

Report on the investigation into
a release of phosphine gas during
cargo discharge on board

Arklow Meadow

Warrenpoint, Northern Ireland
on 5 December 2012



CONTENTS

Page

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

SYNOPSIS 1

SECTION 1 - FACTUAL INFORMATION 2

1.1	Particulars of <i>Arklow Meadow</i> and accident	2
1.2	Narrative	4
1.2.1	Cargo loading	4
1.2.2	The voyage to Warrenpoint	9
1.2.3	Initial gas tests	10
1.2.4	Exposure to fumigant	10
1.2.5	Emergency response	12
1.2.6	Disposal of the fumigant	15
1.3	Crew experience	17
1.4	Vessel safety management	17
1.4.1	Safety management	17
1.4.2	Fumigation of cargoes	17
1.5	Warrenpoint Harbour Authority	18
1.6	The fumigant	18
1.7	Unexpected active fumigant	19
1.8	Guidance on the carriage of fumigated cargoes	19
1.8.1	International guidance	19
1.8.2	UK guidance	21
1.9	Fumigation training	22
1.10	Port safety	22
1.10.1	Port Marine Safety Code	22
1.10.2	Guide to Good Practice on Port Marine Operations	23
1.10.3	The Dangerous Substances in Harbour Areas Regulations 1987	23
1.11	Previous similar accidents	23

SECTION 2 - ANALYSIS 24

2.1	Aim	24
2.2	Fumigant activity	24
2.3	Onboard procedures and actions	25
2.4	Port procedures and actions	26
2.5	The fumigator in charge	26
2.6	Regulation and guidance	27

SECTION 3 - CONCLUSIONS 28

3.1	Safety issues directly contributing to the accident that have been addressed or resulted in recommendations	28
-----	---	----

SECTION 4 - ACTION TAKEN

29

4.1 Action taken by the MAIB

29

4.2 Action taken by other organisations

29

SECTION 5 - RECOMMENDATIONS

30

DOPUNSKA
LITERATURA

FIGURES

- Figure 1** - Extract of General Arrangement
- Figure 2** - Fumigant sock or retainer
- Figure 3** - Polypropylene rope with fumigant socks attached laid on top of the maize cargo
- Figure 4** - Fumigant retainer plan
- Figure 5** - Fumigation warning notice
- Figure 6** - Midday and midnight air temperatures
- Figure 7** - Daily mean sea surface temperature
- Figure 8** - Cargo hold observation platform
- Figure 9** - Fumigant socks on the ground
- Figure 10** - Smoke from fumigant socks inside a bag on *Arklow Meadow*'s port side
- Figure 11** - Denser smoke from bagged fumigant
- Figure 12** - Immersion of fumigant in water
- Figure 13** - PH³ readings in the cargo holds

ANNEXES

- Annex A** - Pre-fumigation documentation provided in Nika-Tera, Ukraine
- Annex B** - Certificate of Cargo Characteristics
- Annex C** - Post-fumigation documentation provided in Nika-Tera, Ukraine
- Annex D** - Atmospheric Gas Test Certificate
- Annex E** - General information on aluminium phosphide issued by the Health Protection Agency
- Annex F** - General information on phosphine issued by the Health Protection Agency
- Annex G** - Food and Environment Research Agency report on the excessive quantities of residual aluminium phosphide following the fumigation of maize cargo on board *Arklow Meadow*
- Annex H** - IMO MSC.1/Circ.1264 – Recommendations on the safe use of pesticides in ships applicable to the fumigation of cargo holds

- Annex I** - MGN 284 (M+F) – Recommendations for ships carrying fumigated bulk cargoes
- Annex J** - MSN 1718 (M) – The safe use of pesticides in ships
- Annex K** - MGN 86 (M) – Recommendations on the safe use of pesticides in ships
- Annex L** - MAIB flyer to the shipping industry

GLOSSARY OF ABBREVIATIONS, ACRONYMS AND TERMS

AB	-	Able bodied seaman
BPA	-	British Ports Association
BPCA	-	British Pest Control Association
BV	-	Bureau Veritas
CEC	-	Certificate of Equivalent Competency
COSHH	-	Control of Substances Hazardous to Health Regulations
CTU	-	Container transport unit
DfT	-	Department for Transport
DoC	-	Document of compliance
DSHAR	-	Dangerous Substances in Harbour Area Regulations 1987
FERA	-	Food and Environment Research Agency
FIC	-	Fumigator in charge
g	-	gram
kg	-	kilogram
HPA	-	Health Protection Agency
IMDG	-	International Maritime Dangerous Goods Code
IMFO	-	International Maritime Fumigation Organisation
IMO	-	International Maritime Organization
IMSBC	-	International Maritime Solid Bulk Cargo Code
ISM Code	-	International Safety Management Code
LEL	-	Lower explosive limit
LFL	-	Lower flammable Limit
MCA	-	Maritime and Coastguard Agency
MGN	-	Marine Guidance Note
MSC	-	Maritime Safety Committee
MSN	-	Merchant Shipping Notice

mt	-	metric tonnes
OS	-	Ordinary Seaman
PH ³	-	Phosphine
PMSC	-	Port Marine Safety Code
ppm	-	parts per million
r.h.	-	Relative humidity
SCBA	-	Self-contained breathing apparatus
SHA	-	Statutory Harbour Authority
SMS	-	Safety Management System
STCW	-	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978, as amended (STCW Convention)
STEL	-	Short-Term Exposure Limit
TWA	-	Time Weighted Average
UKMPG	-	United Kingdom Major Ports Group
UTC	-	Universal Co-ordinated Time
VHF	-	Very High Frequency
WHA	-	Warrenpoint Harbour Authority

TIMES: All time in this report are UTC unless otherwise stated

SYNOPSIS



On 5 December 2012, a fumigated cargo of maize was being discharged from the general cargo vessel *Arklow Meadow* in Warrenpoint, Northern Ireland when it became apparent that the fumigant was still active; fumigant retainers that had been removed from the cargo holds started to smoke.

Cargo operations were immediately stopped and *Arklow Meadow*'s crew were evacuated to the quayside. The local fire brigade was quickly on the scene and established a 50 metre cordon around the vessel. Houses and retail premises surrounding the port area were also evacuated by the police as a precautionary measure. Eight of *Arklow Meadow*'s 11 crew, and a stevedore who had potentially

been exposed to phosphine gas, were taken to hospital for observation and decontamination.

A total of 89 fumigant retainers were recovered from the vessel and shore areas, leaving 21 fumigant retainers unaccounted for. The recovered retainers were neutralised by immersing them in water. It took 5 days for the level of phosphine gas in the vessel's cargo holds to reduce to a safe level.

The MAIB investigation identified that:

- The fumigant compound (aluminium phosphide) had probably remained active due to its tight packaging and the relatively low humidity in the cargo holds during the vessel's voyage from the Ukraine.
- Although the levels of phosphine gas in the atmosphere at the tops of the cargo holds had been assessed to have been safe, the fumigant retainers were not removed from on top of the maize cargo before cargo operations were started.
- Onboard procedures for the carriage of fumigated cargoes were scant and the instructions provided by the fumigator in the Ukraine were not followed.
- Although Warrenpoint Harbour Authority reacted quickly, the port had not developed procedures or emergency plans dealing specifically with the potential hazards associated with fumigants.

A recommendation has been made to the Maritime and Coastguard Agency aimed at improving the guidance available regarding the carriage of fumigated cargoes. A recommendation has also been made to the British Ports Association and the United Kingdom Major Ports Group to help ensure that all UK ports have procedures and emergency plans in place when dealing with fumigated cargoes.

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF *ARKLOW MEADOW* AND ACCIDENT

SHIP PARTICULARS	
Vessel's name	Arklow Meadow
Flag	Ireland
Classification society	Bureau Veritas
IMO number	9440277
Type	General Cargo Ship
Registered owner	Coastal Shipping Plc
Manager	Arklow Shipping
Construction	2010, Mokpo Shipbuilding Ind. Co., Korea
Length overall	136.5m
Registered length	Not applicable
Gross tonnage	9682t
Minimum safe manning	10
Authorised cargo	General cargo including dangerous goods. Grain capacity – 18111m ³
VOYAGE PARTICULARS	
Port of departure	Nika-Tera, Ukraine
Port of arrival	Warrenpoint, Northern Ireland
Type of voyage	International
Cargo information	13276 tonnes maize, fumigated in transit
Manning	11
MARINE CASUALTY INFORMATION	
Date and time	5 December 2012, 0600-1000
Type of marine casualty or incident	Marine incident
Location of incident	General cargo berth, Warrenpoint
Place on board	Cargo holds and main deck
Injuries/fatalities	None
Damage/environmental impact	None
Ship operation	Cargo discharge alongside
Voyage segment	Alongside
External & internal environment	Calm sheltered waters, good visibility and light winds
Persons on board	11



Arklow Meadow

1.2 NARRATIVE

1.2.1 Cargo loading

Arklow Meadow arrived alongside at Nika-Tera, Ukraine at 1910 (UTC+2) on 18 November 2012 to load a cargo of maize bound for Warrenpoint, Northern Ireland. The vessel's master had already been informed by Soufflet Negcoe, the shippers of the cargo, that the maize would be fumigated in transit¹. The shippers had appointed Pro-Tek, a fumigation company based in the Ukraine, to initiate the fumigation process at Nika-Tera. A Pro-Tek fumigator (henceforth known as the fumigator in charge (FIC)²) boarded *Arklow Meadow* shortly after the vessel had berthed.

The FIC inspected *Arklow Meadow*'s four cargo holds (**Figure 1**) and found them to be in a satisfactory condition and gas tight. He then fitted a system of hoses and electric fans into each hold which were to be used to re-circulate the fumigant during the forthcoming passage. The control switches for the electric fans were sited on the main deck.

The FIC provided the master with the following information on the fumigation process:

- *Statement of pre-fumigation notice of compliance* (which showed that the fumigant to be used was aluminium phosphide³);
- *Statement of the ship suitability for fumigation*;
- *Safety information*;
- *Safety equipment checklist*;
- *Statement of the re-circulation system installation*; and
- *Instructions for the re-circulation system operation*.

The documentation (**Annex A**) was written in English and was signed by the master and the FIC.

The FIC also supplied two filters for use in conjunction with respiratory masks held on board, a Russian manufactured bellows-type hand pump and a selection of test tubes to be used for the detection of PH³. The chief officer did not understand the instructions for the use of the pump and tubes which were written in Russian.

¹ A fumigant is a substance that is used to eliminate or control infestation by rodents or insects in cargoes or in areas such as galleys and crew accommodation. The fumigation of grain cargo is commonly completed during a vessel's passage in order to reduce the time a vessel has to spend in port. The value of fumigated cargoes is generally higher than cargoes that have not been fumigated.

² FIC is a term used in the Maritime Safety Committee (MSC) Circular 1264 dated 27 May 2008 (MSC.1/Circ.1264) – *RECOMMENDATIONS ON THE SAFE USE OF PESTICIDES IN SHIPS APPLICABLE TO THE FUMIGATION OF CARGO HOLDS* (see **Paragraph 1.8.1** and **Annex H**). A FIC is a person designated by a fumigation company, government agency, or other appropriate authority who, inter alia, initiates the fumigation process and provides vessels' masters with written instructions on the type of fumigant used, the hazards involved and the precautions to be taken.

