



Bundesstelle für Seeunfalluntersuchung
Federal Bureau of Maritime Casualty Investigation
Federal Higher Authority subordinated to the Federal Ministry
of Transport and Digital Infrastructure

Summary Investigation Report 182/20

Less Serious Marine Casualty

**Deflagration
on the
Danish sail training ship DANMARK
off Fehmarn
on 30 June 2020**

9 December 2020

This summary report within the meaning of Article 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 (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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1 FACTUAL INFORMATION

1.1 Photograph of the ship

Source: Finn Føns



Figure 1: Training ship DANMARK

1.2 Ship's particulars

Name of ship:	DANMARK
Type of ship:	Sailing ship (full-rigged); training ship
Flag:	Denmark
Port of registry:	Copenhagen
IMO number:	5086279
Call sign:	OXDK
Owner:	Styrelsen for Institutioner og Uddannelsesstøtte
Shipping company:	MARTEC (Maritime & Polytechnic College), Frederikshavn
Year built:	1933
Shipyard:	Nakskov Skibsværft, Nakskov, Denmark
Classification society:	DNV GL
Length overall:	74 m (with bowsprit)
Breadth overall:	10 m
Draught (max.):	5.1 m
Gross tonnage:	737
Engine rating:	357 kW
Main engine:	Frichs Maskinfabrik og Kedelsmedie A/S, Aarhus
(Service) Speed:	9.5 kts
Hull material:	Steel
Number of masts:	3
Number of sails, sail area:	26, 1,636 m ²
Minimum safe manning:	14 (plus up to 70 cadets)

1.3 Voyage particulars

Port of departure:	Frederikshavn, Denmark
Port of call:	Frederikshavn, Denmark
Type of voyage:	Training voyage
Cargo information:	None
Manning:	14
Draught at time of accident:	5.1 m
Pilot on board:	No
Number of cadets:	56

1.4 Marine casualty information

Type of marine casualty: Less serious marine casualty acc. to Article 1a(1a) SUG
 Date, time: 30 June 2020 at about 0950¹
 Location: South of the island of Fehmarn (abeam Großenbrode)
 Latitude/Longitude: $\varphi = 54^{\circ}20.0' N$ $\lambda = 011^{\circ}05.3' E$
 Ship operation and voyage segment: Return leg of a training voyage to the Orkney Islands and back. Port of departure/destination: Frederikshavn, Denmark.
 On 30 June 2020, after crossing the southern Sound (Øresund), the anchor was dropped south of the island of Fehmarn (abeam Großenbrode) to shelter from strong winds. The DANMARK was at the anchorage when the accident happened

