Intransit disinfestation of bulk and bagged commodities: a new approach to safety and efficacy

C R Watson¹, N Pruthi², D Bureau³, C Macdonald⁴, and J Roca⁵

Abstract

The concept of using the time that goods are in transit while travelling from point of origin to point of destination has for many years been recognised as both an opportunity for insect infestation to develop, and for insect extermination to be carried out. Methyl Bromide, which has been the most rapid acting and widely used fumigant for many years, is being phased out for environmental reasons under the United Nations Montreal Protocol, and therefore there is an increased requirement for viable alternative strategies.

Phosphine has been available for many years but requires much more time than methyl bromide to be effective, and is similarly toxic to humans. Phosphine is generally recognised as relatively easy to use in many agricultural situations. However in bulk or bagged shipments it is usually difficult to use both effectively and safely. Standards and procedures in respect of these treatments vary extremely widely around the world.

This paper describes how a number of interested organisations located in different parts of the world have recognised the problems involved. As a result a unique collaborative project has evolved. These organisations have considered and taken account of the many diverse and varied conditions. They have co-ordinated the requirements and options, with the objective of researching and establishing procedures that can be used widely to ensure effective insect control and safe working conditions for treatments in bagged and bulk shipments.

Introduction

With increasing demands throughout the world for improved standards of Food Safety the requirement to deliver food free of infestation has also increased. However demands have also increased that require not only freedom from infestation, but also zero or very low residues, no health risks, and no increase in costs.

For many years the treatment of bagged and bulk cargoes travelling between countries has been carried out in a traditional manner that had evolved to meet the needs of the seller. There was a need to change this to meet the new demands, but no obvious or easy solution.

Traditional Treatments

The seller or shipper when loading the goods carries out a treatment to the goods to try to ensure insects will not be found during loading (especially if the representative of the receiver is present) and also that insects are not found when the vessel arrives at the discharge port.

These treatments may be carried out with residual insecticide, methyl bromide fumigant, or phosphine fumigant.

The disadvantages of insecticides are that they only work when insects emerge from the grain and come into contact with residues of the insecticide that have been sprayed on to the grain. This means that some immature stages of the insect may still be alive on arrival at the discharge port because they have not emerged from within the grain and come into contact with the insecticide.

Methyl Bromide and phosphine fumigants which act in a gaseous state can both provide a very quick kill of adult insects. However to kill all stages of the insect (adult, larva, pupa, egg) it is absolutely essential to achieve an even distribution of gas through the cargo and to maintain a lethal concentration throughout the cargo for a long enough period once this even distribution has been achieved.

This is where most fumigations in ships fail. They fail because either the distribution of the gas is poor, or where the distribution is good enough the gas is not retained in all areas for long enough (Leesch, et al., 1987). This information has been available for many years but is largely
What does the receiver or end user of the cargo want

The receiver does not want to receive live infestation at any time but especially from imported cargoes. This is because imported cargoes may contain species or strains that are not present in the receiving country. For example with resistance to phosphine becoming more widespread in some Asian and African countries, it is especially important that these strains are not allowed to enter countries where resistance is not present. In addition, the food processor will not accept commodities that show any signs of live infestation in many countries. In the UK for example most food production companies including flour millers, have a zero insect tolerance policy.

Is it possible to achieve a fully effective intrasit fumigation of goods

In 1994 a group of independent fumigation companies located in different parts of the world drew up a protocol to work together to address these issues. The objective was also to take into account the many variables which existed world-wide but the common factors were

1. A ships hold can be an excellent fumigation chamber if it can be made gastight

2. A lot of research had been carried out by well respected government laboratories throughout the world on the movement and distribution of fumigants and on the concentrations necessary to eradicate a wide range of pests at different temperatures. Most of the research is ignored by exporters when specifying fumigation

3. In some countries systems which provided an excellent distribution of the fumigant were already available (e.g. Degesch re-circulation J System in Europe and USA) while in other countries (e.g. India) they were not

