



# **PHILIP MORRIS INTERNATIONAL LEAF AGRONOMY**

---

## **PHOSPHINE FUMIGATION OF TOBACCO P.M.I STANDARD OPERATING PROCEDURE**

**Leaf document (PMI-IPM Method 751)  
17/11/2003**

PHILIP MORRIS INTERNATIONAL			
PHOSPHINE FUMIGATION TOBACCO PMI SOP PMI-IPM METHOD 751_03.DOC			
Created by:	L. Ruffieux	Creation date:	17/11/03
Last modified by:	L. Ruffieux	Last modification date:	17/11/03
		Ref.:	see path file
		Status:	version 3.0
File path: f:\leaf\agronomy\ipm\methodology\phosphine fumigation tobacco pmi_sop_pmi-ipm method 751_03.doc			
Page 2 of 17			

## TABLE OF CONTENTS

<b>1.</b>	<b>OBJECTIVE OF FUMIGATION .....</b>	<b>4</b>
<b>2.</b>	<b>WHEN TO FUMIGATE .....</b>	<b>4</b>
<b>3.</b>	<b>PHOSPHINE GAS (HYDROGEN PHOSPHIDE).....</b>	<b>5</b>
3.1.	PROPERTIES .....	5
3.2.	FORMULATIONS .....	5
<b>4.</b>	<b>FUMIGATION PARAMETERS.....</b>	<b>6</b>
<b>5.</b>	<b>FUMIGATION INSTRUCTIONS.....</b>	<b>7</b>
5.1.	GENERAL TECHNIQUES .....	7
5.2.	WAREHOUSE FUMIGATION.....	7
5.3.	TARPAULIN FUMIGATION .....	8
5.4.	FUMIGATION CHAMBER .....	8
5.5.	FREIGHT CONTAINER FUMIGATION.....	8
5.6.	FUMIGANT APPLICATION.....	9
5.7.	FUMIGANT MONITORING .....	9
5.8.	AERATION.....	10
5.9.	FUMIGANT DISPOSAL .....	11
<b>6.</b>	<b>FUMIGATORS .....</b>	<b>11</b>
<b>7.</b>	<b>TOBACCO TYPES TO FUMIGATE .....</b>	<b>11</b>
7.1.	RAW TOBACCOS.....	11
7.2.	SEMI-FINISHED PRODUCTS .....	11
<b>8.</b>	<b>FUMIGATION SAFETY AND SECURITY PARAMETERS .....</b>	<b>12</b>
8.1.	GENERAL SAFETY CONSIDERATIONS .....	12
8.2.	PERSONAL PROTECTIVE EQUIPMENT (PPE).....	12
8.3.	MONITORING EQUIPMENT.....	13
8.4.	SECURITY.....	13
<b>9.</b>	<b>CONTINGENCY PLANS .....</b>	<b>13</b>
9.1.	ACCIDENTAL POISONING.....	13
9.2.	SEVERE WEATHER .....	14
9.3.	SPRINKLER ALARM .....	14
9.4.	FIRE IN WAREHOUSE .....	14
<b>10.</b>	<b>PHOSPHINE ABATEMENT.....</b>	<b>14</b>
<b>11.</b>	<b>ALTERNATIVES TO CURRENT FUMIGATION TECHNIQUES.....</b>	<b>15</b>
11.1.	FUMIGATION AFTER PACK-OUT .....	15
11.2.	FREEZING.....	15
11.3.	RE-DRYING .....	15
11.4.	DELAYED/ADVANCED FUMIGATION.....	15

PHILIP MORRIS INTERNATIONAL			
PHOSPHINE FUMIGATION TOBACCO PMI SOP PMI-IPM METHOD 751_03.DOC			
Created by:	L. Ruffieux	Creation date:	17/11/03
Last modified by:	L. Ruffieux	Last modification date:	17/11/03
		Ref.:	see path file
		Status:	version 3.0
File path: f:\leaf\agronomy\ipm\methodology\phosphine fumigation tobacco pmi_sop_pmi-ipm method 751_03.doc			
Page 3 of 17			

12.	REFERENCES.....	16
13.	APPENDICES .....	16
14.	REVISION HISTORY.....	16

## EXECUTIVE SUMMARY

### *Phosphine gas*

Phosphine gas, when used correctly, is effective in eliminating 100% of all life-stages of phosphine-susceptible populations of both insects, which commonly infest tobacco, the cigarette beetle (*Lasioderma serricorne*) and the tobacco moth (*Ephesia elutella*). Moreover, it has been proven to have no effect on the flavour, color or taste of tobacco.

Magnesium phosphide ( $Mg_3P_2$ ) which generates phosphine gas is the fumigant of choice to fumigate PM tobaccos. The packaged magnesium phosphide formulation most widely used today is the Detia Degesch Plate, Fumi-Cel Plate® or Fumi-Strip®. The usual dose of phosphine is 1-1.5 g/m<sup>3</sup> (700-1050 ppm) and one magnesium phosphide plate usually generates 33 g of phosphine.

### *Fumigation responsibilities*

Only licensed/certified professional fumigators (external contracting company) should fumigate Philip Morris International (PMI)-destined tobaccos. These fumigators will have passed government -approved examinations and be certified as such. Equally they will belong to a licensed fumigation company expected to maintain adequate liability insurance. The fumigator will be completely responsible for all the fumigation procedure and for any fumigation failures; a signed contract should clearly state that the fumigator bears full responsibility for sealing, fumigant application, gas concentration readings and safety. PMI affiliates, Third Party Manufacturers (TPMs) or Leaf suppliers will manage directly the contract with the fumigation contractor. A comprehensive understanding of the fumigant, fumigation techniques and all local laws and ordinances must be maintained by the fumigator and obeyed.

