Bundesstelle für Seeunfalluntersuchung
Federal Bureau of Maritime Casualty Investigation

Summary Investigation Report 286/20

Incident

Risk to the health of a dock worker due to electric shock while connecting a refrigerated container to a socket on board the fully-containerised vessel MONTREAL EXPRESS on 29 August 2020

15 May 2024

This summary report within the meaning of Section 27(5) of the Law to improve safety of shipping by investigating marine casualties and other incidents (Maritime Safety Investigation Law – SUG) is a simplified report pursuant to the second sentence of Article 14(1) of Directive 2009/18/EC of the European Parliament and of the Council of 23 April 2009 establishing the fundamental principles governing the investigation of accidents in the maritime transport sector.

The investigation was conducted in accordance with the above legislation. According to said legislation, the sole objective of this investigation is to prevent future accidents. This investigation does not serve to ascertain fault, liability or claims (Section 9(2) SUG).

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

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

Issued by:
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Amendments

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Contents

1 FACTUAL INFORMATION

1.1 Photograph of the vessel

Figure 1: Photograph of the MONTREAL EXPRESS[1]

1.2 Ship particulars

Name of ship:	MONTREAL EXPRESS
Type of ship:	Fully-containerised vessel
Flag:	Bermuda
Port of registry:	Hamilton
IMO number:	9253741
Call sign:	ZCET4
Owner (according to Equasis):	HAPAG-LLOYD AG
Owner (ISM manager):	ANGLO-EASTERN GERMANY GMBH
Year built:	2003
Shipyard:	DAEWOO SHIPBUILDING & MARINE ENGINEERING (Republic of Korea)
Classification society:	DNV
Length overall:	294.00 m
Breadth overall:	32.26 m
Draught (max.):	11.10 m
Gross tonnage:	55,994
Deadweight:	47,840 t
Engine rating:	37,275 kW
Main engine manufacturer/type:	Daewoo Shipbuilding & Marine/B&W 8K90MC-C
Service speed (max.):	21.4 kts
Hull material:	Steel
Minimum safe manning:	18

[1] Source: Dietmar Hasenpusch Photo-Productions.

1.3 Voyage particulars

Port of departure:	Antwerp
Port of destination:	Hamburg
Type of voyage:	Merchant shipping/international
Cargo information:	Containers
Crew:	20
Pilot on board:	No
Number of passengers:	None

1.4 Marine casualty or incident information

Type of event:	Incident
Date, time:	29/08/2020, 2006
Location:	Port of Hamburg; the CTA1 container terminal
Latitude/Longitude:	φ = 53°30.6'N, λ = 009°56.2'E
Ship operation and voyage segment:	At berth made fast
Consequences:	Risk to the health of a dock worker

Extract from Navigational Chart RIVER ELBE, LÜHESAND TO HAMBURG, BSH[2] No DE48 (INT 1455)

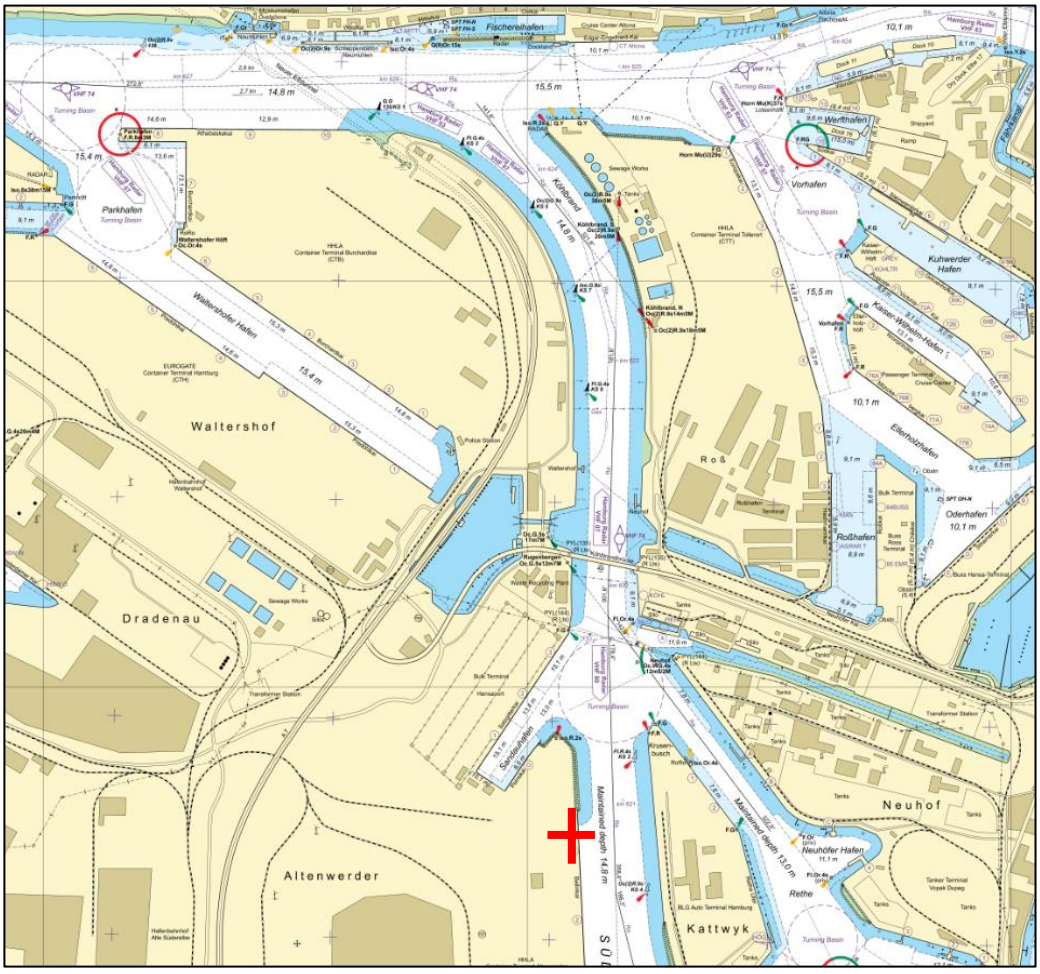

Figure 2: Scene of the incident

[2] BSH: Federal Maritime and Hydrographic Agency.

2 COURSE OF THE INCIDENT AND FINDINGS OF THE INVESTIGATION

2.1 Course of the incident

An incident involving personnel occurred on board the fully-containerised vessel MONTREAL EXPRESS at 2006[3] on 29 August 2020. At this point, the ship was at her berth in the port of Hamburg for cargo-handling operations.

A dock worker had intended to connect a refrigerated container stowed on deck in the area of bay 38/39 to the ship's power supply system. To this end, he went to the nearest terminal/switch box with the plug of the power cable, which was fitted to the container in the usual manner (see **Figures 3 f.**). This was located on the port side of the ship below the hatch coaming in the area of bay 39 (see red marking in the extract from the general arrangement plan in **Figures 5 f.**).

Figure 3: Terminal/switch box beneath the hatch coaming for supplying refrigerated containers with power
(both access panels closed)

Figure 4: Terminal/switch box (lower access panel open)

[3] All times shown in this report are local = CEST = UTC + 2 hours.

