BHUTAN PHYTOSANITARY TREATMENT MANUAL

(BPTM)-2020 (Version 1.0)

ENDORSEMENT

The Bhutan Agriculture and Food Regulatory Authority (BAFRA) as National Plant Protection Organization (NPPO) is entrusted to protect the health of plants and plant products from exotic pest and disease and invasive alien species (IAS). As required by International Standards for Phytosanitary Measure (ISPM43) of the International Plant Protection Convention (IPPC) and also to fulfill the national phytosanitary regulations, BAFRA has developed phytosanitary treatment procedure title "Bhutan Phytosanitary Treatment Manual". Firstly, this will help build phytosanitary measures and capability to facilitate safe global trade in agriculture, forestry to meet the requirements of the trading partners. Secondly, it will support fumigators to effectively carry out the treatment considering the personal safety and operation of the treatment process. With the development of this manual, fumigation treatment services shall be operationalized and the introduction and spread of regulated pests will be prevented.

The manual was developed with generous financial support of EU-RDCRRP and consultancy support of Uniphos Private Limited, Mumbai, India.

Good Luck!

Director General
Bhutan Agriculture and Food Regulatory Authority
Ministry of Agriculture and Forests
Thimphu: Bhutan

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ACRONYM

AlP - Aluminium phosphide.

BAFRA -Bhutan Agriculture and Food Regulatory Authority

CO2 – Carbon Di Oxide

FHAT – Forced Hot Air Treatment

HWIT – Hot Water Immersion Treatment

IPPC- International Plant Protection Convention

IPM - Integrated Pest Management

NPPC- National Plant Protection Centre

NPPO- National Plant Protection Organization

PEL - Permissible Exposure Limit

PPE - Personal Protective Equipment

PPM – Parts Per Million

MSDS – Material Safety Data Sheet

SCBA – Self Contained Breathing Apparatus

SAR – Supplied Air Respirator

SPM - Standard Phytosanitary Measures

TCA-Thermal Conductivity Analyzer

TLV STEL-Threshold Limit Value-Short Term Exposure Limit

TLV - Threshold Limit Value

TLV-TWA - Threshold Limit Value-Time Weighted Average

NPPO – National Plant Protection Officer

PH3– Phosphine

QPS – Quarantine Pre-Shipment
VHT – Vapour Heat Treatment

DEFINITIONS

Absorption– When fumigant molecules penetrate into a material (commodity, soil or other item being fumigated).

Action Threshold – A pest population level that triggers a management response. Sampling and regular observation are necessary to assess threshold levels.

Adsorption– When fumigant molecules stick to the surface of a material (commodity, soilor another item being fumigated).

Aeration- *Fumigant application:* The process of replacing fumigant-containing air or water with fresh air and/or water that contains little or no fumigant. Aeration must follow all fumigation operations.

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.

Air Wash– A method of aeration used in vacuum fumigation. Air washing involves drawing a second vacuum after the exposure period is complete and then breaking this vacuum with fresh air.

Air-Purifying Respirator – A device that uses special canisters to remove particles and toxic vapors from the air. The canisters fit on a face piece and are specific for one type fumigant. Air-purifying respirators are also called gas mask/canister combinations.

Ambient Air Analyzer– A gas detection device that measures the amount of infrared light absorbed by a gas at a selected wavelength. This tells you what gas is present and its concentration.

Antidote– A remedy that may counteract the effects of a pesticide.

Auger– A grain transfer tool used to load and unload grain and other stored products.

Authority – An individual or organization entrusted with the responsibility for granting approval and certification of hot water immersion treatment facilities.

Billowing– When air or gas causes something to bulge outward. In tarpaulin fumigation, this occurs when gusting winds cause a tarp to bulge away from the item or structure that it is covering.

Binning– Placing grain or another raw product into a storage bin.

Biological Control– The use of natural enemies (predators, parasites, or pathogens) to control pests and pest populations.

Blower– A machine that generates and directs an air stream in a particular direction.

Boiling Point– The temperature at which a liquid becomes a gas. Boiling point also indicates the vapor pressure of a fumigant. Boiling point is the temperature at which a fumigant becomes a gas.

Bonnet – The cap that covers the valve and safety cap on a fumigant cylinder. The bonnet protects the valving system from damage and prevents accidental release of the fumigant.

Boxcar– A large, roofed container with enclosed sides used to transport freight. Boxcars usually have sliding doors on each side. Trains usually transport box cars.

Calibrate– To measure and adjust a gas detector so that it reads accurately for the fumigant you use.

Coldspot - 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.

Commodities– Items produced for trade or commerce.

Corrosive– Able to weaken or destroy something gradually.

Cultural Control– A pest control method that involves changing one or more crop production practices (sanitation, cultivation, crop rotation, use of resistant plant varieties, etc.) to create an uninviting or unfavorable environment for pests.

Cuticle– The protective outer covering of an insect.

Deactivate– To make something ineffective. For example, by deactivating fumigant residue, you would be neutralizing its toxic effects.

Desorption– The liberation or removal of a fumigant from treated surfaces and/or substances.

Diffuse– To spread or distribute, to move in all directions.

Diffusion– The process of spreading out or distributing evenly in a space.

Dosage– The concentration of a fumigant (ounces, pm, etc.) times the exposure time (hours, minutes, etc.). The dosage requirements depend on the pest, the fumigant, the temperature, the rate of leakage (some leakage is inevitable), and many other factors.

Drybulb - A sensor for measuring ambient air temperature.

Drywood - Wood that has had its moisture content reduced to less than 20 percent.

Equilibrium – Even distribution. For example, a fumigant has reached equilibrium when there is an equal concentration of gas throughout a given structure.

Exposure– When a person or organism comes in contact with a pesticide by inhalation, ingestion, skin contact, or any other method.

Face piece– The part of a respirator that fits over your nose, mouth, face, or entire head.

Fibre saturation point – The moisture content point of wood at which only water bound in the cell walls remains.

Field Capacity– The moisture level of soil at which air has largely replaced water in soil macropores but not micropores. For example, at 50 percent field capacity, the total space between soil particles is shared equally by air and water, with most of the water being found in soil micropores.

Fines– Broken kernels and pieces of small foreign material within a load of grain.

Formulation – The form in which a pesticide is offered for sale to the user (tablets, pellets, prepacs etc.). A formulation contains both the active ingredient and inert materials.

Fumigant – A fumigant is a pesticide that is a gas, or forms a gas, when applied. In a high enough concentration, this gas (vapor) has pesticidal action.

Fumigation Tape– Strips of adhesive material used to seal doorways, windows, and other areas where gas might escape during fumigation. Fumigation tape has a plastic or vinyl coating that reduces fumigant penetration.

Fumiport - A special opening in a transfer line, small bin, or food processing machine through which you can apply fumigants.

Fumiscope®– A type of thermal conductivity analyzer (TCA) that measures the concentration of specific fumigants. It is lightweight, portable, and operates on 115volt AC (alternating current) or battery power.

Gas Detector– A device used to check the concentration of fumigant in the air.

Gastight– Something that does not allow gas to enter or pass through.

Greenwood – Wood that has not been dried or seasoned and contains a moisture content higher than the fibre saturation point for the tree species.

Ground Seal– The sealing of tarps to the ground to prevent fumigant loss during fumigation.

Harborage – Shelter, a home or refuge for an organism.

Headspace– The open area between the stored product and the ceiling of the storage facility.

Heat chamber - Any closed chamber used for the heat treatment of wood.

Hot Spot– An area in stored grain that is much warmer (10°F or more) than the surrounding grain. A hot spot indicates that the grain has a higher than normal moisture content, possibly caused by insect or fungus activity.

Inert – Not reactive.

Inert Gas– A gas that does not have toxic effects.

Infestation– A pest population that grows so large it becomes harmful or unpleasant.

Insecticide– A pesticide used to control or repel insects or to reduce the unwanted or harmful effects of insects.

***Integrated Pest Management (IPM*)** – A pest management system that uses all appropriate strategies to reduce pest populations.

Macropores– The large spaces between soil particles in which air and water can move readily.

Metabolism– All chemical reactions that take place in a living thing. For example, insects metabolize food to produce energy.

Micropores– The small spaces between soil particles where little air movement occurs, and water moves slowly. Plants absorb most of the water they need from soil micropores.

Moisture content (of wood) - The weight of water within wood measured as a percentage of the weight of oven-dried wood.

Molecular Weight– The sum of the atomic weights of all the atoms in a molecule. All fumigants have a unique molecular weight.

Molecule– The smallest particle of a substance that retains all of the properties of the substance.

Multipurpose Fumigant– A fumigant that controls more than one type of pest.

Neutralize– To counteract the effect of a harmful substance such as a pesticide.

Non-sparking Fan– A machine that safely re-circulates air in potentially explosive environments.

Overexposure – When a person or organism comes in contact with enough pesticide over a long enough period to cause harm.

Pathogen– An organism that causes diseases.

Permissible Exposure Limit (PEL) – An OSHA standard that designates the maximum exposurepermittedasan8-hourtime-weighted average(TWA).

Personal Protective Equipment (PPE)– Clothing or devices used to protect the human body from exposure to pesticides and pesticide residues.

Pest– Any living thing that is undesirable or causes harm to people, property, or the environment. An organism may be a pest in one place but not in another; for example, termites in a house vs. those that recycle dead trees in forest.

Pesticide Resistance– The ability of an organism to tolerate a pesticide. There are different levels of resistance. For example, some insects may be sensitive, weakly resistant, or strongly resistant to a specific insecticide. Total resistance is immunity.

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Plenum– An enclosure in which air or other gases are at a pressure greater than the atmospheric pressure outside the enclosure.

Pulp temperature- Temperature recorded at the center of fruit with the help of sensor inserted into the pulp of the fruit.

PPE (Personal Protective Equipment)– Clothing or devices used to protect the human body from exposure to pesticides and pesticide residues.

PPM (Parts Per Million)– The number of parts of a substance in one million parts of another substance. For example, if a gas detector reads "5 ppm" it means that there are five parts of fumigant to every one million parts of air.

Process Stream– A commodity that is enroute to a storage facility.

Quarantine – A period of time during which a vehicle, commodity, or other item is detained and isolated to prevent pests from entering an area, state, or country. Commodities are often quarantined at shipping ports before entering the United States.

Quarantine area - An insect-proof exclusive area, where treated fruits are kept remaining until loaded into shipping container.

Quarantine pest- A pest of potential economic and/or environmental importance to an area where it is not yet present or is present but not widely distributed and being officially controlled.

Quarantine treatment – Any kind of treatment that is applied for quarantine purpose for elimination of pest in accordance with phytosanitary regulations of the importing country.

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.

Residue– Traces of fumigant that remain after treatment.

Respirator– A device that protects the respiratory tract from irritating and poisonous gases, fumes, smokes, and dusts. Respirators may or may not have equipment that supplies oxygen or clean air.

Safety Data Sheet (SDS/MSDS) – A printed report that details information on the fumigant manufacturer, identity of hazardous ingredients, physical and chemical characteristics, fire and explosion hazard data, reactivity data, precautions for safe handling and use, and control measures.

Schedule- Refer to the pulp temperature raised using water heated to between 46.1- 47.8 ^{0} C for a prescribed period of time.

Seal – To enclose an area so that fumigant gas cannot escape too quickly. A good seal will contain a lethal amount of gas long enough to kill the target pests.

Self-Contained Breathing Apparatus (SCBA)– A type of respirator that supplies fresh air from an outside or portable source. Air enters mask that tightly covers the entire face.

Skinning– Superficial injury, such as to the surface of a grain kernel during harvesting, transport, and storage.

Soil Texture– The relative proportion of the different sizes of mineral particles – sand, silt, and clay, that make up a soil.

Solubility– How readily a substance will dissolve in a liquid.

Sorption– Adsorption and/or absorption.

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*.

Spot (Local) Fumigation– Spot fumigation is used to treat small items or areas with light to moderate infestations. Spot fumigation is also used routinely to prevent infestations from developing or recurring.

Stratification – When fumigants rise or fall, making layers of gas within a confined area. Diffusion is incomplete, leaving some areas untouched by the fumigant. Stratification results in an incomplete treatment.

Supplied-Air Respirator (SAR)– A device that supplies air from a compressed air tank that is located outside of the fumigation area.

Tarpaulin – A semipermeable material used during fumigation to confine fumigant in a specific area during the exposure period.

Tarpaulin Fumigation– Tarpaulin fumigation places items under a tarp or covers an entire structure. Fumigant is released beneath the tarp and held until pest control is complete.

Thermal Conductivity Analyzer (TCA) – An instrument designed to measure the concentration of fumigant gases within a chamber or other enclosure during fumigation.

Threshold Limit Value-Short Term Exposure Limit (TLV-STEL) – The concentration of fumigant to which most workers can be exposed continuously for a short period without having any adverse effects.

Threshold Limit Value (TLV)– The maximum amount of fumigant that can be in the air before conditions are considered unsafe. The TLV is expressed in parts per million (ppm). It is used to monitor short-term exposure.

Threshold Limit Value-Time Weighted Average (TLV-TWA)– The average concentration of fumigant for a normal 8-hour workday and a 40-hour workweek to which workers may be repeatedly exposed

without adverse effect. The TLV-TWA is expressed in parts per million (ppm). It is used to monitor long-term exposure.

Tilth– The physical condition of soil that determines the ease at which it can be tilled or cultivated and its suitability for seed germination and plant growth.

Topdressing – A material such as a pesticide applied to or mixed into the upper surface of grain

Treatment - Any treatment applied to a commodity to eliminate the pest and shall include fumigation, irradiation, hot-water, hot air, vapour-heat and cold treatments

Vault Fumigation– Vault fumigation uses atmospheric or vacuum chambers to treat infested commodities. Vaults may include trucks, boxcars, shipholds, warehouses, and other structures.

Vapor Pressure– The pressure exerted by a liquid or a solid as it volatilizes(becomes a gas).

Vaporize – When a solid or liquid turn into a vapor (gas).

Volatility – The ability of a substance to turn into a gas (vapor) at relatively low temperatures.

Warning Gas– A chemical that can be added to an odorless fumigant to help workers detect the fumigant. Warning gases give off strong smells or have an irritating effect.

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

CHAPTER I: BACKGROUND

1.1. Introduction:

The Bhutan Agriculture and Food Regulatory Authority (BAFRA), Ministry of Agriculture and Forests (MoAF) is the Competent Authority (CA) for biosecurity and food safety systems to promote the quality and safety of food and agricultural related products. BAFRA is also the National Plant Protection Organization (NPPO) of Bhutan and official contact point for International Plant Protection Convention (IPPC).

The standard covers following areas;

1. To render guidelines for registration and certification of Treatment agencies /Treatment operators assessment, auditing.
2. Treatment manual for Chemical and Non chemical method.

1.1. Objectives:

- Protect farmers from economically devastating pest and disease outbreaks.
- Protect the environment from the loss of species diversity.
  - Protect ecosystems from the loss of viability and function as a result of pest invasions.
  - Protect industries and consumers from the costs of pest control or eradication.
  - Facilitate trade through International Standards that regulate the safe movements of plants and plant products.
  - Protect livelihoods and food security by preventing the entry and spread of new pests of plants into a country.

CHAPTER II: APPROVAL PROCEDURE AND DOCUMENTATION

2.1. Registration Authority:

The National Plant Protection Centre (NPPC) under the Ministry of Agriculture & Forests (MoAF) of Royal Government (RGoB) of Bhutan shall be the authority for granting approval and registration certificate to treatment agencies other than BAFRA for conducting approved chemical and non-chemical treatments under Certification Scheme. In Phase I, BAFRA will implement the treatment procedure in facilities at various Plant Quarantine stations for first 3 years. After that treatment service will be open to other organizations/private fumigation agencies. The NPPC shall certify the treatment operators for undertaking quarantine treatments and for long term storage which includes warehouses, site complexes and other type of storage structures.

The use of chemical and non-chemical method is restricted, and it shall be used by the approved treatment agency as per approved treatment guidelines of BPTM-2020 (released by BAFRA). NPPC shall

maintain records of all such registered agency and display on its website. The registered treatment agencies shall carry out treatment operations.

2.2 Registration Protocols:

NPPC will establish a central register of chemical and non-chemical method treatment providers agencies with certified treatment operators. In order to be registered with NPPC, the treatment agencies must have certified treatment operator. The treatment providers, agency with certified treatment operator will be allotted a unique registration number and each certified operator shall be assigned a unique certification number. The registered agency must record the registration/certificate number in all correspondences with NPPC.

The registration certificate of treatment agency (Chemical and Non-chemical) shall be granted initially for a period of **two years** and thereafter revalidated every **two years**. Each treatment operator shall be issued with a certificate and unique certification number and card after successful assessment, which is valid for a period of **two years** initially and thereafter to be revalidated after every **two years**.

The assessment team will conduct renewal assessment as per procedures laid down in the standard **within 45 days.**

2.3 Transfer of certified treatment operator

Transfer of treatment operator from one branch to another branch of the treatment agency is permitted with the prior approval of NPPC.

Further on transfer, the period of validity of treatment operator shall be linked with the validity of branch at which he/she is transferred within the scope of ± six months period otherwise; it will be unchanged unless treatment operator leaves the agency to which he is attached.

When any treatment agency opens a new branch and transfers the treatment operator from old branch, the treatment agency will be assessed for the basic facilities at new place besides the treatment operator and fee as applicable will be charged.

Note: The registration certificate granted by NPPC is valid only as long as the certified treatment operator is working with that treatment agency or company or organization. NPPC should be notified by the registered treatment agency in writing of any changes in arrangements between registered treatment company and the certified treatment operators or changes within the company. The certification granted to the treatment providing agency operator shall be cancelled in the event of leaving the company.

2.4. Renewal of approval of Treatment agency

- If a treatment agency fails to apply for renewal of its registration **45 days** before the date of expiry of the registration a penalty fee will be charged as applicable for revalidation of the registration of such treatment agency for another 30 days from the date of expiry.
- If treatment agency fails to apply within stipulated time, treatment agency shall stand terminated.
- When a treatment agency applies for renewal of registration within stipulated time period, but due to the procedural delay, could not get renewal within time, the treatment agency may continue operative work of chemical and non-chemical method till the receipt of renewed registration certificate.
- Nominated team will conduct renewal audit within 30 days from issuance of nomination letter.
- For renewal of the treatment operator, audit of past treatment activities and technical competence of the treatment operator shall be assessed
- Applicants will be examined for their technical competence through written practical and oral examinations. To qualify the test, treatment operator must secure at least 75% marks in each of the said examination.
- If any candidate fails to qualify the test, he may re-apply.
- If infrastructure and manpower of agency do not justify past treatment activities, the agency shall be put under suspension

2.5 Responsibilities of Treatment providing agency

The agency/service provider should:

- hold a valid approval certificate granted by the NPPC, Royal Government of Bhutan and a permit to import, stock and use restricted pesticides granted by NPPC.
- perform treatment operations always under the supervision of certified treatment operator.
- advise the client on stocking of consignment for carrying out effective treatment; advise the client about the time requirements for complete and successful treatment of consignment; seek information from the client regarding any specific conditions attached to the treatment of consignment.
- inform the client of any other factors that affect treatment of commodity such as impervious package or sportive nature of commodity.
- ensure adopting correct treatment (Chemical and Non-Chemical) practices and follow safety precautions, while undertaking treatment operations.
- ensure not to undertake treatment (Chemical and Non-Chemical) in forbidden places unsafe to public and animal life or of forbidden commodities; submit the information to NPPC timely.
- maintain proper records on stock and use of treatment (Chemical and non-chemical) materials; issue treatment certificate after ensuring that treatment has been carried out effectively; follow the guidelines stipulated in the standard and abide by instructions issued by NPPC from time to time.
- submit monthly report of various activities of agency including stock and use of restricted pesticides in the prescribed format to NPPC

2.6 Responsibilities of certified treatment operator:

- Not to undertake treatments (Chemical and Non-Chemical) in residential areas where

animal/human life exists.

- Display warning signs and take adequate safety precautions during treatment.
- Ensure safety of workers during treatment operations.
- Undertake supervision of all treatment operations.
- To monitor and detect any defects in any treatment equipment and take appropriate measures to fix the challenges in chemical and non-chemical treatments.
- To monitor / repair essential treatment /safety equipment.
- To maintain appropriate record related to treatment including the photograph and video graph of complete practice of treatment (Chemical and Non-Chemical) conducted in the facilities.

2.7. Treatment Certification:

All treatments should be undertaken by approved / registered treatment (Chemical and Non-Chemical) agencies under the supervision of certified Treatment Operator (TO).

Registered/Certified Treatment Operator shall:

- monitor the treatments (Chemical and Non-Chemical) to ensure that treatments are executed as per approved and standard procedures
- record all the details of Treatments in prescribed format confirming that the treatment was carried out in accordance with this BPTM
- Issuance of Treatment Certificate

Chapter III: SPECIFIC REQUIREMENTS FOR CERTIFIED OPERATORS

3. Eligibility of certified operator:

3.1 Educational and Professional Qualifications

S.No	SPM code	Service/treatments	Basic Qualification	Professional qualification	Remark
1	2	3	4	5	6
1	SPM-B1	Phosphine fumigation	Diploma or B.Sc (agriculture) or Forestry or Life science with Chemistry from recognized University but not open university	BAFRA and NPPC approved training (Minimum 7 days) on Phosphine fumigation with computer skills.	Minimum two treatment operators per registration
2	SPM-B2	Forced Hot-Air Treatment Facilities (FHAT) for Wood Packaging Material	Diploma or B.Sc (agriculture) or Forestry or Life science with Chemistry from recognized University but not open university	BAFRA and NPPC approved training (Minimum 7 days) on Heat Treatment with computer skills.	Minimum two treatment operators per registration
3	SPM-B3	Hot Water Immersion Treatment Facilities for fruits & vegetable	Diploma or B.Sc. (agriculture) or Forestry or Life science with Chemistry from recognized University but not open university	BAFRA and NPPC approved training (Minimum 7 days) on Hot water immersion treatment with computer skills	Minimum two treatment operators per registration
4	SPM-B4	Vapour heat for Mango Fruits	Diploma or B. Sc (agriculture) or Forestry or Life science with Chemistry from recognized University but not open university	BAFRA and NPPC approved training (Minimum 7 days) on Vapour heat treatment with computer skills.	Minimum two treatment operators per registration
5	SPM-B5	Controlled Atmosphere CO2 treatment for organic produce	Diploma B.Sc (agriculture) or Forestry or Life science with Chemistry from recognized University but not open university	BAFRA and NPPC approved training (Minimum 7 days) on CO2 treatment with computer skills.	Minimum two treatment operators per registration

3.2. Training Requirements:

- The eligible treatment operators shall be required to undergo training for a period of at least 7 days at any of the training institute approved by NPPC or BAFRA and possess working knowledge of MS Word, MS Excel and internet on computer.
- NPPC/BAFRA will organize 7 days training program annually. All aspiring treatment operators will have to attend to this training program successfully to make themselves eligible to apply for treatment operators.
- NPPC/BAFRA will also organize refresher course for all registered treatment providers from time to time and participation of certified treatment providers is mandatory
- The training programme shall be as per the guidelines prescribed by the NPPC/BAFRA and should be structured to impart technical skills and competency in performance of effective treatment (Chemical and Non- Chemical) operations with all approved treatments.
- The training programme will cover especially the following areas viz., Regulations/National Standards, role of Regulating Agencies and responsibilities of treatment Operators

3.3. Assessment Protocol:

- At least a panel of two technical experts approved by NPPC and BAFRA shall undertake the assessment of treatment agencies for certification/ renewal of registration.
- The technical experts must possess required skill competency in performance of effective Treatment operations with chemical and non-chemical procedures.
- The panel of experts after assessment shall submit a report to NPPC in the format prescribed in Appendix-IV (along with Annexures XV, XVI & XVII) for consideration of registration/renewal of treatment agency with accredited treatment operator.
- Criteria for nomination of Audit team for assessment of treatment agency -Two technical experts possessing required skill competency in performance of effective treatment operation shall be nominated by NPPC

3.3.1. Timeline for conducting audit:

Timeline of 45 days period from the date of issue of assessment/nomination letter shall be applied. However, in case of unavoidable circumstances justification of delayed audit is to be furnished by the audit team.

3.2.2. Process of assessment of treatment operator:

- The treatment operator seeking certification must have undergone the training on treatment practice at the authorized institute and working knowledge of computer and internet prior to assessment.
- The treatment operator shall be assessed by a panel of technical experts approved by NPPC, for knowledge and skill competency to perform effective treatment in line with the Standard set by NPPC

3.2.3. Assessment of treatment operator:

- sound knowledge of regulatory requirements, principles of chemical and Non-chemical treatment procedures.
- ability to carry out the tests needed to ensure that the treatment is successful.
- ability to recognize and analyze the factors leading to successful treatment as well as a failed or potential to fail treatment operations.
- ability to comprehend the standard requirements and hazards associated with the use of chemical and non – chemical treatment methods.
- ability to demonstrate the use of safety equipment and possess knowledge of chemical poisoning, first aid, emergency and safety measures.
- capability to measure chemical concentration in enclosure with the help of monitor and Threshold Limit Value (TLV) in/around the chamber with the help of leak gas detector.
- The treatment operators will be examined for their technical competence through written, practical and oral examinations. To qualify the test, applicants must secure at least 75% marks in each of the said examination. If any candidate fails to qualify the test, he may appear for the said examination for 2nd time but not earlier than 3 months of 1st assessment.

3.2.4. Assessment of equipment & facilities:

The treatment agency shall be assessed for possessing essential equipment and accessories that are required for undertaking chemical and non-chemical treatments and their working condition, availability of a separate secured place for stocking chemical, proper upkeep and maintenance of safety equipment (gas masks / SCBA) and calibration of measuring equipment etc.

3.2.5. Assessment of organization and personnel:

- The treatment company must have an organizational chart with clear job descriptions.
- The treatment company must have sufficient number of technical personnel to carry out its activities. A minimum of two persons shall be required to carry out each treatment activity including an certified treatment operator.
- The treatment agency will arrange training to its personnel in carrying out chemical and non-chemical treatment.
- Treatment Company must have, computer, mass storage device, camera for photo and videography.
- Both, the management of treatment agency and the certified treatment operator must be aware of all the regulatory requirements including the licensing requirements regarding use of chemical and non -chemical methods and the operational requirements outlined in the BPTM

3.4. Issue of Certificate of approval and registration:

Each assessed treatment agency with certified treatment operator shall be issued a certificate of approval in the prescribed format in Appendix

CHAPTER IV TYPE OF PHYTOSANITARY TREATMENT

4. Chemical Treatment

4.1. Aluminium phosphide treatment: Phosphine (PH3)

Phosphine is an effective and widely used fumigant for stored commodity fumigations. Phosphine fumigants have 56% Aluminium phosphide powder formulation available in 10g pouch. Solid metallic phosphides react with water vapor to generate hydrogen phosphide. Warm, moist air speeds up this reaction while cool, dry air slows it. The faster the reaction takes place, the more heat is achieved which increases the probability of spontaneous combustion. It is essential to follow the label application and handling procedures for phosphine products. Phosphine is approved for application of raw agricultural commodities, processed foods, animal feed and their ingredients, tobacco and other non-food items. Fumigation Service and Supply has the experience and can provide phosphine fumigations across a variety of storage structures including:

- Grain bins
- Flat storages
- Ground piles
- Ship holds
- Shipping containers
- Warehouses
- Containers

4.2. Fumigant profile - Aluminium phosphide

Common Name: Aluminium phosphide (AlP) generating Phosphine gas, (PH_3)
Composition:
(a) Active ingredients: Aluminium phosphide 56% w/w/ minimum.

(b) Other ingredients: Ammonium salts, wax, fillersand adjuvant 44% w/w maximum

(c) 3gm of Aluminium phosphide 56% formulation generates 1 gm PH_3 along with NH_3 and CO_2

4.3. Recommended usage – Aluminium phosphide

The 'Recommended usage' of fumigant is given below. This includes commodities, pest organisms, dosage and permissible concentration in air, aeration/waiting period and maximum number of fumigations suggested. However, if there is specific stipulation by the importing country in respect of above parameters, the same is to be adopted.