Section of Navigational Chart INT 1357

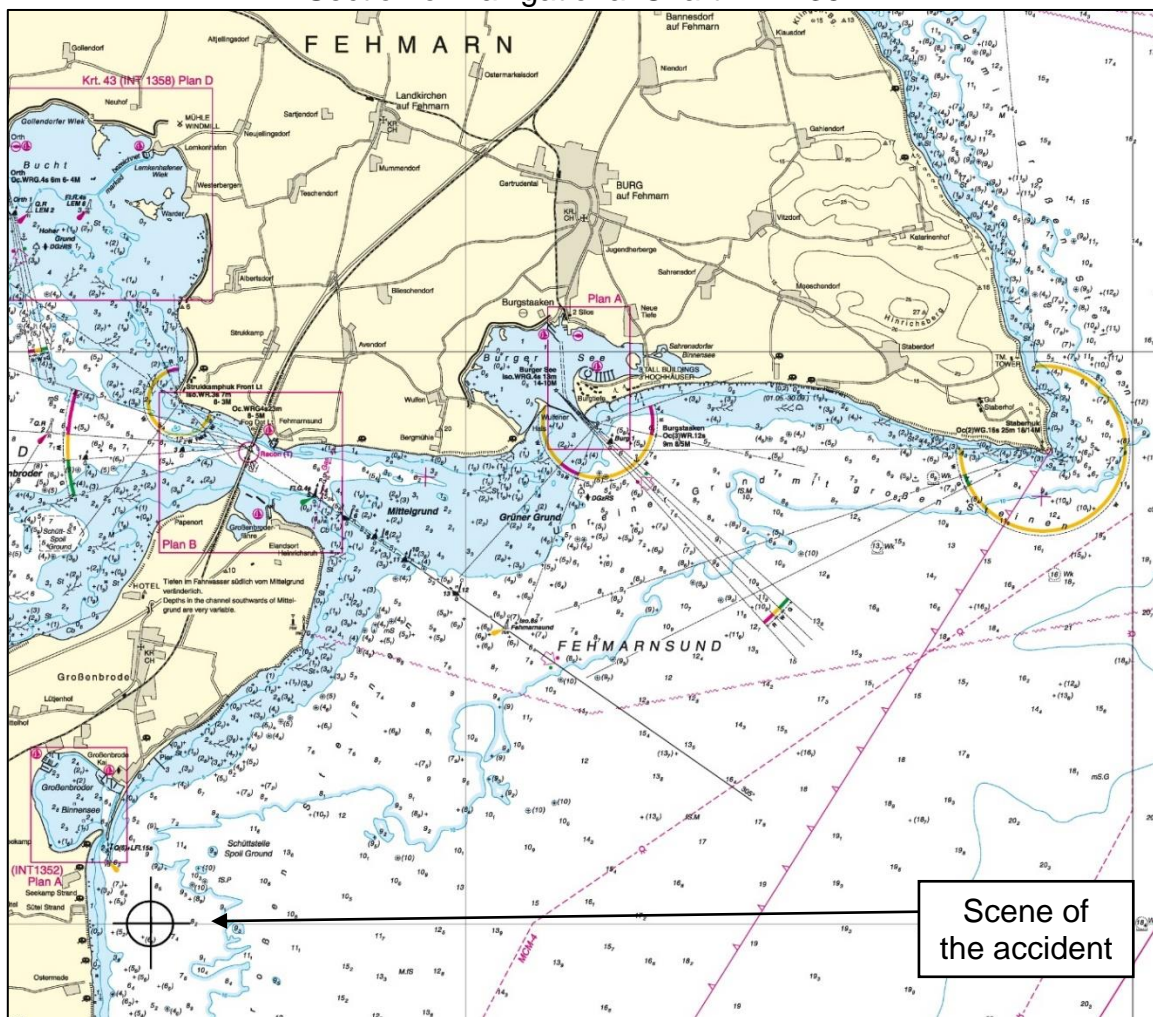


Figure 2: Scene of the accident

¹ All times in this report are local time (Central European Summer Time CEST = UTC + 2 h).

2 COURSE OF THE ACCIDENT AND INVESTIGATION

On 30 June 2020 a deflagration² of pure ethanol occurred on board the DANMARK³, a sail training ship belonging to the Danish merchant fleet. The ethanol had been applied to highly frequented surfaces in busy areas of the ship using a spray bottle and a cleaning rag, in the course of a daily "Corona disinfection" routine. One cadet suffered severe burns in the process. The sailing ship was on a training voyage when the accident happened.

2.1 Course of the accident

The vessel's accident record (also the joint written statement of Master, Chief Officer and three cadets who were involved in the accident but not injured), the written statement of the injured cadet, and the email correspondence between the Master and the BSU were used as a basis for the reconstruction of the course of the accident.

2.1.1 Initial situation

The training voyage was the first to take place after the introduction of lockdown measures in Denmark due to the COVID-19 pandemic. To make it possible to provide training and go back to sea again, the operator of the DANMARK, MARTEC (Maritime & Polytechnic College) in Frederikshavn/Denmark, drew up a hygiene plan based on recommendations by the Danish Ministry of Health. Among other things, it states that *"handrails at tables, on the poop deck, in corridors and in shared spaces are [to be] cleaned every two hours during the day and every four hours at night (when activity is low and only a few people are awake). The same applies to regularly used handles of doors, hatches and entrances."*⁴

The 56 cadets on board during this voyage had already embarked on their training voyage on 27 February 2020, but had to sign off when it was aborted on 23 March 2020 due to Denmark's lockdown measures. Given the reduction in the number of cases, and with a hygiene plan in place, the cadets were able to go back on board on 8 June 2020. The voyage started (and subsequently ended) in Frederikshavn on 13 June 2020 and took the training ship to a turnaround point west of the Orkney Islands (but, to protect against infection, without calling at any ports).

The DANMARK had almost finished the voyage when the accident happened. To shelter from strong westerly winds, she anchored south of the German island of Fehmarn (abeam Großenbrode, see p. 7) on the night before the accident at 0150 on 30 June 2020.

2.1.2 Accident

As on any other day, a group of cadets began the one-hour cleaning duty at 0900 on the morning of 30 June 2020.

