

## Freezers and Type of the Freezer

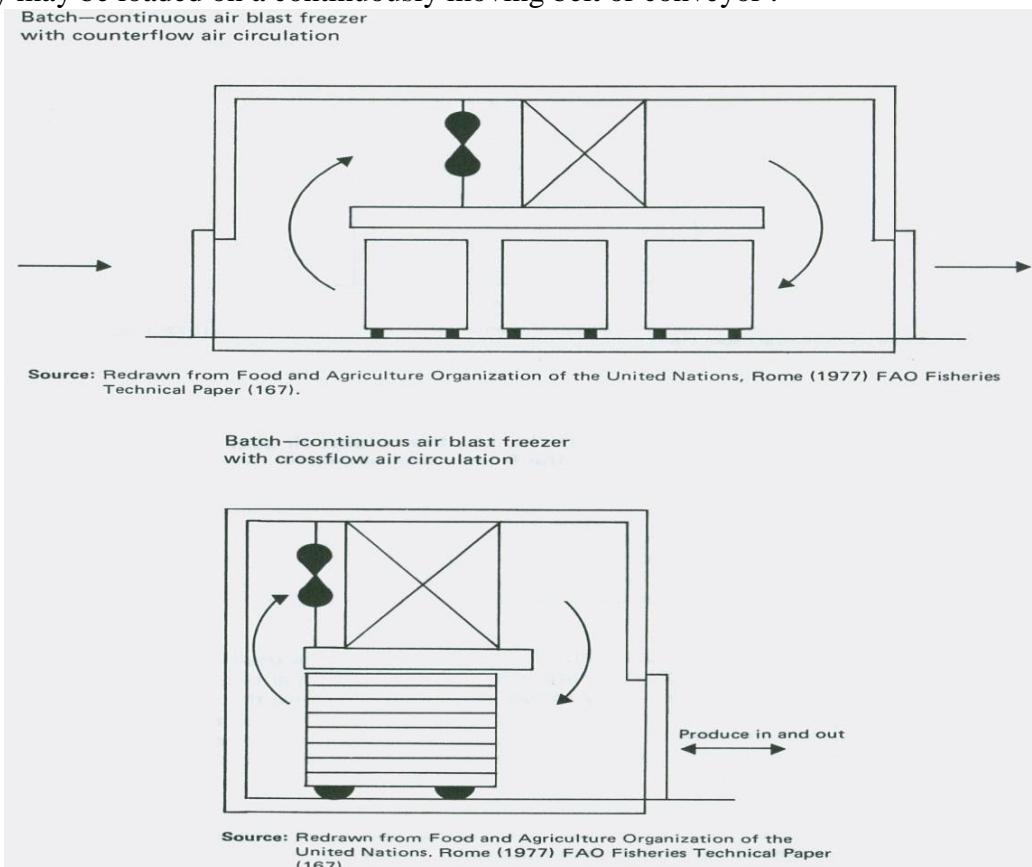
The three basic methods of freezer are,

- Blowing a continuous stream of cold air over the fish- air freezer.
- Direct contact between the fish and a refrigerated space- contact or plate freezer
- Immersion in or spraying with a liquid nitrogen- immersion or spray freezer.

