.5), the wound was about 2.5 cm long and centrally located above the ears at the back of the deceased's head. Given the nature and location of the wound, as well as the location and position of his body when he was found, the law firm's experts have no explanation as to why and where he fell and where (with what) he hit his head (if at all) before, during or after he fell.

The experts only noted that the dust on top of one of the lights permanently installed on the wall was slightly smeared about one metre to the right behind the ladder. This

can be seen in Figure 5 to the right of the picture on closer examination. According to the chief mate, the search party reportedly found a AAA battery on the light, which the chief mate had reportedly taken from the light, possibly smudging the dust on the surface in the process. There were reportedly no traces of blood found on the light. The report also notes that the crew had cleaned the area around the scene of the accident prior to the expert's survey in preparation for unloading in the port of Long Beach.

3.2.1.5 Post-mortem Examination

As a result of the fatal occupational accident, a post-mortem examination of the watchkman was performed. According to the report of the coroner (County of Los Angeles, Department of Coroner), death was due to multiple instances of trauma caused by a blunt object.

The body of the deceased had a laceration centrally on the back of the head above the ears with surrounding skin abrasions. The coroner found bruises and other skin abrasions all over the body.
The internal examination did not reveal a skull fracture or any injuries of the dura mater at the back of the head. Internal injuries include multiple fractures (including the cervical spine) and internal bleeding (including in the spinal cord and abdomen).

The deceased had a BMI of 40.3 kg/m² at the time of death (height: 163 cm, weight: 107 kg).

It is noted that some injuries (e.g. broken ribs) may have occurred during the attempts to resuscitate. Furthermore, neither recent needle penetrations nor other unusual changes, injuries or foreign objects were detected on/in the body.

A comprehensive toxicology analysis did not identify alcohol or common drugs.

The findings of the post-mortem examination indicate that the watchman died due to an accidental fall from a greater height. There were no signs of any third-party involvement.

The department of forensic medicine at the Hamburg-Eppendorf University Clinic (UKE) confirmed this assessment to the BSU after delivery of the autopsy report in English. All injuries can be attributed to a fall from a greater height. There are neither relevant pre-existing diseases that could cause a sudden internal pathological process, nor have any injuries typical of a confrontation been found.[23]

Due to the severe internal injuries, death probably occurred immediately after the fall and before the rescuers arrived at the scene of the accident.

[23] B. ONDRUSCHKA, K. PÜSCHEL: *Opinion G2596-21*. Hamburg: UKE department of forensic medicine, 18 August 2021.

3.2.1.6 Medical Fitness for Service at Sea

According to the requirements of the STCW Convention or STCW Code (Regulation I/9; Section and Table A-I/9; Section and Table B-I/9), all seafarers require a valid medical fitness certificate for serving on board. This certificate must follow the form required by the STCW Code, i.e. it must contain the information listed in Section A-I/9(7) of the STCW Code and be issued by a recognised medical practitioner listed in a public register of the relevant STCW Party.

The STCW lays down a number of minimum standards for physical and medical fitness, in particular with regard to eyesight. Parties to the Convention define further standards individually. They must ensure that seafarers

- have the physical capability to fulfil all the requirements of the basic safety training;
- demonstrate adequate hearing and speech to communicate effectively and detect any audible alarms;
- have no medical condition, disorder or impairment that will prevent the effective and safe conduct of their routine and emergency duties on board during the validity period of the medical certificate;
- are not suffering from any medical condition likely to be aggravated by service at sea or to render the seafarer unfit for such service or to endanger the health and safety of other persons on board, and
- are not taking any medication with side effects that will impair judgment, balance, or any other requirements for effective and safe performance of routine and emergency duties on board.

In Germany, MariMedV lays down the minimum physical and medical standards.

According to Section 12(7) SeeArbG and Standard A1.2(3) MLC, each Party to the STCW shall accept a medical fitness certificate for service at sea issued in accordance with the STCW by another Party. Accordingly, seafarers holding a foreign certificate of fitness for service at sea may work on German-flagged ships if the certificate satisfies the requirements.[24]

[24] GERMAN FLAG: *Recognition and medical certificates.* https://www.deutsche-flagge.de/en/competency/certificates/recognition/endorsement-of-recognition?set_language=en#procedure (3 August 2021).

The deceased watchman held a valid German certificate of fitness for service at sea issued in June 2020 for the deck and other departments of the ship without restrictions. The certificate was issued in the Philippines. The document's authenticity was confirmed by the Maritime Medical Service of the Ship Safety Division (BG Verkehr).

A Philippine certificate of fitness for service at sea issued on the same day by the same doctor also exists.

3.2.2 Similar Accidents

The European Marine Casualty Information Platform (EMCIP) lists numerous accidents involving crew members falling in cargo holds from a vertical ladder on various types of ship. Falls from a height of several metres are often fatal. A brief summary of the key findings of each Investigation, ensuing actions taken and safety recommendations issued follows:[25]

The causes of the accident and conditions facilitating a fall from a vertical ladder in a cargo holds were

- lack of safeguards and markings;
- poor lighting;
- inadequate PPE (including non-use of fall protection equipment and gas detectors);
- incomplete procedural instructions and risk assessments in the safety management manual (SMM)[26];
- dangerous structural dimensioning and execution of cargo hold descents;
- lack of supervision by supervisors;
- failure to comply with company, port and international safety regulations and information;
- lack of information on dangerous cargoes that adversely affect the atmosphere in a cargo hold;
- dirty and thus slippery and buckled ladders;
- insufficient knowledge about how to use protective equipment on board;

[25] It should be noted that not all accidents involving falling from a ladder in a cargo hold were investigated. The investigation reports of other countries evaluated for this report are listed under Sources.

[26] The SMM forms part of the documentation required on board according to the ISM Code for organising the SMS.

– influence of alcohol, and

– fatigue.

As a result, the shipping companies of the ships involved took the following actions:

– installation of a system for fastening safety belts;

– installation of warning and signal markings;

– replacement of ladders and installation of handrails and safety cages (see Figure 6);

– safety briefings and drills for the crew;

– publication of internal safety circulars, and

– revision of the SMM and classification of descents in a cargo hold via vertical ladders as hazardous work.

Figure 6: Measures and Equipment to Prevent a Fall[27]

Left: New railings at ladder access point and new safety cage on the actual ladder
Middle: Energy absorber for attachment to the safety harness with two safety hooks
Right: Yellow and black markings and newly attached steel wire ropes

[27] Sources: Malta Marine Safety Investigation Unit Report 12/2019 and Hellenic Bureau for Marine Casualties Investigation Report 01/2016.

Due to the actions already taken by the shipping companies, the investigating authorities of the countries concerned (Malta, Bulgaria, Greece) only issued a small number of additional safety recommendations:

- review the company's internal procedural instructions (content and wording) to ensure that the crew is familiar with the safety equipment on board, that risk analyses are comprehensive and that permits to work aloft are tailored to requirements on board;

- review the company's internal procedures for the implementation of and compliance with regulations on alcohol and drug consumption, and

- publication of a notice on potential hazards when transporting certain cargoes by the relevant maritime authorities.

A similar fatal accident occurred within the BSU's area of responsibility on the bulk carrier SILVER PEGASUS in 2014.[28] In this case, the Panama-flagged ship was moored in the port of Brake to unload her cargo of soybean meal. When CH3 was empty, the watchkeeping second officer (2/O) climbed down its ladder to check the hold. When the sailors working on deck tried to reach the 2/O shortly afterwards via radio and received no answer, they searched for the 2/O and found him lying on the floor in CH3. An ambulance took the seriously injured person to a hospital, where he died that evening.

In all likelihood, the accident occurred because the ladder in the cargo hold had become slippery due to cargo residues (flour dust) and high humidity during unloading. The investigation also revealed that some of the cargo hold ladders did not have any safety features, such as a safety cage, handrails or anchor points for fall protection equipment. Unlike the vertical ladder used by the 2/O, spiral-shaped cargo hold ladders with railings were installed in some instances and would have provided greater safety than the simple vertical ladder.

To avoid similar accidents, the shipping company of the SILVER PEGASUS urged its crews to use the existing spiral ladders for entering cargo holds at all times in the future, with at least one crew member maintaining a deck watch so as to keep under observation colleagues working there. Furthermore, instructions were published on how to behave when working aloft, which included a risk assessment in the daily distribution of work as well as appropriate measures.

In addition, the BSU issued a safety recommendation to the shipping company, advising it to consider installing personal fall protection equipment on the cargo hold ladders to arrest a fall. The BSU recommended that the Federal Ministry of Transport and Digital Infrastructure advise the IMO to review SOLAS with a view to establishing whether a requirement to use personal fall protection equipment on entering an empty

[28] See Investigation Report 337/14 (Fatal accident on board the MV SILVER PEGASUS in the port of Brake on 20 September 2014), published 13 July 2016.

cargo hold when a certain height is reached should be added to increase the safety of seafarers.

The European Maritime Safety Agency (EMSA) publishes marine casualty statistics in a report annually. In the years 2014 to 2019, 496 seafarers lost their lives while working. At a total of 37% of all personnel accidents, slipping, stumbling and falling are the most common (10% of all falls belong to the 'person overboard' category). Of all fatal accidents, this type of accident also poses by far the greatest hazard (54%). Falling overboard caused the death of 100 seafarers and passengers. With regard to the scene of the accident on board, 22.7% of all personnel accidents can be attributed to cargo holds/spaces and tanks. Almost 80% of all very serious accidents resulting in loss of life occurred on container ships, bulk cargo ships and general cargo ships. These types of ship also had the highest proportion of accidents in the 'people slipping, stumbling and falling' category, which also includes falling from a ladder in a cargo hold.[29]

3.2.3 Legal Framework

The legislation and guidelines for entering cargo holds and using vertical ladders applicable to the SEOUL EXPRESS are set out below. Moreover, current regulations for newer ships and regulations for the subject area discussed are also mentioned but these only apply to other types of ship or ashore. An investigation into whether all mandatory regulations were complied with and whether relevant guidelines were applied, whether it may be appropriate to apply certain regulations for other types of ship to container ships as well, and whether risks associated with the use of vertical ladders are adequately addressed shall also be carried out subsequently. Extracts from and summaries of the standards and guidelines listed below that are relevant to the present case can be found in Annex 9.1.

3.2.3.1 Mandatory International Requirements

- IMO: SOLAS Ch. II-1 Reg. 3-6, Resolutions MSC.134(76) & MSC.158(78)
  Scope: Oil tankers ≥ 500 GT, bulk carriers ≥ 20,000 GT, built on or after 1 January 2006.

- IMO: SOLAS Ch. III Reg. 19.3.6 & Resolution MSC.350(92)
  Scope: All ships engaged in international trade.

- IMO ISM Code, Part A, 7 – Shipboard Operations
  Scope: All passenger ships, as well as oil tankers, chemical tankers, gas tankers, bulk carriers, other cargo ships and mobile offshore drilling units ≥ 500 GT engaged in the international trade and for EU-Member States under the terms of the ordinance (EG) Nr. 226/2006 certain passengers ships as well as cargo ships and mobile offshore drilling units ≥ 500 GT in national trade

[29] EMSA: *Annual Overview of Marine Casualties and Incidents 2020*. http://www.emsa.europa.eu/accident-investigation-publications/annual-overview.html (22 July 2021).

- ILO: MLC, Standard A4.3 – Health and safety protection and accident prevention
  Scope: All ships other than fishing vessels, ships of traditional build, warships or naval auxiliary vessels.

- EU: Directive 92/58/EEC on the minimum requirements for the provision of safety and/or health signs at work
  Scope: Generally applicable in all EU Member States.

3.2.3.2 Mandatory National Requirements

- *Seearbeitsgesetz (SeeArbG)* [German Maritime Labour Act] – Chapter 4: Safety and health protection at work
  Scope: Merchant vessels that fly the German flag.

- DGUV Regulation 1 – Accident prevention regulation – Principles of prevention
  Scope: Employers and insured persons, including in cases where insured persons work in or for the enterprise but are covered by a different social accident insurance institution.

- DGUV Regulation 84 – Accident prevention regulation – Shipping enterprises
  Scope: Employers and insured persons in maritime shipping enterprises, including fishing.

- *Arbeitsstättenverordnung (ArbStättV)* [German Ordinance on Workplaces], Annex 1.3
  Scope: *Inter alia*, means of transport used in public transport.

- *PSA-Benutzungsverordnung (PSA-BV)* [German Ordinance on PPE Usage]
  Scope: Employers and employees at work with the exception of some industries (e.g. companies subject to the Federal Mining Act)

3.2.3.3 International Guidelines and Recommendations

- Cargo Stowage and Securing (CSS) Code, Annex 14
  Scope: Container vessels built on or after 1 January 2015, securing containers on deck.

- IMO Resolution A.1050(27), Revised Recommendations for Entering Enclosed Spaces aboard Ships
  Scope: All ships.

- ILO: Code of practice for accident prevention on board ship at sea and in port
  Scope: All ships.

- IACS[30] Recommendation 132 Human Element Recommendations for structural design of lighting, ventilation, vibration, noise, access and egress arrangements
  Scope: Bulk carriers and oil tankers falling within the scope of Resolution MSC.296(87).

3.2.3.4 National Guidelines and Recommendations

- Ship Safety Division (BG Verkehr): Handbook of Safe Working Practices – Occupational Health and Safety for Merchant Shipping and Fishing Vessels ('Seafarer's Compendium')
  Scope: Ships flying the German flag and operated by German ship operators.

- DGUV Rule 112-198 governing the use of personal protective equipment to prevent falls from a height
  Scope:
  - generally after the employer's risk assessment has shown that the hazards are not avoided or sufficiently mitigated by generally protective technical equipment (collective protection measures) or organisational measures;
  - when selecting and using personal protective equipment to prevent falls from a height.

- DGUV Rule 112-199 governing rescue from above and below with personal protective equipment to prevent falls from a height
  Scope:
  - when selecting and using personal protective equipment to prevent falls from a height for rescues from above and below.

- DGUV Information 208-032 on the selection and use of climbing ladders
  Addressees: Employers, manufacturers, maintenance personnel and experts.
  Scope: Safety-compliant design, maintenance and testing of fixed climbing ladders (predominantly on buildings, in workplaces or as access points to shore-based machinery).

3.2.4 Investigation of Possible Accident Causes

3.2.4.1 Occupational Health and Safety

The investigators considered whether inadequate occupational health and safety could have contributed to the accident in the cargo hold, in particular because the present case involved an occupational accident. To this end, they initially analysed which hazards occur when descending into a cargo hold to read the temperature of dangerous goods containers. Moreover, the shipping company's occupational safety regulations issued within the framework of the SMM and their implementation on board the SEOUL EXPRESS were also considered.

3.2.4.1.1 Potential Hazards and Risk Factors

In terms of occupational health and safety, the main hazards to be considered in the present case are those arising from falls from a greater height. Depending on the cargo hold's ventilation system and characteristics of the cargo being carried, the cargo hold

[30] The IACS is the most significant international association of classification societies.

may also have to be classified a confined or dangerous space. In such confined and potentially dangerous spaces, it must be presumed that the atmosphere in the space may not contain sufficient oxygen or may also contain dangerous gases immediately after opening. Therefore, additional PPE such as a respirator and gas detector, as well as ventilation of the space are required for entry.[31] Other potential hazards when checking containers in a cargo hold include

- slipping/stumbling/falling on deck (e.g. contributed to by vessel movements, inadequate lighting, surrounding objects or slippery surfaces);
- bumping into protruding objects/edges or in narrow passageways;
- limbs being trapped in doors or hatch covers, and
- hazards arising from material defects or fatigue in the equipment or facilities used (e.g. the cargo hold ladder).

For the case at hand, the risk of falling from a greater height is primarily considered. This is one of the most common causes of personal injury or death in the workplace (see Chapter 3.2.2). Various factors can lead to falls from a height:

Spreadsheet 1: Risk Factors for Falls From a Height

Conduct of the employee	*Conduct of the employer*
– non-compliance with procedural instructions (e.g. not wearing PPE); – lack of safety culture (it won't happen to me/us); – lack of attention; – decision to continue even after recognising a dangerous situation; – adopting an unsafe approach or position; – incorrect use of PPE (e.g. choosing inappropriate anchor points for fall protection equipment or not using the chin strap on a helmet); – poor maintenance of safety equipment, and – fatigue.	– inadequate risk assessments and procedural instructions; – ineffective risk reduction measures, for example: • provision of unsafe PPE (e.g. do not comply with standards, damaged, do not fit the wearer properly or not protecting against the given hazards adequately); • insufficient crew training and briefings, and • hazardous areas on board left unprotected (physically by barriers, visually by markings/signage). – intimidation of crew (e.g. through time constraints/targets); – management staff do not prioritise safety, and – non-implementation of working and rest regulations.

[31] K. BENEDICT, C. WAND: *Handbuch Nautik II: Technische und betriebliche Schiffsführung.* Hamburg: Seehafen publishing house, 2011. – ISBN 978-3-87743-826-8, S. 164-172.

3.2.4.1.2 Risk Management and Minimisation

The risk of an event is defined by its probability of occurrence and the severity of the impact if the event were to occur. The ship's safety management system (SMS) in accordance with the ISM Code helps to minimise the risk of an adverse event on board. The general objective of risk control/management measures is to reduce the severity of the impact and/or probability of occurrence of a possible accident to a reasonable level. Such measures can generally be divided into procedural and physical methods. These help to safely manage high-risk activities such as work aloft.

Procedural risk controls include the initial risk assessment, Permit-to-Work[32] systems and training, for example. On the other hand, physical risk controls concern the various items of PPE (e.g. fall protection equipment) or temporary work platforms and scaffolding, for example.

The ship operator's SMM provides for the following general risk management measures (prioritised in the order listed):[33]

- removal of the source of the hazard and/or modification of its characteristics (e.g. use of other systems/devices that pose no or lesser risks);
- technical safety measures (e.g. installation of safety devices);
- organisational measures (e.g. procedural instructions and checklists);
- PPE (e.g. safety clothing or fall protection equipment);
- behavioural measures (e.g. training and familiarisation).

This hierarchy of measures corresponds with the advice in DGUV Information 211-005, which is currently being revised. This DGUV Information is based on the ArbSchG (§ 4) and other related rules from the Ordinance on Industrial Safety and Health (§ 4 Para. 2) and the Ordinance on Hazardous Substances (§ 7 Para. 4), in addition to more specific information on the Technical Rules for Industrial Safety and Health or the Technical Rules for Hazardous Substances. Internationally, a similar but slightly different approach is taken, which is shown in Figure 7 and corresponds to the international standard ISO 45001 (8.1.2).

