The goal of phytosanitary regulations

- To prevent entry and establishment of exotic or non-indigenous organisms that pose a risk to plant life or health
- Entry or establishment must be prevented
- Systems approach may employ independent mitigation measure targeting both entry and establishment

APHIS
Animal & Plant Health Inspection Service

- A branch of the USDA
- Responsible for regulating the import/export and movement within the US of commodities that are subject to quarantine restrictions
Development of Phytosanitary Regulations

- Assessment of Risk
- Systems Approach
- Treatment Schedules

What is a “Systems Approach”?

- “[A] defined set of phytosanitary procedures, at least two of which have an independent effect in mitigating pest risk associated with the movement of commodities.” (Plant Protection Act)

- “The integration of different pest risk management measures, at least two of which act independently, and which cumulatively achieve the desired level of phytosanitary protection.” (UN, FAO 2001)

Steps in the development of “System Approach” Strategies

Step 1
- Pest Harm Identification
  - Impact Analysis, Quarantine Pest Identification and Pest Risk Assessment

Step 2
- Selection of Risk Mitigation Measures
  - Selection of Enforcement Instruments

Step 3
- Review, Evaluation and Adjustment
Strategies used in a Systems Approach

- Pest Free Zones
- Non-host Status
  - Harvest maturity
  - GA sprays - susceptibility to infestations
- Inspection/certification
- Physical Commodity Treatments

Packaging

Containment

Inspection and Certification

Physical commodity treatments

APHIS Treatment Manual
The Desired Level of Control

With the exception of Irradiation the goal of any phytosanitary treatment is to achieve Probit 9 Control.

*Probit 9:*
Treatment should result in 99.9988% mortality of target pest.

3 survivors per 100,000 treated.

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Treatment Schedules for Fruits and Vegetables

- Methyl Bromide Fumigation
- Water Treatment
- High Temperature Forced Air
- Pest Specific/Host Variable
- Irradiation
- Vapor Heat
- Cold Treatment
- Fumigation + Refrigeration of Fruits
- Cold Treatment + Fumigation of Fruits
- Quick Freeze

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T101 - Methyl Bromide Fumigation

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**What is fumigation?**

Fumigation is the act of releasing and dispersing a toxic chemical so it reaches the target organism in a gaseous state.

Chemicals applied as aerosols, smokes, mists, and fogs are suspensions of particulate matter in air and are not fumigants.

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**Methyl Bromide**

- EDB banned in US in 1984
- Widely used - primary quarantine fumigant
- General Biocide - Very effective
- Inexpensive
- Easy to use

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**Current Ways to Use Methyl Bromide**

- As a “Quarantine” treatment for commodities being imported/exported from foreign countries or inter-state within the U.S.
- As a condition of “Pre-shipment” - treated within 21 days of shipment.
- As granted by the Parties to the Montreal Protocol under the “Critical Use Exemption” (CUE) provisions of the Montreal Protocol - done on a yearly basis.
What is FIFRA?
Federal Insecticide, Fungicide, and Rodenticide Act

FIFRA is the principal law that authorizes EPA to regulate the manufacture, distribution, sale and use of pesticides in the US.

FIFRA Section 18 authorizes EPA to allow states to use a pesticide for an unregistered use for a limited time if EPA determines that emergency conditions exist.

Methyl Bromide Recapture

Methyl Bromide fumigation treatment dependent on:
- Host
- Pest
- Temperature
- Duration
- Aeration time
### Selected commodities approved for Methyl Bromide Fumigation (T101)

- grape
- chestnut
- leafy veg.
- avocado
- macadamia
- okra
- citrus
- almond
- asparagus
- stone fruit
- walnut
- corn
- pome fruit
- cut flowers
- root crops
- almonds
- asparagus
- citrus
- stone fruit
- walnut
- corn
- pome fruit
- cut flowers
- root crops
- ornaments
- beans/lentils

Schedule varies with target pest

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### Cherry

**Pest:** Rhynapetus insidiosus (Western cherry fruit fly) and Cydia pomonella (codling moth)

**Treatment:** T101-1 at 84°F—chamber only

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Dosage Rate</th>
<th>Exposure Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>77°F or below</td>
<td>2 lbs</td>
<td>2 hrs</td>
</tr>
<tr>
<td>80°F-85°F</td>
<td>3.5 lbs</td>
<td>2 hrs</td>
</tr>
<tr>
<td>85°F-90°F</td>
<td>5 lbs</td>
<td>2 hrs</td>
</tr>
<tr>
<td>90°F-95°F</td>
<td>6 lbs</td>
<td>2 hrs</td>
</tr>
</tbody>
</table>

Note the temperature x dosage relationship

Source: APHIS Treatment Manual

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Stippling on surface of stone fruits

Lenticel damage on avocado and enhanced chilling susceptibility
Physical Treatments