Two of them (Cadets A and B) cleaned the recreation/classroom on the aft deck. Surfaces that had to be disinfected were wiped with a cloth that had previously been

² See also p. 14.

³ Also 'TS DANMARK', where TS stands for training ship or tall ship.

⁴ Loosely translated extract from the Danish hygiene plan (*beredskabsplan*: contingency plan).

sprayed with ethanol. Two other cadets from the shift (Cadets C and D) were also in the room at the time.

At about 0950, the two cadets on cleaning duty were near the room's waste bin. Cadet B wanted to throw something away and noticed a lighter lying on the floor next to the bin. Reportedly, he decided to test it to see whether it was broken and should also be thrown away. Cadet A claimed he told Cadet B that this was not a good idea in the vicinity of the ethanol, but the latter failed to respond (possibly did not hear him) and ignited the lighter.

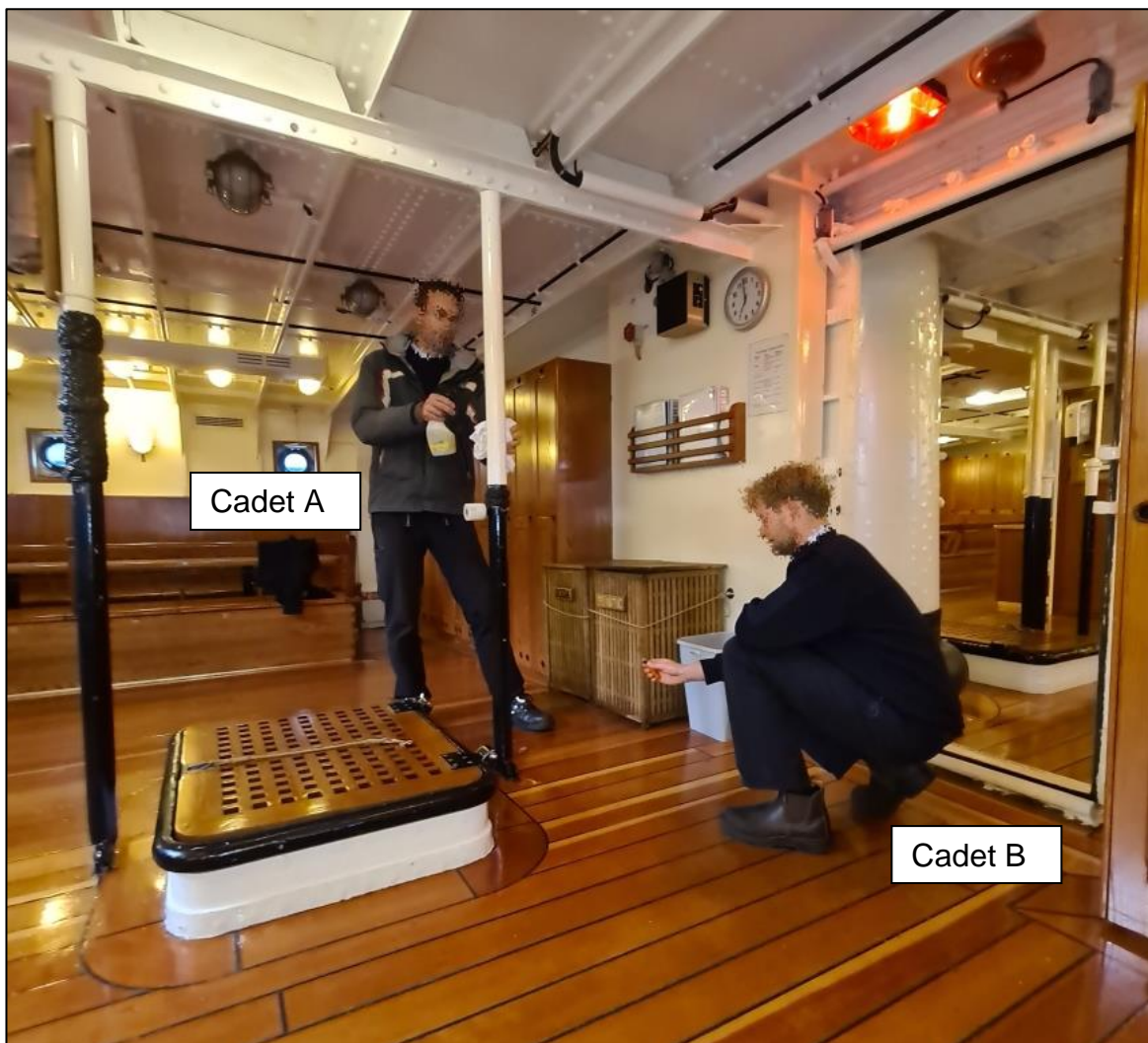


Figure 3: Simulated accident scene

Cadet A was standing directly next to him when this happened, having just sprayed ethanol onto his cloth. The spray mist in the air directly in front of his face (or the gas-aerosol mixture in the room, see also p. 13) caught fire immediately, causing a short but violent deflagration. Describing the deflagration as a "fireball around my field of view", Cadet A dropped his cleaning equipment and rapidly covered his face with his hands; his pullover and belt had also caught fire.

Cadet B wrapped his arms around Cadet A to extinguish the pullover, and slapped the belt until it stopped burning. He helped Cadet A out of his pullover, who hastily took off his trousers because he was afraid of melting synthetic fibres on his skin. Together they were finally able to extinguish the fire on the person.

One of the two uninvolved cadets, Cadet C, reacted quickly and kicked the bottle of ethanol away from smaller fires that had formed on the floor after the deflagration, and extinguished them with the powder extinguisher in the room.

2.1.3 Subsequent events

The Chief Officer and the Bosun were near the scene of the accident when it happened. The cadets called them and they both came to the classroom as quickly as possible. All fires had already been extinguished by the time they arrived.

The Chief Officer took Cadet A, who had suffered burns on his face (where they were the most severe), hands, upper body and legs, to the treatment area in the forward section of the vessel, where the ship's doctor examined him. He took pictures of the injuries and sent them to the *Rigshospitalet* hospital in Copenhagen, from where he received the advice to transfer the injured person to a hospital immediately. The ship's doctor estimated the burns at 8 % of total skin area.

Immediately after the examination, the Chief Officer put Cadet A under a cool shower for a while to cool the burns.