### *Fumigation types*

Fumigations are carried out in a closed space (fumigation site) which is at atmospheric pressure at all times. Tobacco fumigation may be conducted in a warehouse, the volume under a gas-tight (polyethylene) sheet, sometimes called a tent or tarpaulin, a specially constructed fumigation chamber, a fumigation bubble, and freight container. The closed space to be fumigated should be sealed to contain the gas.

### *Fumigation parameters*

Three parameters influence the fumigation efficiency: the tobacco temperature, the exposure-time and the phosphine concentration. They must be controlled to ensure an efficient fumigation and prevent the development of non-susceptible populations of cigarette beetle. As phosphine toxicity is closely related to temperature, fumigation is only recommended when the tobacco temperature is at or over 16°C (61°F). Above the minimum temperature required to fumigate, the phosphine

PHILIP MORRIS INTERNATIONAL			
PHOSPHINE FUMIGATION TOBACCO PMI SOP_PMI-IPM METHOD 751_03.DOC			
Created by:	L. Ruffieux	Creation date:	17/11/03
Last modified by:	L. Ruffieux	Last modification date:	17/11/03
		Ref.:	see path file
		Status:	version 3.0
File path: f:\leaf\agronomy\ipm\methodology\phosphine fumigation tobacco pmi_sop_pmi-ipm method 751_03.doc			
Page 4 of 17			

concentration and the exposure-time will vary dependant upon the tobacco temperature, as described in the following table:

Tobacco pests	Tobacco temperature		Case/bale Centre Phosphine Conc. (ppm)	Min. exposure-time (days)
	(°C)	(°F)		
Tobacco moth & Cigarette beetle	16-20	61-68	300	6
Tobacco moth & Cigarette beetle	> 20	> 68	200	4

Due to the minimum tobacco temperature of 16°C/61°F required to conduct fumigation, alternatives to the normal fumigation procedure described in this document may be needed. These alternatives are fumigation after pack out, freezing, re-drying, delayed/advanced fumigation. Alternatives may be used after approval by PMI Leaf.

## 1. OBJECTIVE OF FUMIGATION

Fumigants are gaseous pesticides that penetrate the tobacco mass (bale, case or hogshead) at atmospheric pressure and, when used correctly, kill 100% of all life-stages of the insects within. Phosphine (PH<sub>3</sub>) or hydrogen phosphide is a fumigant which has been used to fumigate tobacco since 1959 as it kills all life-stages of both major insect pests infesting tobacco, the cigarette beetle, *Lasioderma serricorne* (Coleoptera: Anobiidae) and the tobacco moth, *Ephestia elutella* (Lepidoptera: Pyralidae). Large-scale use by the world-wide tobacco industry was established by 1975 and continues today even if it has considerably decreased over the last years. Prevention by good sanitation practices is indeed the way forward in terms of tobacco pest management, reducing the reliance upon chemical treatments (PMI Method # 753).

**The correct use of phosphine is essential if we are to avoid the selection of resistant strains and eliminate any occurrence of tolerance.**

## 2. WHEN TO FUMIGATE

- All PMI-destined tobaccos prior to export to ensure they are insect-free.
- Tobaccos that must be certified to be insect-free in order to be shipped or received (e.g., to secure a phytosanitary certificate).
- Tobaccos that are infested upon receipt or that are detected as infested in tobacco storage. The decision to fumigate these tobaccos is based on level of infestation, ambient and tobacco temperatures and will be taken in agreement with PMI local Operations personnel.

PHILIP MORRIS INTERNATIONAL			
PHOSPHINE FUMIGATION TOBACCO PMI SOP PMI-IPM METHOD 751_03.DOC			
Created by:	L. Ruffieux	Creation date:	17/11/03
Last modified by:	L. Ruffieux	Last modification date:	17/11/03
		Ref.:	see path file
		Status:	version 3.0
File path: f:\leaf\agronomy\ipm\methodology\phosphine fumigation tobacco pmi_sop_pmi-ipm method 751_03.doc			
Page 5 of 17			

### 3. PHOSPHINE GAS (HYDROGEN PHOSPHIDE)

#### 3.1. Properties

Phosphine is a colorless gas that occurs in the hydrospheric phosphorus cycle. It is toxic to animals and its toxicity is related to temperature.

Phosphine has been proven to have no effect on the flavour, colour or taste of tobacco.

Phosphine may react with certain metals and cause corrosion, especially at higher temperatures and relative humidities. Metal such as copper, brass and other copper alloys, and precious metals such as gold and silver are susceptible to corrosion by phosphine.

Electric motors, smoke detectors, brass sprinkler heads, batteries and battery chargers, forklifts, temperature monitoring systems, switching gears, communication devices, computers, calculators and other electrical equipment may be damaged by this gas. Phosphine will also react with certain metallic salts and therefore, do not expose sensitive items such as photographic films, some inorganic pigments, etc. Aluminium and nickel do not appear to be affected by exposure to PH<sub>3</sub>, and zinc reacts only above 90% RH.

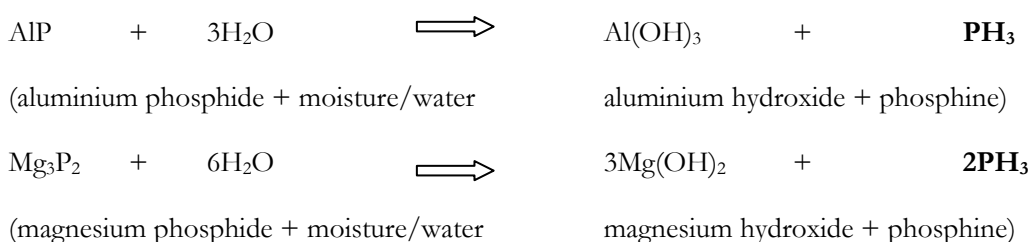
All electrical installations within a structure to be fumigated with PH<sub>3</sub> must be either protected by sealing or removed from the premises prior to exposure. Water sprinkler heads of fire control systems must be either sprayed with an antioxidant or covered with a wax (paraffin) to keep them from becoming corroded. Sprinkler heads made of nickel, stainless steel or chrome-plate are available. If in doubt, conduct a pre-test. The oxides that are formed on exposure to phosphine can be removed by washing the affected parts with a solution of ammonia in water. It should be noted that the pits, which form on the oxidised metals, are not affected by the ammonia treatment.

