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CHAPTER 3

GENERAL REQUIREMENTS FOR REFRIGERATED ROAD TRANSPORT

1. INTRODUCTION

A refrigerated road transport vehicle is exactly what the name implies – a transport vehicle to move refrigerated produce from one point to a destination under cooling. A refrigerated transport vehicle is not a precooling unit, but designed and built to move the maximum payload at a specified temperature. Perishable products must therefore be precooled to the transport temperature and loaded into the refrigerated unit with a minimum increase in product temperature. It is also necessary to understand the dynamics of product temperature changes, the characteristics of the cooling system and the importance of cold air management inside the refrigerated unit. Some of these aspects will be addressed in the following paragraphs. A refrigerated road transport vehicle is called a by a number of different names. The most widely internationally used terms are Refrigerated Motor Transport (RMT) and refrigerated trailers.

2. BASIC REQUIREMENTS FOR REFRIGERATED VEHICLES

2.1 Insulation

Refrigerated road vehicles are insulated with polyurethane foam sandwiched between glass reinforced plastic (GRP) inner and outer skins. The following are minimum specifications:

- **Insulation thickness**

Sidewalls	minimum recommendation	55mm 65mm
Roof, door and bulkhead	minimum recommendation	70mm 100mm
Floor	minimum recommendation	100mm 115mm

- **Heat transfer 0.4 Watts/m^3 °C maximum**
  Most perishable products transported over long distances (table grapes and subtropical fruits) are very temperature sensitive. These products are also transported at high ambient air and road surface temperature conditions. The recommended insulation thicknesses should therefore regarded as the norm to keep heat leakage as low as possible.

2.2 Construction criteria

- **Floor - Should be of a 50mm deep T-bar construction to allow for better flow of return air.**
- **Sidewalls - Grooved or fluted to ensure an air space between the cargo and inner skin of the sidewalls.**
- **Bulkhead - False bulkhead with open bottom entry to allow unobstructed flow of return air.**
- **Doors - Double doors with positive pressure locking mechanism to ensure absolute air tight all round seal.**

2.3 Cooling unit capacity

The two makes of refrigeration units most commonly used in South Africa are Thermo King and Carrier. Models of both makes of cooling units comply with the specifications of and are certified by the International Transport Agreement (ATP). Minimum cooling unit capacity is dictated by the length (load capacity) of the transport vehicle as indicated as follows:

Length of transport vehicle m	Minimum airflow capacity m^3 /h	Minimum heat load capacity Watts
13.6	4137	5,782
14.6	4441	6,217
15.5	4715	6,614

2.4 Temperature requirements
All refrigerated produce must be transported at the optimum product temperature (see Chapter 8) with a maximum deviation of plus/minus 0,5°C from the optimum. Loading only uniformly precooled produce at the optimum temperature is important but equally important is correct and reliable temperature control of the cooling air. Some of the more important aspects and requirements are listed below.

2.4.1 **Temperature control thermostat**

- The temperature control thermostat must control the temperature of the air delivered to the product within a maximum of plus/minus 1,0°C. This means that air must be delivered to the product at the specified optimum temperature (Chapter 8) within a band of not more than plus/minus 1,0°C from the optimum temperature.
- The thermostat functions shall include cooling, heating, defrost and fan speed control
- Position of thermostat sensor. The sensor must be fitted in the delivery air stream after the air has passed over the cooling coil but before it makes contact with the product.
- Calibration of the thermostat. Regular calibration checks in melting ice at 0,0°C (see Chapter 2 Par 4.3.3) must be done at least once every month.

Transport vibration and regular re-adjustments of the thermostat to accommodate different load temperatures however require that the thermostat must be calibrated before every load. A system of thermocouples installed in the delivery and return air plenums simplifies recalibration prior to every load. The closed (sensing) ends of two thermocouple wires are placed in the delivery air (in contact with thermostat sensor) and in the return air plenum respectively. The wires are taken to the outside and the open ends fitted to thermocouple plugs. The delivery (DAT) and return (RAT) air temperatures can therefore be measured with an electronic thermometer from outside the refrigerated compartment. The thermocouple reading of the delivery air temperature must not deviate by more than plus/minus 0,5°C from the thermostat temperature set point when temperature equilibrium is reached. The thermostat must be serviced and calibrated in ice should the difference between the thermostat sensing unit and the thermocouple in the delivery air stream be more than plus/minus 0,5°C.

