BLAST FREEZING APPLICATIONS IN CONVENTIONAL ROOMS

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FREEZING is a widely used method of food preservation. In frozen food, the physical changes and microbiological and chemical activity slows down. Reducing temperature slows molecular and microbial activity in food, thus extending its useful storage life.

Although every product has an individual ideal storage temperature, most frozen food products are stored at −18 to −35°C.

Freezing reduces the temperature of a product from ambient to storage level and changes most of the water in the product to ice. As seen from Figure 1, the freezing process occurs in 3 phases. In the first phase, the food is cooled from ambient temperature to freezing point by removing sensible heat. In the second phase, the phase transition heat of the food is removed by turning the water within it to ice. In the third phase, cooling continues below the freezing point, which removes more sensible heat, reducing the temperature of the product to the desired or optimum frozen storage temperature.

The longest part of the freezing process is the removal of the latent heat of fusion as water turns to ice. Many food products are sensitive to the freezing process, which affects quality, nutritional value, and appearance. Thus, the freezing method and system selected can thus have substantial impact on quality and economy.

The following factors should be considered in the selection of freezing systems and methods for specific products: special handling requirements, capacity, freezing times, quality consideration, hygiene, yield, appearance, manufacturing cost, operating costs, automation, space availability, placement of the product with respect to the evaporator and upstream/downstream processes, durability, maintenance.

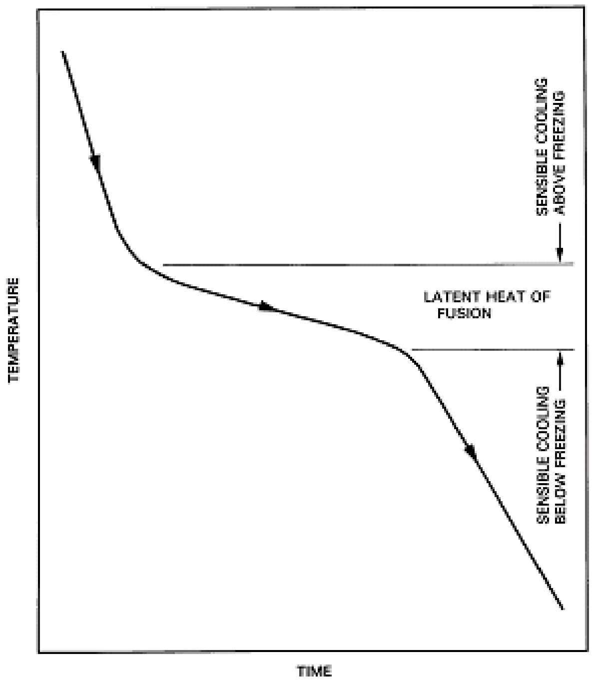


Figure 1

FREEZING METHODS

Freezing methods can be grouped by their basic method of extracting heat from food products

Blast Freezing (Convection)

Cold air is circulated over the product at high velocity, removing heat from the product and releasing in to an air/refrigerant heat exchanger before being circulated.

Contact Freezing (Conduction)

Packaged or unpackaged products are placed on or between cold metal surfaces. The heat on the surface of the product is removed by the metal surfaces that are kept continuously cold by refrigerant circulating within them. Contact freezing provides better results than blast freezing. In contact freezing, it is possible to shock freeze products with regular surfaces on the plates. When we wish to shock freeze units of various sizes, we have to switch to blast freezing.

Cryogenic (Extremely Low Temperature) Freezing (Convection and/or Conduction)

Food is exposed to an environment below −60°C, which is achieved by spraying liquid CO_2 or liquid N_2 into the freezing chamber.

Cryomechanical (With the Combination of Extremely Low Temperature and Mechanical Cooling) Freezing (Convection and/or Conduction)

Food is first exposed to Cryogenic freezing and then finish frozen through mechanical refrigeration.

Special freezing methods, such as immersion of poultry in chilled brine, are also available.

BLAST FREEZERS

Blast freezers use air as the heat transfer medium and make use of the contact between the product and the air. Airflow control and conveying techniques vary from crude blast freezing chambers to carefully controlled models with impressing features.

The earliest blast freezers consisted of cold storage rooms with extra fans and a surplus of refrigeration. While batch freezing is still widely used for certain production lines, the improvements in new applications make heat transfer more efficient and lower the labor required in product movement. In large scale applications of more advanced project development integrate the freezing process into specific production lines.

Although clear standardization is yet to be made on evaporators, and units, shock freezing units are still not offered as ready packaged units. Thus, for the most part they are tailor made to fit specific requirements. Thus, in order to make the right choice the buyer should declare his need to the supplier and the supplier should state the offered alternatives clearly for him to do so.

It must be remembered that a poor shock freezing room diminishes the naked product we place within it by 3%-4%, and lowers its quality; while a fine shock freezing room freezes the product at high quality and with a loss ranging from 0.5%-1.5%.

There is no theoretical loss in contact or immersion type shock freezing.

This paper defines the prerequisites for the good design and operation of shock freezing systems, explaining incorrect practices, without imposing a specific method.

Why choose a blast freezer?

As compared to other freezing methods, the most significant advantage of blast freezers is their versatility and fitness for various uses. Blast freezers tend to be a good choice for products that are irregular in size and shape. Applications like plate freezers are not appropriate for such foods of irregular shape and size. This flexibility and versatility of blast freezers, while providing a significant advantage makes it difficult for the potential user to clearly ascertain what he wants, which easily leads to inefficient use afterwards.

Types of blast freezers

While there are many designs and alignments of blast freezers, they can be grouped in three basic groups:

Continuous (process line) freezers
Batch freezers
Intermittent (half-batch) freezers

1. Continuous (process line) freezers

The product moves continuously within the freezer during the process, which is called a continuous process line cooler. In the continuous freezer, the product is moved into the freezer by conveyors. This method is suited for large scale and mass production with standard packaging and similar freezing times.

2. Batch Freezers

The product is stationary within the freezer, which is called batch freezing.
Examples of batch freezers:
Cold storage rooms (not recommended)
Stationary blast tunnels

3. Intermittent (Half-Batch) Freezers

Push-Through Trolley Freezer

The system operates like a half/batch system when trolleys are used for moving the blast frozen product instead of conveyors. The old trolley remains stationary until the new trolley arrives from the intake end. In this way, as a new trolley comes in, a trolley filled with the frozen product exits from the other end.

DISCUSSION OF BLAST FREEZING METHODS

This paper will discuss batch freezers and push-through trolley freezers which we can call half-batch systems that are two blast freezing methods. Within the scope of these methods, the properties of application of blast freezing in conventional rooms will be discussed. While this is the most widely used method, it is also the method that is used most erroneously due to lack of knowledge or attention.

Cold/Frozen Storage Rooms

Cold/frozen storage rooms that can be used for freezing only under exceptional conditions are unfortunately widely used in our country for the purpose of freezing.