#### 3.2. Formulations

**Magnesium phosphide (Mg<sub>3</sub>P<sub>2</sub>) which generates phosphine gas is the fumigant of choice to fumigate PM-destined tobaccos.**

Numerous trademarked formulations based on aluminium phosphide and magnesium phosphide are available world-wide. However, the packaged magnesium phosphide formulation most widely used today is the Detia **Degesch Plate** or **Fumi-Cel Plate®**, which are available singly, or 20 joined together to form the strip or **Fumi-Strip®**.

Phosphine gas is evolved following exposure to atmospheric moisture:



PHILIP MORRIS INTERNATIONAL			
PHOSPHINE FUMIGATION TOBACCO PMI_SOP_PMI-IPM METHOD 751_03.DOC			
Created by:	L. Ruffieux	Creation date:	17/11/03
Last modified by:	L. Ruffieux	Last modification date:	17/11/03
		Ref.:	see path file
		Status:	version 3.0
File path: f:\leaf\agronomy\ipm\methodology\phosphine fumigation tobacco pmi_sop_pmi-ipm method 751_03.doc			
Page 6 of 17			

Unlike pellets, tablets or sachets, the Degesch Fumi-Cel® and Fumi-Strip® are packaged products that remain intact after the fumigation and retain all of the spent material and are therefore the only formulation acceptable for use with PM tobaccos.

**The usual dose of phosphine is 1-1.5 g/m<sup>3</sup> (700-1050 ppm) and one magnesium phosphide plate usually generates 33 g of phosphine.**

When magnesium phosphide plate is not registered in a country, aluminium phosphide sachets may be considered allowing that deactivation of unspent residues may require weeks and/or considerable labour to puncture the bags to facilitate water entry. Use of aluminium formulations is temporary and must be accompanied with a replacement plan.

Before the application of the fumigant, **the product label must be read carefully and understood.**

#### 4. FUMIGATION PARAMETERS

3 parameters influence the fumigation efficiency:

1. Tobacco temperature
2. Exposure-time
3. Phosphine concentration

They must be controlled to ensure an efficient fumigation and prevent the development of non-susceptible populations of *Lasioderma* and *Ephestia*. The following combination of parameters will ensure the control of all stages of susceptible populations:

**Fumigation is only acceptable when the tobacco temperature is at or over 16°C (61°F).**

***A minimum phosphine concentration of 200 or 300 ppm at the centre of tobacco bales/cases must be maintained during the whole exposure-time. The concentration and exposure-time will vary dependant upon the tobacco temperature).***

Minimum exposure-time required to achieve control of all stages of susceptible cigarette beetle and tobacco moth at 200 or 300 ppm phosphine at the case/bale center:

Tobacco pests	Tobacco temperature		Case/bale Centre Phosphine Conc. (ppm)	Min. exposure-time (days)
	(°C)	(°F)		
Tobacco moth & Cigarette beetle	16-20	61-68	300	6
Tobacco moth & Cigarette beetle	> 20	> 68	200	4

PHILIP MORRIS INTERNATIONAL			
PHOSPHINE FUMIGATION TOBACCO PML SOP PMI-IPM METHOD 751_03.DOC			
Created by:	L. Ruffieux	Creation date:	17/11/03
Last modified by:	L. Ruffieux	Last modification date:	17/11/03
		Ref.:	see path file
		Status:	version 3.0
File path: f:\leaf\agronomy\ipm\methodology\phosphine fumigation tobacco pml_sop_pmi-ipm method 751_03.doc			
Page 7 of 17			

Note: The times given are the minimum exposure-times for the specified concentrations required inside the tobacco. In addition to these times, it is necessary to add the time required in order to generate the phosphine gas, plus the time for this gas to then diffuse into the tobacco.

## 5. FUMIGATION INSTRUCTIONS

All fumigation procedures should be documented and form part of the company fumigation plan and record.

### 5.1. General techniques

Fumigations are carried out in a closed space (fumigation site) which is at atmospheric pressure at all times. Tobacco fumigations may be conducted in: a warehouse; the volume under a gas-tight (polyethylene) sheet, sometimes called a tent or tarpaulin; a specially constructed fumigation chamber; a fumigation bubble; freight containers.

**The closed space to be fumigated should be sealed to contain the gas.**

Some tobacco (such as expanded tobacco or cut-filler) may be wrapped in polyethylene bags (liners), therefore, phosphine will penetrate more slowly. More importantly, the gas may require several weeks to aerate to the required level of less than 0.1 ppm.

### 5.2. Warehouse fumigation

**The main difficulty will be the adequate sealing of the building to prevent gas leakage on a large scale.**

All windows, vents, doors, drains, ventilators, and other cracks/openings must be sealed. Provisions for gas-tight sealing should be included in the design of such closures (e.g. rubber gaskets and clamps). If not, a seal must be made each time the building is fumigated. Heavy masking tape at least 5 cm wide, or polyethylene tape (150 microns [µm] minimum thickness) may be applied over closures. Alternatively, sheets of polyethylene may be placed over the entire opening, and secured around the edges with tape. Wrap and seal roof ventilators with plastic sheet that is high density and at least 150 µm thick.

