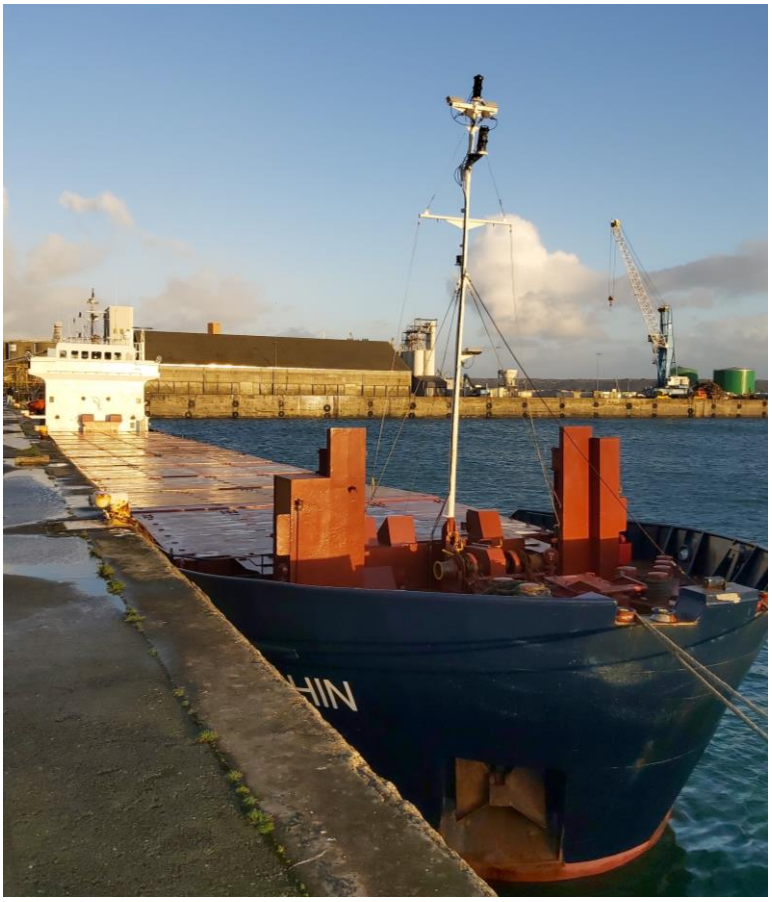
THE COMMONWEALTH OF THE BAHAMAS

FRI DOLPHIN

IMO Number: 9073880
Official Number: 8001449



Report on cargo fumigant poisoning leading to a fatality on 13 February 2020

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1 GLOSSARY

AB	Able-bodied seafarer
Booby hatch	Access hatch for vertical entry, on a raised frame above the deck.
BMA	Bahamas Maritime Authority
g	gram
IMO	International Maritime Organization
ISM	International Safety Management Code
m	metre
MSC/Circ.	Maritime Safety Committee circular
N.O.S.	Not otherwise specified
OOW	Officer of the Watch (officer in charge of a navigational watch)
PH_3	Hydrogen phosphide gas. Also known as phosphorous trihydride, phosphine or phosphane
ppm	parts per million
SOLAS	International Convention for the Safety of Life at Sea
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
STEL	Short term exposure limit is the acceptable average exposure to a substance over a short period of time, usually 15 minutes.
TLV	Threshold limit value, the acceptable limit of a chemical to which a person may be exposed without negative effects.
TWA	Time weighted average is the acceptable average exposure to a substance over a working day, typically 8-10 hours (varied by country).
UTC	Universal Time Co-ordinated

All times noted in the report are given as local time (UTC +1).

2 SUMMARY

Fri Dolphin was chartered to carry a cargo of corn on a short haul voyage in Europe. On completion of loading, aluminium phosphide was placed in the holds to fumigate the cargo in transit.

During the voyage, the vessel experienced heavy weather. On the second day of the voyage, hydrogen phosphide gas (PH_3) entered the accommodation. Several members of the crew were overcome: one crew member died and three others had to be evacuated.

Vacuum/pressure checks and smoke testing identified that the fumigant gas entered the accommodation through the ventilation system via a hydraulic room – the door between the hydraulic room and cargo hold was found to be mounted incorrectly and the fan casing and ventilation duct located in the space, which served the accommodation's sanitary spaces, were not airtight.

The fumigant was not detected by smell and the periodic monitoring for the presence of fumigant inside the vessel did not detect the fumigant in time to avert lethal levels of exposure.

Whilst detailed information on the risks of the fumigant were provided by the fumigation company, the crew were not sufficiently aware of the risks of carrying a fumigated cargo, symptoms of exposure to the fumigant or actions to take if those symptoms were experienced.