In the meantime, the German authorities had been contacted at about 1010. The waterway police ordered for Cadet A to be taken to a German hospital because the accident had occurred in German waters. The rescue cruiser BREMEN from the Fehmarn/Großenbrode station was called. Her tender, the VEGESACK, collected the casualty from the DANMARK 90 minutes after the accident and took him and an accompanying cadet to Großenbrode, from where a rescue helicopter flew (only) him to the University Medical Centre Schleswig-Holstein in Lübeck. Two skin grafts, which involved transplanting skin from his legs to particularly affected parts of his face and ears, were performed over the next 14 days. He was discharged from hospital on 13 July 2020 and continued his recovery at home.

Immediately after the accident, the Master mustered all crew members on deck and told them about the accident. He also informed them about the possibility of seeking support by phone or email from the *Dansk Krisekorps*, a 24-hour counselling helpline for Danish organisations and their staff.

Immediately afterwards, crisis meetings were held both at MARTEC and on board the DANMARK (see also page 15).

The DANMARK left her anchorage at 2030 on the day of the accident and reached Frederikshavn at 2220 on 2 July 2020. The cadets disembarked on the following day and had thus completed a practical part of their maritime training.

2.2 Investigation

Since the DANMARK returned to Frederikshavn shortly after the accident and was no longer in German waters, and since this is merely a summary report of a less serious marine casualty as per German Maritime Safety Investigation Law (SUG), the BSU decided not to pay the DANMARK a visit. The investigation is therefore primarily based on information provided by the Master of the vessel and the relevant inspector at MARTEC, both of whom were extremely helpful.

2.2.1 Training ship DANMARK

The training ship DANMARK is owned by the *Styrelsen for Institutioner og Uddannelsesstøtte*⁵, which forms part of the Danish Ministry of Higher Education and Science. She is operated by MARTEC (Maritime & Polytechnic College) in Frederikshavn. The sailing ship, which was commissioned as a training vessel for the Danish merchant fleet, was built in 1933, initially with up to 120 cadets per deployment. The DANMARK's German Wikipedia entry outlines her history as follows:

"At the beginning of World War II, the ship was on its way to the New York World's Fair. When she arrived, the commander received instructions to stay in the United States. The ship remained at anchor in Jacksonville until the United States entered the war. In 1941 the Danish government approved her use as a United States Coast Guard training ship. [...]."

The ship [...] returned to her home country after the war ended, resuming her role as training vessel in 1946. Following a modernisation in 1959, her capacity was reduced to 80 trainees. In April 2003, operation of the ship was transferred to MARTEC (Maritime & Polytechnic College) in Frederikshavn and she now makes regular voyages for this organisation."

