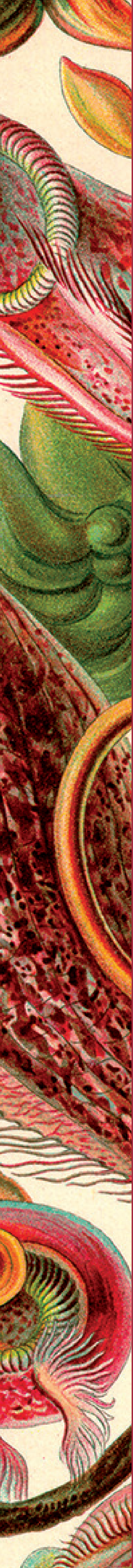

Food and Agriculture Organization of the United Nations

International Plant Protection Convention
Protecting the world's plant resources from pests

FEB. 2017

ENG

Explanatory document for ISPM 15 (*Regulation of wood packaging material in international trade*)

Produced by the Secretariat of the
International Plant Protection Convention (IPPC)

Note: Explanatory documents for International Standards for Phytosanitary Measures (ISPMs) are produced as a result of a decision of the Interim Commission on Phytosanitary Measures in 2004 (reported on paragraph 111 of the report of ICPM-6). They are written to provide supporting information to the standard they refer to and cannot be taken as an official legal interpretation of the IPPC or its related documents, and are produced for public information purposes only. Each document is reviewed by experts acting under the auspice of the Secretariat before publication, and the draft document would be made available to the Standards Committee which may comment in the reviewing process.

This explanatory document has been developed with input from the IPPC's Technical Panel on Forest Quarantine. It was circulated to the Standards Committee (SC) via e-decision in February 2014 and SC comments were forwarded to the authors for their consideration. However, the material presented in the explanatory document remains the opinion of the writer and cannot be interpreted as a decision of the ICPM/CPM. It is hoped that most standards will have one or more explanatory documents associated with them.

Explanatory document for ISPM 15

(Regulation of wood packaging material in international trade)

Written by Shane Sela (lead author), Thomas Schroeder, Matsui Mamoru and Michael Ormsby under the auspices of the IPPC Secretariat.

Approved in 2014, published in 2017

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Introduction and scope

In March 2002, the Commission on Phytosanitary Measures (CPM) adopted ISPM 15*Guidelines for regulating wood packaging material in international trade*. In April 2009, a revised standard ISPM 15 *Regulation of wood packaging material in international trade* was adopted by the CPM-4. The revised standard supersedes the original.

In 2013, CPM-8 adopted the revised Annex 1 Approved treatments associated with wood packaging material and made consequential changes to Annex 2 The mark and its application.

ISPM 15 establishes guidance to national plant protection organizations (NPPOs) on the regulation of wood packaging material, which is known as an important pathway in the movement of quarantine pests. ISPM 15 sets out harmonized requirements for the application of treatments to render wood packaging material practically free of quarantine pests. ISPM 15 also describes the use of an internationally standardized mark to identify compliant wood packaging material.

During the adoption the revised ISPM 15, the CPM recognized that wood packaging material produced under the specifications of earlier versions of the standard continue to present only negligible risks for the movement of pests and therefore should remain certified while in service.

The role of interpreting and implementing ISPM 15 remains the responsibility of NPPOs.

The information contained in this document presents some of the potential ways by which the standard may be implemented.

Definitions

This document uses terms and definitions contained in ISPM 5 (*Glossary of phytosanitary terms*) available on the International Phytosanitary Portal (IPP – www.IPPC.int)[1].

1. Background

Several documented studies and pest risk assessments conducted by NPPOs have shown that untreated wood packaging material can harbour pests which when moved to new areas may cause economic and environmental harm. ISPM 15 describes phytosanitary measures to minimize the risk of pest movement including: the removal of bark; the application of a treatment, and; the identification of compliant wood packaging material with an internationally recognized mark. The standard also requires that the application of these measures occur within an official certification system and proposes the adoption of import controls to monitor compliance.

Wood packaging materials move from country to country and accompany many different commodities, which may not present a pest risk. The regulation of wood packaging material represents a substantial undertaking. Estimates suggest that wood packaging material and cardboard and paper packaging account for the second largest use of wood fibre worldwide. The wood packaging material industry in the United States of America (US) used more than 15.4 million cubic metres of solid wood in 1999 for the construction of wooden pallets and containers. The volumes of wood packaging materials moving in trade are substantial and the industries responsible for production are diverse with little contact or communication with NPPOs, who have traditionally focused on the regulation of agricultural commodities. This latter aspect may be exacerbated, if the legislative authorities of phytosanitary authorities do not contain the necessary powers to regulate conveyances. It should be noted however that the International Plant Protection Convention (IPPC) does recognize and encourage the management of pest risks associated with conveyances as specified in Article I:

> Where appropriate, the provisions of this Convention may be deemed by contracting parties to extend, in addition to plants and plant products, to storage places, packaging, conveyances, containers, soil and any other organism, object or material capable of harbouring or spreading plant pests, particularly where international transportation is involve.

2. Regulated Articles

The standard provides guidance for establishing measures to reduce the risk of pests associated with all types of wood packaging material, including dunnage, crating, packing blocks, drums, cases, load boards, pallet collars, skids or pallets and other wooden units which secure, protect or assist in the movement of a cargo or commodity. “Dunnage” is defined in ISPM 5, but the term is more commonly used to refer to items such as load boards, wood used to separate sawn wood (lumber), bracing within cargo containers, and other loose wood used in securing a cargo during transit. Dunnage is considered by some NPPOs to pose a very high pest risk. Dunnage often consists of large timbers which are more difficult to treat adequately.

Examples of wood packaging material are provided in Appendix 1 of this document.

3. Exempt Articles

ISPM 15 excludes articles made from wood thinner than 6 mm and wood packaging material made exclusively from processed wood material such as plywood, oriented strand board, fibreboard, press board, cardboard, etc. The latter articles have either undergone processes that render them a negligible risk, or the nature of the material used poses little pest risk. The thin layers of wood laminated together to construct sheets of plywood are unlikely to contain most forest pests. Oriented strand board,

[1] Adopted standards, including ISPM 5, are available at: https://www.ippc.int/en/core-activities/standards-setting/ispms/

fibreboard, etc. are made from small chips of wood glued together under heat which are unlikely to contain pests.

There is no additional treatment or marking requirement for wood packaging material made completely from these exempted materials. However, wood packaging material containing both wood and processed wood material should be constructed using wood that has been treated and the unit marked to identify that the wood is compliant with the requirements of ISPM 15. Marking can be placed on the processed wood material to facilitate ease of identification (further information on marking is provided in Section 6.2).

Wine and alcohol barrels are sufficiently treated by the application of high heat and steam during the process used to bend the wood. These barrels are also burned on the inside during a process referred to as "toasting" which is a key part of flavouring process in the manufacture of liquors. Wine and alcohol barrels are therefore exempt from the requirements of ISPM 15. Other barrels, for example those used for transporting food or for decorative use, should be regulated, as treatments effective in killing pests are not applied to the staves as part of the manufacturing process.

The standard also exempts from regulation wood packaging material such as sawdust, wood shavings and wood wool. Sawdust is the fine particles resulting from the blade sawing the wood. Wood shavings are very thin slices of wood manufactured specifically for packaging, animal bedding, etc. which are unlikely to provide sufficient surface area for insect life-stages. Shavings should not be confused with wood chips which are small irregular pieces of wood of varying sizes, which may contain bark pieces and provide sufficient surface area for pests to survive. Wood wool is fine curled shavings of wood smaller than wood shavings but larger than sawdust.

The ability to regulate wood packaging material remaining on board marine vessels or other transport vehicles depends on the limits of national law. The pest risks associated with untreated wood packaging material remaining on board marine vessels are dependent on the life-stages of the pests associated with wood, the proximity of the vessel to suitable habitat, whether the wood packaging materials is held in sealed areas of the vessel, etc. Wood components, permanently attached to a conveyance or container are considered exempt from the requirements. Examples of these include: wooden beams bolted to the floor or sides of a container or to the interior of a rail car in which the wood is used to cushion heavy cargoes; flat racks, which are containers with a steel frame and wooden floor and sides, platform containers which contain a wooden floor, etc. Often this type of wood has been in use for sufficiently long periods that would result in the wood having insufficient moisture to support many pests.

NPPOs need to consider whether certain decorative boxes should be regulated. Presentation boxes for wine, spirits, cigars or other articles may be constructed using some wood that is not exempt (e.g. wood larger than 6 mm). These boxes may, however, present a very low pest risk. The wood used is often of a very high quality and is unlikely to be contaminated with pests. The thickness of the wood is often very thin and represents likely a low risk, or the articles intended use may reduce the risk. It may be appropriate for NPPOs to evaluate the specific phytosanitary requirements for these types of articles on a case by case basis.

4. Establishment of National Requirements

International standards adopted by the IPPC have a special standing under the World Trade Organization's Agreement on the Application of Sanitary and Phytosanitary Measures (WTO-SPS Agreement). For example, the WTO–SPS Agreement states:

> "Sanitary or phytosanitary measures which conform to international standards, guidelines or recommendations shall be deemed to be necessary to protect human, animal or plant life or health, and presumed to be consistent with the relevant provisions of this Agreement […]"

International standards are written as guidance for NPPOs to promote harmonized regulations but are not regulatory instruments in themselves. The standards become effective only when countries adopt the prescribed principles within national legislation or requirements. The period required for national adoption of international standards varies from country to country and importers and exporters should therefore contact the local authorities to determine the policies and requirements for the trade of goods.

International adoption of a standard implies that countries recognize the need for harmonized measures and that these countries are not required to individually provide technical justification for implementation of the standards. If countries require measures beyond those described in ISPM 15, they are obligated to provide a technical justification. The technical justification should be based upon pest risk analysis with careful consideration of the appropriate level of protection.

Since wood packaging material moves through complex and widely dispersed trading patterns, amongst different countries, the addition of country-specific phytosanitary import requirements would result in undesirable complexities in the trade of commodities. The standard balances risk reduction to an internationally recognized acceptable level with least restrictive trade measures. The treatments identified in ISPM 15 do not provide absolute protection against all pests of wood, however, the application of these measures do provide a safer worldwide trading environment in which the majority of risks have been mitigated.

The standard encourages the application of a treatment option before the initial export of wood packaging material in the country of production. The standard also encourages the inspection of imports to monitor compliance. The standard does not obligate NPPOs to ensure that exports comply with ISPM 15 although some countries may possess legislation that requires exporters to comply with the phytosanitary requirements of importing countries. Within the regulatory scheme for the production of compliant wood packaging, NPPOs should carefully consider the importance of approved facilities demonstrating traceability of treatment from the time of application to the time of export. This is particularly important when wood packaging material is repaired or remanufactured. NPPOs should establish stringent requirements regarding how approved facilities must operate to ensure compliance with ISPM 15. This may include maintaining documentary evidence that: treatments are performed as prescribed; wood used in the production of wood packaging material has been treated, compliant wood packaging material does not become confused with non-compliant wood packaging material as it moves through an in-country chain of custody, etc. Further information on possible approaches for the regulation of a producer certification system is provided in Section 6.

When establishing phytosanitary requirements, NPPOs should consider the potential trade impacts caused by implementation. NPPOs should communicate changes to import requirements to exporting countries and to importers and their related industry well in advance. NPPOs must consider that exporting countries require time to establish a compliant exporting framework. Numerous communications, legislative, public administration and policy steps are required to establish the export certification process, some of which are:

- determination of the exporting industry’s capacity to implement changes necessary to comply with requirements (e.g. to establish treatment operations, to change production practices, etc.)
- determination of the legal capacity to introduce legislative changes
- establishment of legislative or public policy
- establishment of third party organizations to oversee producers as required
- communication of proposed requirements
- technical or financial assistance where required to allow the producers to comply with changes
- implementation
- evaluation of the system.

Countries should establish inspection procedures that both verify compliance and mitigate the risks of pest entry associated with non-compliant material. Where appropriate, enforcement activities may include actions to reduce future non-compliances such as notices of violation, civil penalties, forfeiture of goods, prosecution, and others. Inspection programs should be developed to identify imports that pose the greatest risk for pest entry. These may be based upon:

- the origin of imports (areas of similar biogeography to the importing country are likely to pose a greater risk)
- the type of commodity involved and its propensity to be associated with wood packaging material that may present a risk
- the history of importations (certain sources may demonstrate better compliance)
- the level compliance of the individual source or importer, or
- other factors.

Countries should also consider the need for training inspection staff to identify compliant marks, wood packaging material that poses a higher pests risk , and the signs and symptoms of potential quarantine pests (for example exit holes containing frass, insect galleries, life stages of insects, signs of quarantine fungi, and similar). Inspection staff should also be competent in making appropriate decisions in dealing with non-compliant wood packaging. For example, when pests are detected actions to mitigate escape into the environment should be promptly applied. NPPOs should also note that wood packaging material is often transported in cool moist environments where surface fungi may develop (e.g. moulds). These are often ubiquitous organisms that do not pose a quarantine risk and enforcement activities should not be applied to these imports.