No effective assessment of the gas-tight integrity of the hold was made prior to accepting the charter, loading or fumigating. There was no guidance in the Company's safety management system or any formal assessment of the risks associated with carrying fumigated cargoes.

3 DETAILS OF VESSEL INVOLVED

3.1 Fri Dolphin

Fri Dolphin is a general cargo vessel which has been registered under the flag of The Commonwealth of The Bahamas since 2007. The vessel is beneficially owned by the Kopervik Group and technically managed by Kopervik Ship Management Poland Sp. z.o.o.[1] It has the following principal particulars:

Call sign	C6WS4
IMO number	9073880
MMSI number	309938000
Built	Damen Shipyards, Gorinchem, 1994
Length overall	88.18 metres
Breadth	12.5 metres
Depth moulded	6.5 metres
Propulsion power	1520 kW
Gross registered tonnage	2075
Class	RINA

Figure 1: Fri Dolphin (source: marinetraffic.com)

[1] The "Company" under ISM

At the time of the incident, the vessel complied with all statutory and international requirements and held valid statutory certification as required under international conventions.

The vessel's managers held a Document of Compliance under the International Safety Management Code, issued by the Bahamas Recognised Organisation Bureau Veritas.

The vessel was last subject to a Bahamas Maritime Authority Annual Inspection in Rotterdam on 15 April 2019. No deficiencies were identified.

3.2 Personnel certification and qualifications

The Master was a 49 year-old Russian national who held an STCW Master II/2 certificate of competency. He had joined the Fri Dolphin on 10 January 2020 and had been in rank for two years. The Master kept the 8-12 navigation watch.

The Chief Officer was a 48 year-old Russian national who held an STCW Chief Mate II/2 (unlimited) certificate of competency. He had joined the Fri Dolphin on 10 January 2020, this was his first trip as Chief Officer. He kept the 4-8 navigation watch.

The Fumigator-in-charge was a French national who held a certificate as "Operator in fumigation of foodstuffs and premises"[2] in line with French regulations.

3.3 Deceased Crew Member

The crew member who died as a result of exposure to the fumigant gas was a 42 year-old Russian national serving as an AB / Cook. This was his third contract onboard Fri Dolphin and his fourth with the Kopervik Group.

He joined the vessel on 06 January 2020 and was scheduled to be on board for 80 days. The post-mortem did not identify any underlying health issues or other factors that might have had an influence on the incident.

3.4 Environmental Conditions

The vessel experienced several hours of heavy weather leading up to the incident. At the time of the fumigant ingress to the accommodation, the vessel was slow steaming into the weather to reduce motions. The wind was Westerly force 9 and waves were estimated to be in excess of 9m, visibility was moderate. There was no precipitation.

3.5 Fumigant

The compound used to fumigate the cargo was aluminium phosphide[3]. This compound creates the fumigant gas PH_3 as it decomposes due to contact with moisture present in the air (hydrolyzation). The rate of hydrolyzation is dependent on temperature and relative humidity.

[2] Original French "Certificat de qualification technique d'opérateur en fumigation des denrées et des locaux"

[3] Phostoxin® bag blanket, manufactured by Fiche Technique

For in-transit fumigation, aluminium phosphide is placed on the top of the cargo on completion of loading - as PH_3 is heavier than air, the gas sinks, penetrating the cargo during the voyage. The volume of the cargo and the size of the hold must be known to calculate the amount of compound required and whether any additional recirculation machinery is required.

Pure PH_3 is odourless but the addition of ammonium carbamates gives the gas the smell of garlic to provide an olfactory warning. There is no antidote for PH_3 - treatment in the case of exposure is to provide oxygen.

Both aluminium phosphide and PH_3 are listed as dangerous cargoes in the International Maritime Dangerous Goods Code (IMDG), Class 2.3[4], when carried in bulk.

3.6 Recommended practices on fumigation of cargo

Guidance on fumigation of cargo in ships' holds is contained in the 2008 amendments to MSC.1/Circ.1264[5] under section 3 "Recommendations on the safe use of pesticides in ships applicable to the fumigation of cargo holds":

3.1.2.1 Fumigants act in a gaseous phase even though they may be applied as solid or liquid formulations from which the gas arises. Effective and safe use requires that the space being treated be rendered gastight for the period of exposure, which may vary from a few hours to several days, depending on the fumigant type and concentration used, the pests, the commodities treated and the temperature.

3.3.2.1 Fumigation in transit should only be carried out at the discretion of the master. This should be clearly understood by owners, charterers, and all other parties involved when considering the transport of cargoes that may be infested.