On the voyage in question, the DANMARK was sailing with a 14-member regular crew and 56 cadets. Their basic maritime training⁶ generally consists of a four-week shore-based course on ship safety in accordance with the STCW Convention⁷, followed by 11 weeks on a training voyage on board the DANMARK.

2.2.1.1 Crew

Qualifications are listed only for those people directly involved in the accident as well as the DANMARK's Master.

The 62-year-old Danish Master holds a certificate of competency in navigation as defined in Regulation II/2 of the Annex to the STCW Convention (Master, no limitations). He has been a Master on board the DANMARK for the past 20 years, and worked as nautical officer on the DANMARK and the GEORG STAGE (another Danish sail training ship) before that. Apart from his nautical degree, he holds a degree in Management and Organisational Psychology and a postgraduate degree in Communication, and is a Practitioner for Communication, Change and Therapy. He

⁵ Danish Agency for Institutions and Educational Grants.

⁶ *Søfartsuddannelsen* (according to the English definition of the European Centre for the Development of Vocational Training (CEDEFOP)).

⁷ STCW: International Convention on Standards of Training, Certification and Watchkeeping for Seafarers.

has also worked as a teaching assistant at Aalborg University and as an external lecturer at Odense University.

The 34-year-old Danish Chief Officer holds a certificate of competency in navigation as defined in Regulation II/2 of the Annex to the STCW Convention (Chief Officer, no limitations). He had already served on the DANMARK as a *skibsassistent* (able-bodied seaman), Bosun and junior officer before becoming the Chief Officer.

With the exception of the maritime safety training courses, none of the cadets were holders of maritime qualifications, because the training voyage on board the DANMARK is of course a prerequisite for this. They are also Danish citizens and 22 (Cadet A), 19 (Cadet B) and 20 (Cadet C) years old.

2.2.1.2 Training

Cadets on the DANMARK are divided into four training groups that rotate through the different training modules. In addition to watchkeeping on the bridge, daytime duties on deck and the cleaning duties already discussed, they are also taught the basics of navigation and seamanship. For example, the International Regulations for Preventing Collisions at Sea (COLREGs), the basics of marine engineering, maintenance, and first aid form part of the timetable.

2.2.2 Ethanol

Ethanol (UN number⁸ 1170) is a short-chain, aliphatic, monovalent alcohol⁹.

Its molecular formula is C₂H₆O. At room temperature it is a colourless, highly flammable liquid produced by yeast fermentation of substances containing carbohydrates, and is commonly known as the alcohol contained in beer, wine or hard liquor, for example.

Ethanol is used as a solvent for medical or cosmetic substances (fragrances, flavourings, dyes, pharmaceuticals), and also – as on board the DANMARK – as a disinfectant.

⁸ UN number (or substance number): Identification number for all dangerous substances that (during transport) are also regarded as dangerous goods.

⁹ Aliphatic: Non-aromatic (in the case of hydrocarbons).

Monovalent (for alcohols): With only one alcohol molecule (OH group).

The antiseptic properties of ethanol are based on non-specific denaturation¹⁰ of proteins, which in turn are an integral part of microorganism membranes.

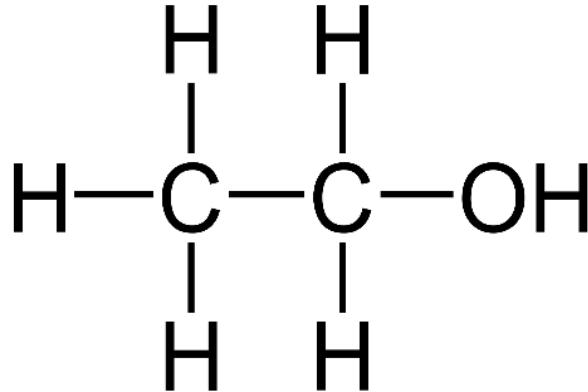


Figure 4: The molecular structure of ethanol

A mixture of ethanol vapours and air is explosive between 3.5 and 15 % (vol.). Although it has an auto-ignition temperature of 455 °C (at 1,013 hPa), ethanol is not classified as explosive because an ignition source is required to cause a combustion reaction under ambient conditions.

Since dilution in combination with the heating effect of fermentation processes creates a risk of explosion when ethanol enters the sewage system, the substance and its containers must be disposed of as hazardous waste. There is no direct risk to the environment, however.

