



# **STATE MARINE ACCIDENT INVESTIGATION COMMISSION**

## **FINAL REPORT 13/15**

very serious marine casualty

**M/V CORINA**

death of a seaman and carbon monoxide poisoning of four other persons  
during the port call in Hanstholm on 28 April 2015

**April 2016**

The examination of a very serious casualty of “Corina” was conducted under the State Marine Accident Investigation Commission Act of 31 August 2012 (Journal of Laws of 2012, item 1068 and of 2015, item 1320) as well as norms, standards and recommended procedures agreed within the International Maritime Organisation (IMO) and binding the Republic of Poland.

The objective of the investigation of a marine accident or incident under the above-mentioned Act is to ascertain its causes and circumstances to prevent future accidents and incidents and improve the state of marine safety.

The State Marine Accident Investigation Commission does not determine liability nor apportion blame to persons involved in the marine accident or incident.

The following report shall be inadmissible in any judicial or other proceedings whose purpose is to attribute blame or liability for the accident referred to in the report (Art. 40.2 of the State Marine Accident Investigation Commission Act).

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## 1. Facts

On 28 April 2015 m/v “Corina” was in Hanstholm in Denmark, where wood pellets – granulated combustible of plant origin – were unloaded.

Around 17:30 the cook informed the chief officer about the absence at the meal of the able seaman (AB) keeping watch at the gangway. The chief officer tried to call the seaman via a VHF radio, but with no result. He did not find him at the gangway, where he should be keeping the watch. Neither was he on deck.

The chief officer started to look for the seaman and found him unconscious in the lashing equipment locker at the bow. He started resuscitation and soon he was joined by the other AB (acting as a bosun), the electrician and a seamen, and then by a port authority officer, who came from the shore having been informed about an accident on board the ship.

In the course of the resuscitation activities two persons (the chief officer and the bosun) lost consciousness, and the remaining two needed assistance, when leaving the room to go on deck. Medical services, fire service and police were called to the ship. The firemen equipped with breathing apparatus transported unconscious persons on deck.

The chief officer and the bosun regained consciousness aboard the ship. The AB resuscitated earlier, despite the intensive resuscitation undertaken by the team of paramedics, did not regain consciousness. A physician, who arrived at the location of the incident, declared the death. All persons harmed in the accident were treated in a hospital.

## 2. General information

### 2.1. Ship Particulars

Name of the ship:	Corina
Flag:	Polish
Owner:	MLEASING Sp. z o.o.
Operator:	Żegluga Gdańska Sp. z o.o.
Classification society:	DNV-GL
Type of ship:	general cargo multi-purpose vessel
Call sign:	SNDO
IMO identification no:	8908545
Gross tonnage:	5796
Construction year:	1990

Machine power:	3370 kW (MaK 8M 552 C)
Width:	18.70 m
Total length:	114.57 m
Material, of which the hull is built:	steel
Minimum crew:	10 persons



*Photograph 1. Corina vessel*

## 2.2. Voyage Particulars

Ports of call in the course of the voyage:	Hanstholm (Denmark)
Destination port:	Dordrecht (The Netherlands)
Type of voyage:	international
Information on the crew:	11 persons of Polish nationality

## 2.3. Accident Information

Type:	very serious marine accident
Date and time of the accident:	28 April 2015, ca. 17:30
Geographical location at the time of the accident:	$\varphi = 57^{\circ} 07,1' N$ ; $\lambda = 008^{\circ} 35,7' E$
Geographical region of the accident:	North-West Denmark, Skagerrak Strait
Nature of the water region:	internal waters, port basin

Weather at the time of the accident:	wind direction NW 4 <sup>o</sup> B, visibility very good, air temperature 8 <sup>o</sup> C
Operational status of the ship in the course of the accident:	the vessel in the course of unloading of pressed combustible - wood pellets lashing equipment locker at the bow
The location of the accident on board the ship:	death of a crew member as a result of poisoning with carbon monoxide and carbon monoxide poisoning of 4 persons in the course of provision of medical assistance to the victim
Impact of the incident on persons:	

#### **2.4. Shore Services and Rescue Action Information**

Units of Danish fire service, which evacuated harmed persons on the deck, were involved in the rescue operation of unconscious persons in the lashing equipment locker. Units of Danish paramedics were involved in resuscitation of the harmed seaman and provision of medical assistance to other persons carrying out rescue activities. Danish police secured the location of the incident in the course of the rescue operation and after its conclusion.

On 29 April 2015 the vessel was inspected by the state of the port and inspectors of Danish PSC. The inspection has not shown any irregularities or shortcomings.

### **3. Circumstances of the Accident**

Between 11 and 20 April 2015 Corina vessel had been loaded with 6800 tonnes of homogeneous granulated plant combustible called wood pellets.

On 28 April 2015 at 8:00 the vessel arrived at Hanstholm in Denmark. At 11:00 the unloading started. From 16:00 the chief officer and the AB kept watch on the deck. At 17:00 the unloading was stopped. The chief officer ordered the duty seaman to check mooring ropes on the bow and then to keep the watch at the gangway.

Around 17:30 the cook informed the chief officer about the absence of the duty seaman at the dinner. The chief did not find the seaman at the gangway. There was no radio contact with him. He started the search and at around 17:40 he noticed open doors to a bosun store under the

forecastle deck. He stepped inside and saw open doors to the room housing cargo doors hydraulic pumps. Inside, the hatch cover of the entry to the lashing equipment locker was open. The chief officer stepped down and found the unconscious seaman lying there.

After assistance was requested by VHF radio, the bosun, the electrician and the seaman arrived at the place of the incident. At 17:52 the chief officer notified the captain about finding the unconscious AB in the lashing equipment locker. The captain notified port services about the accident and asked for medical assistance.