Inspect the building for potential leaks in floor, walls and roof. Give particular attention to the point at which the roof joins the walls; any openings must be sealed. In the case of double-thickness masonry, a gap is frequently left between the two courses of brick or block. If the top of the wall is not tightly capped, gas may escape through weep holes in the outer course. Sealing may be by taping or by coating with a sealant.

Suitable sealants are asphaltic mastic and “vinylite” plastic (polyvinylchloride/acetate copolymer resin in volatile solvents). Various other commercial sealing compounds may be used, but their gas-tightness and inertness to the fumigant must be established before use. Interior masonry walls must be sealed with at least two coats of vinyl-based paint, epoxy resin, or similarly gas-tight materials.

If it is necessary to fumigate a building to which sealant applications is impractical (uncaulked joints in roof or siding, porous masonry, screened louvers, etc.), use gas-tight tarpaulins within the warehouse.

PHILIP MORRIS INTERNATIONAL			
PHOSPHINE FUMIGATION TOBACCO PMI SOP PMI-IPM METHOD 751_03.DOC			
Created by:	L. Ruffieux	Creation date:	17/11/03
Last modified by:	L. Ruffieux	Last modification date:	17/11/03
		Ref.:	see path file
		Status:	version 3.0
File path: f:\leaf\agronomy\ipm\methodology\phosphine fumigation tobacco pmi_sop_pmi-ipm method 751_03.doc			
Page 8 of 17			

### 5.3. Tarpaulin fumigation

Sheet or tarpaulin fumigation is usually conducted within warehouses. Use a seamless sheet of high-density polyethylene sheet of minimum 150 µm thickness. If more than one sheet is required to cover the tobacco to be fumigated, tape the seams so as to be air-tight and not pull apart during the exposure period. The seam must be formed from a 30-cm overlap taped at both edges. Tarpaulin dimensions should fit with the tobacco stack size to be fumigated. Sweep clean the floor area involved and ensure there are no drains or expansion joints that could result in phosphine leakage. During the draping of the sheet over the tobacco stack, ensure that the sheet is not torn by any sharp corner or edge. Remove, pad, or make smooth all such features. Repair all tears in the sheet with tape. If the tobacco is stacked in corners or near walls, make sure that sufficient space exists to permit workers to properly drape the stack and to properly seal the sheet to the floor. Anchor the sheet with overlapping sand snakes or tape. Do not employ solid materials, such as wood, metal, stone, bricks or water snakes, etc. as anchors. Sand snakes must be heavy enough to seal the sheet to the floor (at least 10 cm Ø).

Introduce gas concentration monitoring tubes into the air space under the sheet and into the tobacco case/bale by means of a metallic probe. Seal the sheet to the floor prior to fumigation with small sections left open to permit placement of the plates or strips. After placement, close and seal the openings.

Semi-permanent sheeting (sometimes called a fumigation bubble) is available such as the Bubble® system from Rentokil whose main advantage is gas-tightness. In addition they are equipped with extraction pipes allowing phosphine release during the aeration (see Section 5.8) outside the warehouse.

### 5.4. Fumigation chamber

Fumigation chambers offer advantages including gas-tightness, better control of dosage, and permanency of gas handling equipment. They may be built of metal or masonry and porous materials must be sealed. They may be fitted with heating system and extraction pipes. The extracted gases may be chemically scrubbed (see Section 10).

### 5.5. Freight container fumigation

Freight containers are utilized for phosphine fumigation. They must be in sound condition with no dents or holes in the roof, walls, floor or doors. Tough sticky tape must be used for any additional sealing of the body air vents and for the securing of the door gaskets against the door frame of the container.

Special attention should be given to making the floor gas-tight. If necessary, it can be covered with a polyethylene sheet (at least 150 µm thick).

The container should be parked where it cannot be damaged by any moving vehicle or machine, and at a safe distance from the nearest work site. As a guideline, in a standard warehouse complex, the minimum distance should be 20 m. Ideally, the container should be under a shelter. Each container under gas must have its own warning notices on doors and side walls, and the doors should be padlocked.

**In transit fumigation is not acceptable.**



PHILIP MORRIS INTERNATIONAL		
PHOSPHINE FUMIGATION TOBACCO PMI SOP PMI-IPM METHOD 751_03.DOC		
Created by:	L. Ruffieux	Creation date: 17/11/03
Last modified by:	L. Ruffieux	Last modification date: 17/11/03
		Ref.: see path file
		Status: version 3.0
File path: f:\leaf\agronomy\ipm\methodology\phosphine fumigation tobacco pmi_sop_pmi-ipm method 751_03.doc		
Page 9 of 17		

## 5.6. Fumigant application

One magnesium phosphide plate is recommended to fumigate 33 m<sup>3</sup> (1166 ft<sup>3</sup>) as it generates 33 g of phosphine.

The fumigators wearing respiratory protective gas masks will apply the fumigant according to the steps outlined in the Fumigant Manufacturer's Application Manual (see the Internet site: <http://www.degeschamerica.com>). The plates will be removed from the aluminum foil pouches and should be placed on an appropriate rack, elevated off the floor surface, as the plates could catch fire if they come into contact with water during the fumigation. If the aluminum pouch (bag) is punctured, that fumigant must be deactivated (see Section 5.9) immediately.

## 5.7. Fumigant monitoring

Install sampling lines of 6 mm inner diameter for monitoring phosphine concentrations in the tobacco bale/case and optionally in the airspace (minimum of one meter above floor level), and cap them with a stopper or tape. The points at which the lines exit from the fumigated structure must be sealed. Prior to taking each gas readings, the sampling lines must be purged by using any type of suction apparatus, including the gas sampling pump used with the monitoring tubes. A simple calculation of sampling line volume ( $3.14 \times (0.6/2)^2 \times \text{length of sampling line in cm}$ ) / pump volume (cm<sup>3</sup>) will indicate the number of pump strokes needed to purge.