2.4.2 **Delivery air temperature**

The DAT is the temperature of the air just before it makes contact with the product. The specified DAT (thermostat temperature set point) is also the optimum product transport temperature. It is therefore very important that the temperature control for chilled produce is on the delivery air. Temperature control and measuring sensors must therefore be in the delivery air stream. It must be noted that the DAT increases with an increase in distance from the cooling coil. This increase may be as much as 1°C in the case of refrigerated vehicles with a ceiling mounted air distribution system.

2.4.3 **Return air temperature**

The RAT is the temperature of the air before it enters the return air opening at the bottom of the bulkhead. The RAT is therefore the sum of all the heat removed by the circulating air. This includes residual heat from the product, packaging material, vehicle structure, respiration heat of the product and heat that leaked into the refrigerated compartment. The difference between the DAT and RAT should never be more than 1,5°C because a warmer RAT indicates that the product is warm, that heat leakage is excessive or both. It is therefore essential to precool the vehicle and the product to the transport temperature before loading and to ensure insulation integrity. Note: The temperature control for deep frozen produce must be in the RAT before the air passes over the cooling coil (evaporator).

2.4.4 **Integrated temperature control**

Almost all modern road transport refrigeration units are fitted with integrating electronic temperature control systems. In principle these systems measure both the DAT and RAT and automatically deliver air much colder than the thermostat temperature set point (required DAT) as long as the RAT is warmer than the temperature set point. The DAT is slowly increased as the RAT is reduced and is equal too the thermostat temperature set point when the RAT is close to or at the temperature set point. In practice integrating temperature control means that air will deliver to the product at much colder temperatures if the product is not uniformly precooled to the transport temperature. Avocados loaded at an average pulp temperature of 13°C and to be transported at 7,0°C can be subjected to a DAT of below 0°C for several hours resulting in chilling and freezing injury.

2.4.5 **Temperature measurement and recording**

- **Temperature recorder**
  Every refrigerated road transport vehicle must be fitted with an accurate and calibrated temperature recorder or electronic data logger. The temperature sensor of the recording device must be in the delivery air next to or even fixed to the temperature control thermostat sensor and the DAT thermocouple sensor. The difference in temperature readings between the three sensors should not be more than 2,5°C with an absolute maximum of 0,5°C. The temperature recorder should be able to continuously record at least the DAT, although one reading per hour should be adequate under most operating conditions. It is strongly recommended that the RAT is also recorded in the same way as the DAT.
- **Dial temperature indicator**
  These temperature indicating devices are usually not very accurate but can give the driver a good indication of the temperature situation. The sensor must be installed in the delivery air in the same position as the thermostat, recorder and thermocouple sensors.
- **Delivery and Return Air Temperature thermocouples**
  The position and function of the DAT and RAT thermocouples are discussed above (Par 2.4.2 and 2.4.3)

2.5 Air circulation and distribution

All refrigerated road vehicles are fitted with a ceiling mounted cold air supply and distribution system. This allows for top to bottom air circulation, i.e. with the natural convection flow of cold air. The return airflows back to the cooling coil via the return air plenum (T-bar floor and/or pallet openings) on the floor.

2.5.1 **Air circulation requirements**

Refrigerated air is the only medium that can remove heat from the compartment and the product. The only way that efficient removal of heat can be achieved is to circulate air at the right temperature through the load and around the product. This requires inter alia that:

- A minimum air speed of 1 meter per second ($1m.sec^{-1}$) at a static pressure difference of at least 50mm water gauge is required.
- The air delivery and air return plenums must be clean and unobstructed to allow free airflow to and from the cargo.
- Air delivery ducting or shutes are used with variable results. Only well tested air distribution systems for the particular type of transport unit should be used.
- Ensure correct cargo loading configuration (see par 5 below).