This carries with it all the weaknesses of the earliest freezing applications. The product is left freely within the room, which leads to the result that the whole product does not come in contact with air, which as a negative influence on product quality. Yet a cold storage room is not designed for freezing. The freezing process is very slow in these rooms, which causes the quality of most products to suffer. The extension of the freezing time results in larger ice crystals within the product, hence lower product quality. The faster the freezing process can be made, the smaller the ice particles and the higher the quality.

The temperature of already frozen products in the room, placed there for storage increases significantly by the entry of new products, which is risky for these products. Furthermore, the flavor of the warn product may transfer to the existing products.

This issue can be summarized thus: Freezing in Cold/Frozen storage rooms is not shock freezing and can not be used instead of it!

Stationary Blast Freezing Tunnels

We can say that the stationary blast tunnel (See Figure 2) is the simplest system that can be expected to produce satisfactory results for most product groups. These are properly isolated enclosures with doors suited for the entrance and exit of products. Inside are evaporators and powerful fans. The air circulates over the products in a controlled way. Products are placed on trays, which are then placed into racks in such a way that an air space is left between adjacent layers of trays. The racks are moved in and out of the tunnel manually. It is important that the racks be placed so that air bypass is minimized.

The stationary blast cell is a universal freezer—almost all products can be frozen in a blast cell. Vegetables and other products (e.g., spinach, bakery items, prepared foods, meat patties and fish fillets) may be frozen either in cartons or unpacked and spread in a layer on trays.

In some instances, this type of freezer is also used to reduce to −18°C or below the temperature of palletized, cased products that have previously been frozen through the latent heat of fusion zone by other means. The flexibility of a blast cell is coupled with a disadvantage: that labor requirement is relatively high during loading and unloading. However, it an undisputable application for small quantities. It should be evaluated with other alternatives when large quantities need to be shock frozen.

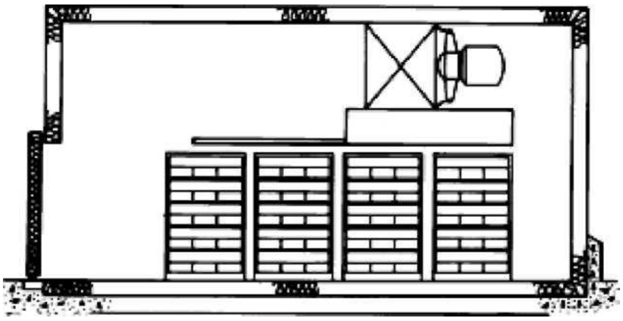


FIGURE 2

The Push-Through Trolley Freezer

The trolleys are fitted with wheels suited for moving on the rails. The trolleys, are usually moved on rails from one end to the other by a pushing mechanism, which is usually hydraulic. One of the important considerations here is the use of special hydraulic lubricants (such as aircraft lubricants) that will not freeze in extremely low temperatures.

The advantage of push-trough systems over the conveyor system is that it ensures that products of large pieces that require long shock freezing times remain within the room according to their shock freezing times.

While these freezers are similar to stationary shock freezers, the only difference is the shortening of the labor and product loading and unloading times. This system is widely used for the rapid freezing of all packaged whole (as opposed to separated into its parts) chickens.

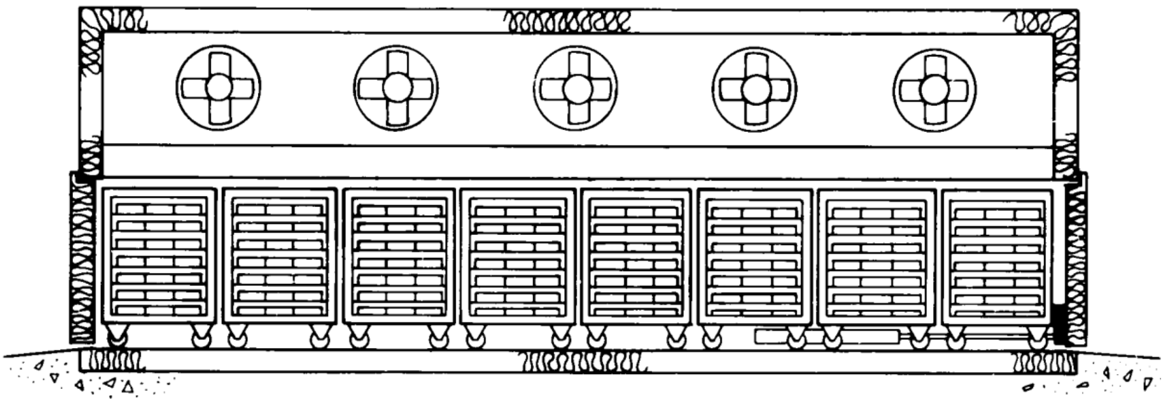


FIGURE 3 Shows a typical scheme of this application

GROUPING SHOCK FREEZERS BY PRODUCT STREAM POSITIONS

Blast freezers can be divided into two groups with respect to airflow positions as serial flow and counter flow blast freezers. In the serial flow version, the airflow is parallel to the movement of the conveyor or trolley; in the counter flow version, the airflow is perpendicular to the movement of products.

In serial flow freezers, under normal conditions a cooler is used and the product moves in the opposite direction to the movement of air; thus the warmest product meets the warmest, and the coldest, nearly frozen product meets the coldest air. In this kind of application, the fan should be stopped in order to prevent the entrance of warm water within the tunnel. A switch that stops the fan when the door opens can be used for this purpose. In counter flow freezers, there is usually more than one fan and evaporator. The trolleys entering and exiting the unit hinder the airflow only slightly.

In the conveyor system, the counter flow freezer is used because of the permanent and flexible bands at the entrance and exit. A disadvantage of the counter flow system is the fact that the evaporator closer to the entrance has to operate more and hence suffers frosting. In order to avoid differences in defrosting periods, an evaporator with much larger fin spacing can be installed at the entrance. Batch freezing is more flexible and is used when various foods frequently need to be frozen in various trolleys and pallets.

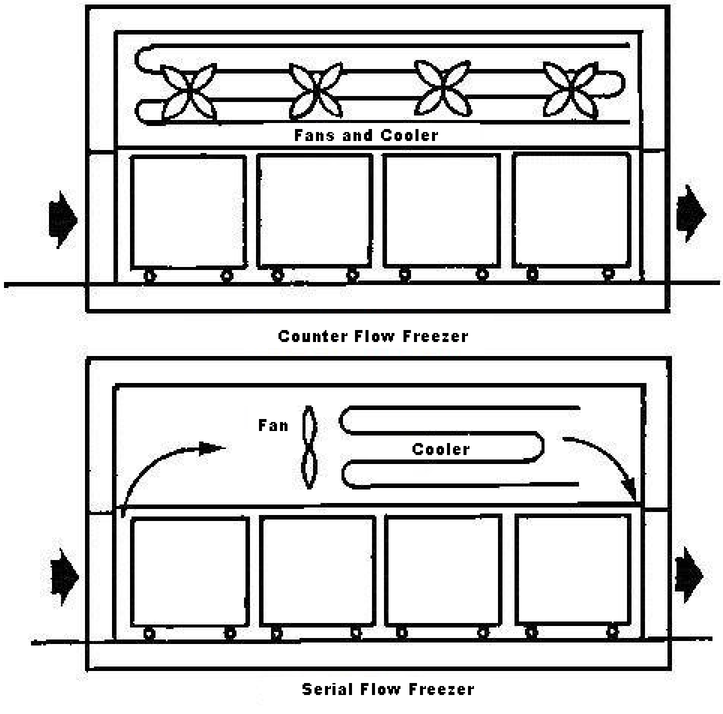


FIGURE 4

Figure 4 shows examples of serial flow and counter flow applications. Careful control and supervision is required to obtain the maximum products without causing overloading during the process of cooling various products.

