

E355 : Cold Chain Management

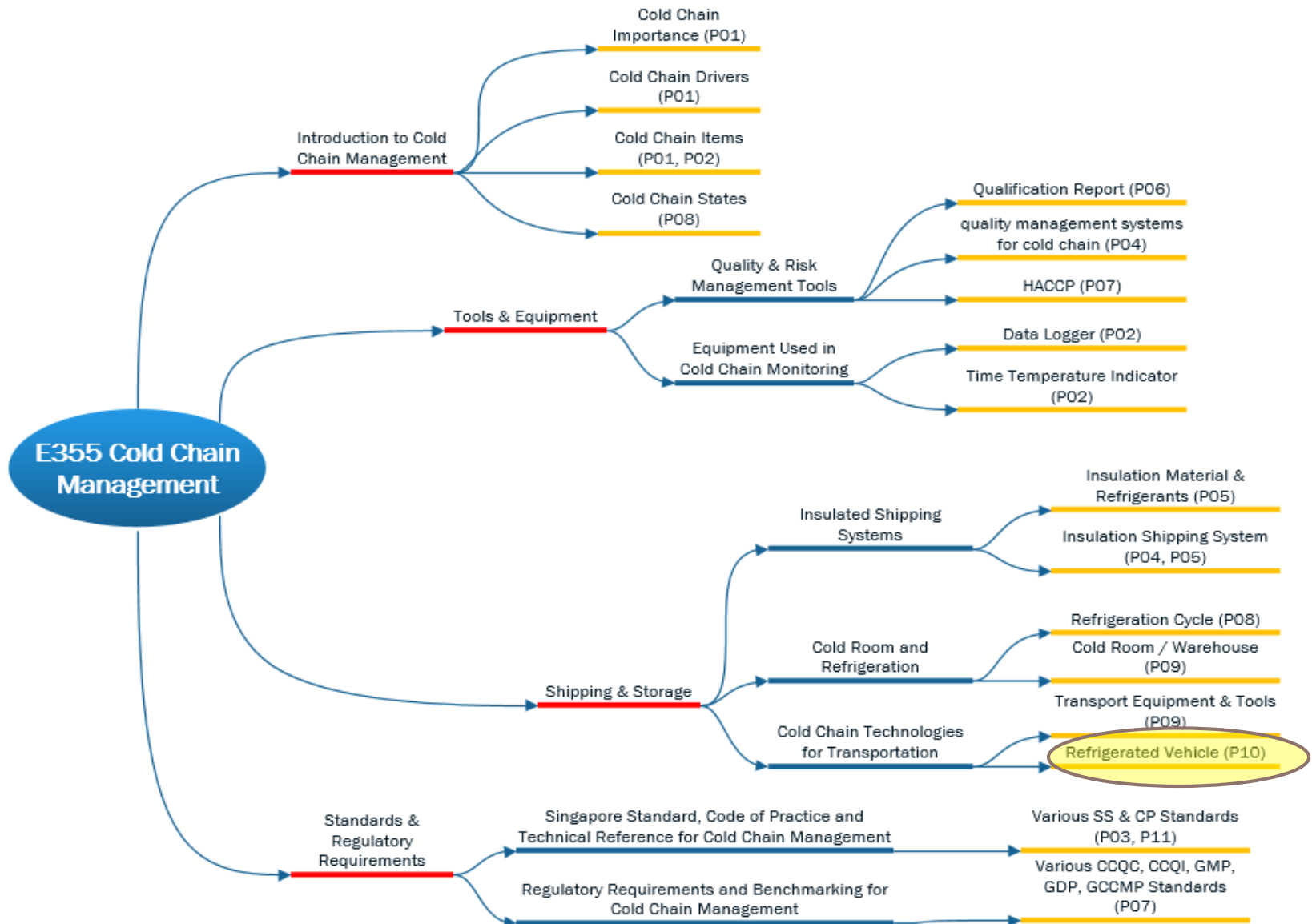
Lesson 10

Cold Chain Transportation

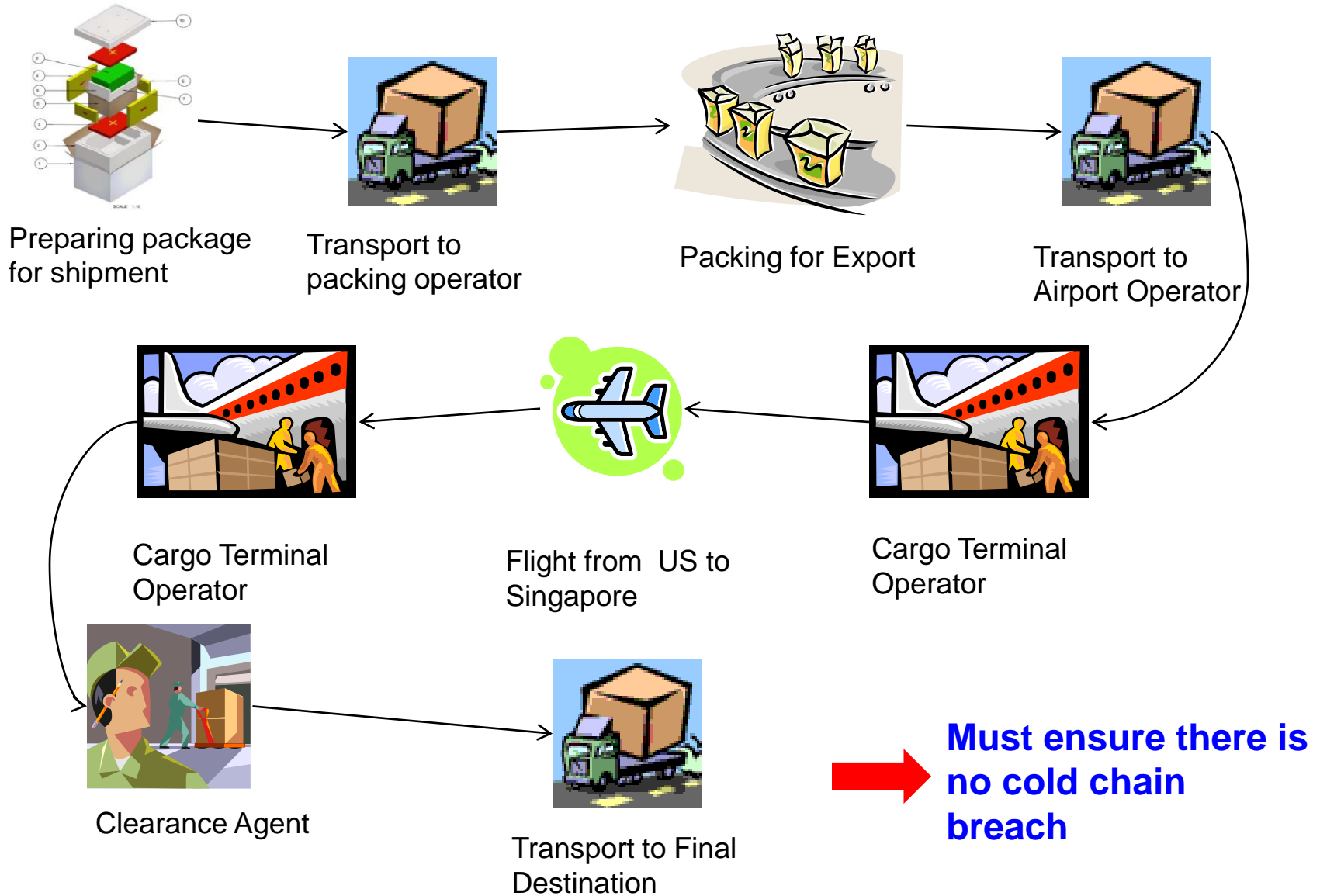
- Recognize the importance of temperature control of cold products during transportation
- Identify and describe the different types of transport equipment and tools used to maintain temperature during transportation
- Describe how cold chain can be maintained during transportation
- List and explain the design considerations for a refrigerated vehicle

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E355 Cold Chain Management - Topic Tree



Recap: Cold Chain Logistics



Recap: Possible Cold Chain Breaks



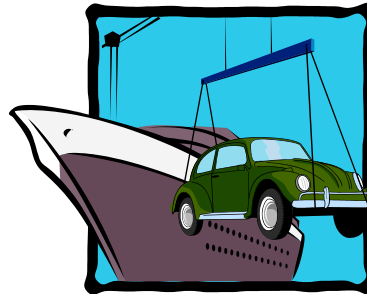
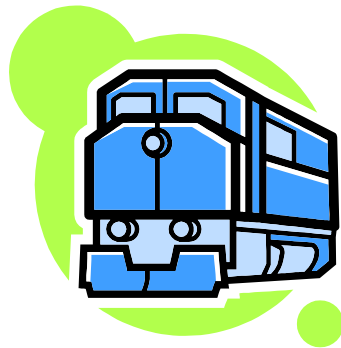
The cold chain requires all parties to understand its role and know the standards to be applied, in order to ensure integrity and quality of products. Cold chain breaks can occur anywhere along the supply chain, including