4.4. Important consideration in treatment:

- Do not re-circulate, follow normal diffusion. Not recommended for vacuum fumigation.
- In order to generate PH_3 from 56% powder formulation free moisture is required. Hence, too dry grain should not be fumigated with Aluminium phosphide pouches.
- Goods covered with or packaged in gas impervious materials (such as plastic wrapping or laminated plastic films, lacquered or painted surfaces, Aluminium foil, tarred or waxed paper) must have the coverings or packaging opened, cut or removed, prior to fumigation.

4.5. Constraints in use of Aluminium phosphide:

- Fumigation should not be attempted at Relative Humidity (RH) less than 50% (grain moisture contents around10%)
- Some insect species are highly tolerant to PH_3 especially at low temperatures and short exposures.
- Oil bearing commodities tend to air slowly and have to be checked for residual PH_3.
- Odour threshold is 2 ppm; unfavorable on long exposure.
- Flammability hazard.
- Brass and copper are attacked.

4.6. Detectors for Aluminium phosphide:

- Paper strip detectors sensitive to 0.3ppm.
- Detector tubes sensitive to 0.01 mgPH_3.

4.6. Recommended Phosphine dosages

Commodity	Pest type	Temperature conditions	Phosphine Dosage (g/m3)	Exposure Days (minimum)	Target End concentration (ppm)
All cereals except paddy rice, legumes & spices	All insects except Khapra beetle	≥25°C	3	7	500
		10-24 °C	3	10	300
	Insects having slow rate of respiration, for example, Khapra beetle	≥25°C	6	10	1000
		10-24 °C	6	14	600
Paddy rice, groundnut with shell,wholespices,legumes.	All insects except Khapra	≥25°C	4-8	7	500
		10-24 °C	4-8	10	300

	beetle				
	Insects having slow rate of respiration, for example, Khapra beetle	≥25°C	4-8	10	1000
		10-24 °C	4-8	14	600
Processed foods: de- oiled cakes, rice bran, flour, suji, meals & crushed Grain (Animal & Poultry food) split pulses (Dals) and other processed foods.	All insects except Khapra beetle	≥25°C	3	7	500
		10-24 °C	3	10	300
	Insects having slow rate of respiration, for example, Khapra beetle	≥25°C	6	10	1000
Empty Go-downs and sheds	All insects except Khapra beetle	10-24 °C	6	14	600

4.7. Stored product insect pests

Almost all types of food commodities, raw or processed, are prone to insect pest attack during storage. Insect pest activity in agricultural produce can start at any stage from harvest to consumption; in some cases, the infestation occurs in the standing crop itself.

Insects such as *Sitotroga cerealella* (on paddy rice), *Sitophilus zeamais* (on maize), *Hypothenemus hampei* (on coffee), *Carpophilus spp.(*on dried fruits), *Caryedon serratus* (on peanuts), and *Callosobruchus chinensis* (on pulses) commence their pest activity in the standing crop or before storage. The stored product insects are relatively small in size (3-5mm average adult size) and are cryptic and go unnoticed when present at low numbers in the commodities. They are highly prolific that several generations occur in a year under favorable climatic conditions.

The stored product insects belong to two principle orders, the Coleoptera (comprising beetles) and the Lepidoptera (moths). There are some minor species e.g., Psocids belonging to the order Psocoptera. In moths only the larvae are destructive while the adults are non-feeding and short living. In the case of beetles, in addition to larvae, in the majority the adults are long living and cause

damage to the stored products by way of feeding and probing. The insects have four life stages i.e. egg, larva, pupa and adult. They may complete their cycle entirely outside the grains, or, in some cases, some of the pre-adult stages develop inside the grains. The life cycle of stored product insect is completed generally in 20 days to 2 months under normal conditions. Nevertheless, some stages of insects such as the Khapra beetle (*Trogoderma granarium*) and some strains of the Tropical Warehouse moth (*Ephestia cautella*)
undergo a state of dormancy or diapause under unfavorable conditions of temperature, and non-availability of food, crowding, etc. Insects that undergo diapauses are generally tolerant to insecticide as well as fumigant treatments.

Ambient temperature, humidity and moisture content of the commodity play important role in the survival and breeding of these insects. The upper and lower limits and the optimum ranges of temperature, humidity and grain moisture vary among species. In general, a temperature range of 25 - 35°C is favorable for their development. For the majority, the upper critical temperature is about 35°C and grain moisture above 15% affects their development due to mould growth. Temperatures less than 20°C generally retard the development of insects.

For instance, the flour beetle *Tribolium castaneum* Stops laying eggs below18°C. For the Cigarette beetle (*Lasioderma serricorne*) and the Drug store beetle (*Stegobium paniceum*) a critical moisture level of 10% in commodities has been reported.

Insect infestation results in losses of the food commodities both in terms of quality and quantity. There are some visible indicators of insect infestation in stored food commodities. When infested, food commodities get contaminated with insect excreta (uric acid mainly), excuviae or cast skins and dead bodies, webbing and secretions. These contaminants pose a major quality control problem in food commodities. Toxicological studies have shown that excess levels of uric acid (excreted by insects) in diet can induce hyperuricemia with associated nephropathy in rats. Insects are also responsible for the dissemination and proliferation of microorganisms including mycotoxigenic fungi.

4A BEETLE PESTS

i) Sitophilus oryzae, the Rice weevil (Curculionidae)

A predominant pest on stored grains and it can also breed on certain pulses and solid cereal products (e.g., pasta). Reddish-brown insects of 2-4 mm size, pronotum with deep punctures; the pits are rounded and closely compacted. They have four dull yellowish spots on the elytra. Adults can fly. Adults have long life up to one year and they lay their eggs throughout their adult life. Up to 150 eggs are laid per female. Larva, an internal feeder develops inside grain.
At 25°C and 70% RH. lifecycle is completed in 36-40 days(egg4-7days, larva 18-22days, pupa 6-14 days and pre-adult stage 3-6days). A similar species, *S. zeamais*, the maize weevil is slightly larger than *S. oryzae*. It is an important pest on stored maize and can also breed in rice as well as wheat. It prefers and breeds in

grain of 20% moisture and therefore infests grain at the time of harvest in the field and in threshing areas.

ii) Rhyzopertha dominica, the Lesser grain borer (Bostrichidae)

Primary pest on cereals (paddy, rice, wheat, sorghum and barley) and decorticated split pulses (dhals). The lesser grain borer is a voracious and destructive pest. Severe damage occurs in the warm, drier areas when grain stacks are left undisturbed for long periods. The insect has higher temperature optima than

any other stored grain pest species (≥30°C) and breeds at a slower rate at 25°C. Development is possible in grain as low as 8% moisture. Adults are dark brown cylindrical beetles, 2-3 mm size with small pits on the elytra; head bent downwards and concealed. The antenna has 10 segments with a loose 3-segmented club. Eggs are laid loosely amongst the grains and the emerged larvae feed on the debris for a while and after second ecdysis they enter the grains where they complete their development and emerge as adults. Some of the larvae, however, will develop in available flour outside the kernels. Adults are strong flyers; consume about 0.32 mg of grain/day. In addition to feeding, the adults and larvae produce more debris and dust of 54 mg on an average during their lives *(S.oryzae* produces only 11-12 mg of dust). About 244-418 eggs per female are laid. The length of the lifecycle ranges from 84 days at 22°C, to25 days at 34°C and 36 days at 38°C. Adults live for 2-3 months.

iii) *Trogoderma granarium*, the Khapra beetle (Dermestidae)

This is the most dreaded among the stored product insects. The insect breeds preferably on cereals but can develop on oil seeds and flours of green gram, cowpea, pigeon pea and Bengal gram. Khapra beetle infestation is very slow to establish but difficult to eradicate once established. Adults are small black or light brown beetles, 1.8 to 3 mm long. Antenna has a distinct club consisting of 3-5 segments. Adults do not fly, short-living and non-feeding. Larvae are yellowish-brown growing up to 6 mm. They are provided with hairs (hastisetae) which enable them to be transported to different places. Eggs (63eggs/female)are laid on the grain. Under normal circumstances as horter larval period of 15 days at 35°C and 73%RH. has been reported. However larval development is prolonged when it enters into diapause. Pupation occurs on the top layer of the food material. Life cycle completed in 25 days under optimum conditions of 33–37°C, 45–75% RH.

Khapra beetle multiplies faster under hot and dry conditions. Khapra larvae under unfavorable conditions enter diapause hiding in cracks and crevices of the stores that are inaccessible to insecticidal sprays. They remain without pupating for a long period (up to 8 years in extreme cases). Even under normal conditions of temperature and adequate food supply, are servoir of

diapausing larvae is maintained. The cryptic nature and extreme persistence due to diapauses have enhanced the pest status of the species.

iv) *Tribolium castaneum*, the Rust-red flour beetle (Tenebrionidae)

Flour beetles, *Tribolium castaneum* are the commonest stored product insects found breeding on cereals containing damaged grains and dockage and milled cereals. In addition, they infest dried fruits, oilseeds, oilcakes, processed foods, spices, insect as well as museum specimens and herbarium. They are unable to feed on undamaged intact grains. In such situations, they depend on the primary pests on whole grains such as *R. dominica* and *Sitophilus oryzae*. *T. confusum,* the confused flour beetle is a particular pest of flourmills in cooler countries/climatic conditions. It cannot fly and found more in grain refuse and spillage than in grain bulks. The life history, habits and appearance are similar for both *Tribolium castaneum* and *Tribolium confusum*. Adults of *Tribolium* spp. are 3 to 4.5 mm long and bright reddish-brown to dark brown in color. They are long-living (about 6 months to 2 years) and destructive. They breed throughout the year. On an average, 2 to 4 eggs are laid per day for more than 5 months. A single female lays up to 1000 eggs. Larvae are cream colored and are external feeders. For *T. castaneum*, development is possible between20 to 40°C. High humidity (≥70% RH) in combination with temperatures in the range of 30° to 35°C are the most favorable for rapid development.

The optimum temperatures for rapid development lies between 35 to 37.5°C at which on a diet of wheat feed and at≥70% RH, the life cycle takes about 20 days. *T. confusum*can develop at 20 to 37.5°C and is very tolerant of dry conditions (10% RH).

v) *Oryzaephilus surinamensis*, the Saw-toothed grain beetle (Silvanidae)

The saw-toothed grain beetle is cosmopolitan infesting cereals, milled products, convenient foods, dried fruits, oilcakes, and oilseeds. It is a major pest on processed and packaged foods. Infestations disperse throughout grain mass aided by the flat, slender shape of the adults.

Adult (2.5 to 3.0 mm length) has flattened body, which is well adapted for crawling into crevices. The margins of the prothorax in adults are saw-like and bear 6 projections on either side, which has given the popular name saw-toothed grain beetle. Thorax has 3 longitudinal ridges. The antennae are short and clubbed. *O. surinamensis* have well-developed wings but generally do not fly. The related species *O. Mercator* (the merchant grain beetle) can fly, is less common and is primarily a pest of oilseeds. The areas directly behind eyes (temple) are curved and wider in *O. surinamensis* where as in *O. mercator*, the same areas are pointed and narrow. Adults of *O. surinamensis* are long-living (6-10 months), very

active, quick moving and can readily cause cross-infestation. A case of survival up to 3 years and 3 months has been reported. A single female lays about 370 eggs. The larvae, external feeders, are white, elongated and somewhat flattened. They attack the germ in whole cereal grains, thereby reducing the percentage germination. At the temperature and humidity of 30 to 35°C and 70% RH. the life cycle takes about 27 to 35 days. The insect pupates in a cell for protection of the comparatively fragile pupa, which is easily damaged by disturbance of the cell.

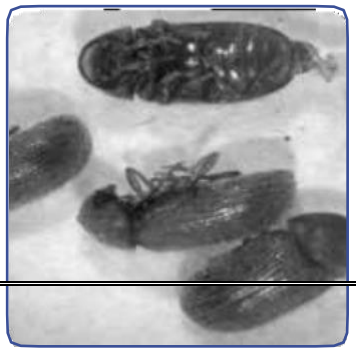
vi) *Cryptolestes* spp. (earlier known as *Laemophloeus*), the Flat grain beetles (Cucujidae)

Attacks stored cereals and their milled or processed products. Adult insects are small (1.5 to 2.0 mm size), elongate, very flat, reddish-brown with characteristic long antennae. The beetles can jump and fly. The different species of are closely similar in their external features and can be identified only by examining their internal genitalia. The two important species are *C. ferrugineus* and *C. pusillus (C. minutus*)Up to 300 eggs per female are laid loosely in the products. Larvae with characteristic tail and horn feed on stored produce. Adults are long living. Life cycle completed in 4 weeks at 30-35°C under high humid conditions (90% RH).

vii) *Stegobium paniceum*, the Drugstore beetle or Spice beetle (Anobiidae)

The insect feeds on a wide range of materials of both vegetable and animal origin. The insect attacks spices and spice products (chilli, curry powder, turmeric), medicinal plants, books and manuscripts. They can penetrate tin foils and sheet lead. Adults are brown coloured, 3 mm size, globular with elytra striated i.e., with fine longitudinal ridges and antennae with loose 3-segmented club. Adult body appears to be straight (unlike hump-backed *Lasioderma*).The temperature range for the development of drug store beetle is 15 to 34°C and ≥35% RH. Development is rapid (40 days for the life cycle) at 30°C and 60 to 90% RH. Adults live for 13 to 65 days depending on conditions, lay about 75 eggs/female. The larva forms a cocoon in which it pupates.

viii) *Lasioderma serricorne*, the Cigarette beetle (Anobiidae)



A serious pest on stored tobacco and cocoa but it attacks a variety of foodstuffs including cereals, cereal products, oilseeds, oilcakes, ginger, turmeric, raisins, pepper, dried fish, dates, drugs, garlic bulbs,

herbarium, and medicinal plants like dry rhizomes of *Acoruscalamus*. Adults,3–4 mm size, brown, globular with long antennae having 11 saw-like segments (serrated). Elytra smooth with fine hairs. Adults look hump-backed. Adults are active fliers, do not feed but can perforate tobacco leaves. They drink readily. They are short-lived (2 to 6 weeks), the time depending mainly on temperature and slightly on humidity. The life span of adults is 30 days at 25°C and 70% RH and 25 days at 30°C. Females lay on an average 110 eggs loosely on the commodity. The larvae are white and scarabaei form. They make a pupal cell out of fragments of food and waste.

ix) *Callosobruchus spp*, the Pulse beetles (Chrysomelidae)

Bruchids are serious pests attacking all kinds of leguminous seeds. The 3 common species are: *C. analis, C. chinensis*and *C. maculatus.* The first two species cause infestation in the field itself. *C. maculatus* is particularly a pest on cowpeas. Adults, globular, 3–4 mm length, with long legs and antennae. They have elytra patterned that do not fully cover abdomen. For *C. analis* the optimum conditions for development are 30-32.5°C and 70-90% RH. and life cycle completed as early as 23 days under the optimum conditions. *C. chinensis*issimilarto *C. analis.* Highest number of eggs (100/female) is laid at 22.30C. Eggs are glued on the outer surface of pulses. Larva upon hatching immediately enters into the grain and develops inside. High temperatures up to 35°C have adverse effects on the oviposition, egg and larval mortality. Adults are non- feeding and very active and fly short distances. There are 2 adult in *C. maculatus*- the "active or flight"form and "normal or flightless" form. High larval density and raised temperature which results from a high density is the most potent to induce the active form. The 'active' form adults emerge 5 or 6 days later than 'normal' form adults.

x) *Caryedon serratus*, the Peanut bruchid (Chrysomelidae)

An important pest on tamarind pod/fruits and peanut in-shell; also attacks fruits/pods of Acacia arabica (Babul) and Cassia fistula. In groundnut, field infestation starts after harvest during sun-drying prior to storage and thereafter continues throughout the storage period. Infestation is restricted to the superficial layers of the bulk. Adults are robust (3.5 to 7 mm long), grayish in color with dark markings on the elytra. They have long legs and antennae; femur of hind leg markedly enlarged. It oviposits on the surface of the groundnut shell/pod. The larva hatches into the seeds without coming to the exterior. Unlike other Bruchids in C. serratus the fully grown larvae leave the seeds, cut exit holes in the pods and pupate in a papery but tough cocoon. Presumably, there is a dormant phase on groundnuts that carries the infestation over from one crop to the other. The adult remains within the cocoon for several days after emergence from the pupa. Temperature range for breeding is 25 to 35°C and the shortest

life cycle of 41 days has been reported at 33°C and 90% RH. Oviposition is greatest at 27°C and 50-70% r.h. Adults short-lived, non-feeding and fly.

xi) ***Araecerus fasciculatus*, the Coffee bean beetle/ Cocoa weevil (Anthribidae)**

A primary pest on stored coffee and cocoa beans but also noticed on maize, tapioca, sweet potato, peanuts, nutmegs and dried fruits. They depend on the high moisture content (12-20%) in the seeds; larvae fail to develop in seeds having <8% moisture.
Adults are dark-brown and 3-5mm long; have long legs and antennae with a loose 3 segmented club. The elytra bear many patches of light-colored setae giving a mottled appearance. The elytra are shorter than the abdomen leaving one abdominal segment exposed. Life cycle varies from 47 to 135 days depending on the moisture content of the beans. At 26% and 60% RH., the life cycle is about 57 days and at 100% RH it is 29 days only. Adults are short-lived, non-feeding and can fly.

xii) *Necrobiarufipes*, the Copra beetle/ Redlegged ham beetle (Cleridae)

It is a pest of copra, coconut meal, oilseeds, cocoa beans, garlic and materials of animal origin (bone meal, fish meal, and dried fish). Shiny blue to bluish green beetles, 3.5-4.5 mm long, and can fly. Both larval and adult stages are active and predatory. Higher relative humidity favour the growth and larval survival. A closely related species, *N. ruficollis*, the Ham beetle / Red-necked bacon beetle essentially feeds on animal material and rarely occur in other commodities.

4B MOTH PESTS

***i)* *Ephestia cautella*, the Almond moth or Tropical Warehouse moth (Pyralidae)**

The almond moth is a major pest infesting stored cereals, oilseeds, oilcakes, nuts, cocoa, chocolates, spices and dried fruits. It has also been recorded in stored tamarind, garlic and dry chilies. Infestations are confined to the surface layers.

Grey coloured moths with labial palps which are short and curved upwards. The forewings (7-14 mm) have darker markings. The larva is tinged with brown or purple dots on its back, which give it a characteristic striped appearance. Female moths lay up to 300 eggs near the vicinity of food. The larvae, which are very active, have a remarkable ability to find entry into apparently closed containers. Under optimum conditions of 32.5°C and 70% RH., development from egg to adult takes about 30 days. The mature larvae have peculiar dispersal behaviour before pupation i.e., mature larvae leave the grain stacks, wander in search of suitable sites for pupation and pupate at different locations. The cocoon is thinner and smaller than that of *C. cephalonica*. Certain strains of *E. cautella* are able to diapause.

ii) *Corcyra cephalonica*, the Rice moth (Pyralidae)

It is principally a pest on milled rice but is able to breed equally on wheat, sorghum, millets, oilseeds (particularly peanuts), dried fruits and some of the spices. It is an important pest in flour mills. Pale brownish moths (15 to 25 mm widths when the wings are spread) appear larger than other stored product moths. When viewed from above, the adults have distinct shoulders. The larvae, 15-20 mm size, are dull-white with long fine hairs and dark brown head. Larvae spin dense cocoons when fully brown. The webbing formed by the larvae is more dense and tough than that of *E. cautella*. The life cycle is completed in 27 days under optimal conditions of 30 to 32.5°C and 70% RH. This insect is tolerant of low humidity of 20% RH.

iii) *Sitotroga cerealella*, the Angoumois grain moth/Paddy moth (Gelechiidae)

An important pest of stored cereals particularly paddy, wheat, maize and sorghum. Adults infest the grains in the field itself (standing crops). Infestation during storage is largely restricted to the surface layer of bulk grain or grain bags. Small delicate moths of (5-7mmlong),silvery-greytogrey-brown
Hind wings (with small black spot in the center) which taper to a point. The wings have a long fringe of fine hairs along the posterior edge. Female lays up to 200 eggs during her life span of 5-10 days. The eggs are attached to the grain. Hatched larva enters into the grain, develop to adult moth in 10-14 days and emerge through visible exit hole. Unlike other moths, *S. cerealella* does not create any webbing. Life cycle is completed in 4 weeks under optimum conditions of 30°C and 75% RH. (range 16-35°C and >30% RH.). Adult moths are good fliers and hence cross-infestation occurs easily.

4C OTHERS

i) *Psocids (Booklice) (Psocoptera: Liposcelididae)*

Psocids, the smallest (≤1 mm long) among stored grain insects are commonly encountered in grain storage depots, food production/processing units and other food commodity storage premises. Adults are wingless with flattened, Translucent to brown colored or striped body and are highly active with Characteristic jerky motion. *Liposcelis* species such as *L. bostrychophila, L.*

*entomophila, L. paetus*and *L. divinatorius* are important. Psocid abundance in grain storage premises is an annoying problem to the go down managers and for the laborers who carry grain in bags as the floor area becomes slippery. They are the scavengers and mould feeders but they could cause visible damage and loss of grain up to 3% in a storage period of 6months. The life cycle includes egg, nymph (3-6 instars) and adult stages. Nymphs as well as adults feed the commodity. The length of the life cycle depends on the type of diet, temperature and humidity. Adult Psocidslivefor6weekstoseveralmonths;the longevity is dependent on food availability and climatic conditions. Relative humidity is particularly important for the survival and productivity of Psocids. Low temperature coupled with higher humidity enable Psocids to survive for longer periods. Below 60% RH. The insects lose water and die due to dehydration. Although there are certain optimum conditions of temperature and RH. for individual species they can survive extremes of temperature to some extent and resurgence of population occurs on the return of favorable conditions.

CHAPTER V FUMIGATION PROCEDURES AND PRECAUTIONS

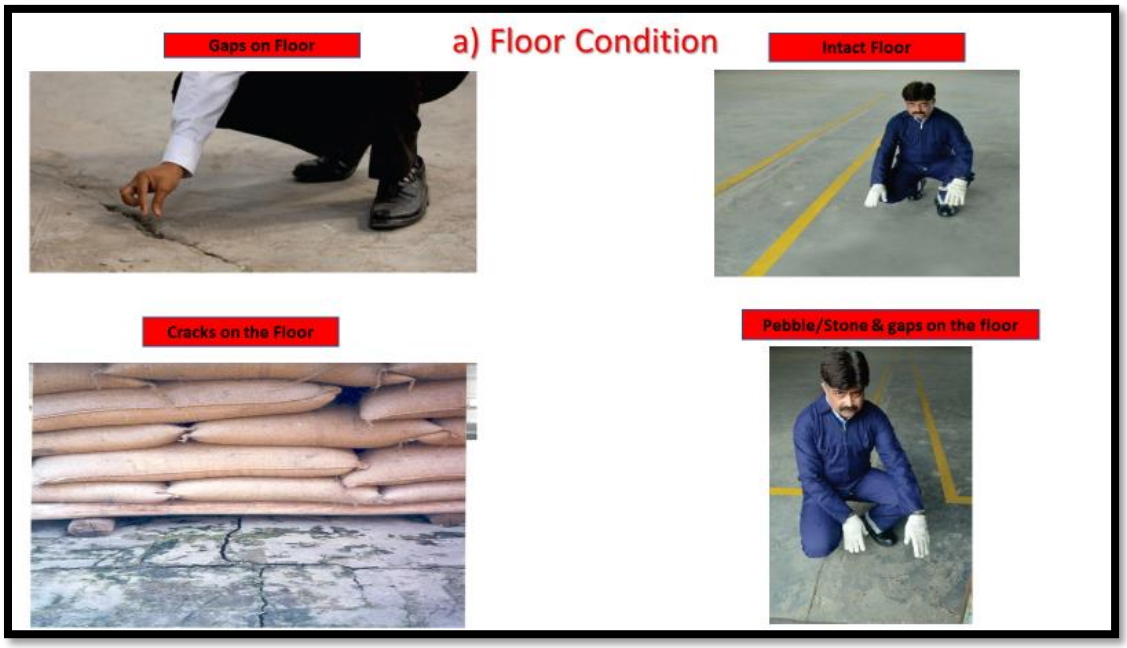
5.1. ALP Fumigation procedure

1. Selection of Site

a. Floor Condition: Intact floor without cracks or drains, Floor not undulated, no pebbles or stones, Raised plinth height

b. Weather Protection: Well ventilated, Sheltered area, rain and wind protected as for as possible

c. Surroundings: No water logging, drainage problem in surroundings



b) Weather Protection

Plinth Height, Cross Ventilation

Leaky Ceiling, bad protection from rain water

Sufficiently Lighted, Well Organized

Sheltered area, rain and wind protected

c) Surroundings

Surrounding not well maintained

Surrounding not well maintained

Surrounding well maintained

Surrounding well maintained

In outdoor stacks, Wind Forces could cause 30% Gas Loss Rate/day during fumigation

2. Preparation of Commodity

a. Stacking: Stacked to allow good circulation leaving enough space around

b. Wrapping: Impervious wrapping removed or slashed

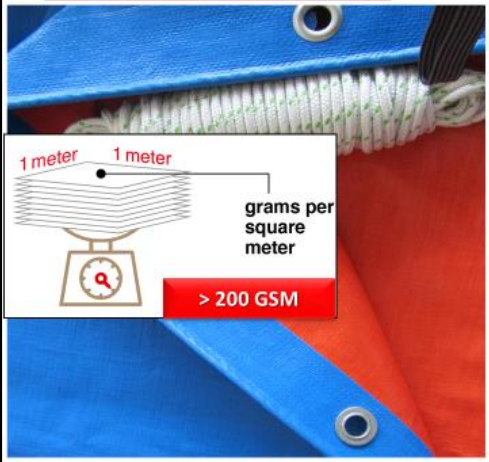
b) Wrapping

3. Preparation and installation of equipment

a. Size & Specification: Sheets of correct size & Specification
b. Sampling Tubes: Gas sampling tubes installed
c. Sand Snakes: Cover the enclosure with sheet and make gas -tight sealing at the ground with two rows of sand Snakes
d. Record temperature & humidity
e. Measure enclosure volume and calculate dosage
f. Hazard Area: Establish and mark out hazardous area and place Danger signs

Correct Size & Specification

a) Size & Specification



b) Sampling Tubes

c) Sand Snakes

Sand snakes: Ideal size 1.2 m Length, 15 cm diameter, filled up to 80% with dry sand

Cover the enclosure with sheet and make gas -tight sealing at the ground with two rows of sand Snakes

d) Recording Humidity, Grain Moisture, Temperature

e) Measuring Enclosure Volume & Calculating Dosage

f) Hazard Area: Surround 3 Meter Risk Area: Unprotected Person Not Allowed & Place Danger Sign

4. Preparation to gas enclosure

a. Testing of Equipment: Test leak checker & monitor for working
b. Respirator Fitting: Wear and test the respirator for correct fitness

a) Testing of Equipment: Leak Checking

b. Respirator Fitting

Fit check before each use!

Negative pressure check: Cover cartridges with hands, inhale gently, and hold breath for 10 seconds. If the facepiece exhibits no leakage, the respirator fits properly

Note:

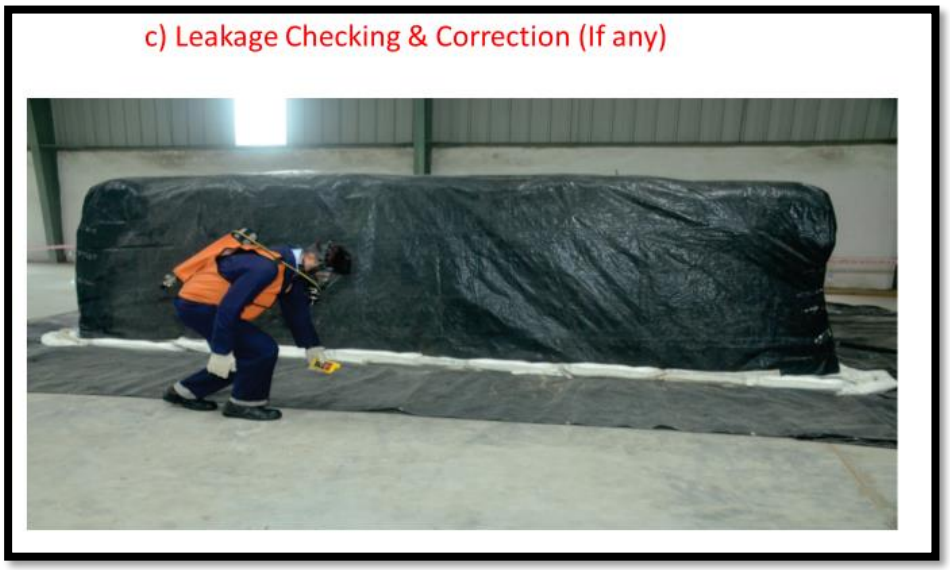
Facial hair does not allow a respirator to seal!