4. Control of the fumigation once it leaves the load port is largely ignored. The responsibility for the completion of the fumigation and the ventilation at the discharge port is generally left to the master of the vessel

5. Safety-In some countries (e.g. Canada) The safety recommendations and regulations set out by the United Nations International Maritime Organisation (UNIMO 1996) are strictly adhered to. In others such as Spain they are often ignored

The objective of the group was therefore to provide the receiver or the end user with the opportunity to choose to specify that he required his cargo to be treated so that all live infestation was eradicated, with little or no detectable residues remaining and using methods and procedures which ensured safety to the crew of the vessel and to all those involved in discharging the vessel

Development Work

It was decided that various methods of fumigation were needed to address various situations and therefore the following schedule of development work has been followed

1. Verification of the efficacy of the Degesch re-circulation J System method

2. Development of a passive system using pre-fitted perforated pipes for use in ships and ports where it is not possible to use a powered re-circulation system

3. Effective deep probing

Verification of the Efficacy of the Degesch re-circulation J System method

Two field trials were completed during 1996

1. Intransit Fumigation using the Degesch J System to comply with the Mozambique Import Requirements of Commodity from countries where Larger Grain Borer (Prostephanus truncatus) is present (Rogerson and Wimspear, 1996)

It was decided to monitor the gas levels in a vessel that was to transport Kenyan Maize as Food Aid and being fumigated with phosphine. It was sailing from Mombassa in Kenya to Beira in Mozambique with the cargo destined for onward trans-shipment to Malawi. The fumigation was being carried out to control the Larger Grain Borer (Prostephanus truncatus) as part of a quarantine programme to prevent this pest establishing itself in the countries (such as Malawi and Zambia) using the east African ports (Refer to Mozambique Plant Quarantine Requirements of January 1996). It is known that if the Larger Grain Borer establishes itself widely it will have a very detrimental effect on the maize crop in this region of Africa

It was suspected that methods of treatment where the aluminium phosphide was placed on the surface or only probed a few metres into the hold were ineffective, and also that some of the vessels used for the shipments were not very gas tight

The fumigation monitoring team consisted of John Rogerson of Igrox Ltd from the UK and Peter Wimspear from Pestmaster in the Republic of South Africa

The ship, the M V Vitagram, was built in Valencia.
Spain in the mid 1970's. She has seven holds with 2 Sampson post natural ventilators (20 metres high) and 2 fan assisted ventilators on each hold, though most of the fans were inoperative. The chain linked McGregor hatches on each hold were opened and closed by winch cables also used on the derricks.

- **Fumigation**

The ship had been fitted with plastic re-circulation pipes prior to loading by Pestmaster of South Africa. A ring of perforated pipes of 150mm in diameter was placed against the sides at the bottom of each hold. This was connected with a T to a non perforated pipe which was tied to the manway ladders and terminated just under the manway hatch at the top of the hold ladder.

When the fumigation team arrived at the ship five of the holds were fully loaded. Sample lines were inserted into each hold using a vacuum sampler (Pneumac, UK) and 18mm I.D. plastic rods.

<table>
<thead>
<tr>
<th>The holds had capacities of</th>
<th>Gas Sample Line Positions</th>
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</thead>
<tbody>
<tr>
<td>Each hold had 5 sample lines</td>
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<tr>
<td>1 = 3963</td>
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<tr>
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<td>3 = 5295</td>
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<tr>
<td>4 = 3391</td>
<td>- 2 Metre Depth</td>
</tr>
<tr>
<td>5 = 5095</td>
<td>- 8 Metre Depth</td>
</tr>
<tr>
<td>6 = 5703</td>
<td>- 10 Metre Depth</td>
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<tr>
<td>7 = 4255m³</td>
<td>- 14 Metre Depth (Bottom)</td>
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</table>

Holds 2, 3, 4, 5, and 6 were fully loaded and contained between 3000 and 4000 metric tonne of Kenyan white maize each. Holds 1 and 7 were slack, with 1 being half full and 7 two thirds full.

