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Planning and engineering data 1. Fresh fish handling

Prepared by

M. Myers
Production Engineer
White Fish Authority
Industrial Development Unit
Hull, England

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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ABSTRACT

Planning, including preparation of prefeasibility studies, and designing facilities and operations of fresh fish handling, storage, distribution and marketing is becoming increasingly important in the countries developing their small, medium and/or large-scale fisheries industries. However, engineering data required for a successful planning are either scattered in numerous publications and therefore difficult to retrieve, or kept by consulting engineers in their private files, or just not readily available, in which case they have to be constructed or estimated every time they are needed.

This document is the first attempt to present selected engineering data, in the specific subject matter field of fresh fish handling under a single cover. It is hoped that the work of the government authorities concerned with planning related to this specific subject matter field of fishery industries, as well as of consultants and other field workers involved, will be facilitated and become more uniform if they use this document.

Major fields covered concern ice, its production, storage and use with fish, chill storage, insulated and non-insulated containers for fresh fish, in-plant transportation devices for fresh fish, as well as fish working premises.





1. INTRODUCTION

The Fishery Industries Division of the Food and Agriculture Organization of the United Nations is receiving numerous inquiries on specific data concerning planning, design and operation of fresh fish handling facilities from governments and Industries mainly of countries developing their fishery industries. In addition, requests for direct assistance in carrying out prefeasibility studies, occasionally of relatively simple nature, in the field of fresh fish handling are received, and in order to provide the assistance often highly specialized engineers have to be engaged since only they have access to some of the required basic engineering data. Also, for other feasibility studies and banking projects in this subject matter field the required engineering data are not always readily at hand.

As a matter of fact, the engineering data concerning fresh fish handling are either scattered in different publications or exist only in the files of individual engineers as they were never published. Considerable effort is in practice wasted by individual engineers to construct the required data for their own use, which results in both heavy duplication of work and often inaccurate data.

This publication is intended to assist field staff in the selection or specification, costing (both capital and running) and planning of facilities or equipment concerned with fresh fish handling and storage. It is not intended as a code of practice. It is hoped that it will help to satisfy requests for information more speedily, to contribute to improved accuracy and to save on efforts on parallel construction of data.

This document does not pretend to include all the relevant data at this stage. It is recognized that a complete presentation would require time and resources which could not be justified for an initial effort, and that some data, such as costs are subject to fast changes. However, the intention of the document is to serve as a core guide to which additional data will be added by the users in the future. The users are, therefore, cordially requested to communicate their comments and all the additional data they find useful to the Fishery Industries

Division. FAO, 00100 Rome, Italy, for later incorporation in an improved, more permanent edition of the document.

The publication is not the result of original research by the author but is based on information available from manufacturers of equipment, from commercial plant operators and from previously published material by numerous organizations, particularly the Food and Agriculture Organization of the United Nations, Torry Research Station, Aberdeen, UK, and The White Fish Authority, Industrial Development Unit, Hull, UK.

It must be stressed most strongly that the costings given in the report are based on UK costs for 1979. Local costs of labour, land, services and costs of delivery and erection can significantly affect these costs. Given an appreciation of local costs relative to the UK, however, these figures can serve as a basis for budget costing and planning failing any better sources of information.





2. PHYSICAL DATA

Fish are commonly classified by physical characteristics or patterns of behaviour and are usually referred to as either pelagic or demersal. The pelagic fish such as mackerel and herring are feeders of microscopic plankton found in the surface layers of the sea. Demersal fish such as grouper, cod and flatfish, live on or near the sea bed and these patterns of behaviour give rise to different fishing techniques. Generally the pelagic species of fish contain higher levels of fat content than the demersal species.

Fatty fish

Fatty fish contain most of the fat content in the body tissues and use it as a source of energy. The fat is concentrated in the flesh about the lateral line running down each side of the body and will vary considerably depending upon the time of the year. The herring for example (*Clupea harengus*), may have a fat content of only 1 percent immediately after spawning and more than 20 percent at other times when feeding well. The percentage increase in fat content is at the expense of the water content with the protein level remaining fairly constant. Figure 1 shows the seasonal variation of fat and water for the mackerel (*Scomber scombrus*) in the UK.

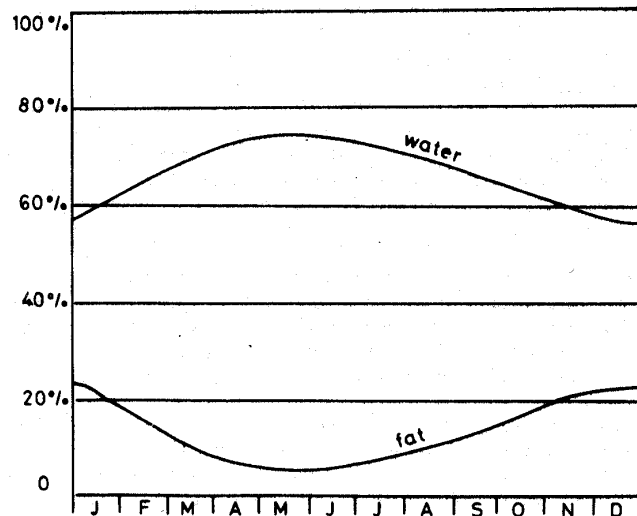


Figure 1. Seasonal variation in composition of *Scomber scombrus*

Lean fish

Lean fish are typically bottom-living fish with low fat content. Usually less than 5 percent. The bulk of the fat is contained in the liver with the muscle having a low fat content.