5. Measures to Reduce Pest Risks Associated with Wood Packaging Material Moving in Trade

5.1 Debarking

The standard requires the use of debarked wood in the construction of compliant wood packaging material. Debarked wood is defined in the ISPM 5. Debarking is an industrial process in which most of the bark of the harvested tree is removed often by metal teeth, knives or chains which tear the bark from the wood. Debarking does not necessarily result in wood which is bark free. The standard requires that the removal of bark should result in wood that contains no more than 3 cm bark in width (regardless of the length) or if the residual bark exceeds 3cm in width, then any individual piece of bark should not exceed 50 square centimetres. Exporting countries should ensure that approved production systems ensure that wood packaging complies with the bark tolerances prescribed in the standard. Some examples of bark on wood are provided in Appendix 2.

Import authorities should recognize that the production of wood and the construction of wood packaging material is generally a mechanized process involving a high turnover of product in a very short period of time. It is therefore common that bark pieces on wood species that are harder to remove the bark from may slightly exceed the tolerances prescribed. Actions may be warranted to mitigate the risks associated with these pieces; however, authorities should recognise that failures may occur and that stringent enforcement activities are most warranted in cases of on-going non-compliance or where multiple non-compliances in a single shipment are observed.

5.2 Approved treatments

Currently, there are three treatments recognized internationally as being effective in providing sufficient protection against quarantine pests associated with wood packaging material. These are two heat treatments and a fumigation treatment using methyl bromide under conditions set out in Annex 1 of ISPM 15. Heat treatment may be achieved by way of conventional heating of the wood within a kiln to a temperature of 56 ˚C for a period of 30 continuous minutes throughout the profile of the wood or by using dielectric heating to heat the entire profile of the wood to a temperature of 60 ˚C for a period of 60 seconds. Based on the current available research the latter is achieved by microwaves with a wavelength of 2.45 GHz.

The treatments prescribed in ISPM 15 have been approved based upon an assessment of the range of wood pests affected by the treatments; the efficacy of the treatments in killing wood pests, and; the technical or commercial feasibility of the treatments for use on wood packaging material. It should not be interpreted that the treatments will kill every pest that may occur in wood. The purpose of the treatments is to reduce the risk of serious pests of significance to forests. The number of species of wood used in the manufacture of wood packaging material, the number of pests that may be associated with the variety of wood species used, the life-cycles and life-histories of the pests involved, and numerous other factors will affect the occurrence and severity of pest infestations associated with the wood used in wood packaging. The measures prescribed in the standard are believed to be sufficiently effective provided that the treatments are applied using good application practices. Specific requirements regarding application practices are provided in the Annex 1 of ISPM 15. Additional guidance is provided in Annexes I and II of this document.

Both heat treatment and methyl bromide fumigation are recognized as being sufficient to permit the ongoing use of the treated and certified wood packaging material indefinitely, provided that untreated wood is not added to the packaging during repairs or remanufacturing. Both treatments are effective against pests present at the time of the treatment, and the resulting treated wood packaging is unlikely to be susceptible to re-infestation.The risk of infestation following treatment is low because the remaining bark surface is insufficient to support most insect development and once debarked, the wood dries sufficiently to lose its suitability as a host for most pests. Some exceptions to this general rule include termites and certain dry wood borers (e.g. Lyctidae).

The efficacy of treatment is greatly affected by the conditions under which the treatment is carried out. NPPOs should ensure that applications are consistently carried out under operational conditions which favour the efficacy of the treatment. In this regard, consideration of the moisture content of the wood, the humidity within the treatment chamber or structure, the starting temperature of the wood to be treated, and the availability of sufficient air circulation will influence the efficiency of treatment.

In establishing systems for achieving compliant supplies of wood packaging material, NPPOs should consider whether the following resources are sufficiently available:

- facilities with adequate technology and competent staff to undertake treatments
- technological guidance in establishing treatment systems
- procedures and equipment to appropriately apply the treatment and means to maintain clear records pertaining to application
- legislative authorities to obligate producers to comply with specified requirements, and
- systems and resources to routinely monitor authorized facilities to ensure ongoing compliance with requirements.

In countries where facilities do not exist to provide treated products, NPPOs should consider permitting that wood officially treated and certified elsewhere may be used within the official production system. NPPOs will have to consider a means for maintaining the traceability of the imported wood while it is moved from the point of treatment through to the certification system. The use of marks or other identification applied to the wood may permit traceability through the system but the NPPO should consider carefully whether the ISPM 15 mark as identified in Annex 2 of the standard should be permitted to be applied to unassembled wood intended for wood packaging material. A facility may receive treated wood which has been used in combination with non-compliant wood to build wood packaging material which then appears to be compliant. It is therefore desirable to prescribe that the ISPM 15 mark is only applied as the last step in the certification process. NPPOs of importing and exporting countries may collaborate in approving other identification marks which may be applied to treated wood intended to be used in the construction of compliant wood packaging material.

5.3 Other treatments

At present, only fumigation with methyl bromide or heat treatment has been approved for use to treat wood packaging material. However, NPPOs should ensure that their legislation or regulations governing the certification of facilities producing compliant wood packaging material or recognizing compliant imports are sufficiently flexible to allow adoption of other treatments as they are approved.

ISPM 28 (*Phytosanitary treatments for regulated pests*) provides the basis for the international approval of phytosanitary treatments. Those wishing to submit potential treatments for inclusion in ISPM 15 should contact the IPPC Secretariat(IPPC@fao.org). It should be noted that the IPPC Secretariat requests submissions based upon needs identified by the Commission on Phytosanitary Measures. If there has not been a call for ISPM 15 treatments, it may still be possible to seek consideration of the treatment by the bodies of the CPM, but it may not be considered immediately.

5.4 Alternative arrangements

The establishment of import requirements which differ from those prescribed in ISPM 15 adds complexity to the trade of commodities reliant on wood packaging material because this material often remains in service for long periods of time and is reused and further distributed.

6. Procedures for production of compliant wood packaging

6.1 Approval of facilities

Approval of a facility (producer, treatment provider, etc.) to use an ISPM 15 mark should only be given by an NPPO or an organization officially authorized by the NPPO. Approval systems should:

- Verify that treatment is undertaken in accordance with the requirements in ISPM 15. Guidance on some of the generally accepted practices for achieving effective treatment are prescribed in Annexes I and II of this document.
- Verify that wood packaging complies with the bark tolerances prescribed in ISPM 15.
- Ensure that approved facilities are applying the mark only to wood packaging material that has been constructed with treated wood or applied to wood packaging material that has been treated.
- Ensure that approved facilities do not transfer the mark to other facilities.
- Ensure that treated and untreated materials that will be used in the construction of wood packaging material are segregated to avoid the incorporation of untreated components into a treated unit.
- Make available to importing countries examples of marks used and lists of approved facilities.
- Ensure that any non-compliance occurring at approved facilities is promptly corrected or the facility's approval withdrawn in such a manner that importing countries can be aware of the change in the facility's status.
- Establish audit and inspection activities at frequencies that routinely verify a facility's compliance and ensure that any corrective actions are implemented effectively.

In establishing a system for the oversight of approved facilities, the NPPO, may need to consider whether:

- Additional resources are required to carry out the authorization, auditing and inspection of facilities.
- Additional resources are required by facilities to meet the prescribed requirements.
- New or increased enforcement or legislative tools are needed for adequate supervision of facilities and monitoring of wood packaging material.
- Training of NPPO staff or other oversight bodies is required.

The NPPO should initially consult with the wood packaging sector to ensure a uniform understanding of the requirements and to factor in any complexities in the local industrial production process. To ensure that only compliant wood packaging material is exported, the NPPO should identify all the critical control points in the production process and ensure that appropriate production controls are established by the approved facility. The NPPO should approve producers of wood packaging material and treatment providers, but may need to consider whether others involved in the production process may affect the integrity of the certification system and should also be supervised. Ultimately, the NPPO in the country in which the wood packaging material is produced should be confident that wood packaging material which has been certified is compliant.

6.2 Marking

ISPM 15 aims to provide a paperless certification system that allows for the ongoing use of treated wood packaging material traceable through certification systems of NPPOs.

The mark must contain the minimum information of:

- the IPPC symbol
- Tthe ISO two-letter country code (see ISO 3166-1-alpha-2 code listed at www.iso.org/iso/english_country_names_and_code_elements)
- the IPPC abbreviation for the approved measures (i.e. HT or MB)
- the control numbers or letters of a facility authorized by the NPPO.

The examples shown in Annex 2 of ISPM 15 should be followed as illustrated. Additionally, several examples of compliant and non-compliant marks are provided in Appendix 3 of this document.

No additional information should be included in the mark and the IPPC symbol must not be altered in any way (e.g. the symbol placed at an angle or a mirror image of symbol is not permitted). The symbol is protected in many countries and used by NPPOs under authority of the FAO. Therefore the mark may only be used by facilities approved by an NPPO.

ISPM 15 does not prescribe a minimum size for the mark but must be easily read by import authorities without the use of visual aids. Some minimum sizes for marks may be prescribed by NPPOs to ensure that officials in importing countries can easily read the mark. The use of red or orange should be avoided because these colours are often used in the labelling of dangerous goods such as toxic or flammable agents.

The mark may not be hand drawn and must be applied so that it remains upon the article being certified without the likelihood of it being removed easily. Tags or other less permanent markings which are attached to the wood packaging material should not be used.

The mark need only be applied to a complete unit, in a visible location, preferably twice on the opposing vertical faces (and in some cases in multiple locations), where it can easily be seen. On pallets, this could be on an inner face of the vertical blocks which separate the floors of the pallet, because these may be more visible to an inspector when looking into a container. Additionally, where wood packaging material is comprised of both manufactured and non-manufactured wood, for ease of visibility, producers may choose to apply the mark to the manufactured component of the wood packaging material. The application of the mark should be interpreted by NPPOs as a symbol that the entire unit is certified regardless of the unit's composition.

Often treated wood used for dunnage is cut to final length at the time of loading. NPPOs may need to give special consideration to how these cut pieces are marked. Options include:

- Multiple applications of the mark along the entire length of the wood. The wood may be then cut to a size where at least one mark (preferably two marks) may remain present on the cut portion. Pieces which are cut to a size less than that necessary to retain one visible mark should not be used.
- Marking at the time of use in a visible location on the final cut piece of treated wood.

In some cases presentation boxes and other packaging units may contain wood greater than 6 mm but still too small to legibly apply the certification mark prescribed in Annex 2 of ISPM 15. Given that risks may be only fractionally greater than those for wood which is 6 mm in width, NPPOs may wish to consider applying greater discretion in regulating wood that is only slightly larger than 6 mm.

The inclusion of dates of production or the date when changes were made to wood packaging material may permit better tracking of compliance and provide relevant additional information on whether infestation after treatment may occur. However, a requirement for dates to be applied is not prescribed in ISPM 15 and if dates are required, this information should appear outside of the certification mark.

Phytosanitary certificates should not be used to verify compliant wood packaging. The standard clearly states that "*the application of the mark renders the use of a phytosanitary certificate unnecessary as it indicates that the internationally accepted phytosanitary measures have been applied [...]* and that *"NPPO's should accept the mark [...] as the basis for authorizing the entry of wood packaging material without further specific requirements."* Requirements for identifying compliant wood packaging on documents accompanying imported consignments should also be avoided.

In general, treatment should precede the marking of the wood packaging material. In exceptional cases only, NPPOs may consider using an official approval procedure which permits wood packaging material to be marked before treatment. In these cases, the NPPO should establish special provisions that ensure that the approved facility can clearly demonstrate the traceability of the wood packaging to treatment.

NPPOs should make available lists of certified facilities along with examples of approved certification marks.

6.3 Reused wood packaging material

Reused wood packaging material is wood packaging material which is used from the time of construction to the end of its service life without any alteration of the wood used in the unit. ISPM 15 allows for this type of wood packaging material, if compliant, to move internationally indefinitely without requirements for re-treatment or re-marking.

6.4 Repaired wood packaging material

Wood packaging material in which one third or less of the wood of the unit is altered is referred to as repaired wood packaging material. Provided only treated wood is used in the repair, no further treatment of the unit is required. A mark must be affixed to each added component. The mark of the original certification of the unit should also remain on the unit, unless the entire unit is retreated.