Water Treatments (T102)

Heat
- Hot Water Immersion (T102)
- Vapor Heat (T106)
- Forced Hot Air (T103)

Cold Treatment (T107)

Irradiation (T105)

Water Treatments (T102)

Non-heated

Soapy Water and Wax
- Cherimoya, Limes,
- Passionfruit from Chile
- Chilean false spider mite of grapes

Warm Soapy Water and brushing
- Durian and other large fruits such as breadfruit for external feeders

Heat Treatments

Generally based on maintaining the plant material at a specific temperature for a specified time; designed to kill plant pests without destroying or appreciably devaluing the infested commodity.
Fruit Heat Tolerance

Goal:
Heat fruit fast without damaging quality yet controlling target pest

Considerations:
- Heating Method
- Treatment Temperature

What is the fastest way to heat a commodity?

<table>
<thead>
<tr>
<th>Heating</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water immersion</td>
<td>*****</td>
</tr>
<tr>
<td>Forced Vapor (wet surface)</td>
<td>*****</td>
</tr>
<tr>
<td>Forced Moist Air (surface dry)</td>
<td>***</td>
</tr>
</tbody>
</table>
Hot Water Treatments

**Principle**
Uses heated water to raise the temperature of the commodity to the required temperature for a specified period of time.
Primarily used for fruit fly hosts

**Schedules**
The time-temp relationship varies with commodity and the pest.
Typically, pulp temp is raised to between 115 - 118°F for a specified period of time.

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Water Treatments (T102) Heated

**Hot Water Immersion**
120.2°F for 20'
Litchi from HI - MFF, OFF
Limes for mealybugs

**Hot Water Dip**
Mango for MFF and MexFF

All require product to be submerged at least 4” below water surface.

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Hot Water Treatment - Mango

Duration of treatment dependent on:
country of origin; target pest species; fruit variety and fruit size
Pulp temperature must be at least 21°C (70°F) at start of treatment
Fruit must be submerged at least 4” below water surface
Water must circulate constantly
Water must be kept at least at 46.1°C (115°F)

<table>
<thead>
<tr>
<th>If the weight of the fruit is:</th>
<th>And the shape of the fruit is:</th>
<th>And the weight is:</th>
<th>Time dip:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metro or Caribbean Islands, north of and including Central America</td>
<td>Flat, elongated</td>
<td>up to 570 grams</td>
<td>45 minutes</td>
</tr>
<tr>
<td>Resinite or varieties®</td>
<td></td>
<td>571 to 579 grams</td>
<td>75 minutes</td>
</tr>
<tr>
<td>Resinite or varieties®</td>
<td></td>
<td>581 to 700 grams</td>
<td>10 minutes</td>
</tr>
<tr>
<td>Resinite or varieties®</td>
<td></td>
<td>701 to 900 grams</td>
<td>110 minutes</td>
</tr>
</tbody>
</table>

Source: APHIS Treatment Manual
Vapor Heat (T106)

Principle
Uses air saturated with water vapor to raise the temperature to a required point and hold the temperature for a specified period.
The latent heat released by the condensation of the vapor raises the pulp temperature quickly and thus prevents damage.
In application, a fine mist and air under forced circulation is present with saturated vapor.
Primarily used for fruit fly hosts.

Schedules
The time-temp relationship varies with commodity and the pest.
Typically, pulp temp is raised to 110 – 112°F during a period of 6 – 8 hours and then holding for several hours; cooling immediately after treatment.

Example of Vapor Heat Treatment

<table>
<thead>
<tr>
<th>Treatment</th>
<th>T106-a: Vapor Heat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Up Time</td>
<td>8 hours</td>
</tr>
<tr>
<td>Heat Up Recording Interval</td>
<td>3 minutes</td>
</tr>
<tr>
<td>Minimum Air Temperature</td>
<td>≤40°C</td>
</tr>
<tr>
<td>Minimum Pulp Temperature at End of Heat</td>
<td>41.5°C/106°F</td>
</tr>
<tr>
<td>Cool Time</td>
<td>6 hours</td>
</tr>
<tr>
<td>Cool Recording Interval</td>
<td>3 minutes</td>
</tr>
<tr>
<td>Cooling Rate</td>
<td>≤40°C</td>
</tr>
</tbody>
</table>

Source: APHIS Treatment Manual

High Temperature Forced Air (T103)

Principle
Really a modification of Vapor Heat.
Maintain dew point temp of chamber 2°C cooler than fruit surface temp to avoid condensation.
Based solely upon center pulp temperature of the fruit.
Primarily used for fruit fly hosts.