The type of freezer to be selected depends on the quantity and type of products as well as the shift arrangement of the plant (such as 12 hour cycles). Other factors affecting the place and style of the blast tunnel are the placement of the other stages of the process and the existing space. The final type of freezer is decided after evaluating the product, process and placement.

Air Circulation

In a well designed and properly operated freezer, the velocity of the air passing over the product must be the same everywhere on the tunnel. In this way, all products are frozen almost uniformly. It is of great importance that the tunnel should be designed in such away that the resistance posed by the products to the flow of air is equal for all air flow cross-sections. The spaces between trays should be uniform, and the spaces below, above and on the sides of trolleys should be kept at minimum. Otherwise the air will take the path of least resistance and flow without hitting the product, rendering the freezing process inefficient.

Air which is used for blast freezing is a poor conductor and has low thermal capacity, thus high air velocity is required for the freezing process. But high air velocity means more powerful and high pressure fans. Since air quantity will drop if the pressure is not sufficient, good shock freezing can not be achieved. A more powerful fan, on the other hand means that more heat is generated which must be removed by the cooling device within the tunnel. While it can vary with various products, the most suitable and economical speed has been found to be between 3-6 m/s. This value denotes the velocity of air in the air passage cross section in an empty room.

Higher velocities than these offer very little benefit. Designing by assuming an air velocity over product of around 5 m/s, in combination with good air distribution within the work area delivers the recommended air velocities over all units within the freezer.

If you do not have adequate space or require shorter freezing times for matching them to working hours or for another purpose, higher air velocities can also be applied.

If poultry is not shock frozen in a short time, its surface becomes black. If the shock time is shortened, product quality rises. For shortening the shock freezing times in these products, an air velocity of 6.5 m/S over the product will yield more favorable results.

The temperature of the air that meets the product and takes on its heat will rise. The extent to which this temperature will rise is directly dependant on the power and dimensions of the fan. If the increase in temperature is great, the product that comes in contact with the warmer return air will freeze more slowly. If on the other hand, the increase in temperature is very low, the placement within the freezer is inappropriate and the spacing between the trays is not regular, powerful fans are required to provide the desired air speed although they would not be under proper conditions.

Even in the most appropriate designs, the cooling load requirement resulting from the fan power in blast freezers is significantly large. In case of appropriate design and placement, the fan power is 25-30% of the cooling load resulting from the product. In some special applications with high air velocity, when combined with poor placement within the freezer, the fan power can match the total thermal load coming from the product.

The tolerable increase in air temperature depends to a large extent on the total freezing time of the product. In a product whose freezing time is 20 minutes, a difference in freezing times that corresponds to the 10% between the coldest and warmest products can be neglected. However, for a batch of products that are frozen in 10 hours, a 1 hour difference that is 10% may not be acceptable.

There is no definite rule of thumb for the acceptable increase in air temperature as it moves over the product. As a general guideline, temperature increases of 1, 2 and 3°C are acceptable. In this case, as far as these temperature increases are concerned, the air entering the cycle at -35°C creates a difference between the freezing of the best and poorest product that equals 3-8% of the total time. In practice, the temperature increase reaches its peak in the beginning of the freezing period and drops to its minimum value toward the end of the period. The recommended values have are average values for the whole of the freezing period.

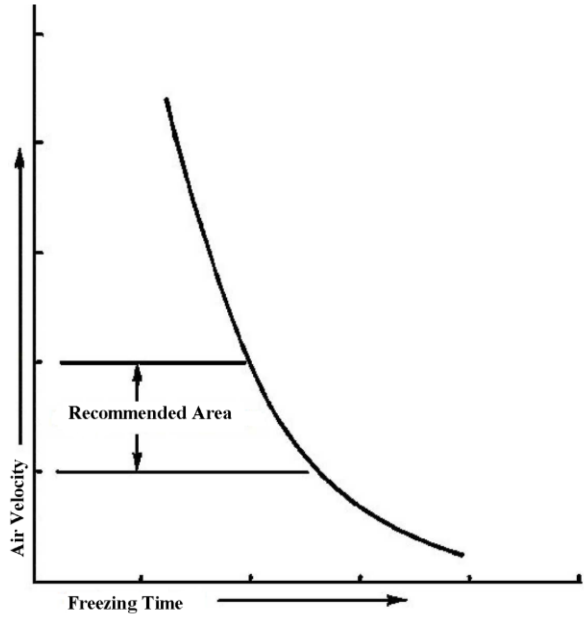


FIGURE 5: Variation of the freezing time as a function of air temperature.

Various Placements of the Evaporator and the Product within the Room

Evaporators used in shock freezers have been standardized to a growing extent and are now being mass produced. These evaporators equipped with high pressure fans providing high air flow eliminate or reduce many placement and installation tasks which must be done by the contractor. There are various versions of these units according to various placements. In our country, FRITERM offers shock freezer evaporators of various constitutions as packaged units. Three sample constructions and room and product placement combinations have been given in the following three figures. (Figures 6.1, 6.2, 6.3)