Chemical composition

The chemical composition of fish depends on the fish species, the season, the condition and the feed of the fish. Main components are water, fat and protein but the low concentrations of carbohydrates, minerals, vitamins, sugars and free amino acids also present are important to flavour, odour and nutritional value. Table 1 gives the composition of the raw flesh of a number of selected species (main components only).

Table 1 Chemical composition

Species	Scientific Name	Water (%)	Fat (%)	Protein (%)
Cod	<i>Gadus morhua</i>	78-83	0.1-0.9	15-19
Redfish	<i>Sebastes sp.</i>	73-79	3.2-8.1	16.8-19.7
Herring	<i>Clupea harengus</i>	60-80	0.4-22.0	16-19
Mackerel	<i>Scomber scombrus</i>	56-74	1.0-23.5	16-20
Hake	<i>Merluccius merluccius</i>	80	0.4-1.0	17.8-18.6
Sole	<i>Solea solea</i>	78	1.8	18.8
Albacore	<i>Thunnus alalunga</i>	59-72	4.3-16.1	21-27

Specific and latent heat

Specific and latent heat values of fish are dependent upon the chemical composition of the fish but for lean fish with a water content of about 80 percent, the specific heat is 0.9 kcal/kg°C for temperatures about -1°C, the temperature at which lean fish starts to freeze. As freezing does not take place at a particular temperature latent heat and specific heats are removed simultaneously. Figure 2 shows the relationship of total heat content for lean fish taking an arbitrary zero of -40°C.

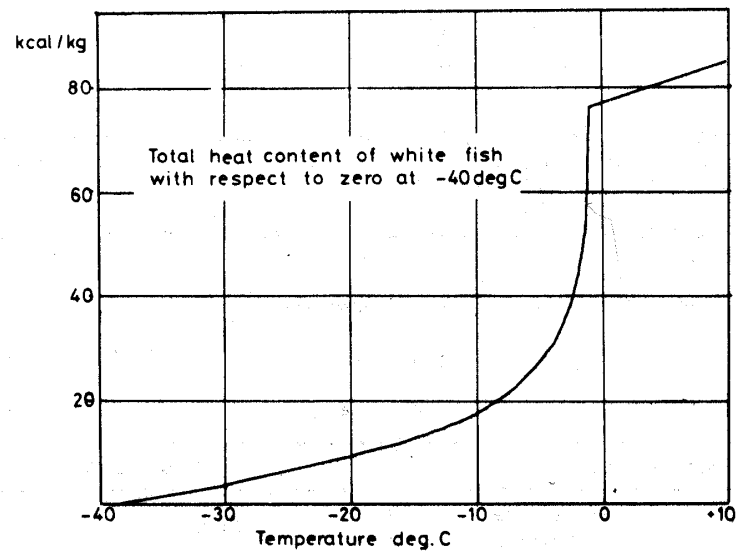


Figure 2. Total heat content of lean fish

The heat content of fatty fish, which has a lower water content than lean fish, will be reduced. A fish with a fat content of 20 percent may start to freeze at -2°C and have a heat content lower by 22 percent. Since the oil content varies seasonally the figures for lean fish may be taken as representing the maximum cooling requirement.

Perishability

When a fish dies spoilage begins due to bacterial, enzymatic and chemical action. On death the bacteria present in the surface slime, gills and intestines, which do no harm to the living fish due to its natural resistance to them start to multiply and penetrate the tissues, the enzymes in the stomach and intestines start to penetrate the belly lining and oxidation of the fat in the flesh occurs. The rate of spoilage is dependent upon the holding temperature and is greatly accelerated at higher temperatures, due to increased bacterial action at the higher temperatures. Freshness is to a certain degree subjective but it can be "measured" against an agreed scale by assessment of appearance, odour and taste. Figure 3 shows how freshness of a lean fish deteriorates with time at selected holding temperatures.

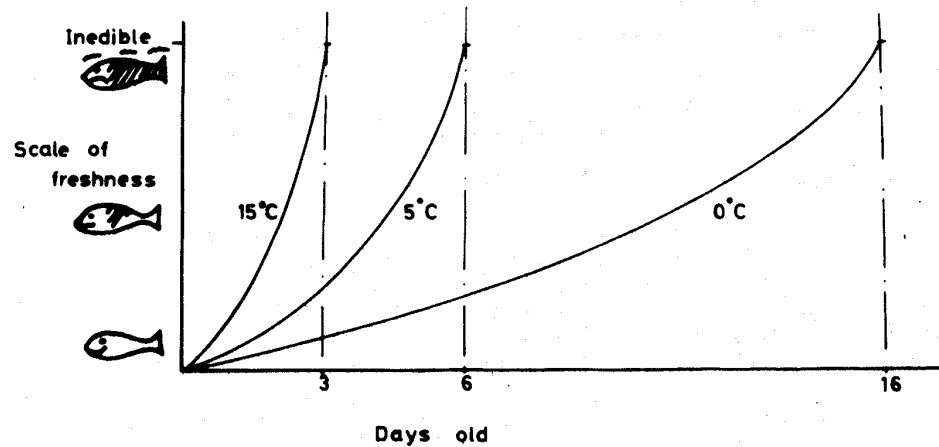


Figure 3. Deterioration of lean fish

Fatty fish will deteriorate far quicker than lean fish due to the higher rate of oxidation of the fat. Herring for example will be unacceptable after five or six days when held at 0°C and after only 30 h when held at 15°C.