- ▶ During Transport to packing
- ▶ When packing
- ▶ Waiting for and loading to transport
- ▶ During transport (if unrefrigerated)
- ▶ Unloading from transport to airport store
- ▶ When moving the dolly on tarmac
- ▶ Awaiting and when loading to aircraft
- ▶ In flight/ On board
- ▶ When unloading the aircraft
- ▶ At break bulk point in airport terminal
- ▶ When loading, unloading truck and during road transport

Modes of Transport for Cold Items



- Water transportation,
- Motor transportation,
- Air transportation,
- Rail transportation



Modes of Transport for Cold Items



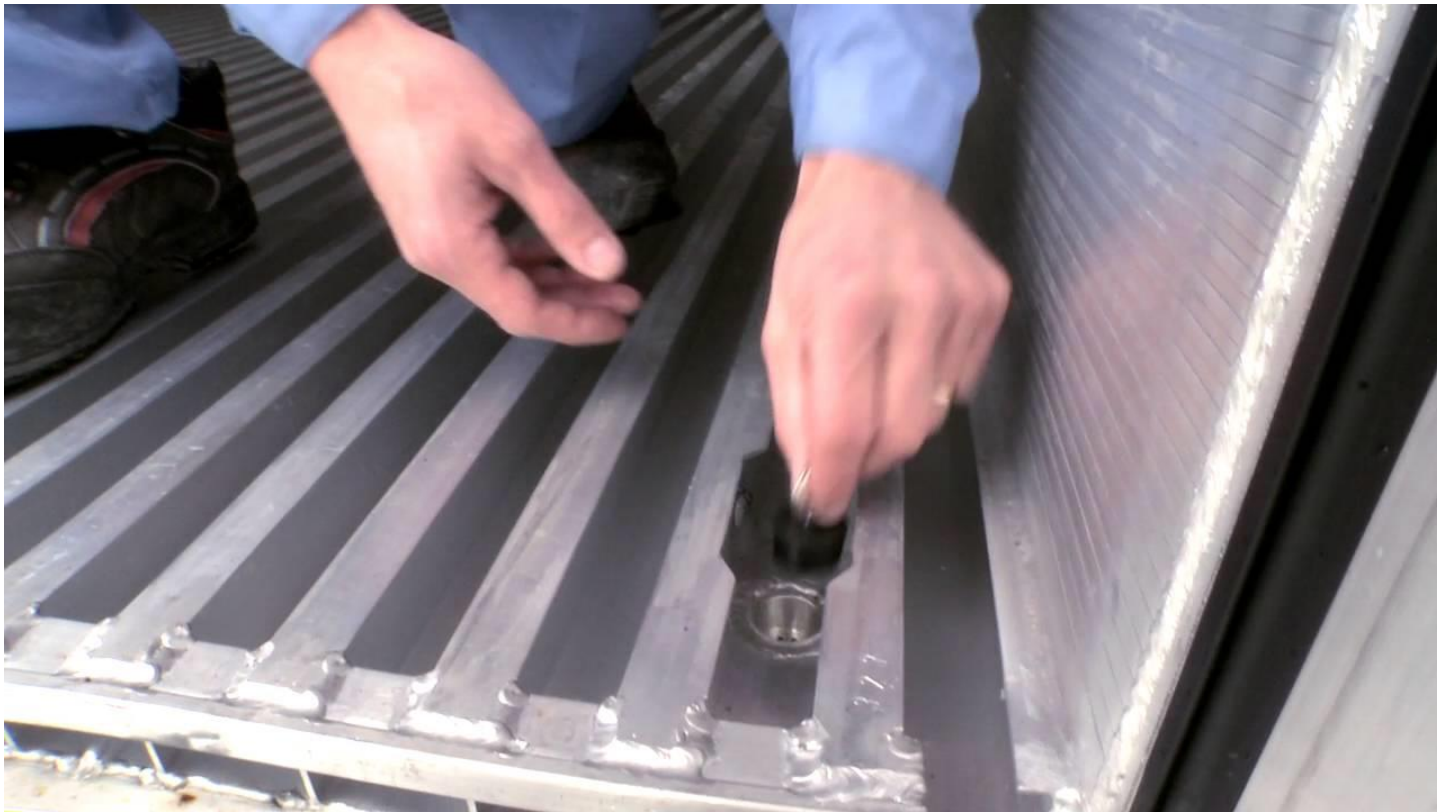
- Domestically, distribution is commonly carried out with refrigerated trucks
- Interfacing transportation modes are crucial in upholding the integrity of the cold chain
- If the linkage between producers, distributors, and customers is not well-controlled, items will be unsafe for human consumption & be a threat to public health