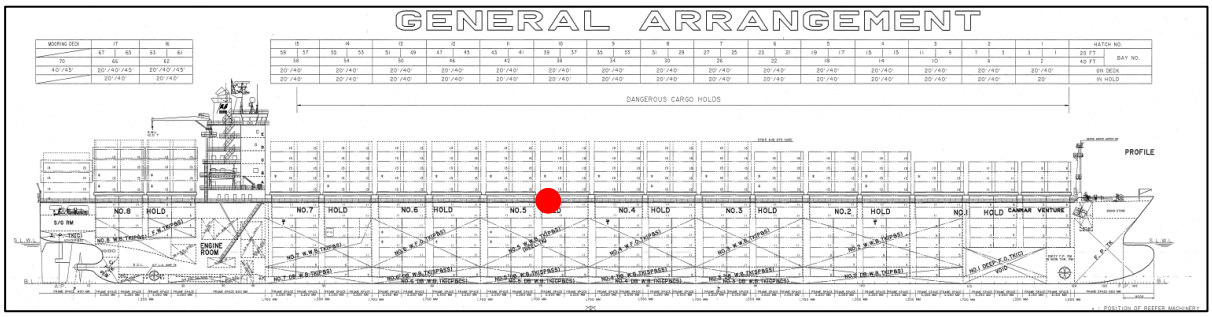

Figure 5: Extract from the general arrangement plan of the MONTREAL EXPRESS (side view)[4]

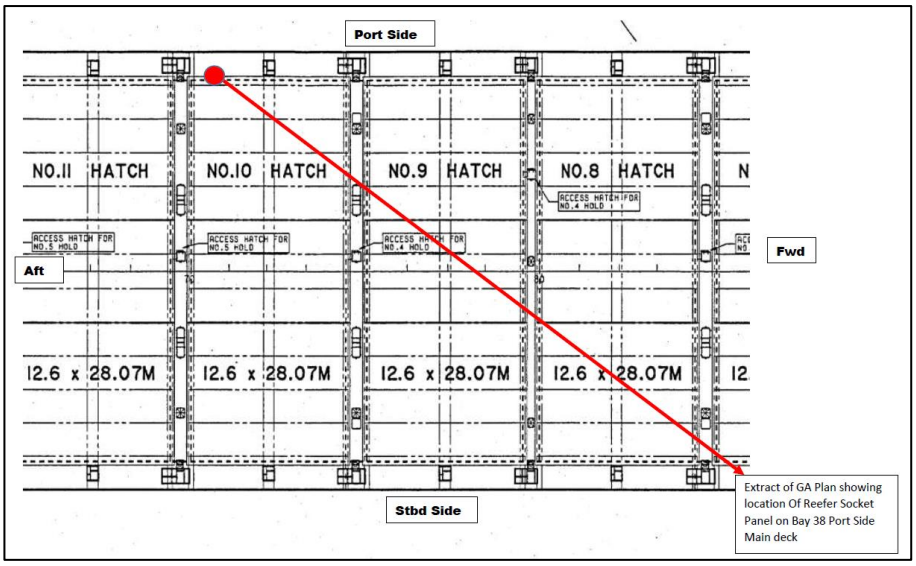

Figure 6: Extract from the general arrangement plan (top view)[5]

There was a sudden flash of light when the dock worker was inserting the cable's plug into the socket. He felt a mild electric shock but was able to leave the scene unassisted and report the occurrence to his supervisor. The latter immediately called an emergency physician and notified the ship's command and Waterway Police (WSP) Hamburg.

The crew of an ambulance was at the scene just a short time later and examined the dock worker, who exhibited no injuries but was in a state of shock. He was taken to hospital for further observation as a precaution but was able to leave it soon after. Apart from him temporarily being in a mild state of shock, the incident did not give rise to any adverse health effects.

2.2 Reporting of the incident to the BSU; categorisation as incident

The WSP informed the Federal Bureau of Maritime Casualty Investigation (BSU) about the incident two days after it occurred. The MONTREAL EXPRESS had already left the port of Hamburg at this point. Accordingly, an immediate visit on board was not possible.

[4] Source: General arrangement plan of the MONTREAL EXPRESS (provided by the ISM manager).
[5] Source: See previous footnote.

The reason for the delayed report was that the police did not initially consider the incident to be a relevant subject of investigation for the BSU due to its benign outcome, but above all due to the fact that it did not involve any crew members of the MONTREAL EXPRESS.

However, when the police were following up the facts of the case, officers became aware of substantive similarities with an earlier incident that had occurred on board the ship during the previous call at the port of Hamburg, i.e. on 4 July 2020. On the above date, a dock worker had also been exposed to a sudden flash of light and even a smoke ignition, described as explosive, while connecting a refrigerated container to the on-board power supply system – again to the terminal/switch box level with bay 39 on the port side. Fortunately, the dock worker concerned suffered no more than a mild shock in this incident, too, but also received emergency care and precautionary medical care at the hospital.

The finding that a dock worker's health had been endangered twice in quick succession in an incident that was comparable in every respect and even on the same ship, the cause of which was evidently a technical issue within the on-board electrical system in each case, prompted the WSP to notify the BSU about the incident on 29 August 2020 and at the same time about that on 4 July 2020.

Even a cursory review of the information provided revealed that the two incidents were not marine casualties within the meaning of paragraphs 2.9.1 and 2.18 of Part 1 Chapter 2 of the Casualty Investigation Code[6], as the dock workers had fortunately not suffered any injuries resulting in incapacity to work for more than 72 hours in either case. However, since in both cases people had been exposed to a health risk directly connected with technical aspects of the ship's operation (in this case evidently technical problems relating to the on-board power supply and installations for connecting refrigerated containers), these were incidents within the meaning of paragraph 2.10 of Part 1 Chapter 2 of the Casualty Investigation Code, as well as suitable subjects of a marine safety investigation under Section 1a(1)(b) SUG.

Accordingly, the BSU's director decided to investigate the incident on 29 August 2020. Full inclusion in this investigation of the largely identical incident on 4 July 2020 was dispensed with on procedural grounds[7]. A detailed (or separate) investigation thereof proved unnecessary. An investigation into the incident of 29 August 2020 was sufficient to reliably clarify how the risk to the health of dock workers could have occurred and what conclusions should be drawn from this.

[6] See IMO Resolution MSC.255(84).

[7] Both national and international maritime safety investigation regulations stipulate that in each case only one accident or incident or coherent chain of events shall be the subject of an investigation report.

2.3 Course, sources and material details of the investigation

The investigation team contacted the ship's Hamburg-based ISM management[8] immediately after the BSU had become aware of the incidents on board the MONTREAL EXPRESS and sighted the corresponding findings of the WSP. Its representative responded to enquiries extremely promptly, providing any information and technical documents requested.

This included a six-page service report from the Canadian 'MRW Mount Royal/Walsh Inc./MARINE & INDUSTRIAL REPAIRS'[9] dated 9 September 2020. On the instructions of the ship's ISM management, the aforementioned company inspected and repaired the terminal/switch box for refrigerated containers in the area of bay 38/39 in the port of Montreal.

Since the MONTREAL EXPRESS called at the port of Hamburg regularly, the BSU's investigation team decided to conduct a visit on board during the next port call scheduled for late September 2020, which then took place on 26 September 2020.

The aforementioned MRW service report had already provided extremely helpful information about the technical causes of the hazards posed by the terminal/control box in question in advance of the visit on board. It also confirmed that the terminal box was now reportedly safe as a result of necessary maintenance measures. In preparation for the planned visit on board, the investigation team nevertheless decided to commission its own external expert in electrical systems and have the latter inspect the technical condition of the on-board power supply for the refrigerated container points.

Accordingly, the expert accompanied the investigation team during its visit on board and inspected the relevant areas on the ship. Together with the investigators, he inspected, *inter alia*, the terminal/switch box for refrigerated containers in the area of bay 39. Moreover, he also conducted a random inspection of the technical condition of another three terminal/switch boxes, as well as of the switch cabinet[10] located below the main deck, which is used to supply power to the terminal/switch boxes.

[8] ISM: International safety management. Based on an internationally binding set of regulations referred to as the ISM Code, operators of seagoing vessels in international service are obliged, *inter alia*, to implement measures for the safe operation of ships and to monitor compliance with those measures. In this context, shipowners regularly call on the services of so-called ISM managers.
[9] Hereinafter abbreviated to 'MRW'.
[10] Note: The switch cabinet is also referred to as 'power supply cabinet'.

In addition to the findings of the WSP's investigation, to the witness statements analysed, to the information from the ISM management, as well as to the observations made during the visit on board, the expert's report formed the key source of information for the findings of the BSU's investigation.[11]

The investigation ultimately also addressed the fundamental question as to whether and, if so, to what extent the on-board power supply system for refrigerated containers is a regular subject of port State control inspections or of surveys and certifications of the classification society. In this regard, the investigation team made contact with the Ship Safety Division (BG Verkehr)[12], which is responsible for conducting port State control inspections in Germany's ports, and with the classification society of the MONTREAL EXPRESS. The two bodies referred to submitted the information requested to the BSU.

2.4 Findings of the investigation

2.4.1 Enquiries of WSP Hamburg on 29 August 2020

As already discussed, WSP officers arrived at the berth of the MONTREAL EXPRESS shortly after being alerted. The dock worker who had suffered the electric shock was in an ambulance on the pier for a preliminary examination by the emergency physician. Before he was taken to hospital for further observation as a precautionary measure, he gave a brief account of the course of events to the officers. In particular, the dock worker pointed out that although he had already inserted the power cable's plug into the socket, he had not yet activated the power supply by means of the switching device provided for this purpose (see white dashed rectangle in **Figure 7**) when the flash of light reportedly occurred.