Around 18:10 the port officer came on board the ship and went to the lashing equipment locker, when the resuscitation action on the unconscious AB was already in progress. The port officer had a defibrillator with her and there was an intention to use it, as the pulse and breath of the victim was hardly detectable. For this purpose, his clothes were cut and electrodes attached to his chest. The defibrillator analysed the heart rate of the victim and diagnosed that “the defibrillation was not recommended”. Therefore, only the cardiac pulmonary resuscitation was continued.

The electrician left the lashing equipment locker and awaited arrival of rescue services on the deck, in order to point to the location of the rescue operation. At 18:18 the first ambulance with paramedics arrived at the pier. Meanwhile in the course of resuscitation activities carried out in the lashing equipment locker the bosun fainted, and soon after the chief officer. At 18:25 the second ambulance arrived, followed by the fire brigade and the police. In addition, the medical rescue helicopter landed on the pier.

The paramedics arriving on board the ship went down to the hydraulic pumps room, located above the lashing equipment locker, assessed the situation and ordered the persons in the locker, who were still conscious, to immediately leave the room. The port officer and the seaman left on their own, supported by the rescuers standing at the hatch. The remaining unconscious persons were evacuated to the deck by the firemen, who came inside the room wearing breathing apparatus.

The chief officer and the bosun regained consciousness when transferred on the deck. The harmed AB, earlier resuscitated in the lashing equipment locker by the crew, did not regain consciousness following his transfer to the deck and intensive resuscitation action by the units of paramedics. Around 19:40 the physician declared death. All persons harmed in the accidents were taken to a hospital for examination.

Around 23:00 fireman from the fire brigade in Hanstholm entered the lashing equipment locker again in breathing apparatus and took the measurements of concentration of gases. They identified carbon monoxide concentration at the level of 282 ppm.

#### 4. The Analysis and Comments about Factors Causing the Accident with Regard to Examination Results and Expert Opinions.

Corina vessel has been operated by the present operator since October 2014. It was built in 1990 as a general cargo multi-purpose vessel adapted to transport of containers and was earlier used to transport containers.

In order to facilitate moving of heavy equipment for lashing containers, an opening with the size of 2100 mm x 1150 mm was designed in the bow bulkhead of cargo hold no I, to the neighbouring storage room, where chains, stacking cones and other equipment for lashing containers were kept.

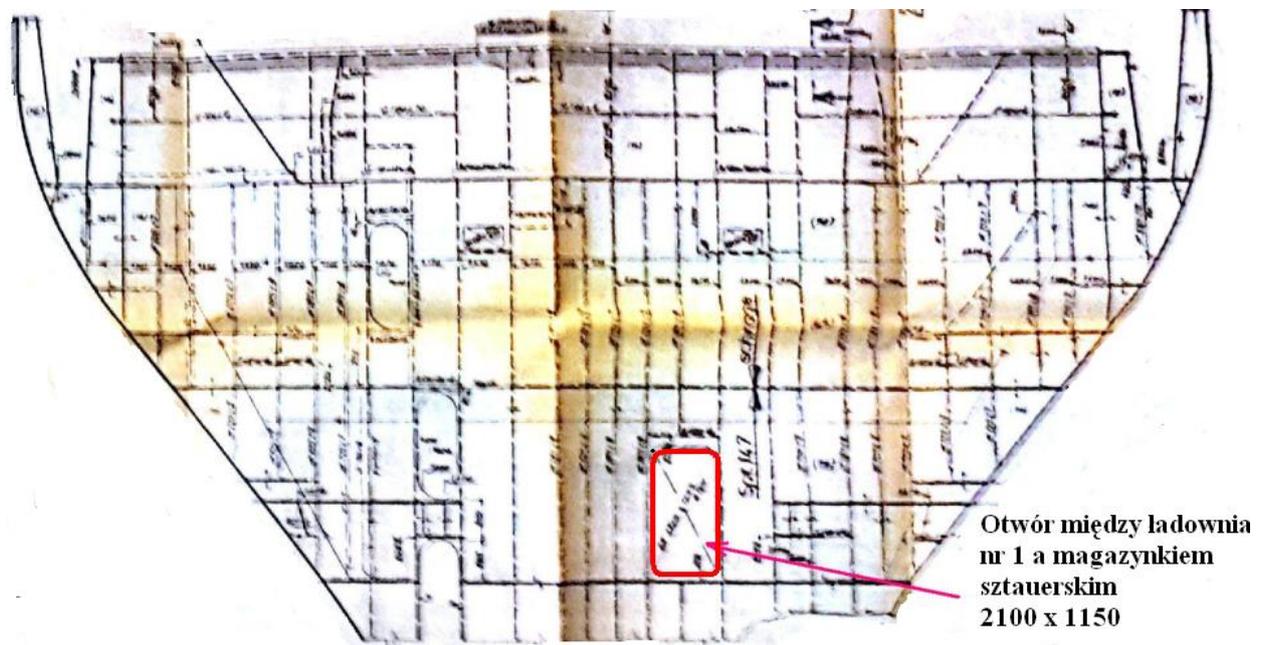
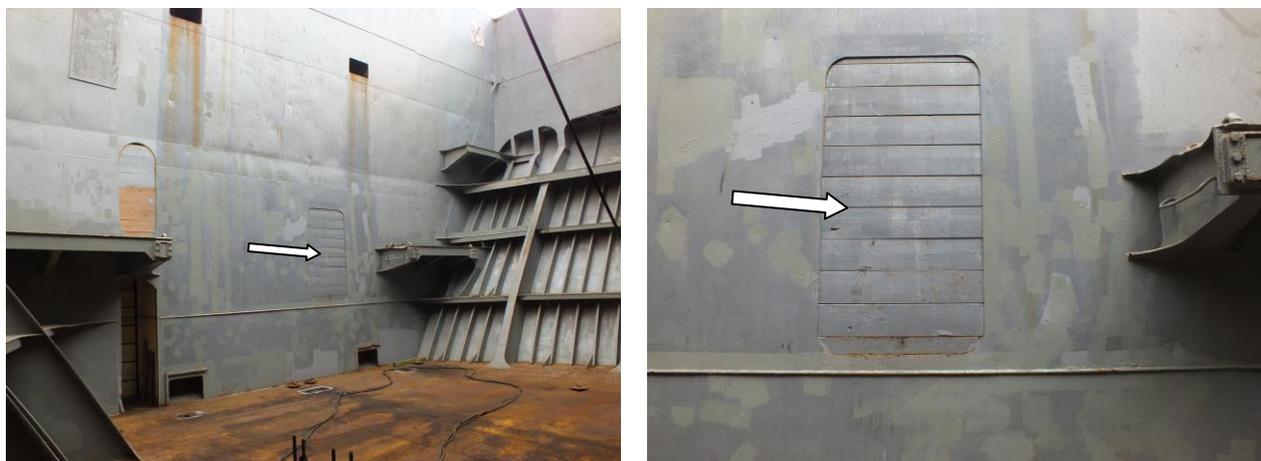