5. Application of gas to enclosure

a. Release Gas: Release required quantity of ALP as per calculated dosage
b. Cover the sheet & place sand bags properly
c. Leakage Checking & Correction (If any): Check for gas leakages around enclosure and correct leakages if any

Opening of AlP pouch

a) Placing of AlP 34g Pouch to release PH3



6. Initial monitoring

a. Measure gas levels on all monitor lines
b. Check to ensure all readings are recorded
c. Reading Frequency: Ensure that concentration reading are recorded at a pre-determined frequency during entire exposure period

a) Measure gas levels on all monitor lines

b. Check to ensure all readings are recorded

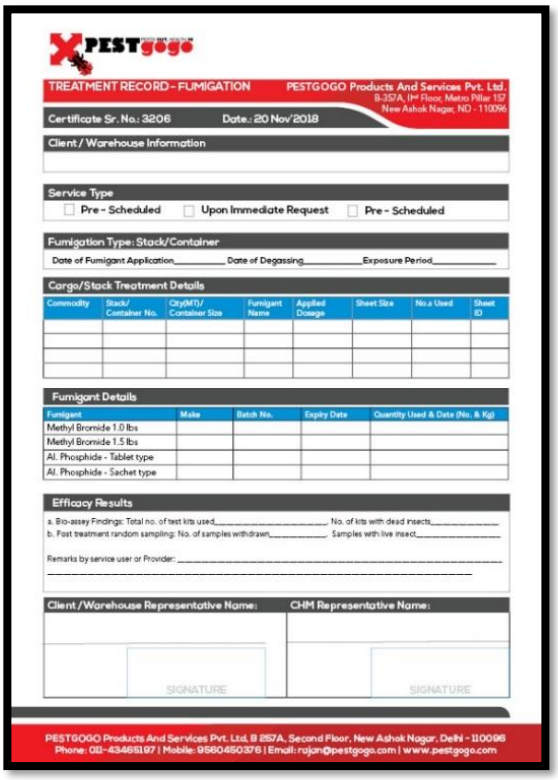
7. End point monitoring

a. Measure gas levels on all monitor lines
b. Check to ensure all levels above standard
c. Declare fumigation successful or failed, as appropriate-document

8. De-gassing / Aeration

- Ensure risk area and surrounds free of un-protected personnel (up to 3 m)
- Wear gas mask and test for fitness
- Open enclosure and allow ventilation
- Test for Thresh hold limit value (TLV) -Continue aeration until gas level below TLV
- Remove warning signs and risk area demarcation

9. Disposal of Fumigant dusts
(Aluminium Hydroxide)



PESTgogo

TREATMENT RECORD - FUMIGATION

PESTGOGO Products And Services Pvt. Ltd.
B-357A, IInd Floor, Metro Pillar 157
New Ashok Nagar, ND - 110096

Certificate Sr. No.: 3206 Date.: 20 Nov'2018

Client / Warehouse Information

Service Type

☐ Pre - Scheduled ☐ Upon Immediate Request ☐ Pre - Scheduled

Fumigation Type: Stack/Container

Date of Fumigant Application_____ Date of Degassing_____ Exposure Period_____

Cargo/Stack Treatment Details

Commodity	Stack/ Container No.	Qty(MT)/ Container Size	Fumigant Name	Applied Dosage	Sheet Size	No.s Used	Sheet ID

Fumigant Details

Fumigant	Make	Batch No.	Expiry Date	Quantity Used & Date (No. & Kg)
Methyl Bromide 1.0 lbs				
Methyl Bromide 1.5 lbs				
Al. Phosphide - Tablet type				
Al. Phosphide - Sachet type				

Efficacy Results

a. Bio-assey Findings: Total no. of test kits used_____ No. of kits with dead insects_____

b. Post treatment random sampling: No. of samples withdrawn_____ Samples with live insect_____

Remarks by service user or Provider: _____

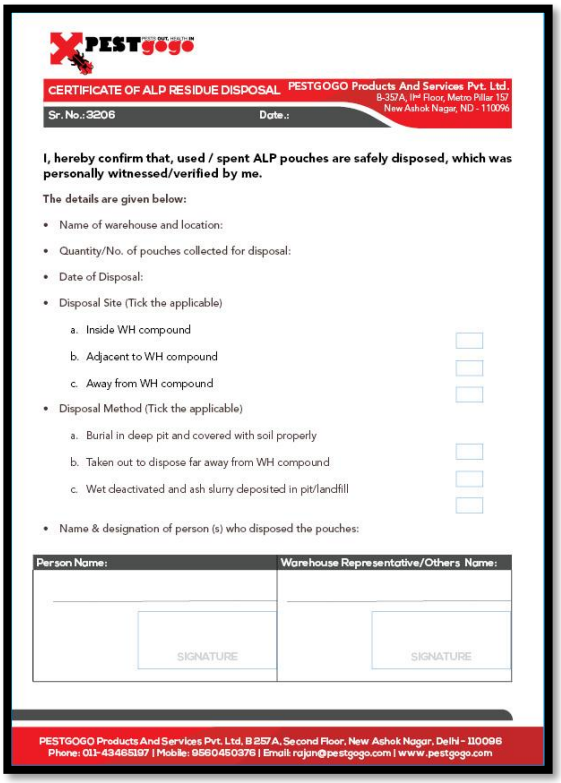
Client /Warehouse Representative Name: CHM Representative Name:

SIGNATURE SIGNATURE

PESTGOGO Products And Services Pvt. Ltd, B 257A, Second Floor, New Ashok Nagar, Delhi - 110096
Phone: 011-43465197 | Mobile: 9560450376 | Email: rajan@pestgogo.com | www.pestgogo.com

Fumigation Certificate

- Fumigant Name
- Stack Details
- Commodity
- Quantity, Dosage, Date
- Sheet Size
- Efficacy Result
- Details of Fumigation Agency



PESTgogo

CERTIFICATE OF ALP RESIDUE DISPOSAL

PESTGOGO Products And Services Pvt. Ltd.
B-357A, IInd Floor, Metro Pillar 157
New Ashok Nagar, ND - 110096

Sr. No.: 3206 Date.:

I, hereby confirm that, used / spent ALP pouches are safely disposed, which was personally witnessed/verified by me.

The details are given below:

- Name of warehouse and location:
- Quantity/No. of pouches collected for disposal:
- Date of Disposal:
- Disposal Site (Tick the applicable)
  - a. Inside WH compound ☐
  - b. Adjacent to WH compound ☐
  - c. Away from WH compound ☐
- Disposal Method (Tick the applicable)
  - a. Burial in deep pit and covered with soil properly ☐
  - b. Taken out to dispose far away from WH compound ☐
  - c. Wet deactivated and ash slurry deposited in pit/landfill ☐
- Name & designation of person (s) who disposed the pouches:

Person Name: Warehouse Representative/Others Name:

SIGNATURE SIGNATURE

PESTGOGO Products And Services Pvt. Ltd, B 257A, Second Floor, New Ashok Nagar, Delhi - 110096
Phone: 011-43465197 | Mobile: 9560450376 | Email: rajan@pestgogo.com | www.pestgogo.com

ALP Residue Disposal

- Number of pouches
- Disposal method
- Disposal site

5.2. Monitoring and Detection of Phosphine during Fumigation

5.2.1.Why detect / monitor Phosphine?

A successful fumigation works on the premise that a certain peak phosphine concentration is generated within 24-48 hours of introducing the fumigant and acertain phosphine concentration is still present at the end of the fumigation, when the sheets are removed, and the commodity aerated. Another important factor is that phosphine is an extremely toxic compound for human beings, with a TLV (Threshold Limit Value) of 0.3 ppm. It thus becomes imperative to both detect and monitor phosphine levels continuously during a fumigation. The reasons for doing so is as follows:

1.Phosphine detection around the fumigated chamber for safety/leak detection:

After the fumigant has been introduced, it is necessary to check for leaks from the fumigation chamber as these leaks will not only be hazardous to any other workers working close by but will also result in the phosphine concentration in the chamber depleting faster, thus, affecting the overall efficacy of the fumigation.

2. As the phosphine concentration has to be maintained at certain pre-determined levels during the entire fumigation period, monitoring phosphine levels inside the fumigation chamber regularly during the entire fumigation period is necessary to ensure that the fumigation is a success.

5.3. Phosphine Detection & Monitoring Products

1. Gas Detector Strips: This constitutes the simplest form of a phosphine gas detector. It consists of a strip of paper impregnated with a sensing chemical. When phosphine comes in contact with this strip of paper, it changes color from a pale yellow to a light pink. The time taken to change color is proportional to the concentration of phosphine in the atmosphere

2. Gas Detector Tubes: This kind of detector consists of a sealed glass tube filled with a sensing chemical. When the target gas is passed through the tube (after breaking off both ends), it reacts with the sensing chemical in the tube and a colored stain is formed. The length of the stain formed is proportional to the gas concentration. With the helpof the printed scale on the tube the gas concentration reading can be directly read. Detector tubes are available for the TLV concentration of 0.1/0.3 ppm and also at the fumigation concentration of 400 to 2000 ppm.

3.Phosphine Dosimeter Tubes: Dosimeter tubes provide a reading equivalent to the concentration time product or the dosage of phosphine given to the commodity over the entire duration of

fumigation. It is not the phosphine concentration only at any time or the time of exposure alone which determines the adequacy of the fumigation but it is the total dose expressed in ppm hrs which determines the insect mortality or the effectiveness of fumigation. Apart from the Chemical detectors described above, arrange of electronic instruments are also available for carrying out functions similar to those performed by detector strips and gas detector tubes. Details of the instruments available for the detection and monitoring of PH3 are given below:

4.Phosphine Alert Leak Detector - for low concentration detection: This low range handheld gas detector can detect PH3 in the TLV level of 0.1 / 0.3 ppm and has a minimum detectable limit of ppm. Using an electrochemical sensor which is highly specific to phosphine and with a very fast response, it helps to protect workers during fumigation operations by alerting them when phosphine concentration is present in dangerous levels. This detector can also be used for detecting leaks from the fumigated chamber, which can then be plugged, helping in ensuring a lesser rate of loss of phosphine from the chamber and thus ensuring a successful fumigation.

5.FumiSense-Pro-Hi – for high concentration monitoring:
This high range portable gas monitor can detect phosphine in the fumigation range of up to 2000 ppm and has a minimum detectable limit of 1 ppm. This monitor provides an excellent means to measure phosphine concentration within the fumigated stack/silo/ship. The powerful inbuilt air sampling pump enables one to draw a sample from within the fumigated area and determine whether the required phosphine concentration has built up.

6.FumiTrack – for automatic high concentration monitoring:
This high range, fully automatic, 4-port unmanned remote gas monitoring system can monitor phosphine concentrations periodically from up to 4 sampling points in the fumigation monitoring range of up to 2000 ppm. With remote (GSM) connectivity options, it has the capability to upload the gas readings to a cloud server, which could then be accessed remotely from any location. This allows fumigators to monitor a fumigation from multiple points and over the entire fumigation period effectively and easily.

To ensure a successful phosphine fumigation it is imperative to follow a proper phosphine leak detection and monitoring regime, because – If you are not monitoring, you are not fumigating!

CHAPTER VI NON-CHEMICAL TREATMENT

6.1. Treatment on Forced Hot-Air Treatment Facilities (FHAT)

6.1.1. Introduction

This document provides guidance for certifying forced hot air treatment facilities for treating wood packaging material to meet the requirements of ISPM-15. The guidelines contained in this Annexure for the heat treatment of wood in conventional heat chambers (dry kilns) typically used for drying wood.

Reference

International Plant Protection Convention, 1997, FAO, Rome.
ISPM-15: Regulation of wood packaging material in international trade, 2017. FAO, Rome
ISPM-07: Phytosanitary Certification System, 2016, FAO, Rome
Guidelines for Regulating Export of Solid Wood Packaging Material, 2004, Dte. of PPQS, Ministry of Agriculture, Government of India.

6.1.2. Outline Requirements:

This standard prescribes the guidelines/ procedures for certification of forced hot-air treatment facilities for treating wood packaging material in accordance with ISPM-15: 'Regulation of wood packaging material in international trade'. As per the ISPM-15, the wood packaging material required to undergo approved treatment such as heat treatment at 56°C for 30 min and marked prior to export. It is, therefore, considered necessary for certification of forced hot air treatment facilities by the Director General of BAFRA to facilitate the approved treatment providers. The treatment reduces pest risk associated with the wood packaging material prior to export and affix the marking on treated wood as per the international standard. To meet the requirements of ISPM-15, it is essential to certify the forced hot air treatment facilities to ensure that wood packaging material including dunnage should be treated and marked in consistence with the provisions of ISPM-15.

6.1.3. 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 changeover 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.

6.1.4 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 were 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 woodby 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.

6.1.5 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 and 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

6.1.6 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 position data 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. BAFRA 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 BAFRA 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.

6.1.7. 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.

a) 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 while in other fans operate at one side of the chamber. In either case, the heated air is forced to move through the stock piled 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 air flow 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 sensor 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.

b) 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 airflow. 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. 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.

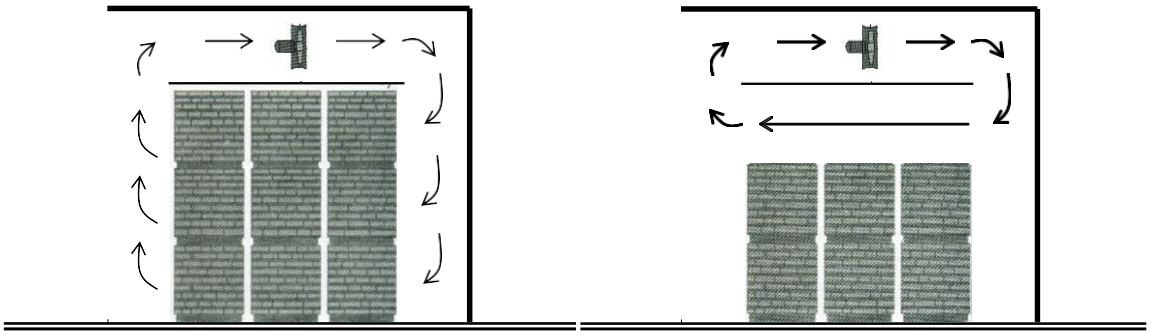
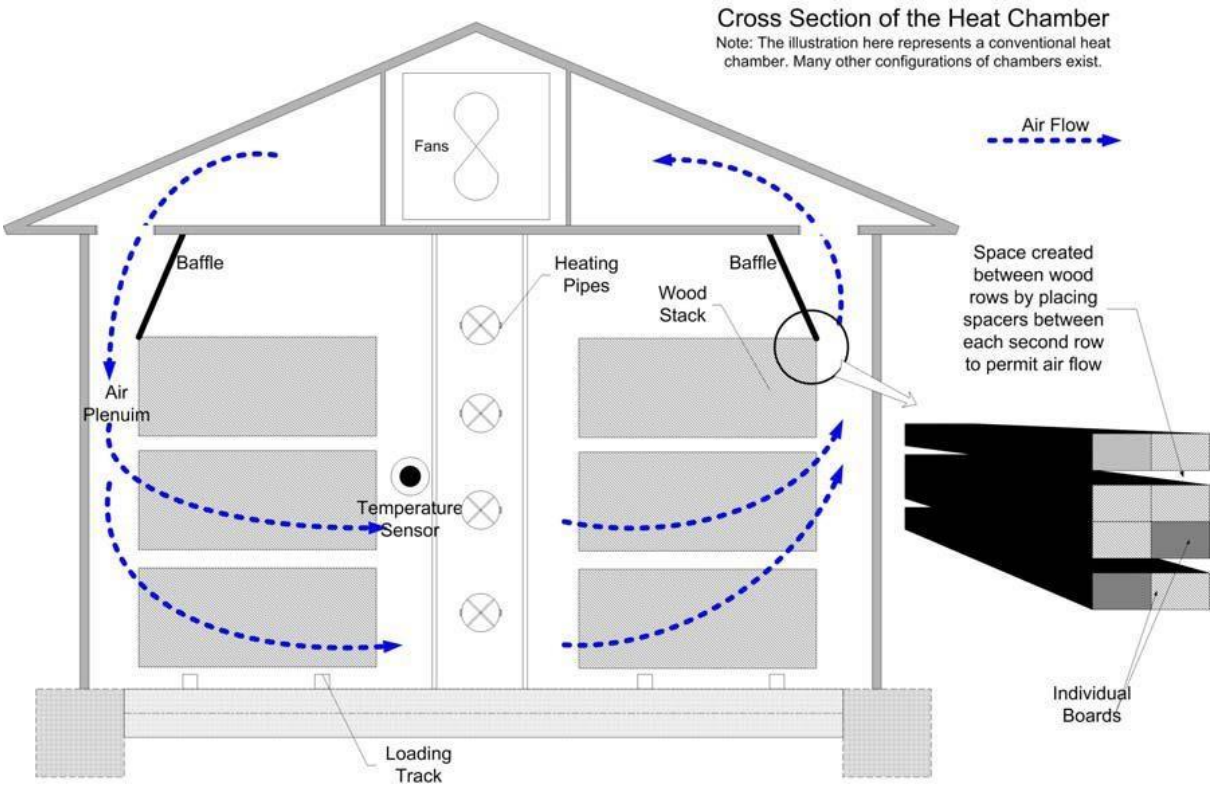


Figure 1: *Schematic illustration of a loaded heat chamber resulting in different air circulation. Left: with a completely stockpiled chamber (cross section), the air circulates through the entire stack and heating is more uniform. Right: in an incompletely stockpiled chamber (cross section), the air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

C) 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.



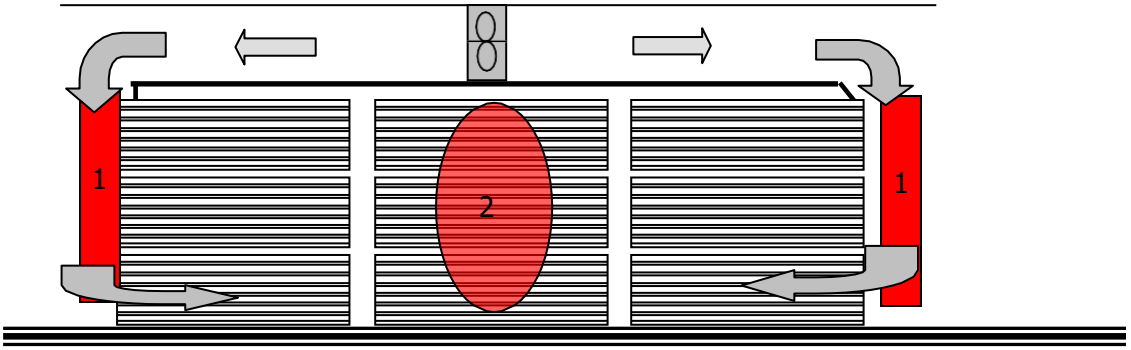
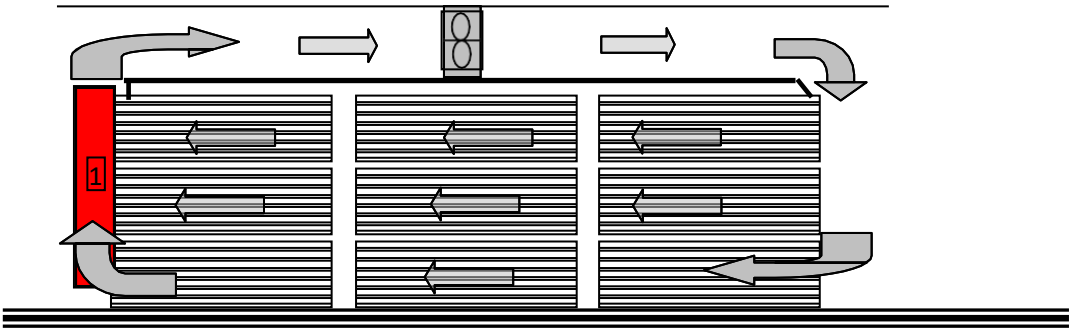


Figure2: A type of heat chamber with the heating pipes in the middle. Temperature sensors should be placed at a location where the air exits the wood stack and is therefore likely to be the coolest.

Figure3:AheatingchamberinwhichtheheatingpipesarelocatedwithafanabovethewoodstackThecoldspotislikelyto 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.



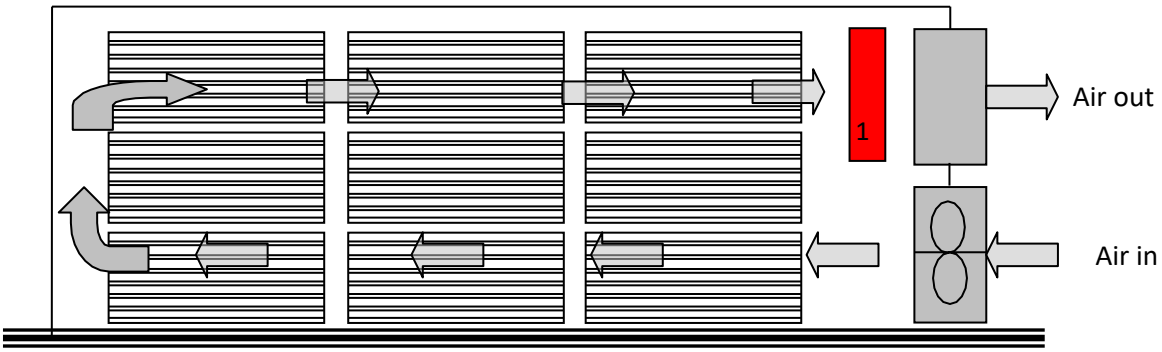


Figure 5: A heating chamber in which heating occurs at the floor of one-side. The temperature sensor is placed at the air exits the wood stack (marked "1").

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.

d) 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.

e) 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.

f) 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, as light 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, producer scan 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 beingtreatedto56°Cfor30minutesandthenthetreatment 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.

g) 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.

h) 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. 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 curves 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 elaboratesystemsthatutilizecomputerizedprogramsanddataloggers.Recordsthereforemaybeinthe 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).

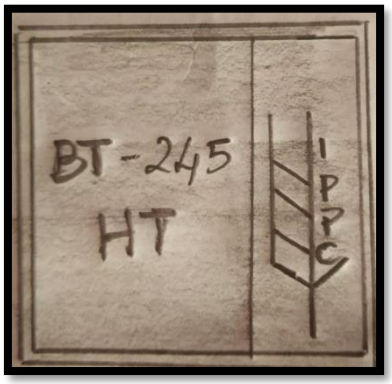
Measuring and recording systems should be calibrated regularly (e.g.annually) by recognized individuals (including manufacturers) or organizations in accordance with manufacturer's specifications. Dry bulb or wet bulb temperature monitoring equipment should be placed in an appropriate position to obtain 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 airflow, 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.

i) 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 airflow. 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 ISPM15 treatments. As the target criterion for ISPM15 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.



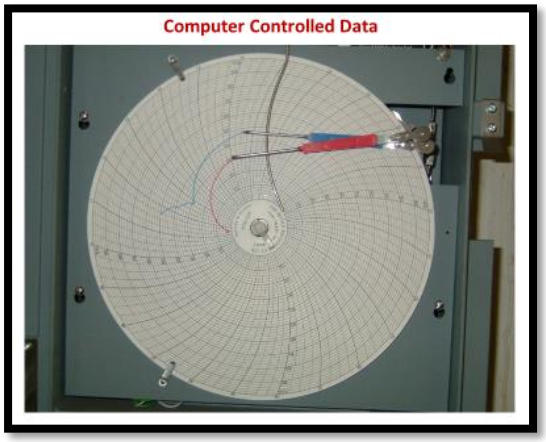
j) Calibration of temperature sensors

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°Cand80°C) Ice or boiling water may not be appropriate to develop a calibration curve that represents the operational temperatures of a sensor in use.

k) 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. 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 30cm (1ft) from the end of

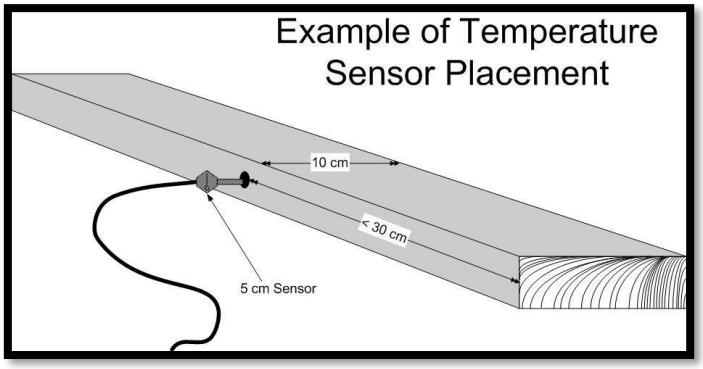


Figure 6: An example of a temperature sensor placement in a wood plank.

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. 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 fastener sand 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 consider 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 airflows.

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.

l) Measurement of temperatures in the colds pot

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.

6.1.8. Pre-Treatment Procedures

The authorized operator should determine the moisture percentage of wood packaging material prior to loading in to the chamber. He should position the calibrated permanent sensors at different heights in front, rear & two sides of the chamber as indicated below:

- ✓ In case of FHAT chamber that has bottom hot-air delivery, the sensors should be hanged at the level of the top layer of pallet.
- ✓ The facility has to identify the coldest point inside the empty heat chamber.

- ✓ In FHAT chamber that has top air delivery, the sensors should be placed at the level of bottom layer of pallet.
- ✓ In a chamber that has top and bottom air delivery, the sensors should be placed at the level of middle layer of the pallets.
- ✓ Two sensors should be inserted to a depth of 5 cm in blocks of fresh wood and placed at appropriate position.
- ✓ The loading of chamber should not be more than 75% capacity of the chamber.

6.1.9. Treatment Procedure

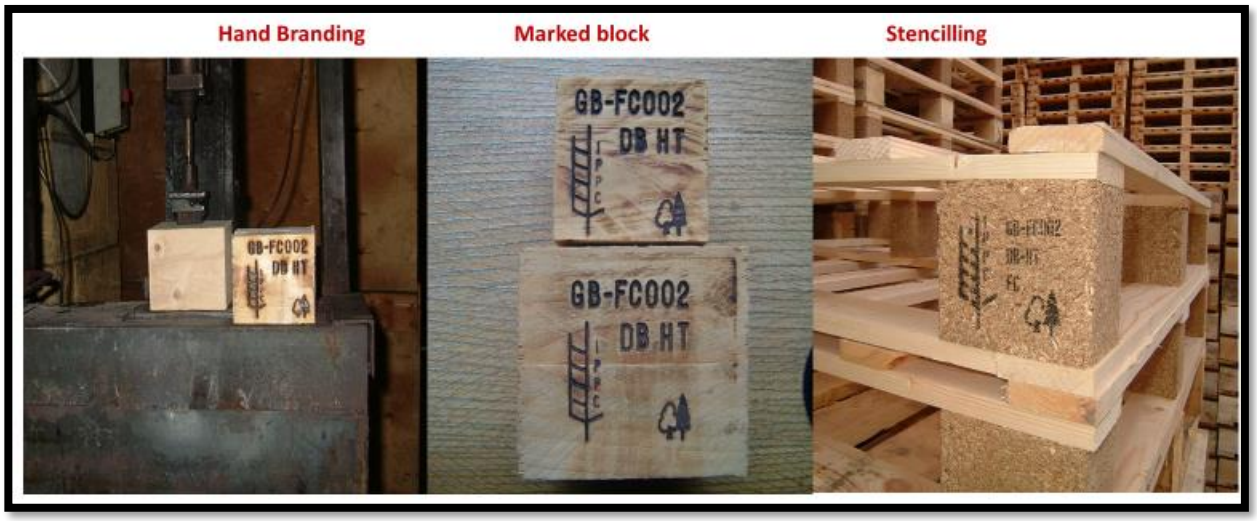
- ✓ After loading the pallets into the chamber, the door should be closed before switching-on the power supply, heaters and the blowers.
- ✓ The heater switch may be set at maximum heat position so as to attain heater temperature at about 74 degree Celsius.
- ✓ The temperature recorder should be set to record temperature at every five minutes or make continuous pen-line recordings as the case may be, colour coded for each sensor, on a graph paper readable in tenths of a degree in 20 Celsius.
- ✓ After warm-up period, the frequency of temperature recordings should be increased to once every two minutes.
- ✓ The dwell time would start when core temperature of wood blocks attains the temperature of 56 degree Celsius.
- ✓ The delivery air must be warmer than the targeted core temperature, but this matter would be left to the discretion of operator.
- ✓ The Director general of BAFRA would not require any particular temperature set point, because the treatment would be based on core temperature of wood and not on air-delivery temperature.
- ✓ The operator could have the flexibility to change the temperature of delivery of air at various times during treatment as well as blower speed.

