

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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Maintain the Cold Chain

- Load from an Enclosed, Refrigerated Dock
- Pre-cool the trailer or container before loading





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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





<https://blog.intel freight-logistics.com/how-tofc-intermodal-helps-shippers-challenged-in-finding-truckload-freight-capacity>

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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 ft³ (70 to 100 m³) 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)

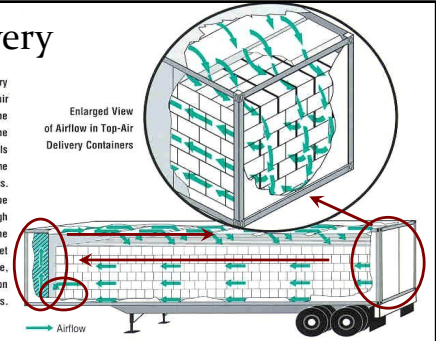


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Top Air Delivery

In top-air delivery containers, air moves down the entire length of the load in channels created during the stowing process. Cartons must be strong enough to support the weight of offset cartons above, and be vented on all four sides.



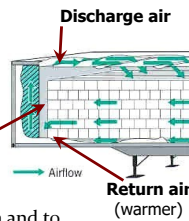
Courtesy of Patrick Brecht and American President Lines

Airflow in Top-Air Delivery Containers

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Desirable Features For Temperature Management

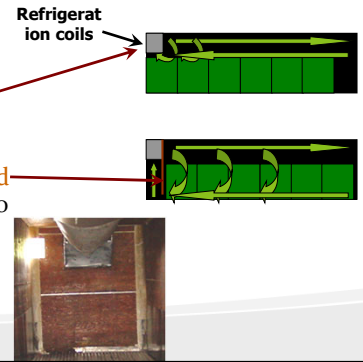
- High capacity fan
- Temperature monitored in discharge from refrigeration unit
- Unrestricted air return to the refrigeration coils
 - Solid front return-air bulkhead
 - Deep floor for air circulation
 - Air channels in walls for air circulation and to help isolate load from the environment



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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 in² of air channel, are much better common duct board floors
 - The common duct board floor has only ~47 in² 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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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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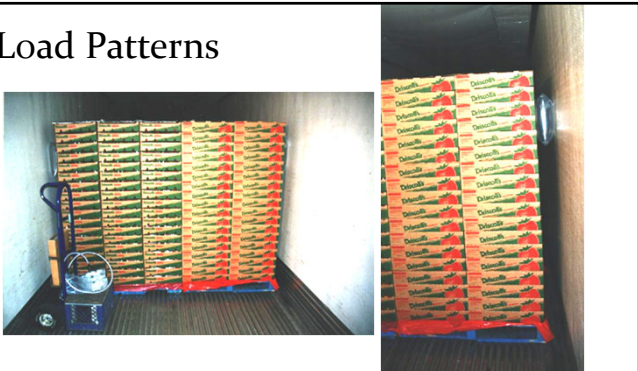

Mixed Loads

- 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 ft³ (56.6 to 65.1 m³) interior volume
 - 2.4 to 2.9 ton (8.4 to 10.2 kW) refrigeration capacity. Can also provide heat

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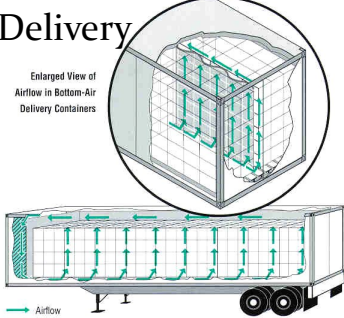
Water Transportation

- 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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Bottom Air Delivery



Enlarged View of Airflow in Bottom-Air Delivery Containers

In bottom-air delivery containers, air is forced through the floor space under the load and up through the cargo. This type of airflow provides the most even temperature management for chilled cargo.

Airflow



Airflow in Bottom-Air Delivery Containers

Courtesy of Patrick Brecht and American President Lines

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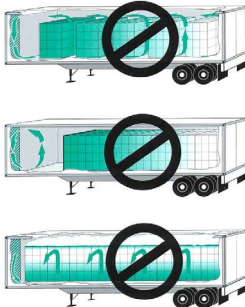
Water Transportation

- 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

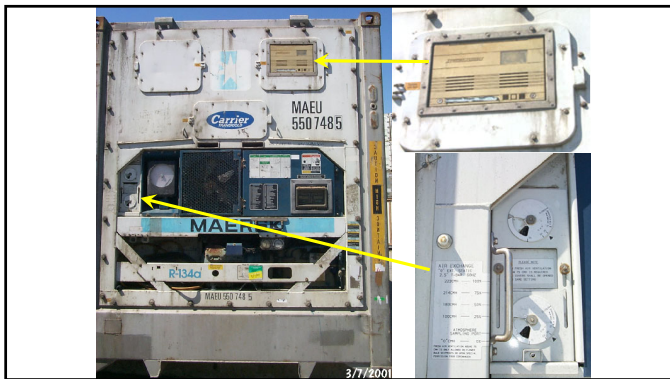


Examples of stowage patterns that cause **short cycling** of air through the load and result in less effective temperature management

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 ft³ (113 m³) 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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