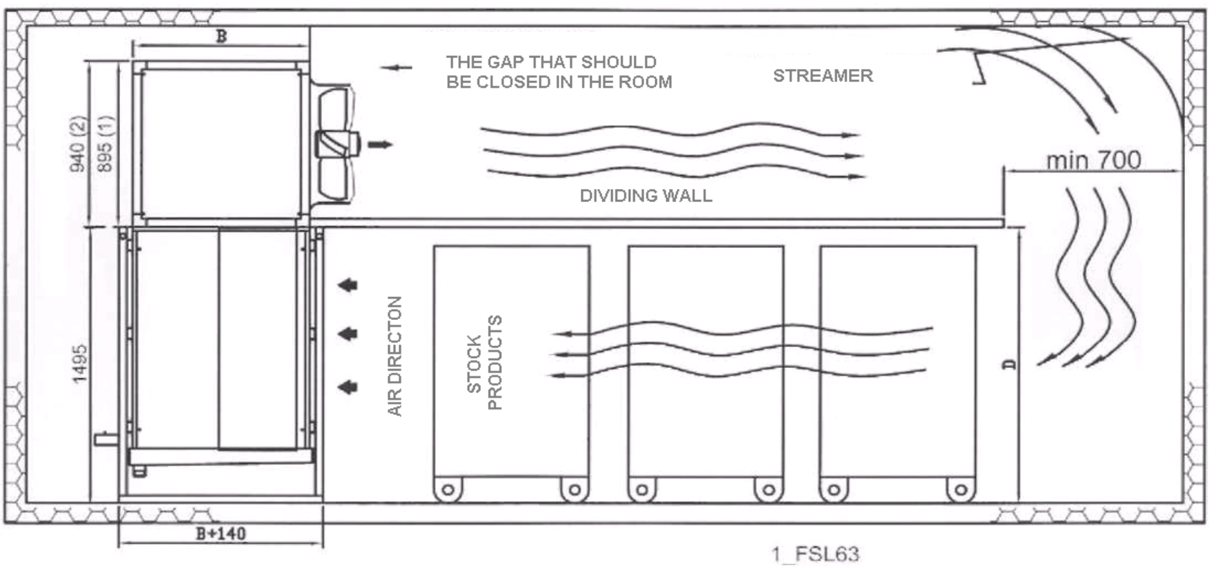


FIGURE 6.1

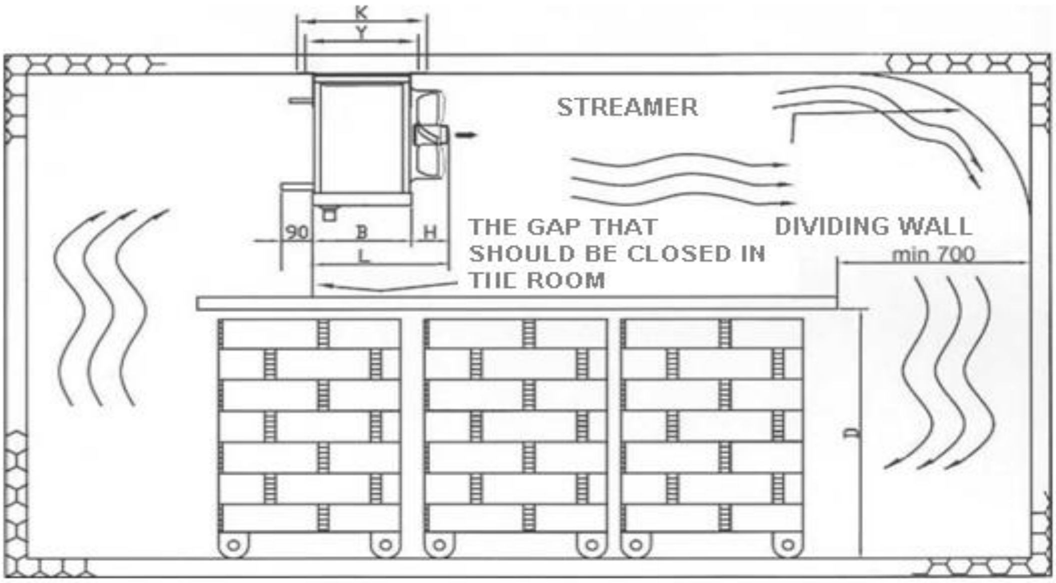


FIGURE 6.2

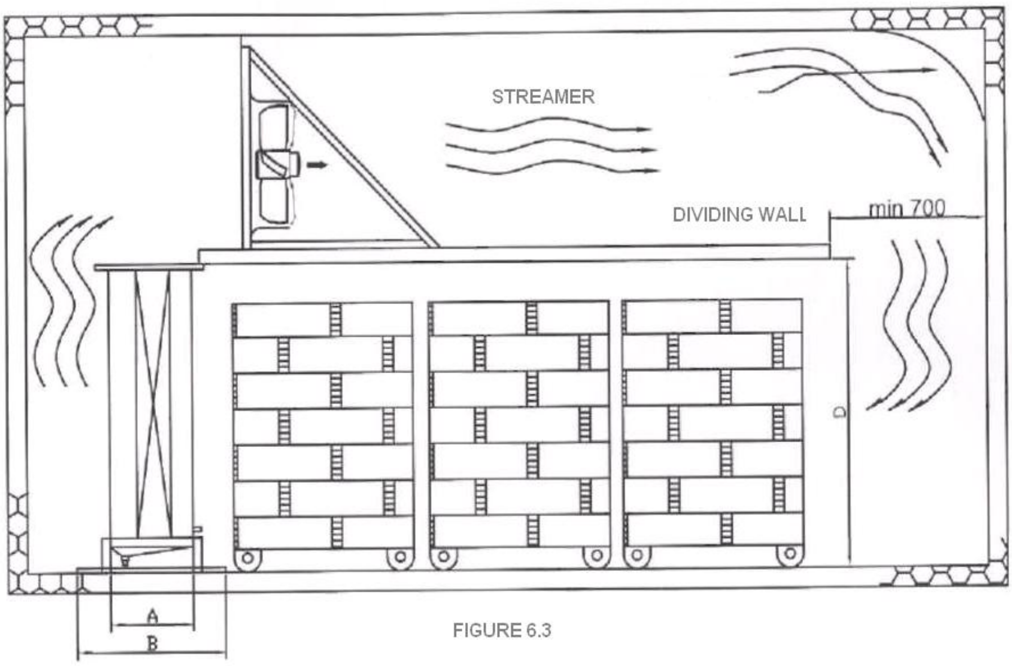
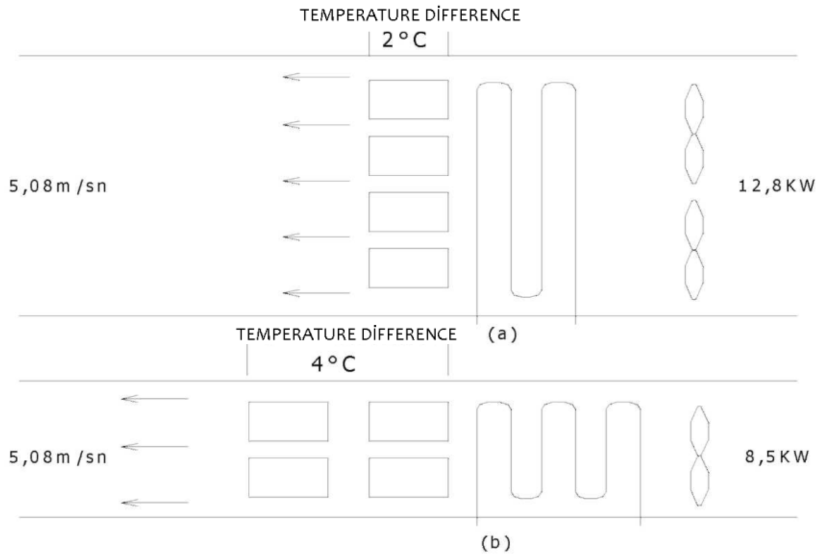


FIGURE 6.3

In order to provide the desired air velocity with less fan power the evaporator is placed on the short edge. When two applications with wide and narrow cross sections are compared for freezing the same quantity of product, the difference in power is 13 kW as opposed to 8.5 kW as seen from the following example. It must be remembered that this will come with additional refrigeration load which will lead to additional cost. This example shows shock freezing of 1 ton of fish loaded on 4 pallets by various methods.