6.1.10. Post-Treatment Procedures

At the end of process, the chamber should be allowed to cool down gradually to an ambient temperature before the door is opened. It should be ensured under no circumstances the treated wood is mixed up with raw wood or stored along with raw wood packaging material to prevent from cross-infestation.

i) Marking of treated wood packaging material

The treated wood packaging material should be marked as per the mark assigned to the approved facility. The mark should be affixed at visible locations and should be stenciled with the black ink or paint (not washable) as suggested in the enclosure to the certificate of approval.



ii) Compliance checks on prescribed procedures

The officer nominated by BAFRA should carry out compliance checks for ensuring that certified facility would meet the requirements set out in this standard in line with ISPM-15, which include monitoring certification and marking systems that verify compliance and establishing treatment procedures including auditing of facilities that apply the measures. Such audit checks/surprise visits should be carried out at least once in every six months period or at any such intervals as may be decided by BAFRA. The nominated officer at the end of audit check/surprise visits to the facility should submit a report to BAFRA of his observations and comments together with the list of non-compliances, if any and preventive and corrective measures to be undertaken.

iii) Safety Precautions:

- Fire Extinguisher at the facility
- Helmet and Safety shoes to be used by the workers and visitors.
- First aid kit to be available at the site.
- Hard hats, Gum boots, Gloves and Goggles to used by the operator

6.2. Hot Water Immersion Treatment Facility for fruits & vegetables

6.2.1. Treatment Schedules

The facility shall under take all the treatment operations as per schedules approved by the BAFRA. The time-temperature relationship varies with the commodity and pest. Usually, the pulp temperature of the fruit raised using heated water between 46.1-47.8 ^{0}C (115^0 and 118^{0}F) for prescribed period of time.

6.2.2. Minimum Requirements of facility

- Location of treatment facility in secured area to prevent re-infestation of treated fruits
- Assured supply of good quality and potable water
- Assured power supply and back up by diesel generator
- Insect-proof screening of all openings to external area to prevent fruit fly entry
- Hygienic handling of fruits during grading, packing &storage at the facility
- Regular calibration of temperature sensors, temperature and humidity recording and pressure testing equipment and maintenance of calibration records
- Adequate air and water vapour circulation system
- Adequate boiler capacity to raise the chamber temperature to about 50-52^{0}C to ensure the pulp temperature of 46-48^{0}C within a ramp up time of 4 hours
- Adequate number of portable/permanent temperature sensors to monitor the temperature of treatment
- Temperature recording through an approved strip chart recorder or data logger
- Adequate measures for disposal rotten fruits/fruit waste at the facility

6.2.3. Approval of the Plans and Drawing of the Facility

Prior approval of the plans and drawings of the facility by the BAFRA shall be required in the case of new facilities to ensure that the minimum requirements of certification prescribed in the BPTM are met with. However, such prior approval of the plans and drawings shall not be required for the hot water immersion treatment facilities that have been established prior to adoption of the BPTM. However, those facilities must meet the minimum requirements of the BPTM for certification. Any proposed changes or improvements such as installation of additional treatment tanks, adding cold storage room and changing the temperature recorder, boiler and replacing the temperature sensors shall be made only with the written approval of the BAFRA.

6.2.4. Check list of Minimum Certification Requirements

a) Location, construction & design of facility

The location, construction and design of the facility should be as per the safety norms and standards prescribed by the concerned local authority and as per approved plans and drawings of the new facility. However, it is preferred to have the facilities integrated with package houses or located near to the ports. BAFRA does not provide any construction details of facility, but only the checklist of minimum requirements of facility for certification.

There are two basic designs of the facility, which shall include the batch system and the continuous flow system.

b) Batch system (Jacuzzi system)

In this system, baskets of fruits are loaded into a platform, which is then lowered into the hot water immersion tank, where the fruits are held at prescribed temperature for a certain length of time, then are taken out, usually by means of an overhead hoist. In this system, the treatment chart must indicate (by an identifiable marking) when a fruit basket is prematurely removed from the tank. Other alternatives include a solenoid switch, sensor or similar device that disengages whenever a basket is removed from the treatment tank, or a locking device to make it physically impossible to remove the fruit until the treatment is fully completed.

c) *Continuous flow system*

In this type of system, the fruit are submerged (either loosely or in wire or plastic mesh baskets) on a conveyor belt, which moves slowly from one end of the hot water tank to the other. Belt speed is set to ensure that the fruits are submerged for the required length of time.
This system requires an instrument to monitor the speed of the conveyor belt. This can be accomplished by attaching a speed indicator (encoder) to the gear mechanism. The belt speed is recorded on the same chart as the time and temperature, and also indicates whether the belt is moving or stopped during the treatment cycle. Smaller fruits require less treatment time than larger fruits. Therefore, conveyor belt speed should be adjustable to accommodate treatments of different lengths of time. As an alternative, the belt speed may remain constant, but the length of the submerged portion of the belt is adjusted according to the length of treatment time required for the particular size of fruit. The conveyor must prohibit either forward or backward movement of the fruit during treatment (due to flotation). Some operators believe that treating fruit while it passes through the system on a conveyor belt is an advantage. However mechanical fruit damage (scratching of the peel) often occurs, if the fruits are not in baskets. The system also occupies much more floor space in the plant than a batch system.

d) Water Quality

The facility shall be located at a site, which has assured supply of potable water. The water used for washing, dipping, or showering the fruit should be chlorinated, and maintained at a level of 50 to 200 ppm to prevent the microbial contamination of fruit at the facility. Also, hydro-cooling tanks must be chlorinated to the same level. This level is easier to maintain if the water is first filtered and run through a flocculation process to remove organic material, which would otherwise bind with the chlorine. Water should be sampled regularly for microbial contamination. Water should be changed, as necessary, to maintain sanitary conditions. Standard operating procedures should be implemented to include water change schedules for all processes that use water. In addition, surfaces that come into contact with water, such as wash tanks, hot water tanks, and hydro-cooling tanks should be cleaned and sanitized as often as necessary to ensure the safety of the produce. Equipment designed to assist in maintaining water quality, such as chlorine injectors, filtration systems and back flow device's, should be routinely inspected and maintained to ensure efficient operation.

6.2.5 Requirements of Electrical/Electronic Components

a) *Wiring*

Electrical wiring throughout the facility must meet the safety norms of local authority concerned. Earth grounding is required for all electrical wiring located in the vicinity of water, to eliminate shock hazard. Wires must be concealed inside metal or PVC conduit to prevent damage.

b) Computers and microprocessors

These shall be located in a climate-controlled (air-conditioned) room, to maintain accuracy and reliability. This room shall be raised above tank level and provide a clear view of the treatment tank(s) and be capable of being locked. This room may also serve as an office for the phytosanitary inspector.

c) Commercial line conditioner (surge protector)

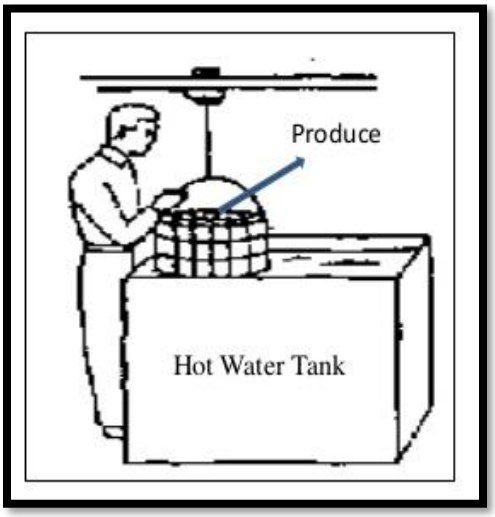
The computers and microprocessors must be provided with surge protector, to provide protection from voltage irregularity (power surges), noise reduction, and harmonic distortion.

d) Diesel power generator

A suitable diesel power generator should be provided for use as a back-up power supply, in the event of a power outage, to provide a secondary source of electricity to enable continued operation of the plant.

e) Fruit Sizing Equipment

The facility should have a fruit sizing equipment (electronic) with an accuracy of +or- 25 gm for sorting out different sized fruits, since no more than 10% of the in any batch are allowed to weigh more than the maximum weight for their particular weight class. The inspecting BAFRA officer shall periodically record the weights of 100 fruits in a particular batch that has been sorted prior to treatment to be sure that the accuracy of the sizing equipment stays within these parameters. If the weight range is too broad, some calibration adjustment will be required on the equipment. Since it is possible for the immature stages of fruit flies to survive in fruit that are under-treated for their weight, it is especially important to assure that all fruits are sorted accurately into precise weight classes, as required by the treatment.



6.2.6. Boilers and Thermostatic Controls

a) Specifications of Boilers

The hot water treatment facility must have a boiler with adequate water heating capacity and thermostatic controls. A boiler used for the purpose of heating the water in a two-tank batch system must have an output rating of approximately 1,000,00 BTU, or 30 horsepower.

b) Thermostatic controls (set point)

The hot water treatment facility should have automatic thermostatic controls accurate enough to hold the water temperature at or above the temperatures prescribed in the treatment schedule for the given duration of time. The temperature set point(s) will be determined and approved during the official performance test and shall be high enough to ensure that the water in the treatment tank will meet or exceed minimum treatment temperature prescribed for the fruit.

Once approved, the temperature set points may not be tampered with. Temperature set points shall remain constant for the entire shipping season.

However, if the operator of the facility requests a change in set points, the inspecting officer of BAFRA shall conduct a new performance test. If this test is unsuccessful, then the operator shall revert to using prior set points. The treatment provider shall have option to use two set points (multiple option) for each tank. In this type of system, the initial dip temperature (set point no. 1) is set slightly higher for the first 5 minutes. The second set point is the temperature to be maintained for the remainder of the treatment. This must be verified during the official performance test, and the same procedure must be repeated on each subsequent commercial treatment. However, this arrangement makes it easier for the tank to pass its performance test. This system works only for tanks that treat only one cage (basket) of fruit (basket) of fruit at a time.

c) Water Circulation System

The facility shall have a water circulation system installed in the tank, to provide uniform water temperatures throughout the treatment process and avoid the formation of cool pockets during treatment. The controls for the circulation pumps or propellers shall be tamper-resistant, to guarantee that the equipment is not turned off during the treatment process. Pulleys on all pumps located within 6 feet of the floor shall be concealed for the safety of personnel working in the area.

Temperatures recorded from the various sensors shall not vary by more than 1°C at any given time after the fruit have been immersed for the first 5 minutes of treatment. The fruit must be kept at least 10.2 cm (4 inches) below the water surface during the treatment, by use of a flotation barrier.

6.2.7. Temperature Sensors

a) Type of sensor

The facility shall have Platinum 100-ohm resistive thermal detectors (RTD sensors) installed permanently in the lower third of the tank. The sensor unit shall be located within the distal 2.54 cm (one inch) of the sensor rod. The sensor shall have an outer sheath of 6.4 mm (0.25 inch) in diameter or less.

b) Number of sensors and their placement

The minimum number required shall at least 10 per tank for continuous flow systems, which must be spaced throughout the length of the conveyor. For batch systems, the requirement is at least two sensors per tank. However, in tanks that treat multiple baskets (cages) of fruit there must be at least one sensor per basket position.

c) ***Tank access for temporary placement of portable sensors***

The hot water tank must be designed to accommodate the temporary placement of numerous portable sensors or probes to be used during the performance testing procedure required for certification or re-certification. During the testing procedure, the temporary sensors shall be

positioned throughout the load of fruit, at the direction of the inspector who conducts the performance test. The facility is required to purchase and have available, 24 portable thermistor or thermocouple sensors (each with its own flexible cord at least 3 metres (10 ft). in length), and a portable temperature monitor which reads to the nearest one tenth of a degree.

d) Certified glass-mercury thermometer

The treatment facility is required to have at least one high-accuracy, water-immersible, certified Centigrade glass-mercury stick thermometer on the premises at all times. This thermometer shall be accurate to 0.1°C (or °F)and will cover the range between 45°C (113 °F) and 47.8°C (118 °F). It will be used as the standard against which all sensors are calibrated. Normally, one glass thermometer is left hanging in each tank during the performance testing procedure.

6.2.8. Temperature Recorder

An automatic temperature recorder (strip chart or data logger) shall be used to record the time and temperature during each treatment.

a) Automatic operation

The instrument used for recording the time and temperature must be capable of automatic operation whenever the hot water treatment system is activated.

b) Long-term recording

The recording equipment must be capable of non-stop recording for an extended period of time. Continuous flow systems must require recording equipment capable of operating for up to twelve consecutive hours.

c) Recording frequency

The time interval between prints will be for every two minutes. Alternatively, a strip chart system may be used which gives continuous color pen lines. The numerical print or pen line representing each temperature channel (sensor) must be uniquely identified by color, number, or symbol. It is not necessary to record temperatures from sensors located in portions of the tank not in use.

d) Accuracy

The combined accuracy of the entire temperature recording system (i.e., sensors, controllers and recorders) must be within 0.3 °C (0.5 °F) of the true temperature (as verified by a certified centigrade glass mercury thermometer).

e) Repeatability

The recording equipment must be capable of repeatability to within 0. l°C of the true calibrated readings when used under field conditions over an extended period of time. Failure to maintain reliability, accuracy and readability in a previously approved instrument will result in cancellation of

approval. The design construction and materials used shall be such that the typical environmental conditions (including vibration) will not affect performance.

f) Calibration

The temperature sensors must be individually calibrated against a certified Centigrade glass mercury thermometer reading in tenths of a degree Centigrade, within the range of 45° to 47.8°C (113 °F to 118°F). The engineering firm that installs the recording equipment shall also calibrate it. (Calibration equipment often used for this purpose includes, for example, a Decade instrument and relay range cards.) The calibration procedure should be done at or near the fruit-treatment temperature around 46.1°C (115°F), but not at 0°C (32°F).

g) Temperature Range

The temperature recorder must be programmed to cover the entire range between 45 ° to 47.8 °C (113 °F to 118 °F), with a resolution of one-tenth of a degree. The range should not extend below 37.8°C (100 °F) nor above 54.4°C (130°F). If the range band of the recorder is wider than this, it must be restricted (narrowed) by proper programming.

6.2.9. Alarm System

An alarm is required for all batch (Jacuzzi) systems. In order to notify packing house employees that a treatment has been completed for a particular basket (cage), an alarm system must be installed. This system may be an audible noise (such as a horn, buzzer, or bell), or a highly visible light, attached to a timing device located on the equipment that indicates time and temperature. Some facilities use both a noise and a light. The alarm system alerts the operator of the hoist to remove a basket from the tank at the end of treatment, to avoid “over-cooking.”

6.2.10. Safeguarding the Treated Fruits

a) Layout and flow pattern

The flow pattern of the fruit moving through the hot water treatment process should be so designed that fruit waiting to be loaded into the hot water immersion tank cannot become mixed with fruit that has already completed treatment. A drawing that shows the proposed layout of the packinghouse shall be submitted to Director General, BAFRA for approval.

b) Garbage disposal

Cut fruit, culled fruit, rotting fruit, and miscellaneous garbage shall be placed into covered containers and removed from the premises daily, in order not to attract fruit flies.

c) Quarantine area

Treated fruit must be brought to an insect-free enclosure immediately after treatment and must remain there until loading into insect-proof shipping containers. The designated enclosure is usually a screened room. Packing line equipment, hydro cooling equipment, and a cold storage room (if any), should be located in this area. Effective procedures shall be enforced to prevent the movement of untreated fruit (accidentally or intentionally) into the insect-free quarantine area.

d) Insect-proof screening

The facility shall have the doors/windows/ventilators provided with insect-proof netting (at least 100 meshes per square inch) to exclude fruit flies. It must be inspected regularly and repaired as often as needed.

e) Air curtain

An air curtain (such as fans or blowers and associated air-directing chambers or enclosures such as baffles, boxes, etc.) shall be located on the wall or ceiling prior to entering any quarantine area. This device shall exclude the possible entry of fruit flies into the insect-free enclosure. Vertically hanging, clear plastic flaps are required at the doors to the insect-free enclosure as a minimum.

f) Loading of treated fruit

Doors leading from the quarantine area to the loading dock shall be kept closed when not in use. When loading, truck vans and containers shall form a fly-proof seal with the exterior wall. Truck vans and containers shall be inspected and disinfected prior to loading. If wooden pallets are used, they must be completely free from wood-boring insects and debarked in compliance with ISPM-15. A numbered BAFRA seal shall be applied to each container before its departure.

6.2.11. Pre -treatment Warming Options

Pre-warming the fruit is sometimes desirable in order to meet the BAFRA requirements that all fruit pulp temperatures must be at least 20.1°C (70°F) before the commencement of treatment. This will ensure that the required minimum treatment temperature of 46.1°C (115°F) shall be achieved within the first 5 minutes of treatment The requirement of having fruit at or above 20.1°C (70°F) in the case of mangoes prior to hot water treatment may not be met (a) when the fruit have come directly from a refrigerated room, (b) when the weather is rainy or cloudy, or (c) in the early morning hours.

These conditions may cause a treatment facility to close temporarily until the fruit pulp temperature has warmed sufficiently to allow treatment. It is the usual practice at many facilities to use the hoist to hang a basket of fruit a few inches above the surface of the hot water tank prior to submerging it.
However, except for the bottom layer of fruit in the basket, the fruit do not absorb a sufficient amount of heat to make this a practical means of pre-warming the entire basket load. To accelerate the pre-warming process, several viable options are available;

a) Treatment Tank

In tanks that treat a single basket (cage) of fruit at a time, pre-heating may be accomplished within the tank itself, by use of a timer or delay switch. (The extra time in the water is not considered as part of the treatment but is in addition to the treatment.) This approach, however, is not feasible to use in a multi-basket tank (in which the baskets enter the tank at different times) and is not an approved option in this instance. Alternatively, a separate hot water tank may be used for pre-heating purposes or hot air may be blown onto the fruit or the fruit may be placed in a heated room.

6.2.12 Post-treatment Cooling Options

Cooling the fruit after hot water treatment is not a requirement of BAFRA. However, from the stand point of fruit quality, many facilities choose to install a system to cool the fruit after removal from the hot water to extend storage life and prevent softening.

a) Refrigerated room

Hot water-treated mangoes may not be moved directly to a refrigerated room until at least 30 minutes following treatment. Allowing the fruit to simply stand for at least 30 minutes after removed from the hot water tank is thought to be helpful in killing immature stages of fruit flies, because the mangoes complete their “cooking” process during that time. The recommended storage temperature for mangoes is 12.8°C (55°F) to 13.9°C (57°F) at 85 to 90% relative humidity. This delay softening and prolongs storage life to approximately 2 to 3 weeks.

b) Fans

BAFRA allows the use of fans in the screen room to blow air over the fruit as soon as they are removed from the hot water tank (if desired). However, the ambient air must not be less than 20.1°C (70°F).

c) Hydro-cooling

BAFRA allows the use of a cool water tank or shower system, but with the following provisions: Hydrocooling (either by showering or water immersion) is optional. However, it may not be done

until a waiting period of at least 30 minutes has elapsed, after the fruit have been removed from the hot water tanks.

During the waiting period and hydrocooling period, the mangoes must be safeguarded in a room or tunnel, separate from the hot water tanks. Water temperature used during hydrocooling is not regulated. However, if it is too cool (below 18°C (65^0F), it may cause some of the fruit to split their skins, making them unmarketable. Water used for hydrocooling should be chlorinated (50 to 150 ppm). Any other chemicals, such as fungicides, are optional, but must be approved by the Directorate of PPQS.

d) ***Safety and Health Checklist***

- An adequate lavatory.
- Fire extinguisher located near the boiler.
- First-aid kit located near moving machinery.
- Hard hats for use by workers and visitors in the treatment and loading areas.
- Approved safety ladders or walkways (catwalks, etc.) for use in observing treatment tank operations.
- Electric power must meet safety code requirements. Electrical wiring, including switches and other connections, shall be contained in metal or PVC conduit, and grounded to prevent electrical shock.
- Steam and hot water pipes shall be insulated or otherwise protected.
- Sufficient lighting shall be provided in working areas.
- Engines, pulleys, drive belts, and other hazardous moving parts, if located within 6 feet of floor level, shall be guarded with a safety shield or barrier
- The admission of children or unauthorized persons into the treatment and packing areas shall be prohibited, if not accompanied by a responsible employee.
- Dirty water in the tanks is a health concern, as well as an embarrassment to the operator. The Directorate PPQS inspector can provide advice on how often the water should be changed. In addition, Directorate PPQS recommends that operators should install a light sensor in each tank, to monitor the turbidity of the water.

6.2.13. Operational Requirements

The entire treatment of fresh fruits shall be under the general monitoring of BAFRA and may be further governed by a signed Work Plan (for foreign facilities) or Compliance Agreement (for domestic facilities).

a) Pre-treatment procedure

The operator of the facility shall conduct all treatments in an approved tank provided with temperature set points during official performance test. The operator should not tamper with

official seals. The operator must check for proper operation of the heating, circulation, and recording equipment before the start of each treatment.

Continuous flow equipment (submerged conveyor belt) will be checked at the start of each day or run. Commodity will not be refrigerated before treatment and must be at or above the prescribed minimum temperature if specified in the treatment schedule. Commodities subject to size restrictions require a preliminary culling procedure to eliminate oversized items prior to treatment.

b) ***Treatment procedure***

The operator should load the immersion tanks in a manner approved by the BAFRA, usually using baskets with perforations that allow adequate water circulation and heat exchange. Each treatment container or lot shall be given an identifying number before being placed in the immersion tank. An automatic temperature recording system shall record the temperature and duration of each hot water dip. A responsible employee of the packing company shall indicate on the printed temperature record the starting time, lot number, duration of each treatment and initial each entry.

c) Post-treatment procedure

All boxes of hot water treated fruit will be stamped *Treated with Hot Water, BAFRA,* together with the numerical designation that APHIS has assigned to the particular treatment facility. Commodities treated at origin will be moved to an insect free enclosure promptly after treatment and maintained insect-free throughout the shipping process. This may be accomplished by using insect-proof containers, screened or enclosed rooms, doors with air-curtains, or some combination of these.

d) Treatment certification

The supervising officer of BAFRA, at the end of successful treatment, will endorse the particulars of hot water treatment on the phytosanitary certificate, if required by the country of export.

e) Essential Equipments for Setting-up of Facility

The essential equipment required for setting-up of hot water immersion treatment facilities given in Appendix-XI for necessary guidance.

6.3. Treatment procedure - Vapour heat for Mango Fruits

6.3.1. Introduction

- The facility shall under take all the treatment operations as per schedules approved by BAFRA
- The time-temperature relationship varies with the commodity and pest. Usually, the pulp temperature of the fruit raised using heated water between 46.1-47.8 ^{0}C (115^0 and 118^{0}F) for prescribed period

6.3.2. Check list of Minimum Certification Requirements

- Location, construction & design of facility
- Requirements of Electrical/Electronic Components
- Boilers and Thermostatic Controls
- Temperature Sensors & Temperature Recorder
- Alarm System
- Safeguarding the Treated Fruits
- Pre -treatment Warming Options & Post- treatment cooling options

6.3.3. Location, Construction & Design of facility

The location, construction and design of the facility should be as per the safety norms and standards prescribed by the concerned local authority and as per approved engineering design and plans. The facility may be integrated with package house for easy of operations. The treatment facilities should be located in a secure area to prevent re-infestation of treated fruits.

6.3.4. Prior Approval of the Plans and Drawing of the Facility:

A prior approval of the plans and specifications showing dimensions, air circulation, and other specifications of the heating and temperature recording systems by BAFRA shall be required in the case of new facilities to ensure that the minimum requirements prescribed in this standard are met with. For this purpose, the owner of proposed facility will send an application enclosing therewith the plans and specifications showing the above to BAFRA for necessary consideration.
After preliminary scrutinization of the plans and specifications, an on-site survey will be conducted by the expert nominated by BAFRA to compare the installation to the approved plans; to check the air and water vapor circulation system, and to check the calibration of the temperature monitoring system. However, the above condition shall not be applicable for the vapour heat treatment facilities that have been established prior to adoption of this standard but those facilities must meet the minimum requirements of this standard. Any proposed changes or improvements in the existing facility shall be made only with the written approval of officer from BAFRA.

6.3.5. Minimum Requirements of facility

The minimum requirements for approval or certification of facility shall include:

- ✓ location of treatment facility in secured area to prevent re-infestation of treated fruits
- ✓ assured supply of good quality and potable water
- ✓ assured power supply and back up by diesel generator
- ✓ insect-proof screening of all openings to external area to prevent fruit fly entry
- ✓ hygienic handling of fruits during grading, packing &storage at the facility
- ✓ regular calibration of temperature sensors, temperature and humidity recording and pressure testing equipment and maintenance of calibration records
- ✓ adequate air and water vapour circulation system
- ✓ adequate boiler capacity to raise the chamber temperature to about 50-52^{0}C so as to ensure the pulp temperature of 46-48^{0}C within a ramp up time of 4 hours
- ✓ adequate number of portable/permanent temperature sensors to monitor the temperature of treatment
- ✓ temperature recording through an approved strip chart recorder or data logger
- ✓ adequate measures for disposal rotten fruits/fruit waste at the facility

6.3.6. Treatment Schedules

The temperature-time relationship varies with the commodity and the pest involved. In case of treatment against fruit flies, the pulp temperature of the commodity will be raised by the saturated water vapor to 46-48 degree Celsius during a ramp up time of 4 hours and then the fruits will be held at the required temperature for a period of 30 min. The exposure periods and the treatment temperatures will vary with kind of fruit fly species and commodity involved. Where more than one fruit fly species is known to infest a commodity, laboratory experiments should be carried out with 100-1000 individuals for determining the most heat tolerant species.

The small- scale trials should be carried out with 3000-5000 individuals to determine the most- heat tolerant stage of determined fruit fly species and this should be further confirmed by large scale treatment trials involving 30,000 populations of first instar larvae of the most heat tolerant fruit fly species, ensuring Probit 9 security level to prove the efficacy of treatment for commercial application.

6.3.7. Operational Requirements

i) Pre -treatment conditioning

The fruits before subjecting to VHT should be conditioned usually at a relative humidity less than 100 percent.

i) Treatment Procedure

All the vapour heat treatments will be carried out only at vapour heat treatment facilities approved by the BAFRA. Temperature sensors are used to determine the pulp temperature of the commodity under treatment, psychrometers are used to determine the existing relative humidity.The tips of the sensors areinserted in the centers of individual fruits and vegetables; a typical sensor placement in the crates is shown below:
Vapor heat processors employing a duct system, which delivers the vapor directly to each individual stack of commodity and which channels the air flow directly through the stack, may utilize the following sensor placement: Bottom, Middle, and Top Layers (A total of 9 sensors); Hot air duct—2 sensors (1 wet, 1 dry = psychrometer);

Vapor heat chamber equipment should be tested for correct functioning before each treatment. The accuracy of each temperature sensing element should be checked once a month during regular use with water at temperatures near the normal treatment temperatures. All sensors, after

calibration corrections, must register the required temperature or above at the beginning of treatment. A 0.3 °C deviation is considered within the range of acceptable tolerance thereafter.

This tolerance applies to the humidity check sensors as well as those for host temperature recordings. Extend the treatment time by an amount equal to any periods when specifications are not met. Chambers must be equipped with recording temperature and humidity indicators. Detailed records of each treatment must be kept. Final calibration values for each temperature sensor must be recorded for the port files.

ii) Post-treatment Cooling

The fruits and vegetables should be cooled immediately after VHT treatment. Allowing the fruit to simply stand for at least 30 minutes after removal from the VHT chamber in insect proofed and well- ventilated room would be helpful before the fruits and vegetables subject to pre-cooling process. The recommended storage temperature for mangoes is 55 °F to 57 °F (12.8 °C) at 85 to 90% relative humidity.

iii) *Quarantine safeguards*

Adequate safeguards must be maintained to prevent re- infestation or contamination of the treated commodities or their containers. Packing rooms must be fly-proof and only treated host material permitted therein.