[32] Generally referred to herein as PtW.
[33] HAPAG-LLOYD AG: *ISM Main Manual – 7.4.01.1 Risk Assessment*. Hamburg: 1 February 2021.

A similar, but slightly different approach is adopted at the international level (see Figure 7).

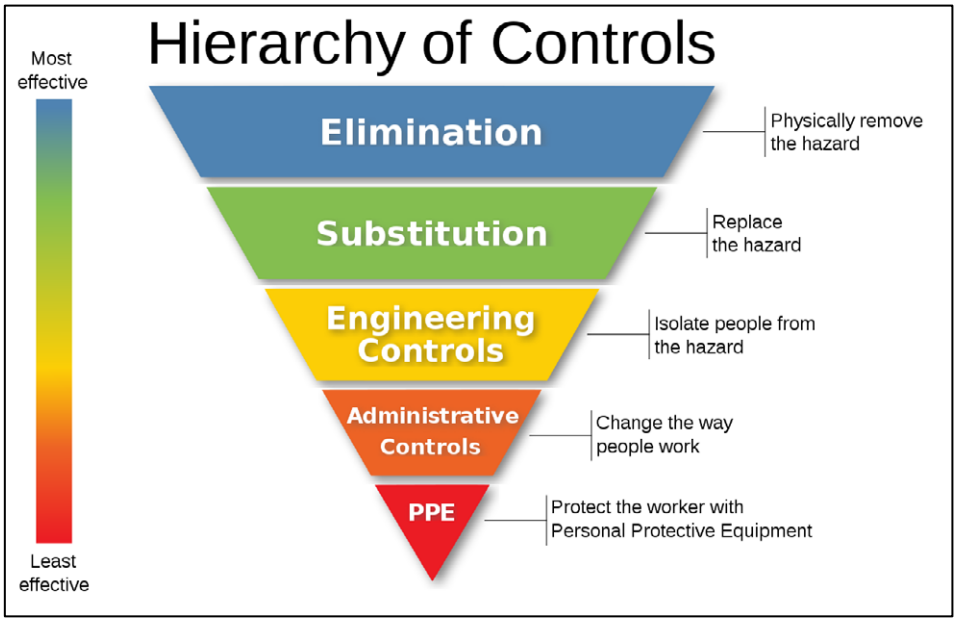

Figure 7: Hierarchy of Controls[34]

The SMM states that prior to the start of potentially hazardous works, an assessment as to whether there are risks of falling from a greater height should be made and it should be ensured that suitable measures for preventing and controlling risks are in place.[35] It also states that high-risk activities – e.g. works/activities involving various risks to human health – may only be carried out in accordance with the procedural instructions of the PtW system.[36] This includes works in areas where there is a risk of falling from a height of more than 2 m. With regard to PPE, it is stipulated that employees must wear a fall protection harness with lanyard and energy absorber in all places where the risk of such a fall may prevail. Furthermore, another person must be on site to supervise the work at least from time to time.[37] [38]

Moreover, according to the SMM, cargo holds are on the list of 'Confined and Dangerous Spaces' due to their limited access and restricted natural ventilation. This necessitates a test of the atmosphere before an inspection, e.g. by means of an electronic gas detector. To this end, it is stated that any mechanical ventilation systems must be switched off for about ten minutes before the atmospheric measurement is carried out by a qualified individual. Similar to activities involving the risk of falling, another person must be posted at the entrance to the confined/dangerous space and maintain continuous visual or radio contact with everybody in that space. If the

[34] Source: THE NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH: *Hierarchy of Controls* https://www.cdc.gov/niosh/topics/hierarchy/default.html (23 May 2022).
[35] HAPAG-LLOYD AG: *ISM Main Manual - 7.4.01.1 Risk Assessment*. Hamburg: 1 February 2021.
[36] HAPAG-LLOYD AG: *ISM Main Manual - 7.4.04 Permit to Work System*. Hamburg: 1 February 2021.
[37] HAPAG-LLOYD AG: *ISM Main Manual - 7.4.03 Personal Protective Equipment*. Hamburg: 1 February 2021.
[38] HAPAG-LLOYD AG: *ISM Main Manual - 7.4.05 Performance and Supervision of Hazardous Works, Attachment 05 Working at Heights*. Hamburg: 1 February 2021.

exchange of air into the open atmosphere is restricted or non-existent, then confined spaces are also classified as dangerous. In this case, it is stated that the dangerous space may only be entered in a certified SCBA. In any case, entry into confined and/or dangerous spaces is only permitted with a permit to work/enter issued by the chief mate or chief engineer. While the SMM states that a PtW may be issued for routine tasks for a period of up to one month, it is stipulated that a PtW for entering confined/dangerous spaces should not be issued until the atmosphere has been tested for oxygen and hazardous gases. Such an atmosphere test is a snapshot in time and must be carried out again before each entry. Accordingly, a valid PtW for such works cannot be issued a longer period. Moreover, the SMM also states that the presence of an additional person outside the confined space, who maintains visual or radio contact with the person in the space and is not permitted to leave her/his post under any circumstances, is mandatory.[39] Unlike in the associated procedure, the 'Date / Time of Permit' line on the form of the corresponding PtW states that here, too, the validity of the PtW for routine work can be extended to no more than one month. Furthermore, the checklist included refers predominantly to the inspection of tanks rather than confined/dangerous spaces in general (see Figure 9).[40]

The option to deviate from the SMM requirements described above for the inspection of cargo holds with permanent mechanical ventilation is not documented in writing. However, the ship operator is of the opinion that a facilitated procedure could reportedly be used in such a cargo hold for a routine activity, as in the present case. In this case, a PtW with an extended validity is reportedly legitimate and a second person at the entrance and further gas-free measurement before entering cargo holds with mechanical ventilation are not necessary.[41]

In addition to procedural instructions for certain hazardous works, risk assessments (RAs) were prepared ashore for certain activities on board in order to identify and assess risks in advance and initiate preventive measures before accidents occur.

During the preparation of an RA, hazards should be systematically identified and subsequently assessed both individually and in context, e.g. as to whether occupational safety measures are necessary.[42]

[39] HAPAG-LLOYD AG: *ISM Main Manual - 7.4.07 Work in Confined & Dangerous Spaces*. Hamburg: 1 February 2021.

[40] HAPAG-LLOYD AG: *ISM Main Manual - 7.4.04 Permit to Work System – Attachment 01 Permission for Tank Inspection and Entry into Confined & Dangerous Spaces*. Hamburg: 1 February 2021.

[41] HAPAG-LLOYD AG via INCE GERMANY RECHTSANWALTSGESELLSCHAFT MBH: *Letter to BSU of 9 February 2022*.

[42] FEDERAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH: *Part 1 Handbuch Gefährdungsbeurteilung: Grundlagen und Prozessschritte*. Dortmund/Berlin/Dresden: February 2021.

An RA was also prepared for the use of fixed ladders. Various risks were identified (see Figure 8), such as the risk of injury due to:

- lack of space around the ladder due to construction features;
- the possibility of bumping into adjacent ship structures;
- accidentally missing rungs of the ladder when ascending or descending, and
- moisture, ice or contamination with oil or grease.

Hazard	Description of Identified Hazard	Existing Control Measures
Use of Fixed Ladders	Risk of injury may exist due to the specific nature of fixed ladders on a ship. With fixed ladders usually having a vertical inclination, adjacent space may be limited subject to construction features of the vessel. Risk of injury such as bruises may exist by hitting accidentally adjacent ship structures. Risk of injury may exist by missing steps while climbing up or down. Stairs may be slippery due to water, ice, or accidental release of fluids such as grease or oil.	QEM/SMM-06-01/7.4.01 Occupational Health and Safety Policy & General Regulations QEM/SMM -06-01/7.4.03 Personal Protective Equipment QEM/SMM-06-01/7.4.05/05-00 Performance and Supervision of Hazardous Works Attachement 05 Working at Heights QEM/SMM -06-01/7.4.04 Permit to Work System (Attachment 04 Permission for Working at Hight) BGV:Handbook of Safe Working Practices Paragraph B3 QEM/SMM-06-01/6.3 Familiarization (obtaining detailed knowledge of working and living spaces on board the vessel) QEM/SMM-06-01/7.1.03 Attachment 01 7/12 (Quarterly check of Ladders) Implementation of HL standart for portable ladders 4Q.2014 FC NFM 10/2014

Figure 8: Extract of RA for the Use of Fixed Ladders[43]

Unlike in the RA for work aloft, the risk of falling from a greater height is not explicitly stated.

The ship operator takes the view that when compiling the description of identified risks in the RA, care should reportedly be taken to ensure that the brevity of other hazard descriptions does not suffer as a result of the description of self-evident factors. The potential danger when using ladders is reportedly part of the reality of life for every human being and listing such dangers is reportedly detrimental to the actual purpose of an RA.[44]

In contrast, the risk management measures – in addition to general requirements for occupational safety and PPE, as well as the initial briefing for new crew members – refer to the SMM procedures for work aloft (see Figure 8). These include the 'Permission for Working at Height' PtW (ISM Main Manual 7.4.04 Annex 04), on the one hand, and Annex 05 to the specifications for the performance and supervision of dangerous works (ISM Main Manual 7.4.05) for work aloft, on the other hand. Checklist Q7.2 on the quarterly inspection of all fixed ladders on board is another risk minimisation measure. This inspection includes a visual check of the general condition, ladder rungs and handrails, the absence of obstacles, as well as adequate lighting.

Reference is also made to Chapter B 3 of the Seafarer's Compendium (Working with Ladders) of the Ship Safety Division (BG Verkehr) on occupational health and safety

[43] HAPAG-LLOYD AG: *Detailed Risk Assessment - 1.1.14 Use of Portable and Fixed Ladders*. Hamburg: 27 January 2021.
[44] HAPAG-LLOYD AG via INCE GERMANY RECHTSANWALTSGESELLSCHAFT MBH: *Letter of 9 February 2022*.

in maritime shipping and fishery.[45] This chapter of the Seafarer's Compendium and the DGUV Information 208-016 (directions for handling ladders and steps) mentioned therein only deal with the use of portable ladders (e.g. single ladders and stepladders). However, some of the instructions for climbing such ladders, such as using both hands for a secure grip or wearing closed shoes with slip-resistant soles, can also be applied to fixed ladders.

The 'Occupational Health & Safety' chapter of the ship operator's SMM deals with activities in confined and dangerous spaces in greater detail. Point E) 1. (e) 'Other Dangers' notes that a fall hazard in confined spaces with limited accessibility poses a greater risk and needs to be considered specifically.[46] This is not reflected in either the RA or the PtW for confined/dangerous spaces.

The ship operator has not laid down any other specific written procedural instructions for the daily round of inspections to ensure the safe carriage of cargo.

3.2.4.1.3 Application of Internal ISM Requirements on Board the SEOUL EXPRESS

The crew and the ship operator both stated that the cargo holds on board the SEOUL EXPRESS had permanent mechanical ventilation, meaning that they must be classified as a confined space according to the SMM's procedural instructions, but not necessarily as a dangerous space.

The watchman was reportedly wearing PPE consisting of a work helmet, work gloves and safety boots when he set out on his inspection rounds in the morning according to witnesses. He reportedly did not have a gas detector or fall protection harness with an energy absorber with him on the day of the accident.[47] Accordingly, it is reasonable to assume that the atmosphere in the cargo hold was not checked in accordance with company requirements. Furthermore, there is no evidence to suggest that the watchman was carrying other items (e.g. a clipboard) that may have obstructed the use of ladders.

As can be seen in Figure 5, in addition to work gloves, a blue work helmet was also found at the scene of the accident. The helmet in this photograph (taken immediately after the accident) is equipped with a chin strap which is supposed to prevent the helmet from falling off the wearer's head or slipping in the event of a fall or other external forces.

During the daily inspection round, no other crew member was assigned the role of 'standby person' at the respective entrance to the cargo holds. The deceased watchman went into the cargo holds without direct supervision and maintained contact

[45] HAPAG-LLOYD AG: *Detailed Risk Assessment – 1.1.14 Use of Portable and Fixed Ladders*. Hamburg: 27 January 2021.

[46] HAPAG-LLOYD AG: *ISM Main Manual – 7.4.07 Work in Confined & Dangerous Spaces*. Hamburg: 1 February 2021.

[47] Unlike the use of a fall protection harness, carrying of a gas detector was mandatory according to the ship operator's procedures. Gas detectors were made available in the ship's office to be collected from there on one’s own responsibility before entering the holds.

with the officer on watch on the bridge with a handheld radio (see 3.1). It was not usual practice to communicate the result of the atmospheric measurement (oxygen content, hazardous gases) to the bridge by radio when entering the cargo holds. From the ship operator's perspective, the result would not have to be submitted since the cargo hold is permanently ventilated and an alarm would go off if a fan failed.

On 1 March 2021, the chief mate issued a PtW for entering confined and dangerous spaces. This was valid until 31 March 2021 and covered entry to all cargo holds and the bow thruster room. In addition to the deceased AB, 17 other crew members countersigned an attached list as executing personnel. The chief mate was both authorising person and supervisor. The checklist in the form was only partially completed (see Figure 9). Measures not taken, such as the presence of a second person at the entrance to the cargo hold or keeping an SCBA available at the entrance, were not marked 'NO' and justified. The requirement to report to the officer on watch via handheld radio when entering and leaving the spaces as an alternative safety measure was not noted on the PtW, either. The mandatory atmospheric test was ticked off as a general 'YES', with a reference to always using a gas detector.

Checklist
(in case of need, additional safety measures shall be documented on separate paper)

	YES	NO	REMARK (to be competed if 'No')
Tank thoroughly ventilated	✓		
Atmosphere tested & found safe (O_2 between 20.6% and 21%; no explosive gas/ air mixtures or CO)	✓		Always use Gas detector
Safety person at tank entrance			
Communication arrangements between person at entrance and those entering			
Adequate illumination	✓		
Breathing Apparatus standby at entrance			
Tank inspection: a) notices at control cabinet and b) securing arrangements (technical means) * in place against unintentional operating of piping system * to be described under 'remarks'			
Tank inspection: 'Access & Manhole Log' established (see page 2)			
Bridge informed:	✓		

Figure 9: PtW Checklist Issued for Entering Confined and Dangerous Spaces[48]

Prior to the accident, a deck officer carried out the last quarterly visual inspection of the ladders on 18 March 2021. All ladders listed on the Q7.2 checklist, including ladders in CH3, were found to be 'OK' and without any deficiencies (evidenced by available documentation).

[48] Source: Hapag-Lloyd AG

3.2.4.2 Shipbuilding – Risk of Falling in the Cargo Hold

The extent to which ship's structural features may have facilitated the accident is investigated below. As already explained in Chapter 3.2.1, falls in a cargo hold are a major cause of accidents.

3.2.4.2.1 General

Due to her dimensions and cargo capacity of almost 5,000 TEU[49], the SEOUL EXPRESS belongs to the 4th generation of container ships and to the so-called Panamax class[50]. The superstructure with the crew quarters and bridge are located in the aft third of the ship. The cargo holds are numbered from bow to stern. Cargo holds 1-5 are forward of the superstructure with 1-4 each containing six bays for 20' containers and about 42.4 m long. CH5 is slightly shorter and has space for four bays. A sixth closed cargo hold as well as an open cargo hold are located behind the superstructure, meaning that 20' containers can be stowed there in a total of eight bays:

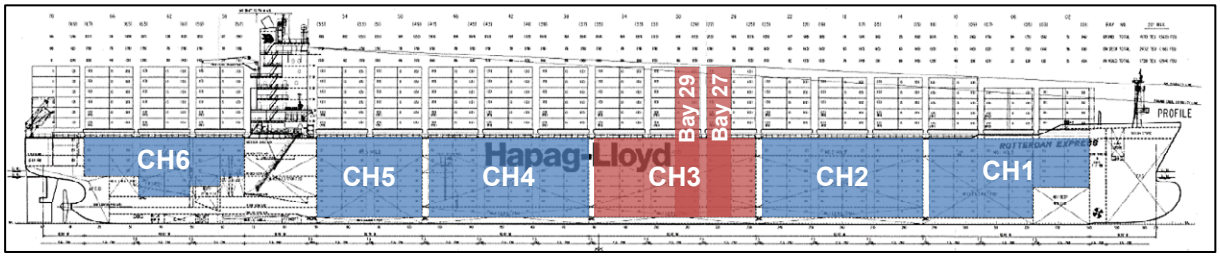

Figure 10: Extract from the General Arrangement Plan of an Identically Constructed Sister Ship[51]

For the stiffening of the hull and for access to the containers, the cargo holds between the 40' bays are subdivided by supporting transverse bulkheads, to which the cell frames/guides for the containers are also attached. These transverse subdivisions in the cargo hold contain companionways from which the containers in the cargo hold can be reached on multiple tiers by several vertical ladders (see Figure 4). The forward access hatch for CH3, where the watchman's fatal accident occurred, is located between Bays 27 and 29 (see Figure 10). As can be seen in Figure 4, three staggered ladders lead down to the 4th stringer deck, where the watchman was found at the foot of the ladder by his colleagues. The height of the 4th stringer deck and thus length of the ladder is 5.2 m (see Figure 4).

[49] TEU - Twenty-Foot Equivalent Unit, 20-foot-standard container.
[50] According to the rules of the Panama Canal Authority, this class of ship could still fit through the smaller locks of the Panama Canal that existed before the expansion in 2016.
[51] Source: Hapag-Lloyd AG (colourisation and remarks by the BSU).

3.2.4.2.2 Lighting in the Cargo Hold

Figure 11 shows that the companionway in CH3 is well illuminated by fixed lighting, which according to the chief mate is always switched on:

Figure 11: View from the 2nd Deck to the 2nd Stringer Deck[52]

3.2.4.2.3 Dimensioning of the Deck Passageways

The width and length of the deck passageways to the vertical ladders in the companionway leading to the next lower deck are 60 cm and 68 cm, respectively, and the actual ladder protrudes 8 cm into the passageway. This produces a free cross-sectional area of 0.60 m x 0.60 m. (see Figure 11). The requirements of Section 21(7) DGUV Regulation 84 and respectively Section 87(7) Accident Prevention Regulations for Shipping Enterprises, which were in force when the keel was laid, are complied with.