The J System fans were installed at the top of the manholes and were wired to run from the inspection light points.

The vessel was loaded by hand by tipping bags of maize into the hold and a space was left between the hatch combing and the deck beams and the top ballast tank walls. If the vessel had been loaded with a mechanical loader the grain thrower would have filled this space.

The fumigators would normally have climbed the Sampson posts and covered each ventilator with a polythene sheet but on this vessel it was too dangerous. The team could therefore only close the flaps inside the ventilator shafts and cover the lower ventilators which had holes in, with polythene.

When working in the holds installing the search lines there were many places where it was possible to see light indicating very small gaps and holes in the hatches. Also there were very small holes in the deck houses where the plates had rusted right through. One of the inlets on the natural ventilator door was broken and held with a rope. This was covered with glue and polythene as were all other accessible potential leakage points.

Each hold was treated with round tablets of aluminium phosphide (3gm) placed on the surface of the cargo at the rate of 1.5 grams of Hydrogen Phosphide per cubic meter. The total cargo loaded was 22996 tonne of white maize. The hatches were closed and sealed and the manholes were closed and sealed. As each hold was fumigated the fans were turned on and left running continuously for five days.

- **Sampling**

Gas samples were taken with an Agndox meter fitted with a Citycell phosphine detector. As the upper limit of the Agndox meter is 2000 ppm (2.78 gm/m³) readings above this limit were read with Drager model 25/a (high level) tubes. At low levels Drager 0 1a (low level) tubes were used. Working areas of the ship were checked frequently for leakage of phosphine. None was found in the main accommodation, engine room and forecastle. However the three deck houses had substantial levels during the first few hours of the fumigation. These areas were designated out of bounds and not used by the crew during the voyage.

After the ship arrived in Beira gas readings were taken with Inspectors from the Mozambique Plant Quarantine services and the final readings recorded. The holds were then opened and left overnight with the fans running for ventilation. Readings the next day confirmed safe levels in the grain below 0.3 ppm. The fans were then removed. The holds were then sampled for insects by the use of vacuum sampling (Probe a vac) at various depths. No live infestation was found although there was an extremely high level of dead insects (mainly Cryptolestes spp).

- **Programme**

1. The vessel loaded in Mombassa from 18/1/96 to 29/1/96
2. The fumigant was applied in Mombassa on 29/1/96
3. The vessel sailed on 29/1/96
4. The vessel arrived off Beira on 3/2/96
5. The vessel berthed in Beira on 9/2/96
6. The vessel commenced discharge in Beira on 10/2/96

- **Findings**

Concentrations recorded during the fumigation are shown in Tables 1–7 below.

It can be seen from Tables 1, 3, 5 and 7 that holds 1, 3, 5, and 7 lost a lot of gas from the surface. This gas leakage was through the hatches and through the holes in the deck house, and on the deck plates.
Table 1. Concentration of phosphine (gms/m³) at various depths recorded during fumigation Hold 1, volume 3963m³.
Dose 15kg ALP

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Table 2. Concentration of phosphine (gms/m³) at various depths recorded during fumigation Hold 2, volume 4796m³.
Dose 18kg ALP

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Table 3. Concentration of phosphine (gms/m³) at various depths recorded during fumigation Hold 3, volume 5295m³.
Dose 20kg ALP

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Table 4. Concentration of phosphine (gms/m³) at various depths recorded during fumigation Hold 4, volume 3391 m³; Dose 13 kg ALP

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Table 5. Concentration of phosphine (gms/m³) at various depths recorded during fumigation Hold 5, volume 5095 m³; Dose 18 kg ALP

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Table 6. Concentration of phosphine (gms/m³) at various depths recorded during fumigation Hold 6, volume 5703 m³; Dose 22 kg ALP