6.4. Treatment procedure on Controlled Atmosphere CO_2 treatment for organic produce

Fumigation with CO_2 for Stored Product Insect Control

6.4.1. Controlled or Modified Atmospheres

Controlled Atmosphere – atmospheric composition within the treatment is controlled or maintained with addition of gas to sustain desired gas levels

Modified Atmosphere – the atmospheric composition within the treated enclosure may change over time and is controlled in an indirect fashion

6.4.2. Factors Affecting Required Exposure Time for CO_2 fumigation Depends On:

- ✓ Concentration of the atmosphere
- ✓ Grain temperature
- ✓ Moisture content of the grain
- ✓ Species and life stage

6.4.3. Fumigation and controlled atmosphere storage

In addition to the poisonous gases that are used for pest control, the normal gases of the atmosphere can be altered to achieve control. The use and manipulation of natural components of the atmosphere, e.g. oxygen, nitrogen and carbon dioxide, to preserve food is referred to as "controlled" or "modified" atmosphere storage. Controlled atmosphere techniques are widely used in the storage of perishable commodities such as fruit, vegetables, cut flowers, etc. to retard ripening and reduce spoilage from micro-organisms. Also, they will control some insects in these products (Morgan and Gaunce, 1975; Aharoni et al, 1981). The most extensive use of controlled atmospheres for insect control is on grain and similar commodities. Here the atmospheres are modified by removing the life-supporting oxygen or by adding high levels of carbon dioxide.

Although the principle of modified atmosphere storage has been used since antiquity, e.g. in hermetic storages, a number of procedures have been developed in recent years to replace the normal atmosphere of a storage for the purpose of controlling pest organisms. In many respects the practice of using modified atmospheres for insect control is closely related to fumigation. Gas-tight enclosures are required, many of the procedures are closely related and the problems are often similar to those found in fumigation. When carbon dioxide is used, it is applied as a fumigant and it functions in a similar way.

Controlled atmosphere procedures are an appropriate substitute for the fumigation of some commodities because the gases involved do not leave harmful residues and often the atmospheres provide superior conditions to normal storage in air. In some cases, the two procedures may be

used in a complementary way to increase effectiveness of a treatment; carbon dioxide increases the toxicity of a number of fumigants to insects (Jones, 1938; Kashi and Bond, 1975).

6.4.4. Basic requirements

Controlled atmosphere systems depend on either depletion of oxygen to asphyxiate organisms or the addition of carbon dioxide to act directly and kill them. In these treatments the new atmospheres are maintained for an adequate period to kill all stages of the organism, and they should have no adverse effect on the commodity. To achieve this the treatment requires:

- a storage structure capable of containing the gas;
- a source of suitable gas or a means of producing the required atmosphere;
- a method of maintaining the atmosphere for the required period of time;
- a method of aerating to remove the altered atmosphere after the treatment.

It should be noted that the controlled atmospheres, which are toxic to pest organisms, are also dangerous to humans and precautions are necessary to ensure that no one is exposed to them without special protection. Although nitrogen itself is non-toxic to humans, the absence of oxygen or the presence of high levels of carbon dioxide is lethal.

6.4.5. Low oxygen atmospheres

Oxygen deficient atmospheres are produced by flushing a storage with nitrogen to displace the normal nitrogen-oxygen atmosphere.Exothermic inert atmosphere generators that consume the oxygen to leave principally nitrogen have been tested and show promise for insect control (Storey, 1973). These generators burn propane or other hydrocarbon fuel to give an atmosphere of less than 1 percent oxygen with about 10 percent carbon dioxide and 89 percent nitrogen. Oxygen can also be removed by the metabolic activity of micro-organisms and insects in hermetic storages, thus producing an atmosphere where insects cannot survive.

For complete insect control the level of oxygen must be maintained below 1.2 percent for one week, at temperatures above 35°C, or more than 24 weeks at 15°C (Table 15).

TABLE:SUGGESTED EXPOSURE TIMES FOR COMPLETE DISINFESTATION OF GRAIN AT LESS THAN 12 PERCENT MOISTURE CONTENT, WITH ATMOSPHERES OF 0 1.2 PERCENT OXYGEN IN NITROGEN.

Grain temp. (°C)	Exposure time (weeks)
15	24
18	15
20	6
23	4
26	3
30	2
35	1

Source: Banks and Annis,1977.

6.4.6. Carbon Dioxide atmospheres

Insects are generally killed more rapidly by carbon dioxide than they are by lack of oxygen. A concentration of 6percent carbon dioxide will give over 95 percent control of most stored grain insects after a four-day exposure at 27°C or higher (Jay, 1971); however, longer periods are needed for complete kill. Banks (1979) suggested that an initial level exceeding 70 percent carbon dioxide and maintained above 35 percent for ten days is appropriate for complete insect control at temperatures above 20°C.

The carbon dioxide gas is applied to storages from a vessel of liquid carbon dioxide with appropriate vaporizers and pressure regulators to control flow rate (Jay and Pearman, 1973). Carbon dioxide in the form of dry ice has also been used for the treatment of grain in freight containers (Banks and Sharp, 1979; Sharp and Banks, 1980) and in conjunction with fumigation of grain with methyl bromide (Calderon and Carmi, 1973).

6.4.7. Gas Tightness requirements

Structures used for controlled atmosphere treatments must have a high degree of gas tightness for the process to be effective and economical. They must be of sound construction and suitably modified so that gross gas loss through apertures, such as ventilators, open eaves and imperfections in the fabric, is prevented. Changes in temperature, atmospheric pressure and wind forces can have a pronounced effect on gas loss from the storage structure.

For storages of 300 to 10 000 tons capacity a gas tightness that corresponds to a decay time of 5 minutes for an applied excess pressure drop of 2 500 to 1500, 1 500 to 750 or 500 to 250 Pa in a full storage has been found satisfactory (Banks et al, 1980). This specification corresponds to a whole area of no more than 1.0 cm^2(0.16 in.2) in a 2 000 tons storage.

Gas is added to maintain concentrations at the required level in a storage over the entire exposure period. One of the main reasons that gas loss occurs is the diurnal temperature variation in the headspace of storage structures. This is less in concrete structures than in unprotected metal bins. Diurnal temperature fluctuations can be reduced by insulation, painting with a highly reflective white paint or by placing a false roof on the bin to leave a ventilated air space next to the permanent roof.

6.5.8. Sealing procedures

In structures other than welded steel, e.g. concrete, bolted or riveted metal, sealing of the entire fabric of the structure may be necessary. Bolted metal bins can be sealed by treatment of each lap joint and bolt location with silicone rubber sealant, thixotropic acrylics or by application of liquid envelope, "cocoon" type, polyvinyl chloride coatings. Concrete surfaces also may need to be coated

with a good sealant that will prevent yes loss and protect the concrete from high levels of carbon dioxide.
The permanent sealing of a 16000-ton capacity shed for fumigation or modified atmosphere storage of grain has been described by Banks et al (1979).
In bins that are very tightly sealed, some precautions are necessary to avoid unusual stresses on the structure caused by external or internal pressure changes. To prevent such changes in a bin that is sealed for a controlled atmosphere treatment, a pressure relief valve must be installed.
If the bin will withstand the pressure, an operating level of + 1 000 Pa (4 in water gauge) appears to be suitable. Lower levels can be used but they should not be less than + 250 Pa. A simple U-tube valve of 8 cm (3 in) I.D. tubing with a liquid trap provides a convenient and fool-proof venting system (Banks and Annis, 1977).

6.4.9. Testing for gas tightness

Structures can be tested for gas tightness using a pressure test system (static testing or pressure decay testing) or a procedure using carbon monoxide as a tracer gas. The pressure decay system is satisfactory for routine testing of bins and is given in some detail here.
To test a sealed structure by the pressure decay method, air is introduced by the gas introduction system from a blower capable of producing 6 m/min (212 ft^3/min) at 2 500 Pa (10 in water gauge). Pressure differentials can be measured conveniently on a portable water gauge. If a pressure of 2500 Pa cannot be reached with such a blower, there may be too much restriction between the blower and the bin or the bin is less gas tight than required (e.g. 3.1 m/min at 2500 Pa for a 2000 ton bin). Care should be taken to ensure that pressure within the bin does not exceed the engineering limitations of the bin or of the sealing that is used. When a pressure of 2500 Pa or the design limit is achieved, air input is cut off in such a way that no air is lost back through the blower. Pressure decay on the water gauge is then related to the period of time involved.

6.4.10. Procedures for establishing controlled atmospheres

Controlled atmosphere storage can be viewed in two phases - the "purge phase" where the normal atmosphere is replaced with the prescribed atmosphere and the "maintenance phase" where the atmosphere is maintained for the desired period of time (Banks and Annis, 1977).

6.4.11. NITROGEN ATMOSPHERE

i) Purge Phase

Liquid nitrogen supplied directly from a road tanker is passed through a heat exchanging facility where it is vaporized and brought to ambient temperature. It is then passed through a flow meter (e.g. "Rotameter") into the gas introduction system of the bin. Five cm (2 in) I.D. PVC drainage piping can be conveniently used to carry the gas. A flow of 3 m/min (106 ft^3/min) has been found to be suitable for purging of bins from 300 to 7000-ton capacity, although this rate may be

substantially increased (e.g. to 8 m3/min) in bins fitted with aeration ducts modified to introduce gas.

However, when gas in introduced directly into the bin at the walls, an increased input rate may be less efficient at lowering the oxygen tension. In cases where a low efficiency distribution system is used, pockets of air may remain which are not purged directly but in which the oxygen is removed through the slower diffusive and convective forces. In these instances, a slower purge rate allows these processes to occur and is not wasteful of gas.

A vent of at least 50 cm^2 (10 in) must be left open in the roof during the purge to prevent dangerous pressure build-up.

It is important that the heat exchanging facility is adequate to bring the gas close to ambient temperature (within 2°C). Cooling of the grain near the introduction point may result in moisture migrating to the cold area on long storage and is also detrimental to the insecticidal efficiency of the process. At 3 m /min (106 ft^3/min) three Forced draught heat exchangers in parallel using 0.4 kW (0.5 h.p.) fans, with an atmospheric exchanger downstream in series, have been found to be just as effective. If icing occurs downstream of the exchangers, the input flow must be reduced.

Gas input must continue uninterrupted until the headspace has been reduced to about 1 percent O2. Purging in the grain mass occurs generally by the passage of a sharp front through the grain and direct displacement of the interstitial air. In the headspace where free gas mixing occurs, decay is exponential. When the headspace has reached 1 percent O2, the purge may be terminated, the top vent and introduction ports closed, and the maintenance input of gas commenced.

The quantity of nitrogen required for the purge is strongly dependent on the ratio of the volume occupied by the bulk to the total storage volume (the filling ratio). Barley has a higher porosity and will require more nitrogen than wheat. In one trial with barley where the filling ratio was 0.80, a volume of 1.9 m^3 N2/ton was consumed. At 3 m3/min the purging of a 2000-ton bin of wheat takes about 12 hours.

ii) Maintenance Phase

After termination of purging, gas input at a lower rate is continued to maintain the atmosphere. The input rate required is determined by the bin capacity, its degree of gas tightness and the weather. At present it is best to adjust the maintenance rates by systematically reducing the flow of gas until the atmosphere is just maintained. At the correct rate, with grain temperatures exceeding ambient ones, the oxygen tension at the base of the bin will rise slightly during the day and fall to about 1 percent at night. The headspace tension should remain low. If the grain temperature is below ambient, or if the atmosphere contains more than 3 percent CO_2, effects will be seen in the headspace, not at the base.

The exposure periods recommended for different grain temperatures with 1 percent O2 in nitrogen have been given above in Table 15. These figures are tentative and subject to revision when further laboratory studies are completed.

*Sitophilus oryzae*is one of the most tolerant grain pests in low oxygen atmospheres, and if there is any doubt about what species are present, the exposure for this pest should be used. In commodities where the pests are *Tribolium spp*. and *Oryzaephilus spp.* Currently available data for *Rhyzoperthadominica* are insufficient for an exact recommendation, but it is considerably more susceptible than *Sitophilus oryzae* and should thus be controlled by the exposures given. Exposure times should be based on the minimum temperature within the grain, not average temperatures. (For further details see Banks and Annis, 1977).

iii)***Atmosphere from inert atmosphere generators.***

A number of inert atmosphere generators with capacities ranging from 1.4 m^3 (50 ft^3)/h to 2800 m (100000 ft^3)/h and capable of producing atmospheres with less than 1 percent oxygen are available on the market. Storey (1973) conducted tests in a 40 x 5.5 m (130 x 18 ft) silo containing 544 tons of wheat with two generators, each one capable of generating 420 m^3 per h of inert atmosphere (<0.1 percent 02' 8.5 - 11.5 percent CO2 plus N2). Using 3 cm (1.5 in) drain feeder pipes connected at the bottom of the bin, he was able to reduce the oxygen level throughout the bin to 1 percent or less in 48 hours.

The oxygen deficient atmosphere moved upward through the grain mass with very little intermixing with the normal atmosphere at a rate about 2.4 m (8 ft)/h. In another bin that was purged with the inert atmosphere prior to filling with grain, the oxygen level throughout the bin, including the headspace, was reduced to less than 1 percent within 24 hours.

Similar tests were carried out by Navarro et al (1979) in welded steel bins containing about 1200 tons of wheat with a generator producing exhaust gases at a rate of 144 m /h. When the generator was in a recirculation arrangement so that the gases were blown in through the roof of the silo and drawn back into the converter through a pipe at the base, the average oxygen concentration was reduced to 0.2 percent in 60.3 h (purge phase).

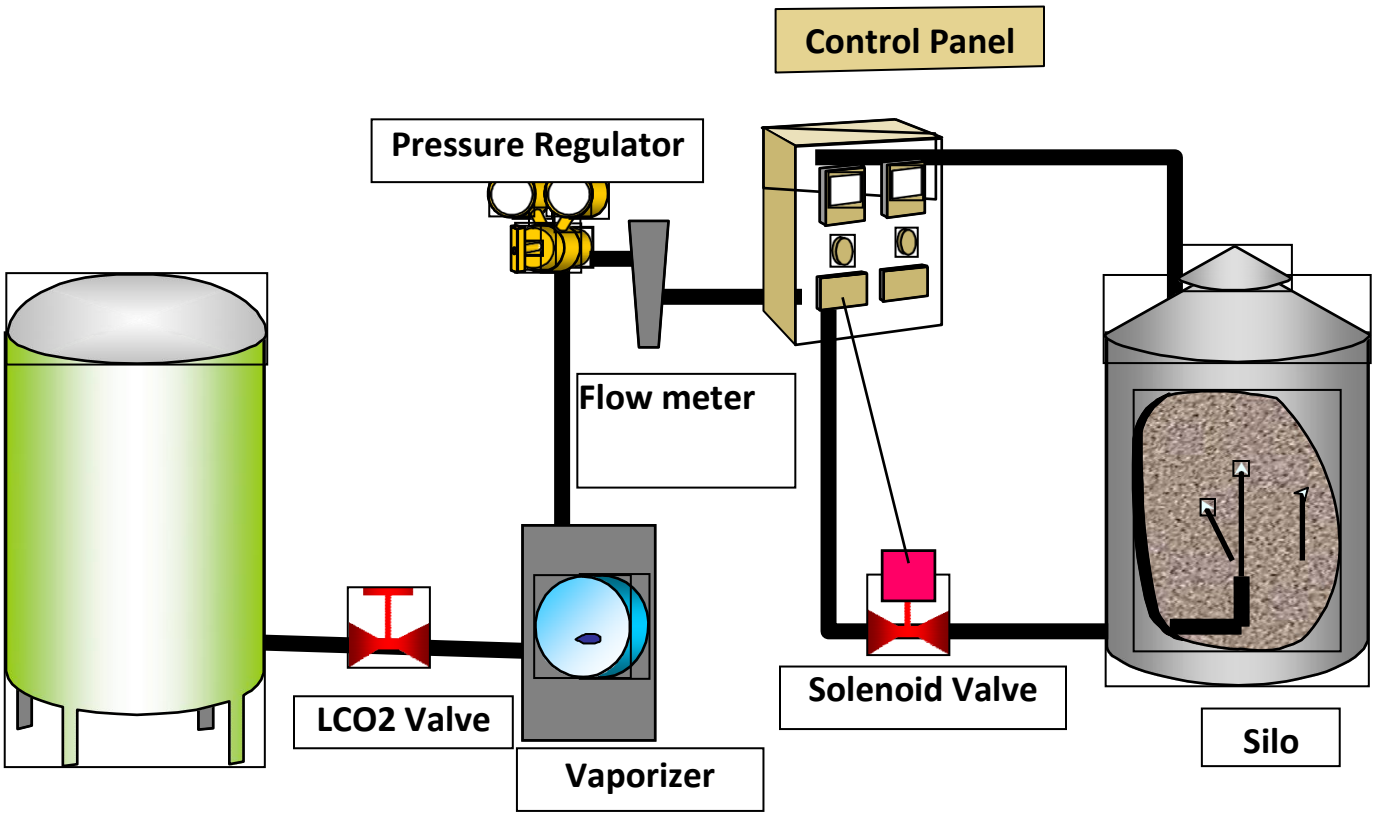
During the maintenance phase, which lasted 21 days, the oxygen concentration was maintained below 2 percent by intermittent operation of the generator for a total of 19.5 h.

It should be pointed out that the moisture content of the wheat was affected by purging with this atmosphere, particularly in the upper layer at the region of introduction of the gases. A plastic sheet was placed below the point of gas entry to prevent moistening of the grain.

6.4.12. CARBON DIOXIDE

i) Grain Storages

Three procedures for establishing high concentrations of carbon dioxide in large silo-type bins have been tested by Jay (1980). These are based on introducing the gas at the top of a filled storage, at the bottom of the storage or with the grain stream during filling. A procedure for introducing the gas at the base of the storage with subsequent recirculation has been found to be effective in controlling a natural infestation of insects and is deemed to be commercially feasible (Wilson et al 1980).



For the latter treatment, liquid carbon dioxide supplied in cryogenic tankers is vaporized in a heat exchanger and the gas is diluted with air to give approximately 80 percent carbon dioxide and 20 percent air. The gas stream is maintained above 30°C with a superheater and introduced at the base of the bin through a 75 mm diameter iron pipe. When the carbon dioxide concentration at the top of the bin reaches a constant level, gas input is stopped and the atmosphere so established is recirculated through a 50 mm diameter plastic duct leading from the bin apex to the introduction port at the base.

With the gas tightness standards specified above, this procedure will give a concentration of carbon dioxide >70 percent initially and this can be maintained at > 35 percent for ten days without requiring additional gas.

2. Freight Containers

Successful tests have also been carried out with carbon dioxide for disinfestation of freight containers loaded with wheat. In trials on gastight general purpose containers filled with commodity and dosed with 37 - 55 kg of crushed dry ice spread over the goods, plus 44 kg in blocks packed in insulated boxes, Banks and Annis (1980, 1981) found that the carbon dioxide level remained over 35 percent for a period of seven days or more and killed all of the test insects.

Tests have also been made for treatment of grain under gas-proof sheets with carbon dioxide (Banks and Annis, 1980).

3. ***Termination of treatment***

After a controlled atmosphere treatment is terminated, the modified atmosphere is gradually displaced by entry of air from outside. The rate at which this happens depends on a number of factors, such as gas tightness of the storage, contents of the storage and the weather, and it may be increased by making larger openings or by active ventilation with a blower. A 2000-ton bin with 5 cm (2 in) diameter openings at the top and base may reach acceptable oxygen levels of 16 percent from the established 1 percent in less than two weeks (Banks and Annis,1977).
Care should be taken to avoid structural damage from the reduced pressures caused by rapid emptying of a tightly sealed storage. Steel bins have been severely damaged by rapid removal of grain without sufficient venting.

NOTE:*Before emptying tightly sealed bins, open access doors or vents to allow adequate air to enter as grain is removed.*

4. ***Safety precautions***

Adequate precautions should be taken when working in areas close to controlled atmospheres or on entering storages that have been treated to avoid any harmful effects. Nitrogen atmospheres containing less than 14 percent oxygen, or more than 5 percent carbon dioxide may be dangerous to human life. Personnel entering a nitrogen atmosphere containing less than 10 percent oxygen may collapse without warning and become unconscious. Carbon dioxide produces respiratory discomfort, lightheadedness and nausea, and unconsciousness may occur in less than five minutes in 9 percent CO_2. In any case, where unconsciousness or respiratory distress occurs through exposure to a controlled atmosphere, the victim must be taken immediately to fresh air.

Portable oxygen monitors or carbon dioxide analyzers should be available on the work site as well as air-line or self-contained breathing apparatus. Gas masks with canisters provide no protection against low oxygen or high carbon dioxide atmospheres. All enclosed working areas close to controlled atmospheres should be well ventilated and gas reservoirs should be kept outside if possible (Banks and Annis, 1977).

*5. **Problems associated with modified atmosphere storage***

In sealed systems, moisture may migrate and condense to produce problems, particularly in grain above 12 percent moisture content. High carbon dioxide or low oxygen atmospheres can inhibit mould and toxin formation and preserve germination under moist storage conditions. However, spoilage will occur once the modified atmosphere is removed unless the grain is dried or processed within a short time (Banks, 1981). Once the modified atmosphere is removed the commodity is open to infestation unless otherwise protected.

Grain kept under a modified atmosphere may develop taint; at higher moisture levels (> 16 percent) this taint may be difficult to remove (Banks, 1981; Shejbal, 1979). High levels of carbon dioxide may cause structural problems in reinforced concrete storages by reducing alkalinity of the steel (Hamada, 1968). The significance of this reaction in grain storage is currently under investigation.

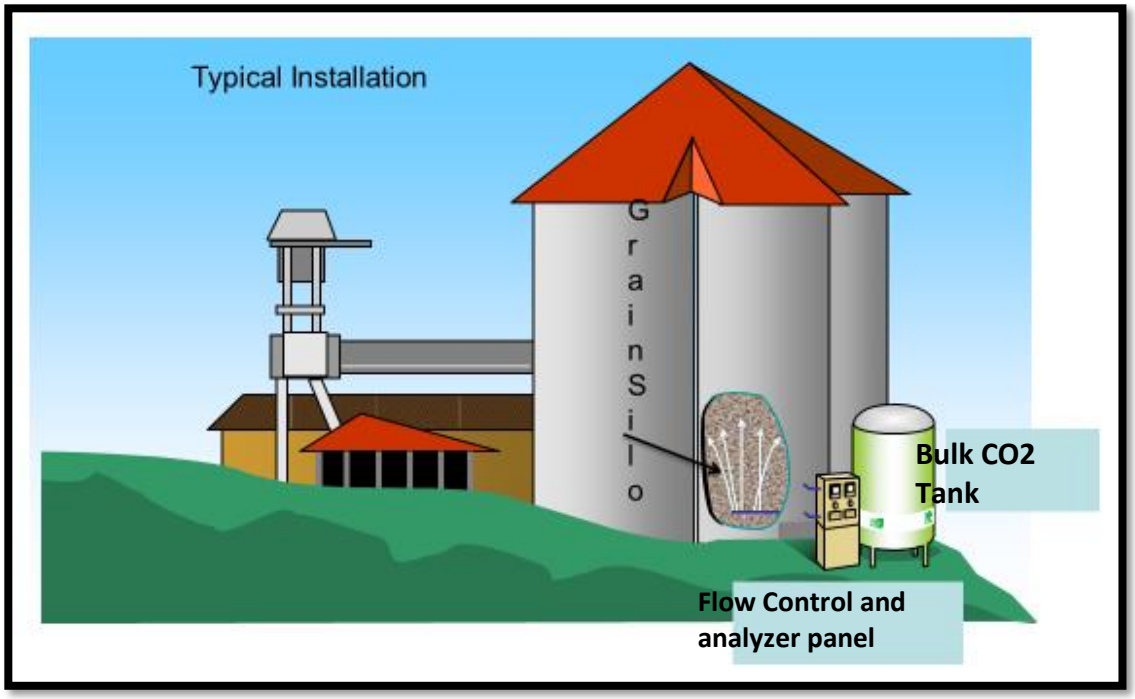
6. Choice of treatment

When a controlled atmosphere procedure is going to be used, the choice between using the nitrogen (oxygen deficiency) method or the carbon dioxide method may be determined by several factors. The amount of time available for the treatment, the suitability of the structure for holding the gas, the availability of the gases or equipment for producing them and the overall cost of the operation are all important.

Carbon dioxide generally kills insects faster than nitrogen (oxygen deficiency) and requires a less stringent standard of gas tightness (Jay, 1980). The comparative cost of controlled atmosphere treatments will depend on the availability and cost of the gases, the amount required and transportation costs, as well as the costs of equipment and labour.

Commodities to be treated using CO2 as Controlled Atmosphere fumigation
Cereals
Pulses
Spices
Oilseeds
Dry fruits
Moisture content should not exceed above 14%

At 25Cº, 60% CO2, all life stages succumb – Navarro et al. 2012



7. Fumigation, controlled atmospheres and forced aeration

The choice of treatment to be used for controlling insect infestations will vary with the type of problem and the relative merits of the treatment. Fumigants can usually be used effectively in storages prepared for controlled atmosphere treatments, as the standards of gas tightness that are required are generally more stringent for the controlled atmospheres.

Also, the quantity of material required, the application costs and the exposure time are usually much less for fumigants than for controlled atmosphere treatments. On the other hand, controlled atmosphere procedures avoid the use of chemical pesticides, leave no harmful residues and can provide superior storage of grain. A combination of fumigation with controlled atmosphere procedures may have some potential, as the effectiveness of fumigants is enhanced by carbon dioxide.

In addition to controlled atmospheres, the forced aeration of grain is closely allied with insect control procedures and may be an integral part of a pest management programme. Calderon (1972) suggested that "a sensible use of ambient or chilled air for aeration of grain offers new possibilities in many parts of the world for preservation of grain without (or with very little) use of chemicals."

The use of fumigants and controlled atmospheres together with forced drying procedures and aeration should be considered as complementary conservation methods that form part of an overall pest management programme.

It must be pointed out that controlled atmosphere procedures are in early stages of development and progressive changes are likely to be made with further experience and research. A select bibliography on controlled atmosphere and aeration procedures up to 1981 is given below and may be referred to when extensive use of these procedures is planned.

Grain Temp.C°	Concentration CO2	Exposure Days
40	60%	1
25	60%	5
20	60%	14
10 – 20	60%	14 – 56

GRAIN PRO

Grain Pro storage solutions designed for organic -use and long-term storage of dry agricultural commodities. It can prevent entry of moisture &oxygen and material is a water resistant and UV protected.

The Grain Pro Cocoon is a flood-protected designed to safely store dry agricultural commodities without the need for chemicals. This solution has low permeability to air and moisture, enabling chemical-free storage and long-term preservation.

Made from high-strength PE with excellent water and gas barrier properties, it is designed to safely preserve agricultural commodities without the need for chemical fumigants.

- Ideal for all-time protection until final use.
- Capacities from 800gr – 15kg – 25/30kg and 69kg.
- Use of external conventional bag for physical protection of the liner.
- Proved quality preservation for up to one year.
- Opportunity to transfer the cost to the buyer and guarantee the quality preservation for long-term commercial relationship.

Grain Pro Accessories

Grain Pro CO2 Analyser is a tool designed to measure carbon dioxide levels within 0% to 100% range. This allows handlers of agricultural commodities to monitor modified and controlled atmospheres, crucial for safely storing valued products.