3.2.4.2.4 Support Struts and Condition of Ladders

The support struts that are welded to the ladders from the side at about the middle of each deck attracted attention during the shipping company's internal investigation (see Figure 5, Figure 11 and Figure 12). Since the ladder support struts span the entire width of the ladder and were installed at the level of a rung between the 2nd and 4th stringer decks in CH3, they could pose a safety risk to the ladder's user. Firstly, the

[52] Source: Hapag-Lloyd AG (comments by the BSU).

ladder rungs are not as easy to grip in the position of the support. Secondly, it is not possible to position the foot straight onto the respective rung when climbing the ladder. Figure 12 illustrates the design more clearly:

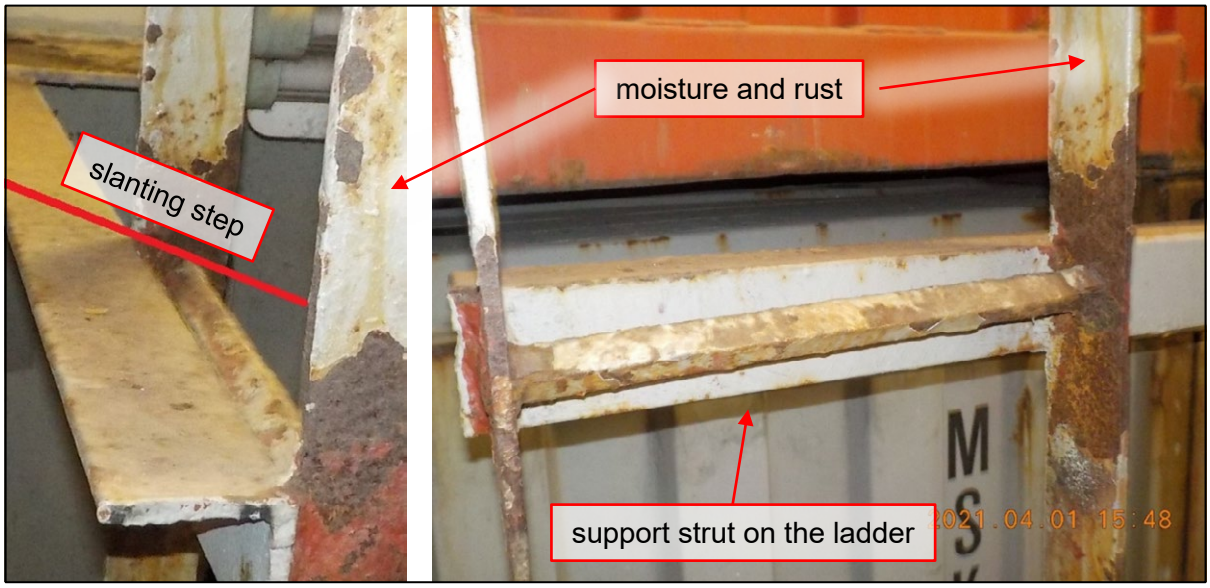

Figure 12: Cargo Hold Ladder with Support Strut, Side and Front View[53]

Due to the installed support strut, this hold ladder does not comply with the mandatory requirements of Section 21(5) DGUV Regulation 84 (formerly Section 87 of the Accident Prevention Regulations for Shipping Enterprises (UVV See)) because the horizontal distance of the rung centre from fixed parts must not be less than 0.15 m. There must be a clear space for the feet of at least 20 cm high and 15 cm deep spanning the width of the ladder above each rung.

Figure 12 also shows that the support strut and ladder have not been welded at right angles (the ladder rung and the angle section of the support strut are not parallel). The ladder's general condition also catches the eye. The metal has superficial corrosion on the side of the rungs. The traces of rust on the ladder's uprights show that it must have been damp in CH3 at some unspecified point in time. However, neither the log entries on the day of the accident, nor the witness statements, nor the official report of the DWD indicate that this was also the case at the time of the accident (see 3.2.1.1).

In accordance with the ISM-Code (Part A, Regulation 10.3), the ship operator's SMS states that ladders should undergo regular maintenance to reduce/prevent corrosion.[54] No deficiencies were found in the general condition of the ladder during the quarterly visual inspection (see 3.2.4.1.2 and 3.2.4.1.3).

[53] Source: Hapag-Lloyd AG (comments by the BSU).
[54] HAPAG-LLOYD AG: *ISM Main Manual – 7.4.05 Performance and Supervision of Hazardous Works – Attachment 11 Lashing and Securing Operations*. Hamburg: 1 February 2021.
HAPAG-LLOYD AG: *ISM Main Manual – 10 Maintenance and Repair of Ship & Equipment*. Hamburg: 1 February 2021.

3.2.4.2.5 Occupational Safety and Markings

On the ladders leading down into the cargo hold, there are neither handrails along the entire length of the ladder, nor fall protection devices, e.g. in the form of safety cages, a vertical lifeline or suitable anchor points for personal fall protection equipment. However, legal requirements are complied with.

The cover of CH3's forward access hatch is painted yellow and therefore contrasts visually with the reddish-brown deck. However, since handrail supports and other items of deck equipment are painted yellow in addition to the hatch cover, it is not immediately apparent that the hatch is the entrance to a potentially dangerous area. Apart from the inscription 'NO.3H(F)' in red lettering, there are no other hazard warnings on the outside of the access hatch. A warning ('BE AWARE OF VERTICAL LADDER') in yellow lettering is painted on the inside of the access hatch (see Figure 13).

Figure 13: Forward Access Hatch to Cargo Hold No. 3[55]

During the BSU's inspection of the scene of the accident on board the SEOUL EXPRESS on 19 October 2021, it was found that there were no handrails for safe entry and exit immediately adjacent to the access hatch. From the perspective of the BSU, the thin handle in the locked but slightly movable hatch cover (see Figure 13) does not

[55] Source: BSU.

provide sufficient support and the yellow support next to the access hatch (bottom right of image) is too far away to hold on to. Nevertheless, the access complies with applicable design regulations, as the ladder is a hold ladder for which no handholds are stipulated at the exit points either in national or international regulations. This was confirmed by the BG Verkehr (Prevention Division).

It was also found that on the lower section of the cargo hold ladder leading to the 4th stringer deck (where the casualty was found), the horizontal space between the centre of the ladder and the fixed components of the upper plating of the transverse beam and the horizontal section of the bulkhead was extremely narrow in two places:

Figure 14: Narrow Space Behind the Cargo Hold Ladder[56]

This means that there is a risk of getting caught on the metal edge directly behind the ladder when using it, thus preventing a safe foothold/grip. The mandatory clearance for the feet above each rung of at least 20 cm high and 15 cm deep does not exist here.

According to information provided by the ship's operator, the cargo holds are only accessed by trained personnel and the cargo hold ladders have been approved by the classification society.

[56] Source: BSU.

3.2.4.3 Excess Weight Among Seafarers

The BSU became aware of the casualty's increased BMI (see Chapter 3.2.1.5) and investigated whether his obesity could have contributed to the occupational accident.

According to height and weight information in his seafarer registration book, the deceased's BMI was 35.7 kg/m² in January 2018. The autopsy report indicated that the watchman's BMI was 40.3 kg/m² at the time of the accident. Based on his height of about 1.63 m, this corresponds to a weight gain of about 11 kg within three years.

3.2.4.3.1 Nutrition on Board

Various international studies[57] [58], including one by the Institute for Occupational and Maritime Medicine in Hamburg, have focused on the nutritional behaviour of seafarers. The findings show that working at sea poses a significantly heightened risk of weight gain, inadequate nutrition, lack of exercise, high occupational stress and thus also cardiovascular diseases. The studies indicate that seafarers from the Pacific in particular, predominantly Kiribati but also the Philippines, are affected by this.

According to the mentioned studies, factors that may have a negative effect on the diet and health of seafarers, depending on shipping company and type of vessel, include:

- very limited individual opportunities to influence the quality and variety of the diet (e.g. due to ordering of provisions by the shipping company, limited shore leave opportunities);
- psychological and emotional stresses of life on board, which can be a stimulus for overeating (shipboard assignments of several months are not uncommon, separation from and limited contact with friends and family, lack of sleep and long working hours, lack of social contact, lack of exercise, little/no shore leave, fixed-term employment contracts, social discrimination, etc.);
- physical stresses (ship movement, noise, vibrations, heavy physical work, shift work, etc.);
- cultural attitudes towards nutrition and the body shape one aspires to;
- irregular meal times due to work schedules;
- different offerings in the officer and crew messes;
- different food offered on board (sometimes facilitating overconsumption) as compared to the usual diet in the home countries of crew members;

[57] OLDENBURG, HARTH, JENSEN: *Overview and prospect: food and nutrition of seafarers on merchant ships*. Published in: International Maritime Health, Vol. 64, No. 4, 2013.

[58] WESTENHOEFER, VON KATZLER, JENSEN, ZYRIAX, JAGEMANN, HARTH, OLDENBURG: *Cultural differences in food and shape related attitudes and eating behaviour are associated with differences of Body Mass Index in the same food environment: cross-sectional results from the Seafarer Nutrition Study of Kiribati and European seafarers on merchant ships*. Published in: BMC Obesity, 2018.

- different needs for education on the topics of healthy nutrition and the (long-term) consequences of incorrect nutrition, and

- limited fitness opportunities and freedom of movement on board for long periods of time.

Inter alia, the following minimum requirements for catering on board are laid down in Germany (see Section 97 SeeArbG):

- nutritional value, quality and variety ensure a suitable and balanced diet;

- drinking water, the water supply facility and its operation comply with the current legal provisions on drinking water;

- meals comply with the current provisions on food (In Germany there are currently more than 700 food-related regulations.[59]).

According to information given by the operator of the SEOUL EXPRESS, it cooperates with a catering company with regard to the catering arrangements for seafarers. The caterer reportedly procures the food, makes meal suggestions and performs consumption analyses. This reportedly ensures that a balanced diet prevails. The master also stated with regard to food management that he believed freshness and balance were important. His observations indicate that awareness of fitness and nutrition has reportedly increased in recent years, especially among non-European crew members. The sports and leisure facilities on board (e.g. sports room with treadmills) are very well received.

3.2.4.3.2 Implications of Severe Obesity and the BMI as an Indicator

The BMI is used globally as an assessment basis for the classification of excess weight and obesity. It is a ratio of body weight to height squared. The deceased watchman's BMI was more than 40 kg/m² (Class 3 obesity). People with a BMI of ≥ 30 kg/m² are generally regarded as obese.[60]

Obesity reduces life expectancy and increases the risk of (chronic) diseases (e.g. diabetes, hypertension, heart attack, stroke, fatty liver, various forms of cancer, sleep apnoea). Overall, obesity is considered a risk factor and trigger for more than 60 secondary diseases.[61] In addition to an increased risk of illness, the general restriction of mobility and endurance, as well as damage to the musculoskeletal system caused by the weight must also be considered in relation to the activity on board. In the case of Class 3 obesity, self-directed dieting is no longer possible and medical monitoring

[59] HAMBURG CHAMBER OF COMMERCE: *Summary of food legislation [in German].* https://www.hk24.de/produktmarken/beratung-service/recht-und-steuern/wirtschaftsrecht/gewerberecht/lebensmittelrecht-1156820 (3 August 2021).

[60] WHO Europe (BRANCA, NIKOGOSIAN, LOBSTEIN): *The challenge of obesity in the WHO European Region and the strategies for response.* Copenhagen: WHO Regional Office for Europe, 2007. – ISBN 978 92 890 3388 6.

[61] VARIOUS PAGES FROM THE WEBSITE OF THE GERMAN OBESITY SOCIETY, https://adipositas-gesellschaft.de/ (5 August 2021).

and treatment is urgently required, as losing weight too quickly alone poses a risk to life through cardiovascular and liver failure.[62]

It should be noted that the BMI does not take into account the physique and thus the distribution of body fat as an indicator of an increased risk of disease and morbidity. Accordingly, alternatives to the BMI as an indicator of morbid obesity were examined during the formulation of MariMedV. However, from a medical point of view, the data necessary for the application of other metrics cannot be collected in a practicable manner during the examination of fitness for service at sea. According to the Maritime Medical Service, there is currently no appropriate alternative to the BMI in terms of legal certainty and verifiability.[63]

3.2.4.3.3 Medical Fitness for Service at Sea

Severe obesity is an exclusion criterion for the granting of a certificate of medical fitness for service at sea in many countries. In 2021, obesity and defective vision were the main reasons for refusal of a certificate of medical fitness in Germany.[64] These aspects are among the easiest to examine, inter alia because actual values are only specified for these in the MariMedV as exclusion criteria and they are not at the discretion of the doctor. Apart from the typical significantly increased risks of cardiovascular disease and immobility, the main problems caused by obesity among seafarers include but are not limited to evacuation in an emergency in confined spaces and via narrow and steep companionways by other crew members, as well as the design of lifesaving appliances (lifeboat seats, lifejackets, immersion suits). In addition to the foregoing are such issues as difficulty when moving and working in small confined spaces or using small access points/manholes, an increased risk of injury in the event of a fall, inability to perform strenuous activities in an emergency (e.g. firefighting while wearing respiratory protection or rescuing others), and exceeding the weight limit for fall protection equipment and other PPE.

The problem of evacuating obese or extremely heavy crew members in an emergency was also evident during the fire in the engine room of the multi-purpose carrier KELLY on 6 September 2019. "Due to his size and weight of about 130 kg [...], it was not possible for the two rescuers to pull the motorman out of the corner of the room. Consequently, the chief mate, the 2nd officer and the chief engineer were asked to provide assistance. It took an enormous effort for them to move the casualty to the deck, [...]."[65]

[62] KLEIN: *Adipositas Grad 3 – das müssen Sie wissen!* – 12 March 2020. https://adipositas-selbsthilfe.com/adipositas-grad-3 (5 August 2021)
[63] Discussion between the Maritime Medical Service and BSU on 11 February 2022.
[64] MARITIME MEDICAL SERVICE OF THE SHIP SAFETY DIVISION (BG VERKEHR): Gründe für Seedienstuntauglichkeit 2021.
[65] BSU Investigation Report 338/19, published on 27 July 2021.

According to Annex 1, 7.1 to MariMedV, anyone with a BMI of more than 40 kg/m² is considered unfit for service at sea in Germany. Each Party to the STCW sets the maximum BMI independently, if at all, as this is not – like the requirements for eyesight – regulated at the international level in the STCW. This means that according to the MariMedV, the casualty was unfit for service at sea (BMI: > 40 kg/m²) at the time of the accident.

3.2.4.3.4 Doubts as to the Fitness for Service at Sea of Crew Members

There may be a reason to believe that a crew member is unfit for service at sea, despite having a valid certificate during shipboard operation. Obesity can be one such reason. According to Section 14(2) SeeArbG, such cases can be reported to the Maritime Medical Service of the Ship Safety Division (BG Verkehr) so as to order that an unscheduled examination be conducted for the individual concerned. Such an examination is a mandatory part of invalidating a crew member's certificate of fitness for service at sea if the crew member fails to refuse it within the period stipulated.

The master and the chief mate told the BSU that the casualty had reportedly appeared to be fit, agile and nimble and that his fitness for service at sea was therefore never called into question. The watchman had reportedly never been unusually exhausted, short of breath or limited in his abilities. He was described as being stocky and broad-shouldered.

3.2.5 Emergency Response Management

For the sake of completeness, the following section will examine whether the emergency response management and the organisation of operations were appropriate and effective, or whether there is potential for improvement in this regard. In particular, the measures initially taken and evacuation of the casualty were examined in greater detail as part of the investigation.

3.2.5.1 Initial Measures – Search and Communication

The chief mate responded immediately after his watchman failed to report in. He handed over the watch as quickly as possible to the 2/O, who was already on the bridge in accordance with normal practice, and informed his superior (the master). He also told him that he reportedly intended to investigate the matter. According to the master, he agreed to this.

The search for the overdue person began immediately. Since the accident happened shortly before all crew members working during the day began their activities, many helpers could be immediately mobilised for the search without sounding the general alarm. On the instructions of the chief mate, the search party split up so as to search for the watchman both in the cargo hold he had last entered and in his cabin. Since his last location was relatively well known due to his radio reports, the search party led by the chief mate found the watchman within a few minutes.

In the meantime, the master went to the board management centre (BMC) to speak with the chief engineer after the chief mate's report. During the conversation, the 2nd engineer joined them, reporting that there was a casualty in the cargo hold and a stretcher was needed. Since the master had a key for the hospital, which is on the

same deck as the BMC, the master and the 2nd engineer immediately went to the ship's hospital, where both a spineboard and a cranable rescue stretcher with vacuum mattress were available. According to the master, he opted for the narrower and more manageable spineboard because he had reportedly assumed at that point that the casualty would reportedly have to be evacuated via the access hatch and vertical ladders. Furthermore, he had not yet been provided with information as to how seriously injured the person requiring evacuation was.

While the engineers took the spineboard to the scene of the accident, the master went to the bridge and first obtained information about the ship's position, speed, distance from land (about 52 nm) and volume of traffic (very calm, little traffic). He then instructed the officer on watch (2/O) to gather various items of information, including on the local MRCC[66]. According to information given by the master, he reportedly also assumed at this point that the casualty may have to be rescued by helicopter. He also reportedly issued orders for the deck officer who was not on watch to be called to the bridge to provide assistance, which then happened. The master also made ready the satphone, checked the reception, switched on his handheld radio and took charge of internal communication.

When the chief mate reported in by radio and requested medical assistance, the master immediately went to the scene of the accident in person. The casualty had already been evacuated to the transverse corridor between Bays 27 and 29, where resuscitative measures were being carried out when the master arrived.

3.2.5.2 First Aid, Evacuation of Casualty and Transport to Ship's Hospital

3.2.5.2.1 Measures According to the Maritime Medical Handbook of the Ship Safety Division (BG Verkehr)

The latest edition of the Maritime Medical Handbook of the Ship Safety Division (BG Verkehr) must be carried on all ships flying the German flag – both in German and in English, depending on the language used on board. It serves the crew as a reference for medical care in emergencies, illnesses and injuries at sea.[67]

Chapter A.2.1 of the Handbook (on first aid) describes the main signs of life-threatening situations and the rules to be followed. A life-threatening situation exists in the event of unconsciousness, severe respiratory disorders, no pulse, severe bleeding and/or self-harm of the victim. The self-protection of the rescuers is prioritised over the protection of third parties. It also stresses that assistance should be given as soon as possible and that action should be taken at the scene immediately, especially in the event of life-threatening emergencies. Transporting the casualty to the hospital first is not an option in such cases.[68]

[66] MRCC: Maritime Rescue Coordination Centre, responsible for coordinating all search and rescue operations.
[67] P. LANGENBUCH, A. EWEN, J. TÜLSNER: *Maritime Medical Handbook*. Hamburg: Carl W. Dingwort publishing house, 2019. – ISBN 978-3-87166-071-9, p. 506.
[68] Ibid., p. 36.