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<td>0 03</td>
<td>0 01</td>
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</table>
Table 7. Concentration of phosphine (gms/m³) at various depths recorded during fumigation Hold: 7, volume 4255m³, Dose: 17kg ALP

<table>
<thead>
<tr>
<th>Time / hours</th>
<th>Bottom 14m</th>
<th>Mid low 10m</th>
<th>Mid high 8m</th>
<th>Top 2m</th>
<th>Head space</th>
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<tr>
<td>15 5</td>
<td>0 92</td>
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<td>0 08</td>
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<td>0 13</td>
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Table 8. Concentration-Time Products (gh/m³) achieved at depths of different Holds with ‘Mean’ and ‘Standard deviation’ Cargo temperature was 30°C (+ or −2°C)

<table>
<thead>
<tr>
<th>POSITION</th>
<th>HOLD 1</th>
<th>HOLD 2</th>
<th>HOLD 3</th>
<th>HOLD 4</th>
<th>HOLD 5</th>
<th>HOLD 6</th>
<th>HOLD 7</th>
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<tr>
<td>14M</td>
<td>78 5</td>
<td>127 6</td>
<td>BLOCK</td>
<td>155 6</td>
<td>19 83</td>
<td>198 45</td>
<td>21 9</td>
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<tr>
<td>10M</td>
<td>79 6</td>
<td>100</td>
<td>125 9</td>
<td>152 7</td>
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<td>196 45</td>
<td>22 3</td>
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<tr>
<td>8M</td>
<td>81 3</td>
<td>106 7</td>
<td>104 7</td>
<td>128 4</td>
<td>27 07</td>
<td>183 19</td>
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</tr>
<tr>
<td>TOP 2M</td>
<td>20 9</td>
<td>95 6</td>
<td>54 3</td>
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<td>HEADSPACE</td>
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<td>NO LINE</td>
<td>53</td>
<td>28 5</td>
<td>12 21</td>
<td>199 3</td>
<td>81 2</td>
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<td>52 42</td>
<td>107 4</td>
<td>84 5</td>
<td>100 58</td>
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<td>36 63</td>
<td>62 67</td>
<td>5 36</td>
<td>7 2</td>
<td>26 87</td>
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</tbody>
</table>

SD = Standard deviation (measure of degree of deviation from average)

Conclusions
1. The amount of gas loss differed significantly in each hold.
2. The distribution throughout the bulk in each hold was relatively even.
3. The low concentrations achieved in the head space indicate that leakage occurred through the hatch covers, decks etc. If the re-circulation system had not been used, then it is likely that gas would have leaked out of the hatch covers etc before it had the opportunity to penetrate into the cargo.
4. Even the lowest \( C \times T \) recorded in the cargo of 19.4 is considerably higher than necessary to eradicate all life stages of Larger Grain Borer at these temperatures. Even if ventilation had commenced after 120 hours (the minimum time to comply with Mozambique requirements) the \( C \times T \) would have been satisfactory in each area of each hold.
5. Due to the variability of gas tightness demonstrated on this vessel we can conclude that it would be unwise to reduce the specification in any respect regarding application rate, exposure period or distribution system. However, as the vessel was so poor we can have confidence from these results that even under the poorest conditions that if this procedure is followed total eradication will be achieved.
6. The maize was moved to Malawi following discharge and it is understood that some remained in store for many weeks or months. Reports indicate that no infestation developed from within the maize during storage which is what would be expected when total eradication of infestation is achieved by a fully efficient fumigation.

(B) Fumigation In Transit and Subsequent Inspections by Cuban Authorities on a cargo of rice from S.E. Asia

A request was received to arrange for a cargo of bagged rice which had already been loaded in S.E. Asia and destined for Cuba to be fumigated. The vessel which had already set sail, was re-directed to Durban R.S.A. The request for fumigation was that it must be fully guaranteed with no live infestation of any type of insect at any stage of the life cycle on arrival in Havana.

