

# Transportation





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# Sources of Information



- Patrick Brecht - PEB Commodities
- Postharvest Technology of Horticulture Crops (UC ANR Pub. 331)
- Maintaining Optimum Perishable Product Temperatures in Truck Shipments (UCD Postharvest Horticulture Series #12)
- Marine Container Transport of Chilled Perishable Produce (UC ANR Pub. #21595)

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# Sources of Information



- USDA Handbooks
  - #593 Export Handbook for US Agric. Products
  - #668 Tropical Products Transport Handbook
  - #700 Agric. Export Transportation Handbook
  - A Business of Details--Exporting High Value U.S. Agricultural Products (video & handbook)

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# Transportation



- Moving perishable commodities from the site of production to the site of consumption
  - Before the industrial revolution, these tended to be shorter distances (often local consumption)
    - Land – transport by humans and animals
    - Water – transport by ships
    - These means of transportation were slow

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# Transportation



- Industrial revolution
  - Urbanization separated areas of production from areas of consumption
  - Development of faster forms of transportation
    - E.g. the steam engine and railroads
  - Better refrigeration

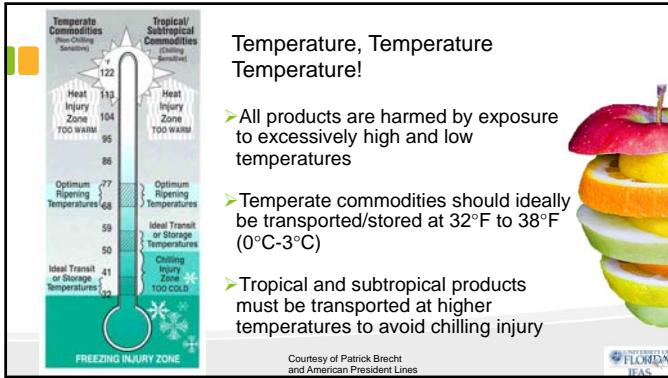
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# Transportation

- Start with high quality produce
  - Packed correctly & precooled
- Match the perishability of the commodity with the transportation system
  - E.g. a product must be able to survive a 4 week journey by ship

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### Transportation Methods

- Highway Trucks
- Marine Containers and Refrigerated Ships
- Rail Cars
- Air

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### Road Transportation

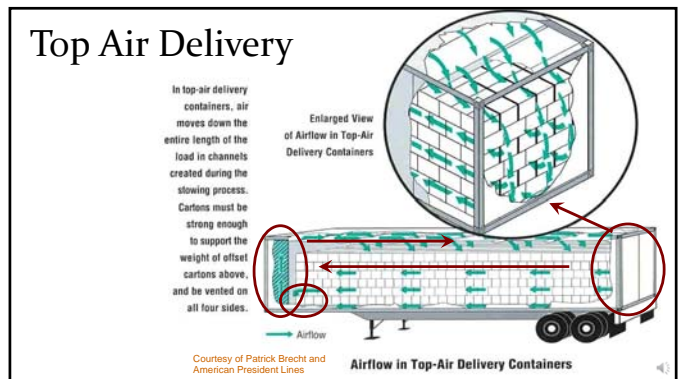
- Types of vehicles:
  - Smaller refrigerated truck
  - Large Tractor-trailers
  - Trailer on flat car (TOFC)
- Used most commonly

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### Road Transportation

- Trailers often:
  - 102 in (8.5 ft or 2.6 m) wide
  - 40 to **53 ft** (12.2 to 16.2 m) long
  - 2,500 to 3,500 ft<sup>3</sup> (70 to 100 m<sup>3</sup>) interior volume
  - 80,000 lb (36,288 kg) gross weight max.
    - Each axle has its own weight restriction
  - 40,000 to 45,000 lb (18,100 to 20,400 kg) load capacity
  - 3.5 to 4.7 ton (12.3 to 16.4 kW) refrigeration capacity can also provide heat

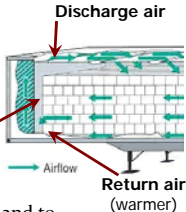
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### Desirable Features For Temperature Management

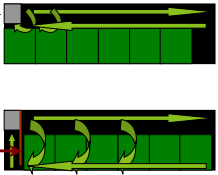

- High capacity fan
- Temperature monitored in discharge from refrigeration unit
- Unrestricted air return to the refrigerated coils
  - Solid front return-air bulkhead
  - Deep floor for air circulation
  - Air channels in walls for air circulation and to help isolate load from the environment



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### Air Return


- Air can “short circuit” back to the refrigeration unit if a bulkhead are not present to force the air to return via the floor.