CHAPTER VII: OCCUPATIONAL HEALTH AND SAFETY PROCEDURE

The occupational health and safety (OH&S) management system, ISO 45001, is a new international standard that provides a framework for an organization to manage risks and opportunities to help prevent work-related injury and ill health to workers. The intended outcome is to improve and provide a safe and healthy workplace. ISO 45001 is intended to help organizations, regardless of size or industry, in designing systems to proactively prevent injury and ill health. All of its requirements are designed to be integrated into an organization's management and business processes. ISO 45001 enables an organization to identify OH&S hazards, risks and opportunities to proactively manage to support worker wellness/well-being. The ISO 45001 standard calls for the organization's management and leadership to:

- Integrate responsibility for health and safety issues as part of the organization's over all plan
- Employees feel their needs and safety are being considered.
- Demonstrate engagement with employees (and where they exist employees' representatives) to create an organizational cultural that encourages active participation of workers in the OH&S management system.
- A strong occupational health and safety management system can help reduce injuries and illness in the workplace.
- May help avoid legal costs and may even reduce insurance costs.
- Create a positive corporate culture supportive of prevention of workplace injury and illness, as well as employee participation.
- Ensure the OH & SMS is integrated into an organizations business process

7.1. Safety rules for fumigators using phosphine

Fumigation is a precise operation requiring considerable expertise, and it cannot be undertaken without proper preparation. It is important that management and their fumigators-in-charge understand this and ensure that proper planning is carried out before a fumigation treatment is done.

- ✓ Check all equipment before you use it. Make sure it is all in good working condition.
- ✓ Examine all gas-proof sheets by suspending them over a lighted doorway.
- ✓ Repair even the smallest holes that could cause gas leaks, since these leaks could result in human injury or insufficient gas concentration to control the target pest.
- ✓ Make sure you have enough phosphine-generating product to do the treatment.

7.2. Guide to fumigation under gas-proof sheets

- Make sure that there are enough sand snakes to seal the enclosure. There must be enough to go around the enclosure twice.
- Make sure a fully equipped tool kit is available.
- Site inspection to be done before fumigation.
- Site to be sheltered from strong wind.
- Fumigation site should be away from residential areas.

- Personal-protection equipment required during fumigation treatments with phosphine.
- Fumigators and other persons at risk from inhaling excessive quantities of phosphine must be provided with either a full-face canister respirator or an open-circuit, self-contained breathing apparatus with a full-face mask.
- Respiratory protection must be worn whenever tests of the atmosphere reveal concentrations of the gas greater than the hygienic standard (currently 0.3 ppm).
- Masks and filter canisters must be issued on a personal basis, and a register of use maintained.
- Canister respirators must be fitted with a filter canister designed for protection against phosphine.
- The facial fit must be tested by closing the inlet to the canister with the palm of the hand and inhaling deeply; the vacuum so created must cause the face-piece to adhere to the face for about 15 seconds.
- With this type of respirator, it is essential that the filter canister be used within its stated shelf life. The filter canister must always be replaced before either its shelf life has expired, or the recommended usage time has been reached.
- The expiry date of a filter canister may easily be calculated since each is marked with the date of manufacture and its shelf life.
- Filter canisters must be stored in a cool, dry, well-ventilated place away from contamination by any fumigants.

7.3. Self-contained breathing apparatus

Persons who have to wear full-face respiratory-protection equipment during a fumigation treatment must be clean shaven, to ensure the best possible gastight fitting to the face. Persons who need to wear prescription glasses while using a respirator must obtain special, armless lens frames that are made specifically to fit inside the visors of such equipment.

- Self-contained breathing apparatus must be available for all uses of phosphineabove15ppm.
- The facial fit of this type of apparatus maybe tested in the same way used for canister respirators, except that the cylinder valve is closed before deep inhalation.

- Skin protection - Gloves, preferably cotton, must always be worn when phosphine-generating sachets are handled. Cotton gloves are less likely to cause sweating than are plastic gloves. Cotton gloves must be washed after use.

7.4. First aid

- The symptoms of phosphine poisoning include: Nausea, vomiting, diarrhea, chestpain, headaches, stomachpains.
- Any person with these symptoms at a fumigation site should be taken to a doctor or hospital for emergency treatment.
- Any person who appears to have been affected by phosphine (by inhaling the gas or dust from a generating product) must be taken at once into fresh air, kept warm, and medical attention obtained. If breathing stops or shows signs of failing, resuscitation must be commenced immediately.
- There is no specific antidote for phosphine poisoning.
- Do not administer any milk, butter, oils (e.g. castor oil), or alcohol.
- No one must enter an area under fumigation, except in extreme emergency, and then only if wearing adequate respiratory protection.
- Self-contained breathing apparatus is the preferred method in emergencies.
- Mild exposure by inhalation causes: malaise, ringing in theears, fatigue, nausea, pressure in the chest, which is relieved by removal to freshair.
- Moderate poisoning causes: weakness, vomiting, chestpain, diarrhea, dyspnea.
- Severe poisoning may occur in a few hours to a few days, resulting in pulmonary edema and may lead to: dizziness, cyanosis, unconsciousness death.
- In sufficient quantities, phosphine affects the liver, kidneys, lungs, nervous system, and circulatory system. Inhalation can cause lung edema and hyperemia, small perivascular brain hemorrhages and brain edema.
- Ingestion can cause lung and brain symptoms, but damage to the viscera is more common. Phosphine poisoning may result in (1) pulmonary edema; (2) elevated SGOT, LDH and alkaline phosphatase, reduced prothrombin, hemorrhage and jaundice; and (3) kidney hematuria and anuria.
- Pathology is characteristic of hypoxia. Frequent exposure over a period of days or weeks may cause poisoning. Treatment is symptomatic.

7.5. Phosphine Safety aspects

- Phosphine is highly toxic to human beings. It is rapidly absorbed through the lungs following inhalation and causes respiratory, gastrointestinal, nervous system and cardiovascular effects. Inhalation of phosphine beyond 7 ppm may be harmful, exposure at 300 ppm onwards is dangerous, 400-600 ppm is lethal within an hour and 2000 ppm is fatal after a few breaths.
- The gas is not absorbed through the skin. There is no evidence for cumulative effects from intermittent low-level exposure of 10 ppm phosphine or less.

- Mild poisoning due to inhalation exposure produces a feeling of fatigue, ringing in the air, nausea, pressure in the chest and uneasiness; these symptoms will normally disappear when the person is removed to fresh air.
- Moderate exposure leads to nausea, gastro-intestinal symptoms accompanied by vomiting, stomach ache, disturbance of equilibrium, strong pains in the chest and difficulty in breathing.
- Exposure to very high concentrations caused strong difficulty in breathing, bluish purple skin color, unconsciousness and death. Detection and monitoring devices for phosphine should be on hand while undertaking fumigation work.
- A first-aid kit should also be available.

7.6. AlP (Phosphine) fumigation: Do's and Don'ts

Do	Carry out fumigation by Accredited Fumigators or trained persons under the direct supervision of an Accredited Fumigator.
	Involve at least 2 trained persons for application of the fumigant.
	Remove all jewellery, watches, rings, necklace, bracelet, and keys from the person applying fumigant.
	Follow the product LABEL and usage instructions.
	Use appropriate RPE equipment during fumigant application and aeration.
	Open QUICKPHOS(Aluminium Phosphide 56%) pouch in ventilated area before dispensing
	Complete the product distribution in one session without any break
	Wash hands and contaminated clothing thoroughly with soap and water after use.
	Use calibrated UNIPHOS leak checker and gas monitor
	Post warning placards in all fumigations to prevent accidental exposure of other workers and bystanders to phosphine gas
	Follow recommended exposure and aeration periods
Don't	Fumigate inhabited buildings
	Fumigate in premises where there is a risk that the phosphine gas could leak from fumigation enclosures into working areas.
	Fumigate structures that cannot be sealed adequately.
	Use when commodity temperature is low (<10°C), relative humidity is <30% or when moisture content of seed material is <9%.
	Heap pouches at one place inside the enclosure.

	Allow water to come in contact with AlP formulations.
	Eat, drink or smoke during fumigant application.
	Wear contact lens when working with Aluminium phosphide pouch formulations.
	Rely on odor as a warning of toxic phosphine concentration level (use RPE)

7.7. Precautions for operators (including type of detectors/canister):

- Do not inhale Aluminium Phosphide dust and Phosphine gas.
- Do not open AlP containers with any sharp metallic device as contents may catch fire due to friction.
- Protective clothing like hand gloves and special respirator with reaction type canister must be worn during fumigation with aeration.
- Do not work alone in any fumigation work.
- Odour of the fumigant should not be relied upon as an indication of poisonous concentration of the fumigant.
- Phosphine detector strips or tubes be used before allowing workers entry into the fumigated premises.
- Smoking or eating at any time during fumigation should be strictly prohibited.
- Persons with punctured ear drums must not be employed for fumigation work.
- Aluminium Phosphide Powder formulation liberate highly toxic Phosphine gas on opening the pouch. The gas is liberated on exposure to air. All fumigation work should, therefore, be planned so that operation of placing the tablets, covering with fumigation covers and closing doors and ventilators should be completed within shortest possible time but not more than 30minutes.
- To ensure uniform and speedy placement/distribution of tablets, the points of application should be decided in advance.
- Warning notices must be pasted at the fumigation site to prevent exposure of employees/public to the gas.
- Phosphine reacts with metals especially with copper or copper containing equipment. So all copper containing equipment and parts in the go-downs or other structures should be protected before the start of fumigation.
- Always open the Aluminium Phosphide pouches in open air.
- In order to have proper distribution of PH_3 gas, 2/3rd of the Aluminium Phosphide pouches should be placed/distributed on the upper half of the stack.

7.8. Medical aid:

a) Symptoms of poisoning:

Phosphine is highly toxic to human beings. The gas is not absorbed through the skin. There is no evidence of cumulative effects from intermittent, low level exposure of 10 ppm or less. At higher concentration, inhalation of Phosphine may produce symptoms including nausea, vomiting, diarrhea, headache, chest pain and massive accumulation of fluids in the lungs before death.

b) Treatment:

The treatment is only symptomatic and supportive. If Phosphine has been inhaled, immediate hospitalization and observation for 72 hours for delayed onset of severe pulmonary edema is advisable. Obtain chest X-ray, examine for infiltrates and perform analysis of arterial blood gases. Maintain PO2 above 60 mg. Hg by instituting in stepwise fashion, the following measures are needed;

- Administration of 60 to 100 percent Oxygen by mask or cannula;
- Intubation and mechanical ventilation, and
- Positive and expiratory breathing. Fluid balance must be maintained; use of diuretic may be required. Steroids may be administered for two to four days to decrease the inflammatory response of the lung.

Treat central nervous system effects symptomatically.

c) Safety Precautions for FHAT:

- Fire Extinguisher at the facility
- Helmet and Safety shoes to be used by the workers and visitors.
- First aid kit to be available at the site.
- Hard hats, Gum boots, Gloves and Goggles to be used by the operator

d) Safety and Health Checklist for Hot water Immersion Treatment

- An adequate lavatory.
- Fire extinguisher located near the boiler.
- First-aid kit located near moving machinery.

- Hard hats for use by workers and visitors in the treatment and loading areas.
- Approved safety ladders or walkways (catwalks, etc.) for use in observing treatment tank operations.

- Electric power must meet safety code requirements. Electrical wiring, including switches and other connections, shall be contained in metal or PVC conduit, and grounded to prevent electrical shock.
- Steam and hot water pipes shall be insulated or otherwise protected.
- Sufficient lighting shall be provided in working areas.
- Engines, pulleys, drive belts, and other hazardous moving parts, if located within 6 feet of floor level, shall be guarded with a safety shield or barrier
- The admission of children or unauthorized persons into the treatment and packing areas shall be prohibited, if not accompanied by a responsible employee.
- Dirty water in the tanks is a health concern, as well as an embarrassment to the operator. The BAFRA inspector can provide advice on how often the water should be changed. In addition, BAFRA recommends that operators should install a light sensor in each tank, to monitor the turbidity of the water.

e) Safety precautions for Vapour Heat Treatment:

- Fire Extinguisher at the facility
- PPE's to be used by the treatment operators.
- First aid kit to be available at the site.
- Hard hats, Gum boots, Gloves and Goggles to be used by the operator

f) Safety precautions for CO2 Treatment

- Adequate precautions should be taken when working in areas close to controlled atmospheres or on entering storages that have been treated to avoid any harmful effects.
- Nitrogen atmospheres containing less than 14 percent oxygen, or more than 5 percent carbon dioxide may be dangerous to human life. Personnel entering a nitrogen atmosphere containing less than 10 percent oxygen may collapse without warning and become unconscious.
- Carbon dioxide produces respiratory discomfort, lightheadedness and nausea, and unconsciousness may occur in less than five minutes in 9 percent CO2. In any case, where unconsciousness or respiratory distress occurs through exposure to a controlled atmosphere, the victim must be taken immediately to fresh air.
- Portable oxygen monitors or carbon dioxide analyzers should be available on the work site as well as air-line or self-contained breathing apparatus. Gas masks with canisters provide no protection against low oxygen or high carbon dioxide atmospheres.

- All enclosed working areas close to controlled atmospheres should be well ventilated and gas reservoirs should be kept outside if possible (Banks and Annis, 1977).

ANNEXURE

Annexure 1. Insect Pests of Stored Food Grains

S.No	Common Pest Name	Scientific Name	Damaging stage	Major host
1	2	3	4	5
CEREALS				
1	Rice weevil	*Sitophilus oryzae**	Larva & Adult	Sorghum, Sweet Sorghum, Bajra, Wheat, Corn, Paddy
2	Lesser grain borer	*Rhyzoperthadominica**	Larva & Adult	Bajra, Wheat, Corn, Paddy
3	Khapra beetle	*Trogoderma granarium*	Larva	Sweet Sorghum, Wheat, Paddy
4	Saw-toothed grain beetle	*Oryzaephilussurinamensis*	Larva & Adult	Sweet Sorghum, Bajra, Wheat, Paddy
5	Grain beetle	*Cryptolestes spp.*	Larva & Adult	Bajra, Wheat, Paddy
6	Angoumois grain moth	*Sitotrogacerealella**	Larva	Bajra, Wheat, Corn, Paddy
7	Tropical warehouse moth	*Ephestiacautella*	Larva	Sweet Sorghum, Bajra, Wheat, Maize, Paddy
8	Rice moth	*Corcyra cephalonica*	Larva	Sweet Sorghum, Bajra, Wheat, Maize, Paddy
9	Psocids	*Liposceli spp.*	Adults	Bajra, Wheat, Maize, Paddy
PULSES				
1	Cowpea beetle	*Callosobruchusanalis**	Larva & Adult	Red gram, Peas, Beans, Green Gram
2	Adzuki bean weevil	*C. chinensis**	Larva & Adult	Red gram, Peas, Beans, Green Gram
3	Cowpea beetle	*C. maculatus**	Larva & Adult	Red gram, Peas, Beans, Green Gram
4	Rice weevil	*Sitophilus oryzae**	Larva & Adult	Red gram, Peas

PEAS				
1	Groundnut borer	*Caryedon serratus**	Larva	Groundnut, Soya Bean, Sesamum
2	Tropical warehouse moth	*Ephestiacautella*	Larva	Groundnut, Soya Bean, Sesamum
3	Merchant grain beetle	*Oryzaephilusmercator*	Larva & Adult	Groundnut, Soya Bean, Sesamum
4	Saw-toothed grain beetle	*Oryzaephilussurinamensis*	Larva & Adult	Groundnut, Soya Bean, Sesamum
5	Flour beetles	*Tribolium spp.*	Larva & Adult	Groundnut, Soya Bean, Sesamum
6	Khapra beetle	*Trogoderma granarium*	Larva & Adult	Groundnut, Soya Bean, Sesamum
VEGETABLES				
1	Flour Beetles	*Tribolium spp.*	Larva & Adult	Okra, Tomato, Brinjal
2	Tropical Warehouse Moth	*Ephestiacautella*	Larva	Okra, Tomato, Brinjal
3	Angoumois Grain Moth	*Sitotrogacerealella**	Larva	Okra, Tomato, Brinjal

*These insects complete part of their life cycle inside whole grain; they are the cause for hidden/internal infestation.

Annexure II. List of Insect pests

Insect Pests of Sweet Sorghum Seeds	
Insect Pest Common Name	**Scientific Name**
Warehouse moth	*Ephestiacautella*
Saw toothed Grain Beetle	*Oryzaephilussurinamensis*
Rice Moth	*Corcyra cephalonica*
Khapra Beetle	*Trogoderma granarium*
Rice Weevil	*Sitophilus oryzae*
Insect Pests of Sorghum	
Rice Weevil	*Sitophilus oryzae*
Maize Weevil	*Sitophilus zeamais*
Granary Weevil	*Sitophilus granaries*
Insect Pests of Corn & Sweet Corn	
Maize Weevil	*Sitophilus zeamais*
Rice Weevil	*Sitophilus oryzae*
Angoumois Grain Moth	*Sitotrogacerealella*
Larger grain borer	*Prostephanus truncates*
Lesser grain borer	*Rhyzoperthadominica*
Red Flour beetle	*Triboliumcastaneum*
Cigarette Beetle	*Lasiodermaserricone*
Insect Pests of Bajra	
Lesser grain borer	*Rhyzoperthadominica*
Rice Weevil	*Sitophilus oryzae*
Red Flour beetle	*Triboliumcastaneum*
Saw toothed Grain Beetle	*Orzaphilussurinamensis*
Flat Grain beetle	*Cryptolestes spp.*
Angoumois Grain Moth	*Sitotrogacerealella*
Rice Moth	*Corcyra cephalonica*
Warehouse moth	*Ephestiacautella*
Psocids	*Liposcelis spp.*
Insect Pests of Beans Seeds	
Cowpea bruchids	*Callosobruchus spp.*
Bean bruchids	*Acanthoscelidesobtectus*
Larger grain borer	*Prostephanus truncates*
Lesser grain borer	*Rhyzoperthadominica*
Rice Weevil	*Sitophilus oryzae*
Red Flour beetle	*Triboliumcastaneum*

Annexure III. Temperature requirements for the breeding of stored Food grains

Species	Optimum Temperature (°C)	Rate of Increase /Pair/Month

Triboliumcastaneum	32-35	70
Cryptolestesferrugineus	32-35	60
Oryzaephilussurinamensis	31-34	50
Ephestiacautella	28-32	50
Sitotrogacerealella	27-31	50
Callosobruchuschinensis	27-31	30
Sitophilus oryzae	27-31	25
Lasiodermaserricorne	32-35	20
Rhyzoperthadominica	32-35	20
Trogoderma granarium	33-37	13
Corcyra cephalonica	28-32	10
Stegobiumpaniceum	25-30	8

Annexure IV. Aluminium phosphide (phosphine releasing) formulations

Active ingredient	Formulations	Comments
Aluminium phosphide	56% 3g tablets, 56% powder 34 g pouches	General purpose fumigant for various stored products
	56% 10g pouches (powder); 15% 12g tablets	Farm level use
	77.5% granules	Used with on-site phosphine generators

Annexure V. Suggested phosphine dosages and target terminal concentrations for effective fumigation

Commodity	Pest type	Temperature conditions	Phosphine Dosage (g/m^3)	Exposure Days (minimum)	Target End concentration (ppm)
All cereals except paddy rice, legumes & spices	All insects except Khapra beetle	≥25°C	3	7	500
		10-24 °C	3	10	300
	Phosphine-resistant insects and Khapra beetle	≥25°C	6	10	1000
		10-24 °C	6	14	600
Paddy rice, groundnut with shell,whole spices and legumes.	All insects except Khapra beetle	≥25°C	4-8	7	500
		10-24 °C	4-8	10	300
	Phosphine-resistant insects and Khapra beetle	≥25°C	4-8	10	1000
		10-24 °C	4-8	14	600

S.No.	Equipment	Specification if any		Minimum No of Units	Purpose
1	2	3	4		5
A	GENERAL				
1	Fumigation Covers (Tarpaulin) (a) Multi layered Cross Laminated Film (MLCL)	As per IS 14611 (1998) (Reaffirmed 2003)		2	To carry out stack fumigations under a temporary enclosure
2	Sand snakes	1-meter length, 15 cm. diameter must be filled about 75% with dry sand so that they lie flat on the floor		According to requirement	To make ground sealing of fumigation sheet/cover so as to make it air tight.
3	Adhesive Tape (Plastic)	2" width	As required	For sealing	For sealing
4	Measuring tape	25m length, roll-in type	1	To measure volume enclosure	To measure volume enclosure
5	Danger/Barricade strips/ Tape	--	As required	For demarcation of danger area	For demarcation of Danger area

Annexure VI. Essential Equipments for Phosphine fumigation

B	GAS MONITORING accessories				
1	Gas sampling tube/pipes	The sampling lines should be made up of crushproof nylon (2mm ID hydraulic hose is effective).	As required	To monitor phosphine gas	To monitor phosphine gas

2	Gas monitoring equipment	Capable of measuring phosphine gas concentration 1- 2000ppm	1	To monitor phosphine gas	To monitor phosphine gas
		Detection for PH3 for leak checking and for personal safety (1-10 ppm range)		To warn the operator for phosphine presence and leak checking	To warn the operator of Phosphine presence and leak checking
4	UNIPHOS gas monitoring / detector kit	Consists of carrying case, detector tubes, spare parts set, gas pump.	1 unit, tubes in pkts	For checking TLV	For checking TLV
5	Detectors strip				For Checking TLV
C	**SAFETY**				
1	Canisters for use with inorganic gases like phosphine	--	2	To protect against Inhalation of fumigant.	To protect against inhalation of fumigant.
2	Phosphine gas detection strips	Test strips impregnated with chemicals for detection of Phosphine gas	1 box	For checking phosphine at TLV	For checking phosphine at TLV
3	Gas mask (Full vision face mask)	As per IS:8523/1977 full vision face mask with corrugated tube, carrying strap	2	To protect against inhalation of toxic fumigant.	To protect against inhalation of toxic fumigant.

4	Portable oxygen cylinder with nose and mouth cap	--	1	Emergency supply of Oxygen	Emergency supply of oxygen
5	Dust Masks		2	To protect against inhalation of chemical dusts, aerosols etc.	To protect against inhalation of chemicals, dusts, aerosalsetc
6	First Aid Box	--	1	To render first aid measure	To render first aid measure
7	Goggles	--	As required	To protect eyes while applying fumigant	To protect eyes while applying fumigant
8	Gloves	Rubberized/PVC	As required	To protect hands from hazardous chemicals	To protect hands from hazardous chemicals
9	Resuscitator	--	1	To restore breathing in case of accidental exposure to fumigant.	To restore breathing in case of accidental exposure to fumigant.
10	Gum boots	--	As required	To protect feet from hazardous chemicals.	To protect feet from hazardous chemicals.
11	Fire Extinguisher	--	As required	To protect against fire hazards	To protect against fire hazards

Annexure VII. Field Fumigation Checklist

CLIENT NAME:
DATE: **TIME:**
Temperature during exposure:
Relative Humidity: **Seed material:**
Moisture content (%):

S.No.	Particulars	Remarks
1	Fumigation site well protected and ventilated	Yes /NO.
2	Fumigation stack free from all 4 sides	Yes /NO.
3	All concerned informed about fumigation plan	YES/NO
4	Condition of Fumigation sheet/cover minimum150 GSM MLCL without pin holes or any damage	Good / Damaged
5	Condition of Sand Snakes 1mt length 15cm diameter with 75% dry sand.	Yes/No
6	Quantity of seed material to be fumigated, No. of bags	MT (----- BAGS)
7	Volume of the stack	(L x H x W) Cu. Mt
8	Recommended Dosage of Fumigant	3gm phosphine per m^3
9	Quantity of fumigant (phosphine) required	
10	Quantity of fumigant aluminium phosphide formulation to be used for a particular stack	Number of sachets(34g)- Total gms -
11	Quickphos formulation Batch no .....Mfg dt.....Exp.dt	
12	Use of Danger/warning placard on Fumigation cover	Yes / No
13	Stack Card attached on fumigation enclosure	Yes /No
17	Duration of fumigation/exposure period, minimum 7 DAYS - terminal target concentration minimum 500 ppm	7 DAYS
18	Date of Fumigation & degassing mentioned	Yes / No

19	Prophylactic treatment carried out outside the enclosure	Yes/ No			
20	Any leakages observed & corrected	Yes/No			
21	**Monitoring Fumigant Concentration** Target terminal concentration must be above not less than 500 ppm	FB	MC	TB	Average
		Day 2			
		Day 4			
		Day 7			
22	Date of Degassing				
23	Phosphine concentration around the site/stack enclosure must be below TLV – 0.3 ppm. Actual Concentration observed…. after 1day aeration 2nd day of aeration 3rd day aeration	Date:PPM:…….			
25	Result of fumigation	Success/ Failure			
26	Residues disposed off as per Product label guidelines	Yes/No			
27	Any other observation				

Fumigation Agency supervisor:

Contact number:

7.