However, the standard also encourages NPPOs to consider that multiple marks may over time make determining the origin of the unit difficult. Therefore NPPOs may require that repaired wood packaging material must be re-treated entirely. In this case, all original marking should be removed and a single certification mark applied. It is highly likely however, that the costs of treatment of an entire repaired unit will far exceed the returns gained by the units return into commerce and as a consequence these units will be discarded. Additionally, NPPOs should carefully evaluate whether demanding the re-treatment of entire units of repaired wood packaging material is an appropriate use of energy or chemicals and whether it may encourage those conducting repairs to operate fraudulently outside of the certification system. Careful review of the provisions for repair should be undertaken by the NPPO in consultation with the repaired wood packaging material sector to determine the appropriate procedures to meeting the standard.

Where the certification of wood packaging material is in doubt or where there is doubt as to whether specific components of wood packaging material may have been appropriately treated, the NPPO should ensure that marks are removed. If the unit of wood packaging material is to be further used in international trade, the unit should be re-treated and re-marked.

6.5 Remanufactured of wood packaging material

Remanufactured wood packaging material is defined as units of wood packaging material in which more than one third of the wood of the unit is replaced. In this case all marks should be permanently obliterated and the entire unit treated prior to the marking of the unit under the certification system of the NPPO of the country in which the repair is undertaken.

6.6 Supervision of manufacture, repair and remanufacture

NPPOs should consider provisions and methods for determining that approved facilities are producing wood packaging materials in compliance with the requirements. NPPOs cannot oversee wood packaging material manufactures at all times and must rely on the validation of production systems to mitigate non-compliance. This is most easily accomplished by monitoring the volumes of treated wood used in the construction of units or by monitoring the volumes of treated wood packaging material. For example, a producer of wood pallets with a treatment facility that accommodates a specific volume of pallets will only produce a specific volume over a period of time. Invoices for the sale of treated pallets should match the volumes treated during the period. Similarly, a producer that uses treated wood to manufacture compliant wood packaging should be able to demonstrate that the volumes of wood packaging produced match the volume of treated wood consumed by the facility within a specified period of time.

Monitoring treatment applications may also be accomplished by testing wood samples for relevant indicator organisms known to infest the wood. The selection of indicator organisms should distinguish between those pests which infest wood from those which may contaminate the wood post treatment.

NPPOs should ensure that their certification system effectively monitors and oversees the repair or re-manufacture of wood packaging material. Monitoring whether replacement of damaged components results in units being considered as repaired rather than remanufactured is a substantial undertaking. At a single facility, during a single production day, significant volumes of units of new wood packaging may be produced along with the alteration of additional volumes of repaired and remanufactured wood packaging. The system should consider that the repair and remanufacture of wood packaging material do not allow any greater potential for the certification of non-compliant wood packaging material than exists with the production of new wood packaging material. Non-compliant wood packaging material that contains a mark may result from:

- the incorporation of untreated wood including the incorporation of wood removed from units which have not been appropriately treated
- the application of the mark to a treated component which is attached to a unit containing untreated components.

Ultimately NPPOs should ensure that certification systems focus on the system which is being utilized by the facility to guarantee that units are being produced in a compliant manner, rather than focussing on whether individual units comply with the specific provisions.

Concerns have been expressed that wood packaging material produced and marked in compliance with the standard may be exported and subsequently used in the construction or alteration of wood packaging material that is not compliant. The resulting unit may appear compliant since it contains a mark. Should a pest be detected on this unit, the original producer or country may be held accountable. NPPOs should consider that once compliant material leaves the certifying country, traceability of the unit becomes less reliable. Therefore, the importing NPPO should consider focusing notifications of non-compliance at repeated cases rather than at single occurrences. In this way, the certifying NPPO can conduct a thorough review of the system at a particular facility based upon the information provided by importing NPPO. Corrective actions can be undertaken to prevent future recurrences of the non-compliance and the overall system will improve.

7. Procedures for Import

7.1 Import controls

Given the potentially large volumes of wood packaging material moving in trade, NPPOs may need to focus limited resources on imports associated with the highest pest risk. Pest risks vary depending on the origin of the wood packaging for instance due to the climatic and environmental factors in the importing and exporting countries influencing pest introduction and establishment. Additionally, NPPOs should consider the following when establishing import programs:

- Importing countries should inform principle trading partners (e.g. WTO notification, although not required) well in advance of the legislative commencement date of import requirements and further changes to these requirements.
- Resources required to inspecting imported shipments.

- Training of staff to identify risk imports; conduct import inspections and carry out phytosanitary actions related to non-compliance associated with the mark or with the identification of regulated pests.
- Tolerance levels to be applied and actions to be taken on non-compliant shipments. These will vary with the degree of risk posed by the non-compliance but may include: treatment, disposal, re-direction, refusal of entry of the wood packaging material or refusal of entry of the commodity and the wood packaging material.
- A strategy for dealing with unmarked wood packaging material. In many cases the wood packaging material which has been in service for many years poses little pest risk given that the wood has dried out and is less likely to provide a suitable environment for pests.

The ability to target high risk imports for inspection will depend on the country's existing legislative framework, inspection resources and training programs. Packing declarations, commercial invoices and other entry documentation may serve as a means of identifying when wood packaging material is accompanying goods not traditionally regulated by NPPOs. Requirements for specific wood packaging material declarations in addition to existing import documentation may severely impact trade and reduce the utility of an internationally harmonized mark. However, most import authorities rely upon the documents accompanying imported consignments as the means of deciding whether a particular consignment is eligible for entry. The addition of wood packaging material declarations to import documentation could facilitate clearance of commodities.

NPPOs will need to consider the logistics of establishing inspection programs. Some considerations include:

- Legislative authorities and procedures for identifying and stopping consignments at the entry point for inspection and any required actions arising from non-compliance.
- Location of the inspection site. Most wood packaging material is generally imported inside containers and this requires room for the removal of the consignment from the container. Loose wood dunnage is often discharged at berthing areas, where inspections may interfere with port activities.
- Equipment and resources to inspect the wood packaging material. Inspection may require heavy equipment to either discharge the commodity from the wood packaging material or the ability to lift the wood packaging material sufficiently to conduct the inspection.
- Procedures and tools necessary to manage non-compliant shipments (e.g. disposal facilities, transportation from site of inspection to site of disposal or treatment, treatment facilities, etc.).

Ideally NPPOs should work with customs authorities to formulate risk-based inspection procedures (i.e. identification of those commodities that are most likely to contain wood packaging material which poses a risk). Such procedures should facilitate the speedy throughput of cargo and ensure that inspections are carried out only where necessary. To remain effective, however, continual monitoring of results must be maintained.

8. Measures for Non-Compliance at Point of Entry

The efficacy of an internationally harmonized approach to regulating wood packaging material is dependent on the activities of NPPOs, treatment providers, producers, exporters and importers habitually complying with requirements. Methods for the treatment, disposal or refusal of entry should be taken by NPPOs to deal with non-compliant wood packaging material. Penalties may also be used to obtain compliance, if within national legislation. Importers should be made aware of the reasons for the actions and non-compliance information should be relayed from the NPPO of the receiving country to the NPPO(s) identified by the markings on the wood packaging material. In the case of wood packaging material that does not contain marks; the NPPO of the receiving country is encouraged to notify the NPPO of the country from which the export originated so that the exporter can be encouraged to obtain compliant wood packaging for future consignments. In order to properly investigate non-compliances, the importing country should provide adequate information including:

- information from marks on the wood packaging material
- the commodity accompanying the wood packaging material
- the name and contact information of the exporter and the importer
- information on any pests detected
- any other information identifying the wood used in the construction of the wood packaging material (e.g. grade or quality marks, etc.).

NPPOs of exporting countries should attempt to trace the origin of non-complying shipments and notify the NPPO of the importing countries of the results of the investigation. Consistent reports of non-compliance may be an indication of a failure in the certification system at a facility. In this case, the facility may be required to adjust its production practices or the NPPO may be required to adjust the requirements of certification program if the issue is consistent amongst several approved facilities. Failures at a facility may be caused by an inadequate application of the treatment, poor separation of treated and untreated materials during construction, insufficient oversight of the treatment process, failure to monitor treatments, etc. Certification system failures may be caused by inadequate requirements, infrequent oversight; insufficient testing of the production practices at facilities, etc.

ANNEX I: A Guide to Heat Treatment (HT)

1. Scope

The guidelines contained in this Annex are for the heat treatment of wood in conventional heat chambers (dry kilns) typically used for drying wood. Newer treatments that include dielectric heating (e.g. radio frequency, microwaves, etc.), hot water baths, etc. are not discussed, although these may be capable of achieving the temperature and time combination to kill pests. Special chambers such as vacuum or condensation dryers etc. are not discussed but several explanations may also be valid for these systems.

2. Background information on heat treatment and kiln-drying

The commercial process of using heat to dry wood dates back to the early 1900s when H.D. Tiemann's manuscript: *The kiln-drying of lumber, a practical and theoretical treatise* provided some fundamental guidance on applying heat to produce wood containing a lower moisture content. Drying made the wood less susceptible to dimensional change over time. Drying also reduced the susceptibility of wood to primary decay organisms as well as moulds and blue-stain fungi, provided the wood remained dry over time. It improved strength characteristics, made the wood easier to process mechanically, and lighter and easier to transport. Kiln-drying of wood often increases the value of the timber commodity.

Kiln-drying is a process to reduce moisture and is not a guarantee that the temperature and duration of heat applied to the wood is sufficient to kill pests. However, the descriptions and practical guidance offered by specifications on kiln-drying can be used in combination with other guidance on heat treatments to develop best management practices. Although some kiln-drying operations may not achieve the temperature and time specifications necessary to kill pests, many can exceed the requirements for heat treatment especially for coniferous wood. Verification that the specific process achieves the phytosanitary requirements is essential in determining whether a particular process is adequate.

3. Heat treatment as phytosanitary process

Heat treatment in the framework of ISPM 15 is a process relying on a minimum wood temperature of 56 °C being reached and maintained for at least 30 continuous minutes throughout the wood. This specification has been proven to be effective at killing most wood related quarantine pests at their different life stages.

The use of heat as a phytosanitary treatment of wood dates to the early 1990s, when a number of countries concerned with the movement of wood pests recognized that some industrial processes of heating wood for commercial purposes was sufficient to kill a range of insects and wood inhabiting nematodes such as the pinewood nematode, *Bursaphelenchus xylophilus*. Research confirmed that heating the profile of the wood including its core to a minimum temperature of 56°C for a period of 30 minutes was effective in killing these pests. More recent work has shown that this heat treatment also kills many fungal organisms associated with wood.

Heat treatment as a phytosanitary treatment does not require moisture reduction and is always prescribed as a minimum wood temperature and for a specified duration, usually measured at the core of each piece of wood because conventional heat treatment heats the wood from the outer to inner part. Heat treatment raises the temperature of the wood that may result in little or no moisture reduction. Heat treated wood may range in moisture content from green (freshly harvested wood) to dry (with moisture contents generally below 20 percent), depending on its initial moisture content and the duration and temperatures during treatment. Heat treatment may be cheaper to apply than kiln-drying the wood and depending on the end use may generally add value to the wood, but may not reduce weight-based freight costs. Wood which has been heat treated without moisture reduction is often more susceptible to invasion by secondary organisms. These are usually not a phytosanitary concern, but may reduce the value and limit the end use of the wood. Also, the mobilization of fatty acids and the surface sterilization of the wood by heat treatment supports the infestation and growth of ubiquitous mould fungi on the wood surface, particularly if the wood is not exposed to surface drying. Mould fungi are not a phytosanitary issue, but may be a quality problem and, depending the infestation rate and fungal species also a human health issue.

Heat treatment is achieved by controlling the temperature within the heat chamber. Chamber temperatures required for effective treatment depend on the:

- kind and condition of the treatment chamber
- volume and direction of air flow through the wood stack
- moisture content of the ambient air surrounding the wood stack during treatment;
- initial temperature of the wood
- moisture content of the wood
- density of the wood
- dimensions of the wood
- species of wood being treated, and
- amount of heat being applied to the chamber, which is determined by the heating system used.

The air flow within the closed chamber depends on the:

- capacity of the equipment in the chamber to move the air
- dimensions of the wood being treated
- size of the air plenum, and
- degree of separation between pieces of wood within the stack.

Given the influence of the above factors, heat treatment relies on the development of treatment procedures that minimize variations in these components within and between treatments.

Most heat chamber schedules are based on maintaining specific dry bulb temperatures and humidity levels throughout a given treatment for a specific wood species and size. These are often specified in a variety of chamber operating guides (dry-kiln operator manuals, heat treatment schedules, generic kiln operating guides, etc.). In many cases, these are modified by chamber operators over time to achieve specific products as demanded by the end user.

Heat treatment without significant moisture reduction of the wood relies on heating the wood as quickly as possible to a minimum temperature throughout its profile. In order to achieve these conditions, the wet bulb depression (the difference in temperature between the ambient air and the temperature near 100 percent relative humidity) should be as small as possible; generally not exceeding 5 °C. A large wet bulb depression wastes energy on evaporation rather than on heating the wood. To achieve the conditions required to heat the wood as quickly as possible, kiln operators rely on adding moisture to the chamber during heating.