3.3.2.3 Before a decision is made as to whether a fumigation treatment planned to be commenced in port and continued at sea should be carried out, special precautions are necessary. These include the following:

> *.1 at least two members of the crew (including one officer) who have received appropriate training (see 3.3.2.6) should be designated as the trained representatives of the master responsible for ensuring that safe conditions in accommodation, engine room and other working spaces are maintained after the fumigator-in-charge[6] has handed over that responsibility to the master (see 3.3.2.12); and*

[4] As detailed within Appendix A (List of generic and N.O.S. proper shipping names) – Insecticide Gas, Toxic, Flammable, N.O.S.

[5] In pursuance of the requirement of SOLAS regulation VI/4 (The use of pesticides in ships), the Circular agreed by the members of the Maritime Safety Committee of the IMO on 27 May 2008, applicable to the fumigation of cargo holds, which apply to carriage of solid bulk cargoes including grain.

[6] A "fumigator-in-charge" should be designated by the fumigation company, government agency or appropriate authority. The Master should be provided with written instructions by the fumigator-in-charge on the type of fumigant used, the hazards to human health involved and the precautions to be taken.

.2 the trained representatives of the master should brief the crew before a fumigation takes place and satisfy the fumigator-in-charge that this has been done.

3.3.2.4 Empty cargo holds are to be inspected and/or tested for leakage with instruments so that proper sealing can be done before or after loading. The fumigator-in-charge, accompanied by a trained representative of the master or a competent person, should determine whether the cargo holds to be treated are or can be made sufficiently gastight to prevent leakage of the fumigant to the accommodation, engine-rooms and other working spaces in the ship. Special attention should be paid to potential problem areas such as bilge and cargo line systems. On completion of such inspection and/or test, the fumigator-in-charge should supply to the master for his retention a signed statement that the inspection and/or test has been performed, what provisions have been made and that the cargo holds are or can be made satisfactory for fumigation. Whenever a cargo hold is found not to be sufficiently gastight, the fumigator-in-charge should issue a signed statement to the master and the other parties involved.

3.3.2.6 The trained representatives of the master designated in 3.3.2.3 should be provided and be familiar with:

.1 the information in the relevant Safety Data Sheet; and

.2 the instructions for use, e.g., on the fumigant label or package itself, such as the recommendations of the fumigant manufacturer concerning methods of detection of the fumigant in air, its behaviour and hazardous properties, symptoms of poisoning, relevant first aid and special medical treatment and emergency procedures.

3.3.2.7 The ship should carry:

.1 gas-detection equipment and adequate fresh supplies of service items for the fumigant(s) concerned as required by 3.3.2.12, together with instructions for its use and the occupational exposure limit values set by the flag State regulations for safe working conditions;

.2 instructions on disposal of residual fumigant material;

.3 at least four sets of adequate respiratory protective equipment; and

.4 a copy of the latest version of the Medical First Aid Guide for Use in Accidents Involving Dangerous Goods (MFAG), including appropriate medicines and medical equipment.

Further guidance is provided in the International Maritime Solid Bulk Cargoes (IMSBC) Code:

3.6.2 When a fumigant is used, such as phosphine gas, for fumigation-in-transit, due consideration shall be given to the severe toxicity of fumigants, taking into account that fumigants may enter into occupied spaces despite many precautions taken. In particular, in the case that fumigant leaks from a cargo hold under fumigation, the possibility should be kept in mind that it may enter the engine-room via pipe tunnels, ducts, and piping of any kind, including wiring ducts on or below deck, or dehumidifier systems that may be connected to parts of the cargo hold or compartments of the engine-room. Attention shall be given to potential problem areas such as bilge and cargo line systems and valves †. In all cases, ventilation

procedures on board the ship during the voyage, should be scrutinized with regard to the possibility of drawing in the fumigant gas such as by incorrect ventilation procedures and settings, vacuum creation due to incorrect closing devices or flap settings, air conditioning and closed loop ventilation of the accommodation. Prior to commencement of fumigation procedures, it should be verified that ventilation flaps and closing devices are set correctly and that means of closing and sealing of all the bulkhead openings (such as doors and manholes) leading from the engine-room to piping tunnels/duct keels and other spaces that in case of leaks could become unsafe to enter during the fumigation are effective, confirmed closed and have warning signs posted. ǂ

3.6.3 Gas concentration safety checks shall also be made at all appropriate locations, which shall at least include: accommodation; engine-rooms; areas designated for use in navigation of the ship; and frequently visited working areas and stores, such as the forecastle head spaces, adjacent to cargo holds being subject to fumigation in transit, shall be continued throughout the voyage at least at eight-hour intervals or more frequently if so advised by the fumigator-in-charge. Special attention shall also be paid to potential problem areas such as bilge and cargo line systems. These readings shall be recorded in the ship's logbook.