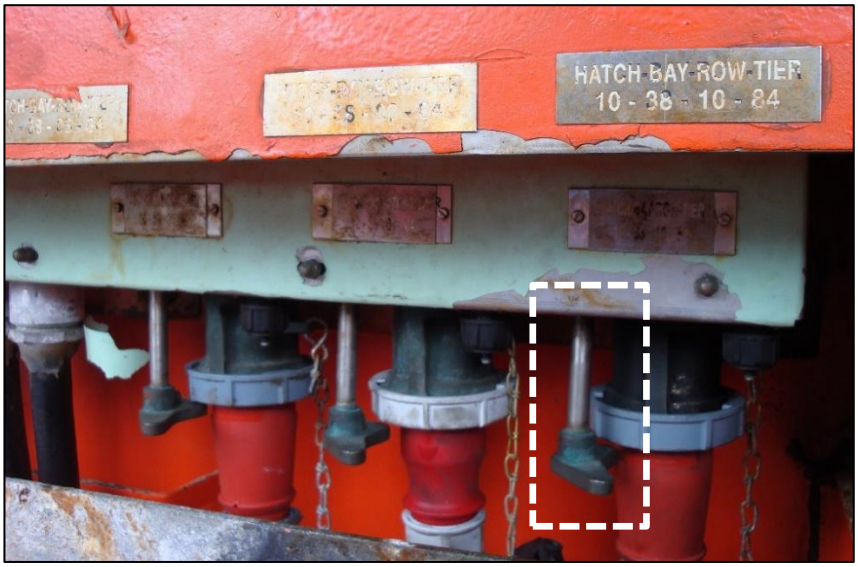

Figure 7: Switching device of the socket used before the incident

[11] Note: The unusually late publication of the report was initially caused by delays in finishing the investigation due to the coronavirus pandemic. In the further course of the investigation, a number of very serious marine casualties that occurred during and after the pandemic then had to be given precedence for reasons of prioritisation.

[12] Hereinafter abbreviated to Ship Safety Division.

The dock worker, who was alone at the scene when the accident happened, was unable to provide further information of relevance.

The WSP officers then inspected the terminal/switch box in the area of bay 38/39. The inner connection base of the plastic housing of the socket used by the dock worker immediately before the electric shock exhibited clear signs of thermal stress (see **Figure 8**).

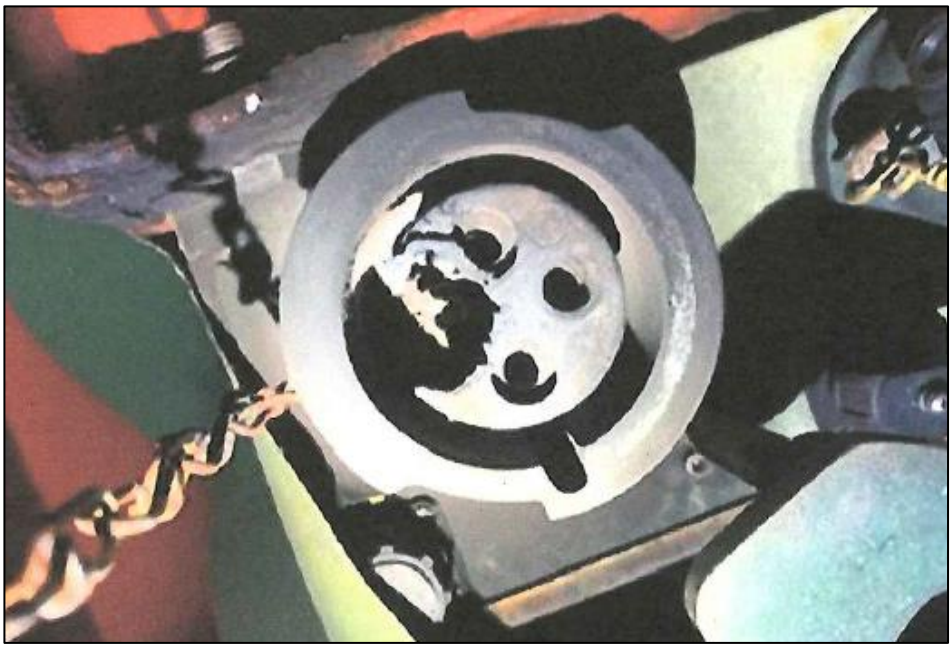

Figure 8: Damaged on-board refrigerated container point[13]

The plug belonging to the refrigerated container, which the dock worker had used and was also damaged by the faulty flow of electricity, had already been replaced in the meantime by an employee of the service company which is based in the port and specialises in carrying out repair works quickly if necessary, so as to be able to supply the container's refrigeration unit with electricity again as quickly as possible via another socket in order to prevent damage to the cargo.

When the police interviewed the ship's electrician, he stated that the destroyed socket was reportedly the one he had installed after the similar incident referred to above had occurred on board the MONTREAL EXPRESS on 4 July 2020.

To substantiate his statement, the police officers were shown an extract from an electronic activity recording system. *Inter alia*, the entry 'Port side faulty reefer socket renewed' is made in it for 6 August 2020 (see red dashed rectangles in **Figure 9**). The entry does not include any further information on the exact position of the replaced socket, however.

[13] Source: WSP Hamburg.

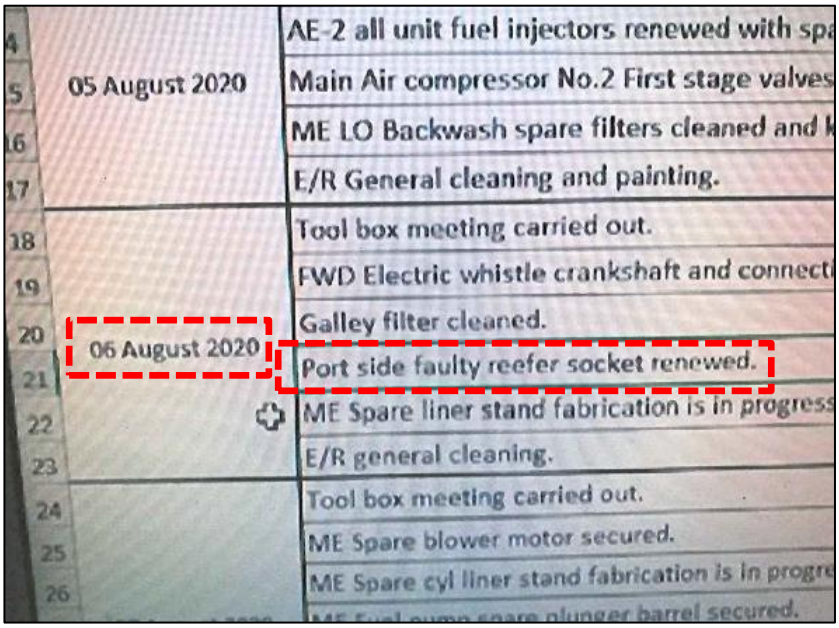

Figure 9: Extract from the electronic activity report[14]

Following the enquiries at the scene, the police officers notified by telephone the Ship Safety Division, whose responsibilities include ship safety inspections in Germany's ports. The officer on call decided that the damaged socket should reportedly not be used for the time being and should reportedly be repaired before the next port call in Hamburg in about four weeks' time. Further administrative directives or even a detention order were not issued. Accordingly, the MONTREAL EXPRESS left the port of Hamburg as scheduled after completion of the cargo-handling operations.

2.4.2 MRW service report of 9 September 2020

According to the MRW service report, a technician from the service company visited the MONTREAL EXPRESS to inspect and repair the terminal/switch box at bay 38/39 when she called at the port of Montreal.

The inspection revealed moisture in the housing of the switch box located in the upper part of the terminal/switch box, which during normal operation is additionally closed by a tightly bolted cover. It was also found that the cable mounted in the switch box housing, which acts as the earth lead for the cover lid, was not attached to the male tab connector mounted on the inside of the cover by means of the female tab connector, as intended (see **Figures 10 and, in particular, 11 and 12** below: photographic documentation of the properly earthed cover in question made during the BSU's visit on board), but rather that the female tab connector had become detached from it. A side effect or possibly even the cause of this detachment of the earth lead from the cover of the switch box housing was that the loose cable had inadvertently been trapped in the rubber seal between the cover and housing box when the cover was fitted (see **Figure 13** below). This compromised the proper sealing of the switch box, i.e. the protection against moisture ingress.