Sea Freight



Sea freight of temperature sensitive items are carried out in 1) a reefer container or 2) an insulated container.

The **reefer container** is introduced in this video.



<https://www.youtube.com/watch?v=gPHFMGb7B4k>

Sea Freight



- ▶ Most ISO containers for transport are either 6m or 12m long, hold up to 26 tons of product, and can be either insulated or refrigerated.
- ▶ Refrigerated containers (or reefer containers) incorporate insulation and have refrigeration units built into their structure, getting their power either from an external power supply on board the ship, in dock, or from generator on a road vehicle.
- ▶ Insulated containers utilize plug-type refrigeration units or may be connected directly to an air-handling system in a ship's hold or at docks.
- ▶ For bulk transportation, refrigerated cargo ships are commonly used.



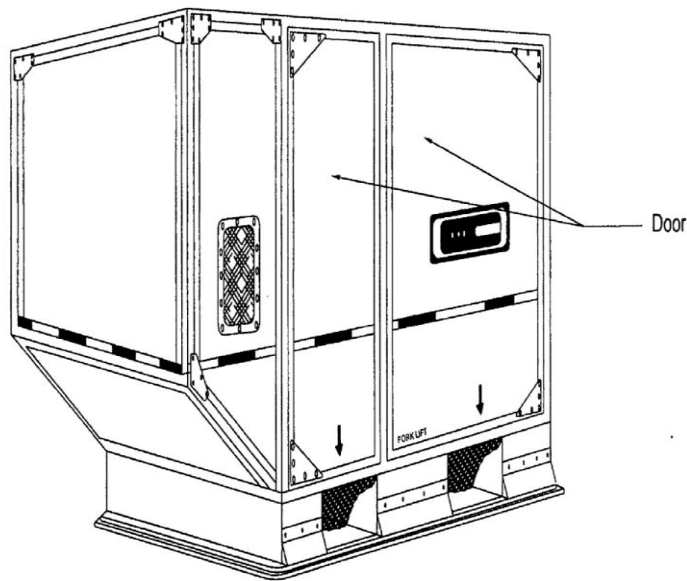
Reefer Container

Air Freight



There are two types of container to transport temperature sensitive shipment by air

- ▶ Insulated containers
- ▶ Airfreight container with temperature control



Air Freight



- ▶ By using insulated containers, it offers a rapid method of distribution, but problems arise because product is usually unprotected by refrigeration for much of its journey.
- ▶ Examples include time spent on tarmac, transport to and from airport, dry ice may not be used when carrying live animals or when products may deteriorate after surface freezing.
- ▶ Temperature of cargo hold varies between 2.5 °C & 21°C, depending on ambient temperature, duration of flight & type of aircraft.

Air Freight



The envirocontainer is used widely as a container for air transport of temperature sensitive items. Watch this video to get a better idea.



<https://www.youtube.com/watch?v=qqJ-4s1hd4U>

Land Transport for Cold Items



- ▶ Currently, land transport ranges from small non-insulated vans to 12m refrigerated containers for long distance road or rail movement.
- ▶ For local transportation in Singapore, pharmaceutical shipments have relatively small volume, hence the usual practice is to use insulated shipping boxes together with non-insulated vans.



- ▶ Temperature monitoring is necessary in these vehicles.
- ▶ Temperature controlled loading dock is essential for transfer into the cold room.