Chapter A.2.2. (on basic resuscitation) takes first responders through the general procedure for resuscitation step by step. Resuscitative measures should be taken immediately if the casualty is unconscious or not breathing. First, the airways should be checked, cleared if necessary, and the oral cavity and throat suctioned. Chest compressions should begin if the casualty is still unresponsive or not breathing. A second person should then prepare the patient for ventilation by means of a Guedel tube with ventilation bag and mask. As soon as it is at the scene, the AED is used and its instructions are followed. A shock is administered if recommended and then chest compressions and ventilation are immediately resumed. If a shock is not recommended, chest compressions and ventilation are continued. Adrenaline should be prepared as a blood pressure booster and for shock treatment and injected intramuscularly after the first unsuccessful shock or five minutes after the AED recommends that no shock is needed. During resuscitation, vital signs should be monitored continuously. If vital signs (breathing, consciousness, blood pressure, pulse) are still not discernible after all resuscitative measures, then chest compressions, ventilation and AED queries must be continued and the Telemedical Maritime Assistance Service Germany (TMAS Germany – Medico Cuxhaven)[69] contacted without delay. If contact with TMAS Germany is not possible for technical reasons, then resuscitative measures should be discontinued 30 minutes after the last shock delivered by the AED.[70] The Handbook does not recommend any action regarding the discontinuation of resuscitative measures if the AED does not deliver a shock. (Shock delivery by the AED is only possible if the device safely detects ventricular fibrillation.)[71]

Chapter A.4.5. of the Handbook deals with rescue from hatches and companionways. A rescue stretcher with integrated vacuum mattress that can be moved by crane, as required on board German-flagged vessels, is referred to as the best means of transporting a patient conservatively. A belt or a fire hose, which can be placed under the arms and around the upper body in a similar manner to a rescue sling, are referred to as alternatives. It is explicitly noted that a belt or hose loop must not be used to rescue unconscious patients and that the latter should wear a helmet.[72]

Chapter C.5.2.2.1. refers to the possibility of a spinal injury after falls from a greater height and immobilisation by means of a cervical collar, which must always be combined with a vacuum mattress for adequate stabilisation of the (cervical) spine.[73] Instructions for the proper use of the cervical collar and the vacuum mattress can be found in Chapters B.2.2.4.2. and B.2.2.4.3. Four rescuers and about 2 x 5 m of space are required for the safe use of the rescue stretcher with vacuum mattress.[74]

[69] The TMAS in Cuxhaven assists and advises seafarers in the event of illness, accidents, maritime emergencies or other incidents necessitating medical advice. The service is available to all ships at sea around the clock, free of charge and anywhere in the world: https://www.deutsche-flagge.de/en/maritime-medicine/tmas?set_language=en (23 September 2021).
[70] LANGENBUCH et al., 2006, p. 37 ff.
[71] DGUV: *DGUV Information 204-010 on automated defibrillation in the context of operational first aid*. Berlin: 2018.
[72] LANGENBUCH et al., 2006, p. 104 f.
[73] Ibid., p. 270.
[74] Ibid., p. 157 ff.

The German Trauma Society's S3 guide (on polytrauma/serious injury treatment) assesses the probability of spinal injuries after a fall from a greater height as increased and goes on to state that the cervical spine should be immobilised during rapid and conservative rescue before the actual technical rescue and that the need for an immediate rescue (e.g. risk of fire and/or explosion) constitutes an exception.[75] In the case of an acute risk to life, such as if there is a need for resuscitation, movement of the spine should be minimised during immediate rapid rescue. However, this can be performed without immobilising the spine using a vacuum mattress, for example. The focus is on keeping the rescue period short.[76]

Chapter C.23 of the Maritime Medical Handbook provides guidance on various topics relating to a death on board. Inter alia, it explains how death can be determined based on at least one certain indicator.[77] Immediately after an unsuccessful attempt at resuscitation, the AED assists the crew in determining death.

3.2.5.2.2 Procedure on Board the SEOUL EXPRESS

While the master was still on the bridge, the chief mate found the watchman on the 4th stringer deck in CH3. For his own safety, he measured the atmosphere in the cargo hold using a lowered gas detector, which he had taken from the BMC before the search began (the atmospheric measurement indicated sufficient oxygen levels and no dangerous gases – see 3.1). Nevertheless, the chief mate decided to enter the cargo hold for the evacuation only with respiratory protection. He instructed the other members of his search party in a timely manner to have lines ready in case the casualty had to be evacuated. There was no special equipment on board for rescuing casualties from confined/dangerous spaces (such as mobile anchor device with special pulley or winch and appropriate lines).

In the case of accidents involving personnel in confined spaces, the ship operator's SMM stipulates that the person posted at the entrance should never enter the space before other rescuers arrive. Furthermore, it states that no one should start a rescue attempt without wearing an SCBA, a rescue harness and, if possible, using a safety line. It is also recommended that a communication link be established between the personnel standing by at the entrance to the room and the watchkeeper on the bridge, in the BMC or in the engine control room.[78]

After the chief mate and an AB (AB1) had climbed down (wearing respiratory protection) to the casualty and the latter was neither responsive nor showing vital signs, he informed the chief engineer up at the access hatch that the casualty must be pulled up using a rescue sling. The chief mate took the prepared rescue sling, which had to

[75] GERMAN TRAUMA SOCIETY: *S3 guide (on polytrauma/serious injury treatment)*. Information as of 07/2016, Recommendation 1.53, p. 100.
[76] GERMAN TRAUMA SOCIETY: *S3 guide (on polytrauma/serious injury treatment)*. Information as of 07/2016, p. 100 f.
[77] LANGENBUCH et al., 2006, p. 476 f.
[78] HAPAG-LLOYD AG: *ISM Main Manual - 7.4.07 Work in Confined and Dangerous Spaces*. Hamburg: 1 February 2021.

be attached to loaded containers or their lashing[79] equipment due to the lack of suitable anchor points (see Figure 15). In the meantime, another AB arrived, put on an SBCA, climbed down to the 4th stringer deck together with the chief mate and the AB1, and helped to lift the unconscious watchman into the sling and then guide him upwards on the line. The chief engineer and the Bosun controlled the lifeline at the access hatch.

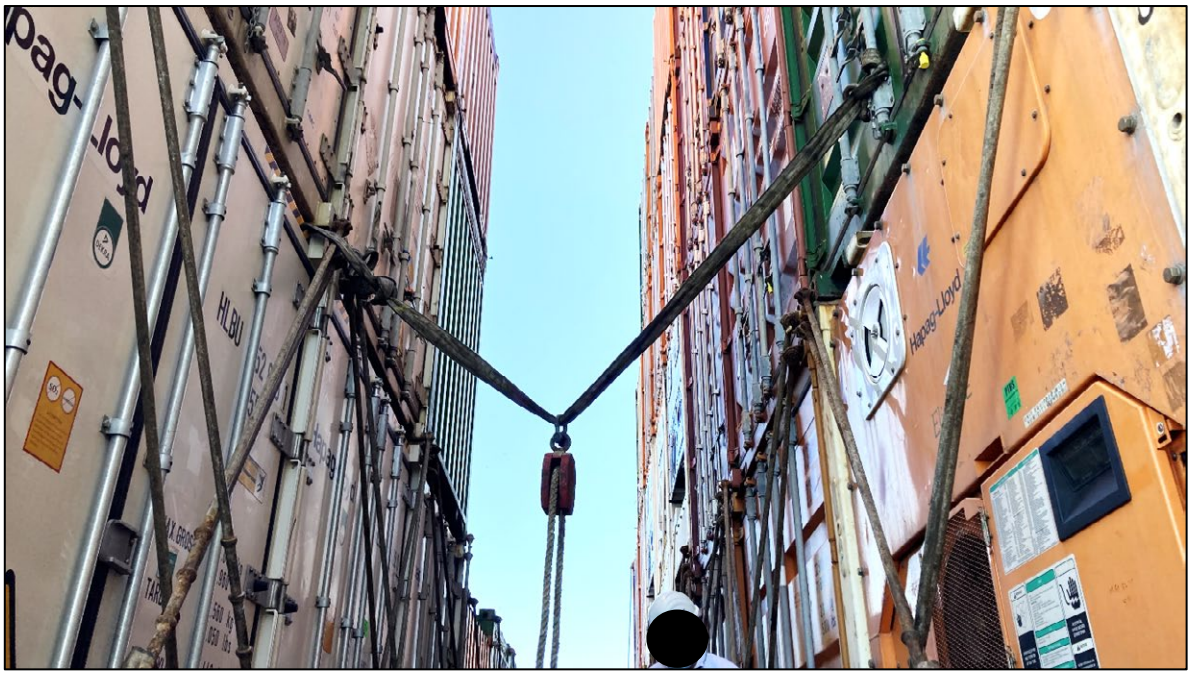

Figure 15: Rope and Snatch Block System for Evacuation via the Access Hatch (reproduced on 19 October 2021)[80]

After the unconscious watchman had been hoisted out of the CH, he was placed on the spineboard and resuscitative measures were immediately started. Meanwhile, other crew members retrieved the AED and the first-aid backpack from the hospital. The casualty was transported to the ship's hospital on the orders of the master, where the attempts to resuscitate were discontinued after chest compressions (alternating between different assisting crew members) for about one more hour due to the continued absence of vital signs. No medication (e.g. adrenaline) was administered during these measures, nor was TMAS Germany or an MRCC contacted.

The chief mate stated that he had not consulted the Maritime Medical Handbook for the evacuation of the casualty or subsequent resuscitative measures. However, it was used later as a source of information for further action after death had been established. The use of further aids from the SMS, e.g. the checklist for rescuing injured personnel[81], was also dispensed with.

[79] Lashing: Securing cargo and other items on board against tipping over and slipping during movements of the ship.
[80] Source: BSU.
[81] HAPAG-LLOYD AG: *Emergency Plans Dallas Express Class – 15. Recoverage [sic] of Injured and Sick Persons*. Hamburg: 1 January 2016.

3.2.5.3 Follow-up and Pastoral Care

The death of a colleague with whom they had worked and lived in close quarters for many weeks on board represents a particular emotional burden for the rest of the crew. The German Seafarers' Mission, the International Seafarers' Welfare and Assistance Network, and other organisations provide psychosocial emergency care in various languages for seafarers after stressful events. Contact is possible around the clock via various channels (telephone, email, online chat, WhatsApp, etc.).[82] [83] Chapter C.23.7. of the Maritime Medical Handbook also provides guidance on how to deal with the death of a crew member.[84]

In response to an earlier fatal occupational accident on another vessel in its fleet, the operator of the SEOUL EXPRESS dedicated a new chapter of the SMM to assisting the crew in processing and dealing with traumatic events.[85]

With regard to the topic of supporting seafarers after a traumatic event, general reference is made to BSU Report 452/19 (Accident with Subsequent Loss of Life on Board the SAJIR in the Roadstead off Ningbo (China) on 19 December 2019), Chapters 3.4.12, 4.9, 5.3, 6.4.5 and 7.3 in particular.

According to information from the ship operator, a cleric helped the crew of the SEOUL EXPRESS to process the situation immediately after the fatal accident involving their colleague in the port of Long Beach and the assistance provided by the 'Post-Emergency Procedures' in the SMM was made use of.

3.2.6 Safety Culture and ISM

The following section examines whether deficiencies in the safety culture on board and/or in the company in general may have contributed to the fatal occupational accident in question.

3.2.6.1 General Considerations

Building on approaches of organisational culture, the concept of safety culture is understood as the common safety-related basic assumptions and norms shared by the members of an organization. These become apparent in the concrete handling of safety in all areas.[86]

The ISM Code broadened the areas of ship safety and environmental protection regulated by the IMO to include shore-based management and is based on a structural approach similar to that of the ISO 9000 standard on quality management system

[82] GERMAN SEAFARERS' MISSION: *Psychosoziale Unterstützung für Seeleute nach belastenden Ereignissen*. https://www.seemannsmission.org/index.php?option=com_content&view=article&id=1482&Itemid=705&lang=de (22 September 2021).
[83] INTERNATIONAL SEAFARERS' WELFARE AND ASSISTANCE NETWORK: *Our work*. https://www.seafarerswelfare.org/our-work/seafarerhelp (22 September 2021).
[84] LANGENBUCH et al., 2006, p. 481.
[85] HAPAG-LLOYD AG: *ISM Main Manual – 6.9 Post-Emergency Procedures*. Hamburg: 1 February 2021.
[86] N. SCHAPER: *Sicherheitskultur*. Published in: Dorsch – Lexikon der Psychologie (30 April 2019). https://dorsch.hogrefe.com/stichwort/sicherheitskultur (25 November 2021).

requirements. However, the success of the ISM Code and its impact on the company depends on how it is put into practice through the SMS. The success of the SMS (reflected in the prevention of marine casualties, for example) and the company's safety culture (ship- and shore-based) are directly related.[87]

The German Flag identifies the following aspects as the building blocks of a good safety culture:

- commitment of the management
  (leading by example to convince employees of the need for occupational and health protection measures; providing good-quality and comprehensive protective equipment[88]);
- communication
  (speaking with each other; explaining the reason for goals and measures and their implementation strategy);
- training and instruction
  (appropriate to own operational requirements);
- motivation
  (to openly express opinions and make suggestions for improvement without fear of disadvantage; consideration of employee suggestions by the general management[88]; fair penalties for unacceptable conduct in relation to all areas of safety[88]);
- proactive safety awareness
  (considered action; no acceptance of risks; no ignoring or disregarding of safe practices);
- continuous improvement
  (reflecting on, questioning and if necessary correcting one's own actions in consideration of changes in the work environment), and
- tailor-made safety measures
  (equipment and procedures tailored to operational characteristics; avoidance of excessive documentation and red tape).[88]

A good safety culture is reflected, inter alia, in the fact that employees not only follow the measures stipulated to enhance safety (compliance, reactive behaviour) but also understand, support and are convinced of their meaningfulness (commitment, proactive behaviour).[89] [90] It will then become habitual and perfectly normal to wear stipulated PPE, use predefined checklists, communicate clearly, as well as assess and consider potential risks during the work process.

[87] M.-J. LEE: *A study on the effectiveness of the ISM Code through a comparative analysis of ISM and PSC Data*. Malmö: World Maritime University, Dissertation, 2016.
[88] Addendum by BSU.
[89] GERMAN FLAG: *Sicherheitskultur*. https://www.deutsche-flagge.de/en/safety-and-security/work-safety/safety-awareness?set_language=en (3 August 2021).
[90] K. LEGGE: *HRM: from compliance to commitment?* Published in: Human Resource Management. Management, Work and Organisations. London: Palgrave, 1995. https://doi.org/10.1007/978-1-349-24156-9_6 (26 November 2021).

The successful development of a good safety culture on board is thus reflected in sustained changes in the behaviour of crew members. Implementing such changes is a particular challenge in the maritime sector due to a number of factors:

- crew changes
  (a percentage of crew members are on leave at staggered times during any given period; high staff turnover in general);
- shift work
  (small time windows when all crew members are on duty at the same time);
- cultural differences[91]
  (national and cultural differences in perception, understanding, prioritisation and dealing with safety (problems); different approaches to conflicts of interest and time management; culture-specific communication behaviour);
- scarcity of resources
  (working safely often requires more time, more personnel and suitable equipment – often in short supply on merchant ships), and
- physical distance from the general management
  (implementation and effectiveness of change management on board by the ship's command can be difficult to control by the general management ashore; officers on board have to be convinced of meaningfulness).

Traditional methods for communicating safety information and learning from near-misses and accidents are fleet notices and circulars, safety alerts, safety meetings or tool box talks. However, as regards changing the mindset and deep-seated behaviour of personnel, there is evidence to suggest that such methods do not achieve the desired result. Reflective learning using simple and engaging materials that are detached from the daily work routine and take into account personal experiences of the course participants has proven in some companies and studies to be more effective than conventional methods.[92] [93]

Implementing the SMS on board and developing a safety culture requires, inter alia, the feasibility, practicability and clarity of the prescribed procedures. If the necessary resources (personnel, time, equipment) are not on board, then the requirements of the SMS cannot be met, despite a good safety culture.

[91] G. BANSE, R. HAUSER: *Technik und Kultur. Das Beispiel Sicherheit und Sicherheitskultur(en).* Published in: O. Rösch (ed.): *Technik und Kultur* (Wildauer Schriftenreihe Interkulturelle Kommunikation, Bd. 6). 2008, p. 61-83.

[92] MARITIME LOGISTICS PROFESSIONAL: *Goal Zero: An Up-close Look at Shell's Safety Culture*. https://www.maritimeprofessional.com/magazine/story/201609/upclose-shells-culture-516318 (26 November 2021).

[93] BROWN BANKHEAD III, R. ; OLMSTEAD, T. A. ; MANNARD, J: *Changing Student Behavior through the Use of Reflective Teaching Practices in an Introduction to Engineering Course at a Two-Year College*. American Society for Engineering Education, 2016. Paper ID #15817.

3.2.6.2 Safety Culture and Implementing the SMS on Board

During the marine casualty investigation, several discrepancies were identified between the practices on board the SEOUL EXPRESS, the requirements of the ship operator's SMS and industry best practice:

- deceased watchman's incomplete PPE – he was not carrying one of the gas detectors provided in the ship's office;
- one single person entered a confined space to inspect dangerous goods containers – no second person was posted at the access hatch;
- the checklist belonging to the issued PtW was incomplete and ambiguous
- the PtW was issued prematurely, before the atmosphere in the cargo hold was checked on the day of the accident,
- the supervising person failed to check the use of a gas detector and presence of a safe atmosphere in the cargo hold on the day of the accident;
- resuscitative measures (chest compressions) were interrupted about 22 minutes[94] after they started at 0838 to transport the casualty to the hospital;
- failure to follow further guidance in the Maritime Medical Handbook (administer adrenaline, contact TMAS Germany), and
- VDR data not backed up when the accident happened.

An alternative safety measure was taken on board in place of the instructions in the SMS, which was not recorded in writing on the PtW:

- the watchman reported in to the officer on watch via handheld radio when he entered and left the cargo holds.

3.2.6.3 Safety Management of the Ship Operator

The ship operator's SMS contains several contradictory, ambiguous and/or impracticable and incomplete requirements, respectively.