[14] Source: WSP Hamburg.

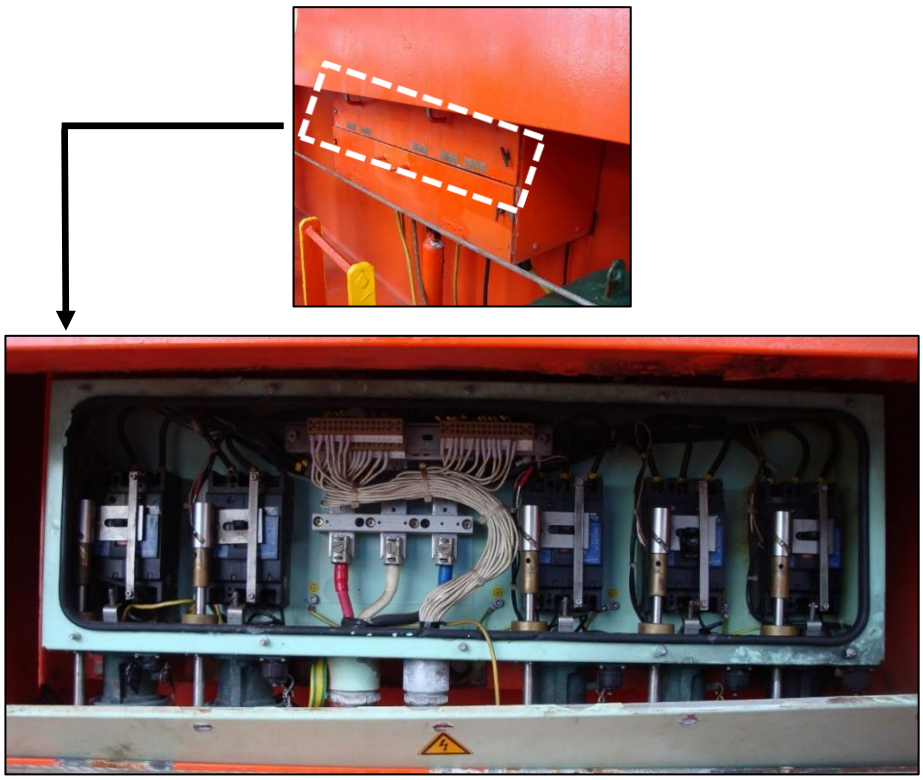

Figure 10: View into the switch box housing after removing the upper access panel of the terminal/switch box and dismantling the cover of the housing box

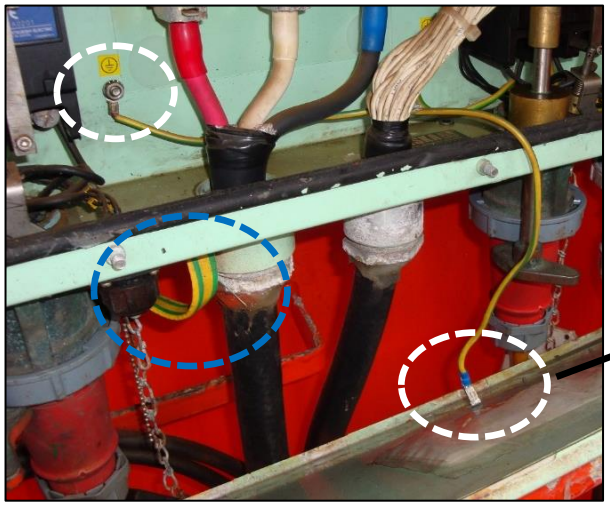

Figure 11[15]

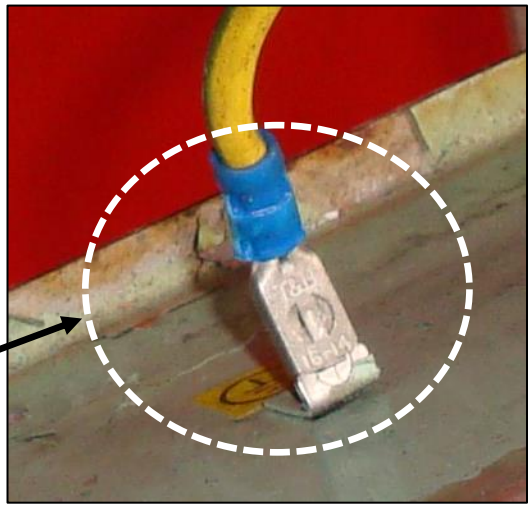

Figure 12

Cover of the housing box earthed with an earth lead bolted to the housing box (Figure 11) and the other end connected to the cover properly by means of a female tab connector (Figure 12)

[15] The blue dashed outline in Figure 11 shows the position of the main earth lead connecting the housing box to the hatch coaming.

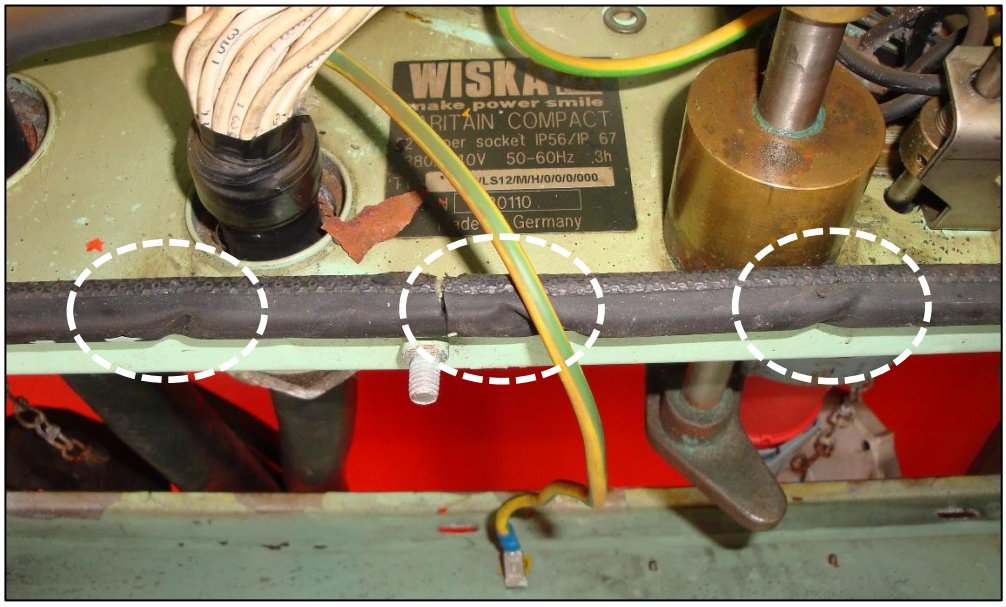

Figure 13: Localised pressure marks in the switch box housing's rubber seal[16]

The technician from MRW also found that the main earth lead, which is supposed to discharge any residual current in the switch box housing toward the hull (here via the hatch coaming) without resistance (see blue dashed outline in **Figure 11** above and **Figure 14** below), was corroded.

Figure 14: Corroded section of the main earth lead below the housing box[17]

[16] Similar to Figures 10, 11 and 12, this photograph was taken during the BSU's visit on board and shows the housing cover earthed properly. The three pressure marks in the rubber seal shown in Figure 13 nevertheless confirm the observation in the MRW service report that the earth lead was trapped at various points between the cover and housing box when the MRW inspection was conducted, but evidently also prior to that, thus compromising its sealing effect.

[17] Source: MRW service report; image detail extracted by this investigation report's author from an image contained therein. With regard to the position of the main earth lead, see also the blue dashed outline above in Figure 11.

The bolt welded to the hatch coaming below the housing box, pointing vertically downward and used for connecting the main earth lead, exhibited particularly distinct signs of corrosion (see **Figure 15**). The defect in question was rectified during the call at the port of Montreal (see **Figure 16**).

