

# Cold stores and containers, Refrigerated containers, Good handling and shipping practices,

## Chapter 1: Construction of cold store

### 6.1 Construction of cold store

A cold store is any building or part of a building used for storage, at temperatures controlled by refrigeration at -18°C or lower.

#### Recommended Storage Temperature

Reducing the storage temperature can slow all the spoilage of fish due to protein denaturation, fat changes and dehydration. The FAO Code of Practice for Frozen Fish recommends that frozen fish products should be stored at temperatures appropriate for the species, type of product and intended time of storage. The International Institute of Refrigeration recommends a storage temperature of -18°C for lean fish such as cod and haddock and -24°C for fatty species such as herring and mackerel. The code also recommends that for lean fish intended to be kept in cold storage for over a year, the storage temperature should be -30°C.

#### Practical storage lives (PSL) of fish products

Product	Storage life in months		
	-18°C	-24°C	-30°C
Fatty fish (glazed)	5	9	>12
Lean fish (fillet)	9	12	24
Flatfish	10	18	> 24
Shrimp (cooked/peeled)	5	9	12

#### 6.1.1 Shape and size

Cold stores can be divided according to construction into single-storey and multi-storey buildings. They can be used as production stores, bulk stores, distribution stores or retail stores. For a long time, the most appropriate shape was a cube for which the ratio of surface to volume is a minimum. This resulted in multi-storey buildings, with a number of disadvantages, e.g., costly foundations, heavy framework, congested handling areas.

The main considerations which have resulted in the appearance and success of single-storey buildings are cost reduction together with mechanized handling techniques.

A single-storey cold store can be easily designed to meet the specific requirements of stacking and handling equipment. Wall and roof constructions can be made lighter as they do not have to support the weight of the product stored, as in a multi-storey building. The main disadvantages are the relatively large ground area covered and the high ratio of surface to volume. The advantages however, normally override the disadvantages.

### 6.1.2 Insulation

The choice of insulation is very important as it accounts for a large proportion of the total construction cost. The insulation material and thickness is also important from an energy point of view. Besides a satisfactory thermal conductivity coefficient the insulation material should also be odour-free, anti-rot, vermin and fire-resistant and impermeable to water vapour.

#### Typical insulation thickness for chill and cold stores utilizing different insulation materials

Insulation	Calculated thermal conductivity (kcal/m h°C)	Thickness (mm)
Polystyrene	0.033	220
Styrofoam FR	0.030	200
Polyurethane	0.025	170

#### Vapour Barriers

Water vapour in the air gives rise to a pressure and together with the other gases present. The partial pressure exerted by the water vapour is proportional to the quantity of vapour present and the vapour in the air will tend to migrate from areas of high partial pressure to areas of low partial pressure. Hence, there is a tendency for moisture in the ambient air to pass through the insulation of a cold store to the area of low partial pressure within. When this vapour is cooled, it condenses and the build-up of ice will eventually affect the insulation properties of the cold store wall and also weaken the structure of the wall or building.

#### Foundations and Frost Heave

Low temperature stores built directly on the ground may require special precautions to prevent the build-up of ice below the cold store floor. The ice formation causes distortion known as “frost heave” (fig.) and in particularly bad cases, it can lead to the complete destruction of the structure of the building. The conditions that give rise to frost heave are rather complex, since they are related to the type and texture of the soil, the insulation properties, the availability of moisture, the dimensions of the store, seasonal climatic variations and other factors. Two methods of preventing frost heave are commonly used. The ground below the store can be heated either by a low voltage electrical mat in the cold store foundation or by circulating a heated liquid such as glycol through a pipe grid built into the foundation. The heat for the glycol is usually obtained from the compressor hot gas through a heat exchanger.

### 6.1.3 Air ingress

Outside air entering the store adds heat and moisture. This moisture will be deposited as frost on any cold surface and will eventually cover the surface of the cooler. Excessive air exchange should be prevented to keep the cold store temperature steady and reduce the frequency of defrosting. Small air locks have been used to prevent the free flow of air in and out of the store.