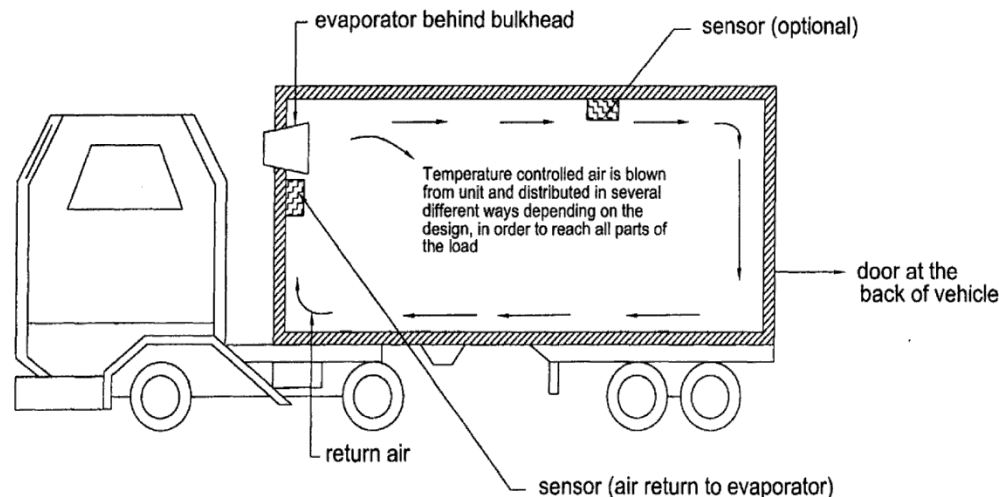
Land Transport for Cold Items



Two Main Components :

- 1) Insulated Container
- 2) Refrigeration Unit or Energy Storage System
 - Mechanical units (most common)
 - Eutectic plates
 - Liquid Nitrogen

Efficient air circulation to remove heat must be present



Standards and Classification of Trucks



International transport vehicles have to comply with ATP rules:

- ATP : Agreement on the International Carriage of Perishable Foodstuffs and on the Special Equipment to be Used for such Carriage.
- It lays down a set of rules and standards that are to be applied to the international transport of certain perishable food.
- It provides a multi-lateral agreement between Signatory Countries (Contracting Parties) for overland cross-border carriage of perishable foodstuffs.

Types of Refrigeration System



Mechanical units

- Different types of independent engine and/or electric motor driven mechanical refrigeration units
- One of the most common is a self-contained 'plug' unit which mounts in an opening provided in the front wall of the vehicle
- Unit can be belt-driven from the vehicle but is usually driven directly from an auxiliary engine
- The engine may use petrol from the vehicle's supply, an independent tank, or liquid petroleum gas



Types of Refrigeration System



Eutectic plates

- Used in refrigerated vehicles serving local distribution chains, consisting of a coil, through which a primary refrigerant can be passed, mounted inside a thin tank filled with a eutectic solution
- Can be mounted on walls and ceilings, or used as shelves or compartment dividers
- Plates can be charged by coupling to stationary refrigeration plants when in depot, or using a condensing unit
- Simple, low maintenance and quiet, but can suffer from poor temperature control



Types of Refrigeration System



Liquid Nitrogen

- Typically consists of an insulated liquid nitrogen storage tank connected to a spray bar that runs along the ceiling of the transport vehicle
- A thermostatically controlled valve controls the flow of liquid nitrogen into the body of the vehicle, which vaporizes instantly thus cooling the air due to the change in latent and sensible heat of the liquid nitrogen
- Advantages include low operating costs and suitability for long-haul



General Requirements for Refrigerated Vehicle

- Clean & free of dirt, debris, offensive odors & any contaminants
- Adequate refrigeration capacity & air delivery system with good circulation
- Tight fitting doors & suitable closures for drain holes
- Free from open seam or cracks
- Contact surface shall be smooth, easily cleaned & sanitized, & maintained in a state of good repair
- Strip curtains can be used to reduce air infiltration when doors are open
- Data of temperature profiles should be recorded, documented & made available for inspection & recording

Factors Influencing Design of Refrigerated Truck



- **Van insulation**
 - A small increase in thickness would greatly reduce the amount of heat that has to be extracted
- **Infiltration of air**
 - Heat extracted from a poorly sealed van can be up to 86% more than from a well-sealed van
- **Initial food temperature**
 - Heat extracted by refrigeration system can be 4 times greater if food is loaded at 7°C than if it is loaded at 0°C
- **Door openings**
 - Door openings greatly increase the heat load, as well as the period of time it is left open

Factors Influencing Design of Refrigerated Truck



- **Weight of fittings and thermal mass of lining**
 - Both fittings and lining form a sizeable refrigeration load and take a finite amount of time to cool, especially if ambient temperature is high and when vehicle is used for different temperatures of food
- **Length of journey**
 - Rate of heat extraction varies inversely with the length of the journey, assuming the number of drop-off points remains the same
- **Solar radiation**
 - Heat absorbed through solar radiation can be convected away(through convection) into ambient air much quicker and significantly reduced heat load when vehicle is moving as compared to it is stationary

Other Design Considerations



Can the temperature set point be tampered with?