Figure 15: Old earth connection[18]

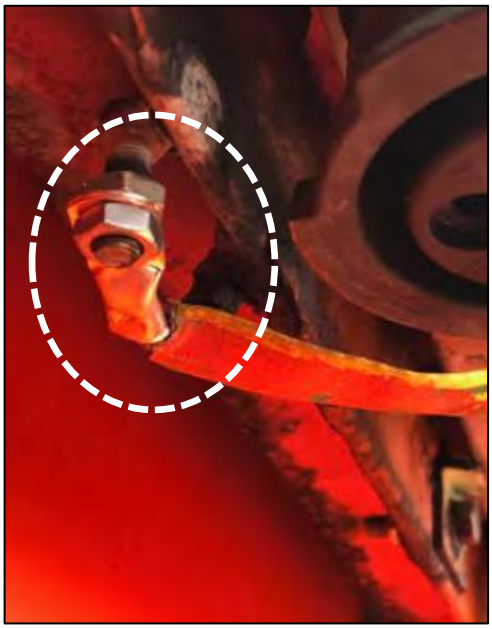

Figure 16: Earth connection after renewal

According to his report, the MRW service technician carried out the following measures on the terminal/switch box affected by the incident during the inspection:

- removal of moisture from the switch box;
- renewal of the connection for the switch box's main earth lead;
- renewal of the earthing for switch box's cover, and
- inspection of the connection and switching device insulation resistances.

It was confirmed that the terminal/switch box at bay 38/39 on the port side could now be used safely again.

A possible inspection of additional terminal/switch boxes in Montreal was not the subject of the service report.

2.4.3 Assessment of several terminal/circuit boxes of the expert commissioned by the BSU in the port of Hamburg

On 26 September 2020, the BSU's investigation team visited the MONTREAL EXPRESS in the port of Hamburg. The team was accompanied by an expert specialising in the assessment of electrical systems and energy technology, *inter alia*. In preparation for the visit on board, the expert had been provided with technical documents and, in particular, circuit diagrams and other relevant information that the BSU had received in

[18] Source Figures 15 f.: MRW service report; image detail extracted by the author of the investigation report from two images contained therein.

the meantime from the shipping company, including the aforementioned MRW service report. Based on this information and due to the visual inspection of the terminal/switch box at bay 38/39 on the port side, as well as of three other terminal/switch boxes (for comparison and as random samples), the expert was able to gain a reliable picture of the technical conditions of relevance to his assignment on board. The causes already discussed in the MRW service report of the hazards to which the dock workers were exposed when connecting the refrigerated containers could be verified unequivocally.

Specifically, the expert stated the following in the report he had prepared for the BSU[19]:

a) General information on the terminal/switch boxes

*There are two versions on board. One version of the box has four sockets, the other version has five sockets.[20] The sockets are basically the 4-pin circular type. The operating principle is the same for both versions. After inserting a plug, e.g. a refrigerated container cable, into the socket, the circuit breaker assigned to the socket and acting as a safety element can be switched on and off mechanically by means of a switching rod via a push and pull lever (see **Figure 17**).*

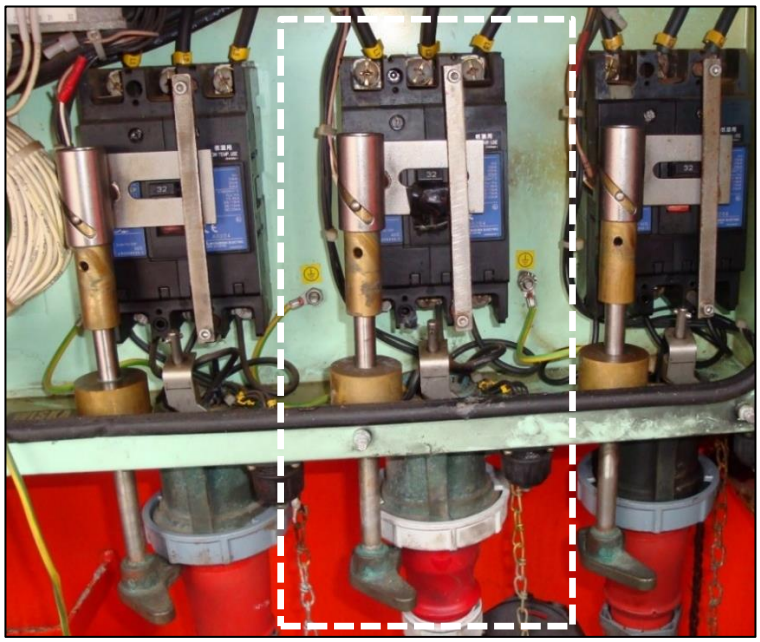

Figure 17: Circuit breaker with push/pull lever
and occupied socket

[19] The following text excerpts set in italics are an abridged and for editorial reasons in places slightly edited but always accurate reproduction of the material passages of the expert's report. Some of the images referred to in the report have been replaced or supplemented by photographs taken by the investigation team.

[20] Note: There are a total of 42 terminal/switch boxes for refrigerated containers.

*Auxiliary contacts on the circuit breaker should be used to show on the panel of the power supply cabinet (located below the main deck) which of the sockets in which terminal boxes are occupied. The display in question on the switch cabinet was defective overall (see **Figure 18**).*

Figure 18: Panel on the power supply cabinet

b) on terminal/switch box 38/39

*It is important to note that the cover seal of the switch box does not close completely due to deformation caused by the earth lead on the removable cover (see **p. 15 Figure 13** above) and therefore moisture can enter the switch box (the clear traces of corrosion on the switching rod in **Figure 19** are indicative of this).*

Figure 19: Traces of corrosion on
the switching rod inside the switch box

*Based on the MRW service report, the expert assumes that the moisture inside the housing of the switch box would result in so-called 'creepage distance formation'. Due to the interrupted PE[21] conductor, the dock worker could suffer an electric shock when touching the switch box housing while inserting the plug of the refrigerated container connection cable (see **Figures 20 f.**).*

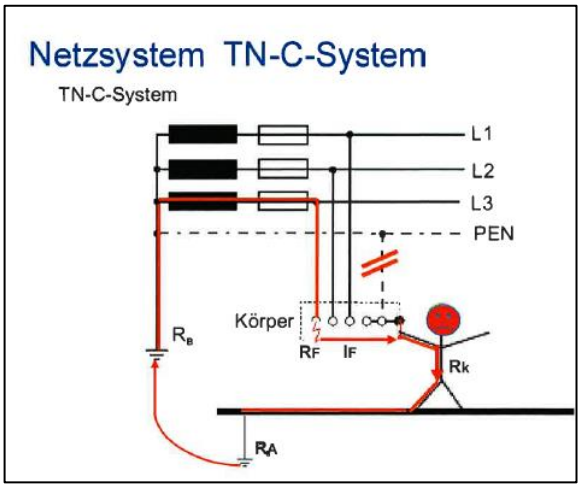

Figure 20:
Interrupted earthing
(possible residual current discharged via the body of the dock worker)

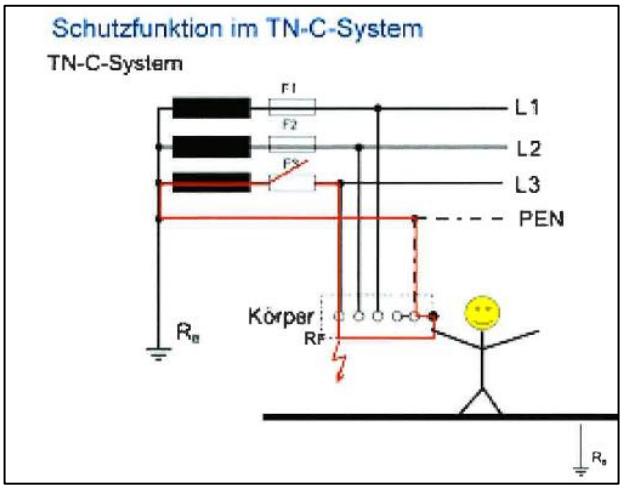

Figure 21:
Switch box housing earthed properly
(residual current discharged via the PE conductor)

*A comparison of the surfaces of the sockets in the switch box at bay 38/39 reveals that the outer-right socket was obviously replaced again after the second incident (i.e. that on 29 August 2020 – see **Figure 22** below).*

Figure 22: Socket base in the terminal/switch box at bay 38/39

[21] PE (protective earth) conductor: Electrical conductor in electrical systems, which helps to keep e.g. a metal housing at earth potential in the event of a short circuit between that and a live conductor (e.g. due to moisture-induced leakage current), and thus to prevent or at least significantly reduce the flow of current through the human body toward earth in the event of contact.

*The expert also noted the replaced earth connection for the switch box below the hatch coaming (see **p. 16 Figure 16** above).*

The expert commented on the repair in question as follows:

The newly made connection was not executed according to professional norms, as a screw lock, such as self-locking nuts, self-locking screws or locking liquid are not visible. Moreover, the cable lug connection should have been fitted with shrinkable tubing so as to prevent water from entering the cable. The screw connection on the switch box housing is exhibiting signs of oxidation.