A curtain of air blown downward or from the side of the doorway can reduce the exchange of air when the door is open. These air curtains, as they are called, can be a useful aid when the door is opened for short intervals. However, they are often abused and doors are often left open for long periods.

#### Floors

The ground loads from a cold store are in the order of 5500-8000 kg/m<sup>2</sup>. This consists of static loads due to

merchandise, structure and concentrated rolling loads transmitted by *e.g.*, forklift trucks and other handling equipment. It is of importance that those loads are investigated in detail for each special project. Most commonly the floor wearing surface is a concrete slab cast on the floor insulation with a thickness of 100-150mm. In cases where intensive traffic is foreseen a special hardwearing top-finish is recommended. Before casting the wearing surface, the floor insulation should be protected by bituminous paper or plastic sheeting, the function of which is twofold.

#### 6.1.4 General layout

A single-storey building can either have one single room or it can be divided into a number of rooms. Normally all the rooms are operated at the same temperature, for fish preferably in the range of  $-24^{\circ}$  to  $-30^{\circ}\text{C}$ . Most stores are built at a higher level than the surrounding yard with a special loading ramp at one or more sides. The loading ramp level corresponds to the height of the most commonly used vehicles.

The engine room should be as close as possible to the position of the air cooling equipment within the store.

Modern large or medium cold stores are built as one-storey buildings designed for mechanical handling, *e.g.*, forklift trucks and automatic stacker cranes. Manual handling is, however, still used for most small-sized stores.

A cold store can be built as an ordinary building using conventional building material, such as bricks, concrete or concrete precast sections to which a vapour barrier and insulation is fitted internally. Modern insulation material, in particular polyurethane, has a strength that can be utilized structurally. Today, this is used for panel designs suitable for all sizes of cold rooms from  $20\text{m}^3$  to  $250\,000\text{m}^3$ . Factory made insulation panels are delivered to the site complete with a vapour barrier and internal cladding, thus reducing the site work to a minimum. There are two basic principles for panel-built cold stores. A common system has an external structure and cladding with wall insulation inside of the columns and the insulated ceiling hanging from the outer roof structure.

The panels normally used in these systems are either polyurethane or polystyrene insulated panels with or without frames. They are manufactured as sandwich panels, one face being the vapour barrier of light-gauge galvanized steel sheet and the other face being the internal finish of plastic-coated galvanized sheet or aluminum sheet. A decorative external cladding is erected on the outside of the columns. The roof insulation is constructed as a suspended ceiling. The roof panels are, in principle, the same as the wall panels, but are sometimes equipped with wooden frames.

The latest development are panels with a rib profile on the external face of aluminum – with polyurethane foam insulation and an internal face of low profile corrugated aluminum. The space between the panels is filled with one component polyurethane foam. The internal cladding is sealed with a PVC strip. One component foam is also used to join wall panels to roof panels and seal around doors, etc, maintaining good insulation properties throughout the building. With this design both the insulation and external vapour barrier are entirely sealed units enveloping the whole building. This means that losses via heat bridges or air leakage are completely eliminated, which gives practical insulation properties closer to theoretical values than normally expected.

## Chapter 2: Refrigerated containers

### 6.2.1 Refrigerated Containers

In a refrigerated transport container or insulated vehicle it is difficult to maintain a low and stable produce temperature. Added to this, the effect of fans, the opening of the door and the presence of workmen is proportionately greater in refrigerated transport than in a large, well-designed storage chamber. Under operating conditions the best temperature obtainable is approximately  $-18^{\circ}\text{C}$  to  $-15^{\circ}\text{C}$ .

It follows that produce should be kept in transport vehicles and containers for as short a time as possible. Very often parked containers are used for cold storage to avoid the expense of constructing a cold store. However one has to keep in mind that parked transport containers and vehicles are not suitable for use as stores for frozen produce except for very short periods and in emergencies. There is such greater risk of loss of quality through temperature fluctuation and desiccation in refrigerated containers than in large, well-designed and well-operated cold store. Storage in transport containers is also very expensive when compared with properly designed cold

stores.