† *Refer to paragraph 3.3.2.4 of MSC.1/Circ.1264.*
ǂ *Refer to paragraph 3.3.2.10 of MSC.1/Circ.1264.*

4 NARRATIVE

On 11 February 2020, Fri Dolphin berthed in Sables d'Olonne, France, to load a cargo of 2750 tonnes of corn in bulk. After preparation of the hold, the space was inspected by cargo interests and, after additional cleaning, loading commenced that afternoon. No assessment was made of the hold's gas tight integrity by the charterers or ship's staff.

After loading was completed, at around 21:45, technicians from SEREC, a fumigation and pest control company, visited the vessel and made preparations for fumigation.

After verbally confirming with the Master that the hold was suitable for fumigation, three bags of aluminium phosphide fumigant were placed in the hold to provide a dose of 1g of active ingredient per cubic meter of cargo. The hatches were then closed and the Master provided with a briefing document pack and equipment for testing for the presence of the fumigant inside the accommodation and engine room.

The Chief Officer was given training on the use of the provided gas detection equipment.

The vessel remained alongside overnight waiting for the tide and departed for Hull, UK, at 06:00 the next morning.

An initial check for the presence of the fumigant was conducted by the Chief Officer at 08:00 on 12 February at two locations in the accommodation and one in the engine room. These checks were then repeated at 20:00 that evening and at 08:00 the following day. During this period, the weather deteriorated and the Master adjusted the passage plan to reduce motions.

At approximately 10:30 on 13 February, a significant wave resulted in water flooding the galley and store through the ventilation trunking. The accommodation's ventilation flaps were then shut and the ventilation system stopped.

After lunch, the crew who were not working retired to their cabins. By 12:45, several of the crew were experiencing headaches, fatigue and severe nausea. This was attributed by different members of the crew to seasickness, a reaction to the food eaten at lunch, or the presence of exhaust gas in the accommodation.[7]

With the exception of the Chief Engineer, who went to the engine room, the affected crew either remained in their cabins, went to the bridge or on to the boat deck to get fresh air.

It was not until around 18:00, when the Master became aware that at least three of the crew were unwell, that the possibility of fumigation poisoning was raised and the

[7] A result of the apparent wind direction and combination of openings on the bridge and accommodation had resulted in exhaust being funnelled into the accommodation for a time after lunch.

information provided by SEREC re-checked. The Master then tested the atmosphere in the accommodation and confirmed the presence of PH_3.

At 18:33, the Second Officer phoned local authorities to report the fumigant in the accommodation and requested assistance. The crew were then moved to the ship's office and Master's cabin, where windows could be opened to increase the flow of fresh air. Sometime before 19:00, for an unknown reason, the AB / Cook returned to his cabin, unnoticed.

At 20:19, a rescue helicopter arrived at the vessel and a winchman was lowered on to the deck, but weather conditions, combined with a technical issue with the helicopter, meant the helicopter had to return to base without the winchman or affected crew. The vessel re-routed to Brest.

At 20:59, the winchman reported to shore that three members of the crew were in a serious condition and that the AB / Cook had been found dead in his cabin.

An hour later, a second helicopter arrived with a medical team and stabilised the three crew, who were evacuated by boat when the vessel arrived at Brest pilot station and eventually recovered in hospital.

5 ANALYSIS

5.1 Previous similar accidents

Year	Flag	Summary	Reference
2008	Romania	One fatality, several crew taken ill. Fumigant ingress to accommodation through ventilation system.	Journal of Occupational Medicine
2008	Antigua & Barbuda	One fatality. Corrosion in hold bulkhead lead to fumigant ingress to victim's cabin.	MAIB report
2010	Cyprus	One fatality. Corrosion in hold ventilation shaft lead to fumigant ingress to the accommodation.	Flag internal investigation
2010	Liberia	All crew taken ill. Extended exposure to fumigant through ventilation system. Hold communicating with engine room and accommodation through electrical conduits.	Flag internal investigation
2015	Malta	One fatality, all crew taken ill. Extended exposure to fumigant through ventilation system.	SMAIC report
2017	Panama	One fatality, several rescuers taken ill. Crew member overcome by fumigant after entering space adjacent to cargo hold whilst wearing fumigator supplied gas mask.	UEIM report
2020	Hong Kong	One fatality. Fumigant ingress to accommodation through electrical conduit.	Hong Kong Marine Department

Common factors: Crew unaware of effects of exposure to fumigant gas. Symptoms were confused with food poisoning or seasickness. Ineffective or inadequate periodic testing regime. Lack of effective physical barriers between fumigated cargo space and accommodation.