Figure 1. Transverse framing of the hull in the location of the opening between the cargo hold and lashing equipment locker (frame 147)



Photograph 2. The opening in the cargo hold bulkhead to the lashing equipment locker

The entrance to the lashing equipment locker leads from the forecastle deck (Photograph 4), through the storage of mooring equipment (bosun store) and the adjacent small room housing the unit of hydraulic pumps of the cargo hold covers (Photograph 5).



*Photograph 3. Entry doors to rooms in the bow of the vessel*



*Photograph 4. Cargo hold covers hydraulic pumps unit room*

The entrance to the pump room is secured with steel bolted doors (Photograph 5), while the manhole to the lashing equipment locker located below is closed by a cover equipped with a rubber seal and wing nuts (Photograph 6).



*Photograph 5. Entrance door to the hydraulic pumps room*



*Photograph 6. The hatch cover of the entry to the lashing equipment locker*

The location of the lashing equipment locker in the bow part of the vessel is shown at Figure 1 below.

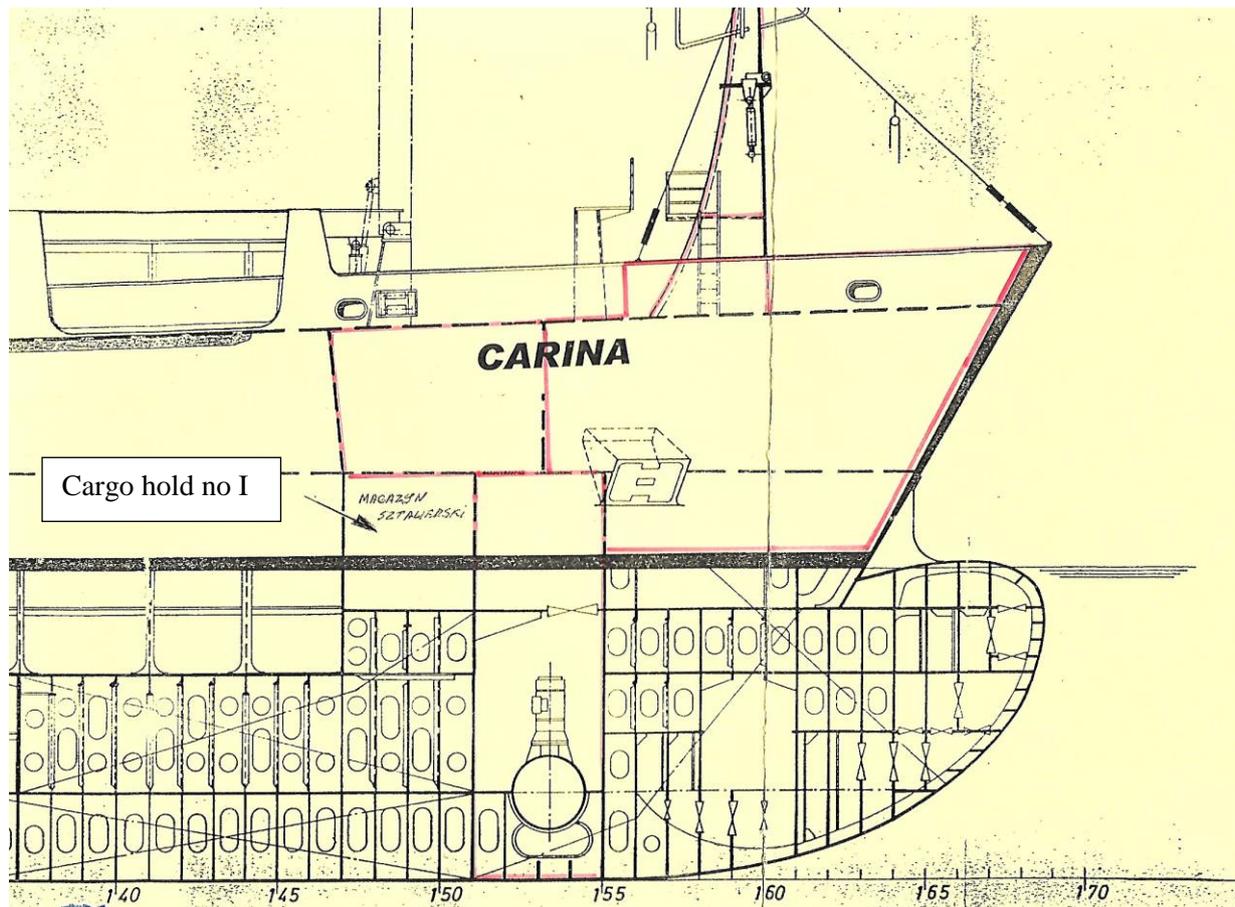


Figure 2. The drawing of the bow part of the vessel - the location of the lashing equipment locker

The operational multi-purpose nature of the vessel envisaged at the stage of design and construction ensures that Corina vessel may carry not only containers, but also general and bulk cargo, including dangerous goods, in line with certificates held by the vessel<sup>1</sup>, issued by the classifier (DNV-GL).