2.5.2 **Fresh air ventilation**

Fresh produce requires oxygen to support respiration. Most fresh produce also produces ethylene gas that triggers ripening and senescence. Products such as avocados, papayas and flowers are very sensitive to ethylene and require high rates of fresh air ventilation to keep the ethylene concentration low. The following guidelines can be given for a 12m vehicle:

Minimum air change rate: $30m^3$ per hour
Maximum air change rate: $250m^3$ per hour
These rates are equivalent to 0,5 and 4,5 complete air changes per hour respectively based on the empty volume of the refrigerated compartment. The higher air change rates should be used carefully because too much fresh air will:

- Ad to the heat load and will therefore put more pressure on the refrigeration system
- Result in a reduced relative humidly (RH) in the air surrounding the product. A reduced RH will result in desiccation of the product.

The minimum fresh air exchange rate should therefore be applied to most fresh produce.

3. PRELOAD CHECKS OF REFRIGERATED ROAD VEHICLE

Each and every refrigerated road transport vehicle must be checked before loading. These checks should include the following:

3.1 **Overall condition**. The vehicle must be in a good state of repair with no cracks between the floor and insulated panels and between the panels. Door seals must be intact and the doors must seal positively with no air leakage.

3.2 **The insulation** shall be intact with no damaged external and internal skins. All joints shall be properly sealed with an approved sealant.

3.3 **The vehicle** shall be clean on the outside to minimize heat leakage. The inside shall also be clean and dry. Special care must be taken to clean the T-bar floor and the air return ducts.

3.4 Precooling and temperature checks

3.4.1 **Precooling of the vehicle** is very strongly recommended because it will:

- Cool the body structure to reduce the heat load after completion of loading
- Allow routine checks on the operation of the cooling unit

The refrigeration unit should operate within the manufacturer's specifications with no excessive heat build up, strange noises or oil leakage.

3.4.2 **Temperature checks** should be done after the unit was precooled for a minimum period of 3 hours or after temperature equilibrium has been reached. The following must be checked and recorded:

- Temperature set point as specified for the load
- DAT as measured with the thermocouple. (Par 2.4.2 above) to be within plus/minus 0,5°C from the thermostat temperature set point.
- RAT as measured with the RAT thermocouple (Par 2.4.3 above) to be stable and within the tolerance as indicated in par 2.4.1 above.

An ice calibration (Chap 2 Par 4.3.3) must be done if the DAT reading deviates by more than 0,5°C from the thermostat temperature set point.

4. PREPERATION OF REFRIGERATED CARGO

4.1 Packaging and palletisation
Adequate delivery air space at the top of the load is essential to allow airflow to all areas within the insulated box. The packaging should allow for adequate and unobstructed airflow in both the vertical and horizontal planes. Carton ventilation must also align with pallet base openings and load stabilization interleaves to allow unobstructed airflow through the total load.

4.2 Precooling of the product
A refrigerated road transport vehicle is not a cold store and can only maintain product temperature. The product must therefore be precooled to the required or specified transport temperature. (See Chapter 8 for product specifications). Proper and uniform precooling is also an important prerequisite for good temperature control in a unit fitted with an integrating temperature control thermostat (par 2.4.4. above).

4.3 Selection of product
The export consignment must be made up according to the buyer's specifications before loading of the refrigerated vehicle. This process must be done in the cold store to maintain optimum product temperature. Sorting and selection at the container-loading depot can result in delays and temperature increases. International specifications re traceability of the product shall apply. This will require cold store and pallet identification as well as vehicle identification and pallet position in the refrigerated vehicle.

4.4 Product temperature recording
Product temperatures must be taken at the time of loading into the refrigerated vehicle. The following information, that also form part of traceability requirements, should be recorded:

- Pallet identification number
- Fruit temperature in center of pallet as measured via a thermocouple
- Fruit temperature of the inner fruit in a carton on the outside of the pallet as measured with a calibrated thermistor (probe) thermometer (see Chapter 2 par 4.2.4).

The completed temperature and pallet data sheet must be:

- Checked and countersigned by the driver of the refrigerated vehicle
- Send (preferably e-mailed) to the respective PPECB port office.