Spoilage can be reduced by washing, gutting, gilling and above all by keeping the fish cool by the use of ice.

Table 2 lists the shelf lives of selected species.

Table 2 Shelf life

Temperate Water		Tropical Water	
Fish	Shelf-life (days)	Fish	Shelf-life (days)
Cod	12-15	Snaper (Brazil)	11-16
Haddock	12-15	Tuna (USA)	29
Whiting	9-12	<i>Synagric japonicus</i> (India)	27
Hake	8-10	Bonga (West Africa)	20
Redfish	13-15	Sea bream (West Africa)	26
Herring	5-6	Burrito (West Africa)	22
Mackerel	7-9	<i>Tilapia</i> (West Africa)	28

Weight-length relationship

The relationship between weight and length of fish may be of interest in the design of fish processing machinery and fish handling equipment. Figure 4 shows the relationship for cod, snapper, flounder, mackerel and trout.

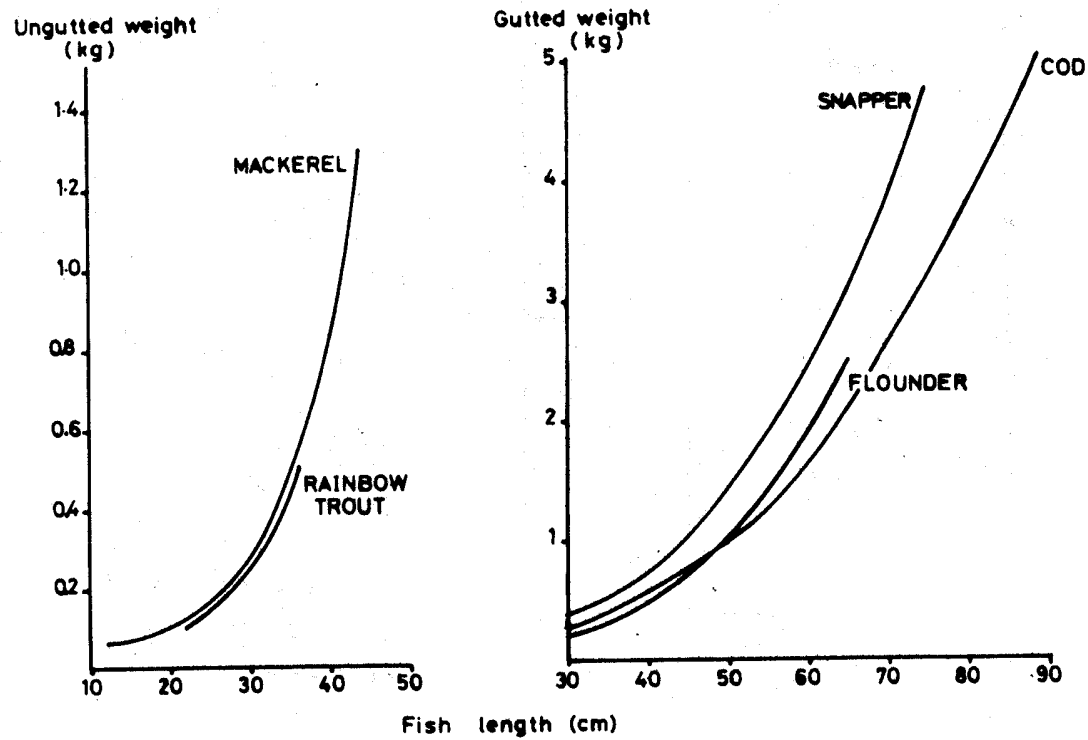


Figure 4. Weight-length relationship

Age-weight relationship

The age-weight relationship of a fish is of particular interest in the husbandry and harvesting of farmed fish and for any given species will depend on the type of feed, the water temperature and quality, the holding method and sex of the fish. As a comparison Figures 5 and 6 show the approximate relationship for salmon, halibut, turbot, plaice, grey mullet, hake and red mullet.

