



CORESTA GUIDE N° 2

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PHOSPHINE FUMIGATION PARAMETERS FOR THE CONTROL OF CIGARETTE BEETLE AND TOBACCO MOTH

1. Introduction

Two insects, the cigarette beetle, *Lasioderma serricorne* and the tobacco moth, *Ephestia elutella*, infest cured tobacco. These pests can be controlled by successful fumigation. The tobacco moth is more susceptible to phosphine than the cigarette beetle and thus the fumigation standards established for control of the cigarette beetle are those that should be used for controlling both insects.

Following trials with phosphine fumigations in Europe in the late 1950s and subsequent testing in Japan and the USA, phosphine became the fumigant of choice in the tobacco industry by 1975.

In the late 1960s, ineffective fumigations as a result of resistance to phosphine were reported in a wide range of insect species. However, at that time, there were no tobacco fumigation failures associated with cigarette beetle resistance. Phosphine resistance was not reported for the cigarette beetle until 1995, when the first ineffective field fumigation was recorded in India. The incidences of failed fumigations and phosphine resistant beetles are being documented with increasing frequency worldwide.

2. Background

The potential of widespread phosphine resistance of cigarette beetles poses a serious risk to the continued successful use of phosphine as a tobacco fumigant. Therefore in 1998, the CORESTA Sub-Group on Pest and Sanitation Management in Stored Tobacco commissioned the Food and Environment Research Agency (Fera) (formerly the Central Science Laboratory) of the UK, as an independent laboratory, to assess the global variability of response by *Lasioderma serricorne* to phosphine. This work showed a range of responses among the phosphine susceptible populations of cigarette beetle, with some able to survive the fumigation treatments used by the industry at that time. In addition a collaborative effort was established with North Carolina State University which focused on the effect of temperature, concentration and exposure-time on fumigation effectiveness.

Having established the fumigation parameters required to achieve 100% mortality of susceptible populations of cigarette beetles, attention was turned to non-susceptible/resistant beetles. In 2003 Fera was once again commissioned to determine the parameters required to achieve 100% mortality of all life stages of all known strains of non-susceptible beetles.

In 2005, working independently, Japan Tobacco and Detia Degesch substantiated the correlation between the lethal concentrations necessary to kill cigarette beetle eggs (the least susceptible stage to phosphine) and the knockdown time of adults exposed to high levels of phosphine. This work was the basis for Detia Degesch to develop a discriminating dose test (*i.e.* a resistance test kit) to distinguish between susceptible and resistant cigarette beetle populations and thus the ability to determine which fumigation standard to use for a given fumigation.

3. Phosphine Fumigation Parameters for Susceptible Cigarette Beetles

The laboratory and field studies confirmed that three parameters influence fumigation effectiveness:

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

These three parameters must be strictly controlled to ensure effective fumigations and prevent the development of non-susceptible populations of cigarette beetles. Based on current knowledge of the effects of temperature, time and phosphine concentration on fumigation effectiveness, the following guidelines for tobacco fumigation will ensure control of all stages of susceptible cigarette beetles:

- *Fumigation is only recommended when the tobacco temperature is at or above 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 depending upon the tobacco temperature.*
- *Strict compliance with the fumigant label (magnesium phosphide plate/strip is the preferred fumigant formulation for the tobacco industry) and local or national regulations is essential.*

Table 1. Minimum exposure-time required to achieve 100% control of all stages of susceptible cigarette beetle and tobacco moth at 200 or 300 ppm phosphine at the bale/case centre

Tobacco Temperature		Phosphine Concentration at the Bale/Case Centre	Minimum Exposure-Time
(°C)	(°F)	(ppm)	(days)
16-20	61-68	300	6
> 20	> 68	200	4

Note: the tobacco temperature must be checked before the start of a fumigation.

Extensive work was performed in the region of 10 °C to 15 °C to provide data indicating concentrations/times that would provide successful fumigations. However, within this temperature range, times in excess of 16 days at concentrations > 300 ppm would be required. Such time/concentration conditions are not considered practical for tobacco fumigations.

4. Phosphine Fumigation Parameters for non-Susceptible Cigarette Beetles

For non-susceptible/resistant cigarette beetles the same three parameters apply and must be strictly controlled to ensure effective fumigations and prevent the development of increased resistance in these populations. Based on the current knowledge of the effects of temperature, time and phosphine concentration on fumigation effectiveness, the following guidelines for tobacco fumigation will ensure effective control of all stages of non-susceptible cigarette beetles:

- *Fumigation is only recommended when the tobacco temperature is at or above 20 °C (68 °F).*
- *A minimum phosphine concentration of 600 or 700 ppm at the centre of tobacco bales/cases must be maintained during the whole exposure-time.*
- *The concentration and exposure-time will vary depending upon the tobacco temperature.*
- *Strict compliance with the fumigant label (magnesium phosphide plate/strip is the preferred fumigant formulation for the tobacco industry) and local or national regulations is essential.*

Table 2. Minimum exposure-time required to achieve 100% control of all stages of non-susceptible cigarette beetle and tobacco moth at 600 or 700 ppm phosphine at the bale/case centre

Tobacco Temperature		Phosphine Concentration at the Bale/Case Centre	Minimum Exposure-Time
(°C)	(°F)	(ppm)	(days)
20-25	68-77	700	10
> 25	> 77	600	6

Note: the tobacco temperature must be checked before the start of a fumigation.

Recognizing that meeting these fumigation parameters may be difficult, the Sub-Group is investigating the efficacy of lower doses for longer periods of time. Should these prove successful, the fumigation standard will be modified accordingly.

5. Safety

Strict compliance with the fumigant label and the local or national regulations is essential not only for efficacy but also for the health and safety of the fumigators and by-standers. Significant adverse outcomes, including death, are possible with misuse.

6. Potential Changes and Impact

The major change in the fumigation guidelines for susceptible beetles from the historical standard of 200 ppm for 48 hours within a 4 day fumigation period, is the extended exposure-time, particularly when temperatures drop below 20 °C. For resistant beetles both concentration and exposure-time are increased significantly. High standards of sealing of fumigation structures are required to ensure the minimum bale/case centre phosphine concentrations throughout the exposure-times. Changes in logistics may be required and costs associated with fumigation may be impacted.

The minimum tobacco temperatures of 16 °C and 20 °C for susceptible and non-susceptible beetles, respectively, required to fumigate may also require changes in timing and logistics, such as, fumigation after pack-out, fumigation in a fumigation chamber fitted with a heating system, delayed fumigation and/or fumigation conducted in the country of destination instead of the country of origin.

7. Implementation

Tobacco fumigation with phosphine is the main Industry tool for pest management of infested tobacco and as such, all possible efforts must be made to enforce good fumigation practices to control infestation and minimize the development and spread of phosphine resistance. The CORESTA Sub-Group on Pest and Sanitation Management in Stored Tobacco is conducting worldwide joint training sessions to share the phosphine fumigation parameters for the control of cigarette beetle and tobacco moth with the Industry.

The presence of resistant beetles has now been documented in Asia, North America, Africa and Australia. Identifying these populations within the countries of origin and implementing fumigation practices to deal effectively with these populations are critical steps that are needed to curb the spread of phosphine resistance and to keep phosphine as a viable insecticide for the tobacco industry.

Only having one fumigant available to the Industry makes the preservation of its effectiveness paramount and difficult. Those circumstances that have led to the development of resistance must be avoided. Poor fumigations must not be tolerated. Fumigation enclosures must be inspected to ensure that there are no leaks, and commodity temperature and phosphine concentration readings must be monitored to ensure that the standards set out in this document are achieved.