Some kiln-drying schedules do not achieve the required wood temperatures necessary to remove pest risks (e.g. 56 throughout the profile of the wood for at least for 30 continuous minutes) but do achieve the industrial standards necessary for drying the wood to the quality being sought by the producer. For example, schedules based on low temperature treatment which dry wood at chamber air temperatures of about 60 °C or less may fail to achieve 56 °C at the core of the wood. Often these types of schedules are used for drying hardwood species or high value products.

The most practical and measurable way to determine whether the phytosanitary standard has been achieved in a heat treatment process is to employ multiple temperature sensors placed in the core of representative pieces of wood located in predetermined areas of the treatment chamber known to be the coolest. These areas are referred to as the cold spot. This will ensure that even pieces of wood heating at the slowest rate within the wood stack have been appropriately heat treated. The orientation and configuration of wood in the wood stack will also influence the location and size of the coolest parts of the heat chamber. In most applications, this level of recording is impractical and often not warranted. In most cases, the heat treatment of wood is a consistent process relying on wood that is of the same size, thickness, species, and so on, and occupying the same volume of the chamber from one treatment to another. Schedules therefore may be based on trials of wood with specific characteristics, or the use of a temperature sensor or several sensors placed in the piece of wood in those parts of the heat chamber predetermined to take the longest time to reach the required temperature (i.e. the cold spot).

For heat chambers that treat constructed wood packaging material, such as pallets, the use of predetermined schedules or single sensors positioned at a predetermined location may not be appropriate if wood dimensions, species, and configurations of the wood stack vary from treatment to treatment. This is particularly true of facilities that treat repaired or remanufactured wood packaging material.

NPPOs should establish specific treatment parameters including processes for measuring treatment efficacy and the auditing of authorized producers. The guidance provided in this Annex seeks to verify that wood being treated has been subjected to sufficient heating as prescribed in ISPM 15. It does not state the extent to which NPPOs may prescribe requirements for individual producers or the parameters necessary to effectively audit those standards. These should be determined by the NPPO when considering the type of facilities providing heat treatment and the extent of sophistication of the treatment approaches being used.

4. Definitions of terms used in this Annex

air plenum	The free space between the wall and ceiling of a heat chamber and the wood being treated in which heated air is forced into and through the wood stack.
cold spot	An area of a heat chamber where wood undergoing treatment is the slowest to achieve a desired temperature, as demonstrated by monitoring the temperature at various points throughout the wood stack.
dry bulb	A sensor for measuring ambient air temperature.
dry wood	Wood that has had its moisture content reduced to less than 20 percent.
fibre saturation point	The moisture content point of wood at which only water bound in the cell walls remains.
green wood	Wood that has not been dried or seasoned and contains a moisture content higher than the fibre saturation point for the tree species.
heat chamber	Any closed chamber used for the heat treatment of wood.
moisture content (of wood)	The weight of water within wood measured as a percentage of the weight of oven-dried wood.
Relative Humidity	The ratio of the amount of water vapour in the air as compared with the amount of water vapour the air is capable of holding measured at a particular temperature.
spacers	Small uniform-sized pieces of material such as wood used to create spaces for air to move across wood surfaces. Also referred to as *stickers* or *fillets*.
wet bulb	A device used to measure the temperature that results when water evaporates from and cools a sensor.
wet bulb depression	The difference between the dry and wet bulb measurements.
wood stack	A volume of wood placed in a heat chamber for treatment

5. Technical requirements for ISPM 15 heat treatment

The following sections describe some of the technical elements which should be considered to achieve ISPM 15 heat treatment.

5.1 The heat chamber

A heat chamber may be constructed in a variety of materials. The materials used in construction should not affect its operation. An array of heat sources may be used including natural gas, oil, electricity, solar power and bio fuels.

Most heat chambers used for kiln-drying work by the "fresh air/discharged air" principle. Air is heated and vented into the chamber with the use of fans. The heated air equilibrates in the chamber resulting in uniform chamber temperatures. In many chambers, fans moving the air are located in the ceiling (Figures 1-4); while in others fans operate at one side of the chamber (Figure 5). In either case, the heated air is forced to move through the stockpiled wood.

For heat chambers that have an artificial heat source such as oil or gas, the heat chamber should be well insulated to minimize heat loss, to keep the heat distribution in the chamber as homogeneous as possible, and to ensure consistency between treatments. Use of insulation barriers both in the walls and below the flooring may be required. Insulation may be detrimental for heat chambers that utilize solar heat.

The construction of the chamber may influence the efficacy of the treatment. Some criteria that should be fulfilled are:

- generally heat chamber doors should not be damaged and should seal to prevent leakage of heat from the chamber
- the chamber itself should be constructed in a manner which minimizes heat loss
- airflow should move consistently through the wood stack, and equipment to direct the air flow, such as baffles, should be available and used
- fans should be used to circulate the air in the chamber
- fans should correspond to requirements of the chamber and should be working according to the manufacturer's specifications. If more than one fan is used all should operate in a manner that maximizes airflow in the same direction
- venting used in the chamber should ensure a uniform temperature distribution
- temperature sensors including cables should be in proper working order
- valves and motors used to reverse or change air flows should operate suitably
- pooling of moisture on floors may be an indicator that the facility is inadequately measuring moisture content, has insufficient air circulation, or other issues which requiring resolution.

5.2 Loading a heat chamber

The way a heat chamber is loaded influences the air flow through the wood stack and therefore the location of cold spots in the chamber and the wood located in these cold spots. To ensure proper air flow through the wood stack the following should be considered:

- The wood stack should be raised off the ground to allow for effective air flow under the wood and to avoid cooling influences from the ground.
- The stack should not be overloaded so as to prevent air flow over the top of the stack.
- The air plenum should contain adequate free space to permit sufficient, uniform air flow through the wood stack.
- The material to be treated should be uniform (e.g. only pallets or only boards) to ensure a homogenous heat distribution. Mixed loads such as pallets and boxes may make it difficult to achieve the recommended temperature and may require multiple temperature sensors to confirm that appropriate treatment has occurred.

- Wood stacks of sawn wood should be stockpiled using spacers or stickers between boards. Spacers must be placed parallel to the air flow direction. Some heat chambers may require special perforated stickers to guarantee the needed air flow.
- In cases where the chamber is not loaded throughout the whole cross section, baffles need to be installed to guide the air flow through the wood stack (see also the section "Air Circulation"). Where baffles are not used, the air will move along the path of lowest air resistance (Figure 1, at right). In this situation, the chamber operator is likely to underestimate the time required to reach core temperatures, since the chamber is likely to heat much faster than the wood.

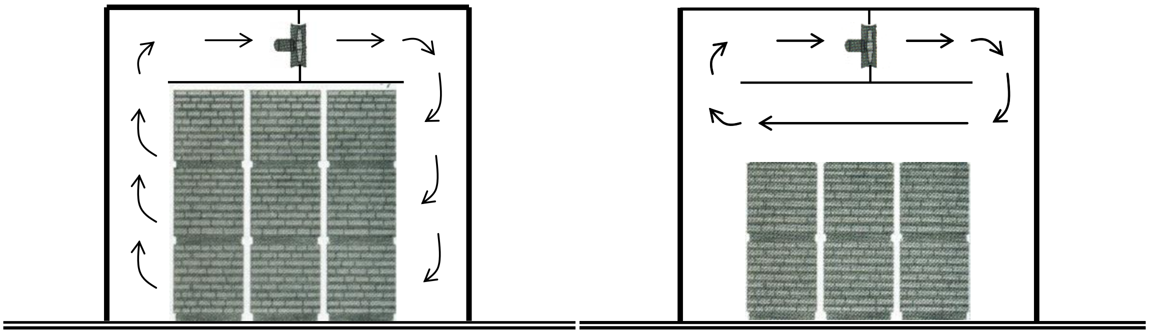

Figure 1: Schematic illustration of a loaded heat chamber resulting in different air circulation. Left: with a completely stockpiled chamber (cross section), the air circulates through the entire stack and heating is more uniform. Right: in an incompletely stockpiled chamber (cross section), the air circulates over the wood stack and the wood is not heated as quickly as the free space in the chamber.

5.3 Air Circulation

Air circulation fans help to ensure controlled movement of heated air within the chamber. Airflow can be measured with the use of anemometers. These may be fixed units monitored by chamber systems or hand operated units that record air flows infrequently to determine if fans are operating within desired parameters. A minimum airflow of 0.5 m/second (100 ft/minute) is recognized as essential for normal chamber operation.

Fans should be installed to ensure air flow in a common direction. Air flow reversal during treatment helps to ensure uniform heating on all sides of the wood, but should not be a requirement. Air flow reversal ensures that wood on both sides of the chamber receive heated air at its maximum temperature. As the air moves through the wood stack, it tends to cool because of evaporation of water from the wood. Fan reversal reduces treatment time by reducing the impact of this cooling effect on the wood on the down-wind side of the stack. Operating a chamber with fan reversal influences the place where the wood heats up slowest (i.e. the cold spot) and therefore the recommend place where temperature sensors should be placed (see also Figures 2-5). However, where fan reversal does not occur, the wood may be effectively treated using higher ambient temperatures or much longer durations to compensate.

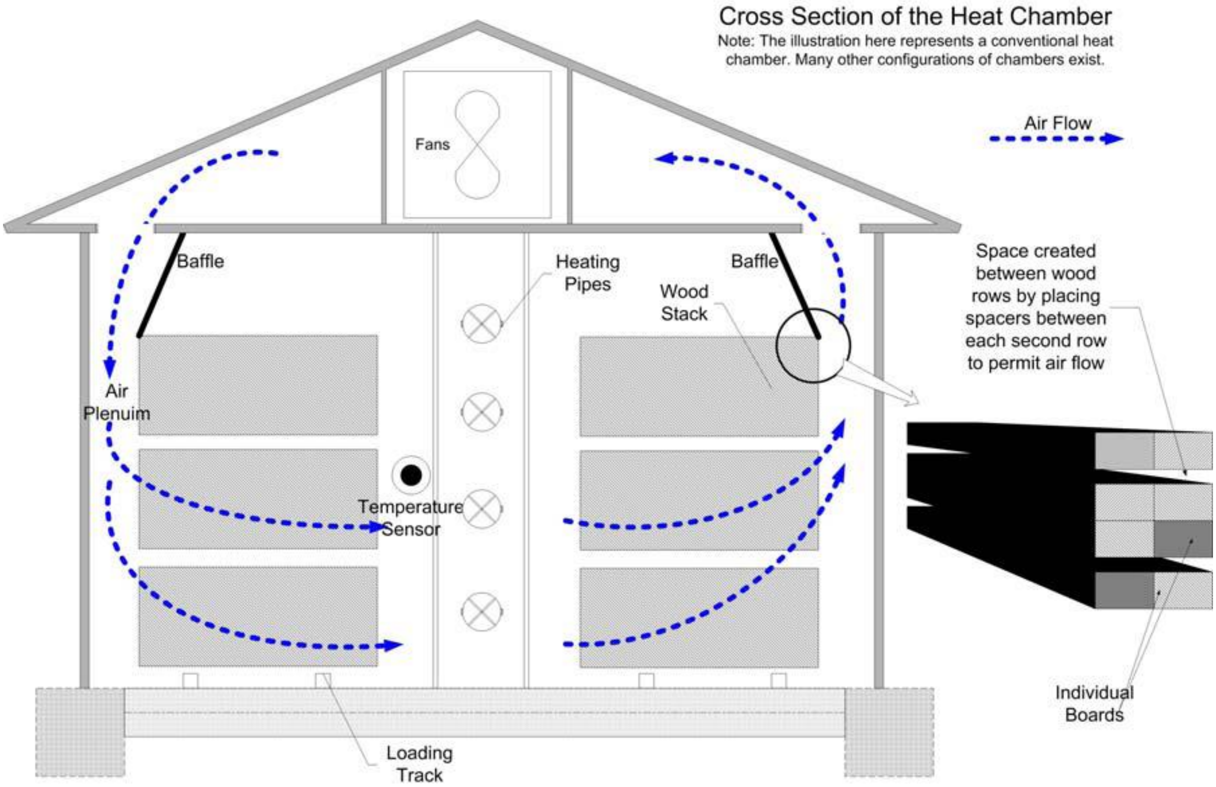

Figure 2: A type of heat chamber with the heating pipes in the middle. Temperature sensors should be placed at a location where the air exits the wood stack and is therefore likely to be the coolest.