In order to prevent moving of bulk cargo between the cargo hold and the lashing equipment locker, the opening in the bow bulkhead was secured with planks inserted into guide bars (Photographs 2, 7 and 8). However, this type of barrier is not gas tight and provide for the possibility of exchange of atmosphere between the two rooms through slits between the planks.

<sup>1</sup> Document of compliance for the carriage of solid bulk cargoes), no 032684/282/14/14 and Document of compliance for the carriage of dangerous goods), no 032684/282/14/15 – both issued by DNV-GL in Hamburg q on 9 October 2014.



*Photograph 7. The lashing equipment locker separated with planks from cargo hold no I*



*Photograph 8. The view from the lashing equipment locker to the cargo hold with planks partially removed*

The design solution applied with the opening in the cargo hold bulkhead had practical advantages when transporting containers, but it turned out dangerous when carrying bulk cargo. The solution complies with the regulations pertaining to construction of ships applied by the class (GL)<sup>2</sup>, but because of unsatisfactory protection of the room adjacent to the cargo hold against entry of a person unaware of the danger inside, entering this room turned out to have had tragic consequences.

The cargo of wood pellets loaded in Archangelsk had been manufactured from wood refuse pressed cylindrically to the diameter of 6-8 mm and the length of 6-40 mm. Before loading, the shipper supplied – in line with the requirements of Regulation 2, Chapter VI of SOLAS Convention<sup>3</sup> – a declaration containing detailed information on the characteristics of the cargo and risks connected to both its loading and carriage.<sup>4</sup>

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<sup>2</sup> The design plans of Corina vessel (former names: Carina, Containership III) had been approved by the classification company Germanischer Lloyd in May 1989, in line with the *Rules for classification and construction of seagoing vessels, Chapter 2-Hull, Edition 1986*. The same provisions are in force today. The bow bulkhead of cargo hold no I is not a collision bulkhead. The transverse collision bulkhead is located on frame no 155 and is the front wall of the thruster room.

<sup>3</sup> International Convention for the Safety of Life at Sea, 1974, drawn up on 1 November 1974 in London. (Journal of Laws of 1984, No 61, item 318 and 319, Journal of Laws of 1986, No 35, item 177) including the Protocol of 1978 on the International Convention for the Safety of Life at Sea, 1974, drawn up on 17 February 1978 in London. (Journal of Laws of 1984, No 61, item 320 and 321) including the Protocol of 1988 on the International Convention for the Safety of Life at Sea, 1974, drawn up on 11 November 1988 in London. (Journal of Laws 2008, No 191, item 1173).

<sup>4</sup> The declaration issued Морское Грузовое Бюро (Marine Cargo Bureau) no МГБ-Д.11.3223.14/Rev.1 of 11 March 2015.

According to the information included in the declaration and in line with the International Maritime Solid Bulk Cargoes (IMSBC) Code<sup>5</sup>, the cargo of wood pellets is included in cargoes belonging to B group and marked with MHB class symbol<sup>6</sup>. Moreover, the declaration contained information that the cargo should be stowed on board the ship in the same way, as goods belonging to class 4.1 defined in the International Maritime Dangerous Goods (IMDG) Code.<sup>7</sup>

The shipper's declaration also contained information that before undertaking loading work, ship's crew should be informed about risks connected with the cargo. The shipper had warned that entry to the cargo hold was possible after 2 hours of airing the hold, with open covers, on condition the oxygen content in the atmosphere was not lower than 20%, while the carbon monoxide concentration was lower than 100 ppm. In case the measurements of concentration of gases were different, cargo holds and adjacent rooms should be ventilated again.

According to the declaration, entry to enclosed spaces of the cargo hold is only allowed for trained persons, with the knowledge of the ship's master, with observation of the recommendations included in IMO Resolution A.1050(27) on entering enclosed spaces.<sup>8</sup> In case of uncertainty on the composition of atmosphere in a room, or when it is established that it is dangerous inside a room - the shipper recommended use of breathing apparatus.

Same safety principles should be observed in case of both loading and unloading of wood pellets.

Unjustified by the needs of ongoing operation of the vessel and unnoticed by other crew members entry of the watch seaman to the bow lashing equipment locker adjacent to the cargo hold, penetrated by carbon monoxide educing from the cargo, contributed to his death.<sup>9</sup>

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<sup>5</sup> *International Maritime Solid Bulk Cargoes Code* approved by resolution MSC.268(85), in force since 1 January 2011.

<sup>6</sup> Group B consists of cargoes which possess a chemical hazard which could give rise to a dangerous situation on a ship. (*IMSBC Code, Section 1, point 1.7.13*).

Materials hazardous only in bulk (MHB) means materials which may possess chemical hazards when carried in bulk other than materials classified as dangerous goods in the IMDG Code (*IMSBC Code, Section 1, point 1.7.19*).

<sup>7</sup> *International Maritime Dangerous Goods Code* approved by resolution MSC.122(75), in force since 1 January 2004.

Class 4.1 includes solid flammable materials.

<sup>8</sup> IMO Resolution A.1050(27) *Revised recommendations for entering enclosed spaces aboard ships*.

<sup>9</sup> Carbon monoxide poisoning as the cause of death of the AB was confirmed in the report from autopsy carried out on 30 April 2015 in the State Autopsy Institute for Jutland, Pathology and Forensic Medicine Department of the Forensic Medicine Institute of Aarhus University (Denmark).

#### 4.1. Human Factors (fault and neglect)

The Commission has considered that Corina vessel's owners had not undertaken measures stipulated in the declaration received from the shipper and that action had not been taken from included information on hazards resulting from loading and carried of the cargo accepted on board the ship. The declaration provided the characteristics of the cargo and its place in the IMSBC Code, as well as referred to the provisions of IMO Resolution A.1050(27), pertaining to entering enclosed spaces on board the ship, observation of which should be unconditionally ensured by the vessel's authorities, which they have not done.