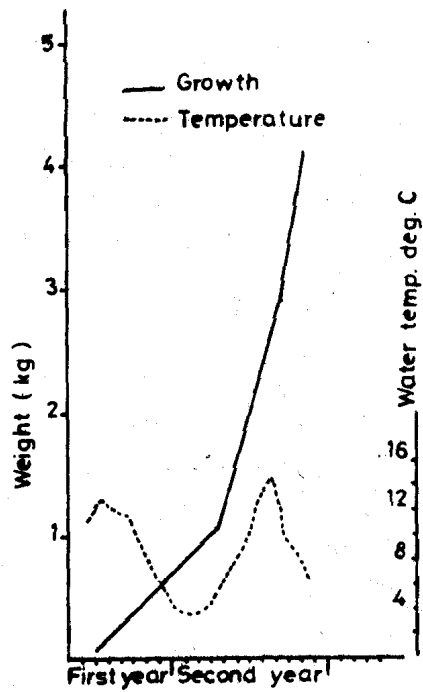


Figure 5 Age-weight relationship for salmon

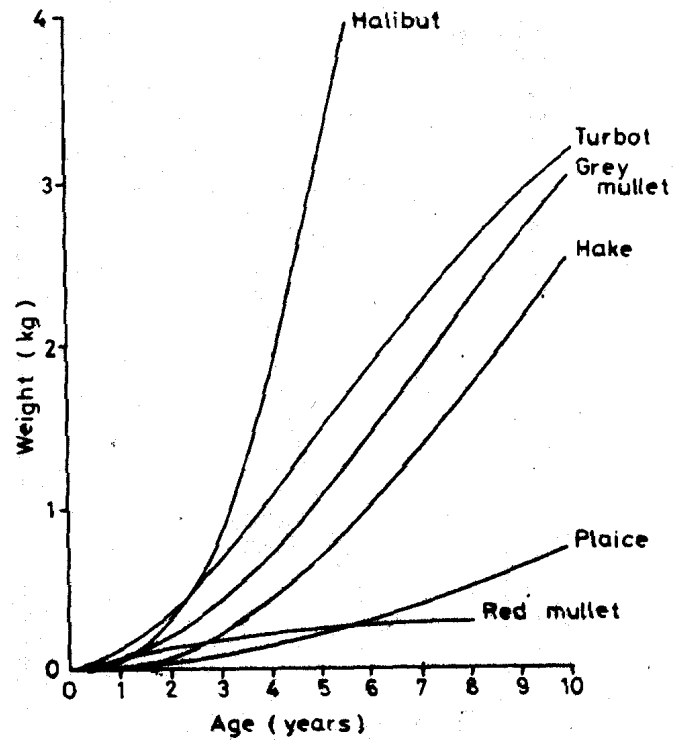


Figure 6 Age-weight relationship for flat and round fish





3. ICE

[3.1 Physical Properties - Fresh Water Ice](#)

[3.2 Seawater Ice](#)

Ice has long been used to cool, and thereby preserve fish both at sea and on-shore. It has a large cooling capacity for a given weight, is relatively cheap, prevents drying by keeping fish moist, is easily portable and maintains a temperature slightly above the freezing point of fish without the need for sophisticated temperature control. It can be made from fresh water or sea water which should in both cases meet micro-biological standards of potable water and be free of objectionable substances. Ice made from polluted water can contaminate fish and reduce its keeping time.

3.1 Physical Properties - Fresh Water Ice

The physical properties of fresh water ice are given in Table 3.

Table 3 Physical properties of fresh water ice

Property	Metric units
Melting point	0°C
Density at 0°C <i>a/</i>	0.92 t/m ³
Specific heat at 0°C	0.49 Kcal/Kg °C
Specific heat at -20°C	0.46 Kcal/Kg °C
Latent heat	80 Kcal/Kg
Thermal conductivity at 0°	1.91 Kcal/mh °C
Thermal conductivity at -10°C	1.99 Kcal/mh °C
Thermal conductivity at -20°C	2.08 Kcal/mh °C

a/ The figure quoted for the density of ice should not be confused with the stowage density of different forms of ice which are given in Table 4

Table 4 Stowage densities of ice types

Type	Stowage (m ³ /t) <i>a/</i>
Crushed block	1.4-1.5
Tube	1.6-2.0
Plate	1.7-1.8
Flake	2.3-2.3

a/ Note that these stowage densities in Table 4 do not necessarily relate to the size of store required for a given weight of ice without allowance being made for handling. See also Section 5, Ice Storage

The cooling capacity of the different types of ice will be practically the same for equal weights but not for equal volumes due to the difference in stowage density. Subcooled ice will have marginally more cooling capacity due to being sub-cooled and dry. Wet ice caused by hot gas or water defrost systems will have slightly reduced cooling capacity due to the free water contained in the ice, as shown in Figure 7, but for practical purposes the cooling capacity of equal weights of ice types can be considered the same.

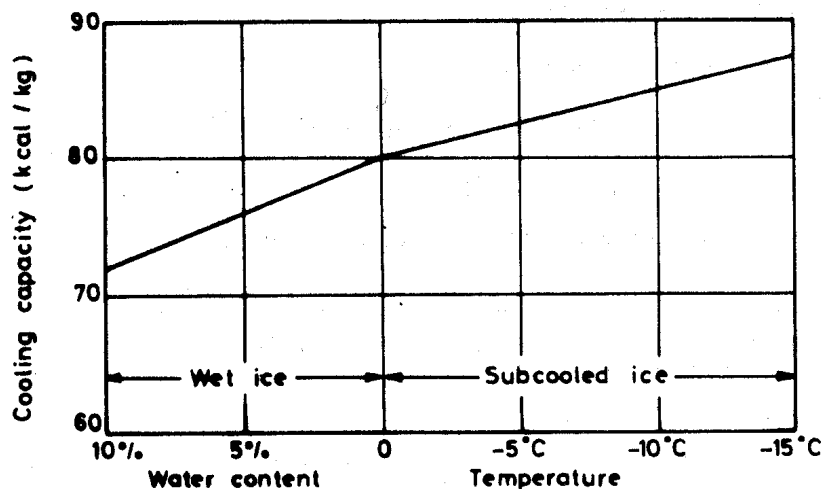


Figure 7. Cooling capacity of ice

The cooling rate or rate of meltage of ice will not be the same for different types of ice and will depend on the surface area of the ice. For example, flake ice has a surface area of over four times that of tube, weight for weight which can be an advantage or a disadvantage depending on its intended application. A poor stowage rate is a disadvantage for applications where space is limited and will give a slightly reduced capacity of fish in a box. Flake ice also has a tendency to bridge over the fish leaving an air space between the fish and the ice, thereby reducing effective cooling but is easier to handle as it is dry and produces the least damage to fish of all the forms of ice.