Ethanol can cause severe irritation if it comes into contact with the eyes, and symptoms of intoxication, nausea and vomiting if swallowed or inhaled.

Typical statements in a material safety data sheet (MSDS) for ethanol are, for example: "Forms flammable/explosive mixtures with air during use.", "Vapours are heavier than air and may spread along floors.", "Keep away from heat/sparks/open flames/hot surfaces. No smoking."

2.2.3 Aerosol formation and deflagration

An aerosol is a heterogeneous¹¹ mixture of solid or, as in this case, liquid particles suspended in a gas (e.g. air). Unlike a spray mist, which consists of larger droplets that can also sink to the ground, an aerosol is generally invisible and relatively stable in the air due to the low mass of the tiny droplets.

A deflagration is a rapid combustion process which (unlike a detonation) takes place below the sound barrier and propagates outwards concentrically from its starting point (without a significant pressure wave), only by the ignition of unburned gas mixture through burning mixture.

¹⁰ Non-specific (medical): Non-targeted, broad-based action.

Denaturation: Structural change of biomolecules such as proteins under loss of their biological function.

¹¹ Heterogeneous: Non-uniform, i.e. the elements contained are separate from one another (in this case not a uniform gas but rather a large number of tiny droplets in the air).

Ethanol has a tendency to evaporate even under ambient conditions, rapidly causing a spray mist of the substance to turn into a mixture of air, gas and aerosol¹². Both the gas and the many tiny droplets (with their very large total surface area) are extremely flammable.

In this particular case, a single source of ignition was sufficient to cause a short but violent deflagration, whereby the people involved apparently did not anticipate the sheer quantity of flammable mixture present in the air. The fact that the injured person did not lose any hair or eyebrows, despite suffering severe burns to the face, is an indication of the short duration of the deflagration.

Due to the accumulation of gas at ground level, small fires continued to burn there in the aftermath of the deflagration until Cadet C reached for the fire extinguisher. Had the spray bottle not been kicked away from the fire, it could have heated up to a temperature high enough to cause a proper detonation (by building up pressure inside the closed bottle). In this respect, more serious consequences were prevented.

2.2.4 First aid for burn injuries

As already discussed, the Chief Officer put the injured person under a cool (not cold) shower after the ship's doctor had examined the latter and approved this course of action. A query by the BSU to the Maritime Medical Service in Hamburg confirmed that this was the best possible course of action. Not acting at all or, for example, applying burn ointment to a large area of skin would have been wrong in a case like this.

Medical assistance was requested immediately afterwards and the injured person was taken to hospital, so that provisional further measures, such as those that would be taken at sea, were not necessary.

The German *Medizinisches Handbuch See* [manual on medical care at sea], the very similar counterpart of which is also available on Danish ships, lists the following initial actions, *inter alia*:

- *extinguish burning clothes;*
- *remove hot [...] clothing as quickly as possible;*
- *brief (a few minutes) localised cooling with tap water (15-20 °C);*
- *NO cooling of very large skin areas with cold water [...];*
- *immediate hospital treatment [...] required for*
 - *second and third degree burns to the face [...];*
 - *possible acute inhalation injury of the respiratory tract (fires or explosions in enclosed spaces, facial burns [...]).*

These measures were carried out to the letter (under correct observance of the difference between "cool" and "cold"), although the size of the burned skin area obviously made a local limitation of the cooling impossible.

¹² MSDSs may also refer to "vapour" instead of "aerosol".

2.2.5 Handling dangerous substances

2.2.5.1 ...in the training programme on board the DANMARK

Safety-related curriculum content on board the DANMARK is always connected to the activity or subject in question (i.e. without “Safety”, or something similar, being a subject in its own right). For example, the following topics are covered across a wide range of subjects: the safety instructions on board the training ship, the handling of personal protective equipment (PPE), the handling of dangerous substances and other chemicals, accident prevention, safe conduct, hazard pictograms, MSDSs, classification according to the IMDG Code¹³, first aid according to the MFAG¹⁴ and EmS¹⁵, as well as near-miss reporting¹⁶ according to the ISM Code¹⁷.

At the beginning of this voyage, the cadets were briefed on the enhanced cleaning duties laid down in the Covid-19 hygiene plan.