Determine phosphine concentrations within the fumigated airspace and within the tobacco case/bale with gas detection tubes such as Dräger, Auer or Kitagawa. More electronic sophisticated devices may be used, but at least one measure in every 20 should be cross-checked with a gas detection tube. Tubes are available to monitor 0.01 ppm and above.

*Freight container and chamber fumigation:*

At a minimum, gas readings must be taken at the centre of the tobacco case/bale at least at the following times following initiation of the fumigation:

- 6-12 h to ensure the phosphine gas is properly generated
- 24h to ensure that the target phosphine concentration (200 or 300 ppm dependant upon the tobacco temperature) has been reached at the centre of the tobacco case/bale
- 120h or 168h (dependant upon tobacco temperature) to ensure that the phosphine concentration has been maintained at or above the target concentration (200 or 300 ppm) for the required exposure-time (96h or 144h).
- At the end of the aeration period (see Section 5.8) to ensure the tobacco mass is less than 0.1 ppm phosphine.

\* Taking additional readings at 48, 72 and 96 hours offers the potential to identify leakage, thus avoiding an undesirable drop in phosphine concentration prior to the completion of the fumigation.

PHILIP MORRIS INTERNATIONAL			
PHOSPHINE FUMIGATION TOBACCO PML SOP PMI-IPM METHOD 751_03.DOC			
Created by:	L. Ruffieux	Creation date:	17/11/03
Last modified by:	L. Ruffieux	Last modification date:	17/11/03
		Ref.:	see path file
		Status:	version 3.0
File path: f:\leaf\agronomy\ipm\methodology\phosphine fumigation tobacco pml_sop_pmi-ipm method 751_03.doc			
Page 10 of 17			

#### *Warehouse and tarpaulin fumigation:*

At a minimum, gas readings at the centre of the tobacco case/bale must be taken at the following times following initiation of the fumigation:

- 6-12 h
- 24h, 48h, 72h, 96h and every 24h until completion of the fumigation
- At the end of the aeration period (see Section 5.8) to ensure the tobacco mass is less than 0.1 ppm phosphine.

During tarpaulin and warehouse fumigations, gas readings must be taken every 24h outside the structure to monitor the airspace around the fumigated structure in order to ensure that the potential for accidental exposures is eliminated. Should a concentration above 0.1 ppm be measured, additional sealing should be carried out.

During the aeration period, the ventilated airspace must be monitored until it is less than 0.1 ppm of phosphine. It is then safe to remove all safety warning notices and to allow access.

Should less than 50 ppm be found in the tobacco after 6-12 hours, it may be assumed that one or more of the following problems exist:

- There are leaks in the structure
- The Fumi-Cel® or Fumi-Strip® is faulty
- The phosphine measuring equipment is faulty

Unless the problem can be solved from outside the fumigated structure, licensed fumigators, working in pairs, wearing approved full face SCBAs, will enter to make an inspection. No one should remain inside a fumigated space for more than 5 minutes without communicating with persons outside and all personnel should be visible to each other at all times. When fumigating under sheet, inspections should be made from outside the sheeting.

During fumigations monitor the airspaces around the fumigation site to ensure no accidental exposures. Monitor the ventilated airspace until it is less than 0.1 ppm of phosphine. Monitor the tobacco mass until it is less than 0.1 ppm before releasing it for transport/processing.

All phosphine gas readings must be recorded on the Certificate of Fumigation (page 16).

### **5.8. Aeration**

Only licensed/certified fumigators using respiratory protective gas masks will open the fumigated structure for aeration. The area should remain open until the ventilated airspace is less than 0.1 ppm of phosphine. Readings must be made by the fumigators wearing respiratory protection. Continue aeration until the tobacco mass is less than 0.1 ppm phosphine before releasing it for transport/ processing; usually 2-4 days are sufficient. However, if polyethylene liners are used as tobacco wrappers, this may require up to 6 weeks.

Respect the local laws relating to environmental release rates of phosphine.

For warehouse aeration, see Section 10: Phosphine Abatement.

PHILIP MORRIS INTERNATIONAL			
PHOSPHINE FUMIGATION TOBACCO PMI SOP PMI-IPM METHOD 751_03.DOC			
Created by:	L. Ruffieux	Creation date:	17/11/03
Last modified by:	L. Ruffieux	Last modification date:	17/11/03
		Ref.:	see path file
		Status:	version 3.0
File path: f:\leaf\agronomy\ipm\methodology\phosphine fumigation tobacco pmi_sop_pmi-ipm method 751_03.doc			
Page 11 of 17			

## 5.9. Fumigant disposal

When the airspace is less than 0.3 ppm, remove the spent plates. Work in the fumigated area may resume after residue removal and when the airspace is less than 0.1 ppm.

Move the spent fumigant in open receptacles to a locked, placarded, fenced, ventilated, on-site wet deactivation site.

Place a maximum of 240 plates into a 110-litre (30 gallon) mesh basket and immerse in 200 litres (55 gallon) of water in a drum. Ensure all plates are covered by water at all times. Leave to deactivate all the unspent magnesium phosphide; usually, 2 days are sufficient.

Dispose of deactivated plates in an authorised landfill or burn. Discharge the water into a sewer, if available, or on to the ground. Obey local environmental regulations.