It was decided to use the Degesch J System which because...
of the way the rice had been stowed could be fitted after loading Pestmaster of South Africa met the vessel in Durban and carried out the fumigation as specified and directed by Igrox Ltd in the UK. It was decided to use this opportunity to test the efficacy of the J System under these most difficult conditions

*Method*

The J System was fitted to the M V ASIAN PROGRESS as the enclosed diagram Fig 4. There was sufficient access down the side of the hold and below the tween deck to allow the Pestmaster technicians to fit the pipes in each hold. Gas sample lines were also fitted in 3 places in each hold.

Aluminum phosphide in retrievable sachets was placed on top of the cargo and the fans switched on. The holds and all access points were sealed and tests carried out for leakage. When all requirements as per IMO Recommendations on the Safe Use of Pesticides in Ships had been met the vessel was allowed to sail on 27th February 1996 with strict instructions to ensure all seals remained intact and the fans switched on until arrival in Cuba.

*Findings - Havana, Cuba - 27th March 1996*

The inspection of the fumigation commenced on board the vessel at approximately 10.30 a.m. with representatives of Cuba Plant Quarantine, Igrox Ltd and the shipper in attendance.

The fans were switched off (No 2 was already not running as it stopped 10 days after the vessel left Durban) and then the access manholes to each hold were opened in turn. The 3 gas sampling lines positioned in each hold were retrieved. The lines were labelled as B (Bottom), M (Middle), H (near to the Top). Samples were drawn using the Agnox Phosphine Meter. Low levels of approximately 1 ppm were recorded on all lines in the first hold checked (No 5). Further samples were then drawn using a Draeger pump and Phosphine Tube 0 1/a. This confirmed that the concentrations were between approximately 0 7 and 1.00 ppm.

The remaining four holds were tested in a similar way and all lines indicated concentrations between 0.6 and 1.00 ppm.

On completion of these measurements the ventilators were opened and the ships ventilation system was switched on. Phosphine was immediately detected by smell on the deck. The hatch covers were opened and the polythene sheets used to seal the holds were removed and ventilation continued. Gas concentration checks carried out indicated it was safe to work in the holds and initial checks were made by Cuba P Q inspectors in each hold to ensure all fumigation ducts and fans had been located correctly, which was confirmed. Ducts to the lower holds could be clearly seen.

The sachets containing the aluminum phosphide residues were collected and taken away for disposal by Plant Quarantine.

Further gas measuring checks with the Draeger equipment were carried out in the air space below the surface and zero or only traces of Phosphine were recorded. The Clearance Certificate was issued at 16:00.

*Observations*

1. The P Q inspectors were very keen to see all aspects of the fumigation system and obviously knew what they were talking about and what to look for. This especially applied to Mr Jacinto Dominguex Luis, the head of the port inspectors and to Mr Omar Amaro Rodriguez. They wanted to see that the fumigation ducts actually went to the bottom of each hold and that they were all connected correctly, and that the holds had been sealed effectively.

2. During the detailed examination of the cargo on Thursday 28th widespread evidence of infestation was found with dead insects (all Tribolium spp.) on almost all the bags.

3. Despite the fact that no ventilation was carried out during the voyage from Durban there was no evidence of moisture damage.

4. Samples were taken by the P Q Inspectors for incubation. No evidence of live infestation was reported.

5. Discharge commenced on from 31st March and continued for 3 weeks. All cargo remaining on the vessel was inspected each day by the P Q inspectors.

*Conclusions*

(a) The concentrations of gas found to be present in Havana although low, indicate that it is very likely that the total concentration time product (CTP) that had been achieved during the fumigation at the sample points had been well in excess of that needed to effect total eradication.

(b) During the 29 day fumigation the gas would have slowly leaked out, broken down, and been sorbed by the commodity. Due to the re-circulation system being used the low levels of gas remaining were found to be evenly distributed, and it is likely that any residues that remain from the phosphine gas in the product will be very low.