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### Air Return


- Air returning to the refrigeration coils can easily be blocked
  - Placing produce on pallets greatly enhances the volume of space for air to return
  - “T-beam” floors, at ~200 in<sup>2</sup> of air channel, are much better common duct board floors
  - The common duct board floor has only ~47 in<sup>2</sup> of air channels (97” wide trailer)



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### Air Return


- Corrugated walls hold cartons of fruit away from the wall better
  - Better cold air flow around the product
  - More easily damaged than flat walls



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### Refrigeration Limits

- Most heat removed by the refrigeration system conducts through the walls or is in air that leaks in
  - Product in contact with walls is warmer
- In most cases, the top air-deliver in trailers does not provide enough airflow to cool the product
  - Always cool product before loading



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### Refrigeration Limits

- Trailers are rated by the Refrigerated Transportation Foundation based on their refrigeration capacity and insulation

Rating	Min. Temp.
C65	65F (18C)
C35	35F (2C)
F	0F (-18C)
DF	-20F (-29C)

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## ■ ■ ■ Road Transportation

- **Relative humidity is usually not controlled**
  - Added water may weaken fiberboard cartons
  - Compromise between carton strength and water loss during transit
  - Water loss can be retarded using liners, wraps, or packages
- **Road trailers are not air-tight enough to allow modified or controlled atmospheres**
  - MA can still be used at the pallet or package level



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## ■ ■ ■ Vibration Injury

- The vibration within a trailer as it moves down the road can damage some produce
  - Product over the axels and at the top of a pallet receive the most vibration
  - Immobilizing product in packages can reduce this injury



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## ■ ■ ■ Vibration Injury

- Vibration can be greatly reduced using **air ride suspension**
  - More expensive, but also improve driver comfort and reduce tire wear
  - Most long-haul tractors have air ride suspension. So load vibration sensitive produce near the front of the trailer



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## ■ ■ ■ Mixed Loads

- **Compatibilities??**
  - Temperature
    - Ethylene production vs. sensitivity
      - Ethylene scrubbers may reduce injury
  - **Moisture Compatibility**
    - Dry produce (e.g. onions) vs. other produce needing high RH
  - **Odor producers vs. odor absorbers**



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## Load Patterns



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## Water Transportation

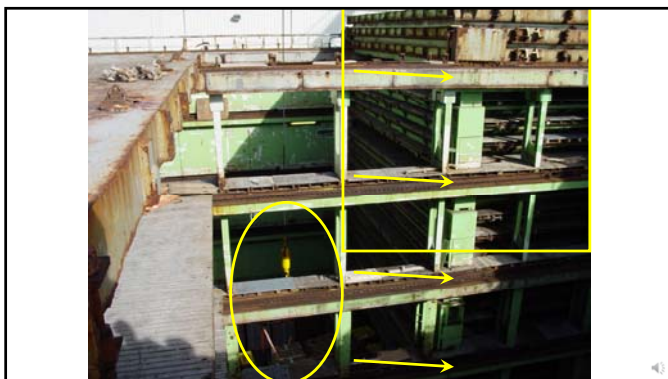
- More economical for long transport (e.g. 1 to 4 weeks)
- Types of shipping:
  - Break Bulk – produce loaded similar to how a cold storage facility might be loaded (only tighter)
  - Containerized Shipping – produce loaded onto containers that are then stacked on/in ships
- MA or CA are possible for both

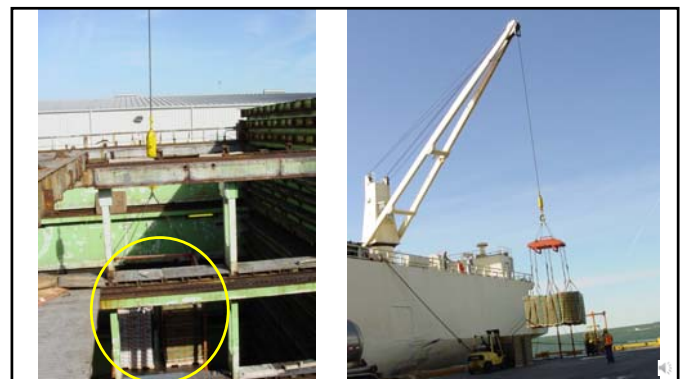
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### Bulk vs. Containers