3.2 Seawater Ice

Seawater is suitable for ice making provided it is not contaminated and produces an ice soft and wet in appearance. It is not stable and during storage the brine tends to leak out leaving fresh water ice. The freezing point is dependent on the salt content as shown in Figure 8. When used to cool fish partial freezing of the fish can occur which is not desirable and salt uptake in the fish flesh is noticeable with prolonged storage. Depending on salinity and the amount of entrapped air it has a density in the range of 0.86 to 0.92 t/m³. It has application where fresh water is expensive or in short supply and can be used for production at sea.

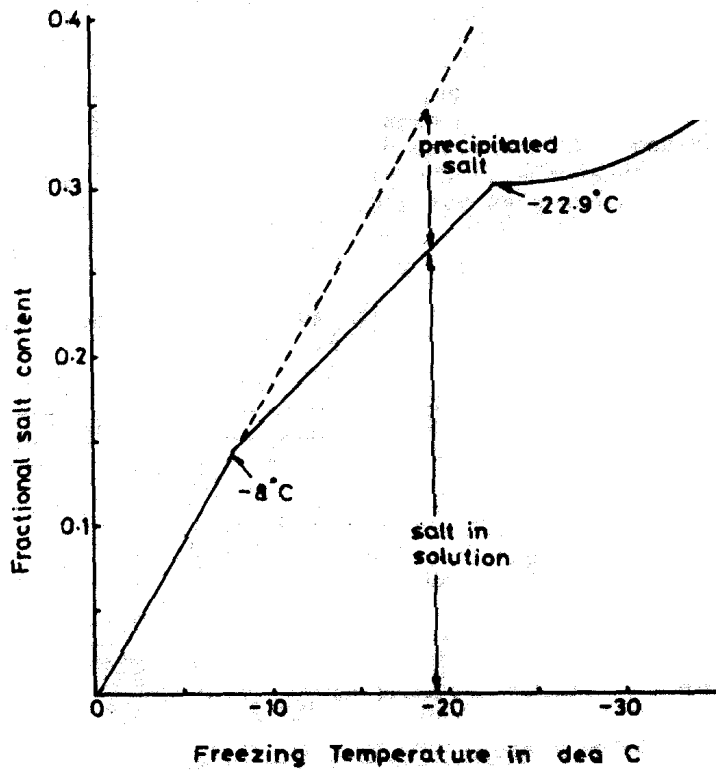


Figure 8. The freezing point of brine as a function of its salt content





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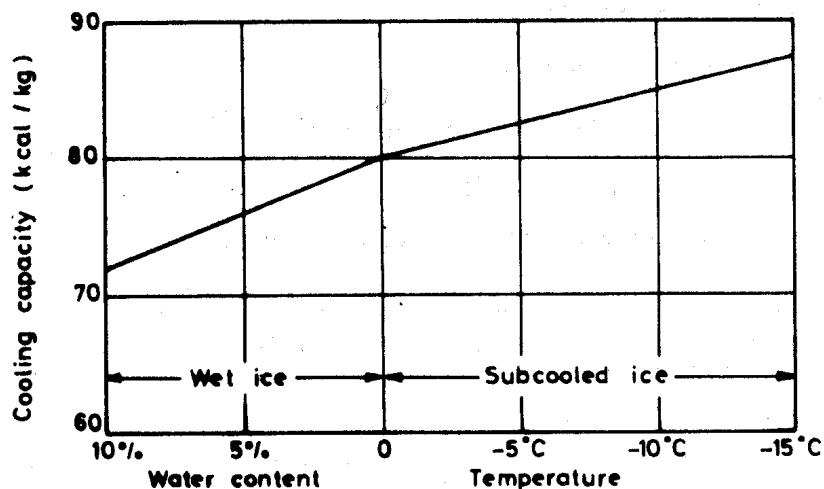