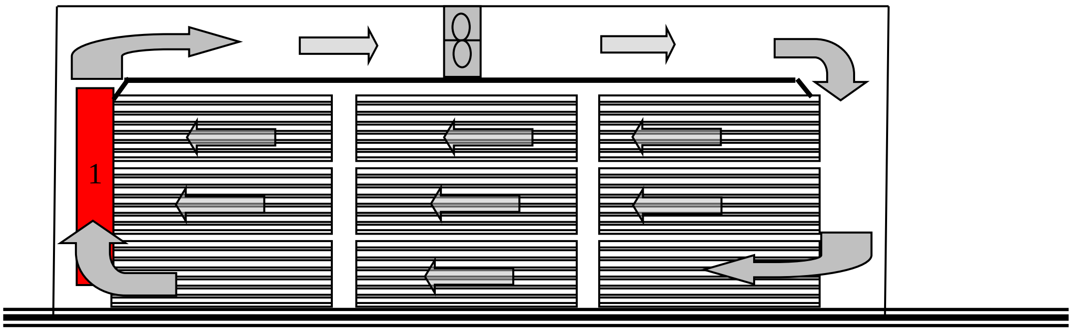

Figure 3: A heating chamber in which the heating pipes are located with a fan above the wood stack. The cold spot is likely to be nearest the exit side of the stack and the temperature sensor should be placed where the air exits the wood stack (marked "1").

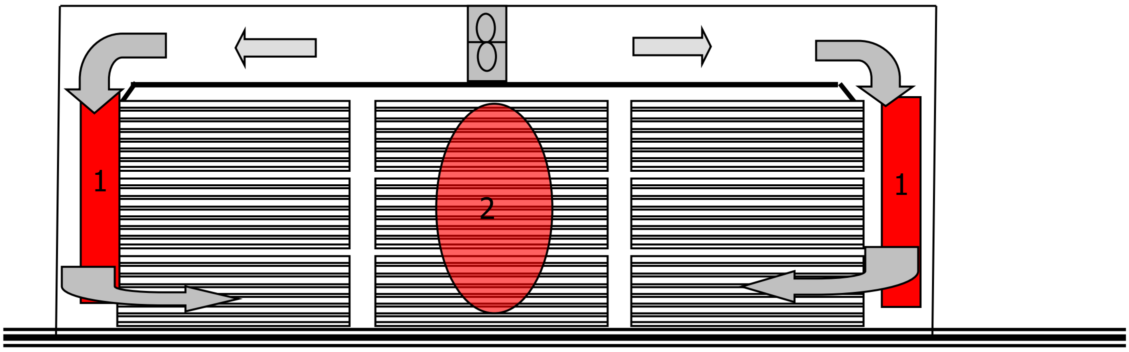

Figure 4: A heating chamber in which heating is bi-directional. If the treatment schedule is long, the cold spot may be at the air exit side of the wood (marked 1). Temperature sensors should be placed along the walls of the chamber. If the schedule is shorter, the cold spots are likely to be in center of the wood stack (marked "2") and sensors should be placed there.

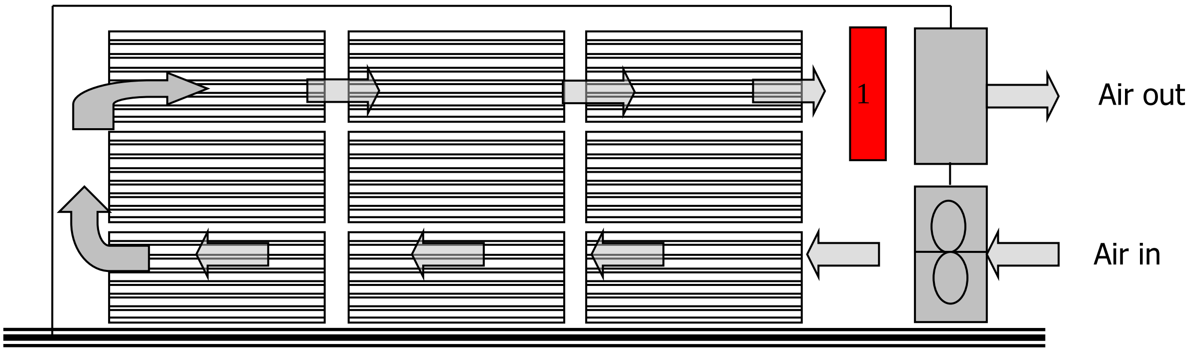

Figure 5: A heating chamber in which heating occurs at the floor of one-side. The temperature sensor is placed at the air exits the wood stack (marked "1").

The heat chamber may use baffles to control air flows through the wood stack. Baffles are generally pieces of canvas, metal or wood used to regulate or deflect air flows within the chamber.

Spacers also may be used to separate layers of wood and therefore increase uniform heating. Spacers should be uniform in size to ensure homogeneous air flow. They should be placed parallel to the air flow direction. For example, 20-30 mm spacers are often used in the heat treatment of hardwoods and 30-50 mm spacers for softwoods. Spacer sizes are dependent on the density and thickness of the wood being treated. In some cases, when small dimension wood is being treated, spacers may be installed between every second or third row of boards. In these cases, the effective thickness for the purposes of determining efficacy of treatment is the cumulative thickness of any pieces that are stacked without spacers. For example, if spacers are inserted at intervals of every three rows, and the thickness of each piece of wood is 20 mm, the overall thickness of the wood being treated should be taken as 60 mm. Operating conditions should therefore require effective heating of wood of 60 mm thickness to ensure that all of the pieces receive 56 °C for at least 30 continuous minutes throughout the profile of the wood. It may also be possible to heat treat a wood stack that contains no spacers. However, in these cases, determining whether individual pieces have been treated effectively is contingent on determining if pieces in the center of the wood stack have received sufficient heated air to achieve required temperatures throughout the profile of all wood pieces for the required time.

Spacers are not usually required when heat treating constructed wood packaging materials, such as pallets. The voids created in the construction of the pallets should provide sufficient air space for the movement of air. However baffling is usually necessary to assure proper air flow.

5.4 Venting

Venting of the heat chamber may be used to exhaust excess moisture released during treatment. However, early in the heating process it may be desirable to retain moist air to aid in the temperature rise of the wood stack resulting in a reduction in the total heating time.

5.5 Humidification

The moisture content of the wood affects the wood's ability to heat. The moisture within the wood rises to the surface, as the wood is heated, cooling the surface and requiring longer heating. Effective heat treatment is therefore dependent on a number of properties that influence the moisture content of the wood such as:

- the thickness of the wood
- the density of the wood
- the direction of the grain of the wood (wood is more permeable in the longitudinal direction)
- structural irregularities of the wood.

Humidification systems using steam injection or units that spray water into the heat chamber may be helpful in ensuring effective heating as air passes through the wood stack. Treatment schedules should account for variation in the thickness, density and initial moisture content of wood being treated. For example, treatment times for wood of higher densities or greater thickness should be longer than treatment times for less dense or thinner pieces of wood.

6. Verification of the Proper Treatment of Wood/Wood Packaging Material

Treatment schedules may be regulated by automatic or semi-automatic systems that monitor temperatures and humidity within the chamber. More basic kilns require the monitoring of sensor data typically collected on a data recorder. Sensors should be routinely calibrated by independent testing authorities or others in accordance with the manufacturer's specifications. This is necessary to verify that the operation of the system is consistent from one treatment to another and within defined parameters of sensor accuracy. Simple calibration of sensors may be accomplished using water baths of different temperatures (including those temperatures likely to be present during the treatment) and a second pre-calibrated temperature measuring device. Variation in sensor accuracy should be accounted for in treatment procedures such that any variation is negated by appropriate changes to the duration or final heating temperatures required during treatment. For example, sensors may vary 1-2 °C once calibrated. This variation could be included when developing temperature and time combinations used for treating the wood. For example, a slight time or temperature adjustment to the schedule can be used to ensure that regardless of the known extremes of variation in a given sensor, the wood reaches and maintains 56 °C for at least 30 continuous minutes throughout the profile of the wood. Although this may result in over treatment of some pieces of wood, producers can be certain that all wood has reached the phytosanitary requirements. Nevertheless the maximum variation of the sensors should be kept as small as possible and NPPOs should set limits. The variation in sensors should also consider the type of treatments being carried out. Where wood is being treated to 56 °C for 30 minutes and then the treatment is stopped, the variability of sensors should be much less than where treatment is applied for industrial purposes and treatment temperatures well exceed 56 °C for periods much longer than 30 minutes, as is frequently done when kiln-drying wood.

6.1 Heat chamber controllers

Heat chamber controllers are computer systems which respond to temperature sensors, wood probes and other kiln equipment to ensure that wood treatment follows the chamber operator's specifications. Controllers will automatically close baffles, reverse fans, etc. in response to timed events or to maximized treatment conditions. Most heat chamber controllers are located in a building adjacent to the chamber and are capable of identifying problems in chamber operations, and either notifying the operator or resolving the issue independently. For example some sophisticated controllers will restart treatments if a malfunction occurs (e.g. power failure, faulty sensor, etc.). Chamber controllers also record treatment data to verify that treatments have been completed according to the operator specifications. Although the complexity of controllers varies, the operator, in consultation with the NPPO should establish documented procedures to deal with non-standard conditions which may occur if equipment fails during the treatment. Some of these may include restarting the treatment or extending the treatment to achieve the required temperature time combinations. Where facilities use published schedules to achieve treatment, the schedules should provide guidance in dealing with equipment failures. If these schedules do not provide guidance, the treatment should be restarted once the equipment is repaired.

6.2 Temperature measurement

Facilities vary in the approaches used to measure temperature during the treatment of wood. Some heat chambers use sensors inserted into the wood to measure core temperatures during each treatment (see Section 6.5). Others measure chamber air temperature, relative humidity, cold spots within the heat chamber and other factors to estimate the wood core temperature. This latter system bases the treatment temperature of the wood on calibration testing carried out during initial replicated verification tests of core temperatures as compared with chamber temperatures, humidity and other factors. The initial series of test treatments uses a sufficient number of temperature sensors placed into the wood at various points throughout the chamber (including and particularly to determine the cold spot(s)). These sensors are inserted into the core of a specific wood species of a specific dimension. The temperature curve of the sensors is then compared with the rates of change in chamber temperatures, relative humidity, etc. to establish a “heating curve” based on these factors. Future treatments can then be performed by measuring more easily obtained factors such as chamber temperatures, relative humidity, etc. provided no changes to the operating conditions are made, including changes in wood species, dimension, initial moisture content, initial wood core temperate (to adjust treatment times for frozen wood for example), etc. Other facilities may utilize established time/temperature schedules published in research documents that recommend specified ambient air temperatures, relative humidity curves, etc. for a particular species and dimension of wood. These schedules often over treat the wood to account for variations in chamber type, operating conditions, etc. but do achieve the minimum required core temperature and time requirements.

Temperature recording devices may vary from simple physical chart recordings of temperature to elaborate systems that utilize computerized programs and data loggers. Records therefore may be in the form of paper charts or, increasingly, computer data bases that record treatment information electronically. Records of sensor readings during treatments should be maintained for review by the NPPO or designated authority for a period of time consistent with the period in which the treated wood is to be utilized in international commerce (e.g. one year). Measuring and recording systems should be calibrated regularly (e.g. annually) by recognized individuals (including manufacturers) or organizations in accordance with manufacturer’s specifications as prescribed in Section 5 above. Dry bulb or wet bulb temperature monitoring equipment should be placed in an appropriate position to obtain accurate information. To ensure accurate readings dry bulb sensors should not be located too close to heat sources that would affect measurement. Wet bulb sensors should be located in the air plenum.

The location of the dry bulb wood sensors should be chosen according to the place where the wood needs the longest time to be heated and therefore to reach the targeted temperatures in the core. In chambers running a one way air flow, the sensors should be placed at the side where the air exits the wood stack. If fan reversal is used, the time of the reversal interval influences the place where sensors have to be placed. Depending on the location of the heating pipes this may be in the middle of the wood stack.

6.3 Number of temperature sensors

Where the heat treatment is determined based upon temperature sensors inserted into the wood at least two sensors should be used. They should be placed in wood which is located in the cold spot of the chamber. The wood piece where the sensor is inserted should be the biggest one located furthest from the source of heat, as this needs more time to heat throughout the whole profile.

Where specific treatment schedules are used and the operating of the chamber is based on temperature sensors placed in the chamber, a minimum of one dry bulb and one wet bulb or two dry bulb temperature sensors should be used. The dry bulb sensors should be placed in the cold spot or at the exit side of the air flow.

The use of multiple sensors ensures that any mechanical failure in a sensor during treatment is detected. This should be used for both heat treatments without moisture reduction as well as during kiln-drying processes that include ISPM 15 treatments. As the target criterion for ISPM 15 is the temperature, other measurements such as wood moisture content do not provide confirmation of treatment.

If the air flow in the chamber is routinely reversed during treatment, an increased number of sensors need to be used to account for a change to the location of the cold spot or for presence of multiple cold spots.