Schedules
The time-temp relationship varies with commodity and the pest.
Can have rapid or slow ramping.
Fruit should be sized.
Typically, pulp temp is raised to 110 – 112°F during a period of 6 – 8 hours.
Cooling after treatment – 30 minute delay.
Example of High Temperature Forced Air

Cold Treatment (T107)

- Treatments vary: -1 to 8°C for days to months
- Tropical and subtropical pests are easier to kill
- Many commodities are chilling sensitive and will not tolerate treatment

- Preconditioning fruit
  - May increase tolerance
  - Conditioning temperature varies; difficult to predict
  - Conditioning period appears to be time and temperature linked

Commodities can be conditioned to tolerate cold treatment
**Examples of Cold Treatment**

**Ceratitis capitata and C. rosa** (Med FF, Natal FF)

**Treatment**  
T307-a Cold treatment

**Complementation**  
- MB fumigation plus refrigeration
- Refrigeration plus MB fumigation

**Schedules Varies**  
- Limited number of commodities approved

**Combination Treatments**

- MB fumigation plus refrigeration
- Refrigeration plus MB fumigation
- Schedules Varies
- Limited number of commodities approved

**Treatments for Austrotortrix spp. and Epiphyas spp.** (light brown apple complex), *Bactrocera tyroni* (QLD FF), *Ceratitis capitata* (Med FF) and other fruit flies

**T108-b** MB followed by cold treatment for Apple, Grape and Pear

**T109-d-1** Cold treatment followed by MB for Apple, Grape and Pear
Controlled Atmosphere Temperature Treatment Systems (CATTS)

- Currently approved for commodities destined for EXPORT from US
- Other uses pending

Combines forced moist or vapor hot air with controlled atmosphere
- Conducted in a chamber similar to a vapor heat or forced hot air chamber
- Atmosphere established first, then temperature

Requires the following
- Product at room temperature before treatment begins
- Air speed equivalent to 1.3 - 2 m/s
- Controlled atmosphere equivalent to 1% O₂ and 15% CO₂
- Relative Humidity ≥ 90%
Currently limited approval
Nectarines/peaches, Apple, Cherry

**Target Pests**
- Codling moth, Oriental fruit moth, W. Cherry FF

**Ramp Temperature**
- Ranges from none to 24°C (75.2°F) per hour

**Final Chamber Temperature**
- Ranges from 45°C (113°F) to ranges 47°C (116.6°F)

**Total Treatment Time**
- Ranges from 25 minutes to 3 hours

**Core Temperature**
- Ranges from 42°C (107.6°F) to 44.6°C (112.3°F)

**Time at Core Temperature**
- 15 to 30 minutes

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**IRRADIATION (T105)**

Approved for all fruit and vegetables that are imported or moved interstate from HI, Puerto Rico and US Virgin Islands. May also be used for selected pests of cut flowers and foliage.

Treatment must be conducted at approved facilities.

Dose mapping required for each commodity and/or size. Different configurations, packaging and/or mixed commodities should also be mapped.

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**Considerations pertaining to irradiation**

- Many hosts are injured at <1000 Gy
- Sterilization dose vs. lethal dose
- Dosimetry
- Not a substitute for good handling
- Cost/Logistics
- Social Issues
Note that minimum doses vary from 60 to 400 Gy.

Examples of injury (< 1000 Gy) which may occur with storage:

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Type of injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avocado</td>
<td>Internal browning; skin discoloration</td>
</tr>
<tr>
<td>LEMON/LIMES</td>
<td>Formation of cavities along segment walls</td>
</tr>
<tr>
<td>Oranges/Grapefruit</td>
<td>Peel damage, including pitting</td>
</tr>
<tr>
<td>Table Grapes</td>
<td>Stem darkening</td>
</tr>
<tr>
<td>Peppers</td>
<td>Calyx discoloration; accelerated discoloration</td>
</tr>
</tbody>
</table>

Approaches for the future:

- **Chemically-Based Alternatives**
  - New Fumigants/New Techniques
  - Volatile Identification/Mating Disruption
  - Emissions Control
- **Non-Chemical/Physical Alternatives**
  - Irradiation
  - Heat/Cold
  - Physical Control – Compression/Vacuum
  - RF Energy
Resource Information

Available in pdf downloadable format at
http://www.aphis.usda.gov/ppq/manuals/

- APHIS Treatment Manual and updates
  - Fruit and Vegetables Manual
  - Cut Flowers and Greenery
  - Export Certification Manual

FAVIR

Fruits and Vegetables Import Requirements (FAVIR)

Welcome to the APHIS Fruits and Vegetables Import Requirements (FAVIR) Database. This online reference allows easy access to regulations and information pertaining to the importation of fruits and vegetables into the United States, its territories, and possessions. Collectively, these regulations are commonly referred to as Quarantine 56, or Q56.

https://epermits.aphis.usda.gov/manual/index.cfm?CFID=1704134&CFTOKEN=2a58b629840420a5-F5952858-9BBA-F0A6-A7CCD990C7504EA9&ACTION=pubHome