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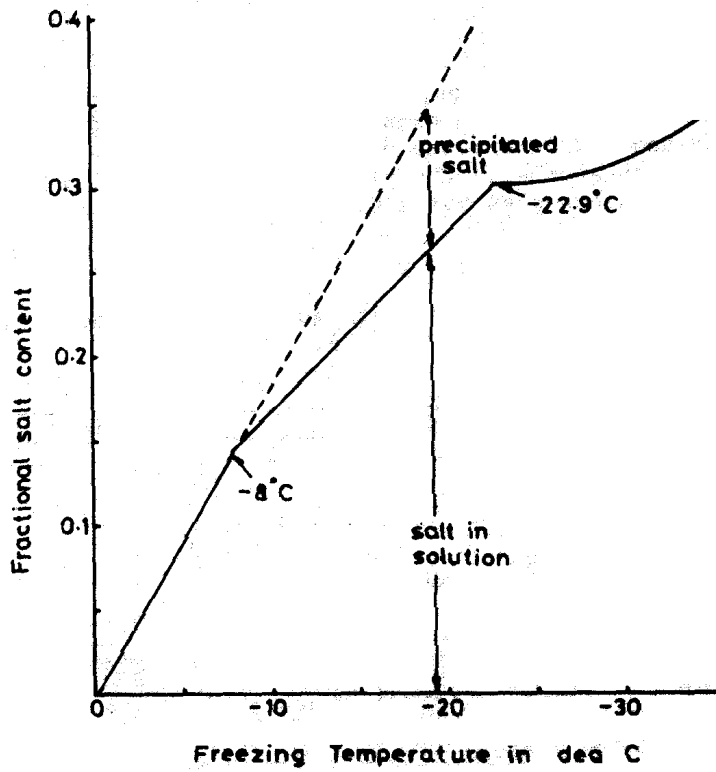


Figure 8. The freezing point of brine as a function of its salt content





4. ICE PLANTS

[4.1 Block Ice](#)

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Types

There are many methods of producing ice and the selection of the most suitable plant for a prospective buyer is not simple. The manufacturing process of one may involve efficiencies or advantages over another or the ice produced by one process may be better suited to the intended application than another. The plant types are usually referred to by the type of ice they produce; common examples being block, flake, plate and tube.

4.1 Block Ice

In the manufacture of block ice, tapered rectangular cans filled with water are immersed in a tank of refrigerated brine as shown in Figure 9.

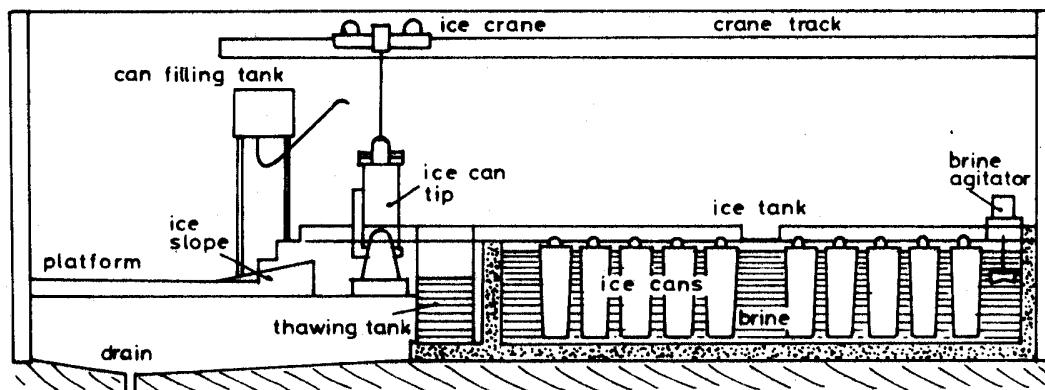


Figure 9. A brine type block ice plant

The brine which is cooled to about -5°C by a refrigeration process extracts the heat from the water and produces block ice within the can. The cans are then removed from the tank and thawed for a short time in a tank of water to release the block from the can. The blocks are then stored in a cold room and can be crushed on demand. The freezing period is typically between 16 and 24 h although plants known as rapid-block are available that have freezing periods of only a few hours. The quick freeze is achieved by the direct evaporation of the refrigerant in a jacketed mould fitted with finger evaporators. The blocks are released by a hot gas defrost and are subcooled to a temperature of -8°C . Rapid block plants require far less floor space than brine tank systems. Figure 10 shows a rapid block plant.

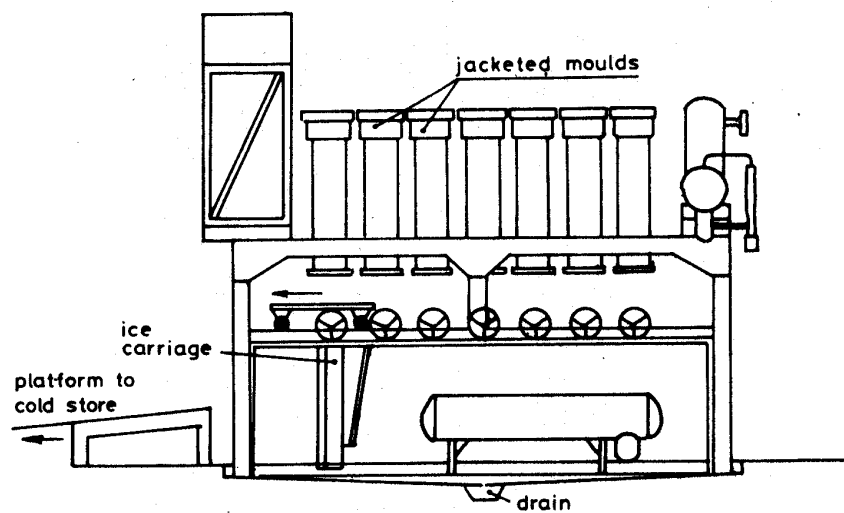


Figure 10. Rapid block plant

Typical block sizes and weights are given in Table 5.