Above is the application with large air flow cross section and high fan power (a)

Below is the application with reduced air flow cross section and low fan power (b)



Air Temperature

The air temperature within the freezer must be low enough to freeze the product in the desired time and to reduce it to the temperature it will be preserved after freezing. To give a practical example, in Great Britain -29°C frozen storage temperature and -35°C freezing temperature is recommended for fish.

Each drop in air temperature causes the freezing period to shorten and the unit cost of the heat removed for freezing to increase. We can liken a cooling compressor to a submersible pump drawing water from a well. The deeper the level from which the pump draws the same quantity of water, the more power it exerts. Likewise, the lower the operating temperature of the cooling compressor, the more power and money it spends for each unit of heat it transfers from the product.

Consequently, the freezer must not be operated under lower temperatures than is required to achieve the required freezing period and final temperature conditions. Naturally, lower air temperatures than -35°C can also be used to achieve some purposes by tolerating the additional cost. These special circumstances may involve the freezing of thicker product or the necessity to abide by an inflexible schedule.

Freezing Time

Freezing time and the quantity of product to be frozen are two parameters that must be known in determining the dimensions, cooling capacities and cooling machines of freezers.

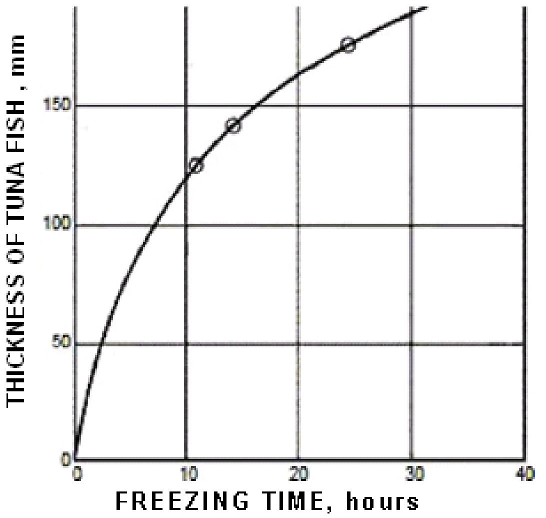


FIGURE 8.1 Freezing time of tuna fish depending on thickness

There is no simple formula in predicting the freezing time of a given product. However, projections and educated guesses can be made depending on previous experiences for products with regular forms. It should be remembered that the effect of packaging on freezing period is just as important as the form of the product. Still, some measurements must be taken to determine the freezing period under actual conditions of tests run during initial installment.

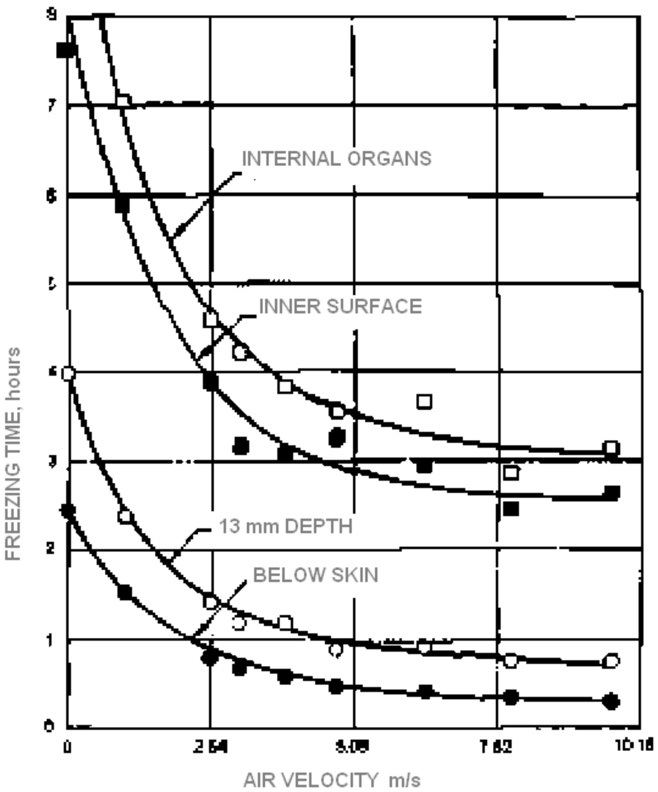


FIGURE 8.2 Freezing time of poultry depending on air velocity

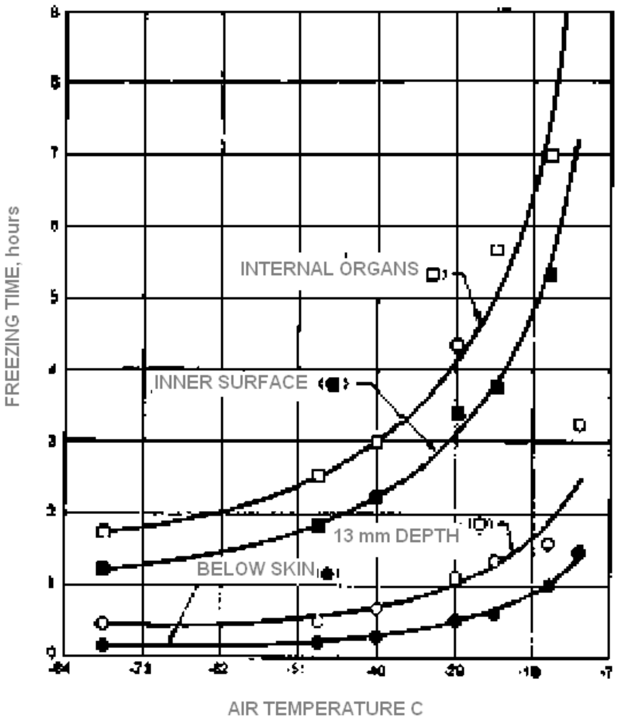


FIGURE 8.3 Freezing time of poultry depending on temperature

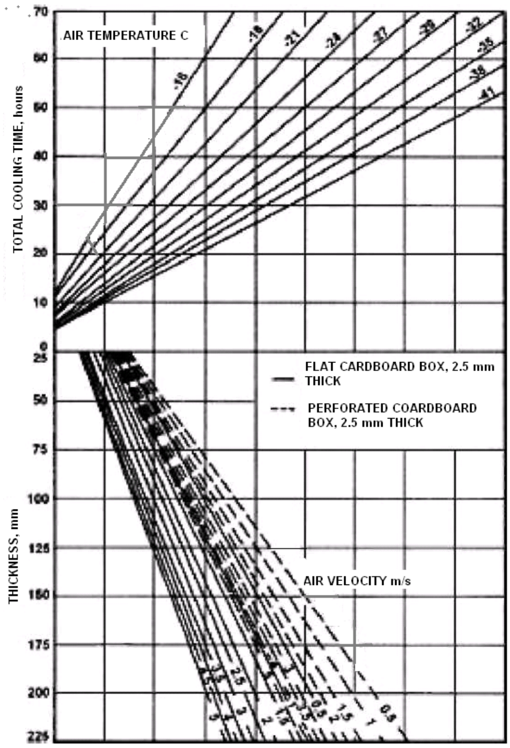


FIGURE 8.4 Freezing time of the meat within cardboard depending on thickness, temperature and air velocity