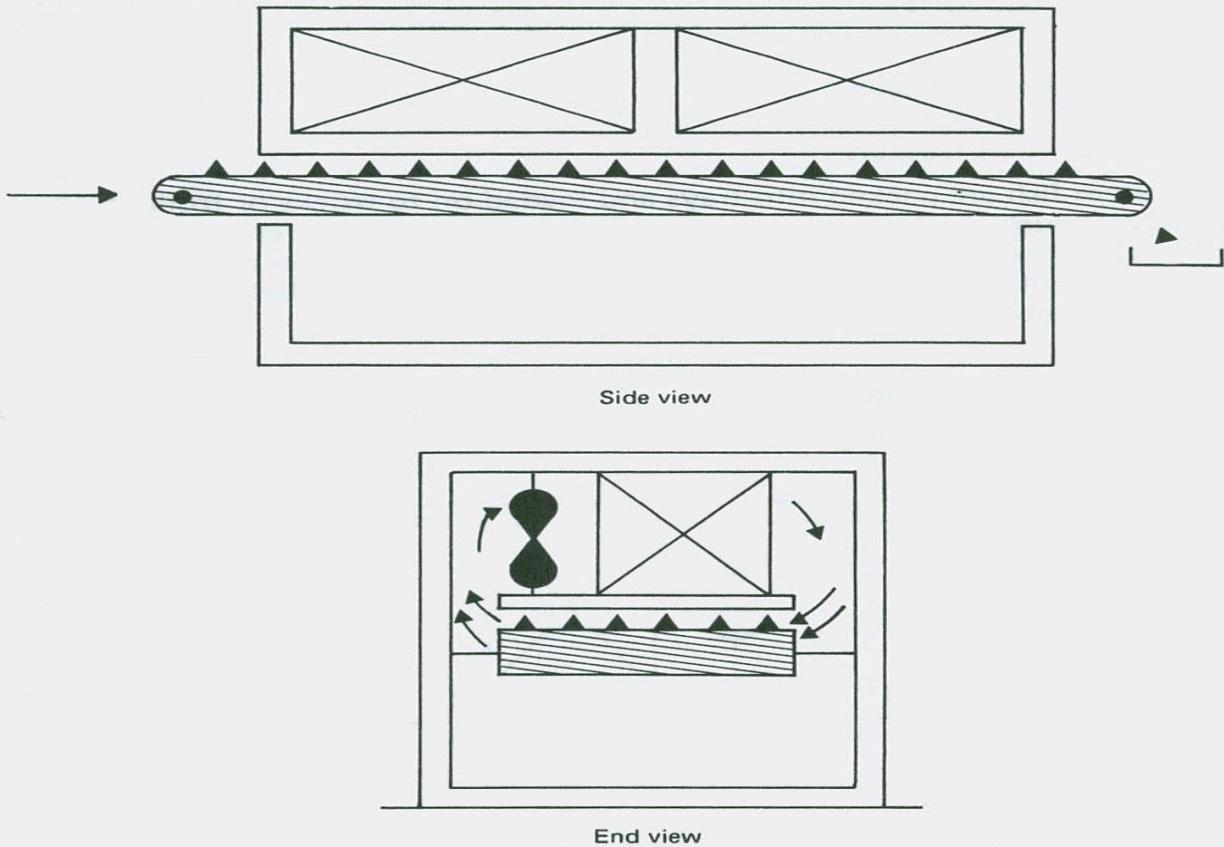
### 5.2.1.Air blast freezer

The big advantage of the air blast freezer is its versatility. it can cope with a variety of the irregularly shape products and sizes to be frozen, the blast freezer is the best choice. In order to obtain uniform freezing rates throughout the freezer, the air flow requires to be substantially the same over each fish or package. A good design fan air speed of 5m/sec been founded to be a good compromise between slow freezing rates and high fan cost and this air speed recommended for most air blast freezing. There are many different designs of air blast freezer both for batch and continuous operation. Details are given of a number of types of air blast freezer in common use. With comment on their suitability for various products and methods of processing and also on their limitations.

In continuous air blast freezer the product move through the freezer usually entering at one end and all leaving at the other. Product may be move through the freezer on trucks or trolleys or they may be loaded on a continuously moving belt or conveyor .



**Continuous belt air blast freezer with crossflow air circulation**



**Source:** Redrawn from Food and Agriculture Organization of the United Nations, Rome (1977) FAO Fisheries Technical Paper (167).