## 6. FUMIGATORS

Only licensed (in-country equivalent)/certified professional fumigators (external contracting company) should fumigate PMI destined tobaccos. These fumigators will have passed government - approved examinations and be certified as such. Equally they will belong to a licensed fumigation company expected to maintain adequate liability insurance. Appoint and train a person to interact knowledgeably with contractors, supervise the fumigation procedure and manage the fumigation contract. Ensure fumigators have a documented current continuous education/training program.

The fumigator will be completely responsible for all the fumigation procedure and for any fumigation failures; make certain that a signed contract clearly states that the fumigator bears full responsibility for sealing, fumigant application, gas concentration readings and safety. PMI affiliates, TPMs or Leaf suppliers will manage directly the contract with the fumigation contractor.

Fumigation should be considered as a specialized service, requiring a high degree of expertise and professionalism. Within the bid process, selection of fumigators should not be based solely on price but should give high consideration to quality of services and safety record. In order to ensure that the fumigators fully comply with this method, PMI affiliates/Leaf suppliers are encouraged to work closely with the fumigators.

## 7. TOBACCO TYPES TO FUMIGATE

All PMI-destined tobaccos must be insect-free, assured by efficient heat treatment or fumigation.

### 7.1. Raw tobaccos

Raw tobaccos must be fumigated prior export, in the country of origin, to ensure they are insect-free, and when detected as infested during storage. The possibility of fumigations at destination instead of origin must be agreed with the appropriate PMI Leaf buyers.

### 7.2. Semi-finished products

Semi-finished products (basic blended strip (BBS); cut-filler (CF); expanded tobacco (ET); improved stems (IS etc); reconstituted tobacco (homogenized HO)) should not be fumigated

PHILIP MORRIS INTERNATIONAL			
PHOSPHINE FUMIGATION TOBACCO PMI SOP PMI-IPM METHOD 751_03.DOC			
Created by:	L. Ruffieux	Creation date:	17/11/03
Last modified by:	L. Ruffieux	Last modification date:	17/11/03
		Ref.:	see path file
		Status:	version 3.0
File path: f:\leaf\agronomy\ipm\methodology\phosphine fumigation tobacco pmi_sop_pmi-ipm method 751_03.doc			
Page 12 of 17			

as heat treatments during their processing ensure they are insect-free. We should prevent their infestation during transportation and storage, via the preventive measures described in the in transit monitoring procedure (see PMI Method # 757) and good storage practices. However should fumigation be absolutely necessary, follow this procedure.

Some tobaccos (such as expanded tobacco, cut-filler) may be wrapped in polyethylene bags (polyliners) which will significantly slow down the gas penetration and the aeration process. For those, an alternative to phosphine should be applied such as freezing (see Section 11.2) although fumigation can be accomplished with enough time (see 5.8 Aeration). Opening the polyliner during the fumigation will accelerate the gas penetration and the aeration process. However this could lead to an OV modification.

## 8. FUMIGATION SAFETY AND SECURITY PARAMETERS

**THE PRODUCT LABEL MUST BE READ CAREFULLY, UNDERSTOOD AND FOLLOWED.**

### 8.1. General Safety Considerations

A comprehensive understanding of the fumigant, fumigation techniques and all local laws and ordinances must be maintained by the fumigator and obeyed. Trained, licensed, experienced fumigation personnel are the only persons to be considered for such work.

**Never fumigate alone.**

No fumigation may be performed unless: the supervisor is trained in the use of the specific fumigant, including procedures for first aid treatment of poisoning; the fumigant is legally registered for use in-country; environmental release laws are obeyed; and correct, safe transportation of the fumigant is possible.

### 8.2. Personal Protective Equipment (PPE)

At least two full-face canister type gas masks and a self-contained breathing apparatus (SCBA) must be on hand and maintained in good repair. At least two appropriate filters must be kept on hand at all times for each mask. A record must be kept of the number of minutes a filter is used, and of the concentration to which it is exposed. Minimum standards must be established, such as one gas filter used for 4 hours – respect the product instructions. The filters must be approved for use with phosphine. Gas masks are used when the exposure to phosphine is likely to exceed 0.1 ppm up to 15 ppm. Above 15 ppm, or when the concentration is unknown, the SCBAs must be used.

All personnel handling any phosphide fumigant will wear dry gloves of cotton or similar material whenever there is the least danger of coming into contact with a fumigant. Contact lenses should not be worn by anyone using a mask. Irreparable damage to the eye may occur if the mask leaks and the gas gets between the lenses and the cornea. Facial hair, such as beards and sideburns, interfere with the proper seating or sealing of a face mask. Such person should not attempt to use masks or participate in any fumigating activity calling for use of such protective equipment as a matter of procedure.

PHILIP MORRIS INTERNATIONAL			
PHOSPHINE FUMIGATION TOBACCO PML SOP PMI-IPM METHOD 751_03.DOC			
Created by:	L. Ruffieux	Creation date:	17/11/03
Last modified by:	L. Ruffieux	Last modification date:	17/11/03
		Ref.:	see path file
		Status:	version 3.0
File path: f:\leaf\agronomy\ipm\methodology\phosphine fumigation tobacco pmi_sop_pmi-ipm method 751_03.doc			
Page 13 of 17			

### 8.3. Monitoring Equipment

Equipment for measuring fumigant concentration must be kept at the work site from the beginning of fumigation until the end of aeration. If indicating reagent tubes (Dräger, Auer, Kitigawa) are used, they must have appropriate ranges for measuring both fumigation levels and trace levels of fumigant. Such tubes have expiration dates printed on them, do not use expired/out of date tubes.

### 8.4. Security

Establish a security perimeter around all fumigation sites and control entry into this area: only fumigators will be allowed in for the fumigation duration.