Annexure VIII. List of Essential Equipments - FHAT

S.No.	Equipment	Make	Quantity	Specifications
1.	Temperature Sensors	Gefron (Italy) or equivalent	Minimum 6	Sensor type: RTD (PT-100) Diameter: 4mm Temperature range: 0-400^{0}C Length: variable (95 mm to 230 mm)
2	PID Temperature Controller with Sensor	Honey Well or Equivalent	1	Controller Type: PID Single loop I/P Signal Type: Analog Universal (RTDs, Thermocouple, mV, mA) O/P Signal Type: Analog (4-20 mA &SSR O/P Digital O/P Type: Relay O/P with Two NO/NC Contact (Rating 5 Amp) Supply Voltage:220 V/50 HZ Working Range:0-200^{0}C Accuracy: 0.5% of Span Cutout Size: 96 X 96mm
3	Paper less Temperature Recorder (Data logger)	Honey Well or Equivalent	1	Input: Six Universal (T/C, RTD, mV, V, mA) Screen size: 5” colour LCD Data Storage: 1:44 MB Floppy Memory Buffer: 2MB Battery Backup Ethernet Connectivity: Provided Fuzzy Logging:Provided Alarm: 32 Integrated Soft Alarms Power Supply: Universal (90-250 V, AC) Dimensions: 144 X 144 mm
4.	Blowers	BIS Marked	As per requirement	Capacity: 12000 CFM Motor: 3.5 K.W. Input Supply: 3 Phase/415 V, 15 A
5	Electrical Heaters (Optional)	BIS Marked	As per requirement	Capacity: 494740 BTU/hr Electric Supply: 150 KW
6	Fire extinguisher	BIS Marked	As per requirement	
7	Computer with accessories (Colour printer etc.)	--	1	
8	Air Conditioner	--	As per requirement	
9	Moisture Meter	--	1	
10	Thermometer (Calibrated)	100 deg. C	1	

Annexure IX. List of Essential Equipment – Vapour Heat Treatment

Equipment	Make	Specification
Temperature Recorder:	**Strip chart type:**	Automatic recording
	Honey Well DPR 3000 Version D4 (12 channel capability) or	Recording time: 12 hrs
	Honey Well DPR 3000 Version D4 (12 channel type)	Frequency of Recording: two min interval
		Recording Type: Numerical print or pen line representing each channel by colour, number or symbol
		Accuracy: With in 0.3^{0}C
		Repeatability: With in 0.06^{0}C
		Measuring range: between 37.8^{0}C and 54.4^{0}C
Chart paper		Scale: ^{0}C
		Scale deflection: 5 mm for each 1^{0}C
		Subdivisions: one tenth or one twentieth of a degree in the range of 45^{0}C to 47.8^{0}C
		Chart speed: 2.5 cm for every 5 min
		Chart length: upto 12 hours in case of continuous flow treatment or sufficient for one entire treatment in batch type system
PID Temperature Controller (Thermostat)		
Temperature Sensors	Cooper Instruments Corporation model 99A or TC100A or Equivalent	Platinum 100 Ohm resistive thermal detectors (RTD) sensors. The sensor units located within the distal 2.54 cm of the sensor rod and sensor shall have an outer sheath of 5.4 mm in diameter or less

Portable sensors or probes	Cooper Instruments Corporation model 99A or TC100A or Equivalent	Thermistor or thermocouple sensors each with its own flexible cord at least 30cm
Portable temperature Monitor	Cooper Instruments Corporation model 99A or TC100A or Equivalent	12 channel type, which can read to the nearest one tenth of a degree
Certified Centigrade glass-mercury thermometer		The thermometer shall be accurate to 0.1^0C and will cover the range between 450C and 47.80C
Constant temperature	------	-------
Hot-water bath		
Steam Boiler		Oil- fired, gas- fired or combination, A boiler used for the purpose of heating the water in a two-tank batch system must have an output rating of approximately 1,000,00 BTU, or 30 horsepower
Diesel Power Generator		
Air-Water vapour Mixing		
Unit & circulation system		
Vapour Heat Treatment Chamber		Made of Stainless steel fitted with steam inlets of appropriate size for holding the fruits in trays
Fruit sizing/grading equipment		Roller type sizing equipment, automatic
Safety Alarm equipment		This system may be an audible noise (such as a horn, buzzer, or bell),or a highly visible light, attached to a timing device located on the equipment that indicates time and temperature.
Fruit Trays		Stainless steel perforated trays for stacking of commodity in treatment chamber
Portable balance		For weighing individual fruits
Water Circulation Pump		
Computer/Microprocessor		

Annexure X. List of Essential Equipments: Hot Water Immersion Treatment

Equipment	Make	Specification
Temperature Recorder:	**Strip chart type:**	Type: Automatic recording type
	Honey Well DPR 3000 Version D4 (32 channel capability) or Honey Well DPR 1000 (6 channel type) or equivalent	Recording time: 12 hrs
		Frequency of Recording: two min interval
		Recording Type: Numerical print or pen line representing each channel by colour, number or symbol
		Accuracy: With in 0.3^{0}C
	Honey Well DPR 3000 Version D4 (32 channel type) or HAACP warrior PTR-4 (4 channel type) or PTR-10 (10 channel type)	Repeatability: With in 0.06^{0}C
		Measuring range: between 37.8^{0}C and 54.4^{0}C
Chart paper		Scale: ^{0}C
		Scale deflection: 5 mm for each 1^{0}C
		Subdivisions: one tenth or one twentieth of a degree in the range of 450C to 47.80C
		Chart speed: 2.5 cm for every 5 min
		Chart length: upto 12 hours in case of continuous flow treatment or sufficient for one entire treatment in batch type system
Temperature Sensors		Platinum 100 Ohm resistive thermal detectors (RTD) sensors. The sensor units located within the distal 2.54 cm of the sensor rod and sensor shall have an outer sheath of 5.4 mm in diameter or less
Portable sensors or probes	Cooper Instruments Corporation model TM 99A or TC 100A	Thermistor or thermocouple sensors each with its own flexible cord at least 30 cm
Portable temperature monitor	Cooper Instruments Corporation model TM 99A or TC 100A	24 channel type, which can read to the nearest one tenth of a degree
Certified Centigrade Glass- mercury thermometer		The thermometer shall be accurate to 0.10C and will cover the range between 450C and 47.80C
Constant temperature	------	-------
Hot-water bath		

Steam Boiler		Oil- fired, gas- fired or combination, A boiler used for the purpose of heating the water in a two-tank batch system must have an output rating of approximately 1,000,00 BTU, or 30 horsepower
Chain Hoist (Electronic type)		Lodestar electronic chain hoist, capacity to 3 tons
Fruit sizing equipment		Roller type sizing equipment, automatic
Safety Alarm Equipment		This system may be an audible noise (such as a horn, buzzer, or bell), ora highly visible light, attached to a timing device located on the equipment that indicates time and temperature.
Fruit crates (plastic)		Standard, plastic fruit crates required for batch system
Portable balance		For weighing individual fruits
Batch system	Agri-Machinery Inc., USA	2 tank system with 4 baskets each with Honey Well strip chart recorder
Continuous flow systems (complete instrumentation)	Fruitico International Mexico	

Annexure XI. List of Essential Equipments – CO2 Fumigation

S.No.	Equipment	Quantity	Range
1	CO2 Monitor	2	Transmission distance of 5kms line of sight
2	CO2 Analyser	1	0 to 100 %
3	Grain Moisture meter	1	

Annexure XII

APPLICATION FOR REGISTRATION OF FUMIGATION AGENCY/ ORGANIZATION WITH ACCREDITED FUMIGATION OPERATOR	
Fumigation Company/Branch Name	
Address (including Tel/Mobile/ Fax/E-mail)	
Manager of the Fumigation agency	
Head of Office particulars Name & Address	
Description of organizational structure of the company/ branch **(Attach a copy of Organization Chart)**	
Area of Operation	
Brief accounts of the activities of the firm	

Details of technical personnel employed by the company/ branch

Name	Date of employment	Designation	Qualifications	Job Work

Particulars of Fumigation Operators for whom the accreditation sought

Name	Applicant's Father Name	Date of Employment	Qualifications (Degree/ University/Subject)*	Accreditation training (Dates/Place)*	Apprenticeship (Period /Name of Supervisor)

***Attach documentary proof in respect of qualifications/ training/ apprenticeship**

Whether the company/ branch has valid State licenses, if so particulars there of (Attach a copy of license)	**Yes/No**
Whether the company/ branch is applying for the registration for the first time under Accreditation Scheme?	**Yes/No**
Is the application for renewal of registration of fumigation company? If so, give the particulars of Regd. Number/date of issue/valid up to (Attach original Registration Certificate)	**Yes/No**
Is the application for revalidation of accreditation of Fumigation Operator? If so, give the particulars of accreditation number/date of issue/valid up to (Attach original Accreditation Certificate)	**Yes/No**

Is the application for additional accreditation operator? If so, furnish the list of accredited Fumigation Operators with the registered fumigation company/ branch (Attach list).	**Yes/No**
Whether the company/branch has all the essential equipment for undertaking fumigation as per the Standard? (Attach list of essential equipment procured by the fumigation agency along with specifications /Number of units – Annexure- I)	**Yes/No**
Is any separate, secured & ventilated storage facility for storing fumigants?	**Yes/No**
Particulars of payment of registration/ renewal fee (Name of the Bank & branch/ DD No). (Attach bank draft)	**Yes/No**
Whether compliance agreement enclosed?	**Yes/No**
Name & Signature of Fumigation Operator applying for accreditation with Date	
Name & Signature of Manager with Date & Seal	

For Official Use by NPPC			
Application Number:	Date of Receipt:	Acknowledgement Issued:	Initialed by/Date:
Date of Scrutinization:		Deficiencies Communicated:	Initialed by/Date:
Date of Assessment:	Assessed by	Assessment Report Received:	Initialed by/Date:
Registration Number:	Date of Issue/ Revalidation:	Registration certificate issued:	Initialed by/Date:
Accreditation Number:	Date of Issue/ Revalidation:	Accreditation certificate issued/ endorsed:	Initialed by/Date:

Acknowledgement Slip –NPPC	
Application Number:	**Date of Receipt:**
Received from M/s:…….. along with Bank Draft No……. for Rs……..	**Dated: on**
Signed by /Date	

Annexure XIII. List of Equipment/Accessories

S.No.	Name of the Equipment/ Accessories	Make	Specifications including ISI, ifany	No. of units available withfirm	Date of purchase / Procurement

Annexure XIV

COMPLIANCE AGREEMENT	
1. From:	**2. To** **NPPC**
(Name of Fumigation Company/ Branch)	
3. Agreement related to:	
Registration of Fumigation Agency and accreditation of Fumigation Operator for undertaking Aluminium phosphide fumigation operations under Accreditation Scheme.	
4. **Applicable Phytosanitary Regulatory Requirements**	
5.I/we agree to the following:	
1.To take all possible precautions for the safety of workers engaged in fumigation operations with Aluminium Phosphide under close supervision of the recognized fumigation operator.	
2. To abide by the provisions of Insecticides Rules while undertaking fumigation and commercial pest control operations.	
3. Not to undertake any fumigation operations with Aluminium Phosphide in residential premises, cattle sheds and other public areas where animal/ human life is present.	
4.To follow all instructions and procedures, prescribed by NPPC authorities in planning, set-up and conduct of fumigation.	
5.To informNPPCany change of address of the firm or transfer, retirement, resignation and death of the recognized fumigation operators within two weeks from the date of effect.	
6. To provide all essential Equipments for fumigation operation and maintain them in good working conditions.	
7. To extend all necessary assistance and cooperation to the officers of NPPCduring annual/ surprise audit check.	
8. To follow correct fumigation practices as specified in the standard.	
9. To keep and maintain up to date all records related to fumigation as specified in the standard and make these available for verification during audit check.	
10. To certify that applicant is not accredited with any other agency and if accredited, No Objection Certificate (NOC) from the earlier agency has been obtained and furnished.	
6. Name & Signature of Fumigation Operator with Date:	**7. Name & Signature ofManager with date:**
8. Verified by(Name & Signature of Authorized Officer):	**9. Approved byNPPC :**

Annexure. XV			
ASSESSMENT REPORT FOR REGISTRATION OF FUMIGATION COMPANY WITH ACCREDITED FUMIGATION OPERATOR			
Name of Fumigation Company / Branch Assessed:			
Date (s) of Assessment			
Name of Manager:			
Name of Fumigation Operator Assessed:			
Details of Assessment of Fumigation Company/Branch			
1	Organizational structure & Technical Resources for undertaking fumigation operations		
	◆ Adequate ◆ Inadequate		
	Comments:		
2	Management Responsibilities/ Commitments to meet the requirements of AIP Standard (licenses/ documentation of fumigation practices/training of workers/health check-ups/safety requirements etc.)		
	◆ Adequate ◆ Inadequate		
	Comments:		
3	Stocking of Essential Equipments & Accessories		
	◆ Adequate ◆ Inadequate		
	Comments:		
4	Calibration and annual servicing of gas monitoring / Leak detectors / Relative humidity measurement & Maintenance of calibration and service records		
	◆ Yes ◆ No		
	Comments:		
5	Maintenance of records of the following for a minimum of 2 years		
	Equipment purchase and calibration records	Stock purchase and usage records	Internal Training records
	◆ Yes ◆ No	◆ Yes ◆ No	◆ Yes ◆ No
	Comments:		
6	Separate storage facilities for fumigants		
	◆ Safe and Secure ◆ Poor Storage		
	Comments:		
7	Operational Plan for servicing & maintenance of respiratory protection equipment(Gas Masks/ SCBAs)		
	◆ Yes ◆ No		
	Comments:		
	Details of Assessment of Fumigation Operator		
8	Knowledge about regulatory requirements, principles of fumigation and general practice		
	◆ Adequate ◆ Inadequate		
	Comments:		

9	Awareness of Responsibilities of Fumigation Operator under the Accreditation Scheme
	☐ Adequate ☐ Inadequate
	Comments:
10	Awareness of fumigation of forbidden commodities or places
	☐ Adequate ☐ Inadequate
	Comments:
11	Knowledge about physicochemical properties and safety formulations of Aluminium phosphide fumigant
	☐ Adequate ☐ Inadequate
	Comments:
12	Knowledge of correct fumigation practices (Dosage/exposure period/ ALP application/ distribution/ RH relationships/ impervious packing materials)
	☐ Adequate ☐ Inadequate
	Comments:
13	Ability to select site for fumigation and make gas-tight enclosure in case of sheet fumigation
	☐ Yes ☐ No
	Comments:
14	Ability to measure monitor gas concentrations during fumigation and testing for gas leakages
	☐ Yes ☐ No
	Comments:
15	Ability to demonstrate use of protective equipment (gas masks/SCBAs), their fitness testing, cleaning & maintenance
	☐ Yes ☐ No
	Comments:
16	Ability to comprehend the label requirements and hazards associated with use of Aluminium phosphide
	☐ Yes ☐ No
	Comments:
17	Knowledge about Aluminium phosphide poisoning, first-aid/safety measures
	☐ Adequate ☐ Inadequate
	Comments:
18	Additional Comments on past performance (where applicable)
19	Recommendation regarding Registration Company with Accredited Fumigation Operator/Additional accreditations
	☐ Recommended ☐ Not Recommended
20	Reasons for not recommending

Name & Signature of Assessors with Date:	
1	2

Annexure XVI - INSEPCTION TEAM ASSESSMENT REPORT

Annexure-1: Particulars of technical expertise (educational qualifications/ training etc.) supported by appropriate documentary evidence.

S.No.	Particulars	(To be filled by Inspection Team)
1.	Name of Expert	
2.	Educational Qualifications	
3.	Institute from where basic training on fumigation acquired	
4.	Reference No. and Date of Approval of Expertise from BAFRA, if any	

Annexure XVII: List of Equipments verified

S.No.	Name of the Equipment / Accessories	Make	Specifications including ISI, if any	No. of units available with firm	Working condition as assessed by the Inspection Team including calibration as applicable

Annexure XVIII	
Certificate of Registration of Fumigation Agency	
	Date of Issue:
Registered Number	**Valid up to:**
*This is to certify that the following fumigation agency/ branch has been assessed and granted registration for undertaking **Aluminium Phosphide** fumigation treatments with an accredited Fumigation Operator in accordance with requirements specified in this BPTM and subject to terms and conditions specified as under.*	
( )	
NPPC	
Name of Fumigation Agency/ branch &Address	
Terms & Conditions:	
1. The Registration Certificate shall be displayed in a prominent place open to public by the Fumigation Agency and the Registration Number shall be quoted in all correspondence with NPPC and in the Fumigation Certificates being issued.	
2. The fumigation agency shall hold valid license for stock & use issued by NPPC	
3. The certificate is valid for the period of **two years** as indicated above unless otherwise renewed by the competent authority. The fumigation agency shall apply for renewal at least 45 days prior to expiry of registration.	
4. The fumigation agency shall undertake all fumigation operations under direct supervision of accredited Fumigation Operator and abide by the conditions specified in Compliance Agreement.	
5. The certificate of registration granted shall be liable to be withdrawn/ cancelled, should the said firm involved in making false records or issue fraudulent certificates or failed to meet the requirements of the Aluminium phosphide Standard	
6. This Certificate shall be valid for undertaking AlP fumigation operations within the State in range of 100 KM from branch headquarters.	
Endorsements: Revalidated/ suspended/ cancelled on by Revalidated/ suspended/ cancelled on by Reinstated on by	
Copy to:	

Annexure XIX

Affix Stamp size Photo ---------- **(Signature of FO)** **&ContactNumber** ----------	**Accreditation Card**	
	No.:	
	Date of Issue:	**Valid Up to:**
	Name of Fumigation Operator:	
	Father's Name of Fumigation Operator:	
	Fumigation Company / Address:	
	Issued by: **NPPC**	

Annexure XX

Onsite Audit Check of Fumigation Company and Accredited Fumigation Operator for Accreditation audit			
Name of Fumigation Company/branch audited			
Name of the Manager			
Name of Accredited Fumigation Operator (s)			
Date (s) of Audit			
Audited by			
Activity	**Clause**	**Yes /No**	**Non- conformity**
Does the fumigation company have adequate Camera for photography/ videography and staff organizational Structure, Computer with internet, resources to carry out fumigation?	2.2.5	**Yes /No**	**Critical**
Does the Fumigation Operator has the necessary qualifications & technical competency?	2.1	**Yes /No**	**Critical**
Does the fumigation company have all the essential equipment for carrying out fumigation operations as per the Standard?	2.2.4	**Yes /No**	**Critical**
Does the fumigation agency maintain records of relevant photographs and/or video graphs as required in the standard for the Aluminium phosphide fumigation treatment?	1.6	**Yes /No**	**Critical**
Does the fumigation company have proper record keeping system?	2.7	**Yes /No**	**Minor**
Is thee any secured &well-ventilated place for storage of fumigants?	2.2.4	**Yes /No**	**Minor**
Is the accredited Fumigation Operator able to demonstrate the knowledge of the Standard & Accreditation Scheme?	2.2.3	**Yes /No**	**Major**
Is the accredited Fumigation Operator directly supervising all the fumigation operations?	1.6	**Yes /No**	**Major**
Is the accredited Fumigation Operator undertaking all responsibilities for which he has been accredited?	1.6 (ii)	**Yes /No**	**Major**
Are the gas monitoring/ temperature measuring equipment/ humidity measuring equipment regularly calibrated to manufacturer undertaking all responsibilities for which he has been accredited?	2.2.4	**Yes /No**	**Major**
Is the gas monitoring equipment being used during fumigation operations?	2.2.3	**Yes /No**	**Minor**
Are the equipment calibrations maintained?	2.7	**Yes /No**	

Is the Relative Humidity (50% or above for best effective use)determined prior to the fumigation through a verifiable source and recorded?	2.2.3	Yes / No	**Major**
Does the goods covered with or packaged in gas impervious materials (such as plastic wrapping or laminated plastic films, lacquered or painted surfaces, Aluminium foil, tarred or waxed paper) must have the coverings or packaging opened, cut or removed, prior to fumigation?	2.1	Yes / No	**Major**
Does the fumigation sheets used meet the permeabilityrequirements as specified in the Standard?	2.2.4	Yes / No	**Major**
Did accredited Fumigation Operator meet the sheet fumigation construction requirements of the Standard?	2.2.3	Yes / No	**Major**
Does the accredited Fumigation Operator monitor gas concentrations at specified times during the fumigation as per the Standard?	2.2.3	Yes / No	**Major**
Does the accredited Fumigation Operator check the fumigation enclosure for gas leakages with the help of leak detector after application of Aluminium Phosphide?	2.2.3	Yes / No	**Major**
Whether protective equipment such as respirators / SCBA being used during fumigation?	2.2.3	Yes / No	**Major**
Have the protective equipment been regularly serviced and maintained in working condition as per the documented plan of the fumigation company?	2.2.4	Yes / No	**Major**
Does the fumigation company undertake regular health check-up of Fumigation Operator & workers?	2.7	Yes / No	**Minor**
Is the enclosure aerated at the end of fumigation and tested gas-free before release?	2.2.3	Yes / No	**Minor**
Are the danger sign-boards displayed during fumigation?	1.6 (ii)	Yes / No	**Minor**
Does the accredited Fumigation Operator has the knowledge about emergency measures/ rescue operations in case of accidental poisoning by AlP fumigant?	2.2.3	Yes / No	**Major**
Does the fumigant purchase during the year match with the quantum of fumigation performed by the agency?	1.5	Yes / No	**Critical**
Does the canister purchase during the year match with the quantum of fumigation performed by the agency?	1.5	Yes / No	**Critical**
Does the maximum number of fumigations performed by agency in a day during the audit period match with the available Accredited Fumigation Operator and the instruments *viz.* gas monitor and leak-checker, the distance between one site to other site (give details thereof in Appendix-IX-aa).	1.5	Yes / No	**Critical**
Name & Signature of Auditee with date (**Authorized Signatory of Company**)			
Name & Signature of Auditor (s) with date **1** **2**			

Annexure XXI

Onsite Audit Check of Fumigation Company and Accredited Fumigation Operator for Renewal Audit			
Name of Fumigation Company/branch audited			
Name of the Manager			
Name of Accredited Fumigation Operator (s)			
Date (s) of Audit			
Audited by			
Activity	**Clause**	**Yes / No**	**Non - Conformity**
Does the fumigation company have valid license / registration?	1.6 (i)	Yes / No	**Critical**
Does the fumigation company have adequate organizational Structure, Computer with internet, Camera for photography/ videography and staff resources to carry out fumigation?	2.2.5	Yes / No	**Critical**
Does the Fumigation Operator has the necessary determined qualifications & technical competency?	2.1	Yes / No	**Critical**
Does the fumigation company have all the essential equipment for carrying out fumigation operations as per the Standard?	2.2.4	Yes / No	**Critical**
Does the fumigation agency maintain records of relevant photographs and/or video graphs as required in the standard for the Aluminium phosphide fumigation treatment?	1.6	Yes / No	**Critical**
Does the fumigation company have proper record keeping system?	2.7	Yes / No	**Minor**
Is there any secured & well-ventilated place for storage of fumigants?	2.2.4	Yes / No	**Minor**
Is the accredited Fumigation Operator able to demonstrate the knowledge of the Standard & Accreditation Scheme?	2.2.3	Yes / No	**Major**
Is the accredited Fumigation Operator directly supervising all the fumigation operations?	1.6	Yes / No	**Major**
Is the accredited Fumigation Operator undertaking all responsibilities for which he has been accredited?	1.6 (ii)	Yes / No	**Major**
Are the gas monitoring/ temperature measuring equipment/ humidity measuring equipment regularly calibrated to manufacturer specifications?	2.2.4	Yes / No	**Major**
Is the gas monitoring equipment being used during fumigation operations?	2.2.3	Yes / No	**Minor**
Are the equipment calibrations records maintained for 2 years.	2.7	Yes / No	
Is the Relative Humidity (50% or above for best effective use) determined prior to the fumigation through a verifiable source and recorded?	2.2.3	Yes / No	**Major**

Does the goods covered with or packaged in gas impervious materials (such as plastic wrapping or laminated plastic films, lacquered or painted surfaces, Aluminium foil, tarred or waxed paper) must have the coverings or packaging opened, cut or removed, prior to fumigation?	2.1	Yes / No	**Major**
Does the fumigation sheets used meet the permeability requirements as specified in the Standard?	2.2.4	Yes / No	**Major**
Did accredited Fumigation Operator meet the sheet fumigation construction requirements of the Standard?	2.2.3	Yes / No	**Major**
Does the accredited Fumigation Operator monitor gas concentrations at specified times during the fumigation as per the Standard?	2.2.3	Yes / No	**Major**
Does the accredited Fumigation Operator check the fumigation enclosure for gas leakages with the help of leak detector after application of Aluminium Phosphide?	2.2.3	Yes / No	**Major**
Whether protective equipment such as respirators/SCBA being used during fumigation?	2.2.3	Yes / No	**Major**
Have the protective equipment been regularly serviced and maintained in working condition as per the documented plan of the fumigation company?	2.2.4	Yes / No	**Major**
Does the fumigation company undertake regular health check-up of Fumigation Operator & workers?	2.7	Yes / No	**Minor**
Is the enclosure aerated at the end of fumigation and tested gas-free before release?	2.2.3	Yes / No	**Minor**
Are the danger sign-boards displayed during fumigation?	1.6 (ii)	Yes / No	**Minor**
Does the accredited Fumigation Operator has the knowledge about emergency measures/ rescue operations in case of accidental poisoning by AlP fumigant?	2.2.3	Yes / No	**Major**
Does the fumigant purchase during the year match with the quantum of fumigation performed by the agency?	1.5	Yes / No	**Critical**
Does the canister purchase during the year match with the quantum of fumigation performed by the agency?	1.5	Yes / No	**Critical**
Does the maximum number of fumigations performed by agency in a day during the audit period match with the available Accredited Fumigation Operator and the instruments *viz.* gas monitor and leak-checker, the distance between one site to other site (give details thereof in Appendix-IX-aa).	1.5	Yes / No	**Critical**
Name & Signature of Auditee with date (**Authorized Signatory of Company**)			
Name & Signature of Auditor (s) with date **1** **2**			

Annexure XXII

Annexure-1: Maximum number of fumigations performed in a day during audit period (half yearly)

S.No.	Date	Number of fumigations	Distance covered by FO in a day (KM)	No. of following items available on fumigation date				**Remarks** (does Agency has manpower & other physical infrastructure to perform such number of fumigation)
				Fumigation sheet	Gas monitor	Leak checker	Canisters used	

Annexure XXIII

Corrective Action Report		
Name of Fumigation Company/Branch:		**Location:**
Details of Non-conformity	**Corrective Action to be taken**	**Proposed date for rectification**
Name & Signature of Authorized Signatory of Company with Date		

Annexure XXIV

Fumigation Record							
Fumigation Company/ Branch						**Regd. No.:**	
						Date:	
Description of Goods fumigated							
Commodity	Quantity	No. of packages	Mode of packing	Shipping marks	Container number (s)	Place of fumigation	
Shipment Particulars							
Vessel Name	Port of loading	Country of Export	Foreign port of shipment	Name of Exporter		Name of Importer	
Details of Fumigation Treatment							
Fumigant	Dosage (g/m^3)/ (g/MT)	Date / Time of Starting fumigation	Date / Time of Ending fumigation	Average Temperature in ^oC	RH %	Quantity of fumigant	Volume / Type of Fumigation enclosure
Record of Monitoring Gas Concentration				**Gas Monitor type Used:**			
			Readings of Sampling Lines				
Date	**Time**	**Time Interval**	**S1**	**S2**	**S3**	**Monitored by**	
		4 hours					
		24 hours					
		End of fumigation					
Ventilation process conducted:		Yes / No	**TLV achieved:**			Yes / No	
Name & Signature of accredited Fumigation Operator with date/Accreditation Number							

Annexure XXV: Annexure-1: Check Sheet of Fumigation

Check sheet along with fumigation record to identify procedures and actions before, during and after each fumigation.

Item of Activity	Details of check	Status
Inspection of Fumigation site	Intact floor without cracks or drains	
	Floor not undulated, no pebbles or stones	
	Located in a safe working area	
	Well ventilated	
	Sheltered area, rain and wind protected as far as possible	
Preparation of Commodity	Stacked to allow good circulation leaving enough space	
	Impervious wrapping removed or slashed	
	Commodity not covered in impervious wrapping	
	Not forbidden commodity	
Preparation and installation of AlP Pouches	Relative Humidity (it should be above 50%)	
	Sheets of correct size & specification	
	Gas distribution line installed	
	Gas sampling tubes installed (minimum of 3 per enclosure)	
	Measure enclosure volume or weight of commodity and calculate dosage	
	Establish and mark out hazardous area and place dangerous signs	
	Cover the enclosure with sheet from top and place 2/3rd of AlP pouches on upper half of the stack and place the remaining in the lower half of stack	
Gas leak checking	Ensure risk area and surrounds are free of unprotected personnel (up to 3m)	
	Test leak checker for working	
	Wear and test the respirator for correct fitness	
	Check for gas leakages around enclosure and correct leakages if any	
First & Second Readings	**First Reading:** After 4-6 hours - Measure gas levels on all monitor lines (Concentration – minimum 15% or 108ppm/M^3)	
	Second Reading: After 24 hours - Measure gas levels on all monitor lines (Concentration - minimum 80% or 576ppm/ M^3)	
	Record and document all readings	
End Point Monitoring (after 120 hrs)	Measure gas levels on all monitor lines (Concentration - minimum 30% or 216ppm/ M^3)	
	Record and document all readings	
De-gassing	Wear gas mask and test for fitness	
	Open enclosure and allow ventilation	
	Verify TLV (0.3ppm)	
	Remove warning signs and risk area demarcation	
	Retrieve AlP pouches remnant and dispose the same appropriately	
Documentation	Complete all documentation and release fumigated goods after ensuring gas-free	

Annexure XXVI

Phosphine Fumigation Certificate	
(Company Letter Head)	**Treatment Certificate No:**
DG - BAFRA Regd. No. Date:	**Date of Issue**
This is to certify that the goods described below were treated in accordance with the fumigation treatment requirements of importing country (_____) and declared that the consignment has been verified free of impervious surfaces/layers such as plastic wrapping or laminated plastic films, lacquered or painted surfaces, aluminium foil, tarred or waxed paper etc. that may adversely affect the penetration of the fumigant, prior to fumigation	
The Certificate is valid for the consignments shipped within 21 days from the date of completion of fumigation	
Details of Treatment	
Name of Fumigant	
Date of fumigation	
Place of fumigation	
Dosage of Fumigant	
Duration of Fumigation (in days)	
Average ambient humidity during fumigation (RH)	
Fumigation performed under gastight sheets	**Yes / No**
Description of Goods	
Container Number (or numerical link) / Seal Number	
Name & Address of Exporter	
Name & Address of Importer	
Type and description of cargo	
Quantity (MTs)/ No of packages/No of pieces	
Description of packaging material	
Shipping mark or brand	
Name & Signature of Accredited Fumigation Operator with seal & date/ Accreditation Number	

Annexure XXVII

STOCK/ ISSUE REGISTER FOR ALUMINIUM PHOSPHIDE (AlP) FUMIGANT

S.No.	Date of Entry	Opening Stock of fumigant	Quantity of fumigant purchased	Particulars of Invoice/ LR/ Bill No. & Dt/stock Transfer No. & Date	Total Stock of fumigant	Quantity of fumigant used / transferred	Closing balance	Signature of Authorised Signatory / Head of Office
1	2	3	4	5	6	7	8	9

Annexure XXVIII

Monthly Statement showing details of fumigation undertaken with Aluminium phosphide (AlP)

Name of Fumigation Company/Branch: (BAFRA Regd.No._____dated)			Month of Reporting:	
Opening stock(Kg)	Qty purchased (Kg)	Total Qty (Kg)	Qty used (Kg)	Closing Balance(Kg)

A. EXPORT: Particulars of fumigation carried out

S. N.	Certificate No. & Date	Commodity	Quantity	Country of Import	Dose of AlP applied	Total quantityof ALPused	Name of Fumigation Operator	Remarks

B. IMPORT: Particulars of fumigation carried out

S. N.	Certificate No. & Date	Commodity	Quantity	Country of Export	Dose of AlP applied	Total quantity of ALP used	Name of Fumigation Operator	Remarks

Annexure XXIX		
SURPRISE CHECK OF ACCREDITED FUMIGATION AGENCY		
1	Name and address ofFumigation agency inspected	
2	Date & time of surprise inspection	
3	Surprise check carried out by	
4	Stock position of AlP on date with the firm (as physically verified)	
5	Discrepancies, if any noted in the Maintenance of stock records (as revealed from checking of invoices & utilization of fumigants records	
6	Whether the firm possess valid Certificate of approval/ permission for use of AlP issued by BAFRA. If so,the date of its expiry?	
7	Whether technical expertise recognized by the Directorate is on pay roll of the Firm on date	
8	Whether the fumigation/ safety Equipment possessed by the firm are in working condition	
9	Whether the firm is submitting regular monthly activity report and returns on stock/use of AlP to BAFRA, if not give reason (should be supported by documentary evidences)	
10	Whether the firm possesses separate place for storage of fumigants	
11	Action taken by the firm on non- compliances /interceptions reported by importing countries during the last one year	
12	Date of last surprise visit and discrepancies, if any noticed and action taken by the firm	
13	Remarks and recommendations of officers	
	Name & Signature of Officers who carried out Surprise check with Date	

Annexure XXX

Checklist for the application of the accreditation of Fumigation Agency with Fumigation Operator(s) for Aluminium phosphide Fumigation

S.No.	Particulars
1.	Application in the prescribed format (Appendix-II) alongwith List of equipment / Accessories(Annexure-1)
2.	Application for recognition of Fumigation Operator (Appendix-II)
3.	Compliance Agreement (Appendix-III)
4.	Organization Chart of the Agency / Branch
5.	Copy of B.Sc., (Ag.) or Forestry or B.Sc. Degree with Chemistry as a subject
6.	Copy of equipment's purchase bills / invoice
7.	Copy of Lease Deed Agreement/ ownership proof of the premises
8.	Whether the applicant is accredited with some other agency? If yes, then original certificate of accredited Fumigation Operator & NOC from theconcerned agency may be furnished.