5.2 Gas ingress

Fri Dolphin has a single box shaped hold and is equipped with movable bulkheads. At the time of the casualty, the bulkheads were stored forward. The accommodation is over two decks, the lowermost being below main deck level. The forward bulkhead of this deck is common with the cargo hold.

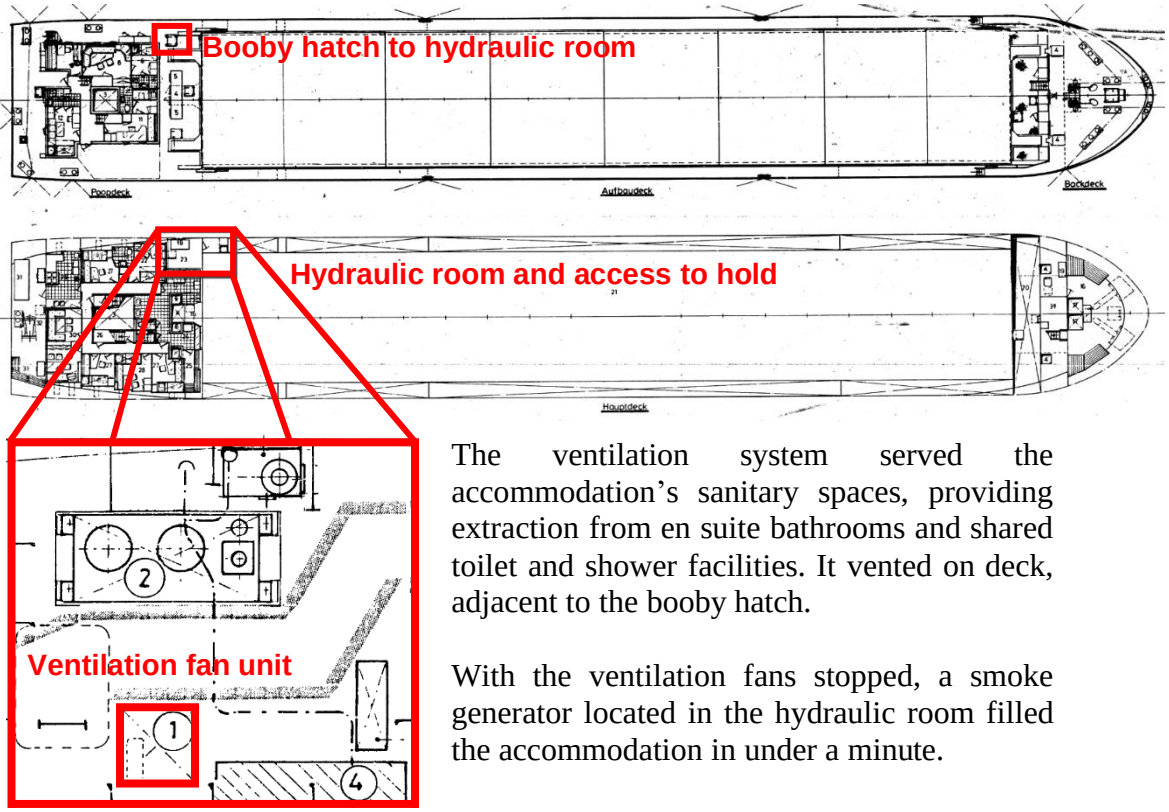
Access to the hold is gained through a booby hatch, forward, or through a hydraulic room, aft. The hydraulic room shares two bulkheads with the accommodation. Ventilation to the hold is arranged with ducts forward and aft. The aft duct passes through the accommodation space and is adjacent to the engine room air intakes.

Post-accident vacuum/pressure checks and smoke testing identified that there were no leaks on the cargo hold's aft bulkhead or in the hold's ventilation duct. All welds and

connections that could be tested were done so under pressure, the rest inspected visually.

Three issues were identified in the hydraulic room:

i. The door to the cargo hold was misaligned and could not be made gas tight, even with all dogs adjusted
ii. There were two stubs of unused and uncapped small diameter pipe running between the hydraulic room and accommodation
iii. A ventilation fan and the associated trunking running through the room was not airtight



The ventilation system served the accommodation's sanitary spaces, providing extraction from en suite bathrooms and shared toilet and shower facilities. It vented on deck, adjacent to the booby hatch.