The site must be secured during the entire duration of fumigation and aeration of warehouses and freight-container. Regular security personnel may be used to periodically check fumigation areas. Such guards must be familiar with all relevant safety procedures for the fumigant. All entrance doors to fumigation areas must be thoroughly posted with warning signs. Signs should be in the local language(s) and include emergency response telephone numbers and the dates the fumigation began and will end.

Local police, fire and health authorities must be notified of all fumigations when required by law. A permanent notification may be made in case of regular chamber fumigations. Insurance coverage as required should be reviewed, as some general liability policies may exclude fumigations.

First aid equipment and procedures must be on-site. Inform local hospital, infirmary, and medical officers of fumigant type, poison symptoms and medical treatment required.

Open containers of fumigant (boxes or cans) in the open air. No person is to be allowed in the structure during fumigation except fumigator's personnel making the application.

All persons likely to come near the fumigation site should be made aware of phosphine properties. The fumigant label and material safety data sheet (MSDS) should be on site at all times.

## 9. CONTINGENCY PLANS

Contingencies must be planned for to allow a rapid response in any emergency. Those responsible for fumigations should review current practices and develop plans to deal with all possible contingencies including:

### 9.1. Accidental poisoning

A member of the fumigation team inhales gas due to accidental exposure and begins to demonstrate symptoms such as fatigue, nausea, chest pains, etc.

*Response:*

- Individual will be moved a safe distance from the fumigated area.
- Individual will be administered medicinal oxygen if necessary.

PHILIP MORRIS INTERNATIONAL			
PHOSPHINE FUMIGATION TOBACCO PMI SOP PMI-IPM METHOD 751_03.DOC			
Created by:	L. Ruffieux	Creation date:	17/11/03
Last modified by:	L. Ruffieux	Last modification date:	17/11/03
		Ref.:	see path file
		Status:	version 3.0
File path: f:\leaf\agronomy\ipm\methodology\phosphine fumigation tobacco pmi_sop_pmi-ipm method 751_03.doc			
Page 14 of 17			

- Individual will be transported to an emergency room for evaluation by a physician. Individual will be escorted by a member of the fumigation team with a copy of Label, MSDS and instructions to physician.
- The fumigator will inform the local hospital and/or Poison Control Center of the incident and that the victim is being transported.

## 9.2. Severe weather

Severe weather, such as high winds, rain, hail, atmospheric inversion, etc. occurs during the fumigation.

*Response:*

- Increase surveillance including additional gas readings and seal evaluations.

Note: Placement and removal of fumigant will not be done in inclement weather.

## 9.3. Sprinkler alarm

There is an alarm that indicates a loss of air pressure in a sprinkler system.

*Response:*

- Security calls sprinkler maintenance personnel to have the sprinkler system checked.
- Security calls fumigator on Emergency Response List to respond with the sprinkler maintenance personnel and conduct phosphine readings in area.
- If the sprinkler system is charged with water or there is an actual flow, fumigator team enters the warehouse with SCBA to identify the problem. If water present, Fumi-Strips® are to be removed and deactivated.

## 9.4. Fire in warehouse

There is an actual fire in a warehouse.

*Response:*

- Security will report fire to the fire department.
- Security calls fumigator and PMI representative on Emergency Response List.
- A guard will remain at the main gate to await the responding fire company.

Responding fire company will be given Fumi-Strip® Label and MSDS and taken to the warehouse in question.

Note: Under no circumstances will fumigators or PMI personnel enter a warehouse that is on fire.

# 10. PHOSPHINE ABATEMENT

According to the local laws relating to environmental release rates of phosphine, it may be recommended/needed at the end of the fumigation, to scrub chemically the exhausted gases with phosphine abatement units. The application of such a procedure should be considered when a large volume is fumigated ( $> 50'000 \text{ m}^3/1'765'000 \text{ ft}^3$ ) or in case of regular chamber fumigation.

PHILIP MORRIS INTERNATIONAL		
<i>PHOSPHINE FUMIGATION TOBACCO PMI SOP PMI-IPM METHOD 751_03.DOC</i>		
Created by:	L. Ruffieux	Creation date: 17/11/03
Last modified by:	L. Ruffieux	Last modification date: 17/11/03
		Ref.: see path file
		Status: version 3.0
File path: f:\leaf\agronomy\ipm\methodology\phosphine fumigation tobacco pmi_sop_pmi-ipm method 751_03.doc		
Page 15 of 17		

## 11. ALTERNATIVES TO CURRENT FUMIGATION TECHNIQUES

**Alternatives to a contractual obligation to fumigate must be approved by PMI local Operations personnel.** This always concerns tobacco fumigated prior to export to the first PMI-destination warehouse.

Due to the minimum tobacco temperature of 16°C/61°F required to conduct fumigation, alternatives to the normal fumigation procedure described in this document may be needed. These alternatives are:

### 11.1. Fumigation after pack-out

Tobacco temperature stays over 20°C/68°F for at least 2 weeks after tobacco redrying and pack out. A rapid cooling period of 3-4 days can generally be observed and then, tobacco temperature decreases slowly. As long as tobacco temperature is at or over 16°C/61°F and ambient temperature is over 4.4°C/40°F, the normal fumigation procedure can be applied.

### 11.2. Freezing

The temperature and time required to ensure effective elimination of insects which commonly infest tobacco are minus 20 degrees C for 48 hours. All of the tobacco product being treated must remain in the freezer for the required time after reaching the target temperature at the core. This may be accomplished in commercial, bulk, draught-assisted (blast) freezers.

Tobacco product should be reconditioned or tempered for several days.

Before using freezing as an alternative to phosphine, characterize thoroughly the process to ensure it may reach the above mentioned criteria.