The expert also noted the following deficiencies when inspecting the switchbox at bay 38/39:

*The switching lever of a low-voltage circuit breaker is provisionally wrapped in insulating tape (see red dashed outline in **Figure 23**) because there is too much play and the ship's electrician explained that this causes a problem when switching on after inserting a plug into the socket.*

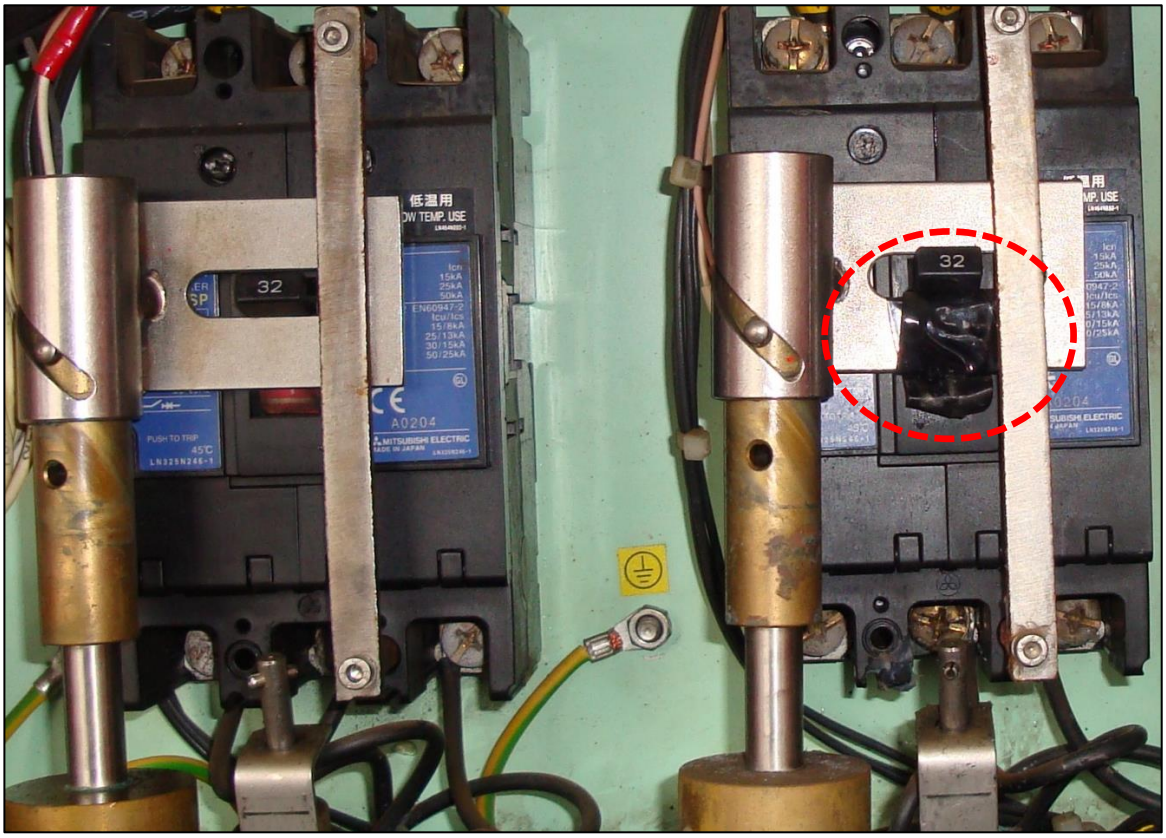

Figure 23: Provisional repair of a switching lever using insulating tape

c) on the terminal/switch box at bay 34/35

*When the switch box cover was opened, the earth lead's female tab connector parted from the male tab connector mounted on the inside of the cover. The female tab connector is wrapped several times in yellow insulating tape (see **Figure 24**). It was not possible to make a force-fit in accordance with professional norms, i.e. a tight connection between the male and female tab connectors.*

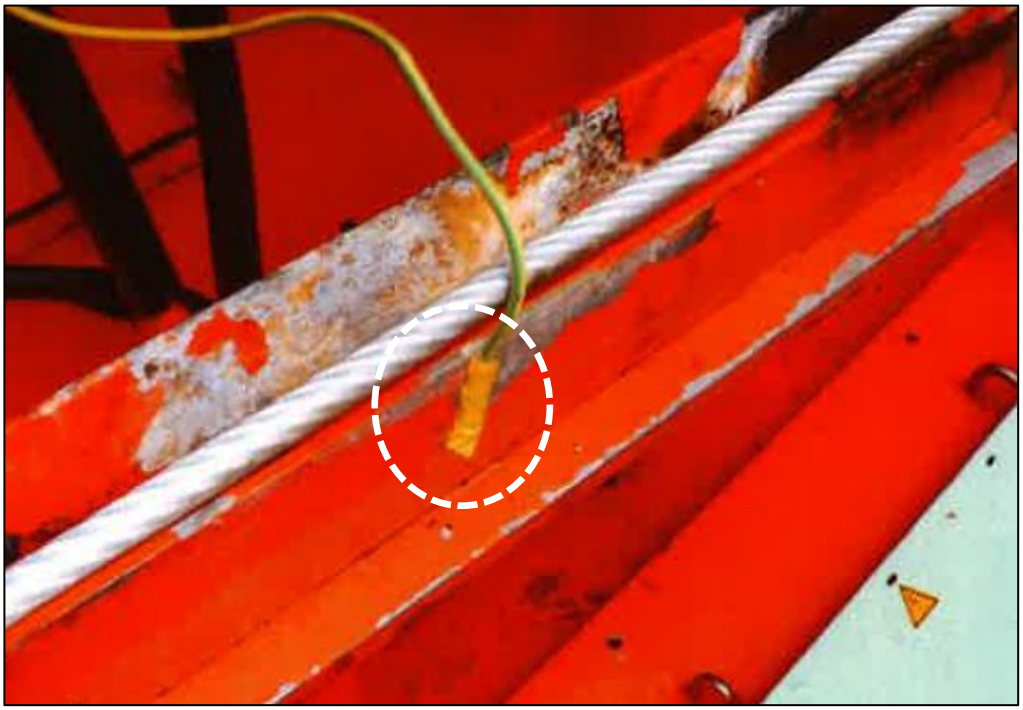

Figure 24: Female tab connector (wrapped in insulating tape)
detached from the male tab connector on the inside of the cover

There was heavy corrosion and visible moisture (drop adhesion) inside the switch box. The seal was no longer properly affixed to the switch box cover, allowing moisture to enter from outside.

*In addition, part of the right-hand socket's PE connection was wrapped in black insulating tape. After the insulating tape was removed, a join that did not comply with professional norms was found between two cable parts. A terminal lug pressed onto the conductor was located at the end of the cable leading to the socket's PE connection. The open end of the partial conductor connected to the earthing point on the back wall of the switch box had been stripped. The stripped end of the conductor was twisted around the eyelet by hand. The copper strands are already exhibiting surface oxidation, meaning that a proper connection cannot be present (see **Figure 25**).*