This omission on the part of the vessel's authorities resulted in crew members being unaware of the risk related to the cargo carried. The information board on the vessel did not carry any information on the type of risk related to the cargo carried and the procedures before entering hazardous spaces. Entries to these spaces were not marked with relevant warning signs and were not properly secured. The affected seaman did not know that he should have notified the chief officer or the ship's master about the intention to go to the lashing equipment locker. Neither was he aware of the hazard prevalent in the room adjacent to the cargo hold.

The entry in the logbook made by the chief officer on the first day of loading (11 April 2015) indicates that the crew had been notified "on the nature of the accepted load of 4.1 class of In IDMG code"<sup>10</sup>, i.e. that it had flammable properties, but they had not been informed on the possibility of cargo educating toxic gases, reducing the content of oxygen in the cargo hold, the possibility of self-combustion in case of high humidity, the risk of explosion in case of high concentration of particulate matter from the cargo in the air, etc.<sup>11</sup>

According to the Commission the vessel's authorities were unaware of the risks related to the cargo accepted on board the ship, despite the fact that the shipper's declaration, as well as the IMSCB Code, to which the declaration referred in several places, clearly pointed to these aspects.

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<sup>10</sup> Information about class 4.1 from IMDG Code (solid flammable loads) included in the shipper's declaration referred primarily to the manner of stowing and separation of the load from other hazardous loads. As the vessel did not carry other cargo (the load of wood pellets was the full-vessel load), there was no need for separation. However, the very information on the class of the hazardous cargo should be an indication for the vessel's owners on the manner of stowing the cargo, including primarily the necessity to stow it away from heat sources, in cargo holds, in which electrical cables, if they pass through them, are in a good condition and are protected from short circuiting and causing electric sparks to appear, and should be a hint on the type of preventive measures, which should be taken in the course of loading operations, such as for example placing of signs forbidding smoking and using open fire and on the selection of appropriate fire-extinguishers in case of fire.

<sup>11</sup> The hazards listed result both from the shipper's declaration and the information on the cargo included in Annex 1 to the IMSCB Code (*Individual schedules of solid bulk cargoes – Wood pellets*).

## 4.2. Organisational Factors

According to the Commission, the factor which had a negative impact both on the circumstances of the accident and the manner of carrying out of the rescue action in the lashing equipment locker, was improperly implemented safety policy of the ship's operator, related to prevention of accidents connected with entering enclosed spaces of the vessel. The ship's operator is obliged to implement such policy by provisions of Resolution IMO A.1050(27).<sup>12</sup>

The Commission has established that persons responsible for the safety of the vessel: the ship's master and managers of the deck and machine department had unsatisfactory knowledge of procedure in place before entering enclosed spaces, carrying out of the rescue operation in such spaces and the methods for identification of hazards. It seems of particular importance, as the duty of these persons was to train other crew members in the course of compulsory exercise, which should be carried out on board the ship.<sup>13</sup>

Instruction I-07/F-5, approved by the ship's operator, which is a part of the ship's operator's Safety Management System, with the title "Working in enclosed spaces", the content of which is modelled on the provisions included in Resolution IMO A.1050(27), did not include assurance resulting from item 4.1 of the Resolution that the ship's operator would carry out a risk analysis in order to identify enclosed spaces. The general information on spaces, which should be treated as enclosed spaces, include in item 3 of Instruction I-07/F-5 (Definitions), is not satisfactory. For example, the ship's operator has not included cargo holds among spaces, which should be identified as enclosed spaces. In the view of the Commission, the Instruction should place an obligation on the ship's master to carry out risk analysis and indicate, which of the spaces on Corina vessel should be identified as enclosed spaces.

In Instruction I-08-2 "Guidelines on alarm and exercises" the Commission has identified the absence of information on carrying out of compulsory alarms and exercises in entering enclosed spaces and in rescue operations in such spaces on the ship. The obligation of carrying out such alarms and exercises, at least once in every two months, results from Regulation 19, Chapter III of SOLAS Convention.

The absence of alarms and exercises on the ship in the scope of entering enclosed spaces and provision of assistance to persons remaining in them was, in the view of the Commission, the

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<sup>12</sup> Resolution A.1050(27) item 3 *Safety Management for entry into enclosed spaces*.

<sup>13</sup> The obligation stems from the new paragraph 3.3. - which came into force on 1 January 2015 - of Regulation 19, Chapter III of the SOLAS Convention, with the following wording: "*Crew members with enclosed spaces entry or rescue responsibilities shall participate in an enclosed space entry and rescue drill to be held on board the ship at least once every two months.*"

reason of unsuccessful and chaotic rescue operation in the lashing equipment locker carried out by the chief officer and other crew members.

Neither the chief officer or the ship master, nor any of the other crew members knew that the lashing equipment locker should be treated as an enclosed space. For this reasons the composition of the atmosphere in this accommodation was not verified before entering it in order to provide assistance to the AB, which caused temporary loss of consciousness (fainting) of several crew members and caused a risk to health and life of the port officer, who came on board the ship after the ship's master had notified the port.

Furthermore, in the same ship's operator's instruction I-08-2 in item 2 (Instructions for procedures in case of a danger), the Commission has found erroneous names of alarms and alarm signals, inconsistent with the names and signals envisaged in § 13 of the Ordinance of the Minister of Infrastructure of 9 December 2014 on specific conditions of navigation of marine vessels (Journal of Laws, item 48).

#### **4.3. Influence of the External Factors including Factors Related to the Marine Environment on the Occurrence of the Accident**

The certificate issued by the shipper on the day before the loading, containing information on the properties of the cargo "at the time of loading it on the ship"<sup>14</sup>, identified the stowage factor of wood pellets as 1,563 m<sup>3</sup>/t and the moisture contents as 9.36%

The loading of wood pellets on the vessel in Archangelsk was carried out for 8 working days. The humidity of air was high throughout the entire period of the vessel's stay at the pier. During the first days there was rain and rain with snow (at times heavy), and on last days it was snowing.<sup>15</sup> It had an impact on the absorption of humidity form the atmosphere by the load and increased its moisture content above the value given in the declaration, despite the fact that the crew tried to close cargo hold covers for the period of precipitation.