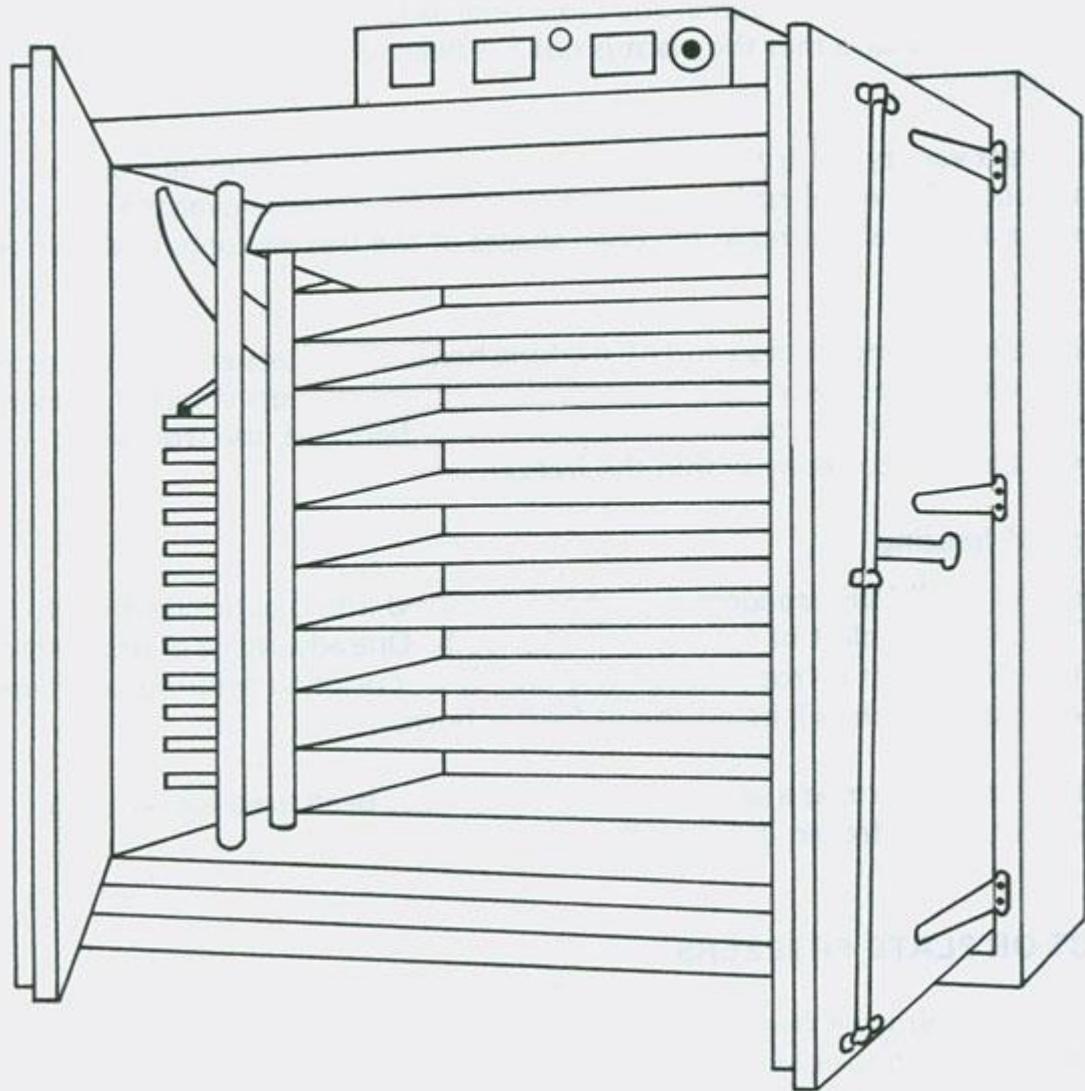
### 5.2.2. Plate freezer

Plate freezer can only be used to freeze regularly shaped blocks and packages. Plate freezers do not have the versatility of air blast freezers. Plate freeze can be arranged with the plates horizontal to form a series of shelves and as the arrangement suggests, they are called horizontal plate freezers. When the plates are arranged in a vertical plane they form a series of bins and in this form they are called vertical plate freezers.

### 5.2.3. Horizontal plate freezers

The two main uses for this type of freezer are the freezing of prepacked cartons of fish and fish products for retail sale and the formation of homogeneous rectangular blocks of fish fillets called laminated blocks for the preparation of fish fillets. The thickness of package or block frozen is 32 to 100mm and the freezer can readily adapt from the thicker to the thinner package provided the range required is made known to the supplier at the time of purchase. Horizontal plate freezers need not be defrosted after each freeze.