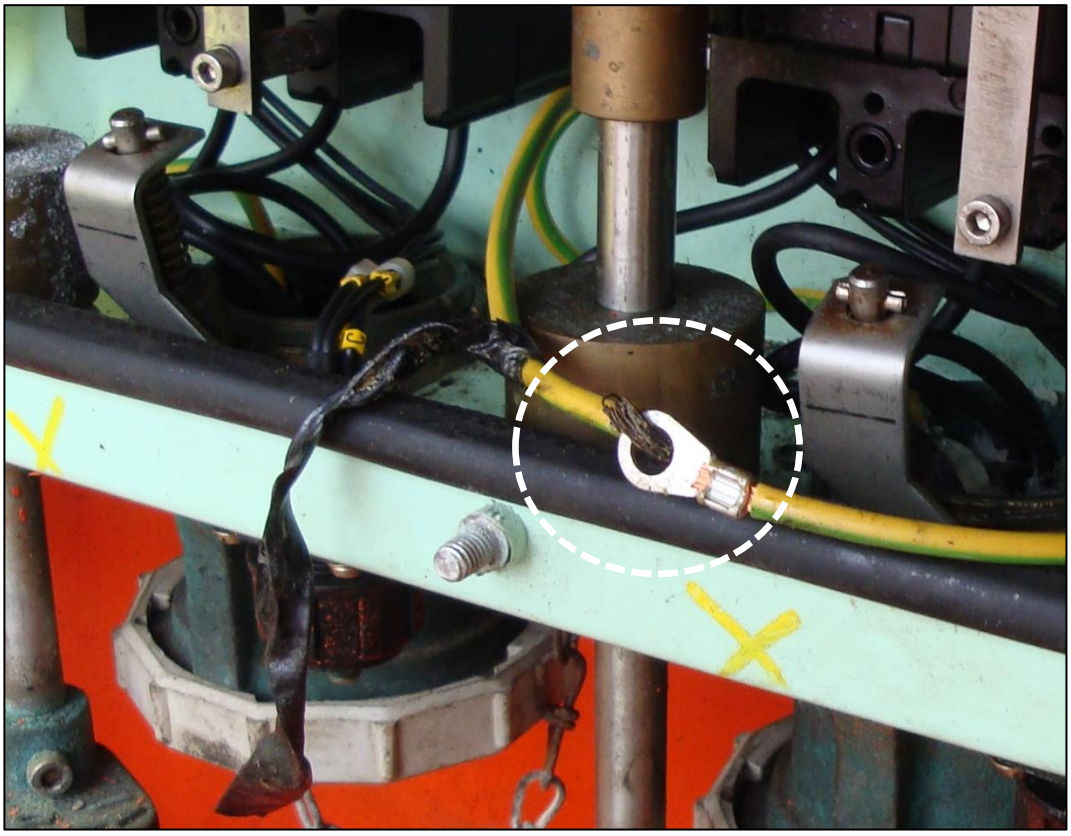

Figure 25: Join that does not comply with
professional norms between two sections of a PE conductor

The new PE connection from the switch box to the hatch coaming has been made in the same manner as that for the switch box at bay 38/39. The related, aforementioned deficiencies must also be noted here.

d) on terminal/switch box at bay 42/43 and 50/51

The PE connections from these switch boxes to the hatch coaming are also new. Here too, the same errors were made during the installation works as in the case of switch boxes 38/39 and 34/35 discussed above.

e) Wiring of a spotlight

*During the inspection of the main deck, a cable connection wrapped in insulating tape and made with screw terminals was found lying on the deck, which could be attributed to a 230-volt electrical supply line for a spotlight temporarily attached to the railing (see **Figure 26**). Such an unprofessional installation poses an acute risk of electric shock, especially in wet conditions.*

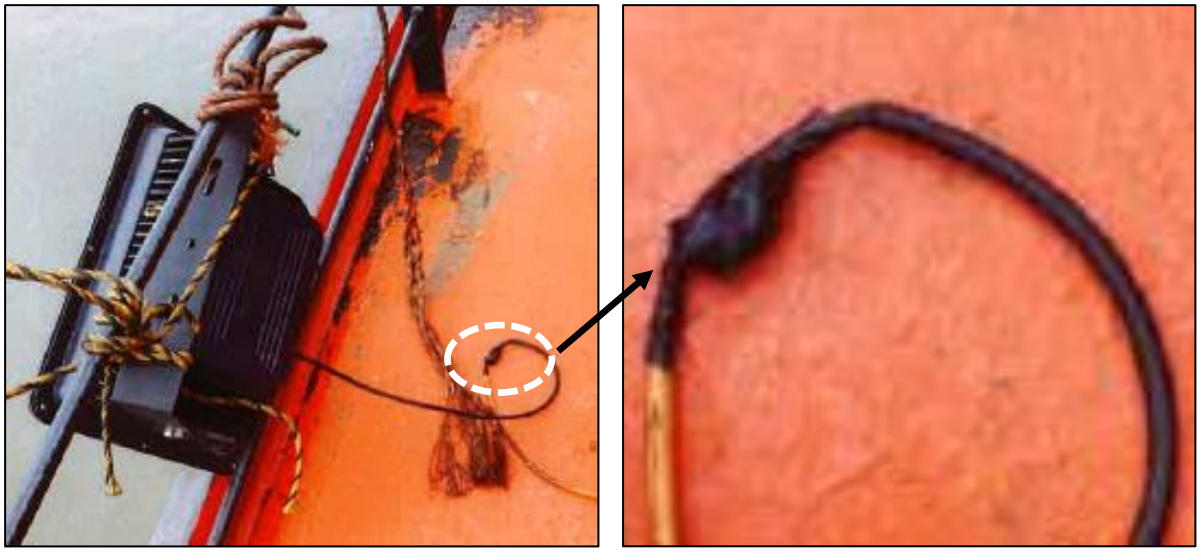

Figure 26: Power supply of a spotlight; joined cable connection

f) Conclusion

As a result of the inspection of the vessel, it can be stated that the PE connections belonging to terminal/switch boxes for refrigerated containers were not executed in accordance with professional norms in places. Defective and corroded parts must be replaced and the switch box seals checked to ensure they are completely watertight.[22]

The earth connections of the terminal/control box covers should be modified and adapted to meet the harsh environmental conditions.

Repeat box inspections that are carried out on a regular basis should become a standard operating procedure.

Contrary to the condition found, the status panels on the power supply cabinets must be operable so as to be able to identify faulty terminal/switch boxes quickly and clearly in the event of a fault.

2.4.4 Statement of the classification society

Referring to the obvious dangers that the inadequate maintenance condition of the refrigerated container terminal/switch boxes may pose for dock workers and ship crews, the BSU has contacted the classification society of the MONTREAL EXPRESS with the following queries:

1.) Does a (possibly random) inspection of the maintenance condition of refrigerated container terminal boxes form part of the inspection schedule during class surveys? If so, at what frequency?

[22] Note: Following the expert's random inspection, the Ship Safety Division ordered that the operational safety of all terminal/switch boxes must be ensured before the ship departs. The shipping company commissioned a service company with this task. All the boxes were then inspected, repaired or taken out of service if the necessary spare parts were not available.

2.) Is DNV aware of the issue described? If so, are classification societies taking steps to counteract this (possibly also at IACS[23] level)?

The classification society commented on this as follows:

Re Question 1.)
Refrigerated container terminal boxes are not explicitly mentioned in our rules for the periodical surveys. However, they are covered by the general requirements for shipboard electrical systems.

During annual surveys, the earthing to the hull of electrical installations must be inspected. Moreover, all electrical installations must be inspected on a sample basis with regard to general condition, brackets and to their physical protection.

I. Annual survey (DNV-RU-SHIP Pt.7 Ch. 1 Sec. 2):
1. [2.1.1, n)] requires verification of the electrical bonding to the vessel's hull
2. [3.1.5] requires examination of cable installations with respect to the general conditions, support and physical protection

Further investigations shall be carried out every five years during the renewal survey. This includes the requirement for resistance measurements.

II. Renewal survey (DNV-RU-SHIP Pt.7 Ch. 1 Sec. 4):

1. [3.1.5] Examination of the switchboards, distribution boards, cable installations, enclosures (e.g. junction boxes) of the safety precautions with respect to shock, fire and explosion protection and other hazards
2. [3.1.5] Requires the insulation resistance of the complete installation to be measured and the results to be presented to the surveyor.

Other internal instructions can be found in DNV-ITG-0301, Sec. 6 – 'Machinery items', which deals with specific points during the survey.

1. [6.9] During the survey attention should be paid to the general condition (maintenance) of the electrical installation and to the preservation of safety measures (fire and explosion hazards and injury from accidental touching)
2. The survey shall include visual inspection of the interior and exterior of the components, as far as practicable, with regards [sic] to:

** defects*
** heat, sparks, or signs of heat and/or sparks*
** corrosion*
** excessive wear*

[23] IACS: International Association of Classification Societies.

** cleanliness (contamination, e.g. spill of oil and dust)*
** correct replacement of parts (rating of fuses, cables and switches)*
** marking.*

The new build rules also stipulate that sockets must be protected to the extent that plugs cannot be inserted or removed when the system is live.

I. Design Rules – DNV-RU-SHIP Pt. 4 Ch. 8 Sec. 8, [1.1, c)] requires socket outlets and plugs for reefer sockets to be provided with interlock preventing inserting / withdrawal when socket outlet is live.

While electrical components on deck must at least satisfy the requirements of the IP 56 international protection class, even higher protection classes are usually installed in practice.

