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Responsible Person:	National Manager Cold Chain Protocols and Standards (Bernard Henning)	
Approver:	General Manager Coastal (Vijan Chetty)	
Department:	Operations - Cold Chain	

1. INTRODUCTION

Most food spoils easily and cannot be stored for any considerable length of time without quality losses occurring.

Chemical and biochemical changes, normally in the form of colour changes (e.g., cloudiness in fruit concentrates or dark browning and dry texture of meat products) take place when the product containing free oxygen (or be exposed to the air) is stored at temperatures as low as minus 12°C. The rate of oxidation depends on several factors such as antioxidant content (e.g., vitamin C), acidity (pH), exposure time and temperature of the product and packaging type.

Microbial changes, harmful residues and contamination can take place at temperatures as cold as minus 12°C. Although most of the bacteria, fungi and yeasts cannot grow at minus 12°C, they can still multiply. Very rapid growth and multiplication will follow if the temperature increases further.

Physical changes, normally in the form of texture changes of the product, “snow” formation on the product and inside the packaging and block freezing, are common problems reported by importers. These changes, especially snow and block freezing can occur at temperatures below minus 18°C and is the result of fluctuating temperatures rather than an increase in actual temperature. It must be remembered that as the temperature varies a process called migratory re-crystallization occurs. The size of the ice crystals increases and decreases depending upon the temperature and the amount of air that contains moisture and ultimately this causes physical damage to the flesh tissue. Upon thawing the tissues which have experienced fluctuating temperatures are much more flaccid and therefore far less appetizing when prepared.

Frozen produce, unlike chilled produce, is dead and do not produce heat of respiration. This means that, for the cargo temperature to increase, heat must be absorbed from the environment and conducted though the insulation to the load.


Correct stowage is extremely important to the carriage of containerized reefer cargo. With frozen cargo, the objective is to provide a circulation of cold air (blanket) around the cargo. Primarily the air circulation between the cargo and the walls, floor and roof will absorb any warm air that has entered through the insulation. The air in-turn will carry the absorbed heat to the evaporator coil where this heat is absorbed and given off to the outside ambient air via the condenser. It is thus essential to have the cargo at the desired set point at the time of loading.

2. PROBLEMS ENCOUNTERED

Different types of frozen produce exhibit different quality problems when not handled and stored at optimum temperatures. Within the foodstuff, microbiological, chemical, biochemical and physical processes occur that causes quality deterioration. Refrigeration technology plays a vital role in controlling these processes because all are retarded by lowered temperature.

Other factors such as processing methods, packaging materials, and packing methods also influence potential quality changes within the product.

Frozen foods must always be stored and transported at or below minus 18°C (See paragraph 4). International regulations allow a maximum of 3.0°C temperature increase (i.e., up to a maximum of minus 15°C) for a short period during the loading and transfer of the product from the cold store into the transport unit. A further requirement is that the temperature must be reduced or re-cooled to minus 18°C or colder as quickly as possible. **It is important to note that all products must be on loading temperature or colder prior to commencement of loading. The tolerance of 3.0°C will only be accepted during the loading process.**

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2.1 Handling process:

- The loading process specifically loose fish generally takes too long. Containers often stand too long after loading.
- Too much product is often being placed in the loading area at ambient temperature, as a result much would be loaded an hour or more later. Staff training is advisable.
- Some cold stores have air locks of which many are warmer than ideal. Some cold stores do not have any air locks at all. As a result, the pulp absorbs too much heat during loading. Ultimately containers are often returned from the container terminals a day or two after loading, cargo having to be removed and re-cooled. Deterioration of the cargo has therefore already occurred. Whatever happens a financial loss will be the result.
- It has also become apparent that a large quantity of deep-frozen fish that PPECB attends the loading of, is foreign cargo, therefore only requires PPECB services if so, requested by the exporters. This means that PPECB is only required to inform the exporter of results and have no due restriction on rejecting such cargo.
- The Regulation states that any foreign product that is mixed in the same vessel, cooling space and receives refrigeration from the same source as a South African product, then the consignment in its entirety is deemed a product of the RSA in terms of the Act.