Table 5 Block sizes and weights

Weight of block (kg)	Mould cross section		Length (mm)
	Top (mm)	Bottom (mm)	
25	270 x 140	240 x 114	1 025
25	190 x 190	160 x 160	1 105
50	408 x 184	378 x 154	1 000
136	560 x 280	535 x 254	1 220

4.2 Flake Ice

Flake ice is formed by spraying water over the surface of a refrigerated drum to freeze it and then mechanically removing it with a blade as shown in Figure 11 overleaf. In some models the drum rotates against a stationary scraper on its outer surface; in others the scraper rotates and removes ice from the inner double-walled stationary drum (as shown). No water is sprayed on the drum immediately in front of the scraper, so that the water is completely frozen and dry on removal. Ice produced by this method is commonly 2-3 mm thick.

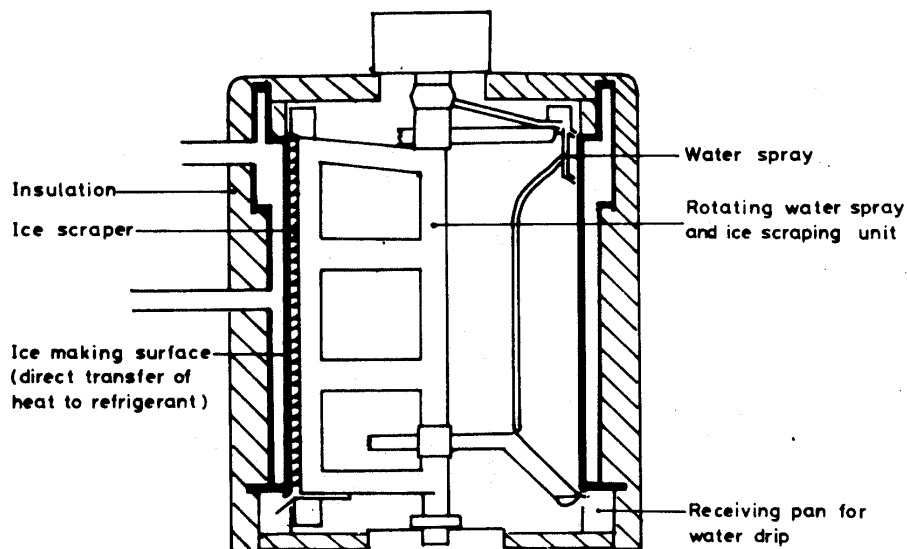


Figure 11. Flake ice plant

4.3 Plate Ice

In the manufacture of plate ice, water is sprayed and frozen onto the outer surface or surfaces of a refrigerated plate to form a sheet of ice which is usually

released by an internal hot gas defrost.

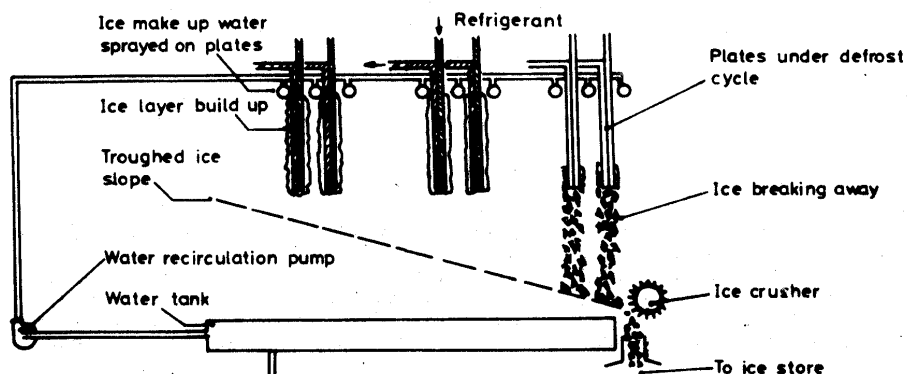


Figure 12. Plate ice plant

Thickness of the ice can be varied, within limits, by alteration of the defrost cycle, but is commonly set between 8 and 15 mm. To produce ice thinner than this would be inefficient due to the refrigeration energy required to repeatedly account for the heat of defrost. As the ice falls it is chopped by a rotating cutter. The process is automatic.

4.4 Tube Ice

Tube ice is formed in a vertical shell and tube vessel by passing water down the inside of tubes which are cooled by the circulation of refrigerant on the outer surfaces as shown in Figure 13.

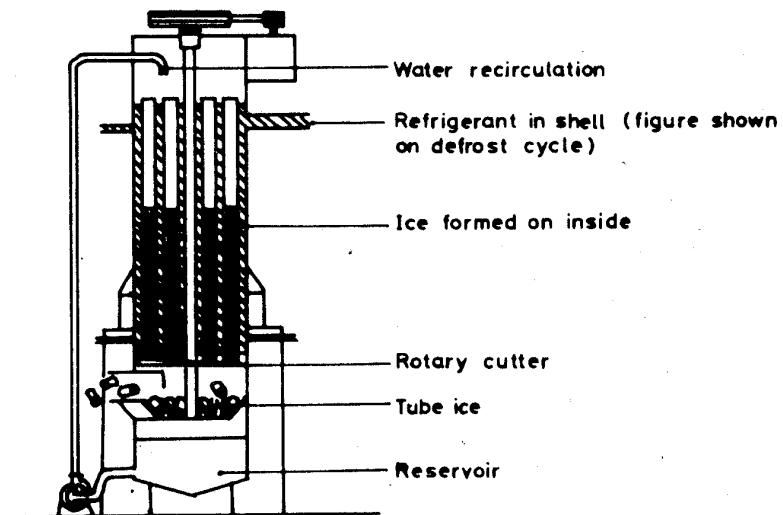


Figure 13. Tube ice plant

When the ice reaches the desired thickness the water flow is stopped automatically, the refrigerant is removed to a surge drum and hot gas is circulated around the tubes causing the ice tubes to melt and slide down. As the ice falls from the tubes it is broken by a rotating knife blade to a desired size. The ice tubes are about 50 mm in diameter with a wall thickness of 10-12 mm.