- Holding capacity:
  - Bulk = ~ 350,000 packages
  - Containers = ~1,000 to 1,500 packages
- Bulk shipping is generally less expensive than containers
  - Bulk containers have large insulated holds with central refrigeration systems
  - Containers = large # of individual refrigeration units
- Containers are easily transported between packinghouse & distribution loading docs
  - Fewer transfer steps. Cold chain no broken




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### Water Transportation

- Containers are often:
  - 96 in (8' or 2.4 m) wide
  - 40 ft (12.2 m) long, 8.5 to 9.5' (2.6 to 2.9 m) high
  - 2,000 to 2,300 ft<sup>3</sup> (56.6 to 65.1 m<sup>3</sup>) interior volume
  - 2.4 to 2.9 ton (8.4 to 10.2 kW) refrigeration capacity. Can also provide heat




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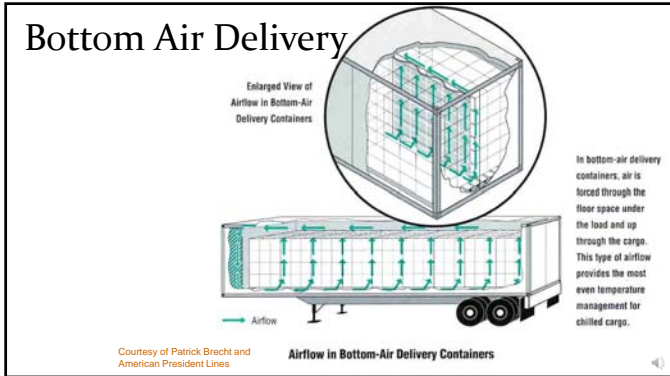
### Water Transportation

- Road weight limits still apply:
  - 80,000 lb (36,288 kg) gross weight max. & each axle has its own weight restriction
  - 40,000 to 48,000 lb (18,100 to 21,700 kg) load capacity



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## Water Transportation

- With proper loading, so that air is forced through the packages, slow cooling (2 to 4 days) can be achieved
  - All open floor space needs to be covered.
  - Block open pallet edges
  - Cartons should have at least **3% venting on top and bottom panels**
  - Vents should align even if cross-stacked.
  - Internal packaging should not block air flow

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## Incorrect Stowage

Examples of stowage patterns that cause **short cycling** of air through the load and result in less effective temperature management

Courtesy of Patrick Brecht and American President Lines

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### ■ Rail Transportation



- Used mostly for less perishable products (e.g. potatoes, onions, carrots) for long distant transport in North America
- Each car usually contains a single commodity



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### ■ Rail Transportation

- Rail cars often have:
  - >4,000 ft<sup>3</sup> (113 m<sup>3</sup>) interior volume. Can haul >100,000 lb (45 metric tons) of product
  - Top air delivery
  - Adequate refrigeration capacity and airflow to slowly cool provided the product is not packed too tightly
  - Fairly air-tight. Untended MA if the drains get clogged

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### ■ Air Transportation

- Provides rapid transport of perishable products
  - E.g. cut flowers, early season cherries, strawberries, and some tropical fruits
- **EXPENSIVE!**
- Very poor temperature control
  - Often no refrigeration & little air flow
  - Handling delays waiting to be loaded
  - MA difficult even at the package level
- Very low humidity



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### Thermostats



- Thermostats should be calibrated regularly
- Supply air temperature sensor vs. return air temperature sensors or both
  - How would loading warm product affect this?
- Ideally, set temperature just above freezing or chilling temperature
  - Newer units with supply air control vary only ~1F (0.5C) around the set point
  - Older systems with return air sensing should be set at least 2F (1C) above the set point

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### Microprocessor Control = Good Insurance

- Measures and controls discharge & return air temperatures
- Documents refrigeration unit performance.
- Optional features
  - Cargo temperature recording
  - Upper/lower set-point limits
  - Atmosphere management (CA & humidity)

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### Placement of Temperature Recorders

FRONT	2	3
	4	5
	6	7
	8	9
	10	11
	12	13
	14	15
	16	17
BACK	18	19
	20	

Three temperature monitors:

1. Inside the first pallet **near the front bulkhead** of the reefer unit to detect any occurrences of short cycling of refrigerated air
2. Inside a pallet **near the center of the load** (position 9, 10, 11, or 12) where product heating is most likely to occur
3. On **the outside rear face of the last pallet** at eye level to record air temperature at the farthest point from the reefer unit. *If only one temperature recorder is used, place it here.*

Do not place temperature recorders directly on trailer walls. This may result in elevated readings that do not accurately reflect the air temperature in the load space.



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