- ambiguity as to whether the mere use of long vertical ladders (height: > 2 m) to access the place of work (without carrying out specific works on or at the ladder) is understood to be work aloft and as such would require a PtW or the use of certain PPE (fall protection equipment);

[94] Time details are taken from the Captain's statemtent of facts, which was created together with the chief mate after the emergency management from memory. According to the ship's operator, it was a short planned interruption in order to better continue resuscitation in the hospital, also because of the bleeding head wound.

- failure to consider the risk of falling from a greater height in the RAs for the use of fixed ladders and for works in confined/dangerous spaces;

- firstly, the possibility to issue a PtW for entering tanks and confined/dangerous spaces for routine tasks for one month (PtW form), and secondly, the requirement to check the atmosphere in confined spaces before issuing the PtW;

- lack of clarity as to which items on the PtW checklist for entering tanks and confined/dangerous spaces are only applicable for tank inspections and which items are always applicable;

- no specifications for (alternative) safety measures for routine tasks, such as the repeated daily inspection rounds of refrigerated and dangerous goods containers in several cargo holds using long vertical ladders, and

- greater risk of falling in confined spaces due to limited access and thus rescue options, and consequently the need for special consideration is indeed identified in the SMM[95], but not included in the corresponding PtW or RA.

Various circumstances on board led to or possibly contributed to the crew acting in a manner that deviated from industry best practice:

- non-existence of special equipment for rescuing people from confined/dangerous spaces (e.g. mobile anchor device (rig/tripod) with special pulley or winch and corresponding lines);

- non-existence of suitable anchor points for fall protection and high angle lifesaving appliances:

  → the rope and snatch block system suspended between the containers had to be improvised;

  → pulling up the casualty was exhausting for the rescuers.

- one of the two stretchers kept in the hospital is not officially approved as a rescue appliance on board (the spineboard – see 4.8.2).

[95] HAPAG-LLOYD AG: *ISM Main Manual – 7.4.07 Work in Confined & Dangerous Spaces*. Hamburg: 1 February 2021.

Chapter 9.1 of the ship operator's SMM sets out the following main objectives of the SMS:

1. Ensure safe operation of the ship in every respect (in relation to people, goods and the environment).

2. Improve the SMS so as to prevent accidents, in particular the recurrence of any incident that has a detrimental effect on safety and/or environmental aspects, whether or not damage could be avoided.

To implement the second point, personnel on board from the management level are explicitly requested to report to the ship operator any incidents that could have an impact on the SMS for further investigation. This investigation aims to learn from such incidents, to improve the SMS and to implement corrective measures so as to develop a continuously improving safety culture.[96]

[96] HAPAG-LLOYD AG: *ISM Main Manual - 9.1 Reports for the Improvement of the Safety Management System*. Hamburg: 1 February 2021.

4 ANALYSIS

After investigating all the information available, the cause of the fall from the ladder could not be conclusively determined. Various aspects that might have facilitated the fall and other factors that could be ruled out as the cause with a high degree of certainty were identified, however. The crew's emergency response management was also evaluated.

4.1 Ambiguities

There were no witnesses to the accident in question and the scene of the accident was not under video surveillance. Therefore, it is only possible to speculate on the exact course of the accident. Since no traces of blood or similar were found on the 2nd stringer deck and the passageways to the next ladder on each deck are staggered and additionally secured by metal gratings (see Figure 11), it is highly likely that the watchman fell from the ladder between the 2nd and 4th stringer deck. If the fall had occurred from higher up, he would probably have landed on one of the upper decks. The cause and exact height of the fall, which is assumed to be a maximum of 5.2 m (see Figure 4), could not be determined. It was also not possible to determine whether the casualty had used the chin strap of his safety helmet properly and whether the rest of his protective clothing (gloves, overalls, safety shoes) fitted properly.

4.2 Factors Requiring Exclusion

After investigating all available evidence, the BSU believes that the following factors can be excluded as possible causes or contributing factors of the accident with a high degree of probability:

(in relation to the watchman involved in the fatal accident)

- lack of competence and professional experience of the watchman (see 3.2.1.2);
- lack of training in aspects relevant to occupational safety at the beginning of his assignment (see 3.2.1.2);
- fatigue due to long working hours and short rest periods (see 3.2.1.2);
- third-party involvement, e.g. in connection with an altercation with other crew members (see 3.2.1.5);
- pre-existing conditions that may have led to dizziness or fainting (see 3.2.1.5);
- influence of alcohol or drugs (see 3.2.1.5);
- unfitness for service at sea at the beginning of his assignment (see 3.2.1.6).

(in general)

- significant movement of the ship due to wind and/or swell (see 3.2.1.1);
- inadequate manning of the ship in general (see 3.2.1.3);

- inadequate lighting in the companionway of the cargo hold (see 3.2.1.4 and 3.2.4.2);

- poor general condition[97] of the ladder (see 3.2.1.4 and 3.2.4.2)

- moisture in the cargo hold and thus reduced coefficient of friction (see 3.2.1.1 and 3.2.4.2);

- reduced oxygen content and/or toxic or flammable gases in the atmosphere (see 3.1 and 3.2.5.2).

4.3 Similar Accidents

The investigation of similar accidents and of statistics shows that both the probability of occurrence and severity of the impact (in particular rescue prospects) and thus the risk of falling from a greater height on board ships is increased by various underlying conditions. Inter alia, this can be attributed to the fact that different crew members have to use various long vertical ladders several times a day for inspection rounds and other works on board. The following aspects already found in other accidents were identified as contributing circumstances (some of which are explained in greater detail in the chapters below) to accidents and their severity of impact:

- failure to wear PPEaF[98];

- incomplete procedural instructions and RAs in the SMM;

- dangerous structural dimensioning and design of the descent into the cargo hold used on a daily basis;

- lack of supervision by superiors, and

- failure to comply with the company's internal safety regulations and information.

4.4 Legal Framework

All risks associated with tasks on board a ship must be assessed in advance according to the ISM Code, MLC and SeeArbG (subsidiaryly from Occupational Health and Safety Act). However, international maritime regulations do not contain many practical design requirements aimed at preventing falls from a height during various activities on board. SOLAS Ch. II-1 Reg. 3-6 specifies several structural requirements for access to tanks and cargo holds – but only for oil tankers and bulk carriers. The installation of fall protection equipment is not required. IACS Recommendation 132 includes the installation of safety cages on vertical ladders longer than 4.5 m, as well as climber safety rails or cables on ladders longer than 6.1 m – but also only for certain oil tankers and bulk carriers.

[97] This refers only to the condition of the actual ladder and not to its structural dimensioning (see Chapter 4.6).
[98] PPEaF: Personal protective equipment against falls from height.

The installation of safety cages in accordance with Annex 14 to the CSS Code is recommended for ladders longer than 3 m and whenever a person may fall from the ladder in a cargo hold on container ships built on or after 1 January 2015. However, these requirements are not mandatory and only apply to areas on deck. Ship operators may apply (e.g. to the DNV classification society) for the additional SAFELASH class notation, which confirms implementation of the requirements of Annex 14 to the CSS Code, on a voluntary basis. The aim of this additional notation is to ensure that safe working conditions prevail, in particular safe access to safe workstations, during container securing operations on deck.[99] The SEOUL EXPRESS does not fall within the scope of Annex 14 to the CSS Code due to her year of construction (2000) and does not have the SAFELASH notation according to her certificate of class.

For a practical approach and harmonised enforcement of health and safety risk regulations, flag states publish both binding regulations and non-binding guidelines. At the international level, the ILO has published a code of practice on accident prevention on board ships at sea and in port. This recommends the wearing of a fall arrest/rescue harness to facilitate evacuation in an emergency in confined/dangerous spaces. However, as with the Seafarer's Compendium (from the Ship Safety Division (BG Verkehr)), the ILO's code of practice does not address protective measures when using fixed, long vertical ladders. IMO Resolution A.1050(27) (Revised recommendations for entering enclosed spaces aboard ships) does not mention the risk of falling in such spaces on board, either. The Seafarer's Compendium does not refer to enclosed cargo holds (such as on bulk carriers and container ships) as examples of dangerous spaces in Chapter B 13. However, Chapter B 23 (Gas-Free Measurement) indicates that gas measurements must be made before entering cargo holds.

According to DGUV Regulation 84 (Accident prevention regulation – Shipping enterprises), working paths with a risk of personnel falling on German-flagged ships shall be provided with protective equipment designed to prevent personnel from falling from heights (Section 4(6)). In contrast to hold ladders, climbing ladders must have protective devices to prevent falling, preferably climbing protection devices, if necessary (Section. 4(7)(a)). Exactly when there is a need for such protective devices is not clearly specified.

From the point of view of the BG Verkehr (Prevention Division), the mere use of long vertical ladders (without carrying out works on or near the ladder) is not classified as dangerous work. Although the Seafarer's Compendium contains illustrations of people wearing PPEaF while using a long vertical ladder (see Figure 16), it is not explicitly required for this activity in any section of the Compendium.

[99] DNV AS: *Rules for classification: Ships – DNV-RU-SHIP Pt.6 Ch.8. Living and working conditions, Sec. 3 Safe working conditions in container securing operations - SAFELASH*. Edition July 2021. https://rules.dnv.com/docs/pdf/DNV/RU-SHIP/2021-07/DNV-RU-SHIP-Pt6Ch8.pdf (7 December 2021).

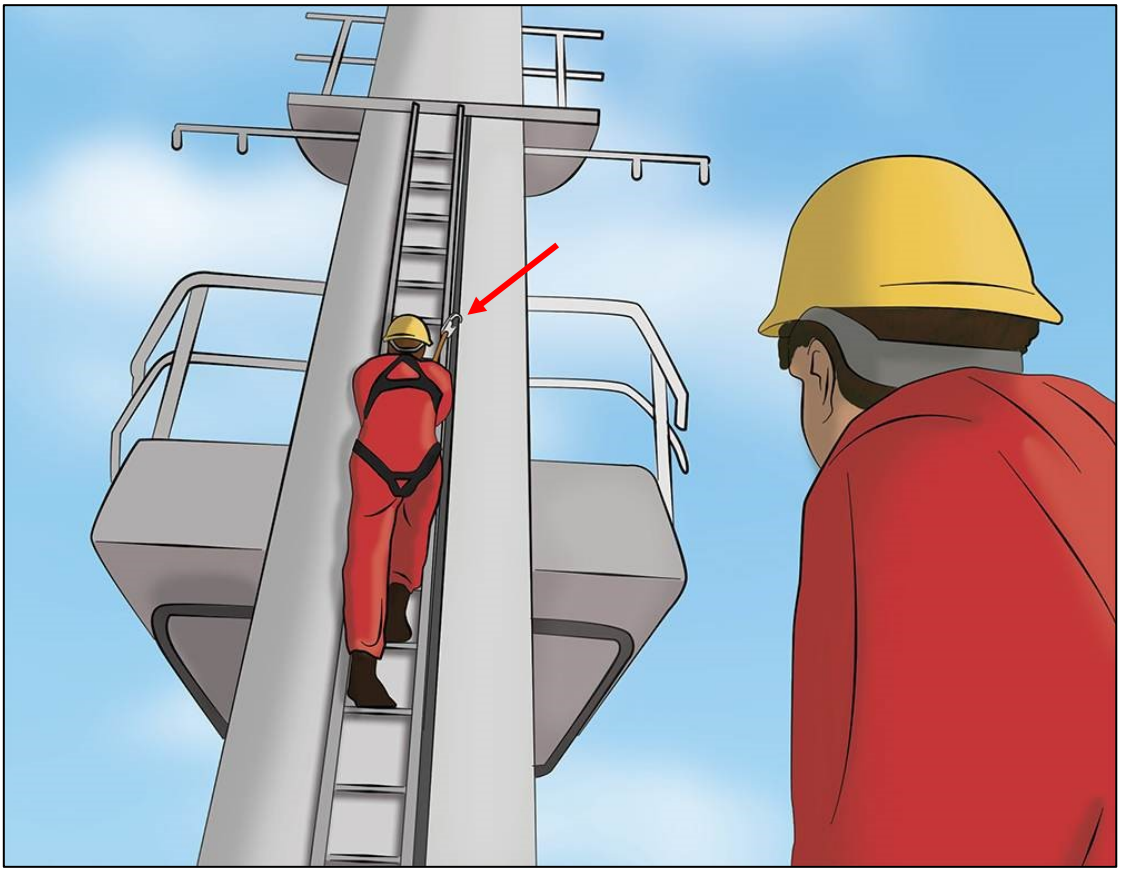

Figure 16: Wearing PPEaF when Using a Climbing Ladder[100]

The person in the image is using a guided-type fall arrester on the ladder's right-hand side (red arrow).

In Germany, there are more explicit recommendations for the design and use of shore-based long vertical ladders, e.g. in buildings or shafts. According to DGUV Information 208-032, due to the higher risk of falling, fixed ladders are only permissible if the installation of a stairway is not technically possible for operational reasons or if the ladder only has to be used occasionally, for example. Climbing ladders with a falling height of more than 5 m must be equipped with devices to prevent falling, insofar as this is technically possible. In the case of climbing ladders that have to be used when rescuing people or in enclosed confined spaces, a climbing protection device must be provided, while a safety cage is not permitted. Such precise specifications do not exist for maritime shipping.

[100] Source: SHIP SAFETY DIVISION (BG VERKEHR): *Seafarer's Compendium*, A – Personal protective equipment, A 7 – Personal fall protection equipment. 2014. https://kompendium.bg-verkehr.de/bgverkehr/xhtml/document.jsf?docId=bgverkehr_hbsee_a/bgverkehr_hbsee_a-Documents/hbsee_a07/hbsee_a07.pdf&alias=bgverkehr_hbsee_a_hbseea07_1_&anchor=&event=navigation (7 December 2021), arrow inserted by the BSU.

4.5 Occupational Health and Safety

The BSU investigation has shown that when entering cargo holds and using long vertical ladders in that context, occupational safety measures should be taken to eliminate the risk of falling from a greater height as well as hazards in confined spaces (atmosphere hostile to life).

4.5.1 Risk of Falling

In the present case, no sufficient measures were taken to adequately minimise (e.g. by technical measures, organisational measures or PPE) the probability of occurrence and/or the severity of impact of a fall when using long cargo hold ladders. Although access to the cargo hold ladder is clearly visible due to the coloured access hatch with labelling on the inside of the cover (see 3.2.4.2), i.e. people cannot accidentally step into the companionway and are not exposed to any sudden danger, the BSU believes there is still a risk of falling from the actual ladder. Causes may include slipping because of dirt and/or moisture, ill-fitting protective clothing, fatigue, carelessness or a loss of balance due to a wide range of different factors. The severity of the impact of a fall is increased by the falling height due to the length of the ladder(s) and poor accessibility of the lower decks with the rescue stretcher.

On board the SEOUL EXPRESS and on comparable container ships, the need to use long vertical ladders in cargo holds several times a day also increases the probability of a fall, at least whenever refrigerated and/or dangerous goods containers have to be checked in the hold on a daily basis. Accordingly, the BSU believes that the use of PPEaF is appropriate for falling heights of more than 2-3 m. In particular, measures should be taken to ensure that the user is not hindered unnecessarily while descending/ascending when such ladders have to be used frequently. Accordingly, an energy absorber with two safety hooks (see middle image in Figure 6) is not considered practicable in this particular case. Firstly, its correct use would significantly increase the time required for such daily routine activities, and secondly, the ladder is gripped with only one hand during the continuous repositioning of the safety hooks.

The BSU takes the view that if an accident necessitating rescue via hold ladders occurs in a cargo hold, as in the present case, then it is unsuitable to have safety cages as an only device for protection against falling (see DGUV Information 208-032). Safety cages can make entering the hold difficult for the user when she/he is wearing an SCBA and associated compressed air cylinders on her/his back or also the accessibility of the lower decks with the rescue stretcher (width: 60 cm), thus complicating a rescue.

4.5.2 Atmosphere Hostile to Life

Due to the permanent mechanical ventilation of the cargo hold, the result of the atmospheric measurement by the chief mate shortly after the accident and the autopsy report, the BSU does not believe that the accident was caused by a lack of oxygen or toxic gases. However, since ordinary gas detectors cannot identify all dangerous gases, gas poisoning cannot be ruled out with absolute certainty and wearing respiratory protection while rescuing the casualty was therefore justified.

The SMM generally classifies cargo holds as 'confined space', regardless of whether they are permanently mechanically ventilated, or not. However, the ship operator allows room for discretion and the possibility of a 'facilitated procedure' for routine activities in ventilated cargo holds (see 3.2.4.1). The BSU takes the view that there is a need for clarification in the ship operator's SMM as to which procedural instructions are to be followed in the case of routine activities in ventilated cargo holds and which safety measures are necessary. A corresponding risk analysis would then have to be carried out for the preparation of new procedural instructions.

Due to a cargo hold's classification as confined/enclosed space according to the ship operator's SMM and the IMO Resolution A.1050(27), an appropriate warning sign should be placed at the entrance to remind people who need to enter the cargo hold of the hazards and need for a PtW, as well as to discourage unauthorised entry:

Figure 17: Combined Warning, Prohibition and Mandatory Action Sign for Confined/Dangerous Spaces[101]

4.5.3 Permit to Work and Risk Assessments

The investigation of the PtW system's handling has revealed that both the actual system and its implementation on board were not effective in the present case. While the specified handling with PtWs according to the SMM is partly contradictory, concrete specifications for safe access to confined spaces were not implemented on board. Moreover, the checklist belonging to the PtW used is only partially suitable for the inspection of cargo holds (see 3.2.4.1). There is a risk that this will lead to confusion among those who use the documents and train others in the SMS.

The possibility of a PtW validity of up to one month for routine tasks makes nonsense of the basic principle of a PtW. A PtW should be updated each day and limited to a

[101] Source: INTELLI PERMIT: *The Confined Space Permit to Work*. https://www.intellipermit.com/the-confined-space-permit-to-work/ (20 December 2021).

specific task carried out by individual crew members at a fixed location within a limited time frame. If routine tasks involving hazardous works must be carried out on board on a multi-day basis, this may create a conflict between formal-, personnel- and time-related requirements for the daily issue of a PtW and the resources available for this in shipboard operation. In this case, practicable alternative risk management measures must be found.