2.2 Dual loading

2.2.1 Ongoing temperature related problems are experienced when containerizing frozen loose fish at more than one cold store, that is, part loading at one store and completing the container load at another.

It has therefore been decided that dual loading of loose fish will no longer be allowed.

Ensure that loose fish consignments are consolidated for loading at one load point only.

2.2.1 Dual loading of cartons of fish may nevertheless be reconsidered on certain conditions as follows. The following would also apply to certain other non-highly sensitive frozen commodities to which the exporter has given his consent.

2.2.1.1 All products must be properly pre-cooled to a uniform temperature of minus 23°C and colder.

2.2.1.2 The loading process must take place quickly and without delays.


2.2.1.3 The container must be loaded immediately on arrival at the second load point.

2.2.1.4 The container must be plugged into the electrical supply immediately on arrival at the terminal.

2.3 Quayside loading of loose fish:

The following conditions must be strictly adhered to:

- The quay area must be hosed down prior to loading.
- No sorting must take place during the loading process.
- Avoid direct wind into container. Loading should preferably take place through an open top container.
- Discharge fish onto clean plastic sheeting, prior loading into container.
- Avoid exposure of product to direct sunlight.
- Do not operate during rainy conditions.
- Loading process must be uninterrupted. Avoid delays and close container doors immediately.
- At no stage may the cargo in the container be warmer than minus 20°C.
- Loading must be completed within four hours.
- Arrange for immediate removal of full container. A maximum of two hours is allowed before re-cooling

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must be applied.

2.4 Recommendations to improve the cold chain process:

- Organizing the cargo in the cold store prior to the start of loading will speed up the process. It is apparent that operators waste much time searching for cargo during the loading period thereby delaying the process unnecessarily.
- A conveyer belt or similar system can be advantages in certain instances specifically where carton cargo is being loaded.
- Installing plug points to supply electrical power to a container. The advantage of having this facility is that the containers can be pre-cooled prior to loading, specifically if loading is to take place 1 hour or more later. This will at least cool the container ambient air and if it operates long enough, will cool the insulation as well. On completion of loading the container can be plugged on power until the truck arrives to cart it to the terminal. On some occasions this can be some hours. An additional advantage and value-added service is that the container settings can be verified. Not all containers have a battery backup to check the settings, and some have battery backup that often do not work at all for varying reasons.
- Every person from the operations manager to the laborer must be made aware that fish is a commodity that warms up very quickly, therefore utmost attention must be taken to ensure that loading takes place as fast as possible.
- While loading a container the door must be closed during tea and lunch breaks or any other breaks for that matter that may arise.
- Never load a container in the open with the doors facing the direction that the wind is coming from.
- Do not load a container in the open i.e. at an unprotected facility during poor weather conditions.
- The Shipping Lines have a responsibility to monitor temperatures at the container after loading. It has been noted that the defrost cycle must be initiated more often in some instances or less often in others. This makes a huge difference in assisting the re-cooling of the cargo. The way in assessing this is to observe the amount of water draining out during a defrost cycle. If very little water is noted, then the defrost cycle must initiated less often and vice versa if a large amount of water is observed escaping from the drain.

3. PRECAUTIONS


3.1 Product temperature

Unacceptable temperatures of mainly frozen loosely exported fish in containers has for many years been a problem for both exporter and PPECB.

Most people do not realize that frozen products are as sensitive to fluctuating temperatures as what avocados are for example.

Fluctuating temperatures during any part of the cold chain are very detrimental to the market quality of frozen foods. Re-cooling frozen foods to the thermostat set point after even a slight temperature rise causes moisture to migrate from the product to the colder surfaces of the packaging materials. The result of this is product dehydration and undesired frost build up inside the packages. Product quality losses will increase with the amount of temperature rise and frequency of re-cooling. Thawing can take place as cold as minus 17°C with some products and between minus 9.0°C and 0.0°C for others.