(c) As the system could not be fully fitted as normal in Durban because the cargo was already loaded, did the gas reach all parts of the cargo? Because of the way the cargo was stowed with gaps between the bags at regular intervals, and the way the fumigation ducts were positioned in the lower holds, it was concluded that the gas would almost certainly have reached everywhere evenly. This was apparent because despite thorough and continuous checking of the cargo throughout the 3 week discharge, including incubation of samples, no live insects were found.

(d) Ventilation in future could commence 10 days or so after application of fumigant. The re-circulation system correctly fitted, will result in high CTP's in 10 days in all parts of the cargo. These CTP's will result in fully
development of any infestation, and by
commencing ventilation after a ten day fumigation
period, it will be likely to eliminate any possibility of
condensation damage which could occur in certain types
of weather conditions.

Development of a passive system (Fig. 5)

In India where no powered re-circulation systems (e.g.
Degesch J System) is available, a request was received from
buyers to provide a fumigation system which had as far as
possible similar benefits to the re-circulation system, which
ensured good distribution and that all residues were
removed.

This led IMFC members Pest Control M Walshe of
Bombay with assistance from Igrox Ltd of the U K to
develop a system specifically for this requirement.

The system used was an adaptation of the passive system
developed by Bob Davis of the USDA in the USA in the
1980's.

Two fumigations took place in western India at the ports
of Bedi and Navlakhi. Both ports are anchorage ports.

The vessels which loaded the wheat in bulk were both
Bulk Carriers and Tween Deckers.

The following procedure was used:

Fumigation used Aluminium Phosphide in pre-packed
sachets in chains of 50's & 10's. Each sachet weighed 34
grams. The rate of application was 3 grams of Phosphine per
tonne.

100 mm diameter reinforced PVC pipes were
purchased and were then drilled with holes of about 5mm
The drilling was done as evenly as possible. Care was taken
to ensure that the reinforcements were not damaged. The
pipes chosen were rigid and reinforced so that they would
not be crushed by either the wheat, or when they were
passed through the manholes and laid in the lower holds.

To assist adequate dispersion and penetration of gas in the
tween decks perforated pipes were inserted into the grain
cargo vertically.

A cotton string was run end to end into the pipes laid in
the lower holds. The concept was that the sachets would be
lowered in from the top and the string would pull the sachets
into the pipes to their full depth.

As a further experiment weights of 2.5 & 11bs were
specially made, to be used to pull the sachets deep into the
pipes. Tests were run to see how deep the weights would
go. The results showed that this was likely to work
satisfactorily.

After completion of loading, when tests were carried out
to determine whether it was possible to pull the strings laid
through the pipes, this system proved unreliable. However
the alternative plan of using the weights was used
successfully.

For treatment in the Tween Decks, sachet chains of 10'
sachets were let down using the 10lb weights into the
pipes which were laid vertically in the grain.

For the lower holds sachet chains of 50' sachets were
lowered using the 2 5lbs weights. Also chains were secured
by ropes so that they would be easily retrievable on arrival at
discharge port.

Fumigation was carried out as per I M O procedures
regarding safe working practices. The Masters of the
vessels were given comprehensive sets of paperwork giving
details pertaining to type of fumigant, safety
recommendations, first aid, ventilation/discharge
instructions, use of gas monitoring equipment etc., together
with all required safety equipment and training of crew in its
use.

The vessels sailed for Turkey where they were met on
arrival by IMFO agents. All residues were satisfactorily
removed and tests throughout discharge showed no evidence
of any live infestation anywhere in the cargo.

The vessels used for these tests were:

M V Oscar Jupiter fumigated at Bedi on 9-1-1996
Discharged at Turkish Port on 24-1-1996

M V Andreas V fumigated at Navlakhi on 9-2-1996
Discharged at Turkish Port on 26-2-1996

The conclusion reached by Pest Control M Walshe & Igrox
Ltd was that this method though relatively labour intensive
can provide a satisfactory option (where the journey time is
at least 10 days) for a thorough fumigation of bulk or bagged
cargoes, when it is required that residues must be removed
and where it is not possible to use a powered re-circulation
system.