Annexure XXXI

Forced Hot Air Treatment Certificate	
(Company Letter Head)	**Treatment Certificate No:**
(DG, BAFRA Regd. No. Date:)	**Date of Issue**
This is to certify that the goods described below were treated in accordance with the Hot Air treatment requirements of importing country () and declared that the consignment has been verified free of impervious surfaces/layers such as plastic wrapping or laminated plastic films, lacquered or painted surfaces, aluminium foil, tarred or waxed paper etc. that may adversely affect the Hot air treatment.	
The Certificate is valid for the consignments shipped within 21 days from the date of completion of Hot Air Treatment	
Details of Treatment	
Name of Treatment	
Date of Treatment	
Place of Treatment	
Duration of Treatment	
Temperature during Treatment	
Description of Goods	
Heat Chamber - Seal Number	
Name & Address of Exporter	
Name & Address of Importer	
Type and description of cargo	
Quantity (MTs)/ No of packages/No of pieces	
Description of packaging material	
Shipping mark or brand	
Name & Signature of Accredited Treatment Operator with seal & date/ Accreditation Number	

Annexure XXXII

Data Sheet for Vapour Heat Treatment (VHT) Facility for Fresh Fruits & Vegetables

1. **Name of the VHT Facility:**
2. **Location/Address of Facility:**

3.Type of Facility: Manual / Automated

4.Accommodation / Space Particulars (enclose plan and drawings (ground/elevation)						
Office	**Computer**	**Receiving**	**Operational**	**Pre- Cooling**	**Cold Storage**	**Other**
Space (m^2)	**Room (m^2)**	**Area (m^2)**	**Area (m^2)**	**(m^2)**	**(m^2)**	**(m^2)**

5.Total Carpet Area:

6.Particulars of Computer and/or Microprocessor facility

- ✓ *Computer:*
- ✓ *Microprocessor:*
- ✓ *UPS/Surge Protector:*

7.Diesel Power Generator

- ✓ *Make:*
- ✓ *Capacity (HP):*

8. **Fruit Sizing Equipment**
   - ✓ *Make:*
   - ✓ *Specifications*

9. **Steam Boiler**
   - ✓ *Make:*
   - ✓ *Heat Capacity:*
   - ✓ *Type:*

10. **Air-water vapour circulating system**
    - ✓ *Pump type:*
    - ✓ *Number of Pumps:Circulation Capacity*:

11. Temperature sensors (permanent)

- ✓ ***Type:***
- ✓ ***Make/Supplier:***
- ✓ ***Number of Sensors:***
- ✓ ***Placement plan:***

12.Portbale sensors with monitors for use during official performance testing

- ✓ *Make:*
- ✓ *Type:*
- ✓ *Numbers:*

13.Certified glass mercury thermometer for use during official performance testing

- ✓ *Make*
- ✓ *Range*
- ✓ *Numbers*

14. Temperature Recorder

- ✓ *Type*
- ✓ *Make*
- ✓ *Model*
- ✓ *Duration of recording*
- ✓ *Frequency*
- ✓ *Accuracy*
- ✓ *Repeatability*
- ✓ *Range*
- ✓ *Ports*

15.VHT chamber

- ✓ *Dimensions*
- ✓ *Capacity*
- ✓ *No of compartments*
- ✓ *No of fruit trays/Size*

16.Description of pre -cooling/cold storage facilities:

17.Name & signature of technical operator with date

18.Name & signature of Facility Manager with seal & date

Annexure XXXIII

Check Sheet for Preliminary Evaluation/Testing of the Vapour Heat Treatment Facility for Fresh Fruits & Vegetables

S.No.	Evaluation/Testing of Activity	Status (Yes/No/NA)
1	Location, construction & design of facility as per safety norms and as per regulations of local authority	
2	Engineering plans and drawings are approved by BAFRA (applicable for new facility)	
3	Assured supply of potable water and chlorination of water at appropriate levels (50-200ppm) to prevent microbial contamination	
4	Compliance with minimum requirements of certification as per this standard	
5	Electrical wiring throughout the facility meet the safety norms and regulations of local authority including earthing and PVC conduiting	
6	Control panels/Electric Meters etc., are adequately weather protected	
7	Computers/microprocessors are located in air-conditioned to maintain accuracy and reliability and installed with surge protectors/UPS	
8	Support of Diesel generator to have uninterrupted power supply	
9	Fruit sizing equipment installed	
10	Steam boiler with adequate water heating capacity and thermostatic controls and performance testing	
11	Installation of vapour heat treatment chamber with vapour inlets	
12	Installation of air and water vapour circulating system and checking	
13	Installation of permanent RTD temperature sensors in the chamber	
14	Installation of PID Controller and testing the performance	
15	Installation of strip chart recorder/data logger and performance testing	
16	Installation and checking of alarm or other safety system	
17	Insect-proof screening of doors/windows/ventilators to exclude fruit flies	
18	Name and Signature of Technical Operator with date	
19	Name and Signature of Facility Manager with seal and date	
20	Verified by (Name/Signature/Designation of expert / office of DG,BAFRA) with date	

Annexure XXXIV

Director General of BAFRA	Record No:
	Date:
Instruction and Worksheet for Calibrating Portable Temperature Sensors	

1.Name of the facility:

2.Location and address of the facility:

3.Name of facility Manager:

4. Name of the person calibrating the sensors:

CALIBRATING INSTRUCTION

The instructions for calibrating portable temperature sensors that will be used in performance tests for hot water treatment tanks are as follows

- Assign each portable sensor a unique number (write sensor numbers on a piece of duct tape or tag and attach them near **'dry'** end of each sensor
- Submerge the **'wet'** end of the sensors into a circulating hot water bath in a temperature range of 46.1^0C - 48.9^0 C in close proximity to the bulb of submersible certified glass mercury thermometer. Both must be submerged to same depth. The mercury thermometer used as Standard for calibrating portable sensors should read one tenth of a degree Centigrade.
- Record the temperature obtained from each portable sensor and the mercury thermometer in succession. Calculate the difference between the two temperatures, if any and record this also.
- If the temperature shown by the portable sensor falls within 0.3^0C of the temperature shown on certified mercury thermometer, then this sensor considered to be within tolerance limit and may be used in the performance test. Any sensors reading outside the tolerance limit do not meet this Standard for accuracy and should not be used and the same may be recommended for destruction.

Temperature recordings in ^{0}C				
Portable Sensor No.	**Sensor Reading**	**Thermometer reading**	**Difference**	**Remarks**
Signature of the person calibrating sensors with date				

Annexure XXXV

Director General, BAFRA	Record No:
	Date:
Test of the Accuracy of the Permanent RTD Sensors Installed in Vapour Heat Treatment Chamber/Pulp Sensors	

1.Name of the facility:

2.Location and address of the facility:

3.Name of facility Manager:

4. Name of the person testing the sensors:

Testing Instructions:

The instructions for testing the accuracy of permanent RTD sensors installed in hot water treatment tanks, which are connected to a temperature recorder installed in control room, are as follows:

Calibrate all available portable sensors against the certified glass mercury thermometer (see appendix) standard

- Select the portable sensor that shows the least deviation from the certified mercury standard. This particular sensor will now be used as a tool for testing the accuracy of each of the permanent RTD sensors installed in the chambers/pulp sensors
- The calibrated portable sensors are suspended in the vapour heat chamber or tied to a plastic stand at the samelevel of permanent RTD sensors fixed in each compartment of the chamber or inserted into pulp in level with pulp sensors.
- Raise the temperature of vapour heat chamber to 46- 48^{0}C by running the air-water vapour circulation system toensure uniform distribution of air-water vapour. Plug the portable sensor into a handheld digital monitor and read the display. Compare this reading with display on the data logger or strip chart recorder in the control room (You may need an assistant for this purpose). Record the results from the chart on this form at different temperature segment levels. Repeat the procedure for each permanent sensor in the vapour heat chamber.
- Decision: If the temperature shown on the display in control room matches the temperature shown on the hand-held portable temperature monitor (as calibrated), then the permanent sensor in the chamber is acceptable. If the two temperatures do not match exactly, but are within 0.3 C, then this small amount of deviation is considered within tolerance limits. Any permanent sensor that fail this standard must be repaired or replaced;

Hand held digital temperature monitor (Portable sensor number: _____used)				**Make/Model of Temperature Recorder (_____)**		
RTD sensor No/ Location (Fruit Tray Position)	Reading obtained (C) hand held	Correction factor (+ or -)	TRUE reading (0C)	Reading obtained (0C) (in control room)	Difference between (0C) (4-5)	Remarks
Signature of person testing sensor with date						

Annexure XXXVI

DirectorGeneral, BAFRA	Date of Test
Actual Performance Test for Vapour Heat Treatment Facility	
Name of the Facility:	Location:
Facility Manager:	
Fruit variety tested:	Stage of Ripeness:

Temperature at start of test:

Thermostatic set point	Temperature of steam	Fruit Pulp	Ambient air
Notes:			

Fruit Tray No_____ Position _____Test No_____

Readings taken at specific times (minutes)before calibration adjustment, if any. Use one or two pulp sensors per each compartment of chamber for each level. Indicate pulp sensors with an asterisk (*)

Portable sensor No*	**Calibration adjustment**		**0-1**	**2-Jan**	**3-Feb**	**4-Mar**	**5**	**30**	**60**	**75**	**90**
		Time									
		Temp									
		Time									
		Temp									
		Time									
		Temp									
use at least three portable sensors											
Name & Signature of Inspecting Officer with Date											

Annexure XXXVII

Director General, BAFRA		Record No:
		Date
Sensor Location Diagram, Fruit Weights and Pulp Temperatures		
Name of the Facility	*Tank No*	*Test Number*

Instructions:

Show sensor numbers and their approximate location within each tray (Use 3 or 4 sensors per basket. Place an asterisk (*) besides fruit pulp sensors (Use 1 or 2 per test). Indicate by arrow the direction of vapour flow in the chamber.

Weight (g) of ten fruits selected at random	*Weight (g) of six largest fruits*	*Fruit pulp temperature (taken at random)*	*Net weight of a typical field crate of mangoes*
Number of field crates per loaded basket			
Mean weight (g)	*Mean wt (g)*	*Mean temp*	
Remarks			
Name & Signature of Recording Person with date			

Annexure XXXVIII

_____ (Name & Address of Facility)		T.R. No: Date:	
Treatment Record			
1. Name of the commodity:			
2.Batch No:		**3.Quantity (Wt/No):**	
4. Fruit Variety:		**5.Stage of ripeness**	
6.Destined to:		**7.Port of shipment**	
8.Treatment schedule			
9.Distinguishing marks if any		**10.Container particulars**	

11.Temperature at start of test			
Thermostatic set point: ___0C	***Temperature of steam: ___0C***	***Fruit pulp: ___0C***	***Ambient air: ___0C***

12. Temperature recordings during treatment time **(**Recordings at every 5 min intervals madethrough a data logger or strip chart recorder. Attach log sheets					
Permanent RTD Sensor No	***Calibration factor***	***Location (Ambient/Fruit pulp/Tray No)***	***Position (Top/Middle/Bottom)***	***Time of record (ST/RT/ET*)***	***Temp in 0C***
*ST: Start time; RT: Ramp up time; and ET: End Time.					

Mean weight of fruits (in g)		Mean number of fruits per tray (Avg. of six fruits per tray)	Mean Net Weight of fruit tray
Average of six random fruits	Average of six large fruits		
Name & Signature of the technical operator with date			

Annexure XXXIX

Vapour Heat Treatment Certificate	
(Company Letter Head)	**Treatment Certificate No:**
(DG, BAFRA Regd. No. Date:)	**Date of Issue**
This is to certify that the goods described below were treated in accordance with the Vapour heat treatment requirements of importing country () and declared that the consignment has been verified free of impervious surfaces/layers such as plastic wrapping or laminated plastic films, lacquered or painted surfaces, aluminium foil, tarred or waxed paper etc. that may adversely affect the Vapour heat treatment.	
The Certificate is valid for the consignments shipped within 21 days from the date of completion of Vapour heat Treatment	
Details of Treatment	
Name of Treatment	
Date of Treatment	
Place of Treatment	
Duration of Treatment	
Temperature during Treatment	
Description of Goods	
Vapour Heat Chamber - Seal Number	
Name & Address of Exporter	
Name & Address of Importer	
Type and description of cargo	
Quantity (MTs)	
Description of packaging material	
Shipping mark or brand	
Name & Signature of Accredited Treatment Operator with seal & date/ Accreditation Number	

Annexure XXXX

Data Sheet for Hot water Immersion Treatment (HWT) Facility for Mango fruits						
1.Name of the HWT Facility						
2.Location of Facility						
3.Type of Facility			Batch system/Continuous flow system			
4.Construction & Design particulars						
Office space	Computer room	Receiving area	Operational area	Pre- cooling room	Cold storage room	Other areas

5.Particulars of Computer/Microprocessors/UPS/Surge Protector etc)

- Computer:
- Microprocessors:
- UPS/Surge Protector:

6.Diesel Power Generator

- Make:
- Capacity (HP):

7.Fruit Sizing Equipment

- Make:
- Specification

8.Boiler

- Make:
- Heat Capacity:
- Type:

9.Water Circulation System:

- Pump type:
- Number of Pumps:
- Circulation Capacity:

10.Temperature sensors (permanent)

- Type:
- Make/Supplier:
- Number of Sensors:
- Placement plan:

11.Portable sensors with monitor for use during performance testing

- Make
- Type:
- Numbers:

12.Certified glass mercury thermometer for during performance test

- Make
- Range
- Numbers

13.Temperature Recorder

- Type
- Make
- Model
- Duration of recording
- Frequency
- Accuracy
- Repeatability
- Range
- Ports

14.Description of alarm system (**Applicable only in case of batch system**)

15.Description of conveyor type/speed indicator/gear mechanism (**Applicable only in case ofcontinuous flow system**)

16.Treatment Tank

- Type:
- Dimension
- Capacity
- Number of tanks
- Cages type:
- Fruit holding capacity:

17.Description of hydrocooling system, if any:

18.Description of packing/grading system, if any:

19.Name & signature of technical Operator with date

20.Name & signature of authorized signatory with date

Annexure XXXXI

Check Sheet for Preliminary Evaluation/Testing of the Hot Water Immersion Treatment Facility

S.No	Evaluation/Testing of Activity	Yes/No	Critical status
1.	Location, construction & design of facility as per safety norms and as per regulations of local authority		Critical
2.	Engineering plans and drawings are approved by the PPA (applicable for new facility)		Critical
3.	Assured supply of potable water and chlorination of water at appropriate levels (50-200 ppm) to prevent microbial contamination		Critical
4.	Compliance with minimum requirements of certification as per this standard		Critical
5.	Electrical wiring throughout the facility meet the safety norms and regulations of local authority including earthling and PVC conduiting		Critical
6.	Control panels/Electric Meters etc., are adequately rain protected		Critical
7.	Computers/microprocessors are located in air-conditioned to maintain accuracy and reliability and installed with surge protectors/UPS		Critical
8.	Support of Diesel generator to have uninterrupted power supply		Critical
9.	Installation of fruit sizing equipment (required for batch system)		Critical
10.	Boiler with adequate water heating capacity and thermostatic controls.		Critical
11.	Installation of treatment tank (Installation of adequate water circulation system and testing)		Critical
12.	Installation of adequate number of calibrated RTD temperature sensors in the tank		Critical
13.	Installation of time/temperature control switches & testing		Critical
14.	Installation and testing the performance of temperature recorder/data logger and recording frequency		Critical
15.	Installation and checking of alarm system (required for batch system		Critical

16.	Installation and checking of Lodestar electronic chain hoist system (required for batch system)			
17.	Installation and testing of conveyer /speed indicator/gear system (required in case of continuous flow system)			Critical
18.	Insect proof screening of doors/windows/ventilators to exclude fruit flies			Critical
19.	Installation of air curtains prior to entry into quarantine area			Critical
20.	Installation of hydro-cooling system (optional)			Non-critical
21.	Installation of grading and packing system (optional)			Non-critical
22.	Name and Signature of Technical Operator with date			
23.	Name and Signature of Manager/In-charge of facility with date and seal			
23.	Verified by (Name/Signature/Designation of officer of BAFRA) with date			

Annexure XXXXII

Director General, BAFRA	Record No:
Instruction and Worksheet for Calibrating Portable temperature sensors	**Date:**
1. Name of Facility	
2.Location/Address of facility	
3.Name of Facility Manager	
4. Name of the person calibrating the sensors	

CALIBRATING INSTRUCTION

The instructions for calibrating portable temperature sensors that will be used in performance tests for hot water treatment tanks are as follows

- Assign each portable sensor a unique number (write sensor numbers on a piece of duct tape or tag and attach them near **'dry'** end of each sensor.
- Submerge the **'wet'** end of the sensors into a circulating hot water bath in a temperature range of 46.1^0C - 48.9^0C in close proximity to the bulb of submersible certified glass mercury thermometer. Both must be submerged to same depth. The mercury thermometer used as Standard for calibrating portable sensors should read one tenth of a degree Centigrade.
- Record the temperature obtained from each portable sensor and the mercury thermometer in succession. Calculate the difference between the two temperatures, if any and record this also.
- If the temperature shown by the portable sensor falls within 0.3^0C of the temperature shown on certified mercury thermometer, then this sensor considered to be within tolerance limit and may be used in the performance test. Any sensors reading outside the tolerance limit do not meet this Standard for accuracy and should not be used and the same may be recommended for destruction.

Temperature recordings in ^{0}C

Portable sensor No	Sensor Reading	Mercury Reading Difference	Remarks
Signature of the person calibrating sensors with date			

Annexure XXXXIII

Director General,BAFRA	Record No:
Test of the Accuracy of the Permanent RTD Sensors Installed in Hot Water Treatment Tanks	**Date:**
1. Name of Facility	
2.Location/Address of facility	
3.Name of Facility Manager	
4. Name of person testing the sensors	

TESTING INSTRUCTIONS

The instructions for testing the accuracy of permanent RTD sensors installed in hot water treatment tanks, which are connected to a temperature recorder installed in control room, are as follows:

- Calibrate all available portable sensors against the certified glass mercury thermometer (see appendix) standard
- Select the portable sensor that shows the least deviation from the certified mercury standard. This particular sensor will now be used as a tool for testing the accuracy of each of the permanent RTD sensors installed in the tanks.
- Using 2 metres PVC rod and duct tape, fastened the wet end of the portable sensor wire to one end of the rod,being careful not to cover the metal sensor tip with the tape. Tape the sensor wire also to the center, opposite end of the rod to remove the slack.
- Raise the water temperature in the tanks to 45.1 - 48.9 C and run the pump to ensure uniform distribution of heat.Inspect the sides of the tank to locate the exact position of each permanent RTD sensor. Using the portable sensor and rod assembly, dip into the hot water until the portable sensors comes in close proximity of the tank sensor. (Note: - Each basket position should have its own sensor). Plug the portable sensor into a hand-held digital monitor and read the display. Compare this reading with display on the data logger or strip chart recorder in the control room (You may need an assistant for this purpose). Record the results from the chart on this form. Repeat the procedure for each permanent sensor in the tank.
- Decision: If the temperature shown on the display in control room matches the temperature shown on the hand heldportable temperature monitor (as calibrated), then the permanent sensor in the tank is acceptable. If the two temperatures do not match exactly, but are within 0.3 C, then this small amount of deviation is considered within tolerance limits. Any permanent sensor that fail this standard must be repaired or replaced;

Hand held digital temperature monitor (Portable sensor number: _____used)				**Make & Model of Temperature Recorder (_____)**		
Tank No/RTD Sensor No (Basket Position)	Reading Obtained (0C) hand held	Correction factor (+ or -)	True reading (0C)	Reading obtained (0C) (in control room)	Difference between (0C) (4-5)	Remarks
Signature of person testing the sensor with date						

Annexure XXXXIV

Director General of BAFRA			Date of Test
Actual Performance Test for Hot Water Immersion Tank			
Name of the Facility		Location	
Facility Manager			
Fruit variety tested:		Stage of Ripeness:	
	Temperature at start of test		
Thermostatic set point	Water in the tank	Fruit pulp	Ambient air

Notes:

Basket No._____ Tank No_____ Test No_____

Readings taken at specific times (minutes)before calibration adjustment, if any. Use one or two pulp sensors per tank. Indicate pulp sensors with an asterisk (*)

Portable sensor No*	Calibration adjustment		0-1	1-2	2-3	3-4	5	30	60	75	90
		Time									
		Temp									
		Time									
		Temp									
		Time									
		Temp									
		Time									
		Temp									

***use at least three portable sensors**

Name & Signature of Inspecting Officer with Date

Annexure XXXXV

Director General of BAFRA			Record No:
Sensor Location Diagram, Fruit Weights and Pulp temperatures			Date:
Name of the Facility		Tank No	Test Number

Instruction

Show sensor numbers and their approximate location within each basket (Use 3 or 4 sensors per basket. Place an asterisk (*) besides fruit pulp sensors (Use 1 or 2 per test). Indicate by arrow the direction of water flow in the tank (If the tank is of unusual safe, example round please use the reverse side of the pump to draw a diagram showing the position of baskets and sensors).

Basket 1	Basket 2	Basket 3	Basket 4	Basket 5

Weight (g) of ten fruits selected at random	Weight (g) of six largest fruits	Fruit pulp temperature (taken at random)	Net weight of a typical field crate of mangoes
Mean weight (g)	Mean weight (g)	Mean temp	No of field crates per loaded basket
Remarks			
Name & Signature of Recording Person with date			

Annexure XXXXVI

Director General BAFRA	Report No:
Performance Test Report for certification of Hot water Immersion Treatment Facilities for Mango fruits	**Date:**
1.Name of Facility	
2.Location/Address of Facility	
3.Type of Facility	
4.Name of the Facility Manager (including telephone number, Fax etc)	
5.Dates of Inspection	
6.Test carried out by (Name & Designation of officers of BAFRA)i ii	

7.Actual installation of facility is in line with engineering plans and drawings approved by PPA (applicable in case of new facility) or no alterations or modifications affected to existing facility since last performance test

- Yes
- No
- Not applicable

Comments:

8.Inspection of the heating, water circulation, and alarm systems, and checking to see that all necessary safeguards (including screens, fans, locks, and air curtains) are secure and operational.

- Secure and operational
- Insecure and Non-operational

Comments:

9.Calibration of portable sensors with certified glass mercury thermometer (**see Appendix-5**)

- Sensor readings are within tolerance limits
- Sensor readings are outside tolerance limits

Comments:

10.Test of Accuracy of permanent RTD sensors positioned in the tank (**see Appendix-6**)

- RTD sensors passed the test
- RTD sensors failed the test

Comments:

11.Actual performance test of hot water immersion tank **(see Appendix-7 & 8)**

- Passed the test.
- Failed the test

Comments:

12.Remarks & Recommendations for Certification o

- Recommended for Certification
- Requires modifications
- Not Recommended for Certification

Comments:

13.Signature of inspecting officers of BAFRA with date

	Director General BAFRA

Certificate No.		**Date of Issue:**
		Valid up to:

Annexure XXXXVII

Certificate of Approval of Hot Water Immersion Treatment Facility

This is to certify that the hot water immersion treatment facility as described below has been inspected and after official performance test approved for treating fresh fruits in line with the requirements of the Standard and subject to terms and conditions specified below:

Date:	_____	
Place	(	)
Description of Facility		
Name of facility		
Location/Address of Facility		
Type of Facility		
Capacity of Facility		
Terms & Conditions:		

1. The Certificate should be displayed at prominent place and available for verification during inspections to the facility;

2. Any changes or modifications or additions to the facility shall be made with the written approval of BAFRA

3.The certificate shall be valid for a period of one year from the date of issue unless otherwise revalidated prior to expiry for treating fresh fruits

4.All the treatment operations should be performed by a qualified operator of the firm and necessary treatment records/data log sheets are maintained for necessary verification

5.All the treatments should be performed as per the schedules approved by BAFRA.

1. The certified facility should abide by the instructions and guidelines issued by BAFRA from time to time
2. The certified facility shall comply with the requirements and conditions stipulated in the Compliance Agreement.

Endorsements

Revalidated on _____ by_____

Revalidated on_____by_____

Cancelled on _____by_____

Re-certified on_____ by_____

Copy to:

Annexure XXXXVIII

Hot Water Immersion Treatment Certificate	
(Company Letter Head)	**Treatment Certificate No:**
(DG, BAFRA Regd. No. Date:)	**Date of Issue**
This is to certify that the goods described below were treated in accordance with the Hot water immersion treatment requirements of importing country () and declared that the consignment has been verified free of impervious surfaces/layers such as plastic wrapping or laminated plastic films, lacquered or painted surfaces, aluminium foil, tarred or waxed paper etc. that may adversely affect the Hot water immersion treatment.	
The Certificate is valid for the consignments shipped within 21 days from the date of completion of Hot water immersion treatment	
Details of Treatment	
Name of Treatment	
Date of Treatment	
Place of Treatment	
Duration of Treatment	
Temperature during Treatment	
Description of Goods	
Treatment tank - Seal Number	
Name & Address of Exporter	
Name & Address of Importer	
Type of cargo	
Quantity (MTs	
Description of packaging material	
Shipping mark or brand	
Name & Signature of Accredited Treatment Operator with seal & date/ Accreditation Number	

Annexure XXXXIX

Controlled atmosphere CO2 treatment	
(Company Letter Head)	**Treatment Certificate No:**
(DG, BAFRA Regd. No. Date:)	**Date of Issue**
This is to certify that the goods described below were treated in accordance with the Controlled atmosphere CO2 treatment requirements of importing country () and declared that the consignment has been verified free of impervious surfaces/layers such as plastic wrapping or laminated plastic films, lacquered or painted surfaces, aluminium foil, tarred or waxed paper etc. that may adversely affect the Controlled atmosphere CO2 treatment.	
The Certificate is valid for the consignments shipped within 21 days from the date of completion of Controlled atmosphere CO2 Treatment	
Details of Treatment	
Name of Treatment	
Date of Treatment	
Place of Treatment	
Dosage of CO2	
Duration of Treatment	
Temperature during Treatment	
Description of Goods	
Container - Seal Number	
Name & Address of Exporter	
Name & Address of Importer	
Type and description of cargo	
Quantity (MTs)/ No of packages/No of pieces	
Description of packaging material	
Shipping mark or brand	
Name & Signature of Accredited TreatmentOperator with seal & date/ Accreditation Number	