With the ventilation fans stopped, a smoke generator located in the hydraulic room filled the accommodation in under a minute.

Figure 2: Fri Dolphin general and specific arrangement

Whilst the ventilation fan and trunking not being airtight was a hidden defect, the misalignment of the hydraulic room door was visibly noticeable. MSC.1/Circ.1264 section 3.3.2.4 requires cargo holds to be inspected and/or tested for leakage by the fumigator-in-charge and member of the ship's crew prior to loading. The fumigators did not arrive at the vessel until after loading was complete and, as such, this inspection could not be conducted as required. No inspection was made by ship's staff to confirm gas tight integrity of the hold.

Checks on vessel's suitability and gas tight integrity was therefore limited to verbal confirmation with the Master and Chief Officer that the hold did not have any known issues, a hold smoke-sampling system or any open connection with the engine room or duct keel.

5.3 Ventilation

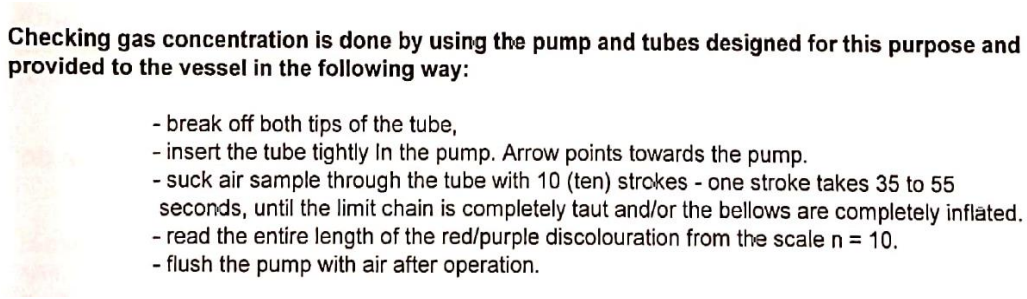
After the water ingress on the morning of 13 February, the accommodation's ventilation flaps were closed and the ventilation was stopped. No consideration was given to the potential knock on effects of this action or the additional risk posed by the fumigated cargo.

The ventilation was stopped approximately 36 hours after the application of the aluminium phosphide. It is estimated that by this time the compound would be fully hydrolysed, creating a positive pressure of PH_3 in the hold. Stopping the accommodation's forced ventilation and closing of the ventilation flaps resulted in the positive pressure being lost in the accommodation and allowed the fumigant to enter the accommodation via the sanitary ventilation system and, to a lesser extent, by the unsealed stubs of pipe.

5.4 Protection and Monitoring

SEREC provided the vessel with two full-face gas masks and a set of spare filters. SEREC offered to provide additional breathing apparatus (at a cost) but this was rejected.

Equipment for continuous monitoring for the presence of PH_3 was not available onboard. The SEREC provided the vessel with a manual pump gas detection equipment and 20 gas detection tubes. The tubes could be used in multiple locations in each test period if no gas was detected.



Checking gas concentration is done by using the pump and tubes designed for this purpose and provided to the vessel in the following way:

- break off both tips of the tube,
- insert the tube tightly In the pump. Arrow points towards the pump.
- suck air sample through the tube with 10 (ten) strokes - one stroke takes 35 to 55 seconds, until the limit chain is completely taut and/or the bellows are completely inflated.
- read the entire length of the red/purple discolouration from the scale n = 10.
- flush the pump with air after operation.

Figure 3: Extract from SEREC manual

Testing was advised to be conducted every eight hours in the accommodation, engine room and other working areas of the vessel. Testing was not conducted at this frequency - the Chief Officer tested twice a day, after his watch – and no assessment was made of when an increased frequency might be required, such as in heavy weather.

An increased periodic testing frequency may have identified the fumigant earlier, but, in any event, periodic testing may not be sufficient to detect the presence of fumigant in time to avert lethal levels of exposure. Once exposed to the fumigant, several members of the crew became immobilised in minutes.

The manual testing process was complex and time-consuming, taking up to half an hour to test on both decks of the accommodation and in the engine room. Equipment for the continuous monitoring for the presence of dangerous gas, including PH_3, is widely available, either as a fixed atmosphere monitoring unit or personal "gas badges" that monitor personnel's individual time weighted average (TWA) exposure

as well as short term exposure. Both unit types produce an alarm well below dangerous levels.

5.5 Safe levels of exposure

Chemicals, fumes, dusts and fibres which can result in harm to a person's health are classified as 'hazardous substances'. Safe exposure limits to hazardous substances are generally known as occupational exposure limit values or threshold limit values (TLV).