³ aluminium phosphide produces phosphine gas (PH³)

GENERAL ARRANGEMENT

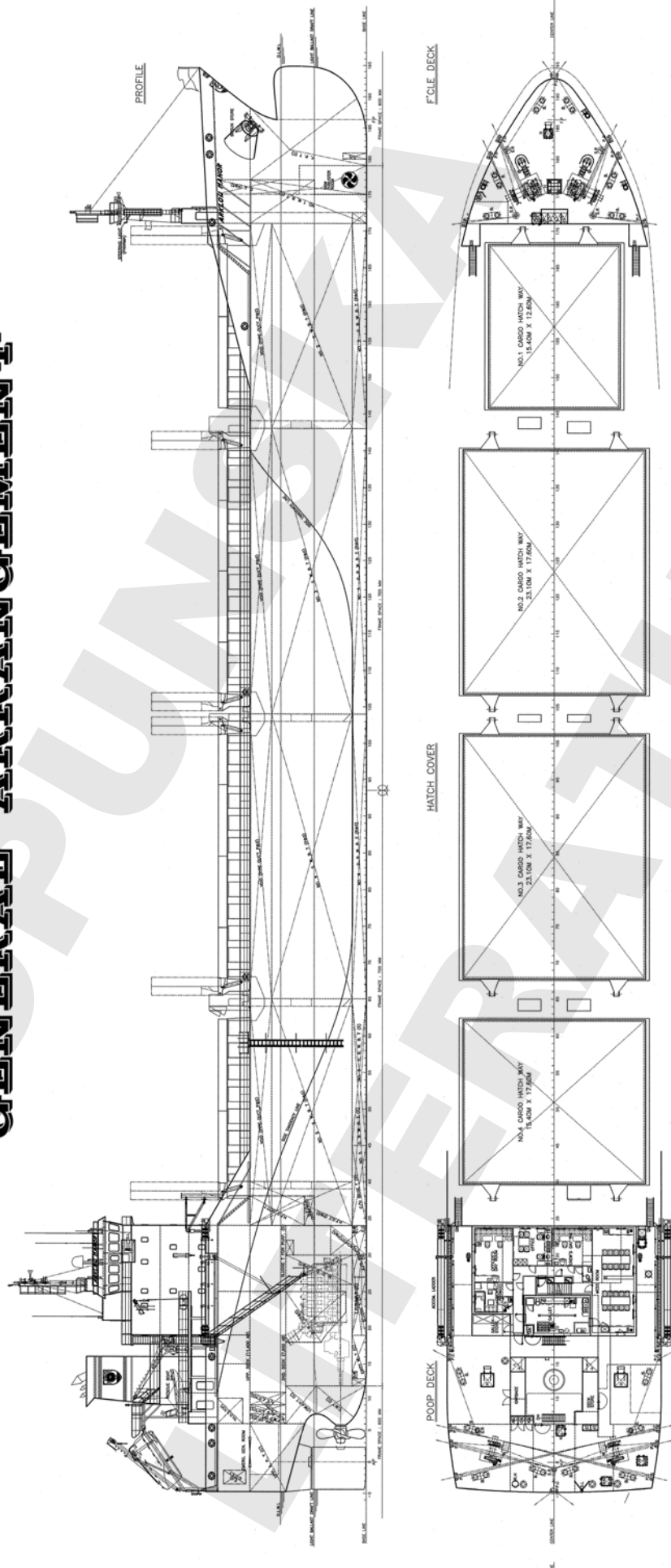


Figure 1: Extract of General Arrangement

The FIC checked that there were two sets of self-contained breathing apparatus (SCBA) on board, and he explained to the chief officer that the recirculation fans were to remain running constantly for 72 hours after the cargo hold had been fumigated. The fans were then to be switched on and off for 8-hour periods throughout the remainder of the passage.

By 1230 (UTC +2) on 20 November, the loading of 13276 tonnes of maize on board *Arklow Meadow* was complete. The temperature of the maize cargo was 10°C and its middle moisture content was 11.5% (**Annex B**).

The FIC returned on board *Arklow Meadow* with several assistants to complete the fumigation operation. Accompanied by the chief officer, an able bodied seaman (AB) and an ordinary seaman (OS), the FIC and his assistants went onto the main deck; respiratory masks were not worn.

The fumigators placed the fumigant on top of the maize cargo in each hold in turn, with the ship's crew closing each hold hatch cover on completion. The fumigant was contained in synthetic fabric retainers or 'socks' (**Figure 2**). The socks were approximately 40cm long and contained about 250g of aluminium phosphide pellets; each pellet weighed 3g. The socks were tied to small diameter polypropylene ropes with between six and eight socks attached to each rope (**Figure 3**). The ropes were laid athwartships across the cargo and tied off by the port hatch coamings. Three ropes of fumigant were used in holds 1 and 4, and five ropes of fumigant were laid in holds 2 and 3 (**Figure 4**). A total of 110 fumigant socks containing 82.5kg of aluminium phosphide tablets were placed on top of the cargo. The FIC calculated that the minimum time required for the fumigant to fully disperse and expire was 168 hours.



Figure 2: Fumigant 'sock' or retainer



Figure 3: Polypropelene rope with fumigant socks attached laid on top of the maize cargo

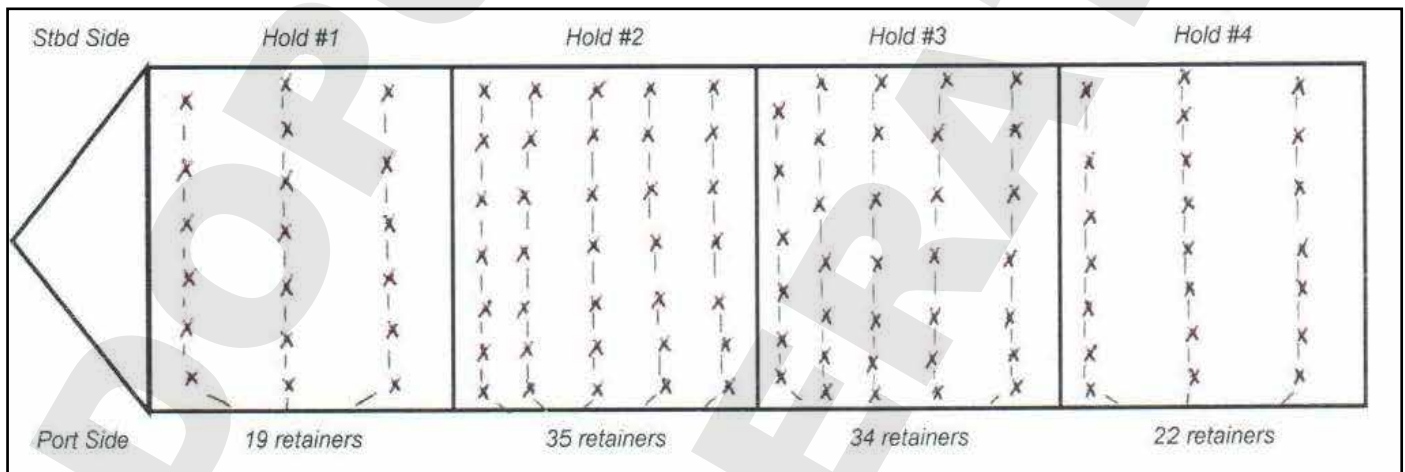


Figure 4: Fumigant retainer plan

When all of the hatches were secured, the FIC placed warning notices by the hold access points (**Figure 5**) and switched on the recirculation fans. The FIC then gave the following documentation (**Annex C**) to the master:

- *In transit fumigation certificate;*
- *Voyage safety check list;*
- *Maintaining safe conditions;*

- *Instruction for aerating the hold;*
- *Fumigation plan;*
- *Hydrogen Phosphide (Phosphine) gas detection procedures;*
- *Statement of hand over responsibility for maintaining safe conditions [sic];*
- *Fumigation safety log; and*
- *Fumigant dosage and quantity plan*



Figure 5: Fumigation warning notice

The FIC also provided written instructions in English for the operation and testing of the bellows hand pump and test tubes. The master signed and gave copies of the documentation to the FIC. The *Instruction For Aerating The Holds* included:

Retrieve used residue-retaining sleeves from the fumigated hold after the surface has been aerated to below 0.3ppm of hydrogen phosphide (PH₃). Use a wire basket or other open-mesh container for collection of the residue-retaining sleeves. Do not confine exposed residue-retaining sleeves by stacking or by placing them in sealed containers. This may lead to a build up of dangerous levels of gas, which could cause flash or cause fire. Keep collected residue-retaining sleeves in dry place in open air away from vent intakes until docking. Arrange with Quarantine Inspection for disposal of residue-retaining sleeves by means and at the site approved by local authority after ship's docking.

On arrival at the discharge port the master should not allow discharge of the cargo to commence until he is satisfied that the cargo has been correctly ventilated and aluminium phosphide residues that can be removed, have been removed and that any other requirements of the discharge port have been met. [sic]

1.2.2 The voyage to Warrenpoint

Arklow Meadow sailed from Nika-Tera at 0700 (UTC+2) on 21 November 2012. The chief officer switched off the re-circulation fans in the cargo holds after they had been operating for 72 hours. He then switched the fans on at 0800 each morning and then off at 1600 each evening. The midday and midnight air temperatures recorded on board during the voyage are shown in **Figure 6**. The daily mean sea temperatures are shown in **Figure 7**.