## Horizontal plate freezers



There is no direct contact between the fish and the freezer plates when freezing by this method since the fish is always packaged before freezing. If the operator is also careful not to spill water on the plates during loading and unloading, the freezer may be operated with only a light brush between each freeze to remove surface frost, and a proper defrost may only be necessary once or twice per day. A hot gas defrost arrangement is the quickest method to defrost an HPF, but even with this method, it may take 30 min or more. The defrosted plate must be completely free from frost or ice and dried before the freezer is used again.

Horizontal plate freezers intended to be operated with a hot gas defrost are fitted with additional pipe work which allows the cold refrigerant to be discharged from the bottom of the freezer as the defrost proceeds. Without this special pipe work and operating valves, a hot defrost would clear the top plates only and leave the cold refrigerant in the plates at the lower levels. As in all hot gas defrost systems, the refrigeration system must have an adequate load to provide sufficient hot gas for an effective defrost. This system would therefore be better applied when there are two or more freezers operated from a common refrigeration system and each freezer will then be defrosted in turn while the others are in operation.

Horizontal plate freezers are often run without a defrost during the working day and the doors are left open overnight to allow the plates to defrost. This, however, is usually insufficient and water is hosed on the plates to assist the defrost procedure. Defrosting is easier when a secondary refrigerant is used or when the freezer operates with a pump circulated primary refrigerant. With these systems, a reservoir of warm liquid can be made available for pumping through the plates. An HPF will only operate correctly if good contact is made on both the top and bottom surfaces of the pack or tray to be frozen. If the product is frozen from one side only due to poor contact on the upper surface, the freezing time could be three or four times as long as the time achieved with good contact on upper and lower surfaces. The plates of the HFP are closed by means of a hydraulically operated piston to make contact with the upper surface of the product. The pressure applied can readily be varied to suit the product but  $0.5 \text{ kg/m}^2$  is common and is increased by a factor of two as the fish expands during freezing.

#### **5.2.4. Vertical plate freezers**

The main advantage of using this type of freezer is that fish can be frozen in bulk without any previous requirement to package or arrange on trays. The plates form what is in effect a bin with an open top and fish are loaded directly into this space. This type of freezer is therefore particularly suitable for bulk freezing and it has also been extensively used for freezing whole fish at sea. The maximum size of block made by this method is usually 1070mm x 535 mm. Other dimensions of block, however, can be produced and block thickness can vary from 25 to 130 mm. The block dimensions selected will depend on the fish to be frozen and also the maximum block weight that can be readily handled by the operators. Maximum block dimensions and weight are limited by the physical effort required from the operator to lift the block, and by the ease with which he can handle the block so that damage to the fish is kept to a minimum. In most cases, fish can be loaded between the plates without wrappers and water need not be added either to strengthen the frozen block or improve the contract with the plates. Fish such as cod and haddock produce compact blocks with a block density of approximately  $800 \text{ kg/m}^3$ .