Deep probing

The deep probing method was developed by Denis Bureau
and his team at Adalu Ltd in Canada.

Several factors were taken into consideration during
development of this method:

1. The Canadian Government's requirements with regard to
efficacy and guaranteed results that must be met for
issuance of a phyto-sanitary certificate.
2. The constraints with respect to certain parameters that
control the reaction, such as the temperature of the
grain, water and air, as well as the time of exposure
related to the duration of the trap.
3. Different studies on phosphine diffusion throughout a
mass of grain.
4. Recommendations on in-transit fumigation contained in
the (FGIS) guide.

Description of the Method:

System Components Figure 6

Platform and probe pipe with pneumatic or mechanical
propulsion.

Probe 2 types of probe are available for fumigation.
The first is aluminium, 2.5 inches in diameter.
any time When an infestation ISIdentified m a cargo dunng
Probmg method smce the early 1990’s The first vessel
umfonnly distributed throughout the gram InaSS and thereby
very rapidly regardless of the gram temperature
combmed system diffuses the fumigant through the gram
Circulationsystem With hoses The fumigant ISplaced on top
method to use Several 4 mch probes are mserted mto the
re-circulation system are likely to prove to be most efficient
such as large silos and ShiPS, the 4 mch probes connected to
platform and vacuum system are used to insert the probe to
the desired depth, then the fumigant ISgradually released as
the probe travels upward Dust retamers cannot be used
with this type of application
The probe can also be connected to a re-circulation system
for faster, residue free fumigation (Fig 6), in this case the
fumigant is put in dust retamers on top of the gram
For silos, warehouses and ships less than 20 metres deep,
the long sleeve or sachet chain can be used It is 10 metres
long, and is introduced with the alternative 4 inch plastic
probe
Suitable sleeve or sachet dust retamers are currently
being developed and will be available shortly
For very high volumes of over 20,000 metric tonnes,
such as large silos and ships, the 4 inch probes connected
to re-circulation system are likely to prove to be most efficient
method to use Several 4 inch probes are inserted into the
grain with the system, then they are connected to a re-
circulation system with hoses The fumigant is placed on top
of the grain
• New Compounds such as the Horn Generator and Eco-fume
With the arrival of these new fumigant production
technologies and the deep probing system, the combined
benefits will be a major asset for food protection. The
combined system diffuses the fumigant through the gram
very rapidly regardless of the grain temperature
The Deep Probing technology enables the fumigant to be
uniformly distributed throughout the grain mass and thereby
reduces the time of penetration and equalisation of the gas
within the grain Such efficacious product distribution
increases the efficiency and speed of the fumigation process
The advantage the technology offers in that it can be used at
any time. When an infestation is identified in a cargo during
loading, the Deep Probing method can be used with excellent results
• Results
Numerous cargoes have been treated using the Deep
Probing method since the early 1990’s The first vessel
treated was the M V ALEKSANDER ABERG, when it was
in the Atlantic Ocean off Canada taking a cargo of wheat to
Russia The outside temperature was 10°C and the
temperature of the grain was 5°C. The grain had been
identified as being infested by the Canadian Grain
Commission. The Deep Probing technique was used to solve
the problem, making it possible to deliver the cargo to
Russian insect-free

Conclusion
The Deep Probing method, developed to deal with the
infestation by insects of grain shipped from Canadian ports,
has many advantages and development work continues so
that it can be used elsewhere in the world