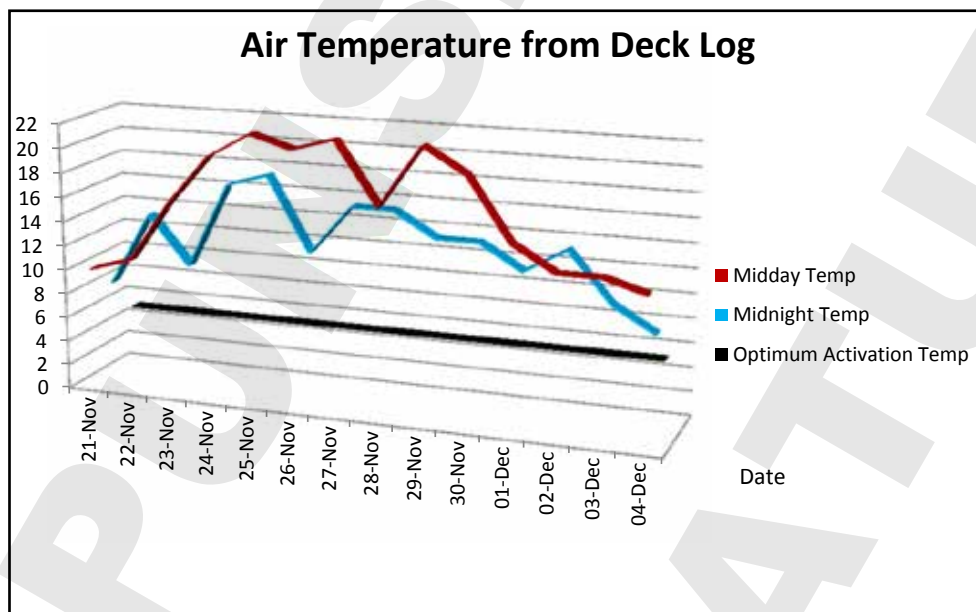


Figure 6: Midday and midnight air temperatures

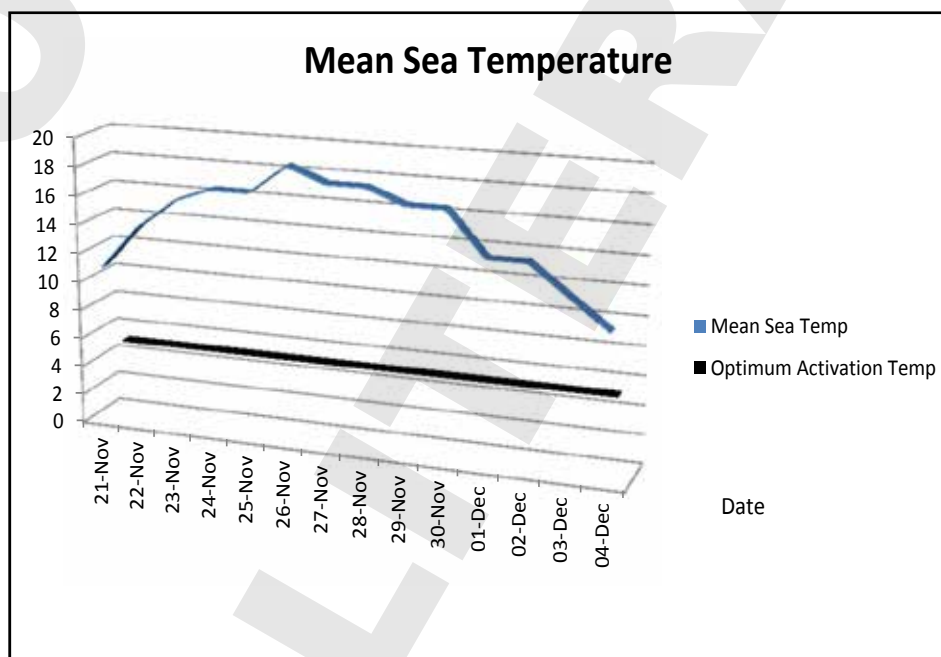


Figure 7: Daily mean sea surface temperature

At 2130 on 4 December 2012, *Arklow Meadow* arrived off Warrenpoint where the master decided to let the vessel drift rather than anchor. *Arklow Meadow*'s agent in Warrenpoint, Samuel Stewarts and Sons of Newry (Stewarts), had been instructed by Soufflet Negcoe via email to "*deal with all aspects of de-fumigation*". Accordingly, Stewarts had advised the Warrenpoint Harbour Authority (WHA) that the vessel was carrying a fumigated cargo. The agent had also, as on previous occasions with other vessels, arranged for an independent consultant to test the atmosphere at the top of the cargo holds before the vessel entered Warrenpoint.

1.2.3 Initial gas tests

At 2250 on 4 December 2012, the consultant boarded *Arklow Meadow* from a pilot boat and explained to the chief officer that he intended to issue two certificates provided the PH³ level was below 0.3ppm. The first certificate would indicate that the cargo was safe to be discharged by persons working outside the hold, and was required before discharge could commence. The second certificate would indicate that the holds were safe to enter and could not be issued until the cargo discharge was complete and the atmosphere in the holds had been re-tested.

Due to intermittent rain, the chief officer and the AB only opened the cargo hatches far enough to enable the consultant to test the atmosphere above the cargo from the observation platforms sited towards the middle of each hold (**Figure 8**). The consultant tested the atmosphere at the top of each hold using a Dräger hand pump. The initial levels of Ph³ detected exceeded 0.3ppm so the cargo hold hatches were left slightly ajar to allow the holds to vent.

While the consultant, the chief officer and the AB waited in the cargo office, the consultant informed the chief officer that not all of the maize cargo was to be discharged at Warrenpoint. The chief officer was unaware of this change and realised that he would have to re-calculate the cargo discharge plan.

At 0025 on 5 December 2013, the consultant re-tested the atmosphere at the top of the four cargo holds. As the levels of PH³ were between 0.0 and 0.2 ppm, the consultant issued an atmospheric gas test certificate (**Annex D**). In addition to the level of PH³, the certificate also included the levels of oxygen and hydrogen sulphide⁴.

The consultant informed the chief officer that it was now safe to discharge the cargo but that he did not know who would be removing the fumigant residue. The hold hatches were then closed due to the intermittent rain. At 0130, a harbour pilot embarked on board *Arklow Meadow* and the consultant disembarked via the pilot boat.

1.2.4 Exposure to fumigant

At 0330 on 5 December 2012, *Arklow Meadow* berthed starboard side to alongside WHA's timber berth. Soon after, the chief officer received confirmation that only 8000t of the cargo was to be discharged at Warrenpoint. As cargo operations were due to start at 0600, the chief officer started to calculate the quantities of cargo to be discharged from each of the holds.

⁴ The consultant initially re-tested the atmosphere at the top of the cargo holds using the test tubes supplied to the vessel in the Ukraine. He was unable to obtain a reading and reverted to the use of his own equipment.



Figure 8: Cargo hold observation platforms

At 0600, the chief officer was still working on his cargo plan but he told the OS keeping the watch on deck that he could start to discharge cargo from holds 2 and 4. Accordingly, the OS opened the hatch cover on hold 4 followed by the hatch cover on hold 2. Two shore cranes were available; one crane was positioned forward to work holds 1 and 2 and the other crane aft to work holds 3 and 4. Both cranes discharged into hoppers. The forward hopper fed a conveyor belt leading to on-site storage sheds; the contents of the aft hopper were loaded into trucks.

Shortly after the cargo discharge had started, the OS was hailed by the aft crane driver working hold 4. The driver had snagged one of the ropes of fumigant with the crane's grab, and he asked the OS to remove the ropes from the top of the cargo. The OS was aware that it was dangerous to touch the fumigant socks so he pulled the polypropylene ropes towards the port side of the hold and then placed the fumigant socks on to the deck.

The OS then went to hold 2, where he noticed a number of the fumigant socks had already been discharged with the cargo. He removed the remaining socks from the top of the hold and put them on to the deck on the port side. As he did so, the socks began to smoke. The OS quickly moved the socks onto the hold's observation platform and the smoke appeared to stop. The OS also moved the fumigant socks taken from hold 4 onto hold 4's observation platform. On completion, the OS went to the cargo office and told the chief officer about what had happened. As the fumigant socks were no longer smoking, the chief officer decided that no further action was necessary.

At 0700, the AB took over from the OS on deck. During the watch handover, the OS informed the AB that the fumigant socks had to be removed from holds 1 and 3 once they were opened.

By 0800, the chief officer had revised his cargo calculations. He went onto the main deck and instructed the AB to stop the cargo discharge from hold 2 and to start discharging from hold 1. The chief officer then left the main deck and told the master about the fumigant socks that had been smoking earlier. Meanwhile, the AB opened the hatch on hold 1 but, before he could remove the fumigant socks, the crane driver started to discharge the cargo.

At approximately 0845, the WHA operations manager arrived at *Arklow Meadow's* berth to monitor the progress of the cargo operations. He quickly noticed a rope and pieces of fabric (which were later identified as socks containing the fumigant) in the forward hopper and instructed a stevedore to remove them. As the stevedore lifted the rope and the fumigant socks clear of the hopper, one the fumigant socks burst open, and its contents spilled on to the ground (**Figure 9**).

1.2.5 Emergency response

The operations manager and a number of stevedores gathered around the spilled residue. They were aware that the maize cargo had been fumigated so the operations manager informed the harbourmaster of the situation via Very High Frequency (VHF) radio. The operations manager also stopped the discharge of cargo from *Arklow Meadow* and instructed the stevedores to cordon off the spillage.



Figure 9: Fumigant socks on the ground

The harbourmaster's office contacted Stewarts, who confirmed that the fumigant used on board *Arklow Meadow* was aluminium phosphide. The harbourmaster researched the properties of the fumigant in the International Maritime Dangerous Goods Code (IMDG code) and then boarded *Arklow Meadow* at 0920.

During discussions with the master, the harbourmaster instructed the AB to collect the socks from the observation platforms by holds 2 and 4 and to put them into a black plastic bag to keep them dry. The plastic bag was then placed on the port side of the main deck adjacent to hold 4.

Soon after, at about 0930, the harbourmaster and *Arklow Meadow*'s master were informed that there was smoke coming from the port side of the vessel's main deck (**Figure 10**). The harbourmaster and master investigated and saw that the smoke was coming from the plastic bag next to hold 4, and that it was increasing in density (**Figure 11**). On the advice of the harbourmaster the vessel was evacuated; sleeping crew were woken and the master and the crew mustered on the quay.

At 0940, WHA alerted the local fire brigade, which arrived 7 minutes later and quickly established a 50 metre cordon around *Arklow Meadow*. Houses and retail premises surrounding the port area were also evacuated by the police as a precautionary measure.

Eight of *Arklow Meadow*'s crew and a stevedore, who had potentially been exposed to PH³, were taken to hospital for observation and decontamination. Four shore workers were also decontaminated on the quay.



Figure 10: Smoke from fumigant socks inside a bag on *Arklow Meadow*'s port side



Figure 11: Denser smoke from bagged fumigant

1.2.6 Disposal of the fumigant

Following the arrival of the fire brigade, fumigators were appointed by both WHA and the cargo receivers to attend the vessel. At 1421, the fumigator appointed by the cargo receivers assumed responsibility for the disposal of the fumigant residues. The fumigator collected 30 socks from beside the shore hopper, 22 socks from inside the plastic bag (10 of which had been reduced to charred remnants); and 34 socks from hold 3. Three socks were also removed from a nearby shed where some of the discharged grain had been stored. The fumigant socks were then neutralised by immersing them in water (**Figure 12**). During this process the fumigant ignited, resulting in the release of a high volume of dense smoke, following which the combusting material was quenched by the fumigator wearing breathing apparatus. The fire brigade left the scene at 1730.

As up to 21 fumigant socks remained unaccounted for, the grain shed was searched the following day. Due to the high level of PH^3 (2.4ppm) detected in the cab of the mechanical grab used during the search, the driver quickly exited and donned breathing apparatus to allow him to continue.

The level of PH^3 in all of *Arklow Meadow's* four cargo holds was found to be very high and, even with the assistance of mechanical ventilation, it still took 5 days for the PH^3 level to reduce to below 0.1ppm (**Figure 13**)



Figure 12: Immersion of fumigant in water

Phosphine levels during forced ventilation

Phosphine (ppm)	Hold 1	Hold 2	Hold 3	Hold 4
Highest Day 1	122	270	150	153
Lowest Day 1	77	174	145	132
Highest Day 3	100	220	176	Gas Free
Lowest Day 3	2	15	76	Gas Free
Highest Day 4	Gas Free	Gas Free	110	
Lowest Day 4	Gas Free	Gas Free	58	
Highest Day 5			Gas Free	
Lowest Day 5			Gas Free	

Figure 13: PH³ readings in the cargo holds

1.3 CREW EXPERIENCE

Arklow Meadow's master was a Polish national and had served mainly on board general cargo vessels throughout his career. He had been a master for over 9 years, first serving on board *Arklow Meadow*, which was the largest vessel that he had commanded, during the summer of 2011. The master held a Polish STCW II/2 Master's Unlimited Certificate of Competency with an Irish Certificate of Equivalent Competency (CEC).

The chief officer was also a Polish national. He was newly promoted and had joined *Arklow Meadow* for the first time in November 2012. However, he had served on one of her sister vessels and was comfortable with the vessel's operation. The chief officer held a Polish STCW II/2 chief officer's Unlimited Certificate of Competency with an Irish CEC. At the time of the incident, the chief officer had been on duty for 13 hours and had achieved 6 hours of rest in the previous 24 hours.

The master and chief officer had previously sailed together and an easy working relationship had developed between them. Both officers had served on board vessels that had carried fumigated cargoes a few times during their careers but not in their current ranks. Neither the master nor chief officer had completed a dangerous goods course or gas testing training beyond the level necessary to obtain their certificates of competency⁵.