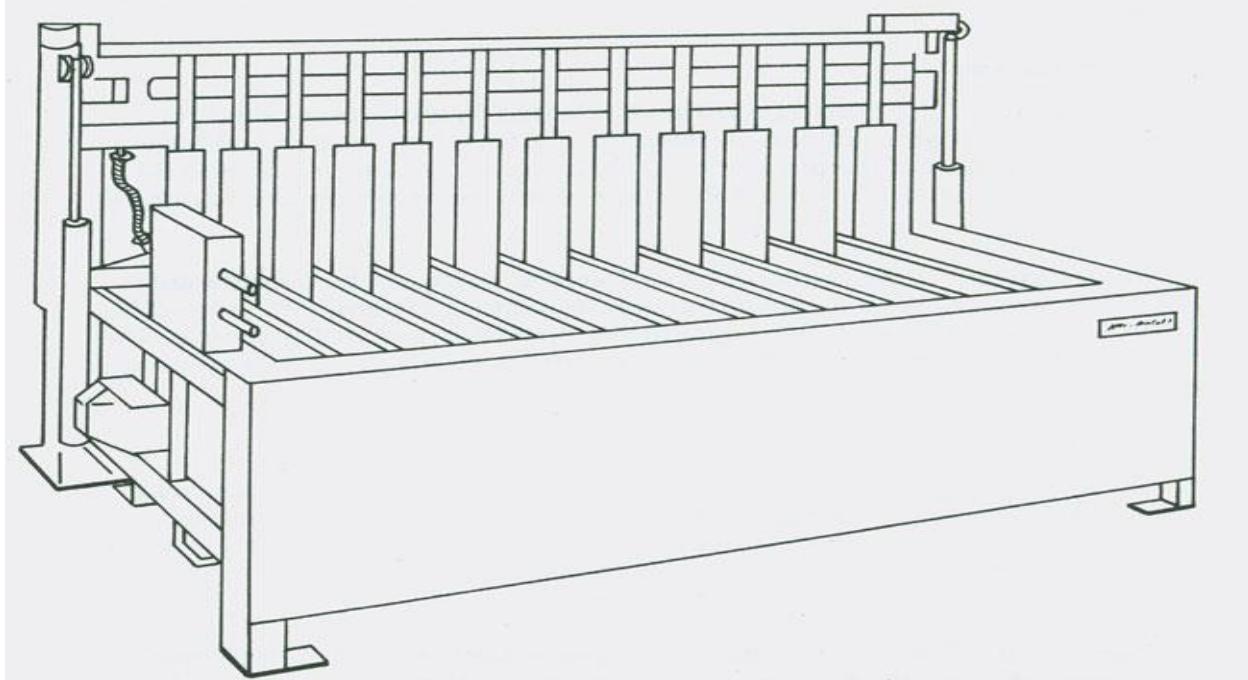
With fatty fish such as herring, it has been found advantageous to use wrappers and add some water to fill the voids in the block. Fatty fish do not form blocks which are as firm and strong as blocks made from lean fish especially during seasons when the oil content of the fish is high. Water added to the block helps to strengthen the block, protects the fish during subsequent handling and reduces the effects of dehydration and oxidation during cold storage. Well formed, rigid blocks are particularly important when freezing at sea. The frozen product is handled under particularly adverse operating conditions and poorly formed blocks would result in a high percentage of broken blocks and loose fish. Machine filleting or splitting of the fish, for instance, may be difficult if fins and tails are broken. Wrappers have therefore been used when freezing fatty fish in VPF to protect the exposed fish on the outside of the block. A wrapper that has been found suitable for this purpose is a single layer paper bag, coated internally with polyethylene, and shaped to fit the space between the freezer plates. Wrappers made from polyethylene and other plastic materials were found to be difficult to handle and constituted a danger when stacked due to slipping.

Fish frozen with wrappers will inevitably require a longer freezing time due to the insulating properties of the wrapping material. Some types of wrapper would have a considerable effect on freezing time but the material described did not increase the freezing time by a significant amount.

Vertical plate freezers are defrosted to release the blocks of fish after each freeze. Fish in