Increased moisture content accelerates chemical processes related to decomposition (oxidation) of wood pellets, reduction of oxygen content in the air and generation of carbon dioxide. As the cargo loads were filled with the cargo approximately in 96%, the oxygen from the air in the cargo holds was quickly absorbed by the load and the atmosphere in the cargo cold quickly filled with the poisonous carbon monoxide and other gases generated in the process of oxidation of the load.

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<sup>14</sup> *Certificate of the transport cargo characteristics at the time of loading. Reg. No. MCB-C.11.2332/01.15*, of 10 April 2015, issued pursuant to requirements included in Regulations 2 and 6 of Chapter VI of SOLAS Convention and requirements included in Chapter 4 of the IMSBC Code.

<sup>15</sup> [www.wunderground.com](http://www.wunderground.com)

#### **4.4. Conditions for Carriage of Wood Pellets Cargo and the Analysis of International Law in this Area**

In the late 1980s in Nordic countries manufacturing and bulk transport of new granulated combustible of plant origin wood pellets, was started. In mid 1990s, where exports of large quantities of this cargo from Canada to Europe by sea started, safety issues related to conditions, in which this cargo should be stored, loaded and carried, came into view. At first it was about ensuring mechanical and chemical integrity of wood pellets in poorly ventilated spaces, such as silos and cargo holds on ships.<sup>16</sup>

The tragic accident of 2002, in which one person died and two other suffered serious health impairment as a result of carbon monoxide poisoning in the port of Rotterdam (the Netherlands) in one of cargo holds of Weaver Arrow vessel, which had come with a load of loose wood pellets from Vancouver (Canada) was the reason for first warning and guidelines being issued for ships' crew members, as well as workers in marine ports, pertaining to the nature of this cargo and potential related hazards.

Research initiated in Canada and then carried out in Sweden and Austria in hazards related to the characteristic chemical process, which takes place in the course of carriage of loose wood pellet loads, facilitated identification of hazards related to such carriage. It was determined that during carriage wood pellets, as a bulk cargo, educe large volumes of carbon monoxide, carbon dioxide, as well as small volumes of methane, as a result of oxidation process absorbing oxygen from spaces in which they are carried. This phenomenon is particularly dangerous because of the fact that in human body carbon monoxide blocks transportation of oxygen by red blood cells, causing its shortage particularly in the brain, which leads to death as a result of cerebral oedema.

In the course of the research it was noticed that also other wood derivatives and food products had properties similar to wood pellets and behave in the same way, when transported as bulk cargo.<sup>17</sup>

Subsequent tragic deadly accidents related to carriage of wood pellets on ships in 2005-2007<sup>18</sup> led to a situation, where safety issues related to carriage of this cargo starter to be treated

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<sup>16</sup> [www.cargohandbook.com/index.php/Wood\\_pellets](http://www.cargohandbook.com/index.php/Wood_pellets)

<sup>17</sup> In 2011, in Resolution MSC.318(89) the MSC Committee approved amendments to the IMSBC Code, in which it introduced the new cargo category „*Wood Products – General*”.

<sup>18</sup> Gruvön port (Sweden, 2005) - death of one person on Eken ship. Wilmington port (East Coast of USA, 2005) - death of one person on Saga Forest Carrier ship. Helsingborg port (Sweden, 2006) - death of one person and one other person seriously injured on Saga Spray ship. Skelleftehamn port (Sweden, 2006) - death of one person on Noren ship. Timrå port (Sweden, 2007) - death of two persons on Fembria ship. Finland (2007) - death of one person, who entered 10 ton silo with wood pellets.

as one of priorities. In 2007 Canadian association of wood pellet manufacturers WPAC<sup>19</sup> developed the Material Safety Data Sheet for wood pellets in bulk. In 2010 Canadian British Columbia University published the research on - among others - safety of storage of bulk wood pellets and their carriage, in the manual *The Pellet Handbook*.<sup>20</sup> The primary recommendation of the authors and a warning at the same time is the information that persons working in places of storage and loading of large volumes of wood pellets should be at all times equipped with both oxygen and carbon monoxide sensors. Application (use) of only oxygen sensor or only carbon monoxide sensor would not suffice to correctly assess the situation in a space with wood pellets.

The provisions on sea carriage of wood pellets were for the first time introduced by IMO to the Code of Safe Practice for Solid Bulk Cargoes (BC Code)<sup>21</sup> in 2004. Earlier this type of cargo had been treated as a granulate of wood pulp and provisions included in Appendix B to the BC Code pertaining to *Wood Pulp Pellets* had been applied. As in fact wood pellets were not (and are not) pulp and the Code only included information that the cargoes of *wood pulp pellets* generate carbon dioxide and absorb oxygen from spaces, and did not mention the hazard related to the presence of dangerous carbon monoxide, at the request of the DSC Subcommittee<sup>22</sup> IMO amended the BC Code and created a separate cargo category - wood pellets, the description of which included information about the hazard related to generation of carbon monoxide. The amendment was approved by Resolution MSC.193(79).

In December 2008, with the Resolution MSC.268(85), the MSC Committee approved International Maritime Solid Bulk Cargoes (IMSBC) Code. The Code came into force on 1 January 2011 and replaced the BC Code, which had been in place since 1965 and had been amended on numerous occasions. In Annex 1, the IMSBC Code lists and describes wood pellet cargo with its full characteristics, including warnings related to hazards, which can materialise during bulk sea carriage. In January 2013 cargoes referred to as wood pulp pellets were removed from the Code.