6.4 Calibration of temperature sensors

Both chamber and wood temperature sensors need to be calibrated regularly. From the technical point of view it seems to be reasonable that the calibration should be carried out at least once a year. Generally the complete measuring chain (sensor, cable, data logger, etc.) has to calibrated, not only the isolated sensor. Calibration has to be carried out in accordance with the manufacturer’s specifications, guidance from approved calibration and testing companies or using procedures approved by the NPPO. The calibration should include at least three tests of temperatures to establish a calibration curve. The temperatures used during testing should represent temperatures used during the treatment process (e.g. 20 °C, 56 °C and 80 °C). Ice or boiling water may not be appropriate to develop a calibration curve that represents the operational temperatures of a sensor in use.

6.5 Wood Temperature Sensors

Where certification of treated wood or wood packaging material is based upon sensors inserted into the wood, the NPPO should establish standards for the number of sensors necessary in a particular configuration of wood in the chamber to ensure that all the wood is treated to the prescribed standard. A sufficient number of core temperature sensors should be used to measure and record wood temperature. The use of five to thirteen sensors is recommended by some NPPOs during the initial approval (testing) process of a facility. The size of the heat chamber; the species, density and sizes of the wood being treated; the source of heating; the size and number of the cold spots within the chamber; fan speeds; or other factors will influence the number of temperature sensors necessary to be certain that wood has been treated effectively. The use of sensors enables the performance of the chamber to be evaluated at a number of locations and thereby determine the cold spot. To effectively heat treat all the wood in the stack, wood located at the cold spot must reach and hold 56 °C for a minimum of 30 continuous minutes. Wood located in other areas of the chamber would achieve 56 °C for a minimum of 30 minutes earlier during the treatment process.

The use of multiple core temperature sensors is not necessary for each treatment once the chamber has been calibrated. Nevertheless a minimum of two sensors should be used, so that the failures of one sensor would be discovered immediately as described in the Section 6.3. The use of a sensor inserted into the core of the wood of the largest thickness, positioned in the cold spot or several sensors placed at the cold spots will provide ongoing assurances of achieving phytosanitary requirements. Once calibration testing is complete, wood species and sizes, and configuration of the wood stack in the heat chamber must remain consistent with the initial test treatments to meet the phytosanitary standard.

When temperature sensors are used, these should be inserted into holes bored into the core of the wood. Sensors should be placed in the thinnest dimension of the wood at a minimum 30 cm (1 ft) from the end of the board or at the mid-point of the board, if the board is less than 1 m (3 ft) long. The length of the sensor should be appropriate to ensure that the tip is at the centre of the wood. Where appropriate, each hole should be back filled with a material that prevents the entry of ambient air into the hole to avoid the possibility of adversely influencing the temperature reading.

Some sensor designs (e.g. metal capped sensors) prevent the entry of air into the hole and therefore do not require back filling. Figure 6 below provides guidance on the placement of the sensor.

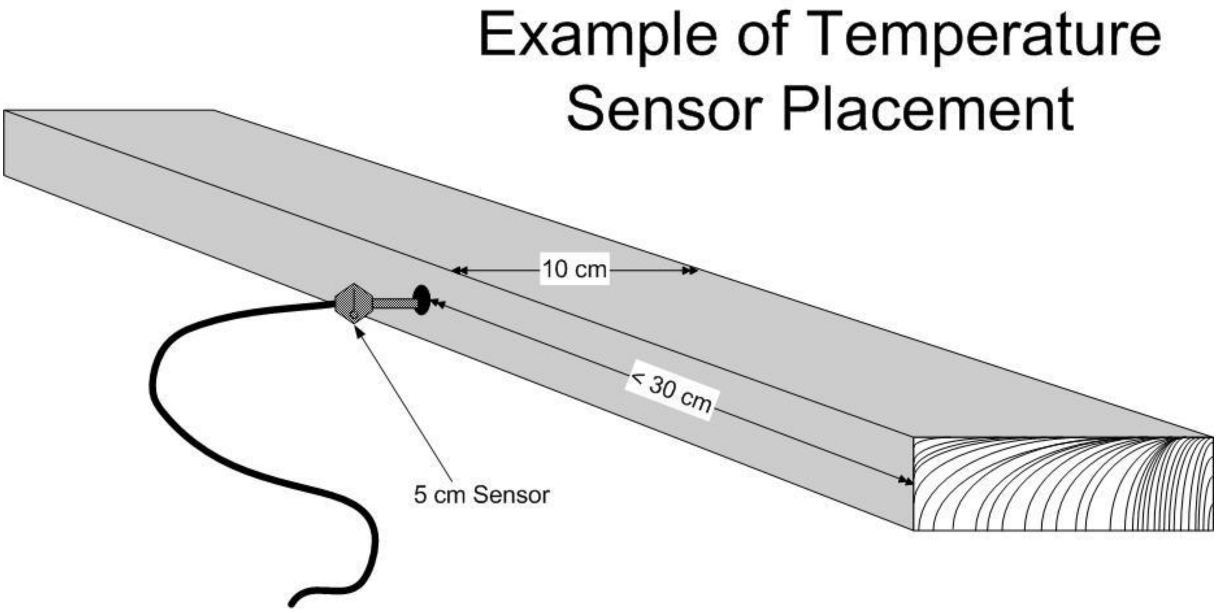

Figure 6: An example of a temperature sensor placement in a wood plank.

When treating assembled wood packaging material, such as pallets, care is needed to ensure that sensors are appropriately positioned to avoid heat transfer along metal fasteners, such as nails, that could interfere with the integrity of the temperature recorded by the sensor. The sensor should be placed parallel to metal fasteners and inserted in the piece of wood in the unit that is known to take the longest time to heat treat (e.g. the piece with the largest dimensions). If units are constructed of both manufactured wood and solid wood, the sensor should be placed in the piece of solid wood with the largest dimensions. Boards should be drilled and probed in the narrowest dimension, so that the tip is at the centre of the piece. Placement of sensors should take into account the loading of the wood stack and locations of voids in the wood packaging material that may create false temperature readings as a result of sensors being located in direct air flows.

The following recommendations on the sensors and cables ensures accurate recording of temperatures:

- Electronic sensors should be used (fluid-filled thermometers are not reliable).
- Resistance thermometer or thermocouples should be used (pyrometers which measure thermal radiation are not reliable for measuring temperatures throughout the profile).
- A sensor diameter of 3–6 mm is ideal, thinner sensors are difficult to handle.
- Round sensors should be used and rectangular should be avoided.
- The measuring element of the sensor should be located at its tip.
- The sensor casing should be insulated to avoid influencing the measuring element.

6.6 Measurement of temperatures in the cold spot

Often the air flow within the heat chamber is irregular as a result of the location of the wood stack, variations in individual fan speeds, cracks or leaks in the chamber walls or doors, or other factors. These can result in the ambient air temperature being less than uniform within the heat chamber but uniform from treatment to treatment. Schedules should account for areas in the chamber where the wood is slow to heat to the prescribed temperature. This may be achieved by placing temperature sensors specifically in the cold spot. The cold spot may also be influenced in size or number by the species, dimension and density of wood being treated.

ANNEX II: A Guide to Methyl Bromide Treatment

1. Introduction

Countries are encouraged to reduce reliance on methyl bromide in consideration of obligations and initiatives under the *Montreal Protocol on Substances that Deplete the Ozone Layer*. In 1992, the Montreal Protocol added methyl bromide to a list of substances which are known to deplete the ozone layer. The 196 countries which have ratified the Protocol have agreed to phase out use of methyl bromide by 2015. Although permitted to be used for quarantine and pre-shipment uses beyond 2015, many countries are seeking to remove methyl bromide use completely. In 2008, CPM-3 agreed that, in recognition of the desire to minimize the use of methyl bromide, contracting parties should, where possible, take actions to replace methyl bromide usage by increasing the application of alternative phytosanitary measures, reducing the volumes of methyl bromide used, or minimize or eliminate the release of methyl bromide to the atmosphere by physical means[2]. Methods of recapturing methyl bromide used in treatments or using heat treatment as a preferred option are most suitable. However, methyl bromide is an effective pest control and where alternatives do not exist; its use will mitigate pest risk concerns.

Methyl bromide is a highly toxic product. Treatment providers should follow appropriate procedures established in material safety data sheets, read labels carefully and follow national regulations and other appropriate guidance regarding its safe use.

Guidance on the application of methyl bromide for the quarantine treatment of wood is also contained in several publications provided in Appendix IV of this document.

Methyl bromide fumigation is known to be effective in managing most pests of wood such as wood-boring beetles, bark beetles, termites, nematodes and some fungi. Methyl bromide fumigation is commonly used during transport where only a short time line for treatment is available. Appropriate procedures are critical to achieving effective and safe application. Methyl bromide is a serious toxin capable of causing respiratory and pulmonary damage in humans.

Methyl bromide kills a wide range of pests, is applicable to many kinds of plants causing relatively little chemical injury, and it has a low boiling point which allows for ease of evaporation and diffusion. It penetrates well into open spaces and has a low level of gas sorption into many plant commodities. Methyl bromide is relatively inflammable and is unlikely to explode on use. These characteristics make it possible to fumigate using methyl bromide in a wide range of locations or environmental conditions, from fumigation warehouses and chambers to tarpaulin covers on open ground. Methyl bromide can be applied using compressed gas cylinder or compressed pressure-proof tins. Being colourless and odourless, methyl bromide gas leakage can be difficult to detect and requires the use of flame reaction type gas detectors or gas detector tubes, or the addition of odour reagents such as chloropicrin.

Table 1: Physical/chemical properties of methyl bromide

Chemical Formula	CH_3Br
Molecular Weight	94.95
Weight of 1 Litre	4.24 g
Gas Gravity	3.27
Boiling Point (°C)	3.56 ~ 4.5
Solubility in Water	1.34 (25°C)
Vaporization Heat (Cal/g)	61.52

[2] See the CPM-3 report available at https://www.ippc.int/publications/cpm-3-2008-report-third-session-cpm-warning-file-800-kb-spanish-version-revised-3-jul-0

Freezing Point (°C)	-93.66
Odour	Chloroform-like
Color	Colorless
Explosion Limit (20°C /1 atmosphere)	13.5~14.5%, 533~572 g/m^3
Flash Point (°C)	-
Ignition Point (°C)	537

Factors affecting fumigation include gas concentration, fumigation time, and temperature during fumigation, resistance or tolerance of pests against the chemical, diffusion rate of the gas, penetration of the gas, gas sorption onto or into the commodity, and the rate of gas leakage.

2. Relationship Between Pest Biology and Methyl Bromide

The ability of pests to resist or tolerate methyl bromide varies considerably depending on the species. The same species may also show different levels of susceptibility depending on the life stage at the time of exposure (e.g. egg, larvae, pupae, adult), and susceptibility can vary at the same life stage depending on its age (e.g. number of days after hatch, number of days after pupation, whether the insect is dormant, etc.). Pest susceptibilities are also known to vary depending on physical or physiological characteristics such as the type and amount of feed before fumigation, population density, etc.

In general, when comparing the susceptibility of the different insect life stages to methyl bromide to that of the adult; the susceptibility of eggs is equivalent to or less than adults, larvae slightly greater, and pupae significantly more than adults.

3. General Guidance on Methyl Bromide

Methyl bromide fumigation is the application of bromomethane gas into an enclosed space. All fumigants are toxic and care should be taken during application. Most countries, if allowing methyl bromide treatment, have established strict regulation of the application, transport, storage and recapture of the chemical. Qualifications of treatment providers are often also prescribed. The following is additional guidance.

The treatment should be applied according to the label and following the requirements prescribed in Annex 1 of ISPM 15 by trained and authorized treatment providers. If a discrepancy exists between the label and the guidance contained in ISPM 15, NPPOs should only authorize treatment in accordance with ISPM 15 if it is permitted under national legislation. If the treatment is not permitted, NPPOs should not permit certification of wood packaging material treated contrary to the requirements in the standard.

Methyl bromide is in the form of gas at room temperatures and is normally stored by cooling and liquefying the gas in a compressed gas cylinders or pressure-tight tins. The compressed cylinder is usually filled with compressed air to maintain a high pressure. The cylinder is equipped with a siphon tube and valve. By opening the valve with the cylinder kept erect, the chemical blows out in the form of a mist through the siphon tube.

The pressure-tight tin usually contains 500 grams of methyl bromide, and is used for dosing in small quantities. This kind of dosing is normally done with an apparatus called an opener which, when fitted to the can, punches a hole releasing the gas. Its main advantage is that dosing can be done safely from the outside.

Storage of the gas

- The gas should be stored in a cool, dark adequately-ventilated place (normally at or below 40 °C) which should be appropriately secured when not in use.