Re Question 2.)
Damage to refrigerated container points and their terminal boxes is not unknown. It is regularly cited as a deficiency in survey reports and repairs are required. In this respect, the procedures are sufficient for identifying such deficiencies and since it is not a procedural deficiency, the issue has not yet been on the agenda at the IACS.

2.4.5 Statement of the Ship Safety Division

The BSU also contacted the Ship Safety Division, which is responsible for port State control inspections in Germany, to ascertain whether random inspections of the maintenance condition of the terminal/switch boxes for refrigerated containers form part of the (international) inspection schedule during port State control inspections. The Ship Safety Division gave the following reply:

- *random inspections of the maintenance condition on deck are made. These random inspections do not necessarily include refrigerated container sockets, however;*
- *the scope and procedures for port State control inspections are based on recommendations of the IMO (Resolution A. 1155(32)) and the port State control inspection guidelines of the PMoU[24];*
- *the more general 'Guidelines for port State control officers under the MLC[25], 2006' deal with accident protection;*
- *an '(international) inspection schedule' for port State control inspections is not available;*
- *as far as flag State control inspections by classification societies are concerned, the respective scope is based on Assembly Resolution A. 1156(32);*
- *the 'Guidelines for flag State inspections under the Maritime Labour Convention, 2006, as amended' deal with accident protection.*

[24] The 1982 Paris Memorandum of Understanding (PMoU) – or Memorandum of Understanding on Port State Control – forms the basis for unannounced inspections of seagoing ships flying a foreign flag in the ports of PMoU Member States.
[25] MLC 2006: The 2006 Maritime Labour Convention contains basic employment and social rights for seafarers.

3 ACTION TAKEN

The ISM-management of the MONTREAL EXPRESS provided the BSU with the following information in response to an inquiry as to whether/which consequences were drawn from the facts by the shipping company.

Anglo-Eastern Management, Germany, made a call to all container ships of the company with the instruction to conduct an unscheduled safety meeting and ensure that the following steps are taken:

- *The responsible deck crew ensures that the protective caps are fixed, if the sockets are not in use during the cargo operations.*

- *The chief engineers/ship's electricians ensure, that the reefer container socket boxes for the refrigerated containers and the associated spare parts are carefully maintained on board.*

- *Defective reefer container socket boxes must be repaired before they can be used again. If the repairs are delayed, the defective reefer container socket boxes must be blocked in order to prevent an accidental use.*

- *The seals of all cable glands and connections leading from the reefer container socket boxes must be checked.*

- *The integrity of the earthling wires of the reefer container socket boxes must be checked. In order to prevent omissions in this regards, inspection of the earthing cables is included as a three-monthly routine in the ship specific PMS[26].*

- *An inspection of the reefer container socket boxes by a shore based service company must be included as an annual routine in the ship specific PMS.*

- *It must be ensured that the checklist for the safety (CLD Cont-03) is completed item by item prior to commencing cargo operations and the stevedore/foreman are strictly instructed to wear an appropriate PPE[27] protective clothing including high voltage gloves.*

- *Working on connecting/switch boxes during rain/moisture should be avoided.*

[26] Note BSU: PMS = Planned maintenance system on ships = Maintenance system (software) to be maintained in accordance with the ISM Code, which enables ship owners and operators to plan, carry out and document the maintenance of ships at intervals in accordance with the requirements of the classification society and the manufacturer.

[27] Note BSU: PPE = Personal Protective Equipment.

4 CONCLUSION

An analysis of all available information made it possible to clarify, beyond doubt, the cause of the electric shock suffered by the dock worker while connecting the refrigerated container to the on-board electricity supply system of the MONTREAL EXPRESS. The expert commissioned by the BSU's assessment of the relevant power supply equipment was particularly helpful in this respect.

Following the assessment of all sources of information, it is clear that moisture inside the inadequately sealed terminal/switch box at bay 38/39 (port side) caused a so-called 'creepage distance formation'. Since the PE conductor was interrupted or at least its functionality severely impaired by corrosion and/or a loose contact at the same time, the residual current caused by the creepage distance formation was not (only) discharged directly via this conductor toward the hull of the ship. Instead, at least part of the residual current flowed through the body of the dock worker when he touched the switch box housing, causing him to suffer an electric shock.

The assessment of the terminal/switch boxes on board the MONTREAL EXPRESS revealed that the design of the protective earthing (use of a female tab adaptor at the end of the earth lead and a male tab adaptor mounted on the removable housing cover, as well as connection of the main earthing of the terminal/control box to the hatch coaming by means of a screw connection that was completely exposed to external influences and not well secured) was highly susceptible to contact impairments and contact losses.

One factor facilitating the course of events leading up to and during the accident was that although the ship was manned by a ship's electrician, the maintenance condition of the randomly inspected terminal/switch boxes and associated supply cabinets was inadequate. Internationally binding rules[28] state that the granting of a certificate of proficiency as a ship's electrician requires sound expertise in the use, monitoring, maintenance and repair of electrical equipment, machinery and systems on board, as well as knowledge of the relevant aspects of occupational health and safety and accident prevention. Nevertheless, maintenance works carried out in individual boxes in the past evidently involved methods of repair that did not comply with the generally recognised rules of technology.

It is also clear that the potential risk posed by the terminal/switch box was not an isolated case (in relation to the MONTREAL EXPRESS). This is evident from the fact that prior to the publication of this investigation report, WSP Hamburg, which had become aware of this problem, subsequently notified the BSU of five further incidents in which comparable health hazards to dock workers during the connection of refrigerated containers had occurred on five different container ships of other shipping companies in the port of Hamburg alone. Fortunately, what all cases had in common was the fact that the people affected were not seriously injured.

The accumulate on of such incidents gives rise to concerns that STCW Contracting States do not always pay sufficient attention to ensuring that the required specialist

[28] See STCW Code Annex Chapter III Section A-III/7, in particular.

knowledge (see above) of a ship's electrician actually exists in full when they issue certificates of proficiency for this responsible role on board.

Another aspect contributing to the risk of accidents arising from poorly maintained terminal/switch boxes for refrigerated containers is that this area of technology on board is evidently not a particular focus of inspectors during class surveys and port State controls. Although both the requirements of the classification societies and the international rules and regulations for port State controls provide for random inspections of the boxes in question, which are also subject to stringent design regulations, the terminal/switch boxes on board the MONTREAL EXPRESS inspected by the BSU's expert exhibited various defects that had evidently existed for some time. Accordingly, these boxes had not been inspected for quite some time.

It is reasonable to assume that dangerous incidents relating to the connection of refrigerated containers frequently occur in ports around the world but that they are not reported due to their benign outcome and therefore not investigated. This in turn is probably one of the main reasons why (random) inspections of the relevant equipment on board do not appear to be sufficiently prioritised given the serious dangers defective electrical systems may pose.

Both the classification society of the MONTREAL EXPRESS and the Ship Safety Division responsible for port State control inspections in Germany's ports have made clear in their statements that the existing survey and inspection regime provides sufficient opportunities for identifying inadequately maintained terminal/switch boxes for refrigerated containers. Accordingly, the BSU sees no need to address safety recommendations to the above bodies in this regard.

However, it must be questioned whether the current control frequency actually delivers an effective basis for remaining sufficiently aware of the existing potential risk, which is evidently not restricted to extremely isolated cases. Shipping companies, classification societies and bodies responsible for port State controls should therefore be made more aware of the dangers described by means of this summary investigation report and the timely publication of generally applicable lessons learned.

Safety recommendations to the shipping company of the MONTREAL EXPRESS are not necessary. With the measures implemented (see Chapter 3 above), which can be regarded as exemplary, it has responded appropriately to the potential hazards identified.

5 SOURCES

- Information and technical documentation, including on-board power supply equipment for refrigerated containers and a report about Action taken, from the ship's ISM management
- Statement of facts from the master of the MONTREAL EXPRESS
- Findings of the investigation of Waterway Police Hamburg
- Service report from the service provider, MRW Mount Royal/Walsh Inc., Marine & Industrial Repairs, Job # 27465, 09/09/2020, Montreal, Quebec, Canada
- Expert report from Dipl.-Ing. Harald Eden on behalf of the Federal Bureau of Maritime Casualty Investigation, file reference GTA-BSU-09-20, 03/11/2020, Oldenburg
- Statement of DNV, email dated 19/05/2023
- Statement of the Ship Safety Division (BG Verkehr), email dated 08/05/2023
- Photograph of the MONTREAL EXPRESS, Dietmar Hasenpusch Photo-Productions, Schenefeld