Can the refrigeration system be connected to an external power supply?

Where is the controlling thermostat?

Is there a temperature display in the vehicle?
Is it alarmed?



What is the maximum height for loading?

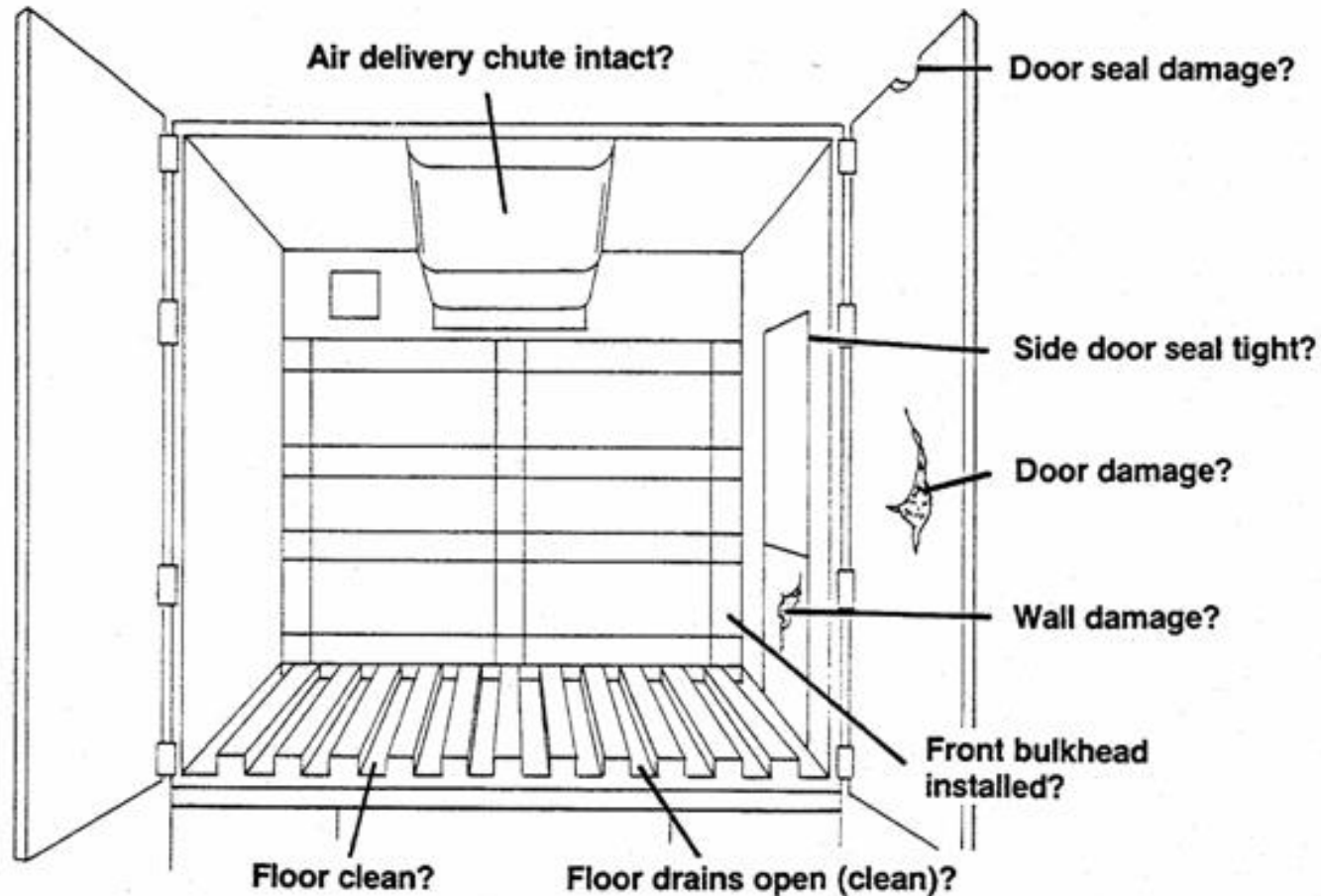
Can the doors be secured?