1.4 VESSEL SAFETY MANAGEMENT

1.4.1 Safety management

Arklow Meadow was managed by Arklow Shipping, which is based in Arklow, County Wicklow, and operates 44 general cargo vessels. The ship manager's International Management System (ISM) Document of Compliance (DoC) was issued by Bureau Veritas (BV) in November 2010. BV had also issued *Arklow Meadow*'s ISM Safety Management Certificate and her IMDG DoC following vessel audits in 2011.

1.4.2 Fumigation of cargoes

The vessel's safety management system (SMS) included a section titled "fumigation", which stated:

6.1.3 Fumigation of Grain Cargoes

- 1. Advise office immediately*
- 2. Ascertain exact product used and chemical properties*
- 3. Crew precautions*

⁵ The STCW oral examination syllabus for a chief officer includes the stowage, securing and care of cargoes. Knowledge of the IMDG Code and the International Maritime Solid Bulk Cargo Code (IMSBC Code) is included in the deck officer of the watch syllabus and, although not specifically listed in the chief officer's examination, a candidate presenting themselves for a superior certificate is expected to have demonstrated their knowledge in the subjects at previous examinations.

Arklow Meadow's master did not refer to this part of the vessel's SMS when advised that the maize cargo loaded in Nika-Tera was to be fumigated. There was no communication between the master and Arklow Shipping regarding the fumigation of the cargo, and Arklow Shipping was not aware that a fumigated cargo was to be carried.

1.5 WARRENPOINT HARBOUR AUTHORITY

WHA is the statutory harbour authority (SHA) for Warrenpoint⁶. In 2012, the port imported 155 dry cargoes, of which 50 were grain. Two of the grain cargoes were fumigated cargoes; both were imported from the Ukraine. WHA requires vessels carrying fumigated cargoes to be issued with a 'gas free' certificate (regarding the atmosphere at the top of the cargo holds) before berthing alongside. However, the handling of fumigated cargoes or of incidents involving fumigated cargoes is not referred to in the port's operational or emergency procedures.

1.6 THE FUMIGANT

The fumigant used for cargo fumigation is PH_3 , which is generated by compounds such as aluminium phosphide at a ratio of 3:1. General information on aluminium phosphide and PH_3 issued by the Health Protection Agency (HPA) is at **Annexes E and F**. The aluminium phosphide is usually placed in retainers on top of the cargo and emits PH_3 as it decomposes when exposed to moist air. As PH_3 is heavier than air, the gas penetrates down through the cargo and eliminates infestations. Pure PH_3 is odourless and is highly toxic, though it usually smells of garlic or rotting fish due to the inclusion of ammonium carbamates in the product to provide warning. Both aluminium phosphide and PH_3 are listed as dangerous cargoes in the IMDG Code when carried in bulk (IMDG Class 2.3).

In the UK, an 8-hour time weighted average (TWA) exposure limit⁷ of 0.14 mg m^{-3} (0.1ppm), and a short-term exposure limit (STEL)⁸ of 0.28 mg m^{-3} (0.2 ppm) are applied to PH_3 . In some countries, a TWA of 0.3ppm is used. The lower flammable limit (LFL) of PH_3 in air is 1.8% volume (v) by volume in air⁹.

The fumigant used on board *Arklow Meadow* had the brand name of GIN and was licensed for use in the Ukraine. The exposure time required for the fumigant to be effective was dependent on the temperature. The durations recommended by the manufacturer were:

5°C - 10°C: 10 days

11°C - 15 °C: 7 days

⁶ WHA's powers are conferred in The Warrenpoint Harbour Authority Order (Northern Ireland) 2002.

⁷ In the UK, workplace exposure limits under the Control of Substances Hazardous to Health (COSHH) Regulations are subject to a time weighted average which is the maximum average concentration of a chemical in air for a normal 8 hour working day and 40 hour working week.

⁸ The STEL is the maximum average concentration of a chemical in air to which workers can be exposed for a short period (usually 15 minutes).

⁹ The LFL is the lower end of the concentration range over which a flammable mixture of gas or vapour in air can ignite at a given temperature and pressure. The term is frequently interchanged with the term lower explosive limit (LEL).

1.7 UNEXPECTED ACTIVE FUMIGANT

As part of its investigation the MAIB commissioned a fumigation expert at The Food and Environment Research Agency (FERA) to report on the unexpected quantities of active aluminium phosphide in *Arklow Meadow's* cargo holds during the discharge of maize in Warrenpoint. The executive summary of FERA's report (**Annex G**) included:

The smoke generated by the socks on the deck and in the bag indicates the presence of large quantities of residual aluminium phosphide in the socks which produced sufficient phosphine to exceed 1.8% on the wet deck. This suggests that the formulation had not completely broken down.

Three factors have been identified which could have caused a slower than usual release of phosphine resulting in large quantities of residual aluminium phosphide:

- 1. Too much product contained in socks of low volume. This makes it difficult for water vapour present in the air to penetrate to the centre of the sock.*
- 2. Unusually dry commodity causing low relative humidity.*
- 3. Low temperature in maize slowing the production of phosphine.*

It is not possible to determine which the most important factor was in this case. However, the available evidence suggests that both 1 and 2 were significant.

1.8 GUIDANCE ON THE CARRIAGE OF FUMIGATED CARGOES

1.8.1 International guidance

International guidance on fumigation on board ships is contained in MSC Circ 1264 (**Annex H**). The fumigation procedure is explained in detail together with the responsibilities of the master, crew and the FIC. The term FIC is not defined in the circular but is used widely within the industry and is accepted to be the person in charge of the fumigation process.

The recommendations made in the circular include:

- 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, when considering the transport of cargoes that may be infested.*
- 3.3.2.2 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 has handed responsibility to the master (see 3.3.2.12); and

- .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.*

3.3.2.6 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 the 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.*

3.3.2.15 If it is essential to ventilate a cargo hold or holds, every effort should be made to prevent a fumigant from accumulating in accommodation or working areas. Those spaces should be carefully checked to that effect...

3.3.2.16 Prior to the arrival of the ship, generally not less than 24 hours in advance, the master should inform the appropriate authorities of the country of destination and ports of call that fumigation in transit is being carried out. The information should include the type of fumigant used, the date of fumigation, the cargo holds which have been fumigated, and whether ventilation has commenced...

3.3.2.17 On arrival at the port of discharge the requirements of receiving countries regarding the handling of fumigated cargoes should be established. Before entry of fumigated cargo holds, trained personnel from a fumigation company or other authorized persons, wearing respiratory protection, should carry out careful monitoring of the spaces to ensure the safety of personnel. The monitored values should be recorded in the ship's log-book. In case of need or emergency the master may commence ventilation of the fumigated cargo holds under the conditions

of 3.3.2.15, having due regard for the safety of personnel on board. If this operation is to be done at sea, the master should evaluate weather and sea conditions before proceeding.

3.3.2.18 Only mechanical unloading that does not necessitate entry of personnel into the cargo holds of such fumigated cargoes should be undertaken....

3.3.2.19 During the final stages of discharge, when it becomes necessary for personnel to enter the cargo holds, such entry should only be permitted subsequent to verification that such cargo holds are gas-free.

1.8.2 UK guidance

The Maritime and Coastguard Agency (MCA) has issued recommendations for ships carrying fumigated bulk cargoes in Marine Guidance Note (MGN) 284 (M+F) (**Annex I**). The main points of the MGN are:

- 2.1 There may be an incorrect assumption that the concentration of toxic fumigant in the holds and access ways of the ship is sufficiently low to avoid safety and health risks to ship and shore personnel or enforcement officers when the ship arrives in the port of discharge.*
- 2.2 There are reported incidents where employees have been exposed to the fumigant, usually phosphine, causing health problems; and*
- 2.3 Ships containing bulk cargo under fumigation, unlike in container transport units (CTUs), have no requirement to be labelled as such, and therefore may not be visibly recognised as a potential health and safety risk. It should be noted that there is a requirement in the 'Code of Practice for Merchant Seamen' to ensure that fumigation warning signs are conspicuously displayed on cargo units or spaces under fumigation.*

In August 1998, the MCA issued conditions and recommendations on the safe use of pesticides in ships in Merchant Shipping Notice (MSN) 1718 (M) (**Annex J**) and MGN 86 (M) (**Annex K**) respectively. MSN 1718 (M) states, inter alia:

- 1. Where fumigation in transit is undertaken on short sea voyages, it is likely that the fumigant tablets may not have fully decomposed before arrival at the discharge port. In such cases, when the presence of personnel in cargo spaces is required, it is important that adequate respiratory protection (e.g. self-contained compressed air breathing apparatus) is worn until all fumigant residues have been removed and the spaces have been thoroughly vented.*
- 2. Responsibility for the fumigation process, including, if appropriate, the provision of means to remove any residues, lies with the fumigator. However, where fumigation in transit is to take place, the responsibility to provide safe working conditions on board ship rests with the master. He must ensure that at least two members of his crew including one officer have received appropriate training...*

3. *If fumigant tablets are applied to a cargo in a retrievable form, their residues, whether completely spent or not, must be immediately removed from the cargo spaces upon arrival at the discharge port...*
4. *Some of the gases and other agents commonly used for fumigation are flammable and, unless used strictly in accordance with manufacturer's instructions, may create a fire hazard...*

MGN 86 (M) highlights:

In one case, failure to comply with the recommended procedures caused a number of people to be hospitalised after exposure to phosphine gas generated in a cargo of grain fumigated with Aluminium Phosphide during the sea passage. The fumigant tablets were not fully decomposed and, hence, the fumigation process was not fully completed before the vessel arrived at the discharge port...

1.9 FUMIGATION TRAINING

There are no international training standards or minimum qualifications required by fumigators. In the UK, a competent fumigator is generally recognised to be a person who has completed a training programme organised by a recognised industry body such as the British Pest Control Association (BPCA). BPCA's training programme consists of two parts: a generic course on basic fumigation procedures followed by more detailed training in specific areas such as ships and cargoes.

1.10 PORT SAFETY

1.10.1 Port Marine Safety Code

The Port Marine Safety Code (PMSC) was established following a review of the Pilotage Act in 1998. The PMSC provides a national standard in the UK for every aspect of port marine safety and aims to enhance safety for those who work in ports, their ships, passengers and the environment. The PMSC applies to all harbour authorities in the UK that have statutory powers and duties, and includes:

- 5.10. *A harbour master also has powers to prohibit the entry into a harbour of any vessel carrying dangerous goods, if the condition of those goods, or their packaging, or the vessel carrying them is such as to create a risk to health and safety, and to control similarly the entry on to dock estates of dangerous substances brought from inland. The harbour master also has powers to regulate the movement of vessels carrying dangerous goods. Prior notice must be given to bring dangerous substances into a harbour area from sea or inland. The period of notice is normally 24 hours, although the harbour master has some powers of discretion on both the period and form of the notice. Harbour authorities have a duty to prepare emergency plans for dealing with dangerous substances.*

1.10.2 Guide to Good Practice on Port Marine Operations

The Guide to Good Practice on Port Marine Operations (The Guide), which supplements the PMSC, was developed by representatives of the port industry, the Department for Transport (DfT) and the MCA. The Guide contains information and provides general guidance on how harbour authorities can comply with the PMSC, including their responsibilities for emergency preparedness and response.

1.10.3 The Dangerous Substances in Harbour Areas Regulations 1987

The Dangerous Substances in Harbour Areas Regulations (DSHAR) apply to every harbour and harbour area in Great Britain. They require harbour authorities, among other things, to prepare and keep up to date an effective emergency plan for dealing with emergencies which involve dangerous substances that are brought into or handled in the harbour.