Note: The condition of the refrigerated vehicle and cargo as well as transport and product temperatures will be checked by PPECB at off loading. For more detail see Chapter 5.par 3.1.14.

5. LOADING EQUIPMENT AND PROCEDURES

Most perishable produce for transport and export are packed in cartons on pallets. This system allows for quick and efficient handling and loading but requires special equipment. Some products, especially some deep frozen products are handled loose. This requires manual handling and loading with associated delays and temperature increases. Some of the more important considerations are discussed in the following paragraphs.

5.1 Loading equipment

5.1.1 Forklifts and pallet jacks
Only battery-operated forklifts may be used for loading and off loading of refrigerated vehicles. Hand operated pallet jacks can also be used and work very well for smaller operations.

5.1.2 Air locks and loading bays

Refrigerated produce must never be exposed to ambient temperature and humidity conditions. This will result in unwanted temperature increases and condensation on the product and packing material Insulated and temperature controlled air locks connecting the cold store directly with the refrigerated vehicle should always be used. This applies for both loading and off loading of refrigerated vehicles and containers. Loading and off loading bays are also a requirement for efficient and fast loading and off loading of large volumes of perishable produce. The objective is to provide a strong and stable loading platform the same height as the floor of the refrigerated vehicle. Battery powered forklifts and pallets jacks must be able to move freely into and out of the refrigerated vehicle.

5.2 Loading procedure

The loading of refrigerated cargo must be as quick as possible to avoid any temperature increases and condensation. The following are important requirements:

- There must be no openings between pallets or cartons (the cargo) or open floor spaces because this will result in short circuiting of the air without moving through the load to remove the heat.
- Cargo must never be loaded above the horizontal load line (at least 80mm from the ceiling) or beyond the vertical load line (end of the T-bar floor section) at the door end.
- Cargo must never be stowed right up against the sides and an air space of at least 20mm must be provided for the cold air to flow between the inner sides of the transport unit and the cargo. Ribbed or fluted inner sides are recommended as it assists air circulation.
- Cartons and pallets must be stowed in such a way that it allows unobstructed vertical airflow channels from the door and right up to the bulkhead at the cooler end.
- Loading must be completed within 30 minutes. The doors must be closed and cooling applied during breaks in loading.
- The doors must be closed properly and door rubbers must seal all round to avoid heat leakage and the ingress of moisture into the refrigerated compartment.

5.3 Confirmation of transport temperature

The consignee and the driver of the refrigerated vehicle must make absolutely sure that:

- The temperature control thermostat is set to deliver air at the required temperature.
- The accompanying transport document is completed, that the temperature set point is recorded and that both the consignee and the driver of the vehicle sign the temperature data document.

5.4 Maximum axle weight

The specified axle weights must be obeyed to prevent overloading of the vehicle. Should it be necessary to load fewer pallets, all open floor spaces must be covered or pallets stacked down to cover such spaces. This is to ensure that no short-circuiting of cold air takes place and that all the air moves through the load.

6. TRANSPORT TEMPERATURE MAINTENANCE

6.1 Checks during and on completion of loading

Optimum transport temperatures can only be achieved if:

- The product was uniformly precooled to the transport temperature.
- The cooling unit of the refrigerated vehicle operates within the design parameters and specifications
- The refrigerated compartment was precooled to the transport temperature
- Temperature increases during loading were kept to the minimum.

It is also very important to:

- Ensure that the temperature control thermostat is set to deliver air at the specified temperature.
- That at least one pulp temperature reading per pallet is taken and recorded.

6.2 During transport

The refrigeration unit must run continuously until off loading. The driver must therefore ensure that there is sufficient diesel to power the cooling unit. The driver must also:

- Check the dial thermometer reading at least every two hours.
- Check the condition and status of the cooling unit at least once every four hours.
- Communicate all malfunctioning of equipment, deviations in temperatures and delays to the off loading depot.

6.3 During off-loading

Vehicle condition transport and product temperatures will be checked during off loading (See Chapter 5.par 3.1.14).