- The storage place should be covered with a light-weight roof made of non-combustible or flame retardant materials to avoid direct sunlight, and should be a structure which does not allow gas to remain stagnant inside should a leak occur.
- Flammable items should not be placed within two meters of storage and the storage area should be free corrosive or reactive chemicals such as chlorine.
- Other than items required for application, such as measuring instruments, should not be placed in the storage site.
- Access to the storage site should be limited to appropriately trained staff.
- Should it becomes necessary to temporarily place cylinders or tins outdoors, appropriate precautions such as notices, limits on handling, etc. should be taken

Handling of the gas

- Cylinders or tins should be handled with care to avoid leaks.
- Before transport, cylinders and tins should be checked for leaks. Transport should be undertaken in a manner that prevent leaks.
- After use partially used cylinders should be resealed.
- In the case of a spill or leak the site should be evacuated and the gas permitted to diffuse.
- Appropriate safety clothing such as a gas mask and gloves should be used when handling gas cylinders or undertaking fumigations.
- A gas detector should be used to detect leaks or areas of gas build-up since methyl bromide emits little or no odour at a low concentration.
- Care should be taken when heating gas since pressure may result in rupture of the cylinder or tin. Methyl bromide should not be heated to temperatures above 40 °C.

3.1 Methyl bromide penetration of wood

Penetration of fumigants is limited by a number of factors including: the moisture content of the wood; the presence of bark; the thickness of the wood; the density of the wood; and the ability of the fumigant to enter all pieces of wood within the treatment enclosure. Methyl bromide is much less likely to penetrate green wood with bark than dry wood without bark. ISPM 15 (Annex 1) requires that fumigations be applied to only debarked wood of a thickness no greater than 20 cm.

Leakage of the chemical during the treatment should be avoided both for safety and efficacy reasons. Treatment providers should use gas-proof sheets or sealed enclosures. Methyl bromide does not penetrate metal allowing for treatment in many types of transport containers. Sheets should be checked prior to treatment to ensure that seams are sealed and they are free of tears. Applications under gas-proof sheets should be sealed using “snakes” (bags 1¼ m to 2 m in length and greater than 10 cm in diameter containing sand or water) laid on the sheets to ensure a tight seal between the sheet and the ground or by burying the sheet edges in soil. Treatment providers should check for leaks once insertion of the gas occurs.

During treatment with methyl bromide, the applicator must consider the extent of likely sorption of the fumigant by the commodity and any other compounds within the enclosed treatment area. Sorption is the uptake of the chemical by the free space in the wood or other objects in the treatment area. This “loss” of the compound affects the ability for the gas to diffuse through all of the wood necessary to effectively kill pests. Moisture in the wood or within the treatment enclosure plays an important role in the sorption of the gas. As far as possible, any free water should be avoided or removed before fumigation. The inner surfaces of the enclosure should be made of material that does not take up excessive amounts of methyl bromide. Where necessary a gas-proof sheet may need to be placed between an inner surface of the enclosure and the wood to be treated to prevent sorption.

3.2 Measuring the methyl bromide dose

Most fumigation is carried out on the basis of a dose, usually expressed as a weight over a prescribed time period. However, given such factors as sorption and leakage, the concentration of the gas required to effectively kill pests is more relevant in determining treatment efficacy. Depending on the factors already noted, the volume of gas available to reach pests in the wood will vary. The efficacy of fumigants is achieved by testing varying concentrations of gas applied against target pests. The concentration required over a given time to achieve the required level of mortality is the lethal concentration. This concentration over the stated treatment duration is referred to as the concentration-time (CT) product or "concentration over time". Table 1 of Annex 1 of ISPM 15 provides CT products for methyl bromide fumigation of wood over a 24 hour period.

Temperature and humidity are factors known to influence the concentration of methyl bromide required to achieve an effective treatment. The fumigant concentration required to achieve a specified level of efficacy has been shown to be inversely correlated to the temperature at which it is applied. This means that as the temperature of the chamber and wood decreases, the concentration of the fumigant must increase to achieve the expected level of efficacy. For reasons of practicality, most fumigations occur at near-constant temperatures, by applying a prescribed dose at a minimum set temperature and measuring the levels of fumigant within the enclosed space over a period of time. Although subject to the variability of sorption, leakage and other factors, the information provided in ISPM 15 Annex 1 Table 2 is an example of treatment dosages that could be followed to achieve the prescribed CT products at three different temperature levels. NPPOs should work with treatment providers to ensure that dosage applied to wood packaging material being treated meets the CT products prescribed in Table 1 of Annex 1 in ISPM 15.

3.3 Applying and monitoring methyl bromide

Methyl bromide, which is often supplied as a liquid, may freeze when being released and is therefore often inserted into the enclosure using a vaporizer. Vaporizers work by heating the liquid methyl bromide with water, creating a vapour in the treatment enclosure which ensures rapid and even distribution of the gas. Fans should be used to make sure that the gas is uniformly distributed throughout the enclosure.

Dosage during initial insertion and at prescribed intervals during the treatment should be monitored. A variety of gas analysers can be used to determine the concentration of gas during treatment. Sampling lines should be inserted into the enclosure to measure the level of methyl bromide at a location furthest from the point of insertion to ensure that the gas has dispersed throughout the enclosure. In large fumigation enclosures (e.g. an area > 5 m^3) multiple sampling lines should be used. To ensure effective dispersion of the gas, the wood should not be loaded to more than 80 percent of the available space in the enclosure, allowing sufficient gas movement through the wood. Wood should not be wrapped in gas impervious materials such as plastic sheeting, waxed papers, shrink wrap, polyfoam materials, etc.

Treatment providers should monitor temperatures in the enclosure and adjust dosages as required. Treatments should not be conducted when temperatures are below 10 °C. Should the temperature fall below 10 °C for an extended period (e.g. 1-3 hours), during treatment, the treatment should be restarted when temperatures are above the minimum and will remain so for the duration of the treatment. Accuracy of monitoring equipment should be calibrated. NPPOs can also validate if the treatment dose was sufficient by using appropriately calibrated "Cross Check" sachets (small plastic bags containing two solutions which absorb and react to methyl bromide). Colour transformation of the solutions in the sachet when mixed indicates whether sufficient methyl bromide is present. Specific sachets can be used to measure specific CT values over a given period.

4. Considerations for Methyl Bromide Fumigation

4.1 Gas concentration

In general, the insecticidal effect of methyl bromide increases as the gas concentration increases at a constant temperature.

4.2 Fumigation time

Insecticidal effects of methyl bromide increase as the fumigation time increases at a constant temperature (see Figure 1).

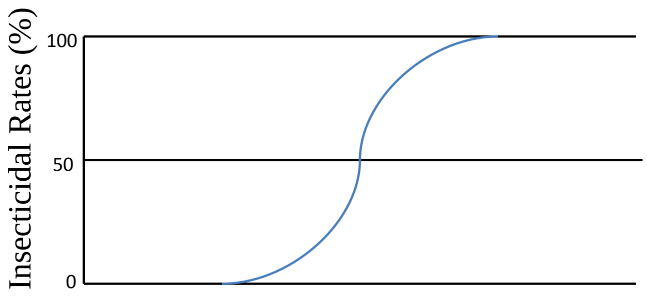

Figure 1: Fumigation Time-Insecticidal Rate Curve
(Constant Gas Concentration)

4.3 Relationship between concentration, time and temperature

The impacts of gas concentration, fumigation time and fumigation temperature on insecticidal effects are indicated above. However, these impacts do not act independently. When the fumigation temperature is constant, insecticidal effects are determined by multiplying the gas concentration by the treatment time.

CT = K, where C = gas concentration (g/m^3); T = treatment time (hour); and K = a constant according to temperature and type of pest.

Furthermore, the temperature dependency is given by:

log CT = K - n logt, where C = gas concentration (g/m^3); T = treatment time (hour); t = treatment temperature (°C); and K, n = constants according to the temperature and type of pest.

4.4 Numeric value and conversion method as used in fumigation

Dosage and gas concentration for fumigation are in general shown as weight/volume or volume/volume. The weight/volume shows how much weight of gas is contained in the air of a constant volume. In general, the administered dose is shown as the number of grams per one cubic meter (g/m^3), while gas concentration is shown as the number of milligrams per one litre (mg/litre). Volume/volume is often expressed as a percentage or parts per million.

In an effort to reduce the use of methyl bromide resulting from repeating fumigations which fail to achieve an adequate CT product in the required time, research undertaken demonstrated that while the applied CT value is important, efficacy of the treatment was less sensitive to the actual time taken to reach the required CT value. For example, an extension of 2 hours could be used to offset a gas leakage rate which is greater than expected during a treatment. However, an extension of the treatment time may not be necessary, if the initial application rates are appropriately increased to account for any expected leakage. The following may be used as practical guidance in considering CT values at the end of the treatment:

- Where the concentration after 24 hours meets or exceeds the minimum final concentration in Table 1 of Annex 1 of ISPM 15, the treatment has achieved the required dose.
- Where the concentration after 24 hours is no less than 95% of the minimum final concentration in Table 1 of Annex 1 of ISPM 15, an extension of the treatment for up to 2 hours may be used to ensure the required CT product is achieved.
- Where the concentration after 24 hours is less than 95% of minimum final concentration in Table 1 of Annex 1 of ISPM 15, the treatment has failed to achieve the required dose and must be repeated.

4.5 Infiltration of methyl bromide gas

Diffusion of gas into the wood packaging material to be fumigated is called "infiltration". While methyl bromide infiltrates well into most wood types, some types of wood are significantly resistant to methyl bromide infiltration. Experiments have shown that methyl bromide may not reliably penetrate into some wood types when their smallest dimensional cross-section is in excess of 20 cm.

4.6 Temperature during fumigation

Higher temperatures during treatment result in increased insecticidal effects and increased metabolic activity of target pests. Combined, the reaction rate of the active ingredients of a fumigant will increase with increased temperature. However, even in the low-temperatures, where pest metabolic activity may be low, insecticidal effects can be present (Figure 2).

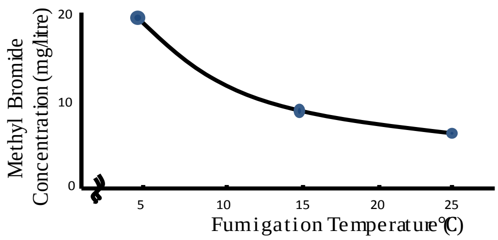

Figure 2. Effects of temperature on Methyl Bromide dose required to achieve LC99 after 24hrs fumigation.

As methyl bromide has a boiling point of around 3.6 °C, uniform gas concentrations cannot be maintained when fumigating in ambient temperatures below 5 °C. In operational conditions, temperatures may vary considerably over the duration of a fumigation, to ensure temperatures do not drop below 5 °C, the treatment schedule sets a lower measured limit on temperatures at 10 °C. A minimum temperature of 10 °C was also used in much of the research used to support the use of methyl bromide fumigation on wood packaging, limiting the evidence of the efficacy of methyl bromide at lower temperatures.

4.7 CT product

During fumigation, if the gas concentrations are measured each hour (after the fumigant has reached equilibrium within the chamber, each measurement (at T1, T2…Tn (hr)) can be described as a series of measured gas concentrations (C1, C2…Cn). From these measurements a CT product can be calculated as follows:

CT value ($g.hr/m^3$)

= C1T1 + C2T2 + ------ + Cn-1Tn-1

= {(C1 + C2)(T2.T1) + (C2 + C3)(T3.T2) + ------ + (Cn-1 + Cn)(Tn.Tn-1) } / 2

where

C1: gas concentration after T1 hr. (g/m^3)

C2: gas concentration after T2 hr. (g/m^3)

Cn-1: gas concentration after Tn-1 hr. (g/m^3)

Cn: gas concentration after Tn hr. (g/m^3)

To ensure an adequate estimation of the CT value, gas levels within the treatment enclosure need to be measured at a number of time intervals. The ISPM 15 schedule specifies the minimum number of measurement time intervals necessary (2, 4 and 24 hours). However, if issues such as excessive gas leakage or gas sorption are likely to significantly affect the fumigation dose, further measurements should be taken to ensure an adequate estimate of the CT value.

4.8 Diffusion of gas

When gas concentrations in the air vary, gas will diffuse from areas of higher concentration to areas of lower concentration. When liquefied gas is introduced into one part of a closed space, the liquid starts to evaporate forming a gas “bubble” which diffuses throughout the entire space over time. Diffusion will continue as gas concentrations become uniform throughout the space (Figure 3). For effective fumigation, it is necessary to create this uniform condition as soon as possible. The speed of diffusion varies with factors such as the type of gas, differences in gas concentrations, presence of other gases, chamber temperature, presence and intensity of convection (e.g. due to agitation), quantity and types of wood packaging material being fumigated, condition or loading of the cargo on the wood packaging material, and the method of applying the fumigant.