TLV is considered in terms of the effects of a short-term exposure, generally 15 minutes, and a longer term exposure, generally the length of the working day. These are known as short term exposure limit (STEL) or time weighted average (TWA) however different terms may be used in different countries[8].

MSC.1/Circ.1264 identifies that the gas-detection equipment should be provided together with "occupational exposure limit values set by the flag State regulations for safe working conditions". SEREC guidance identified a threshold limit value of 0.3 parts per million. It did not specify if this was a STEL or TWA.

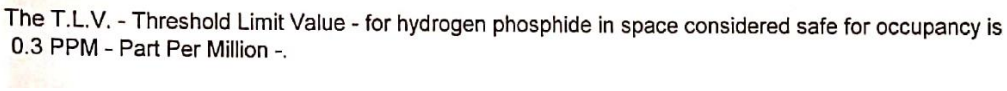

The T.L.V. - Threshold Limit Value - for hydrogen phosphide in space considered safe for occupancy is 0.3 PPM - Part Per Million -.

Figure 4: Extract from SEREC manual

The Bahamas does not have any regulations identifying occupational exposure limit values for phosphine. A review of countries that have identified and published STEL and TWA limits for phosphine identifies a that a 0.3ppm TWA is appropriate for some flag States and not for others:

	Time weighted average	Short term exposure (15 minute)
UK & EU	8 hour - 0.1 ppm	0.2 ppm
USA	10 hour - 0.3 ppm	1 ppm
Australia	8 hour - 0.3 ppm	1 ppm

The fumigator's guidance on TWA was not in line with regulations set in France or the UK.

5.6 Training

The fumigator-in-charge provided training to the Chief Officer on the use of the gas detector tubes and the contents of the fumigation information pack. This training was not provided to a second member of the crew.

The Chief Officer provided a fumigation briefing to the available crew – at least two members of the crew were not present. It is unclear whether the deceased crew member was present as the Chief Officer could not recall and no records were kept. Those members of the crew that were not present did not receive any further information on the operation or its risks. For those that did attend, the content of the

[8] TLV may also be considered in terms of momentary or "ceiling" exposure and lifetime exposure

briefing was not adequate enough to highlight the risks that in-transit fumigation posed or symptoms of poisoning to sufficiently alert the crew when taken ill.

None of the crew reported smelling the carbide/garlic smell added to the fumigant as an olfactory warning. Those that could remember poor quality of air in the accommodation associated it with the ingress of exhaust gases, sewage or other unknown issues. In any event, the carbide additive did not provide sufficient stimulus for anyone that smelled it to take action.

5.7 Safety management

The International Safety Management (ISM) Code requires[9] the Company to establish procedures for key shipboard operations concerning the safety of personnel on board.

The Company's safety management system did not include any procedures to ensure the vessel was suitable for the in-transit fumigation prior to accepting the charter and did not contain any guidance on the carriage of fumigated cargo.

No risk assessment for the carriage of fumigated cargoes was conducted and no contingency plans had been developed for the occurrence of fumigant ingress to the accommodation.

Whilst the safety management system made reference to weather routing, no guidance was provided on navigation in heavy weather. This was reflected in the vessel's passage plan[10], which did not make any allowance for the forecasted heavy weather or any special precautions required for the cargo being carried.

The safety management system did not provide any guidance on maintaining gas tight integrity of the hold or conducting the pre-loading inspection/test, as required by MSC.1/Circ.1264 section 3.3.2.4. There were no historical records of any gastight assessment being made of the hold.

There were no maintenance records available for the hydraulic room/hold door or the sanitary ventilation system.

[9] Section 7, Shipboard Operations

[10] SOLAS Chapter V Regulation 34 (Safety of Navigation) The voyage plan shall anticipate all known navigational hazards and adverse weather conditions

6 CONCLUSIONS

No steps were taken to ensure the vessel was suitable for the in-transit fumigation prior to accepting the charter. There was no documented risk assessment for in-transit fumigation and no assessment of the hold's gas tight integrity was made prior to loading.

There was no contingency plan dealing with crew exposure to the fumigant.

The charterers commissioned an inspection of the hold for cleanliness / suitability for cargo but no checks were made for suitability for fumigation.

The hydraulic room/hold door was not gas or watertight. This had not been identified as part of the vessel's planned maintenance schedule.

Only one member of the crew was provided training from the fumigator-in-charge.

At least two members of the crew were not present for the Chief Officer's fumigation briefing. For those that were briefed, it did not adequately highlight the risks of the operation or symptoms of poisoning to sufficiently alert the crew when taken ill.