Although the changes are not easily recognized, even at temperatures as low as minus 18°C, certain frozen foods may deteriorate from fat oxidation and enzymatic changes. Certain microorganisms may develop at temperatures around minus 7.0°C and above, adding to deterioration and contamination of the food. It must be said that the higher the temperature, the greater the rate of deterioration.

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It is obviously apparent that the loading cold stores are aware that over the year's temperature problems exist as many of the containers are removed from the deep-sea terminal and returned to the loading cold store for unpacking and re-cooling. The unfortunate result is that the temps being warmer than minus 18°C, has caused thawing of various substances within the flesh and consequently separation of moisture and other materials.

Re-cooling the product to its freezing point of –18°C means that deterioration has already set in the form of moisture crystallization. Once the fish is defrosted for eating, signs of dehydration and freezer burn will be dissatisfying present. The taste will also be adversely affected.

3.2 Time Temperature Tolerances (TTT)

The TTT is defined as the total cumulative time that the product is not under cooling during pre-shipment handling operations.

The standard maximum cumulative TTT of 12 hours must be applied to ensure minimum quality loss and condensation. It must nevertheless be stressed that this maximum TTT must not be aimed at being a norm. Obviously the smaller the TTT the better it is for the product temperature and ultimately the quality.

3.3 Stowage pattern

Frozen cargo in **cartons** must always be block stacked and be protected from heat penetration from the outside.


It is advisable to place a wooden grating at the doors when loose fish is loaded to prevent cargo from spilling/sliding out at the point of discharge. Always ensure that the return air grid of an integral container is not damaged or obstructed during the loading process. All containers have a maximum height load line marked inside on the sidewalls. The cargo height must never exceed the line. This space must always be left to allow an uninterrupted airflow from the cargo to the “return intake opening” to the refrigeration unit.

When loading **drums** (concentrate) ensure that a loose plate or strongly made spacer is used for the second tier. Steel strapping or loose wooden gratings must secure cargo at the door end.

Free air circulation all around the load is essential. It is desirable to have floor channels or floor racks at least 6 cm deep for air circulation under the load. If the floors are flat, then the cargo must be placed on pallets.

At least 8 cm of space must be provided between the load and the rear doors to let air flow freely around the rear of the load. Ribbed sidewalls are recommended to allow air circulation between the wall and the load. At least 10 cm of space should be left between the ceiling and the top of the load for unobstructed return airflow over the load. Ideally it is important to prevent heat that penetrates the insulated containers from reaching the cargo by keeping the load encircled with an envelope of cold air. Frozen product in contact with the walls will act as a heat sink and absorb any heat conducted through the walls, therefore a film of air separating the cargo from the sidewalls is essential.

It is self-evident that whatever packaging is used, it must be secure. What is important is that while remaining secure, the packaging must allow air to circulate freely around the periphery of the container and in the area of the door. The important criterion here is to have uniform distribution of air throughout the load. This requires the cargo to be uniformly stowed. Different sized packaging generally dictates different stacking patterns.

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The higher the resistance to the air pressure developed by the fans, the smaller the volume of air will be that passes over the cargo and, subsequently, the lower the rate of heat exchanged between the air and the cargo. In an extreme case, a high resistance to air flow will mean that cargo will have relatively little or no air flowing over it and certainly low or no airflow closer to the door end i.e. further away from the cooling unit. Conversely, if cargo is stowed with large gaps and no resistance, the air will short-circuit through the low-resistance areas and return to the refrigeration unit without cooling the bulk of the cargo further away from the refrigeration unit. As stated earlier, the key to uniform cooling is uniform air distribution.

The ideal stowage pattern should permit free movement of delivery air whilst restraining any movement of the cargo. Frozen products require a very simple stowage arrangement provided they are loaded at the specified carriage temperature.

4. TEMPERATURE CONDITIONS GUIDELINE

The basic requirements for importing countries are the same, although the regulation may sometimes read differently. The following serves as an example of the requirements laid down by most countries importing from the RSA.

4.1 Product temperature requirements

4.1.1 Frozen produce must be at or colder than the specified transport temperature with a maximum of 6.0°C below the set point temperature prior to the commencing of loading into the mode of transport.