Unlike various international guidelines on safe entry into confined spaces (see 4.4 and 9.1.3), the ship operator's SMM refers to the risk of falling in confined spaces and their greater impact on safety due to restricted accessibility.[102] However, the risk of falling is not taken into account in either the corresponding RA or the PtW. Although the risk of falling from a greater height is also not explicitly mentioned in the separate RA on the use of fixed vertical ladders, the PtW for work aloft is indicated as a measure for risk management (see 3.2.4.1). However, such a PtW is not usually intended to cover the mere use of the ladder if work is not also being carried out on or from the ladder. From the perspective of the BG Verkehr (Prevention Division), using the ladder to get to the place of work does not constitute dangerous work for which a PtW would be necessary.

The BSU is of the opinion that to minimise risks appropriately, existing risks must be comprehensively identified and considered, especially those with a high probability of occurrence and impact severity. The present case has once more shown that a risk of falling from a greater height with possibly fatal consequences prevails even when simply using a vertical ladder in the cargo hold. This should be taken into account in the relevant RAs and in the form belonging to the PtW for confined spaces so as to be able to take appropriate risk mitigation measures.

4.6 Shipbuilding – Risk of Falling in the Cargo Hold

The dimensioning of the access hatch, the deck passageways and the hold ladders in CH3 on the SEOUL EXPRESS comply with applicable regulations for container ships of this size and year of construction. However, due to the lack of horizontal clearance (less than the required 15 cm) between the hold ladder and fixed components (support strut as well as load-bearing upper plating and horizontal section of the bulkhead) between the 2nd and 4th stringer deck, the requirements of Section 21(5) DGUV Regulation 84 are not met.

The ladder's welded lateral support struts give rise to a slanted step on one of the rungs, especially between the 2nd and 4th stringer decks, and also make them harder to grip (see Figure 12). This can impair safe access to the cargo hold. It has not been possible to conclusively determine the extent to which this contributed to or was a factor in the accident.

Moisture combined with dirt, cargo residues, flaking paint and/or rust particles can make the ladder slippery and its use dangerous. However, it should be noted that ladders, railings and gangways, etc., which provide access to cargo holds, are often

[102] HAPAG-LLOYD AG: *ISM Main Manual – 7.4.07 Work in Confined & Dangerous Spaces*. Hamburg: 1 February 2021.

made of square and flat iron sections, as in the present case. Their edges and welded joints are a weak point in any coating system, especially in areas where abrasion or mechanical damage is possible (see MSC.1/Circular.1279). In the present case, there is no specific evidence to suggest that a poor general condition of the ladder contributed to the accident.

Design requirements and guidelines for climbing ladders and hold ladders on board various types of ship are not uniform (see 3.2.3 and 9.1). There are no binding international construction specifications that reduce the risk of a fall in the cargo hold or the lower deck for access points to a cargo hold below deck, which the crew have to use on a daily basis, on container ships such as the SEOUL EXPRESS (by the dimensioning of the ladder or the alternative installation of a stairway, for example). There is also no requirement for ladders to be fitted with fixed guides for guided-type fall arresters or for the presence of suitable PPEaF anchor points in general. However, in the context of occupational safety there is also no international PPEaF standardisation to ensure compatibility of fixed guide rails for fall arrest systems from different international manufacturers, for example.

The absence of suitable anchor points for both PPEaF and rescue appliances in the area of the cargo hold companionway complicate the practical use of PPE, on the one hand, and the safe rescue of a casualty from the cargo hold, on the other (see 3.2.4.2 and 3.2.5.2).

4.7 Excess Weight Among Seafarers

Given the findings of the autopsy report and various statements of the crew, the casualty's increased BMI was not classified as the cause of the accident. There is no evidence to suggest that the casualty's increased BMI impaired his daily work on board or that he had serious comorbidities due to his excess weight. A poor diet or insufficient opportunities for sport on board could not be identified.

A post-mortem examination can help to determine the cause of death but may not always be able to reliably detect sudden events such as constriction of the coronary arteries or cardiac rhythm disorders due to excess weight or other temporary impairments (e.g. dizziness and/or blackness before the eyes). Therefore, this aspect cannot be ruled out with certainty as a factor which may have facilitated the accident.

Challenges that overweight seafarers may be faced with on board include complicated evacuation in an emergency, insufficient dimensioning of personal and general lifesaving appliances, fall protection equipment, other PPE, as well as access points and manholes (see 3.2.4.3), for example. However, such problems not only arise among overweight seafarers, but also among those who have an above-average body weight because of their height or muscular build. It appears that there is currently no alternative to using the BMI as an indicator of morbid obesity (limit: 40 kg/m²) in the examination of fitness for service at sea, however.

4.8 Emergency Response Management

4.8.1 Procedure on Board the SEOUL EXPRESS

The crew's emergency response management was carried out without the assistance of procedural instructions, checklists, guidelines or other decision-making aids. On the one hand, this resulted in several required actions being performed improperly or not at all (see 3.2.5 and 3.2.6.2). On the other hand, the casualty was quickly found and evacuated from the cargo hold, however. The measures carried out by the crew did neither cause the death of the watchman nor contributed to it.

In contrast to the requirements of the SMM, the deceased watchman entered several confined/enclosed spaces (cargo holds) without being accompanied by another crew member. As a result, his whereabouts and the accident itself were initially unknown after the officer on watch on the bridge could no longer make radio contact. If a standby person had been posted at the cargo hold's access as stipulated, then the fall could have been reported to the bridge immediately. It would then also have been possible to take all necessary equipment to the scene of the accident immediately to provide medical care and evacuate the casualty. Furthermore, the general alarm or another suitable alarm with public announcement could have been released immediately after the report was received on the bridge, meaning all crew members would then have been available according to their task on the muster list.

The master took charge of internal communications on the bridge and management of the emergency response following the 2nd engineer's notification of the need for a stretcher to evacuate a casualty. In the course of emergency response management, several items of material information, such as severity and nature of injuries and which of the available stretchers was needed (spineboard or cranable rescue stretcher with vacuum mattress), were not sufficiently communicated in the BSU's opinion. Accordingly, in his position on the bridge the master was not fully informed about the situation in the cargo hold or the plan for evacuating and caring for the casualty.

According to the muster list, the chief mate should assume the role of on-scene commander in an emergency. In this case, he was actively involved in the rescue and operated in the cargo hold wearing respiratory protection. This means that he simultaneously took charge of the tasks of the on-scene commander – this role was not performed by any other crew member until the arrival of the master – and the tasks assigned to the deck squad. By acting contrary to the emergency response according to the muster list, the chief mate burdened himself with additional tasks instead of delegating them.

The medical care given to the casualty and method of rescue did not comply with the recommendations of the Maritime Medical Handbook in several respects (see 3.2.5.2). However, since the casualty was in need of resuscitation and an atmosphere hostile to life in the cargo hold could not be ruled out, the casualty had to be evacuated from the potentially dangerous area as quickly as possible, regardless of by what means. A rescue involving relocation in the rescue stretcher, immobilisation of the cervical spine,

configuration of the vacuum mattress while wearing respiratory protection, and ongoing resuscitation by laypeople did not represent a practicable option.[103]

The lack of special lifesaving appliances and appropriate anchor points made it difficult to evacuate the casualty from the cargo hold and exposed several people involved to a greater risk. If no containers had been stowed on deck next to the access hatch, it would not have been possible to suspend the pulley/block system there safely and at a suitable height. The use of a simple snatch block without backstop would have resulted in the casualty falling almost out of control if the lifeline was released accidentally. This also exposed the rescuers in the cargo hold to an additional risk of injury. Due to the staggered arrangement of each ladder above/below the next and the simple block (in contrast to tackles/pulleys), a great deal of force was needed to pull the casualty up.

4.8.2 Using a Spineboard as a Lifesaving Appliance on Board

The dimensions of the cranable rescue stretcher with vacuum mattress repeatedly ensured that the more manageable spineboard was chosen for transporting casualties after a fall from a height. (see BSU Investigation Report 452/19)

The cranable rescue stretcher approved by the BG Verkehr and forming part of the medical equipment is about 60 cm wide, the spineboard about 43 cm. However, the rescue stretcher is the optimum solution for a vertical rescue due to the integrated footrest. Although transporting a casualty through the narrow passages, stairways and hatches on board with the narrower spineboard appears easier at first glance, the Maritime Medical Service is of the opinion that it is not suitable for a vertical rescue with the attached belt system by medical laypeople.[104] Transporting casualties on deck and in the superstructure alone makes it necessary to tilt, adjust or rotate the stretcher to pass through passageways on board, which are often narrow due to the ship's architecture. Unlike the spineboard, the rescue stretcher with integrated vacuum mattress can ensure stable transport of casualties without them slipping or moving unintentionally on the stretcher. During the BSU's visit on board the SEOUL EXPRESS, it was confirmed that the scene of the accident could have been reached with the wider and longer rescue stretcher, albeit with various difficulties due to the spatial configuration and dimensions of the passages on and below deck.

Handling the rescue stretcher is described in the Maritime Medical Handbook and practiced during medical refresher courses. However, correct use of the spineboard and also weighing up when using the spineboard instead of the rescue stretcher may be appropriate is neither part of the medical training of seafarers nor addressed in the Maritime Medical Handbook. From the perspective of the Marine Medical Service, it is therefore unreasonable to expect the crew, as medical laypeople, to choose correctly between the spineboard and rescue stretcher when under stress in an emergency.[105]

[103] Opinion of the Maritime Medical Service dated 4 February 2022.
[104] Discussion between the Maritime Medical Service and BSU on 11 February 2022.
[105] Ibid.

The system of maritime medicine in Germany and for ships flying the German flag consists of many components[106], which are interrelated and build upon each other in some instances. From the BSU's point of view, the initiative displayed by ship operators in terms of providing additional equipment is basically commendable and to be welcomed. However, in the case of medical issues, the Maritime Medical Service of the Ship Safety Division (BG Verkehr) and the *Ausschuss für medizinische Ausstattung in der Seeschifffahrt* [Committee for medical equipment in the maritime shipping sector][107] should first be consulted and deviation from this well thought-out system avoided. This also applies with regard to the spineboard, which is not consistent with the 'State of medical knowledge in maritime shipping'[108] and not considered suitable medical equipment in the opinion of the Committee.

4.8.3 Using the Maritime Medical Handbook as an Instruction Manual

Acting as a guide for the immediate response is not the primary function of the Maritime Medical Handbook, as there is no time to use it outside the ship's hospital. In November 2021, the Maritime Medical Service published emergency cards to supplement the Maritime Medical Handbook and as a new component of the emergency bag, which is also part of the medical equipment on board. These close the information gap in the rescue chain, help with the most important initial medical measures at the scene of the accident and summarise the emergency measures in a concise and clear manner in the event of life-threatening emergencies. Unlike in Chapter A. (emergency cases) of the Handbook, the emergency cards also address injuries to the (cervical) spine, so that these are taken into account when casualties are rescued and transported. Since the emergency cards were not issued until after the accident, crew members of the SEOUL EXPRESS did not yet have this valuable aid at their disposal.

Neither the Maritime Medical Handbook nor the emergency cards provide recommendations for action with regard to the discontinuation of resuscitative measures if no shock was delivered by the AED. (Shock delivery by the AED is only possible if the device safely detects ventricular fibrillation.)

4.9 Safety Culture and ISM

With regard to the ship operator's safety management processes, Chapter 3.2.6 identifies various aspects that make it difficult to implement the requirements of the SMS on board (contradictions, ambiguities, impracticality). This opposes the development of a safety culture on board and the selection of appropriate safety

[106] Examinations of fitness for service at sea, telemedical assistance, medical equipment and facilities, Maritime Medical Handbook, emergency bag with emergency cards, initial medical training and refresher courses.

[107] The Committee is chaired by the Federal Ministry for Digital and Transport (BMDV). The Maritime Medical Service of the Ship Safety Division (BG Verkehr) is responsible for management. The BMDV appoints members of the Committee for three years at a time. Due to its composition, the Committee constitutes a panel of experts in maritime medicine and pharmacology.

[108] State of medical knowledge, published in the BMDV Gazette or in the Federal Gazette by the BMDV. On the day of the accident, the *Sixth notice of the state of medical requirements in maritime shipping* of 18 February 2022 (BAnz AT 02.06.2020 B8) was authoritative. It has since been superseded by the *Eighth notice* of 21 October 2021 (BAnz AT 03.11.2021 B6). None of the amendments concerned the approved stretcher.

measures. Correct handling of checklists and procedural instructions on board is, inter alia, also an assurance for the crew that they are acting in the interests of the ship operator. To that end, the instructions in the various documents must be both clear and practicable on board.

The BSU takes the view that the listed discrepancies between the practices on board and the requirements of the company's internal SMS as well as good professional practice point to the fact that there is room to improve both the safety culture on board the SEOUL EXPRESS and the SMM in certain areas. This is underlined by the fact that by way of derogation from the SMM, the crew considered it necessary to take alternative safety measures (see 4.5).

5 CONCLUSIONS

After investigating and evaluating all the available information, the BSU has arrived at various conclusions. Building upon this, specific safety recommendations are subsequently given so as to avoid comparable accidents in the future.

5.1 Cause of the Accident

The specific cause of the watchman's fall could not be determined. However, several factors were identified that may have contributed to or facilitated the occupational accident. Some of these have also been identified in similar accidents in the past.

Under the management of the ship operator of the SEOUL EXPRESS, another fatal accident already occurred in 2019 due to a fall from a greater height in a cargo hold (see BSU Investigation Report 452/19 SAJIR). The generally high number of fatal accidents involving falls on container, bulk and general cargo ships with similar facilitating circumstances suggests that risk minimisation (taking into account the hierarchy of measures (see Figure 7)) is necessary to reduce the number of accidents.

The IMO has already identified a corresponding need for action and a working group was commissioned with the analysis of accident investigation reports on falls from greater heights and the deduction of appropriate recommendations (see 6.4). It was identified that tasks involving the risk of falling, are not always considered as hazardous work, so that no appropriate measures for preventing falls or minimising their impact are taken.[109]

5.2 Occupational Health and Safety

- Classifying the use of long vertical ladders (to reach the place of work, for example) as non-dangerous work means there is a lack of binding regulations and measures for occupational safety in relation to this hazardous routine activity. – *The risk seafarers are exposed to is increased by not wearing PPE and the dimensioning of cargo hold companionways that are used on a daily basis.*

- The risk of falling from a greater height must be taken into account in the RA, PtW, other SMS procedural instructions, as well as in national and international guidelines for entering confined/dangerous spaces. – *A comprehensive analysis of all hazards is a prerequisite for the development of appropriate risk management measures.*

- Implementation of the procedural instructions of the SMS relating to occupational safety on board is not always practicable given the basic conditions there. – *Ambiguities, contradictions and impracticalities within the SMS must be eliminated for successful implementation of the procedural instructions on board. Only then can the intended safety measures lead to the desired risk minimisation.*

- Ignoring seemingly obvious and commonplace hazards in the RA leads to incomplete risk control measures and gaps in occupational safety. – *This poses an*

[109] IMO: III 8/4, Lessons Learned and Safety Issues Identified from the Analysis of Marine Safety Investigation Reports – *Report of the Correspondence Group on Analysis of Marine Safety Investigation Reports*, 21.2. London: 22.04.2022.

unacceptable risk due to the significantly increased hazard potential when working on board (adverse working, environmental and living conditions).

- On existing ships, it is necessary to focus on organisational and behavioural protective measures, as well as on PPE to minimise the risk of falling from greater heights. – *Since mandatory structural changes in the world's merchant fleet are difficult to implement, technological innovations (e.g. permanent monitoring of the atmosphere in a cargo hold via sensors) could make the work of seafarers safer.*

5.3 Shipbuilding

5.3.1 Risk of Falling in a Cargo Hold

- Current mandatory construction rules for container ships do not provide sufficient protection for crews against falls from a greater height during shipboard operation. – *Ship design and construction standards could provide a number of ways to minimise the risk of falling from a greater height for seafarers and others on board new ships. (Removal of the origin of the danger and/or modification of its characteristics, technical safety measures (see 3.2.4.1).) Long vertical ladders in cargo hold companionways, in particular those used on a daily basis (e.g. for cargo inspections), pose an increased risk and there should be a binding requirement to replace them with stairways or inclined ladders with handrails on new ships.*

- A lack of international standardisation for fall protection equipment complicates the adoption of binding regulations on the installation of fixed guide rails for guided-type fall arresters on the vertical ladders of a seagoing ship. – *Guide rails must be generally compatible with the systems used by dockworkers in other countries or other kinds of guided-type fall arrester, for example. Following the standardisation of PPEaF, permanently installed guide rails could then be made mandatory for hold ladders and climbing ladders.*

- Due to the support strut that was attached level with a rung and proximity of the ladder to other fixed components, CH3's companionway poses a risk of accident and injury. – *Compliance with the shipbuilding standards stipulated by the flag state, the classification society and the IMO is mandatory and should be confirmed within the framework of Port State Controls and other audits.*

5.3.2 Dimensioning

- The small dimensioning of hatches, companionways, passageways and other routes on board make it difficult to rescue casualties with the rescue stretcher. – *Given the dimensions of the stipulated lifesaving appliance, it would be appropriate to increase the width of certain areas on board to ensure the uncomplicated and rapid transportation of casualties.*

5.4 Excess Weight Among Seafarers

- Although the BMI cannot identify or gauge the causes and corresponding consequences of obesity, from today's perspective it is the only practicable and legally secure measurement in the context of the examination of fitness for service at sea. – *Other assessment methods would first have to be established and recognised for use in the examination of fitness for service at sea.*

- BMI-related rules for fitness for service at sea and resulting upper limits for body weight and stature are partly in conflict with the technical specifications and rules concerning safe operation of the ship and all her equipment. – *Depending on body size and stature, even non-obese seafarers may exceed the maximum weight permitted for personal and general lifesaving appliances and PPE.*

5.5 Emergency Response Management

- Non-use of checklists, guidelines and other decision-making aids may lead to a failure to take necessary measures or follow best practices in emergency situations. – *During an acute emergency or traumatising experience, habitual behavioural strategies may be unsuccessful and thoughts may not be completed in a meaningful way. The use of checklists relieves those concerned of the need to have all necessary steps readily available with the right prioritisation.*

- Sharing important information in the context of emergency communication between the organisational units on board (ship's command unit, operational unit, etc.) is necessary for making the right decisions. – *In particular, the master and the chief mate (in the capacity of on-scene commander) should have an identical picture of the situation at hand in order to determine the required equipment and further course of action.*

- Should it be necessary to deviate from the emergency response according to the muster list due to existing circumstances, then it must be ensured that all tasks are still adequately covered by personnel and, if necessary, are delegated accordingly. – *In particular, leaders in the emergency response organisation must be able to focus on their core tasks (staff leadership, overview of the situation, decision-making responsibilities).*

- The risk of injury to casualties in dangerous spaces and their rescuers could be reduced by using special industrial rescue appliances designed for the sector. – *Suitable anchor points[110] must be available for the attachment of such equipment and also for the use of PPEaF (e.g. fall arrester with integrated energy absorber). These could be permanently installed or in the form of mobile anchor devices on board.*

[110] An anchor point is appropriate if the technical requirements according to DIN EN 795 (Personal fall protection equipment - Anchor devices) are met (e.g. with regard to load capacity).