Carriage of solid bulk cargoes other than grains may only be carried out in accordance with the provisions of the IMSCB Code. Information included in the Code and a supplement attached to it, are to a certain extent guidelines for port authorities, ships' operators and ships' masters on safety related to carriage of cargoes described therein.

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<sup>19</sup> Wood Pellet Association of Canada.

<sup>20</sup> G. Thek, I. Obernberger, *The Pellet Handbook. The production and thermal utilization of biomass pellets*. Routledge, 2010.

<sup>21</sup> *Code of Safe Practice for Solid Bulk Cargoes (BC Code)* approved by Resolution MSC.193(79) in December 2004.

<sup>22</sup> Sub-Committee on Dangerous Goods, Solid Cargoes and Containers.

Despite the fact that the IMSCB Code precisely identifies potential hazards to human health and clearly describes requirements pertaining to carriage of wood pellets, the number of deadly accidents and tragic poisonings with carbon monoxide in the course of carriage and storage of this cargo has not been decreasing.<sup>23</sup>

Practically all accidents, which take place during carriage and storage of wood pellets, take place in enclosed rooms (spaces). Therefore such accidents should be treated in the same way as accidents taking place in enclosed spaces, where the composition of atmosphere was not verified before entry, to which IMO Resolution A.1050(27) refers: *Revised Recommendation for entering enclosed spaces aboard ships*.<sup>24</sup>

The research carried out by the Marine Accident Investigators' International Forum (MAIIF)<sup>25</sup> on causes of accidents in enclosed spaces on ships in 1991 – 2008 indicate that authorities investigating marine accidents from 18 countries recorded 120 deaths in such accidents, while 123 persons were harmed.

Following the analysis of accidents it has been determined that the causes included:

- deviations from approved procedures,
- ignorance,
- absence of identification and proper designation of hazardous spaces on ships,
- instinctive and emotional nature of rescue activities, not supported by knowledge and exercise.<sup>26</sup>

Resolution A.1050(27), the text of which has also been included in the supplement to the IMSBC Code, includes specific recommendations related to safety procedures aiming at prevention of accidents, which happen to ships' crew members entering enclosed spaces, in which there is either a shortage of oxygen, or its contents is reduced, or the atmosphere contains flammable or toxic gases. The provisions of the Resolution are not only pertinent to ships' crews, but also to ships' operators, putting obligations on them, including development of a "safety

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<sup>23</sup> Finland (2008) - death of one person working in a small (10 ton) silo with wood pellets. Bornholm (Denmark, 2009) - death of two persons on Amirante ship (pellets had been loaded the day before). Germany (2010) - death of one person, who entered a silo with 150 tonnes of wood pellets. Dublin (Ireland, 2010) - death of one person, who entered a silo with 7 tonnes of wood pellets. Switzerland (2011) - death of a pregnant woman, who entered a silo with 100 tonnes of wood pellets.

<sup>24</sup> Resolution A.1050(27) of 2011 replaced Resolution A.864(20) approved by IMO in 1997. Resolution A.1050(27) defines the enclosed space as the space with limited openings for entry/exit, improper ventilation and not intended (designed) for continuous stay of crew members. The Resolutions defines the following as enclosed spaces: cargo holds, bottom tanks, fuel tanks, cofferdams, chain lockers, duct keels, crankses of engines, waste tanks and adjacent connected spaces, i.e. regular unventilated spaces used for carriage of cargo, but which may have the same atmosphere as enclosed spaces, which may for example include manholes to cargo holds.

<sup>25</sup> *Marine Accident Investigators' International Forum (MAIIF)*.

<sup>26</sup> There are data connected to this last cause, which show that the similar number of persons die when attempting to rescue those, who lost consciousness after entering spaces with hazardous atmosphere.

strategy” related to prevention of accidents in the course of entering enclosed spaces, and ensuring that risk analysis is performed on their ships and all enclosed spaces on ships are identified.

The Resolution devotes a separate chapter to hazards related to carriage of individual types of cargo on ships, including solid bulk cargoes. The provisions of the Resolution draw attention to the possibility of dangerous atmosphere being generated in cargo holds and adjacent spaces, during carriage of such cargoes and they refer to provisions of the IMSCB Code.

The template of the entry permit is an attachment to Resolution A.1050(27). It is composed of several parts, including one devoted to preparations to entry - completed by a ship’s master or a person authorised by him/her, a check-list - completed by a person intending to enter an enclosed space, a part devoted to breathing apparatus and persons responsible for supervision of persons entering.

The recommendations including in IMO Resolution A.1050(27) have been deemed unsatisfactory by certain institutions involved in issues related to accidents or results of accidents in enclosed spaces.<sup>27</sup> Opinions expressed by them<sup>28</sup> had an impact on the amendment approved by MSC Committee, introduced by Resolution MSC.350(92) with 1 January 2015 to Regulation 19 in Chapter III of SOLAS Convention, envisaging an obligation to carry out alarms on ships at least once in every two months, aiming at exercising entering to enclosed spaces and rescuing persons from such spaces.

Despite the evolution of provision related to carriage of wood pellets and access to enclosed spaces, which is beneficial to safety, Corina vessel has witnessed another deadly accident of a crew member and carbon monoxide poisoning of four other persons. When investigating this accident, the Commission has noticed that the causes were typical for the majority of tragic

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<sup>27</sup> Such institutions include, among others: BIMCO (*Baltic and International Maritime Council*), *Nautilus International*, *The London P&I Club (Protection and Indemnity Association)* and *The Nautical Institute*.