Note:


The container set point temperature was booked at minus 18°C then the cargo temperature in the cold store prior to loading is acceptable up to minus 24°C. Should the pulp temperature indicate colder than minus 24°C then the container set point must be reset to minus 24°C with necessary booking and document amendments?

The reason for instituting this requirement is because the cooling unit defrost heaters may switch on automatically and warm the cargo, specifically that which is closer to the discharge air. The refrigeration system will not commence cooling until such time that the temperature of all products in the container reaches the set point temperature. The required set point temperature must be verified with the shipping line prior to making the booking, because not all units are compatible to operate colder than minus 24°C. Specialized containers will be required for this purpose. **The product must also be at a uniform temperature** because mixed temperature (warm and cold) cargo, even at temperatures of minus 15°C to minus 18°C will cause snow formation and the remaining cargo to warm up.

4.1.2 A maximum temperature increases of 3.0°C will be allowed during the loading of the product from the deep freeze cold store into the container.

Notes:

If the product is to be shipped at minus 18°C (deep frozen produce), it must be pre-cooled to minus 18°C or colder prior to loading into the container. Should the temperature of the product increase during loading to minus 15°C, loading will be stopped, and the product will have to be re-cooled to minus 18°C or colder before loading can be recommended.

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In the case where the shipping temperature is minus 21°C or colder, it will be allowable for the pulp temperature to be 3.0°C warmer, prior to loading, in other words, a 3.0°C tolerance will be applicable to a maximum produce temperature of minus 18°C.

This 3.0°C tolerance will however not be relevant for minus 20°C, minus 19°C or minus 18°C shipments as the minimum allowable pulp temperature for deep frozen produce, prior to loading, remains at minus 18°C.

Examples:

*F-22 - Shipping temperature: minus 22°C
Allowable pulp temp: minus 19°C or colder*

*F-21 - Shipping temperature: minus 21°C
Allowable pulp temp: minus 18°C or colder*

*F-20 - Shipping temperature: minus 20°C
Allowable pulp temperature: minus 18°C or colder*

*F-18 - Shipping temperature: minus 18°C
Allowable pulp temperature: minus 18°C or colder*

4.1.2 Products to be shipped at a maximum temperature of minus 20°C or colder.


- **Marine Products** – Abalone, Crayfish, Crustaceans, Lobster, Squid and Mussels
- **ICE Cream**

4.1.3 Products to be shipped at a maximum temperature of minus 18°C.

Animal tissue and products – all types
 Fish - fresh and processed,
 Fruits – whole, pulp, purée, concentrates,
 Juices and concentrates
 Meat – all types
 Vegetables – whole, pulp and purée
 Cheese – depending on type and maturity,
 Dried and processed vegetables and meat
 Egg - pulp, white

4.1.4 Products to be shipped between minus 15°C and minus 18°C.

Butter - minus 15°C
 Egg Products - (Salted and Sugared)
 minus 15°C to minus 18°C

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5. SUMMARY

It can be concluded that the following factors are of paramount importance in maintaining quality of frozen cargo during transportation.

- 5.1 The product must be at or below the specified carrying temperature (usually minus 18°C or colder) and the temperature must be as uniform as possible. If marine products have been allowed to become warmer than minus 12°C during or after loading, then re-inspection must be done by the applicable authorities.
- 5.2 Please note that the 6°C tolerance (Par. 4.1) is only applicable to the product temperature prior to loading, therefore at the time when cargo is presented for export, it must be at a temperature of minus 18°C or colder or as otherwise specified in this document. Although not ideal, a maximum of 3.0°C warming of the product will be acceptable during the loading process.
- 5.3 The cargo must be block stowed to allow adequate cold air circulation at the bottom, top and sides. This means that the cargo must be in minimum contact with the sides of the container and not stowed above maximum load height in a container (Red line). Achieving this will ensure unrestricted delivery and return air movement through the evaporator plenum.
- 5.4 In the case where cargo is booked at minus 18°C and the product temperature is colder than minus 24°C then the container must be reset to a colder setting at the loading point. All documentation must be amended to the new temperature setting.