- Lifesaving appliances that are neither approved for use on board by the BG Verkehr nor by the Committee for medical equipment in the maritime shipping sector should not be used. – *If ship operators wish to keep additional equipment on board, this should be discussed with the Maritime Medical Service. The crew must also be trained in which lifesaving appliances are suitable in any given case and how to use them in safety trainings and exercises.*

- The spineboard should no longer be kept available and used as a lifesaving appliance on board. – *The Committee for medical equipment in the maritime shipping sector did not approve the spineboard in the past and does not consider it suitable as a lifesaving appliance on board seagoing ships.*

- The Maritime Medical Handbook and the emergency cards should be supplemented by a recommendation to discontinue resuscitative measures if the AED does not initiate. – *Comprehensive instructions help the crew to take the right action in exceptional situations that cause extreme psychological stress, such as fatal personal accidents.*

5.6 Safety Culture and ISM

- The ship operator's procedural instructions, RAs and PtWs (theoretical level) should be adapted to reflect the reality on board (practical level; availability of resources, spatial conditions, frequency of work to be performed). – *The selection and enforcement of both appropriate and practicable occupational safety measures determines their effectiveness.*

- The ship's command should enforce the ship operator's occupational safety requirements and supervise their implementation by the crew. – *Failure to comply with the SMS facilitates occupational accidents.*

- The ship's command should report discrepancies between shipboard practices and the SMS and the reasons for them to the ship operator and/or address them in audits. – *A culture of open communication and feedback is essential for the ship's command and the ship operator to work together to continuously improve the SMS (e.g. with regard to the practicability of procedural instructions).*

6 ACTIONS TAKEN

6.1 Ship Operator

The ship operator reported that further support struts were found near rungs on various ladders on all sister ships of the SEOUL EXPRESS. A fleet-wide circular issued in August 2021 made ship's commands aware of this and of the potential risk of falling when using the ladder. The ship's commands were urged to inspect and identify all support struts and other obstructions on ladders and to inform the ship's operator of their location and design. Specific solutions were then to be found for the slightly differing designs in cooperation with the respective superintendent. (See Annex 9.2 Hapag-Lloyd AG: Fleet Circular 'FMS 18/2021 Ladder Support'.)

On board the SEOUL EXPRESS, the support strut on the ladder in CH3 between the 2nd and 4th stringer decks was moved backwards:

Figure 18: Moved Ladder Support Strut in CH3[111]

The height of the support strut was not changed, as can be seen to the right of the above image. This modification has resulted in a gap of about 10-11 cm between the centre of the rung and support strut. Accordingly, the design is still not in accordance with the standard, as a clearance of 15 cm behind the rung is not given.

[111] Source: BSU's visit on board the SEOUL EXPRESS on 19 October 2021.

As can be seen in Figure 18 as compared to Figure 12, the ladder was also preserved. There is no corrosion or moisture visible on the ladder's surface.

In addition to the SEOUL EXPRESS, 11 other ships became aware of comparable designs, often on several ladders, in the course of investigations made in connection with Fleet Circular 18/2021. Since structural measures were evidently not feasible in many cases, warning signs indicating the possible risk of falling due to obstacles on the ladder were installed instead.

The ship operator also informed the BSU about a forthcoming revision of the internal PtW system. From the ship operator’s point of view, the permanently ventilated cargo holds of the SEOUL EXPRESS are not to be classified as enclosed/confined spaces. They are supposedly designed for regular access by skilled workers in any loading condition.

The BG Verkehr (Ship Safety Division) considers cargo holds on large container ships, "beyond the possible hazardous atmosphere, not to be a space with special characteristics requiring the application of the recommendations [of IMO Res. A.1050(27)]. Both the access to these spaces and the routes arranged there, permanent lighting and ventilation facilities located therein are significantly different from other enclosed spaces exemplified in the resolution, including, for example, ballast and heavy fuel oil tanks and void spaces such as bulbous bows, etc., which are not designed for more frequent, regular access."[112] Since the ship-specific identification and determination of the concrete hazards and risks in connection with the inspection of the hold is the responsibility of the shipping company, BG Verkehr only assumes that a hazardous space exists if the shipping company's internal risk assessment identifies a (possibly) hazardous atmosphere.[112]

The BSU does not share the viewpoint of BG Verkehr and the ship operator on the classification of cargo holds on large container ships as unenclosed/-confined spaces, at least if the access to the hold does not have a large access hatch that can be passed without obstruction, even with rescue equipment (e.g. compressed air breathing apparatus), and if there are no stairs. If the access is dimensioned as the accident site on board the SEOUL EXPRESS, with the smallest possible access hatch (clear width and length of 60 cm) and a vertical ladder more than five meters long directly below the hatch, in the view of the BSU at least one of the characteristics of an enclosed space specified in the international definition of the IMO (Res. A.1050(27), see 9.1.3) is fulfilled: "*Limited openings for entry and exit*". Access to the cargo holds is not via the large cargo hatches, but via cargo hold access hatches/companionways. Thus, with a full cargo hold and closed hatches, there is only one escape route from the companionway and thus only one 60 x 60 cm access for rescue forces. In the opinion of the BSU, this results in an increased risk when entering the hold, which must be reduced by suitable safety measures.

[112] Statement BG Verkehr, Ship Safety Division, 26 July 2022.

Morever, the ship operator's SMM was updated and corresponding documents were made available to the BSU. According to the ship operator ambiguities and contradictions regarding the PtW for accessing tanks and confined/dangerous spaces (see 3.2.6.3) have been eliminated and specifications for safety measures for the performance of routine tasks were amended. For routine entry into permanently ventilated and lit cargo holds or their companionways, a PtW, a gas-free measurement and a guard at the entrance are no longer required. Alternatively, continuous communication between the person(s) entering and either the bridge (OOW) or another person outside but in the vicinity of the hold shall be established and ensured, including appropriate reporting facilities and intervals (at least every 10 minutes). Accordingly, a UHF radio as well as additionally a portable gas detector must be carried in the hold.[113]

From the point of view of BG Verkehr (Ship Safety Division), the ship operator's approach in evaluating the cargo holds and deriving protective measures basically complies with the applicable national and international requirements. BG Verkehr considers the protective measures to be plausible and appropriate under the conditions described.[114]

In addition, the risk of falling from a greater height is planned to be included in the risk assessments for the use of permanently installed ladders and working in confined/dangerous spaces as well as the corresponding procedures. The particular risks in confined spaces due to restricted means of access and rescue are also planned to be taken into account.

[113] HAPAG-LLOYD AG: *ISM Main Manual - 7.4.05 Performance and Supervision of Hazardous Works, Attachment 12 Daily & Routine Work in Cargo Holds*. Hamburg: 01 April 2022.
[114] Statement Ship Safety Division, BG Verkehr, 26 July 2022.

6.2 Ship's Command of the SEOUL EXPRESS

In addition to the implementation of the aforementioned fleet circular 18/2021, yellow and black markings were applied to the deck passageways on the various levels of the forward companionway in CH3 on board the SEOUL EXPRESS. This indicates an increased potential hazard when using the vertical ladders:

Figure 19: Yellow and Black Markings on a Deck Passageway[115]

6.3 Maritime Medical Service

In the course of the investigation, the BSU informed the Maritime Medical Service about the missing reference in the Maritime Medical Handbook to a possible discontinuation of resuscitative measures if the AED does not deliver a shock. As a result, supplementation of the recommendations for action was added to the list of planned updates for a forthcoming edition of the book.

It should be possible to discontinue resuscitative measures if the defibrillator fails to deliver a shock for more than 30 minutes and the patient shows no signs of life.

[115] Source: BSU's visit on board the SEOUL EXPRESS on 19 October 2021.

6.4 IMO Sub-Committee on Implementation of IMO Instruments (III)

The Sub-Committee on Implementation of IMO Instruments decided that various accidents that frequently occur, including occupational accidents involving falls from a height, must be analysed. For this and other topics, the 'Correspondence Group on Analysis of Marine Safety Investigation Reports' was tasked with analysing accident investigation reports, forming subsequent conclusions, and making recommendations based on them. The BSU is also involved in this analysis.

The recommendations of the working group on falls from a height could contribute to the development of new international standards or adaptation of existing standards to improve safety on board.

7 SAFETY RECOMMENDATIONS

The following safety recommendations do not constitute a presumption of blame or liability in respect of type, number or sequence.

7.1 Federal Ministry for Digital and Transport (BMDV)

7.1.1 Proposals to the IMO

The Federal Bureau of Maritime Casualty Investigation recommends that in its capacity as flag state representative, the Federal Ministry for Digital and Transport, in cooperation with other interested States and organisations, propose the following to the IMO:

.1 Introduction of the mandatory installation of safe companionways through vertical passageways, e.g. by stairways or inclined ladders with handrails instead of long vertical ladders, in cargo holds of new container ships which need to be regularly accessed e.g. for cargo care/inspection but also by dock workers;

.2 adoption of regulations for new cargo ships on increased dimensioning for hatches, companionways, passageways and other routes on board to ensure and take into account the safe and smooth emergency transport of casualties using standard stretchers;

.3 revision of the Resolution A.1050(27) – Recommendations for Entering Enclosed Spaces aboard Ships, taking into account the risk of falling from a greater height and its particular implications in confined/dangerous spaces in the process.

7.1.2 Special Rescue Appliances on Board Ships

The Federal Bureau of Maritime Casualty Investigation recommends that in its capacity as the German flag state administration's technical supervision body, the Federal Ministry for Digital and Transport enquire with the operators of ships flying the German Flag, how SOLAS III/19.3.6 and, in particular, the requirements for equipment for efficient rescue of casualties from confined/dangerous spaces are met. The experiences with such equipment, especially with rescue equipment designed for the industry, should be shared and evaluated in order to adavance the use of such equipment also on an international level.

7.2 Federal Ministry for Digital and Transport (BMDV) and BG Verkehr, Ship Safety Division

The Federal Bureau of Maritime Casualty Investigation recommends that the Federal Ministry for Digital and Transport and the Ship Safety Division of BG Verkehr, in cooperation with other interested states, propose to the Paris MoU Advisory Board the topic "Occupational Safety - Hazards from Falls from Heights" for upcoming Concentrated Inspection Campaigns within the framework of Port State Control.

7.3 Federal Ministry for Digital and Transport (BMDV) and Federal Ministry of Labour and Social Affairs (BMAS)

The Federal Bureau of Maritime Casualty Investigation recommends that the Federal Ministries of Digital and Transport and of Labour and Social Affairs, in cooperation with the Standardisation Body for Ship and Marine Technology of the German Institute for Standardisation, develop proposals for an international standardisation of personal protective equipment against falls from a height in the maritime sector in order to realise compatibility of the equipment of different manufacturers with permanently installed guides for travelling fall arresters (e.g. on vertical ladders).

7.4 Ship Operator of the SEOUL EXPRESS

The Federal Bureau of Maritime Casualty Investigation recommends that the ship operator of the SEOUL EXPRESS, Hapag-Lloyd AG,

.1 consider the risk of falling from a greater height in the risk assessment and permit to work for confined/dangerous spaces and the risk assessment for the use of ladders, with a view to establishing appropriate risk control measures;

.2 reduce the risk of falling from a height on hold ladders of existing ships by means of organisational and behavioural protective measures, the provision and use of personal protective equipment and/or the use of technical innovations;

.3 ensure that hold ladders are designed in accordance with the mandatory requirements of Section 21 of DGUV Regulation 84 and that all requirements are met;

.4 mark confined/enclosed and dangerous spaces with warning signs in accordance with EU Directive 92/58/EEC;

.5 on the German-flagged ships in its fleet, provide only lifesaving appliances that are specified according to the current 'State of medical knowledge in maritime shipping', as notified by the BMDV, and consult the Maritime Medical Service of the Ship Safety Division (BG Verkehr) and the Committee for medical equipment in the maritime shipping sector with regard to additional medical equipment;

.6 consider providing its crews with special rescue appliances for rescuing casualties from confined/dangerous spaces, which are designed for the industry and adapted to the particular conditions on board.

.7 insturct their ship’s commands on the occasion of the present marine casualty to

.1 ensure that the VDR's emergency storage is activated and that data are backed up for the period in question in the event of an emergency or other particular incident;

.2 ensure that the telemedical services of TMAS Germany (Medico Cuxhaven) are made use of in the event of illnesses/injuries or if medications marked with a '☎' in the Maritime Medical Handbook and/or in the 'State of medical knowledge in maritime shipping' have to be administered;

.3 enforce the ship operator's occupational safety requirements within the framework of the SMS on board and supervise implementation thereof by the crew;

.4 report discrepancies between the practices on board and SMS requirements (due to ambiguities, contradictions, impracticalities and/or a lack of resources, for example) to the ship operator for continuous improvement of the SMS;

.5 make use of decision-making aids in emergency situations, establish a common understanding of the situation in the ship's command group through efficient communication, and ensure that all tasks are adequately covered by personnel and, if necessary, delegated accordingly.

7.5 BG Verkehr (Prevention Division)

The Federal Bureau of Maritime Casualty Investigation recommends that the Prevention Division of BG Verkehr pay increased attention to compliance with the mandatory requirements of Section 21 DGUV Regulation 84 during ship inspections.

7.6 DNV as Classification Society of the SEOUL EXPRESS

The Federal Bureau of Maritime Casualty Investigation recommends that the classification society DNV ensure compliance with construction rules for ladders and that they inspect them within the scope of compliance surveys and newbuilding inspections.

8 SOURCES

- Written explanations/submissions
  - ship's command;
  - ship's operator;
  - classification society DNV;
  - BG Verkehr, Prevention Division;
  - BG Verkehr, Ship Safety Division

- Testimonies of the master and the chief mate (interviews on 23 August 2021 in the BSU's office building)

- Various internal specifications of the company as part of the SMS

- Expert opinion/technical papers
  - the Gordon & Rees Scully Mansukhani law firm, United States;
  - autopsy report of the County of Los Angeles, Department of Medical Examiner – Coroner;
  - department of forensic medicine at the Hamburg-Eppendorf University Clinic;
  - Maritime Medical Service of the Ship Safety Division (BG Verkehr).

- Official weather report of the *Deutscher Wetterdienst* [German Meteorological Service] (DWD)

- Investigation reports of other states:
  - Transport Malta, Marine Safety Investigation Unit: Investigation Report No.: 13/2020 and 12/2019;
  - Hellenic Bureau for Marine Casualties Investigation: Marine Casualty Safety Investigation Report 01/2016;
  - Republic of Bulgaria – Ministry of Transport, Information Technologies and Communications (Aircraft, Maritime and Railway Accident Investigation Directorate): Final report on the investigation into a very serious marine casualty – Death of a seafarer while falling in the cargo hold of the MV ANNA M on 8 December 2014.

- Various national and international guidelines and pieces of legislation identified and explained within the report

- Internet and literature sources shown accordingly as footnotes

9 ANNEXES

9.1 Relevant Extracts from and Summaries of the Standards and Guidelines Referred to in Chapter 3.2.3

9.1.1 Mandatory International Requirements

IMO: SOLAS Ch. II-1 Reg. 3-6, Resolutions MSC.134(76) & MSC.158(78)

Scope: Oil tankers ≥ 500 GT, bulk carriers ≥ 20,000 GT, built on or after 1 January 2006.

(Summary)
Vertical ladders should have an angle of inclination of between 70° and 90° and should not be skewed by more than 2°. If the rungs of ladders are fitted against a vertical surface, the distance from the centre of the rungs to the surface shall be at least 150 mm. With regard to width and construction, reference is made to accepted international or national standards.

If a vertical distance of more than 6 m has to be covered, e.g. from the upper access to the bottom of a cargo hold, then an inclined ladder/stairway must be installed. The following is specified for these inclined ladders/stairways: angle of inclination < 70°, width of the treads (or distance between the uprights) at least 400 mm, treads shall be equally spaced at a distance apart of between 200-300 mm, handrails on both sides at a suitable height, sufficiently dimensioned resting platforms at a maximum height of 6 m.

IMO: SOLAS Ch. III Reg. 19.3.6 & Resolution MSC.350(92)

Scope: all ships engaged in international trade

3.6.1 Enclosed space entry and rescue drills should be planned and conducted in a safe manner, taking into account, as appropriate, the guidance provided in the recommendations developed by the Organization*.

_____

* Refer to the Revised Recommendations for entering enclosed spaces aboard ships (resolution A.1050(27)).

3.6.2 Each enclosed space entry and rescue drill shall include:

.1 checking and use of personal protective equipment required for entry;
.2 checking and use of communication equipment and procedures;
.3 checking and use of instruments for measuring the atmosphere in enclosed spaces;
.4 checking and use of rescue equipment and procedures; and
.5 instructions in first aid and resuscitation techniques.

IMO: ISM Code, Part A, 7 – Shipboard Operations

Scope: All passenger ships, as well as oil tankers, chemical tankers, gas tankers, bulk carriers, other cargo ships and mobile offshore drilling units ≥ 500 GT engaged in the international trade and for EU-Member States under the terms of the ordinance (EG) Nr. 226/2006 certain passengers ships as well as cargo ships and mobile offshore drilling units ≥ 500 GT in national trade

The company (ship operator) should establish procedures, plans and instructions, including checklists as appropriate, for key activities and shipboard operations concerning the safety of the personnel, ship and protection of the environment. The various tasks should be defined and assigned to qualified personnel.

ILO: MLC Regulation 4.3 & Standard A4.3 – Health and safety protection and accident prevention

Scope: All ships other than fishing vessels, ships of traditional build, warships or naval auxiliary vessels.

(Extract, summary)
Regulation 4.3.
3. adoption of laws and regulations and other measures, taking into account relevant international instruments, by flag States to set standards for occupational safety and health protection and accident prevention […].