The regulations apply to or are in relation to any dangerous substance, with exceptions. Among the exceptions listed is:

1. (2) (c) *a dangerous substance when carried –*
 - (iii) *by a vessel as a result of a fumigant*

1.11 PREVIOUS SIMILAR ACCIDENTS

The MAIB is aware of a number of incidents since 1990 in which vessels carrying fumigated cargoes have arrived in UK ports with unexpectedly high levels of PH³ in the cargo holds and have required several days of mechanical ventilation before the cargo was safe to be discharged. However, it is possible that many other similar incidents have not been reported.

In 2008 a crewman on board the cargo ship *Monika*¹⁰ was found dead in his cabin. The vessel was carrying a fumigated grain cargo, and pinholes were found in the cabin deck where it overhung the cargo hold. The crewman had died from PH³ poisoning and the MAIB issued a safety flyer to remind mariners and fumigation authorities and companies of the requirements of the IMO's recommendations on the 'Safe Use of Pesticides on Ships'. It also highlighted the importance of regular testing for fumigant gas in accommodation and other spaces on passage as any characteristic smell can be easily masked.

On 21 December 2010 16 crew members fell ill and were evacuated from the bulk carrier *Hermann Schoening* on Lake Erie, Canada. The vessel was carrying a grain cargo which had been fumigated with aluminium phosphide in Milwaukee, USA. The crew were affected by dangerous levels of PH³, which it is reported had escaped from a cargo hold into a conduit and had been circulated in the crew's accommodation.

¹⁰ http://www.maib.gov.uk/publications/completed_preliminary_examinations/completed_preliminary_examinations_2008/monika.cfm

SECTION 2 - ANALYSIS

2.1 AIM

The purpose of the analysis is to determine the contributory causes and circumstances of the accident as a basis for making recommendations to prevent similar accidents occurring in the future.

2.2 FUMIGANT ACTIVITY

Five hours before the discharge of *Arklow Meadow*'s maize cargo was started, the level of PH^3 in the atmosphere at the top of the cargo holds was measured to be less than 0.2ppm. As a consequence, a certificate was issued indicating that it was safe to discharge the cargo (**Annex D**).

However, the smoke emitted from the socks removed from the cargo holds (**Figure 10**) when they came into contact with the wet decks, along with the high levels of PH^3 that were subsequently recorded in the holds (**Figure 13**) and in the shore grain store (**Paragraph 1.2.6**), show that the fumigant on board *Arklow Meadow* was still very active. The atmospheric readings obtained from the tops of the cargo holds prior to discharge were therefore misleading.

It is evident from the exposure times recommended by the manufacturer of the aluminium phosphide used on board *Arklow Meadow* (**Paragraph 1.6**), that temperature is a key factor in the speed and effectiveness of the fumigant in generating PH^3 in cargoes in transit. In this case, the temperature of the maize cargo was 10°C when loaded on board *Arklow Meadow*, and the air and sea temperatures generally remained above this temperature during the vessel's 14 day voyage (**Figures 6 and 7**). Therefore, although the FIC's estimate, that the exposure time required was 7 days, was possibly optimistic, the aluminium phosphide should nevertheless have been fully broken down and inactive by the time the vessel arrived off Warrenpoint if its decay was dependent on temperature alone.

FERA's report on the unexpected quantities of active aluminium phosphide found on board *Arklow Meadow* (**Annex G**) identified that, in addition to the temperature of the cargo, too much aluminium phosphide in the socks and the low relative humidity in the hold could also have been significant in slowing the release of PH^3 during the voyage.

Fumigant pellets are designed to react with moist air to produce phosphine. However, the fumigant pellets on board *Arklow Meadow* were tightly packed in the synthetic fabric socks (**Figure 2**) and it is likely that the pellets towards the centre of the socks had little or no exposure to the water vapour in the atmosphere until they were agitated when the socks were moved either by hand or by the crane grab. Furthermore, as the maize cargo had a middle moisture content of 11.5%, it was relatively dry (in the UK, grain cargoes are stored with a middle moisture content of around 14.5%) and the resulting relative humidity in the sealed cargo holds was possibly too low to trigger the generation of PH^3 .

2.3 ONBOARD PROCEDURES AND ACTIONS

The actions taken on board *Arklow Meadow* during the voyage to Warrenpoint and after her arrival show that neither the vessel's master nor her crew were aware of their responsibilities or of the risks involved when carrying a fumigated cargo. Despite the documentation and instructions provided by the FIC in Nika-Tera being comprehensive (**Annexes A and C**), and the master and chief officer having some previous experience in the carriage of fumigated cargoes, a number of safety-related actions were either not completed or were not completed correctly. In particular:

- The master was not involved in the decision to carry a fumigated cargo and he had not discussed the intended 'fumigation in transit' as required by the vessel's SMS.
- The crew was not briefed on the fumigation process.
- The chief officer was not familiar with the use of the bellows hand pump and test tubes in the test kit, and therefore the atmosphere in the crew accommodation and working areas was not tested periodically.
- The re-circulation fans in the cargo holds were not operated as instructed.
- The crew working on the deck did not wear respiratory masks when the atmosphere at the top of the cargo holds was being tested or when the cargo holds were being vented.
- The fumigant residue was not removed from the cargo holds until after the discharge of the maize cargo had started.
- The fumigant residue removed from the holds by the crew was not correctly handled.
- Other than moving fumigant socks from the deck to the hold's observation platform, no action was taken when the socks first started to smoke.
- No action was taken when it became clear that some fumigant socks had been discharged with the maize cargo.

With the fumigant still active, the failure to remove the fumigant residues from the cargo holds before cargo operations were started, and the subsequent incorrect handling of the fumigant residue that was eventually removed, resulted in the ship's crew and shore workers being exposed to high levels of PH³. The consequences of the crew's actions were that fumigant socks were inadvertently distributed into the shore hoppers and potentially into the food chain, and the fumigant socks that were placed onto the wet deck and then into the confines of a plastic bag soon reached their LFL and started to smoke.

It is evident that the chief officer was either not shown the instructions given to the master by the FIC in Nika-Tera (**Annex C and Paragraph 1.2.1**) or that he did not read or understand them. However, it is possible that the chief officer's decision-making in Warrenpoint was affected to some degree by a lack of sleep prior to the start of cargo operations, a reliance on the atmospheric test certificate issued by the consultant prior to the vessel's arrival, and a pre-occupation with

making the short notice changes to his stowage calculations. Nonetheless, as the smoking fumigant was unexpected, it should have at least triggered the chief officer into suspending the cargo discharge and investigating the matter further.

The fatality on board *Monika* in 2008 and the injuries to the crew on board *Hermann Schoening* in 2010, both of which were due to exposure to PH³ in accommodation areas, demonstrate that the dangers posed by fumigated cargoes cannot be underestimated. Therefore, notwithstanding the apparent infrequency with which the crew had carried fumigated cargoes, the ignorance of the fumigation process shown by *Arklow Meadow*'s master and chief officer, and the scant nature of the guidance provided in the vessel's SMS manual (**Paragraph 1.4.2**), are of concern.

2.4 PORT PROCEDURES AND ACTIONS

WHA reacted quickly to the discovery of active fumigant in *Arklow Meadow*'s maize cargo. On seeing that fumigant had been discharged into the shore hoppers, the port's operations manager and harbourmaster took a number of logical and positive steps which helped to limit the exposure of persons to the fumigant. These included: the immediate stopping of the cargo operations; the cordoning off of the burst fumigant sock; the call to the ship's agent to confirm the fumigant used; the reference to the IMDG Code to determine the hazards posed by PH³; and, the alerting of the fire brigade.

Nevertheless, that the stevedores discharged fumigant retainers into the shore hoppers, the means by which they were moved from the hoppers, and the placing of fumigant retainers in a plastic bag, all indicate that the hazards associated with fumigated cargoes had not been specifically considered in WHA's procedures and emergency plans.

Poor harvests in the UK over the last 2 years have led to an increase in imported grain cargoes and a corresponding increase in fumigated cargoes. This trend may continue but, as identified during this investigation, many ports other than Warrenpoint, which occasionally accept fumigated grain cargoes, have yet to implement procedures and emergency plans specifically dealing with this cargo type. Although fumigated cargoes are exempted from the requirements of DSHAR, this and previous accidents and incidents (**Paragraph 1.11**) indicate that UK ports must be prepared to deal with the threat fumigant poses to the health of ships' crews, port workers and to other persons in close proximity. In line with the spirit of the PMSC this should be achieved through the development of procedures and emergency plans which should take into account, inter alia, the suitability of berths, the approval of fumigators, the disposal of fumigant (active and expired) and the briefing of shore workers.

2.5 THE FUMIGATOR IN CHARGE

The consultant who tested the atmosphere at the top of the cargo holds when *Arklow Meadow* arrived off Warrenpoint, and then confirmed that it was safe to discharge the maize cargo from outside the holds, was not a qualified fumigator. He had not been contracted to de-fumigate the vessel and the certificate that he issued (**Annex B**) did not take into account that the fumigant socks inside the hold could still be active when agitated or when coming into contact with moisture. The certificate was based solely on a snapshot of the atmosphere at the top of the holds and, as such, it was misleading.

Prior to discharging fumigated cargoes, it is logical that masters and port authorities are able to verify that the persons certifying that it is safe to work the cargo are qualified to do so. In this case, the consultant was not suitably qualified to de-fumigate the vessel as requested by the cargo's shippers but he had been engaged by the ship's agent in line with its usual practice. As a result, his presence on board provided a false sense of security to both the ship's master and the WHA.

In the absence of internationally recognised qualifications for fumigators, the provision of suitably qualified fumigators is potentially difficult to achieve in many countries. To try and establish common high standards, the International Maritime Fumigation Organisation (IMFO) was formed by a number of fumigation companies in 1994. IMFO champions the "Port to Port" service, in which the FIC at the load port communicates directly with the FIC at the discharge port to provide a seamless service. In extreme cases, an FIC may travel with the vessel from the load port to the discharge port.

However, such services are only optional. In the UK, where fumigator training is regulated and controlled by the BPCA, it should be possible for port authorities to maintain a list of fumigators who have successfully completed both the generic and ship-specific sections of the association's training programme, and who are aware of the applicable national regulations and are approved to work in their port areas. The establishment and use of a list of 'approved' fumigators would give assurance to both ports and masters alike.

2.6 REGULATION AND GUIDANCE

The recommendations contained in MSC Circ. 1264 (**Annex H**) have been widely promulgated and are available in various publications such as the IMDG Code. Although the recommendations lack some detail with regard to de-fumigation, particularly the removal of fumigant residues, this aspect of the fumigation process is clarified in MSN 1718 (**Annex J**) and MGNs 86 and 284 (**Annexes K and I**).

However, the statement in MSN 1718 that where fumigation is undertaken on short sea voyages the fumigant might not fully decompose is potentially misleading. The circumstances of this case and the findings of the FERA report (**Annex G**) demonstrate that the release of PH³ is dependent on factors other than temperature, such as the tightness of packing and the relative humidity. Therefore, fumigant can remain active after longer voyages, not just short sea voyages.

Moreover, although MSN 1718 and MGNs 86 and 284 are clear, it is unfortunate that the information and requirements they contain is spread over the three notices. The notices overlap to some degree, but all must be read to gain a proper understanding of fumigated cargoes and the safe use of pesticides in ships. In addition, the notices provide little practical advice regarding the development of port procedures or emergency plans, or on the suitability of a fumigator's qualifications and training in the UK. In view of these observations, a review and consolidation of these notices is warranted.