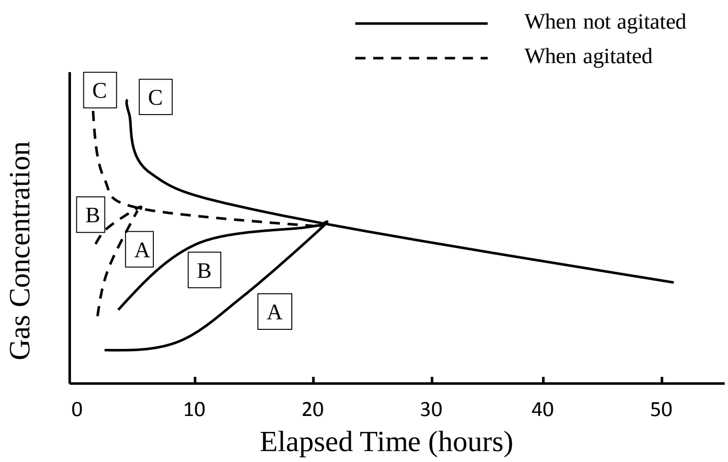

Figure 3. Gas diffusion in a fumigation chamber over time: A-Upper, B-Middle, and C-Lower chamber gas probes

As the gravity of methyl bromide is large, the diffusion rate of the gas during fumigation is relatively slow. During the early part of fumigation, the gas may remain stagnant on the floor. A fan may be required to distribute the gas. Any physical obstacles to gas circulation should also be removed including overloading (above 80 percent), the use of gas impermeable wrapping, etc.

Gas leakage from the fumigation site will reduce gas concentration lowering insecticidal effects.

4.9 Sorption and desorption of methyl bromide

In general, when gas is brought into contact with a solid, it gravitates to the surface of the solid, forming a very thin membrane-like layer. This phenomenon is called “adsorption”. In some cases, gas infiltrates the solid and may cause a chemical change. This is called “absorption”. Together these two phenomena are called “sorption”. Usually adsorption is maximised in a short time, and the volume involved is greatest when temperatures are lower. Absorption continues over a relatively long period, and the volume involved tends to increase when temperatures are higher. Wood packaging material with a large surface area or high moisture content has a greater level of gas adsorption.

“Desorption” is the reversal of sorption when gases re-enter the atmosphere from the fumigated commodity. When the air is exhausted after fumigation, gas concentration around the fumigated wood packaging material will rapidly drop, allowing the gas adsorbed to the fumigated wood packaging material to evaporate.

During fumigation, sorption lowers the ambient gas concentration. Thereby the insecticidal effects of the gas may be reduced, unless the dose is supplemented at certain points throughout the fumigation process.

Some forms of cargo, packaging material or containers or ground surfaces can absorb significant quantities of methyl bromide. Care needs to be taken to ensure effective treatment rates are not compromised by excessive sorption.

5. Types of Fumigation

5.1 Warehouse or chamber fumigation

A common layout for warehouse or chamber fumigation with methyl bromide is as provided in Figure 4. Before application of the gas, openings such as windows and ventilations should be sealed with the exception of openings for dosing.

Methods available for dosing include: inserting a pressure-proof hose from a dosing hole to dispense chemicals from outside the warehouse, and; use of a vaporizer. Regardless of the method of applying the gas, the applicator should prevent the chemical from spraying onto the wood packaging material. After the dosing has commenced openings should be sealed and the fumigation carried out for the required length of time.

When the wood packaging material is loaded into the warehouse, it should not interfere with the diffusion of the gas. An agitator, such as air blowers may be placed on the floor or ceiling of the warehouse or chamber to disperse the gas uniformly throughout the enclosure. In the case of an air-tight warehouse or chamber, care should be taken during sampling since the pressure inside the enclosure may have risen significantly higher than the pressure outside.

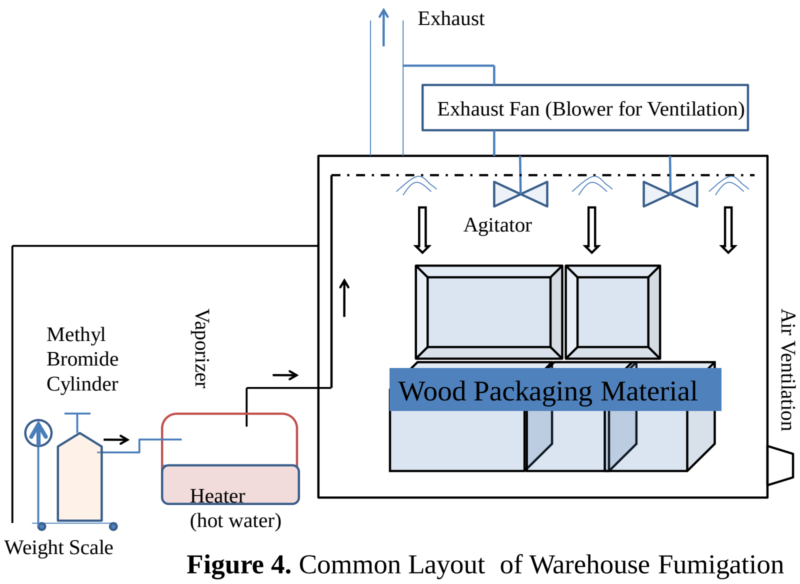

Figure 4. Common Layout of Warehouse Fumigation

5.2 Tarpaulin fumigation

A common layout for tarpaulin fumigation of wood packaging materials is shown in Figure 5. Sheets, 0.15 mm or more in thickness, should be arranged over piled-up wood packaging materials and held down at the base by three or more staggered rows of sand or water-snakes (i.e. plastic or burlap tubes filled with sand used to hold the tarpaulin firmly to the ground). The chemicals are dispensed from outside by way of a pressure-proof hose attached to the gas cylinder or an opener in the case of or 500 gram cans. The enclosure should be sealed for the duration of the treatment.

In order to avoid breakage of sheets, canvas or non-absorbing matting should be placed over protruding parts of the materials to be treated before sheets are applied. To prevent sheets from being lifted by winds, heavy weights, pegs, nets, or ties should be used hold down the sheets or the sheet ends buried in the soil. The gas releasing operation must be done with due consideration to the direction of wind, proximity to homes, and other potential human and environmental risks in and around the site. When degasing the treatment area to the atmosphere, gas concentrations should be lowered by gradually opening the bottom of the sheets at corners.

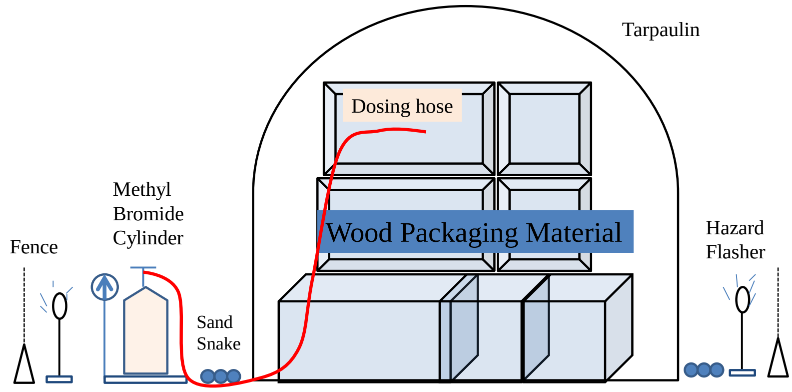

Figure 5. Common Layout of Tarpaulin Fumigation

APPENDIX I: Examples of Wood Packaging Material[3]

Image 1 - Pallets

Image 2 - Dunnage used in sawn wood shipments

Image 3 - Shipping boxes

Image 4 - Wooden spool

[3] Images contained in this Appendix are provided by the Canadian Food Inspection Agency.

Image 5 - Dunnage attached to stone shipments

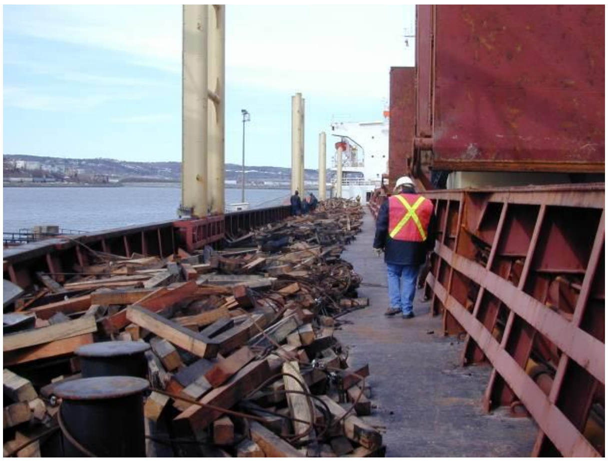

Image 6 - Ship borne dunnage

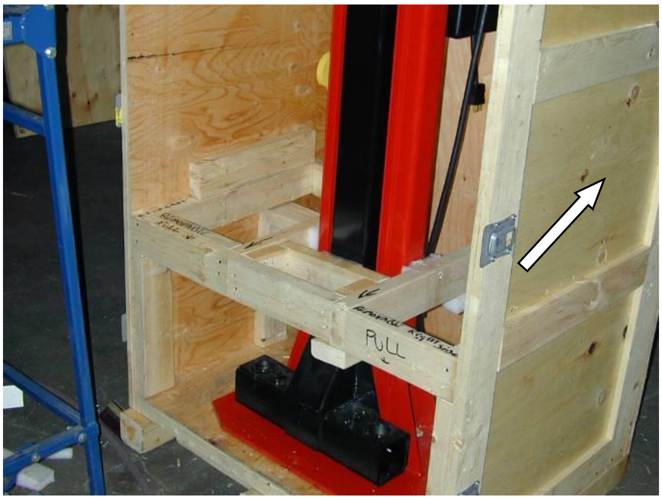

Image 7 - Shipping crate
Note the plywood identified by the arrow is exempt

Image 8 - Shipping crates on wooden pallets

Examples of exempt commodities

Image 9 - Plywood and metal pallets

Image 10 - Plastic and fibre-form pallets

APPENDIX II: Examples of Bark on Wood Packaging Material[4]

Image 1– Wane on edge of board is not regulated.

Image 2 - Bark on edge of board is less than 3 cm wide therefore the board complies with bark tolerances.

Image 3 - Bark on the edge of the board. The knife is 2 cm by 15 cm, therefore the board complies with tolerances. The board below the one with a knife, only contains wane (discoloured cambium) and is therefore compliant.

[4] Images in this appendix provided by the Canadian Food Inspection Agency.

Image 5 - Bark on the edge is wider than 3 cm and the piece is greater than 50 cm^2. The bark must be removed or the piece may not be used in wood packaging material.

Image 6 - Bark exceeds tolerances. This ship borne dunnage does not comply.

APPENDIX III: Examples of Marks

Conforming Marks

Image 1[5] – Mark matches example 6 of Annex 2 of ISPM 15. Additional information included outside the borders of the mark.

Image 3[6] – Mark matches example 1 of Annex 2 of ISPM 15.

Non-Conforming Marks

Image 2[6] – Information beyond what is prescribed in Annex 2 of ISPM 15 contained within the borders of the mark.

Image 4[6] – Mark does not contain the required borders.

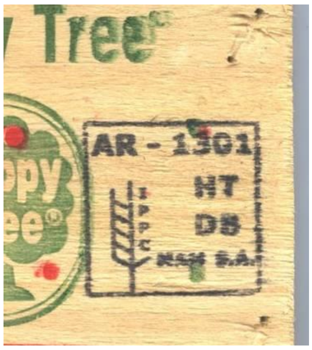

Figure 3[6] – Orientation of information does not match the examples in Annex 2 of ISPM 15. Information included within the borders of the mark exceeds the requirements.

[5] Images provided by Council of Le Conseil de l'industrie forestière du Québec (CIFQ).

[6] Images provided by the Canadian Food Inspection Agency.

APPENDIX IV: Resources on Fumigation

Ministry of Agriculture, Government of India. 2005. *Quarantine treatments and application procedures: I. methyl bromide fumigation*. Faridabad, India. Available at http://www.plantquarantineindia.org/pdffiles/NSPM%2011%20Quarantine%20Treatment%20(MB)%20Standard.pdf (last accessed 2014-04-23).

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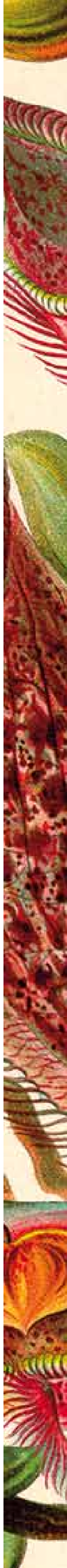

IPPC

The International Plant Protection Convention (IPPC) is an international plant health agreement that aims to protect cultivated and wild plants by preventing the introduction and spread of pests. International travel and trade are greater than ever before. As people and commodities move around the world, organisms that present risks to plants travel with them.

Organization

- There are over 180 contracting parties to the IPPC.
- Each contracting party has a national plant protection organization (NPPO) and an Official IPPC contact point.
- Nine regional plant protection organizations (RPPOs) work to facilitate the implementation of the IPPC in countries.
- IPPC liaises with relevant international organizations to help build regional and national capacities.
- The Secretariat is provided by the Food and Agriculture Organization of the United Nations (FAO).

International Plant Protection Convention (IPPC)

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