Standard A4.3
1. The laws and regulations and other measures to be adopted in accordance with Regulation 4.3, paragraph 3, shall include the following subjects:
(a) the adoption and effective implementation and promotion of occupational safety and health policies and programmes [...], including risk evaluation as well as training and instruction of seafarers;
(b) reasonable precautions to prevent occupational accidents, injuries and diseases [...], including measures to reduce and prevent [...] the risk of injury or disease that may arise from the use of equipment and machinery [...];
(c) on-board programmes for the prevention of occupational accidents, injuries and diseases and for continuous improvement in occupational safety and health protection, involving seafarers' representatives and all other persons concerned in their implementation, taking account of preventive measures, including engineering and design control, substitution of processes and procedures for collective and individual tasks, and the use of personal protective equipment; and
(d) requirements for inspecting, reporting and correcting unsafe conditions and for investigating and reporting on-board occupational accidents.

EU: Directive 92/58/EEC on the minimum requirements for the provision of safety and/or health signs at work

Scope: Generally applicable in all EU Member States.

(Extract)
Section II – Employers' obligations
Article 3 – General rules

1. Employers shall provide safety and/or health signs as laid down in this Directive where hazards cannot be avoided or adequately reduced by techniques for collective protection or measures, methods or procedures used in the organization of work, or ensure that such signs are in place.
2. The signs used for [...] sea [...] transport shall be installed, wherever appropriate [...] inside undertakings and/or firms.

Annex I – General minimum requirements concerning safety and/or health signs at work

2. Types of signs
2.1. Permanent signs
2.1.1. Permanent signboards must be used for signs relating to prohibitions, warnings and mandatory requirements and the location and identification of emergency escape routes and first-aid facilities. […]
3. Interchanging and combining signs
3.1. Any one of the following may be used if equally effective: a safety colour or a signboard to mark places where there is an obstacle or a drop, […].

Annex II – Minimum general requirements concerning signboards
3. Signboards to be used
3.2. Warning signs

Figure 20: General Danger Sign[116]

3.3. Mandatory signs

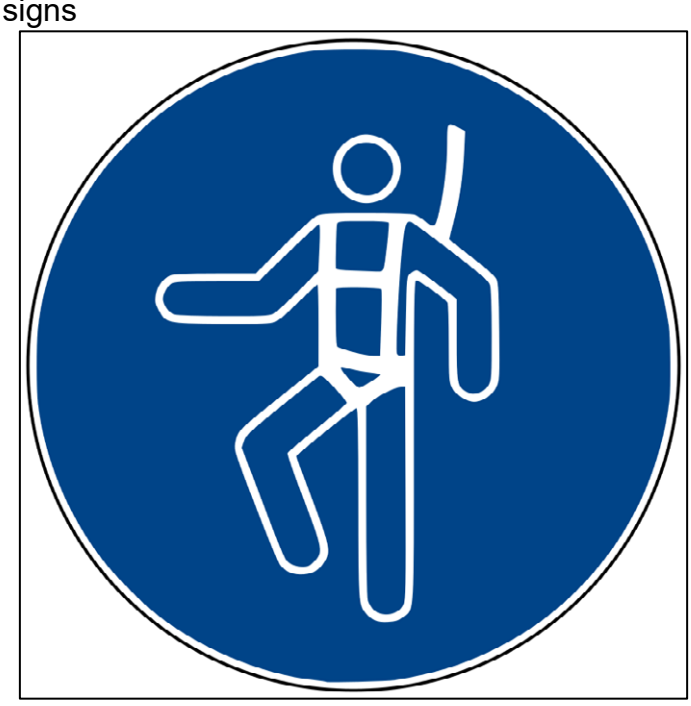

Figure 21: Safety Harness Must Be Worn[117]

[116] Source: DIN EN ISO 7010:2020-07, Graphical symbols – Safety colours and safety signs – Registered safety signs (ISO 7010:2019), W001.
[117] Source: DIN EN ISO 7010:2020-07, Graphical symbols – Safety colours and safety signs – Registered safety signs (ISO 7010:2019), M018.

9.1.2 Mandatory National Requirements

SeeArbG – Part 6, Chapter 4: Safety and health protection at work

Scope: Merchant vessels that fly the German flag.

(Extract)
Section 114 General protection against operational hazards

(1) The shipowner shall be obliged to equip and maintain the entire operation of the ship and all tools, [...] such that the crew members are protected against [...] work-related health risks, as well as other risks to life, health and morals to the extent permitted by the type of ship operation. In particular, the shipowner shall ensure that the master is provided with the necessary means to guarantee [...] adherence to the statutory regulations in respect of occupational safety and health and hours of work. […]
(2) The crew members shall adhere to the occupational safety and health measures.

DGUV Regulation 1 – Accident prevention regulation – Principles of prevention

Scope: Employers and insured persons, including in cases where insured persons work in or for the enterprise but are covered by a different social accident insurance institution.

(Extract)
Section 2 Employer's basic duties

(1) The employer shall take the measures necessary to prevent occupational accidents, occupational disease and work-related health risks and to ensure effective first aid. […]

Section 3 Assessment of working conditions, documentation requirements and duty to provide information

(1) The employer shall conduct an assessment, [...] of the risks faced by the insured persons in connection with their work in order to determine which of the measures referred to in Section 2(1) are necessary.

DGUV Regulation 84 – Accident prevention regulation – Shipping enterprises

Scope: Employers and insured persons in maritime shipping enterprises, including fishing.

(Extract)
Section 4 Work and accommodation areas, traffic routes, access to the vessel

(6) Workstations or traffic routes with a risk of persons […] falling […] shall be provided by the employer with protective facilities designed to prevent insured persons from falling […].
(7) The employer shall ensure that climbing ladders and rungs are safe for use. This includes that they
    (a) have protective devices against falling, preferably climbing protection devices, if necessary
    (b) have a holding device at their step-out position.

Section 8 Dangerous work on seagoing vessels
(1) When assessing the working conditions as per Section 3 DGUV Regulation 1, the employer shall provide a list of the duties associated with special dangers, for use during ship operation. Entering or accessing hazardous areas is to be taken into account.
(2) The employer shall ensure that the order to carry out dangerous work as defined in Par. (1) is given in writing. The necessary protective measures shall be recorded in the order.

Section 21 Hold ladders
(3) The employer shall ensure that vertical hold ladders longer than 10.00 m are arranged in such a way that they offer the possibility of resting on platforms, sitting brackets, or similar arrangements.
(5) The employer shall ensure that the hold ladders are at least 0.30 m wide. The distance between the rungs must be 0.30 m. The horizontal distance of the rung centre from fixed parts shall not be less than 0.15 m. The rungs shall be aligned and made of square steel bars with one edge up.
(7) The employer shall ensure that the free cross-section of access hatches is at least 0.60 m x 0.60 m. Deck openings and casings in which hold ladders are installed shall have the same free cross-section.

→Section 21 DGUV Regulation 84 was incorporated from Section 87 of the former UVV See and serves to implement ILO Convention 152 (dock work). With regard to para. 5, the associated implementation instructions specified: "The free space for the feet above each step shall be 0.20 m in height and 0.15 m in depth for the full width of the ladder."

Arbeitsstättenverordnung (ArbStättV) [German Ordinance on Workplaces], Annex 1.3
Scope: Inter alia, means of transport used in public transport.

(Extract)
Safety and health signs
(1) Regardless of the following requirements safety and health signs shall be used if it is not possible to prevent or sufficiently limit hazards to safety and health of workers through technical or organisational measures. […]
(2) Signs must be displayed according to the nature of the hazard permanently or temporarily in accordance with the specifications of Council Directive 92/58/EEC [...].

PSA-Benutzungsverordnung (PSA-BV) [German Ordinance on PPE Usage]
Scope: employers and employees at work with the exception of some industries (e.g. companies subject to the Federal Mining Act).

(Extract)
§ 2 Provision and use
(1) [...] the employer may only select and provide employees with personal protective equipment which
1. meet the requirements of the *Verordnung über das Inverkehrbringen von persönlichen Schutzausrüstungen* [German Ordinance on the Placing on the Market of Personal Protective Equipment],
2. provide protection against the hazard to be prevented without itself entailing a greater hazard,
3. are suitable for the conditions prevailing at the workplace, and
4. meet the ergonomic requirements and the health needs of the employees.

(2) Personal protective equipment must fit the employees individually. It is basically intended for use by one person. If circumstances require use by different employees, the employer shall ensure that health hazards or hygiene problems do not arise.

(3) If several items of personal protective equipment are used at the same time by one employee, the employer must coordinate these items of protective equipment in such a way that the protective effect of the individual items of equipment is not impaired.

(4) By means of maintenance, repair and replacement measures as well as proper storage, the employer shall ensure that the personal protective equipment functions well and is in a hygienic condition throughout the period of use.

9.1.3 International Guidelines and Recommendations

Cargo Stowage and Securing (CSS) Code, Annex 14

Scope: Container vessels built on or after 1 January 2015, securing containers on deck.

Guidance on ensuring safe working conditions when securing containers on deck

6.1.1 Risk assessment (summary, extract):

- performed at the design stage (shipbuilding);
- *inter alia*, assessment of the risk of falls from a height;
- adequacy of the access to all areas necessary to safely perform container securing operations.

6.2.4 Ladder and manhole design (summary, extract):

- angle of inclination between 65° and 90°, provided with handrails if angle of inclination between 65° and 75° with spacing of no more than 540 mm;
- fitted with guard hoops [safety cage] if ladder's height is more than 3 m and whenever a person may fall from the ladder in a cargo hold;
- Safety cage:
  - evenly spaced iron hoops that are no more than 900 mm apart;
  - 750 mm spacing from the rung to the back of the hoop;
  - hoops with evenly spaced longitudinal joints.
- continuation of the ladder uprights at least 1 m above the bottom of the platform to be reached;
- access opening must be protected with handrails or access covers;
- manhole openings that may present a fall hazard should be highlighted in contrasting colour around the rim of the opening.

IMO Resolution A.1050(27)

Scope: All ships.

Revised recommendations for entering enclosed spaces aboard ships

2 Definitions (summary, extract)

Enclosed space means a space which has any of the following characteristics:

- limited openings for entry and exit;
- inadequate ventilation; and
- is not designed for continuous worker occupancy.

Examples include but are not limited to cargo spaces and adjacent connected spaces (e.g. accessway to cargo hold with the same atmospheric characteristics).

→ The recommendations of Resolution A.1050(27) relate almost exclusively to hazards due to reduced oxygen content or contamination of the atmosphere with dangerous gases. Risks arising from falls from a greater height in enclosed spaces are not addressed. As an additional precaution, the use of a rescue harness and, where practicable, lifeline is recommended when entering spaces in which the atmosphere is classified as (presumably) unsafe, however. This is to facilitate evacuation in the event of an accident.

ILO: Code of practice for accident prevention on board ship at sea and in port
Scope: All ships.

The ILO Code of practice for accident prevention on board ship at sea and in port includes recommendations similar to those contained in IMO Resolution A.1050(27) in relation to entering enclosed or confined spaces. However, by way of derogation the use of a rescue harness is recommended at all times to facilitate evacuation. Chapter 15 describes various measures to minimise risk during work aloft or outboard. Unlike working with portable ladders or rope ladders (e.g. pilot ladders), the use of fixed vertical ladders, e.g. in cargo holds, is not addressed. It does not specify when an activity is to be considered work aloft and appropriate precautions are required (e.g. risk of falling from a certain height).

IACS Recommendation 132 Human Element Recommendations for structural design of lighting, ventilation, vibration, noise, access and egress arrangements
Scope: Bulk carriers and oil tankers falling within the scope of Resolution MSC.296(87).

4.6.4 Structural arrangements
C) Vertical ladders (summary, extract):

- skid/slip resistant, evenly spaced rungs with a coefficient of friction of 0.6 or greater measured when wet;
- angle of inclination between 80° and 90°;
- at least 750 mm clearance in front of the ladder;
- between 175 mm and 200 mm clearance behind the ladder;
- ladders should be staggered and individual ladders shall not be longer than 6.0 m; intermediate or connecting platform for ladders longer than 6.0 m;
- horizontal or vertical handholds at manholes and passageways projecting at least 1,070 mm above the access level of the ladder;
- safety cages on ladders longer than 4.5 m;
- climber safety rails or cables on ladders longer than 6.1 m.

9.1.4 National Guidelines and Recommendations

Ship Safety Division (BG Verkehr): Handbook of Safe Working Practices – Occupational Health and Safety for Merchant Shipping and Fishing Vessels ('Seafarer's Compendium')

Scope: Insured persons of BG Verkehr or the ships on which they work.

(Extract, summary)
A – Personal protective equipment
A 7 – Personal protective equipment against falls from a height
How to use personal fall protection equipment
When there is the danger of a fall from a height during a job, suitable personal fall protection equipment must always be used. A danger of a fall during jobs on board of vessels can develop for example [during]:

- work aloft:
  - jobs at and on masts;
  - jobs near opened cargo holds;
  - jobs with on-board cargo gear;
  - relashing of cargo;
  - jobs at the superstructure and at cargo hold walls;
  - jobs at height in the engine room.
- outboard jobs.

If there is a risk of falling down more than one metre or if there is a risk of sinking-in (e.g. into bulk cargoes), fall protection measures are necessary.

Preparing the use of personal fall protection equipment:

- […];
- it has to be determined […] how a person who has fallen from a height can be rescued immediately;
- suitable rescue equipment, like for example rescue winches, winch-down devices, rescue slings or additional full body harnesses for the rescuers, has to be prepared and kept on standby for immediate use;
- […].

B – General ship's operations
B 3 – Working with ladders
[The comprehensive information on ladders and their safe use only relates to stepladders and straight ladders, but not to fixed vertical ladders.]

B 13 – Enclosed [sic] spaces
Enclosed spaces are narrow rooms with a limited access or closed rooms with insufficient ventilation where an atmosphere can develop which has a deficiency of oxygen or can be toxic or explosive.

[…]

Enclosed spaces include for example
- lubrication oil tanks, slop tanks, cargo tanks;
- boilers;
- cofferdams, pipe tunnels;
- cargo pump rooms;
- fuel tanks;
- ballast tanks, double bottoms, double bottom tanks;
- exhaust ducts, scavanging [sic] air ducts.

[…]

B 23 Gas-free measurement
It is only permitted to enter enclosed spaces and tanks after it has been determined that there is no risk to do so. […]

Gas-free measurements are, for example, necessary in
- fuel tanks, lubricant tanks, slop tanks;
- cargo holds;
- cargo tanks;
- boilers;
- cofferdams;
- pipe tunnels;
- cargo pump rooms;
- ballast tanks, double-bottom (tanks);
- exhaust ducts, scavenging air ducts.

[…]

DGUV Rule 112-198 governing the use of personal protective equipment to prevent falls from a height

Scope: - generally after the employer's risk assessment has shown that the hazards are not avoided or sufficiently limited by generally protective technical installations (collective protective measures) or organisational measures;
- when selecting and using personal protective equipment to prevent falls from a height.

DGUV Rule 112-199 governing rescue from above and below with personal protective equipment to prevent falls from a height

Scope: - when selecting and using personal protective equipment to prevent falls from a height for rescues from above and below.

(Extract)
3 Provision
Possible situations necessitating the use of rescue systems are emergencies involving people

- working at workstations from which there is a risk of falling and that are difficult to reach because of their height and position and where employees wear personal protective equipment to prevent falls from a height;
- working at workplaces that are difficult to access [...];
- working in [...] confined spaces.

5 Assessment and selection (extract)
5.2. Assessment
The employer [shall] carry out an assessment of the equipment available to determine whether it is

- suitable for carrying out the rescue within a reasonable period [...], and
- suitable for the conditions at the workstation.

DGUV Information 208-032 on the selection and use of climbing ladders

Addressees: Employees, manufacturers, maintenance personnel and experts.
Scope: Safety-compliant design, maintenance and testing of fixed climbing ladders (predominantly on buildings, in workplaces or as access points to shore-based machinery).

(Extract)
2.1. Risk assessment
Basic selection
Due to the increased risk of falling and the greater physical effort, climbing ladders are only permissible if the installation of a stairway is not technically possible.
Based on a risk assessment, climbing ladders may be selected if access is required only occasionally (e.g. for maintenance work) by a small number of trained employees. It must be ensured that a rescue is possible.

Fall protection
The choice of fall protection (safety cage or PPEaF) depends on the protective function and its effectiveness.

Rescue concept
The lifesaving appliances provided must cover all necessary rescue situations.

2.2 General requirements for all types of climbing ladder and their attachment
Entry and exit level
The entry and exit on a fixed ladder must be safe to walk on. To that end, the holding device shall extend at least 1.10 m beyond the exit surface.

Installations to prevent falling
People using a climbing ladder are exposed to a particular risk of slipping and falling. Accordingly, climbing ladders must be fitted with protective devices to prevent slipping, e.g. from the rungs, or falling or at least to reduce the effects.
Equipment designed to prevent falls from a height can be fixed (climbing protection device, safety cage) or mobile (e.g. tripod with fall arrester and hoisting function).

Climbing ladders with a falling height of more than 5 m must be equipped with devices to protect against falling, insofar as this is technically possible. Such equipment includes

- guided-type fall arrester with fixed guide (climbing protection devices);
- guided-type fall arrester with mobile guide (rope protection devices);
- continuous safety cage starting between 2.2 m and 3 m above the entry level;
- components or struts which, due to their arrangement and nature, are suitable for replacing the safety cage.

For falling heights exceeding 10 m, only PPEaF (e.g. climbing protection devices) may be provided.
This also applies (irrespective of falling height) to climbing ladders

- which have to be walked on when rescuing people;
- in enclosed and confined spaces (e.g. silos, shafts) [...].

A safety cage is not permitted here.

General requirements for climbing ladder types (Chapter 3)
[The international and national standards vary for different climbing ladder types].
Foot clearance
The climbing ladder must be mounted using sufficiently large brackets so that the gap from the axis of the rung to the wall, including existing wall projections, is not less than 150 mm at any point.

4.3 Personal protective equipment
The employer shall […] provide and keep in good working order the personal protective equipment (PPE) necessary and appropriate for safe use of climbing ladders. […]

The climbing protection device (fall arrester and rail or wire rope) must not be used as an anchor device and for workstation positioning. Guiding the fall arrester by hand and leaning out to the side can affect the safe functioning of the fall arrester.

The intermediate connection of the guided-type fall arrester must not be extended for connection to the chest loop or arrester loop of the safety harness. Extending the intermediate connection increases the risk of injury and can even pose a threat to life during fall arrest. This is due to the increase in force – especially with greater falling distances – during the impact of the fall, which affects both the user's body and the fall arrest system when using fixed ladders with fall arresters. This means that its safe function is no longer guaranteed. […]