2.2.5.2 ...in comparable German training programmes

In German maritime training programmes, the handling of dangerous substances is taught in a similar manner. Potential hazards and safety-promoting conduct are usually not considered independently but rather within the framework of the subject or activity in question (e.g. in the context of the materials and supplies needed to operate the ship, metalwork, maintenance and repairs, conservation, dangerous cargo, PPE, fire or safety drills and exercises, first aid, etc.).

In this respect, there is no difference between the training programmes for Technical Ship Operation Assistant, Ship Mechanic, Navigational or Technical Assistant Officer.

The only difference is a classification into command or supporting duties – training courses aimed solely at an officer's career (i.e. both Assistant Officer programmes) contain additional elements that do not only qualify the recipient to receive instructions on working with dangerous substances, but also to give such instructions.

2.2.5.3 ...in the ISM and safety system of the DANMARK and MARTEC

Common perils of the ISM and safety system – i.e. both the handling of substances known to be dangerous and the processing of accidents in the proper manner – are managed extremely well on board the DANMARK.

Working with dangerous substances

There are clear safety regulations for preventing fire, e.g. a ban on any kind of open fire inside the superstructure. Smoking is only permitted within a small, specially designated area on deck.

The MSDSs of the substances on board, as well as the regulations arising from them,

¹³ International Maritime Code for Dangerous Goods.

¹⁴ Medical First Aid Guide for Use in Accidents Involving Dangerous Goods.

¹⁵ Emergency Response Procedures for Ships Carrying Dangerous Goods (or Emergency Schedules).

¹⁶ Reporting and internal handling of near-miss accidents in order to derive safety lessons from them.

¹⁷ International Safety Management Code.

are also properly handled. For example, the containers for those substances are marked with the respective pictograms, and instructors or supervisors provide briefings before hazardous materials are handled.

Processing accidents

Immediately after the hazardous materials accident, the DANMARK's Safety Committee¹⁸ came together in order to draw conclusions for the operation of the vessel and to avoid similar incidents in the future. Decisions were made to switch from spray bottles to pump dispensers, to scale back the additional hygiene measures (and thus the use of ethanol) after 14 days of isolation at sea, to obtain white cloths (which are to be rinsed thoroughly with water after use) for work with ethanol only, and to mark ethanol containers (spray bottles and later pump dispensers) with larger hazard pictograms.

A review was also carried out ashore at MARTEC, where the aforementioned crisis meeting took place at the same time. The *Søfartsstyrelsen* (Maritime Authority) was notified and one of its representatives came on board on 1 July 2020. In the course of their inspection, they found that the risk assessment prepared for the cleaning process was too general and needed to be more task-specific. The new risk assessment was completed on 5 July 2020. But MARTEC pre-empted this regulation on 2 July 2020 by ordering that disinfection with ethanol was to be completely stopped on board the DANMARK, and soapy water was to be used instead.

The "new" hazard, however (due to the large-scale distribution of ethanol with spray bottles), was not sufficiently incorporated into the safety management system (SMS) of MARTEC and the DANMARK.

Incorporation of unknown dangerous substances

The MSDS for ethanol is a part of the SMS (which in turn originated ashore at MARTEC) and, as such, was on board. It points to both the substance's flammability and its tendency to evaporate and accumulate at ground level. There is a recommendation for respiratory protection to be used in rooms without ventilation.

Nevertheless, the dangerous nature of ethanol is not accounted for at any point in the SMS chain:

- MARTEC (understandably) focused on personal conduct relating to social distancing measures or washing hands when drawing up the hygiene plan. It contains no information on the flammability of ethanol or ventilation requirements.
- Moreover, neither portable exhaust fans or ventilators nor respiratory protection, for example, were used on board the DANMARK, even though this would have been appropriate (at least for the amount of ethanol used). So the recommendations in the MSDS were not implemented at this point, either.
- In this context, it is reasonable to assume that the cadets were not given a warning to this effect in the course of their briefing on the enhanced cleaning duties, either.

¹⁸ A ship's Safety Committee generally comprises at least the ship's command and the safety officer. Usually there are also other members, such as instructors.

- This explains why, at the end of this information chain, Cadet B apparently knew too little about gas and aerosol formation or accumulation at ground level and, when he ignited a lighter in the middle of this "cloud", was not aware of the danger. Notwithstanding the fact that this action was, of course, prohibited in the first place.

It can only be assumed that the incorporation of this hazard into the SMS did not succeed because ethanol is an everyday product (e.g. as the main component of commercially available disinfectants), and is only dangerous in quantities such as those dispersed here. It is quite possible that ethanol was even on board for cleaning purposes long before the accident. This may have contributed to the impression that it was already known to be harmless.