<sup>28</sup> In the view of the Commission, a controversial opinion departing from the previous direction of regulations pertaining to entering enclosed spaces, was presented in mid 2013 by experts from the Nautical Institute, involved in safety issues in enclosed spaces. They conclude that access of crew members to any space on a ship should not be limited solely by warnings and prohibitions. Entry to such locations should be treated as a “routine activity”, while rescuing persons from hazardous spaces should be exercised in the course of alarms. The authors of this opinion admitted that intuitively it was hard to agree with such opinion, however taking into account the number of accidents which continue to take place, they believed that it was time to bring out relevant equipment and devices for monitoring of the atmosphere from ships’ storage, make changes in ships’ quality system instructions and properly train crews. In their view creation of subsequent prohibitions and orders in subsequent provisions and regulations creates a barrier for something, which should be obvious and routine.

incidents, which took place on ships over many years, and resulted primarily from human errors.<sup>29</sup>

## **5. Description of Examination Findings Including the Identification of Safety Issues and Conclusions.**

The Commission has deemed that the cause of the deadly carbon monoxide poisoning of the AB on Corina vessel was his entry - for unknown reasons, unjustified by the needs of ongoing operation of the vessel and unnoticed by other crew members - to unsigned and unsecured lashing equipment locker at the bow adjacent to the cargo hold filled with wood pellets, penetrated by carbon monoxide educing from the wood pellet cargo stowed in the cargo hold.

The cause of carbon monoxide poisoning of four other person, including three Corina vessel crew members was badly prepared and wrongly carried out operation aiming at rescuing the victim, in a space which atmosphere contained carbon monoxide. The factor which contributed to high concentration of carbon monoxide in the lashing equipment locker was the absence of ventilation (natural and mechanical) in this locker.

At the time of the accident Corina vessel was in good technical order. The construction of the transverse of the bulkhead of cargo hold no I on frame 147, in which an opening with the size of 2100 mm x 1150 mm had been cut out, facilitating passage from the cargo hold to the lashing equipment locker, was compliant with the provisions of the classification company, which exercised technical supervision over the vessel. However, securing the opening in the bulkhead only with planks did not guarantee gas tightness and facilitated penetration of carbon monoxide educed by wood pellets from the cargo hold to the lashing equipment locker.

The vessel was adequately manned, it held the required documents, was equipped with relevant equipment facilitating safe entry to enclosed spaces (supply-exhaust fans) and carrying out of rescue operations (breathing apparatus).

However, the vessel's operator did not meet the requirements of international marine law (including Regulation 19, Chapter II of SOLAS Convention and recommendations resulting from IMO Resolution A.1050(27)) in the scope of safety policy pertaining to prevention of accidents related to entry to ship's enclosed spaces. Safety policy improperly implemented by the ship's operator, incomplete and outdated instructions under the Safety Management System,

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<sup>29</sup> The experts from *The London P&I Club* consider the following as the characteristic components of human error: excessive self-confidence, shortcomings of procedures, instinctive and emotional action replacing knowledge and relevant training ([www.ukpandi.com/loss-prevention/article/593-8-08-enclosed-space-entry-worldwide-842/](http://www.ukpandi.com/loss-prevention/article/593-8-08-enclosed-space-entry-worldwide-842/)).

resulted in crew's unawareness of hazards present on the ship in case of carriage of hazardous bulk cargoes and in absence of crew members' knowledge on procedures in emergency situations, such as the necessity to provide assistance to a person, who lost consciousness, which resulted in instinctive and emotional action, replacing professional rescue activities in line with procedures established for such incidents.

## 6. Safety Recommendations

The Commission has deemed it expedient to provide Corina vessel's operator, Żegluga Gdańska Sp. z o.o., with recommendations on safety, which are proposal of action, which could contribute to preventing similar accidents in future. The recommendations pertain to implementation of the ship's operator's safety policy related to carriage of hazardous bulk cargoes and access to enclosed spaces on ships.

The State Commission on Maritime Accident Investigation recommends:

- 1) introducing changes to procedures included in the Safety Management System so that they include up to date requirements included in Regulation 19, Chapter III of SOLAS Convention pertaining to alarms and exercises in entering enclosed spaces and rescuing persons from them;
- 2) ensuring that enclosed spaces are identified on ships and the level of risk that may occur in them is assessed, depending on their locations on the ship and the way they are used, as well as ensuring that information on these spaces and hazards is displayed in a visible place on board the ship and is accessible to the crew;
- 3) ensure marking with warning signs of spaces, entry to which in specific operational statuses could pose a hazard to health or life of persons, and that entries to such spaces are secured in a manner prohibiting entry without the consent of a person responsible for safety;
- 4) before enrolling them on a ship, referring persons designated by the ship's operator and responsible for implementation of the safety policy on ships (ship's master, chief officer, chief engineer) to trainings on "entering and rescuing from enclosed spaces" and on "assessment and limitation of the risk of hazards.

The Commission has noted the efforts of Corina vessel's operator undertaken following the accident, aiming at improvement of the ship's operator safety management system, including development of new instructions related to enclosed spaces on ships. However the Commission

sees the need for further action related both to the substance and quality of documents drafted by the ship's operator.

Furthermore, the Commission recommends that changed are introduced to instruction I-08-2 (Instructions for procedures in case of a danger), in the scope of names of alarms and alarm signals, in order to make them consistent with the names and signals envisaged in § 13 of the Ordinance of the Minister of Infrastructure of 9 December 2014 on specific conditions of navigation of marine vessels (Journal of Laws, item 48).

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## 9. Glossary and Abbreviations

DNV-GL (*Det Norske Veritas-Germanischer Lloyd*) –Norwegian-German classification company

GL (*Germanischer Lloyd*) – German classification company

IMO - International Maritime Organization

BC Code – Code of Safe Practice for Solid Bulk Cargoes

IMSBC Code – International Maritime Solid Bulk Cargoes Code

MHB - material hazardous only in bulk

MSC - Maritime Safety Committee

ppm - parts per million

## **10. Information Sources**

Notification of the accident

Documents of the vessel

Materials from hearing of witnesses

Materials and documents received from the ship's operator

## **11. Composition of the Accident Investigative Team**

The team carrying research activities has been composed of:

Team leader: Marek Szymankiewicz – SMAIC Secretary

Team member: Tadeusz Gontarek – SMAIC member