### **The Cold Chain**

Temperature is the single most important factor influencing fish spoilage. The cold chain is a temperature chain. It means 0°C for fresh fish and -20°C for frozen fish from the producer to the consumer. Temperature rise and temperature fluctuation will accelerate quality deterioration and it should to be avoided. Especially sensitive to temperature abuse are fresh, live and lightly cured (e.g. smoked fish) products. These should be kept at 0-1°C, and their temperature should never rise above 3°C.

Temperature fluctuations accelerate the reformation of small ice crystals into larger crystals damaging the cells. Also, desiccation will increase because of temperature fluctuations.

The insulated transport vehicles and containers shall be provided with adequate quantities of coolant or good mechanical refrigeration. Refrigeration requirements vary considerably depending on the duration of transportation, the temperature at which a product has to be maintained, the quality of insulation material, the dimensions of a container and the temperature of the environment.

### **6.2.2 Loading**

The transport vehicle has to be pre-cooled for several hours prior to loading. With pre-cooling a large rise of product temperature will be avoided. Furthermore frozen and chilled fish should not be left outside for a considerable length of time and exposed to high temperatures. To avoid such exposure fast loading and unloading is required.

### **Transit Points**

This shipper should take into consideration that transit points like airports often do not have proper refrigeration facilities, or because of mismanagement, chilled consignments are not stored in refrigerated rooms while in transit. When no refrigeration facilities are available, more coolant should be used. Alternatively the consignment might be re-iced during transit. The best way to avoid temperature abuse at transit points is to have good organization and planning.

### **Temperature Monitor**

To check on temperature abuse, continuously working monitors have been developed. These give proof of proper temperature control or abuse during road transport, at airport terminals and so on. Because of the financial risks involved it is necessary to use such monitors especially with large or high value consignments.

## **Chapter 3: Good handling and shipping practices**

### **6.3.1 Fresh fish**

The important factors in the distribution of fresh fish are speed, cleanliness and the need to keep the fish well chilled. The fish must not be handled repeatedly.

Everything likely to come into contact with the fish has to be clean. Bacteria may be picked up from dirty surfaces, tools, uniforms and hands. This will accelerate, fish spoilage and may endanger public health. Fish boxes, trucks, loading platforms have to be cleaned and disinfected before use.

For shipping fresh fish, refrigerated transport is required. Temperature is the single most important factor influencing fresh fish spoilage. Chill fresh fish with ice immediately and keep it cool. Mix the fish and ice well. Ice must always remain in sufficient quantities for effective chilling and to separate the fish from each other and from the supporting surfaces. The air temperature in the container should be 2-3°C to allow the ice to melt slowly.

Fresh Fish Spoilage

- Coldwater fish spoils faster than warm water fish.
- Fatty fish spoils faster than lean fish.
- Smaller sized fish spoil faster than larger fish of the same species.
- Round fish spoils faster than flat fish.
- Shark spoils faster than lean fish.

**Fresh Fish Fillets**

Direct contact between fillets and ice is not recommended. Water will soften the texture and affect appearance. Separate the ice from the fillets e.g. by using plastic sheeting. Be sure to chill the fillets properly before packing. Chilling after packing is difficult because of the tightly packed mass of fish flesh.

**Frozen Fish**

For shipping frozen fishery products refrigerated transport is required. The cold chain has to be maintained at all times. The normal working temperatures in modern cold stores for quick frozen foodstuffs are -30 to -25°C. Retail cabinets, in which the product should be stored for no more than a few weeks, usually operate at about -18°C or a little lower.

Do not try to freeze fresh produce or try to lower the temperature of frozen fish when shipping. Prior to shipment always check the product temperature with a thermometer. Frozen fish should be handled with care. Rough handling, such as throwing, will cause the frozen flesh to crack, damage the skin and fins and these defects will inevitably show up when thawed.