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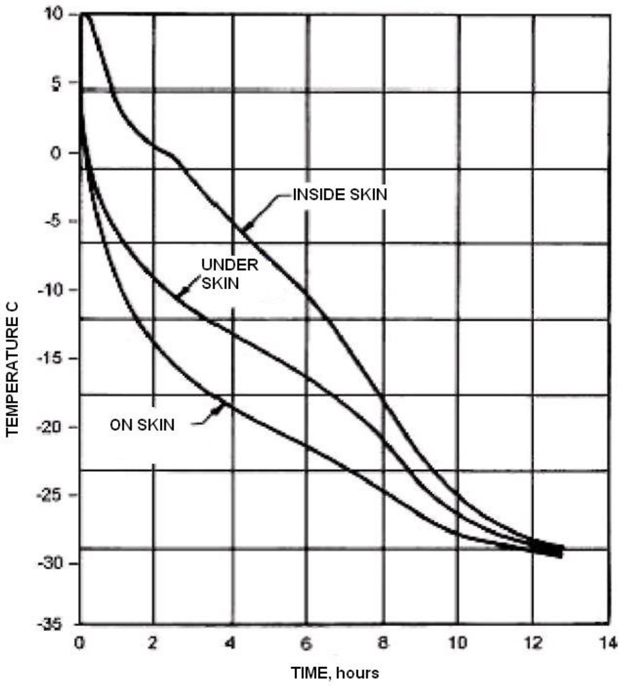


FIGURE 8.5 Temperatures as a function of time in 9.5 kg of turkey during freezing

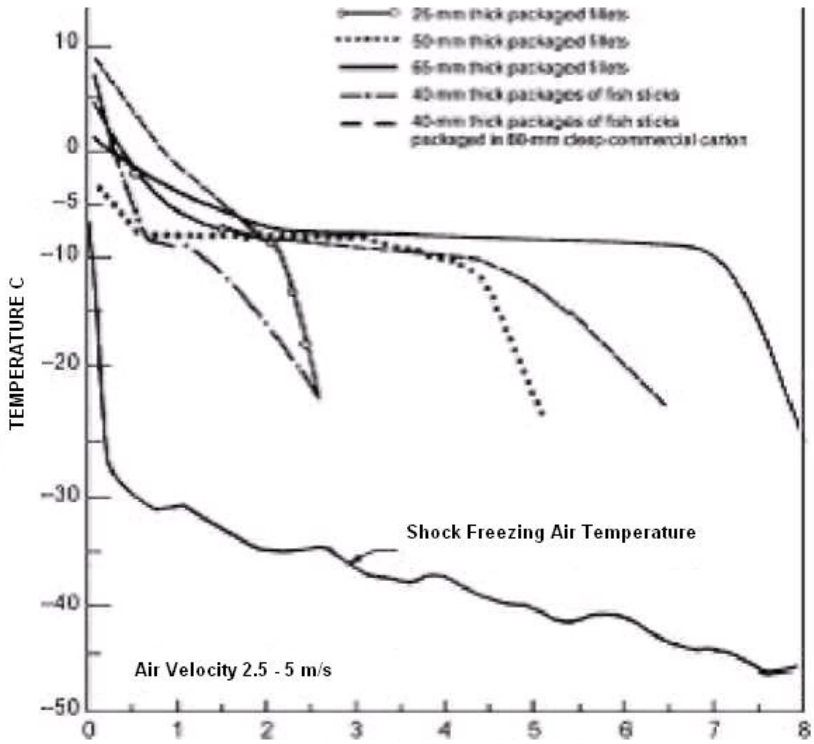


FIGURE 8.6 Freezing time fish fillets depending on temperature and air velocity

Freezer Capacity

To achieve the desired result in a blast freezer, the shape and dimensions of the tunnel, the size and capacity of evaporators and refrigerating machines should be in harmony with each other. But, the versatile and flexible nature of the shock freezer makes a design that is ideal for any circumstance difficult. The product that is to be placed within the freezer can vary according to type, shape size and freezing period. In this case, the optimum design conditions should be determined accurately.

Let us examine the matter with an example. Suppose that one blast freezer has the capacity to freeze 2 tons of product A per hour with a freezing time of 4 hours. In this case the size of the room will be such that it can take in 8 tons of product; and the cooling machines and evaporators will have corresponding specifications.

Yet if 8 tons of product B with different shape and a freezing time of 2 hours is placed within the same freezer, in this case the cooling machines will have to have the capacity to freeze 4 tons of product per hour and they will be overloaded. On the other hand, if 8 tons of product C which has a freezing time of 8 hours is loaded within the freezer, in this case the cooling machines will have to operate with a capacity of freezing 1 ton per hour and they will operate well below their design specifications. Table 5 shows these three loading scenario.

In this if an attempt is made to use the freezer that has been designed for product A by filling it up completely with products B and C, this will be a wrong and incorrect use of the freezer.

If all three products are frozen within this room, the sizing of the room should be made so as to hold 16 tons of product C and during operation 16 tons of C, 8 tons of A and 4 tons of B should be frozen in separate single batches. Only in this case the cooling machines used for refrigeration will have been used in accordance to their design conditions. Though loading and unloading can be made rapidly for product B that requires quick freezing.

Table 5 Blast freezer loading methods

Products	**Product Quantity**	**Freezing time**	**Required Cooling Power**	**Nominal Cooling Power**	**Notes**
	tons	**hours**	**tons/hour**	**tons/hour**	
A	8	4	2	2	The freezer has been loaded correctly
B	8	2	4	2	The freezer has been overloaded
C	8	8	1	2	The freezer has been loaded below capacity

When knowing the freezing time and loading quantity of a specific product, it becomes possible to calculate the refrigeration load required to freeze it and to bring it to frozen storage temperature. This calculation assumes correct loading of the product. Only with correct loading can the product be shock frozen with the minimum energy set forth in the design. If 2 times the product specified in the design is placed within the shock freezing chamber, the normal freezing time of the freezer does **not** double. In other words, when 16 tons of product is placed within a room designed to shock freeze 8 tons of product in 4 hours, the shock freezing time is not 8 hours. A longer period of time (for example 10 hours) will be required. As a result of this inefficient and low quality shock freezing will occur. The correct practice is to place the prescribed quantity of product within the chamber.

Table 6 The heat that must be drawn from white fish at various entry temperatures

Entry temperature °C	Storage temperature °C	Heat which must be removed kW/kg
1.67	-28.9	85.6
4.44	-28.9	88.2
6.67	-28.9	91.1
10.0	-28.9	94.0
12.8	-28.9	96.6
15.6	-28.9	99.5

Yet if various types of fish with various slight differences will be frozen, the design should be made with respect to the one among them that is likely to draw the most heat. In practical commercial applications, the 129 kW/kg value is taken including a safety margin as the refrigeration load for freezing fish with blast freezers. There is always a safety margin in the refrigeration load to tolerate inefficient operation and partial overloading. Naturally, the loads resulting from the transmission, from the fans and lighting, from the warm air, from warm trolleys, pallets and trays must also be added to the load resulting from the product while calculating the refrigeration load.