Is the monitoring equipment calibrated, and can a hard copy of the temperature record be provided?

Are there cold or hot spots inside the vehicle?

Can moving partitions be used to adjust the freezer compartment space?

Refrigerated Vehicle Maintenance Considerations



Inside width adequate for load?
Inside height adequate for load?
Door height adequate for load?

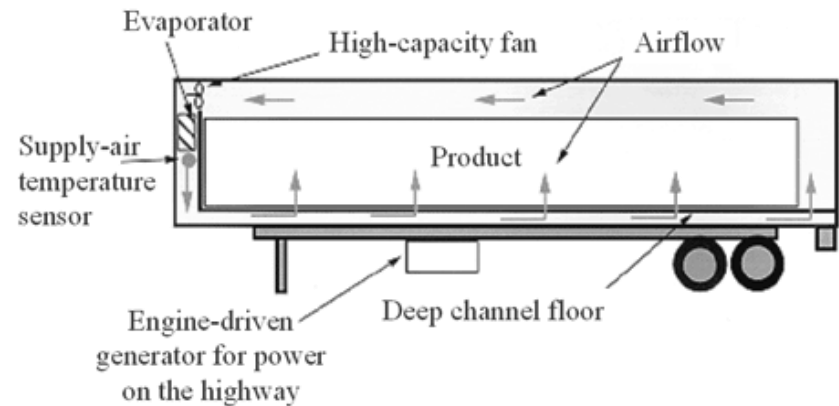
Load bars used to secure load?
Trailer precooled before loading?
Refrigeration unit operates satisfactorily?

Types of Air Delivery

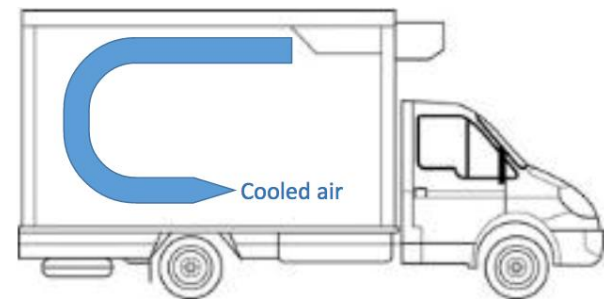
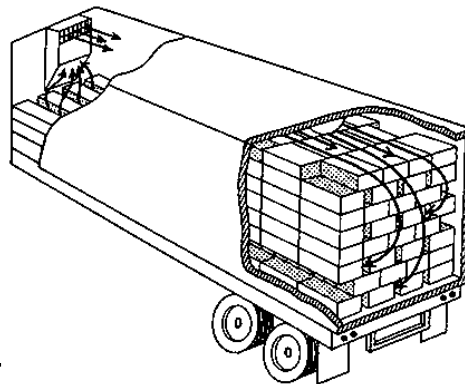


Bottom-air delivery in reefer containers ensures better temperature as air flow is more uniform. When loading we must ensure entire floor is covered, else cold air will bypass produce.

T-Bar flooring



Top-air delivery in refrigerated trucks, air moves over the top of the load then back to the front to the refrigeration unit.



Transportation Practices for PTSP – Do's



1. Pre-cool refrigerated compartment
2. Maintain correct temperature
3. Turn on refrigerating unit throughout the journey.
4. Turn off refrigeration unit during loading & unloading while doors are ajar & power-on immediately upon completion; If not, hot air will rush into the anteroom and cause condensation.
5. Plan and take the shortest routes
6. Keep vehicles clean and in good condition
7. Protect perishables with appropriate packaging
8. Brace the load so that it will not move around during transit
9. Transfer of products done in a fast and hygienic manner

Transportation Practices for PTSP – Don'ts



1. Allow products to be exposed to incorrect temperature
2. Load above the maximum load height mark of the vehicle
3. Load warm products into the vehicle
4. Leave doors open unnecessarily



Learning Objectives



- ▶ Recognize the importance of temperature control of cold products during transportation
- ▶ Identify and describe the different types of transport equipment and tools used to maintain temperature during transportation
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