When the accident was processed, however (which, as mentioned, worked extremely well), this error was recognised and rectified. Ethanol has been incorporated into the system in a manner that fully accounts for its dangerous nature (it is no longer used as a cleaning agent), and it is reasonable to expect that an incident of this nature will not be repeated on board the DANMARK, nor within MARTEC's sphere of responsibility.

3 CONCLUSIONS

During their training programme on board the DANMARK, and also before that as part of their basic safety training, the cadets are taught comprehensive safety-relevant knowledge and behaviour. In each field of activity and training these are constantly deepened, both generally and in relation to the specific conditions of this vessel. The fast and appropriate action of the cadets immediately after the deflagration underlines this fact.

The BSU concludes that inadequate training of the cadets did not cause the accident.

In this particular case, the SMS on board the DANMARK and ashore at MARTEC initially proved its worth. All first aid and emergency measures were set in motion skilfully, quickly, and with the necessary expertise. The subsequent processing was immediate and comprehensive, and the countermeasures decided upon were implemented swiftly. Similarly, rules that would have prevented the accident, had everyone complied with them, were already in force (ban on all sources of ignition within the superstructure).

The BSU concludes that the system used on the DANMARK and at MARTEC for responding to emergencies and for analysing problems functions as intended by the ISM Code, and that neither its structure nor its implementation were responsible for the accident.

However, the “new” cleaning agent (at least when dispensed on this scale), ethanol, was not adequately incorporated into the SMS. Despite the existence of material safety data sheets, the dangerous nature of the substance was not properly identified at any point:

- neither in the preparation of the hygiene plan at MARTEC;
- nor in its implementation on board the DANMARK;
- nor during the briefing of cadets by the instructors, and finally
- nor by Cadet B, who stood at the end of this chain.

At no point was the use of protective clothing or, for example, fans for artificial ventilation considered. At no point was the strong aerosol formation of ethanol an issue. As a result, no awareness of the danger that ethanol can pose under these conditions could be formed at any point.

The BSU concludes that this inadequate incorporation into the SMS was the main cause of the accident. It meant that no one could develop the appropriate hazard awareness, and this fact was partly responsible for the ignition of the lighter (no matter how ill-judged – and forbidden – this act may have been in the first place), which ultimately triggered the deflagration.

This case shows that even seemingly everyday substances can be more dangerous than is generally assumed – even outside of the engine room.

The BSU decided to use the summary report format for this case because it sees no reason to issue any safety recommendations. After the accident, ethanol as a hazardous substance was properly incorporated into the safety management system, and the subsequent processing of the accident by MARTEC and on board the DANMARK, as well as the conclusions and measures taken, leave nothing to be desired.

4 SOURCES

Unless otherwise noted, the below information was retrieved or received between 30 June 2020 and 3 August 2020. For better comprehension (and for internal use only), documents in the Danish language were translated using an online translation programme.

- Email correspondence with the Master of the DANMARK and the responsible inspector at MARTEC
- Data sheet of the DANMARK from on board
- The DANMARK's Royal Danish Certificate of Nationality
- Combined accident record and joint written statement of the Master, the Chief Officer, and the three cadets who were not injured during the accident (30 June 2020)
- Written statement of the injured cadet
- Hygiene plan (*beredskabsplan*) from MARTEC (29 May 2020)
- Photographs of the injured person taken by the ship's doctor immediately after the accident (30 June 2020)
- Various German, Danish and English Wikipedia entries
- www.contactout.com (retrieved on 23 July 2020)
- The DANMARK's watchkeeping schedule for the voyage in question
- Selected educational content from the DANMARK's training plan (safety-related)
- Training plans for Technical Ship Operation Assistant, Ship Mechanic, Navigational and Technical Assistant Officer
- Minutes of the safety committee meeting (30 June 2020)
- Inspection report of the *Søfartsstyrelsen* (Danish Maritime Authority), 1 July 2020
- MSDSs for ethanol (both the English version on board and the German version from Carl Roth GmbH & Co KG for comparison)
- Seafarer's Compendium – occupational health and safety in maritime shipping and fisheries, Ship Safety Division (BG Verkehr), 2012: Handling of dangerous substances
- Email correspondence with the director of the Maritime Medical Service in Hamburg (6 July 2020)
- *Medizinisches Handbuch See* [manual on medical care at sea], Ship Safety Division (BG Verkehr), 2019