Safety
The United Nations International Maritime Organisation
sets out clear recommendations for safety in
‘Recommendations on the Safe Use of Pesticides on Ships
Revised 1996’ Many fumigation companies ignore these
rules for reasons of economy Even in 1998 several vessels
have arrived at UK and other ports around the world with no
gas masks or fumigant detection equipment on board. This
practice still appears to be widespread The fumigant has
saved money by not supplying the safety equipment,
probably because he is under pressure from the exporters to
keep the price as low as possible In this situation who is
liable if crew members are killed – is it the fumigator, the
exporter, or the receiver? The answer is that probably all
three will have some responsibility depending on the
contract between them. All this risk can so easily be
removed if the following points are adhered to
1 Clear documented instructions are provided to the
Master
2 Sufficient supplies of the correct safety equipment are
placed on board
3 Ship owners instruct their masters to refuse to sail unless
requirements of UNIMO are adhered to
4 An IMFO member is appointed to be responsible for the
fumigations

Control of efficacy and safety
If on arrival at the discharge port the vessel is met by a
correctly trained and briefed fumigation company then both
efficacy and safety aspects can be controlled.
Fumigant levels can be checked, the grain inspected,
fumigant and fumigant residues removed and the receiver
can be certain he has an insect and residue free cargo
delivered with no risk regarding safety.
This concept has clear advantages not only to the receiver
but also to the ship owner and his master and crew, and all
other parties involved in the movement and storage of the
cargo
Future

Through the IMFO Group network this concept of safe, reliable, efficient intransit fumigation is being taken up by receivers when they become aware of the tremendous advantages it can provide. The actual cost of the fumigation charge may be slightly higher but the benefits to the receiver far outweigh the extra cost. Some of the more enlightened traders and exporters can also see the advantages and opportunities to ‘add value’ to their sales.

With the phasing out of methyl bromide, the likely increased use of phosphine and the continuing pressure on food standards throughout the world the group believe that the scientific but practical approach they are taking to these situations will continue to attract interest throughout the world.

References

Annex

PHOSPHINE APPLIED ON SURFACE or PROBED A FEW METRES INTO CARGO

Gas moves down very slowly from surface

After 5–7 days some gas should reach 10–12 metres at effective concentrations

Gas very unlikely to reach 15–20 metres in effective concentrations however long the voyage

Fig. 1. Traditional fumigation of cargo ships hold using phosphine.

METHYL BROMIDE APPLIED ON SURFACE

Gas moves down rapidly from surface – concentrations only sufficient to kill adults

Gas moves down from top half of hold – concentrations only partially effective

Higher concentrations on lower third of hold – effective but very difficult to ventilate. Results in high residues.

Fig. 2. Traditional fumigation of cargo in ships hold using methyl bromide.
Fig. 3. Fumigation of cargo in ships hold using phosphine and the J. system.
Vacuum system is used to assist probe pipe to penetrate the grain.

The platform can also be used to enable mechanical force to probe the pipe in the grain.

Vacuum system with vortex effect to give good efficiency on the probing phase

Vacuum system with vortex effect to give good efficiency on the probing phase

Vacuum system with vortex effect to give good efficiency on the probing phase

Vacuum system with vortex effect to give good efficiency on the probing phase

Vacuum system with vortex effect to give good efficiency on the probing phase

Probing pipe consists of double pipe with special design head to permit rapid delivery of solids fumigant or dust retainer.

A mix of grain and air is sucked by the system to give effortless penetration of the probe in the grain.

Fig. 4. Fumigation using deep probing system
Distribution of aluminium phosphide through the grain with the deep probing system, average of 6 inserts per hold

Fig. 5. Deep probing method-passive system.

Fumigant is applied on the surface of the grain in solid or gaseous form

Installation of probing system after loading for re-circulation

Fig. 6. Recirculation system.
The Hydrogen Phosphide gas (Phosphine) is generated at the surface and then the fan pushes the gas and air mixture into the lower hold. The tween decks are closed but are never gas/air tight and therefore the gas and air mixture must recirculate between the holds. As the hatches are made air/gas tight and the fumigant is almost the same density as air, the currents of air created in the holds rapidly ensure phosphine gas will reach all parts of the cargo.

Fig. 8. Fumigation of cargo in bulk carriers/tween deckers ship holds with phosphine using a passive system.