### 11.3. Re-drying

Re-drying is the process by which the moisture content of tobacco is regulated as preparation for storage. A “steamed” tobacco temperature of at least 60°C/140°F for 3 minutes (or 70°C/158°F for 2 minutes or 55°C/131°F for 4 minutes) is required to kill all life stages of both cigarette beetle and tobacco moth.

It is possible to achieve these conditions during normal re-drying but before using re-drying as an alternative to phosphine, characterize thoroughly the cycle to ensure it will result in 100% insect elimination.

### 11.4. Delayed/Advanced fumigation

Schedule fumigations to ensure they will be conducted when tobacco temperature will be at or over 16°C/61°F. During storage prior to or after fumigation, ensure the ambient temperature is below 15°C/59°F as the adults of both tobacco moth and cigarette beetle don't fly at such temperatures and (cross-)infestation will not therefore occur.

PHILIP MORRIS INTERNATIONAL		
<i>PHOSPHINE FUMIGATION TOBACCO PMI SOP PMI-IPM METHOD 751_03.DOC</i>		
Created by:	L. Ruffieux	Creation date: 17/11/03
Last modified by:	L. Ruffieux	Last modification date: 17/11/03
		Ref.: see path file
		Status: version 3.0
File path: f:\leaf\agronomy\ipm\methodology\phosphine fumigation tobacco pmi_sop_pmi-ipm method 751_03.doc		
Page 16 of 17		

## 12. REFERENCES

- PMI Method # 753: “Post-harvest Tobacco Infestation Control”.
- PMI Method # 757: “Post-harvest Tobacco, Infestation Prevention: In transit Monitoring of Tobacco with Pheromone traps”.

## 13. APPENDICES

- Fumigant label, MSDS, Manufacturer’s Applicator Manual, Placard: see the Internet site: <http://www.degeschamerica.com>

## 14. REVISION HISTORY

Issue 1 - 03/1991	Original method written by L. Ryan & J.-M. Freymond.
Issue 2 - 07/2001	Complete revision.
Issue 3 - 11/2003	Partial revision


Written by L. Ruffieux

Checked and approved by Hal Teegarden



PHILIP MORRIS INTERNATIONAL		
PHOSPHINE FUMIGATION TOBACCO PMI SOP PMI-IPM METHOD 751_03.DOC		
Created by: L. Ruffieux	Creation date: 17/11/03	Ref.: see path file
Last modified by: L. Ruffieux	Last modification date: 17/11/03	Status: version 3.0
File path: f:\leaf\agronomy\ipm\methodology\phosphine fumigation tobacco pmi_sop_pmi-ipm method 751_03.doc		
Page 17 of 17		

Certificate of Fumigation (complete and file associated with the tobacco lot information)

PMI-DESTINED TOBACCO FUMIGATION		
(via Standard Operating Procedure - SOP, PME Method # 751)		
TOBACCO SUPPLIER	NAME	ADRESSE
LOT NUMBER		
FUMIGATION CONTRACTOR (or FUMIGATOR)		

**Tobacco description**

Type:	Net Weight:	Infested with:
Crop Year:	Quantity: (No. of Cases)	Cigarette beetle: Yes__ No__
Grade:	Poly Lined: Yes__ No__	Tobacco moth: Yes__ No__

Tobacco temperature (center of case/bale) recorded prior fumigation: \_\_\_\_ °C

**Fumigation description**

Enclosure Type: Container\_\_ Sheeted stack\_\_ Whole warehouse\_\_ Chamber\_\_ Other\_\_

Fumigant Name: \_\_\_\_\_

Formulation: Pellet\_\_ Tablet\_\_ Bag\_\_ Plate\_\_ Other\_\_

Total Volume Fumigated (m3): \_\_\_\_\_ Dose PH3 (g/m3): \_\_\_\_\_ Total Fumigant used (g): \_\_\_\_\_

Total Hours under Gas: \_\_\_\_\_ Total Hours of Aeration: \_\_\_\_\_

Fumigant wet deactivated: Yes\_\_ No\_\_

Dates/Time: Fumigant placed \_\_\_\_/\_\_\_\_/\_\_\_\_, \_\_\_\_ Aeration begun \_\_\_\_/\_\_\_\_/\_\_\_\_, \_\_\_\_

Aeration completed \_\_\_\_/\_\_\_\_/\_\_\_\_, \_\_\_\_

Minimum ambient (surrounding) temperature recorded during fumigation: \_\_\_\_ °C

**Fumigation data**

**NOTE:** The minimum requirement is 300ppm phosphine for 6 consecutive days, when tobacco temperature is 16-20°C and 200ppm phosphine for 4 consecutive days, when tobacco temperature > 20°C.

**No fumigation if tobacco temperature is below 16°C.**

Gas reading must be taken at the center of one case/bale, away from the fumigant placement, USING A PROBE.

The first reading shall be made 6-12 hours after fumigant placement.

The tobacco consignment can be moved/transported only when < 0.1ppm phosphine is reached in the tobacco.

Time After Fumigant Placement (hours)	indicative actual	6	12	24	48	72	96	120	120	144	168	End of aeration
<b>Fumigation</b>												
Phosphine Conc. (ppm)	Airspace*											
	Tobacco Case/Bale											
<b>Aeration</b>												
Phosphine Conc. (ppm)	Airspace (surrounding)											
	Tobacco Case/Bale-until 0.1ppm											

\* optional

**Comments:**

(For example, corrective actions made due to gas leaks, etc)

**Signatures:**

(Attesting the information entered above is correct, that the fumigation practices adhered to the consignees instructions and that all fumigant residues were removed from the consignment).

Supervising Fumigator: Name \_\_\_\_\_ Signature \_\_\_\_\_ Date: \_\_\_\_\_

For the Supplier: Name \_\_\_\_\_ Signature \_\_\_\_\_ Date: \_\_\_\_\_