SECTION 3 - CONCLUSIONS

3.1 SAFETY ISSUES DIRECTLY CONTRIBUTING TO THE ACCIDENT THAT HAVE BEEN ADDRESSED OR RESULTED IN RECOMMENDATIONS

1. The low levels of PH³ detected at the tops of the cargo holds prior to the discharge of the maize cargo, and the issue of a certificate indicating that it was safe to work the cargo from outside the holds, were misleading. [2.2]
2. When the cargo discharge was started, the fumigant on top of the maize was still active, probably due to the way it was packed together with the low humidity in the cargo holds during the vessel's voyage from the Ukraine. [2.2]
3. Neither the vessel's master nor her crew were aware of their responsibilities or of the risks involved when carrying a fumigated cargo, and a number of safety-related actions were either not completed or were not completed correctly. [2.3]
4. The failure to remove the fumigant residues from the cargo holds before cargo operations were started, and the subsequent incorrect handling of the fumigant residue that was eventually removed, were pivotal to the exposure of the ship's crew and shore workers to high levels of PH³. [2.3]
5. The ignorance of the fumigation process shown by *Arklow Meadow*'s master and chief officer and the scant nature of the guidance provided in the vessel's SMS manual are of concern. [2.3]
6. WHA had not specifically considered the hazards connected with the handling of ship's discharging fumigated cargoes in its procedures and emergency plans. [2.4]
7. Many UK ports which accept fumigated grain cargoes have yet to implement procedures and emergency plans specifically dealing with this cargo type. [2.4]
8. The consultant who tested the atmosphere at the top of the cargo holds when *Arklow Meadow* arrived off Warrenpoint, and then confirmed that it was safe to discharge the maize cargo from outside the holds, was not a qualified fumigator. [2.5]
9. The establishment and use of a list of 'approved' fumigators would give assurance to both ports and masters alike. [2.5]
10. The requirements and guidance published by the MCA on fumigated cargoes and the safe use of pesticides include only temperature as the key factor in fumigant decay and provide little advice regarding the provision of qualified fumigators or the development of port procedures and emergency plans. [2.6]

SECTION 4 - ACTION TAKEN

4.1 ACTION TAKEN BY THE MAIB

The MAIB has issued a safety flyer to the shipping industry highlighting the circumstances of this accident and the lessons to be learned (**Annex L**).

4.2 ACTION TAKEN BY OTHER ORGANISATIONS

Arklow Shipping has:

- Completed its own investigation into the accident.
- Revised its risk assessments to include fumigation operations.
- Provided clear instructions for masters and crew for fumigation of cargoes within its SMS.

The British Pest Control Association has:

Undertaken to maintain a list of UK-trained fumigators who are qualified to be a 'fumigator in charge' on board vessels carrying fumigated cargoes, and to make the professional details of these fumigators available, on request, to interested bodies such as port authorities, ships' agents and charterers.

SECTION 5 - RECOMMENDATIONS

The **Maritime and Coastguard Agency** is recommended to:

2013/225 In consultation with the Health and Safety Executive, the Port Skills and Safety Organisation, and other industry bodies as appropriate, review, consolidate and reissue the guidance provided to UK stakeholders on the loading, carriage and discharge of fumigated cargoes to highlight the importance of:

- The potential for a fumigant to remain active due to factors such as temperature, relative humidity, voyage length, and fumigant method.
- The retention of suitably trained and qualified fumigators at both the load and discharge ports.
- Ships' crews being aware of their responsibilities.
- UK port authorities having robust procedures and contingency plans when receiving vessels with fumigated cargoes.

The **United Kingdom Major Ports Group** and the **British Ports Association** are recommended to:

2013/226 Through its Marine and Pilotage Working Group, develop a revision of the Guide to Good Practice on Port Marine Operations to reflect the revised guidance to be issued by the MCA, and in the meantime ensure that ports are aware of:

- The potential dangers posed by fumigants.
- The importance of suitably qualified fumigators certifying, where applicable, that the cargo can be safely discharged and that all fumigant has been removed and safely disposed of.
- The importance of developing procedures and emergency plans to cover the inadvertent or unexpected release of fumigant from a fumigated cargo.

Safety recommendations shall in no case create a presumption of blame or liability



IMO

E

Ref. T3/1.01

MSC.1/Circ.1264
27 May 2008

**RECOMMENDATIONS ON THE SAFE USE OF PESTICIDES IN SHIPS
APPLICABLE TO THE FUMIGATION OF CARGO HOLDS**

- 1 The Maritime Safety Committee, at its sixty-second session (24 to 28 May 1993), approved the Recommendations on the safe use of pesticides in ships (MSC/Circ.612), proposed by the Sub-Committee on Containers and Cargoes at its thirty-second session.
- 2 The Maritime Safety Committee, at its eighty-fourth session (7 to 16 May 2008), approved the Recommendations on the safe use of pesticides in ships applicable to the fumigation of cargo holds, which apply to carriage of solid bulk cargoes including grain in pursuance of the requirement of SOLAS regulation VI/4, proposed by the Sub-Committee on Dangerous Goods, Solid Cargoes and Containers at its twelfth session, set out in the annex.
- 3 The Committee agreed that the Recommendations should not apply to the carriage of fresh food produce under controlled atmosphere.
- 4 Member Governments are invited to bring the Recommendations to the attention of competent authorities, mariners, fumigators, fumigant and pesticide manufacturers and others concerned.
- 5 The present circular supersedes MSC/Circ.612, as amended by MSC/Circ.689 and MSC/Circ.746 with regard to the fumigation of cargo holds.

ANNEX

RECOMMENDATIONS ON THE SAFE USE OF PESTICIDES IN SHIPS APPLICABLE TO THE FUMIGATION OF CARGO HOLDS

1 INTRODUCTION

1.1 Insect and mite pests of plant and animal products may be carried into the cargo holds with goods (introduced infestation); they may move from one kind of product to another (cross-infestation) and may remain to attack subsequent cargoes (residual infestation). Their control may be required to comply with phytosanitary requirements to prevent spread of pests and for commercial reasons to prevent infestation and contamination of, or damage to, cargoes of human and animal food both raw and processed materials. Although fumigants may be used to kill rodent pests, the control of rodents on board ships is dealt with separately. In severe cases of infestation of bulk cargoes such as cereals, excessive heating may occur.

1.2 The following sections provide guidance to shipmasters in the use of pesticides* with a view to safety of personnel. They cover pesticides used for the control of insect** and rodent pests in empty and loaded cargo holds.

2 PREVENTION OF INFESTATION

2.1 Maintenance and sanitation

2.1.1 Ship cargo holds, tank top ceilings and other parts of the ship should be kept in a good state of repair to avoid infestation. Many ports of the world have rules and by-laws dealing specifically with the maintenance of ships intended to carry grain cargoes; for example, boards and ceilings should be completely grain-tight.

2.1.2 Cleanliness, or good housekeeping, is as important a means of controlling pests on a ship as it is in a home, warehouse, mill or factory. Since insect pests on ships become established and multiply in debris, much can be done to prevent their increase by simple, thorough cleaning. Box beams and stiffeners, for example, become filled with debris during discharge of cargo and unless kept clean can become a source of heavy infestation. It is important to remove thoroughly all cargo residue from deckhead frames and longitudinal deck girders at the time of discharge, preferably when the cargo level is suitable for convenient cleaning. Where available, industrial vacuum cleaners are of value for the cleaning of cargo holds and fittings.

2.1.3 The material collected during cleaning should be disposed of, or treated, immediately so that the insects cannot escape and spread to other parts of the ship or elsewhere. In port it may be burnt or treated with a pesticide, but in many countries such material may only be landed under phytosanitary supervision. If any part of the ship is being fumigated the material may be left exposed to the gas.

* The word *pesticide* as used throughout the text means fumigants. Examples of some commonly used pesticides are listed in appendix 1.

** The word *insect* as used throughout the text includes mites.

2.2 Main sites of infestation

2.2.1 *Tank top ceiling*: If, as often happens, cracks appear between the ceiling boards, food material may be forced down into the underlying space and serve as a focus of infestation for an indefinite period. Insects bred in this space can readily move out to attack food cargoes and establish their progeny in them.

2.2.2 *'Tween-deck centre lines, wooden feeders and bins* are often left in place for several voyages and because of their construction are a frequent source of infestation. After unloading a grain cargo, burlap and battens covering the narrow spaces between the planks should be removed and discarded before the holds are cleaned or washed down. These coverings should be replaced by new material in preparation for the next cargo.

2.2.3 *Transverse beams and longitudinal deck girders* which support the decks and hatch openings may have an L-shaped angle-bar construction. Such girders provide ledges where grain may lodge when bulk cargoes are unloaded. The ledges are often in inaccessible places overlooked during cleaning operations.

2.2.4 *Insulated bulkheads near engine-rooms*: When the hold side of an engine-room bulkhead is insulated with a wooden sheathing, the airspace and the cracks between the boards often become filled with grain and other material. Sometimes the airspace is filled with insulating material which may become heavily infested and serves as a place for insect breeding. Temporary wooden bulkheads also provide an ideal place for insect breeding, especially under moist conditions, such as when green lumber is used.

2.2.5 *Cargo battens*: The crevices at the sparring cleats are ideal places for material to lodge and for insects to hide.

2.2.6 *Bilges*: Insects in accumulations of food material are often found in these spaces.

2.2.7 *Electrical conduit casings*: Sometimes the sheet-metal covering is damaged by general cargo and when bulk grain is loaded later, the casings may become completely filled. This residual grain has often been found to be heavily infested. Casings that are damaged should be repaired immediately or, where possible, they should be replaced with steel strapping, which can be cleaned more easily.

2.2.8 Other places where material accumulates and where insects breed and hide include:

The area underneath burlap, which is used to cover limber boards and sometimes to cover tank top ceilings.

Boxing around pipes, especially if it is broken.

Corners, where old cereal material is often found.

Crevices at plate landings, frames and chocks.

Wooden coverings of manholes or wells leading to double-bottom tanks or other places.

Cracks in the wooden ceiling protecting the propeller shaft tunnel.

Beneath rusty scale and old paint on the inside of hull plates.

Shifting boards.

Dunnage material, empty bags and used separation cloths.

Inside lockers.

3 CHEMICAL CONTROL OF INSECT INFESTATION

3.1 Methods of chemical disinfection

3.1.1 *Types of pesticides and methods of insect control*

3.1.1.1 To avoid insect populations becoming firmly established in cargo holds and other parts of a ship, it is necessary to use some form of chemical toxicant for control. The materials available may be divided conveniently into two classes: contact insecticides and fumigants. The choice of agent and method of application depend on the type of commodity, the extent and location of the infestation, the importance and habits of the insects found, and the climatic and other conditions. Recommended treatments are altered or modified from time to time in accordance with new developments.

3.1.1.2 The success of chemical treatments does not lie wholly in the pesticidal activity of the agents used. In addition, an appreciation of the requirements and limitations of the different available methods is required. Crew members can carry out small-scale or “spot” treatments if they adhere to the manufacturer’s instructions and take care to cover the whole area of infestation. However, extensive or hazardous treatments including fumigation and spraying near human and animal food should be placed in the hands of professional operators, who should inform the master of the identity of the active ingredients used, the hazards involved and the precautions to be taken.

3.1.2 *Fumigants*

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. Additional information is provided on two of the most widely used fumigants, Methyl bromide and Phosphine, in appendix 1.

3.1.2.2 Since fumigant gases are poisonous to humans and require special equipment and skills in application, they should be used by specialists and not by the ship’s crew.

3.1.2.3 Evacuation of the space under gas treatment is mandatory and in some cases it will be necessary for the whole ship to be evacuated (see 3.3.1 and 3.3.2 below).