The fumigant entered the accommodation via the sanitary ventilation system and unsealed stubs of pipe when positive pressure in the accommodation, provided by the ventilation system, was stopped.

The periodic monitoring of the accommodation and engine room atmosphere was not conducted at the specified frequency. In any event, periodic monitoring did not detect the fumigant in time to avert lethal levels of exposure.

The fumigant's carbide additive did not provide sufficient olfactory warning to the presence of the fumigant.

Once fumigant poisoning was identified, insufficient steps were taken to prevent loss of life.

Whilst not contributory to the outcome of the gas ingress, The Bahamas does not have any regulations identifying occupational exposure limit values for phosphine and regulatory limits vary greatly from State to State. The fumigator's guidance on maximum exposure limits was not in line with the thresholds established in the country of loading or discharge.

7 LESSONS TO BE LEARNED

Companies must have adequate procedures in place to assess the suitability of a vessel to carry fumigated cargoes.

Masters of vessels used for in-transit fumigation must ensure that the hold is gas tight before loading. Extreme care should be taken to assess the integrity of ventilation trunks, shared bulkheads, duct keels and electrical conduits that might allow passage of gas into accommodation or working areas.

Masters of vessels used for in-transit fumigation must be aware of the potential impacts of changing ventilation arrangements with regard to the possibility of drawing in the fumigant gas by vacuum creation due to adjusting closing devices or flap settings, air conditioning and closed loop ventilation of the accommodation.

Periodic atmosphere monitoring is not as effective as continuous monitoring.

All crew must be fully aware of the risks and mitigation measures required to carry fumigated cargo safely. All should be fully briefed on the particulars of the smell of the fumigant, effects of poisoning and actions to take if exposed.

8 ACTION TAKEN

The Bahamas Maritime Authority has issued a Safety Alert, drawing attention to the hazards of fumigation and precautions required to reduce risk to acceptable levels.

Damen has provided a list of identical and similarly designed vessels that have, or may have, a ventilation system that possess the same risk. The Bahamas Maritime Authority has contacted the respective flag States requesting their immediate attention.

Kopervik Group has addressed the structural issues that lead to gas ingress onboard the Fri Dolphin. The Company has shared lessons learned from the incident through its fleet and added sections to its safety management system on fumigation and navigation in heavy weather.

SEREC has re-iterated the availability of continuous monitoring equipment to vessels taking fumigated cargo but reports that take up is low due to the marginal increase in cost. To ensure gastight integrity of vessels to be fumigated, SEREC has appointed a marine surveyor to conduct ultrasound tests. Surveys are not mandatory and take up is effect by perceived risk of the vessel being put off-hire where issues are detected.

9 RECOMMENDATIONS

The Bahamas Maritime Authority (flag State)
The Bahamas should consider, together with other interested States, proposing to the International Maritime Organization the requirement for continuous gas monitoring affixed within the accommodation and engine spaces of vessels carrying fumigated cargoes.

The Bahamas should consider, together with other interested States, proposing to the International Maritime Organization an international standard of occupational exposure limit values for safe use of pesticides in vessels applicable to the fumigation of cargo holds.

As an interim, The Bahamas should consider implementing occupational exposure limit values for safe use of pesticides in vessels where fumigation of cargo holds is undertaken.

The Bahamas should consider a review of the effectiveness of the Load Line Surveys carried out by Recognised Organisation pertaining to ventilation systems and fixed access openings, ensuring gastight and watertight integrity is assured for the safe carriage of fumigated cargoes. The Bahamas should also consider a review of the effectiveness of the ISM audits carried out by the Recognised Organisation pertaining to the adequacy of risk assessments for the safe carriage of fumigated cargoes.

SEREC
Improve procedures to ensure that inspections, training and briefings are conducted in line with the requirements of MSC.1/Circ. 1264.

Revise guidance on TLV in line with national requirements.

Consider providing additional material to assist crews to identify the presence of fumigant and information that clearly communicates the hazards of fumigation, symptoms and actions to take when TLV is exceeded.

Kopervik Group
Incorporate the requirements of MSC.1/Circ. 1264 into its cargo fixing process.

Ensure comprehensive risk assessments for the carriage of dangerous and potentially dangerous cargoes is incorporated in its safety management system and assist crews in the completion of risk assessments for fumigation, grain cargo and navigation in heavy weather.

Develop contingency plans for the occurrence of fumigant ingress to the accommodation and engine room spaces.

Improve guidance on passage planning to ensure forecasted weather and cargo considerations are incorporated into the appraisal, planning, execution and monitoring of the voyage.