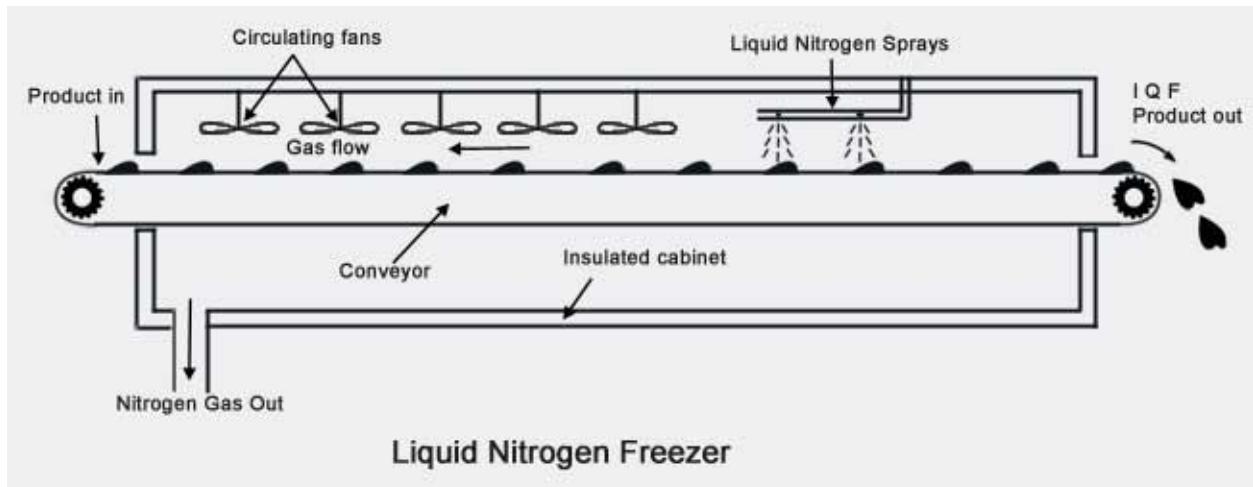
VPF are in direct contact with the plates and the force required to release the blocks without a defrost would be excessive and result in plate damage. The defrost time for a VPF need not exceed 3 or 4 min if a suitable supply of defrost gas or hot liquid is available. If a primary refrigerant is used in the plates, a hot gas defrost is generally used and when there is a multiple freezer installation, the freezers are defrosted in turn with the other freezers in operation providing the necessary refrigeration load for the compressor. When a secondary refrigerant is used, a reservoir of hot liquid has to be maintained and pumped through the plates to displace the cold liquid present. With this arrangement, it is possible to return the bulk of the cold liquid to the low temperature reservoir at the start of defrost, and also return the warm defrost liquid to the hot liquid reservoir for reheating at the start of the next freeze. This arrangement reduces the quantity of liquid interchanged at each defrost but even with this system provision must be made to maintain the liquid charges in both the cold and hot systems at the correct level.

**Multi-station vertical plate freezer  
with top unloading arrangement**



### 5.2.5. Liquid nitrogen freezer

In this freezer, the product is brought into direct contact with the refrigerant. The fish on the stainless steel conveyor belt initially come into contact with the counter current flow of nitrogen gas at a temperature of about -50°C. As the fish progress through the freezer, the temperature of the cooling gas progressively falls to -196°C. This initial stage of cooling in the gaseous nitrogen partially freezes the fish and also preconditions the product before it is passed below the liquid spray where freezing is completed by the boiling liquid. During this precooling stage, up to 50 percent of the product heat is extracted and the remainder of the heat transfer takes place in the small area below the sprays. After leaving the spray zone, the last stage in the freezer is used for the fish temperature to reach equilibrium before the fish are discharged. If fish are cooled directly below the sprays without preconditioning, they are physically damaged due to the sudden change in temperature which sets up thermal stresses within the fish.



The main advantage of the nitrogen freezer is that freezing is very quick and the physical size of the freezer is correspondingly small. The freezer is operated without the need for compressors, condensers or coolers; therefore maintenance requirements are minimal and the power required to operate the freezer is very low. Liquid nitrogen cannot be retained economically in a pressure vessel and continuous venting is required to keep the contents cool and the internal pressure down. One estimate given is that 0.5 percent of the stored contents is lost each day by this method. In addition, about 10 percent has been estimated to be lost during the transfer of liquid from the tanker to the storage vessel although the customer is not charged directly for this loss. This method of freezing is more expensive than most others, being at least four times more costly than conventional air blast freezing, or even higher if the freezer is only used intermittently with partial loads.

Although the freezer is small and there is no refrigeration machinery requirement, storage space and access is required for the liquid nitrogen tank. The main disadvantage of this type of freezer in most developing countries is that delivery of nitrogen would be expensive and there may be no guarantee of regular supplies.