What happens when the freezer is incorrectly loaded in the tunnel?

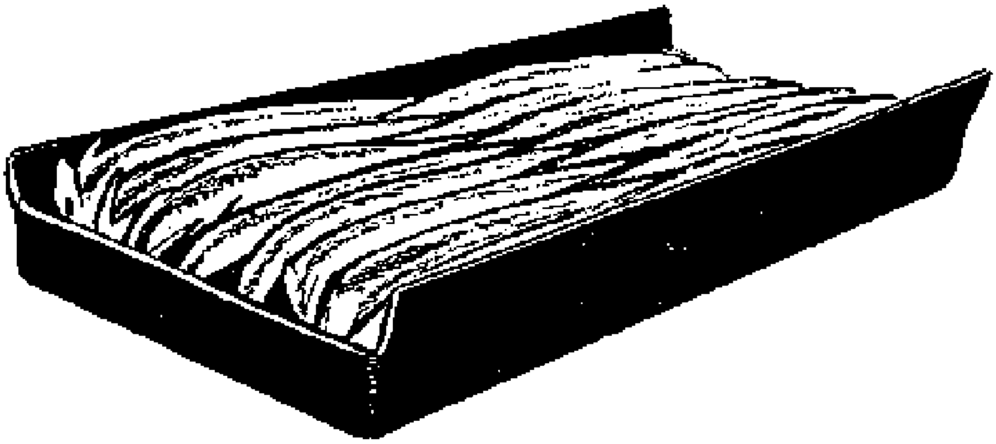
If the room is overloaded, the air temperature rises and freezing time extends; at the same time, the outlet pressure of the refrigeration compressor rises. In this case the automatic high pressure safety system halts the system, or a pressure safety valve set in, but in systems not equipped with proper safety measures this can lead to serious damage in the compressor. It can also endanger personnel in proximity.

Loading the room with less than its capacity does not lead to as serious problems as overloading, but increases operation costs. In this case, primarily the air temperature drops below the predicted value and the facility operates in less economic conditions than design specifications. Operation in very low temperatures that may occur in case of loading below capacity increases wear and tear in compressor bearing. An automatic low pressure safety system is used to prevent permanent damage that can occur if compressor inlet pressure drops to very low figures. Some compressors have a capacity control system that compensates. However, even in this case, the operation of the machine is inefficient and costly as compared to optimum load.

For general purposes in blast freezing applications two stage compressors are used in temperatures below -35°C. Two stage compressors are more suited for operation in low pressure that is frequent in loading below capacity as well as being less sensitive to the risk of damage; they also operate more efficiently, hence more economically in low temperatures. Utmost effort should be made and the specified points should be heeded to make sure that a shock freezer operates correctly and handles the freezing process with minimum cost.

Many products are placed within the room on trays. The trays should be able to transfer the heat well; they should be sturdy and easy to unload.

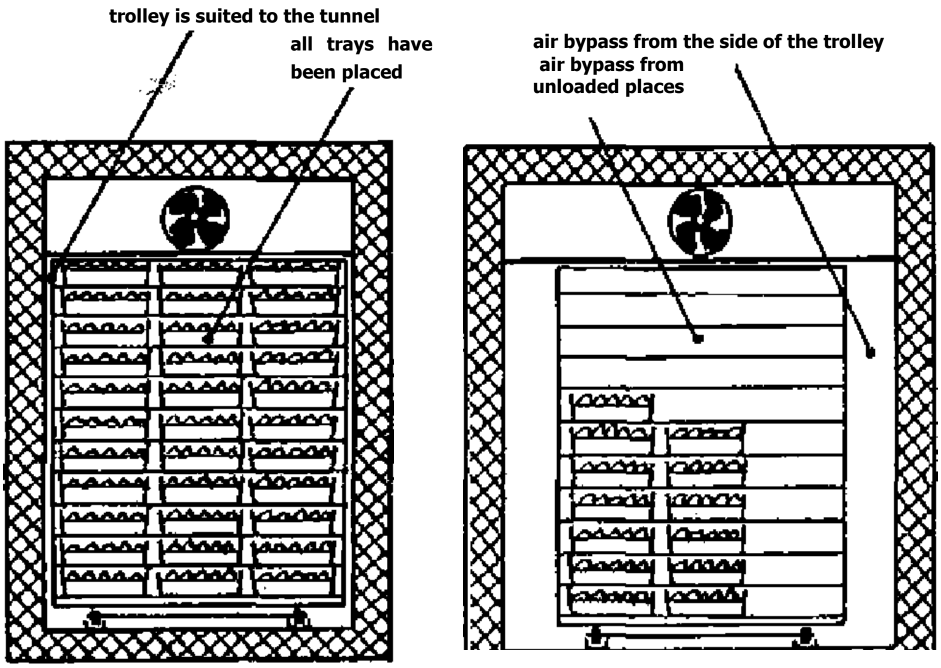
Figure 9: A typical tray that can be used for many products



The sides of the trays that will encounter air flow are less than the height of the product that is arranged inside them, as seen from the figure. In this way, it is ensured that air will pass over the product with closer contact. The remaining edges of the tray have been kept higher than the product level to avoid spilling the product during unloading after freezing. Aluminum 14-16 is a suitable material for freezing trays.

Another type of tray that is recommended for various products is that which is easy to unload, is perforated, allows air to enter from one end and exit from the other quite easily.

The spacing between the trays is very important. For the bottommost tray, the distance from the top of the product to the upper tray should be 2/3 of the product thickness and must not exceed 50 mm. In other words, the space between the top surface of a 75 mm thick product to the tray above it must be 50 mm. In this case, the trays should be placed on shelves 125 mm apart. Trays should be evenly distributed to the entire air flow cross section of the room. In this way, the resistance of the product to air flow will be uniform throughout. The trolleys or pallets carrying the trays should be placed with no spaces, in this way gaps where the air will bypass the product will be avoided.



CORRECT **INCORRECT**

FIGURE 10: Correct and incorrect methods of loading for blast freezers

In cases where pallets or trolleys will be partially loaded, the existing pallets and trolleys should be evenly distributed with respect to the air flow cross section in order to enable even flow of air. Sometimes artificial (empty) packages should be placed beside real packages to ensure even air flow and prevent air bypasses that will extend freezing time.

Sometimes pallets are loaded without shelves or spaces between. A certain number of packages are piled on top of one another with no space left between the packages, which increases the thickness of the product to be frozen and hence the freezing time.

The effect of product wrapping and packaging

All kinds of wrapping and packaging extends the freezing time of the product. This extension does not result solely from the isolating effect of the packaging material, also from the air frequently left between the packaging and product that causes additional isolation. For the most part, the effect of this air is more than that of the packaging. The effect of packaging in a closed container on the freezing time of smoked herring is seen in Table 6.