3.1.2.4 A “fumigator-in-charge” should be designated by the fumigation company, government agency or appropriate authority. He should be able to provide documentation to the master proving his competence and authorization. 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, and in view of the highly toxic nature of all commonly used fumigants these should be followed carefully. Such instructions should be written in a language readily understood by the master or his representative.

3.2 Disinfestation of empty cargo holds

3.2.1 An empty cargo hold may be fumigated. Examples of some commonly used pesticides are listed in appendix 1. (For precautions before, during and after fumigation of cargo holds see 3.3 below.)

3.3 Disinfestation of cargoes and surrounds

3.3.1 *Fumigation with aeration (ventilation) in port*

3.3.1.1 Fumigation and aeration (ventilation) of empty cargo holds should always be carried out in port (alongside or at anchorage). Ships should not be permitted to leave port until gas-free certification has been received from the fumigator-in-charge.

3.3.1.2 Prior to the application of fumigants to cargo holds, the crew should be landed and remain ashore until the ship is certified "gas-free", in writing, by the fumigator-in-charge or other authorized person. During this period a watchman should be posted to prevent unauthorized boarding or entry, and warning signs should be prominently displayed at gangways and at entrances to accommodation. A specimen of such a warning sign is given in appendix 2.

3.3.1.3 The fumigator-in-charge should be retained throughout the fumigation period and until such time as the ship is declared gas-free.

3.3.1.4 At the end of the fumigation period the fumigator will take the necessary action to ensure that the fumigant is dispersed. If crew members are required to assist in such actions, for example in opening hatches, they should be provided with adequate respiratory protection and adhere strictly to instructions given by the fumigator-in-charge.

3.3.1.5 The fumigator-in-charge should notify the master in writing of any spaces determined to be safe for re-occupancy by essential crew members prior to the aeration of the ship.

3.3.1.6 In such circumstances the fumigator-in-charge should monitor, throughout the fumigation and aeration periods, spaces to which personnel have been permitted to return. Should the concentration in any such area exceed the occupational exposure limit values set by the flag State regulations, crew members should be evacuated from the area until measurements show re-occupancy to be safe.

3.3.1.7 No unauthorized persons should be allowed on board until all parts of the ship have been determined gas-free, warning signs removed and clearance certificates issued by the fumigator-in-charge.

3.3.1.8 Clearance certificates should only be issued when tests show that all residual fumigant has been dispersed from empty cargo holds and adjacent working spaces and any residual fumigant material has been removed.

3.3.1.9 Entry into a space under fumigation should never take place except in the event of an extreme emergency. If entry is imperative the fumigator-in-charge and at least one other person should enter, each wearing adequate protective equipment appropriate for the fumigant used and a safety harness and lifeline. Each lifeline should be tended by a person outside the space, who should be similarly equipped.

3.3.1.10 If a clearance certificate cannot be issued after the fumigation of cargo in port, the provisions of 3.3.2 should apply.

3.3.2 *Fumigation continued in transit*

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. Due consideration should be taken of this when assessing the options of fumigation. The master should be aware of the regulations of the flag State Administration with regard to in-transit fumigation. The application of the process should be with the agreement of the port State Administration. The process may be considered under two headings:

- .1 fumigation in which treatment is intentionally continued in a sealed space during a voyage and in which no aeration has taken place before sailing; and
- .2 in-port cargo fumigation where some aeration is carried out before sailing, but where a clearance certificate for the cargo hold(s) cannot be issued because of residual gas and the cargo hold(s) has been re-sealed before sailing.

3.3.2.2 Before a decision on sailing with a fumigated cargo hold(s) is made it should be taken into account that, due to operational conditions, the circumstances outlined in 3.3.2.1.2 may arise unintentionally, e.g., a ship may be required to sail at a time earlier than anticipated when the fumigation was started. In such circumstances the potential hazards may be as great as with a planned in-transit fumigation and all the precautions in the following paragraphs should be observed.

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 has handed over that responsibility to the master (see 3.3.2.12); and
- .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.

3.3.2.5 Accommodation, engine-rooms, areas designated for use in navigation of the ship, frequently visited working areas and stores, such as the forecastle head spaces, adjacent to cargo holds being subject to fumigation in transit should be treated in accordance with the provisions of 3.3.2.13. Special attention should be paid to gas concentration safety checks in problem areas referred to in 3.3.2.4.

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.

3.3.2.8 The fumigator-in-charge should notify the master in writing of the spaces containing the cargo to be fumigated and also of any other spaces that are considered unsafe to enter during the fumigation. During the application of the fumigant the fumigator-in-charge should ensure that the surrounding areas are checked for safety.

3.3.2.9 If cargo holds are to be fumigated in transit:

- .1 After application of the fumigant, an initial check should be made by the fumigator-in-charge together with trained representatives of the master for any leak which, if detected, should be effectively sealed. When the master is satisfied that all precautions detailed in 3.3.2.1 to 3.3.2.12 have been fulfilled (refer to model checklist in appendix 3) then the vessel may sail. Otherwise, provisions outlined in 3.3.2.9.2 or 3.3.2.9.3 are to be followed.

If the provisions of 3.3.2.9.1 are not satisfied,

either:

- .2 After application of fumigants, the ship should be delayed in port alongside at a suitable berth or at anchorage for such a period as to allow the gas in the fumigated cargo holds to reach sufficiently high concentrations to detect any possible leakage. Special attention should be paid to those cases where fumigants in a solid or liquid form have been applied which may require a long period (normally from 4 to 7 days unless a recirculation or similar distribution system is used) to reach such a high concentration that leakages can be detected. If leakages are detected, the ship should not sail until the source(s) of such leakages is(are) determined and eliminated. After ascertaining that the ship is in a safe condition to sail, i.e. no gas leakages are present, the fumigator-in-charge should furnish the master with a written statement that:
 - .2.1 the gas in the cargo hold(s) has reached sufficiently high concentrations to detect any possible leakages;
 - .2.2 spaces adjacent to the treated cargo hold(s) have been checked and found gas-free; and
 - .2.3 the ship's representative is fully conversant with the use of the gas-detection equipment provided.

or:

- .3 After application of the fumigants and immediately after the sailing of the ship, the fumigator-in-charge should remain on board for such a period as to allow the gas in the fumigated cargo hold or spaces to reach sufficiently high concentrations to detect any possible leakage, or until the fumigated cargo is discharged (see 3.3.2.20), whichever is the shorter, to check and rectify any gas leakages. Prior to his leaving the ship, he should ascertain that the ship is in a safe condition, i.e. no gas leakages are present, and he should furnish the master with a written statement to the effect that the provisions of 3.3.2.9.2.1, 3.3.2.9.2.2 and 3.3.2.9.2.3 have been carried out.

3.3.2.10 On application of the fumigant, the fumigator-in-charge should post warning signs at all entrances to places notified to the master as in 3.3.2.8. These warning signs should indicate the identity of the fumigant and the date and time of fumigation. A specimen of such a warning sign is given in appendix 2.

3.3.2.11 At an appropriate time after application of the fumigant, the fumigator-in-charge, accompanied by a representative of the master, should check that accommodation, engine-rooms and other working spaces remain free of harmful concentrations of gas.

3.3.2.12 Upon discharging his agreed responsibilities, the fumigator-in-charge should formally hand over to the master in writing responsibility for maintaining safe conditions in all occupied spaces. The fumigator-in-charge should ensure that gas-detection and respiratory protection equipment carried on the ship is in good order, and that adequate fresh supplies of consumable items are available to allow sampling as required in 3.3.2.13.

3.3.2.13 Gas concentration safety checks at all appropriate locations, which should at least include the spaces indicated in 3.3.2.5, should be continued throughout the voyage at least at eight-hour intervals or more frequently if so advised by the fumigator-in-charge. These readings should be recorded in the ship's log-book.

3.3.2.14 Except in extreme emergency, cargo holds sealed for fumigation in transit should never be opened at sea or entered. If entry is imperative, at least two persons should enter, wearing adequate protection equipment and a safety harness and lifeline tended by a person outside the space, similarly equipped with protective, self-contained breathing apparatus.

3.3.2.15 If it is essential to ventilate a cargo hold or holds, every effort should be made to prevent a fumigant from accumulating in accommodation or working areas. Those spaces should be carefully checked to that effect. If the gas concentration in those areas at any time exceeds the occupational exposure limit values set by the flag State regulations, they should be evacuated and the cargo hold or cargo holds should be re-sealed. If a cargo hold is re-sealed after ventilation it should not be assumed that it is completely clear of gas and tests should be made and appropriate precautions taken before entering.

3.3.2.16 Prior to the arrival of the ship, generally not less than 24 hours in advance, the master should inform the appropriate authorities of the country of destination and ports of call that fumigation in transit is being carried out. The information should include the type of fumigant used, the date of fumigation, the cargo holds which have been fumigated, and whether ventilation has commenced. Upon arrival at the port of discharge, the master should also provide information as required in 3.3.2.6.2 and 3.3.2.7.2.

3.3.2.17 On arrival at the port of discharge the requirements of receiving countries regarding handling of fumigated cargoes should be established. Before entry of fumigated cargo holds, trained personnel from a fumigation company or other authorized persons, wearing respiratory protection, should carry out careful monitoring of the spaces to ensure the safety of personnel. The monitored values should be recorded in the ship's log-book. In case of need or emergency the master may commence ventilation of the fumigated cargo holds under the conditions of 3.3.2.15, having due regard for the safety of personnel on board. If this operation is to be done at sea, the master should evaluate weather and sea conditions before proceeding.

3.3.2.18 Only mechanical unloading that does not necessitate entry of personnel into the cargo holds of such fumigated cargoes should be undertaken. However, when the presence of personnel in cargo holds is necessary for the handling and operation of unloading equipment, continuous monitoring of the fumigated spaces should be carried out to ensure the safety of the personnel involved. When necessary, these personnel should be equipped with adequate respiratory protection.

3.3.2.19 During the final stages of discharge, when it becomes necessary for personnel to enter the cargo holds, such entry should only be permitted subsequent to verification that such cargo holds are gas-free.

3.3.2.20 Upon completion of discharge and when the ship is found free of fumigants and certified as such, all warning signs should be removed. Any action in this respect should be recorded in the ship's log-book.

4 REGULATIONS FOR THE USE OF PESTICIDES

4.1 National and international controls on pesticide usage

4.1.1 In many countries the sale and use of pesticides are regulated by governments to ensure safety in application and prevention of contamination of foodstuffs. Among the factors taken into account in such regulations are the recommendations made by international organizations such as FAO and WHO, especially in regard to maximum limits of pesticide residues in food and foodstuffs.

4.1.2 Examples of some commonly used pesticides are listed in appendix 1. Pesticides should be used strictly in accordance with the manufacturer's instructions as given on the label or package itself. National regulations and requirements vary from one country to another; therefore particular pesticides which may be used for treatment of cargo holds and accommodation in ships may be limited by the regulations and requirements of:

- .1 the country where the cargo is loaded or treated;
- .2 the country of destination of the cargo, especially in regard to pesticide residues in foodstuffs; and
- .3 flag State of the ship.

4.1.3 Ships' masters should ensure that they have the necessary knowledge of the above regulations and requirements.

5 SAFETY PRECAUTIONS – GENERAL

5.1 Fumigation

5.1.1 Ship's personnel should not handle fumigants and such operations should be carried out only by qualified operators. Personnel allowed to remain in the vicinity of a fumigation operation for a particular purpose should follow the instructions of the fumigator-in-charge implicitly.

5.1.2 Aeration of treated cargo holds should be completed and a clearance certificate issued as in 3.3.1.8 or 3.3.1.10 before personnel are permitted to enter.

5.2 Exposure to pesticides resulting in illness

5.2.1 In the case of exposure to pesticides and subsequent illness, medical advice should be sought immediately. Information on poisoning may be found in the Medical First Aid Guide for Use in Accidents Involving Dangerous Goods (MFAG) or on the package (manufacturer's instructions and safety precautions on the label or the package itself).

APPENDIX 1

FUMIGANTS SUITABLE FOR SHIPBOARD USE

The materials listed should be used strictly in accordance with the manufacturer's instructions and safety precautions given on the label or package itself, especially in respect of flammability, and with regard to any further limitations applied by the law of the country of loading, destination or flag of the ship, contracts relating to the cargo, or the shipowner's instructions.

1 Fumigants against insects in empty cargo holds

TO BE APPLIED ONLY BY QUALIFIED OPERATORS

Carbon dioxide
Nitrogen
Methyl Bromide and carbon dioxide mixture
Methyl Bromide
Hydrogen cyanide
Phosphine

2 Fumigants against insects in loaded or partially loaded cargo holds

CARE IS NEEDED IN SELECTING TYPES AND AMOUNTS OF FUMIGANTS FOR TREATMENT OF PARTICULAR COMMODITIES

Carbon dioxide
Nitrogen
Methyl Bromide and carbon dioxide mixture
Methyl Bromide
Phosphine

3 Fumigant information

3.1 *Methyl Bromide*

Methyl Bromide is used in situations where a rapid treatment of commodities or space is required. It should not be used in spaces where ventilation systems are not adequate for the removal of all gases from the free space. In-ship in-transit fumigations with Methyl Bromide should not be carried out. Fumigation with Methyl Bromide should be permitted only when the ship is in the confines of a port (either at anchor or alongside) and to disinfest before discharge, once crew members have disembarked (see 3.1.2.3). Prior to discharge, ventilation must be done, forced if necessary, to reduce the gaseous residues below the occupational exposure limit values set by the flag State regulations in the free spaces. (See procedures for ventilation in 3.3.2.17 to 3.3.2.19).

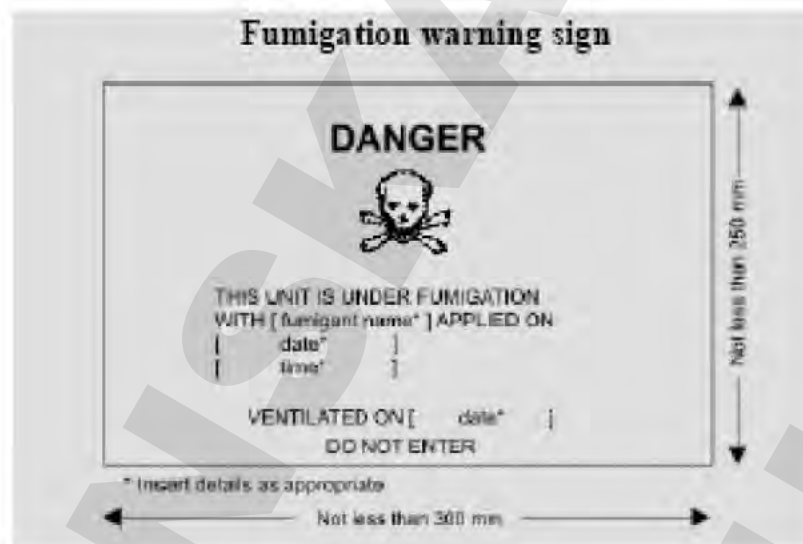
3.2 *Phosphine*

3.2.1 A variety of Phosphine-generating formulations are used for in-ship in-transit or at-berth fumigations. Application methods vary widely and include surface-only treatment, probing, perforated tubing laid at the bottom of spaces, recirculation systems and gas-injection systems or their combinations. Treatment times will vary considerably depending on the temperature, depth of cargo and on the application method used.

3.2.2 Any discharge of active packages producing Phosphine gas represents a significant risk to the public who may encounter them at sea. It should therefore be ensured that all waste and residues are disposed of in an appropriate manner, either by incineration or by disposal on shore, as recommended by the manufacturer. **Clear written instructions must be given to the master of the ship, to the receiver of the cargo and to the authorities at the discharging port as to how any powdery residues are to be disposed of.**

3.2.3 These will vary with each formulation and the method of application. Prior to discharge, ventilation must be done, forced if necessary, to reduce the gaseous residues below the occupational exposure limit values set by the flag State regulations in the free spaces (see procedures for ventilation in 3.3.2.17 to 3.3.2.19). For safety aspects during the voyage see 3.3.2.3.

APPENDIX 2



APPENDIX 3

MODEL CHECKLIST FOR IN-TRANSIT FUMIGATION

Date:
 Port: Terminal/Quay:
 Ship's name:
 Type of fumigant: Method of application:
 Date & time fumigation commenced:
 Name of fumigator/company:

The master and fumigator-in-charge, or their representatives, should complete the checklist jointly. The purpose of this checklist is to ensure that the responsibilities and requirements of 3.3.2.11, and 3.3.2.12 are carried out fully for in-transit fumigation under section 3.3.2.9.

Safety of operations requires that all questions should be answered affirmatively by ticking the appropriate boxes. If this is not possible, the reason should be given and agreement reached upon precautions to be taken between ship and fumigator-in-charge. If a question is considered to be not applicable write "n/a", explaining why, if appropriate.

PART A: BEFORE FUMIGATION

	SHIP	FUMIGATOR- IN-CHARGE
1 The inspection required before loading has been performed (3.3.2.4)	[]	[]
2 All the cargo holds to be fumigated are satisfactory for fumigation	[]	[]
3 Spaces, where found not to be satisfactory, have been sealed	[]	[]
4 The master or his trained representatives have been made aware of the specific areas to be checked for gas concentrations throughout the fumigation period	[]	[]
5 The master or his trained representatives have been made familiar with the fumigant label, detection methods, safety procedures and emergency procedures (refer to 3.3.2.6)	[]	[]
6 The fumigator-in-charge has ensured that gas-detection and respiratory protection equipment carried on the ship is in good order, and that adequate fresh supplies of consumable items for this equipment are available to allow sampling as required by 3.3.2.13.	[]	[]
7 The master has been notified in writing of:		
(a) the spaces containing cargo to be fumigated	[]	[]
(b) any other spaces that are considered unsafe to enter during the fumigation	[]	[]

PART B: AFTER FUMIGATION

The following procedure should be carried out after application of fumigant and closing and sealing of cargo holds.

	SHIP	FUMIGATOR- IN-CHARGE
8 Presence of gas has been confirmed inside each hold under fumigation	[]	[]
9 Each hold has been checked for leakage and sealed properly	[]	[]
10 Spaces adjacent to the treated cargo holds have been checked and found gas-free	[]	[]
11 The responsible crew members have been shown how to take gas readings properly when gas is present and they are fully conversant with the use of gas-detection equipment provided	[]	[]
12 Methods of application:		
(a) Surface application method	[]	[]
Initial rapid build-up of the gas in the upper regions of hold airspace with subsequent penetration downward of the gas over a longer period		
or		
(b) Deep probing	[]	[]
More rapid dispersion of gas than in (a) with lower concentrations in upper regions of airspace in the hold		
or		
(c) Recirculation	[]	[]
Rapid dispersion of gas throughout hold but at lower initial gas levels with subsequent build-up of gas levels which, however, may be lower due to even distribution		
or		
(d) Other	[]	[]
13 The master or trained representatives have been briefed fully on the method of application and the spread of the gas throughout the hold	[]	[]
14 The master or trained representatives have been made:		
(a) aware that even though the initial check may not indicate any leaks, it is essential that monitoring is to be continued in the accommodation, engine-room, etc. because gas concentrations may reach their highest levels after several days	[]	[]
(b) aware of the possibility of the spreading of gas throughout the duct keel and/or ballast tanks	[]	[]
15 The fumigator-in-charge has supplied a signed statement to the master conforming to the requirements of 3.3.2.12 for his retention	[]	[]
The above has been agreed:		
Time:		Date:
For Ship:		Fumigator-in-charge:
Rank:		

FLYER TO THE SHIPPING INDUSTRY

Crew evacuated following exposure to phosphine gas



Arklow Meadow: smoke from fumigant residue during discharge of maize cargo

NARRATIVE

On 5 December 2012, a fumigated cargo of maize was being discharged from the general cargo vessel *Arklow Meadow* in Warrenpoint, Northern Ireland when it became apparent that the fumigant (aluminium phosphide), which had been placed on top of the cargo before the vessel sailed from the Ukraine 14 days earlier, was still active.

Before the vessel's arrival in Warrenpoint, the atmosphere at the tops of the cargo holds had been tested and was less than 0.2ppm. Cargo operations had started and a number of fumigant retainers had been landed into hoppers and stores ashore before the remainder were removed from the cargo by ship's crew.

The fumigant retainers removed by the crew were initially placed on the wet deck, where they started to smoke. The smoking soon stopped when the retainers were moved to the holds' observation platforms. Meanwhile, a number of fumigant retainers had spilled onto the ground when they were being taken out of a hopper by a stevedore.

At this point, cargo operations were stopped and the spilled fumigant on the quay (**Figure 1**) was cordoned off. The fumigant retainers that remained by the vessel's holds were also collected and placed inside plastic bags. However, these soon started to smoke, so the crew were evacuated ashore. The local fire brigade was alerted and they reacted quickly to arrive on the scene. A 50 metre cordon was established around the vessel and houses and retail premises surrounding the port area were evacuated as a precautionary measure. Eight of *Arklow Meadow's* crew and a stevedore who had potentially been exposed to phosphine gas were taken to hospital for observation and decontamination.



Figure 1: Fumigant retainers and spilled fumigant



Figure 2: Disposal of the fumigant

A total of 89 fumigant retainers were recovered from the vessel and shore areas, leaving 21 fumigant retainers unaccounted for. The recovered retainers were neutralised by immersing them in water (**Figure 2**). It took 5 days for the level of phosphine gas in the vessel's cargo holds to reduce to an acceptable level.

SAFETY LESSONS

Fumigants are dangerous if not handled correctly and appropriate precautions are not taken. To improve the safety of ships' crews and shore workers when handling fumigated grain cargoes, vessel owners, managers and crews, shippers and port authorities are strongly advised to take into account the lessons to be learned from this accident. In particular:

- A number of factors may cause a fumigant to remain active, regardless of the length of voyage. Where possible, all fumigant residues should be removed from the cargo holds before cargo discharge commences.
- The removal and disposal of fumigant and fumigant residues is potentially hazardous and should, wherever possible, be undertaken by a qualified fumigator.
- Owners and ship managers should ensure that comprehensive procedures and guidance covering the carriage of fumigated cargoes is provided on board their vessels.
- Masters must take responsibility for the safety of their crews when carrying fumigated cargoes. This requires compliance with the appropriate international recommendations, national requirements, and the instructions provided by the fumigator at the load port.
- Port authorities handling fumigated cargoes need to develop and implement procedures and emergency plans for the handling of fumigated cargoes, including: maintaining a list of accepted fumigators, the briefing of stevedores and other shore workers, and the safe disposal of fumigant (active and expired).

This flyer and the MAIB's investigation report are posted on our website:
www.maib.gov.uk

For all enquiries:

Marine Accident Investigation Branch
 Mountbatten House
 Grosvenor Square
 Southampton SO15 2JU

Email: maib@dft.gsi.gov.uk
 Tel: 023 8039 5500

October 2013