Table 6 The effect of wrapping and boxing on the freezing time of herring

Packaging method	Freezing time - hours
Wood box, wrapped in paper, lid closed	17-9
Wood box, wrapped in folio , lid closed	17-2
Wood box, wrapped in paper, no lid	16-3
Wood box, wrapped in folio, no lid	16-2
Wood box, unwrapped, lid closed	14-7
Wood box, unwrapped, no lid	8-0

As seen from the table, removing the lid of the box and allowing the air to flow over the unwrapped product significantly reduces the freezing time.

The table also shows that whatever the material used in wrapping, the main effect on freezing time results not from the material of the wrapping, but from the fact that it cuts the contact of flowing air with the top surface of the product.

When comparing foil wrapping of the product to the lid of the wooden box, it is seen that the folio is a better conductor and has less of an effect on freezing time; because the lid of the wooden box offers more effective isolation.

Naturally freezing in open metal trays takes much less time, in this case the packaging is done afterwards, but in this case labor is required twice. This method is used when the shortest freezing time is targeted.

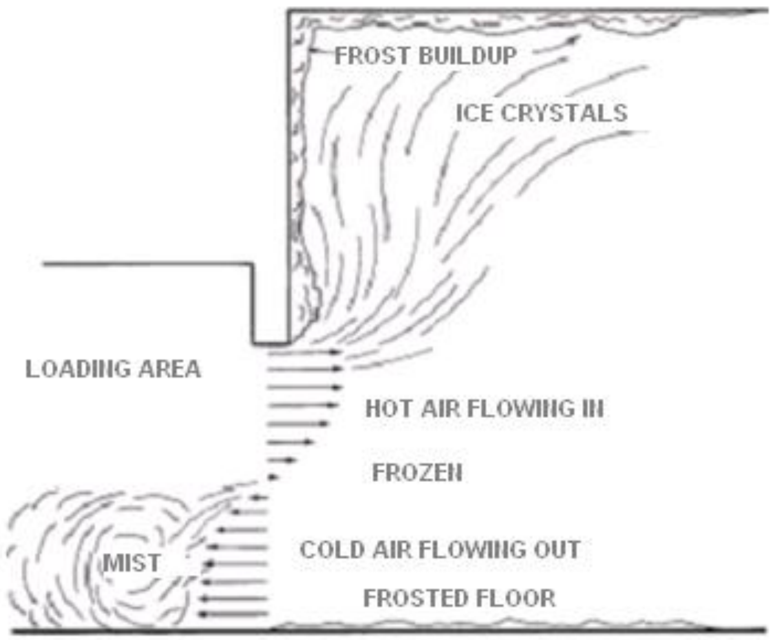
Defrosting of blast freezers

Frosting occurs predominantly in the air intake side of evaporators, and in the wall of the room where the warmest product resides, as the water vapor in the air that results from evaporation of the water within the product or from filtration freezes on the cold evaporator surfaces. Frosting should be melted with regular intervals, otherwise the accumulating resistance will weaken air flow and reduce the efficiency of the cooling system. In unwrapped products approximately 1-2% of the weight evaporates and accumulates on the evaporator surface as frost.

The frost in the form of dust can be cleaned from accessible points carefully with a soft brush. In commercial applications, defrosting can be made by halting the system after operation, opening the doors and allowing the room to warm up. Yet, this method takes too much time and over condensation can harm the structure of the room. It is best to run a controlled heating by keeping the doors closed.

Hot gas defrost, water spray and electrical defrost methods are used as defrosting systems. In case the gas in the evaporator is purged before the start of the defrosting, the process can be expedited in all three methods. The defrosting time in evaporators is important thus systems capable of quick defrost should be installed.

Figure 11 shows the typical movements of hot, cold air and frosting on room walls.



Condenser selection

Condensers are generally selected according to climate conditions, the availability of water and economic criteria. In cases where water is expensive, evaporative condensers or air cooled condensers are preferred.

Air cooled condensers are usually preferred for small units. Incorrect loading leads to an increase in air temperature within the room and extended frozen time. In this case, the compressor is overloaded and is faced with the risk of reaching high pressure. Condensers with safety should be selected in order to prevent overloading which may cause damage in the compressor. Condenser selection is usually left to the discretion of the supplier of the refrigeration machine.

Specifications of the customer

In ideal conditions, the customer should specify the following while ordering a blast freezer. In cases where they cannot provide all of the information, they should provide as much as they can and provide all information about the minimum product, the considered freezer, the space available and other facilities.

1. The type of product that will be frozen
2. The shape, size and packaging method of each product to be frozen
3. Freezing time of each product
4. The daily freezing quantity by weight that is desired for each product
5. Normal daily operation time
6. The desired average air temperature within the room
7. The desired average air speed within the room
8. The intended method of loading products within the room
9. Schematic plan of the intended blast freezer
10. A schematic plan of the facility and the position of the freezer tunnel.
11. Availability of electricity and water
12. The condenser type preferred if any, air, water or evaporative
13. Maintenance options

Specifications of the supplier

Suppliers should hand a written placement plan and specifications of the tunnel. Before proceeding to the list pertaining to the other information that should be provided, we must mention a very frequent mistake regarding the defining of cooling capacity. The cooling capacity is often expresses n terms of motor power HP, which is a very crude denotation. Sometimes capacities are expresses in daily cooling capacity or the daily quantity of loaded product without clarifying the definition of a day, as in 8 hours or 24. To avid confusion, the capacity should be expresses in terms of cooling capacity per hour. At the same time, the quantity of product that can be shock frozen should also be specified. Another mistake while expressing capacity is to neglect the operating temperature. The compressor capacities should not be given in unrealistic nominal conditions for these operating conditions. The capacity that is provided should be the capacity at the lowest operating temperature specified for the freezing process.

REFRIGERATING MACHINES

1. Type and number of compressors.
2. Compressor operating conditions
3. Total cooling capacity
4. The cooling capacity of each compressor under design conditions

5. Compressor motor power in HP
6. Electrical power requirement
7. Compressor safety equipment
8. Type and number of condensers.
9. Water expenditure in terms of water cooled condenser
10. Circulation pump in water cooled condensers
11. Fan motor power in air cooled condensers
12. Machine placement scheme indicating the required space

REFRIGERATING SYSTEM

13. The refrigerant used
14. System type
15. Initial charge quantity of refrigerant
16. Pump power in terms of pumped refrigerant circulation
17. Redundancy if any
18. Temperature control method
19. Temperature control intervals.

THE FREEZER TUNNEL:

20. Tunnel placement scheme
21. Loading quantity in weight for each defined product
22. Freezing capacity per hour for each product
23. Daily loading capacity for each product for a regular work day taking into consideration the time of loading and unloading
24. The recommended loading procedure
25. The air temperature within the tunnel
26. The number and capacity of evaporators
27. The number and capacity of fans
28. The air temperature within the empty tunnel
29. The air velocity over the product
30. The temperature increase in air resulting from the heat received from the product
31. The defrosting method
32. The instruments provided
33. Type of isolation
34. Thickness of isolation
35. Isolated cabin installation method
36. Steam isolation
37. Exterior coating
38. Interior coating
39. Door heaters
40. Measures for the prevention of frosting, if any
41. Lighting

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