4.5 Selection

In the selection of an ice plant, many considerations need to be made relating to capital costs, running costs, availability of skilled servicing, water supply and the preferred type of ice. No plant is universally superior to all others and the selection of plant needs to be made with knowledge of local conditions and requirements. Manufacturers will meet a customer requirement from a given range of equipment and can manipulate specification to suit a particular market or to meet competition. In the selection of equipment or comparison of competitive tenders, it is essential to consider the total costs of production; both running and capital. It is possible that a plant of low capital cost could have high running costs resulting in a higher cost of ice than a plant of higher initial cost but lower running costs. It is essential to fully understand and appreciate a manufacturer's specification and exclusions.'

It is usual at the appraisal stage of an investment to prepare a technical/economic analysis based on estimated capital and running costs. The analysis should help not only in financial planning and pricing but in selection of plant as the relative local costs of electricity, water, finance and labour will influence the design specification.

As an example, the following analysis provides a cost estimate of ice production. The analysis is based on a flake ice factory of 150 t/24 h. The capital and running costs used are 1979 costs in the UK. The analysis assumes a location on the dockside and includes no allowance for distribution.

A Cost Estimate of Ice Production

Flake ice plant - 150 t/24 h

Total years production = 120 t/24 h x 5 d x 52 weeks = 31 200 t (at 91% capacity utilization)

Capital cost of plant = US\$ 1 000 000

Costs/year	US\$	% of annual cost
1. Labour (inc. of Soc.Sec. payments, etc.)	50 000	12.7
2. Electricity	68 000	17.0
3. Water	8 000	2.0
4. Office supplies	6 000	1.5
5. Depreciation (plant at 10 years, buildings at 15 years)	83 000	21.0
6. Capital interest at 10%	100 000	25.3
7 Maintenance	20 000	5.1
8. Land, rent, taxes and insurance	10 000	2.5
9. Audit, legal and bank charges	3 000	0.8
10. Taxes on profit	20 000	5.1
11. Dividend to shareholders	24 000	6.1
12. Miscellaneous (pension fund, bad debts, etc.)	<u>3 000</u>	0.8
Total annual costs	395 000	

US\$

Cost of ice/t	12.7/t
Assume sale price	17.0/t
Revenue from sales	530 400
Profit	135 400
Return of investment	13.54%

It is clear from the analysis that the correct selection of capacity of plant and store to meet the size and pattern of demand is of importance. If the plant is overspecified and underutilized the fixed overheads will be carried by a disproportionate volume of sales and the unit costs will be high.

The ice store should be sized according to both the volume and pattern of demands. Ice production and demand are seldom in phase and the store acts as a buffer helping to overcome daily fluctuations between production and demand. It also acts as a buffer in the event of a temporary breakdown of plant or interruption of services. Stores are commonly 2-4 times the daily production capacity.

To assist the supplier or refrigeration contractor in selection and design, the buyer should make available as much information as possible regarding local costs and site conditions, etc. The following lists the more important considerations:

- Production capacity desired under local ambient conditions
- Ice storage capacity desired
- Purpose for which ice is to be used
- Preferred type of ice, and in the case of block, the block size
- Maximum ambient temperature and humidity and annual fluctuations
- Cost and availability of local labour including skilled
- Temperature, pressure and purity of ice make-up water
- Cost of make-up water
- Temperature, pressure and type of condenser cooling water
- Cost of cooling water
- Information on electricity supply: voltage, cycles, phase, maximum installed power, maximum starting current allowable. Cost of electricity/unit and details of any reduced rate for off-peak use.
- Detail of any physical or planning restrictions of the intended site
- Detail of site soil tests
- Particulars of grant aid, or soft loans (if any) toward capital or running costs of plant and conditions attached to aid
- Cost of capital (interest)

From the information provided selection of plant can be made that will satisfy any site restrictions and produce ice at a minimum cost.

4.6 Capital Costs

It is often necessary for purposes of financial planning that budget costs are known before a detailed analysis is available. To assist in financial and technical planning the following tabulated data is an attempt to provide an order of costs and physical data for different types of ice plant inclusive of store. The figures shown in Table 6 are based on information provided by plant operators in the UK and assume UK cost levels (1979) and ambient conditions. It must be stressed most strongly that these figures cannot be used universally without considerations to local site conditions and costs, but they do provide a datum from which rough budget costings may be estimated given a general appreciation of local costs compared with those of the UK.

Table 6 Capital costs (US\$)

Type	t/24 h					
	2	5	10	20	50	100

Block (brine)			500 000	600 000	800 000	1 300 000	1 900 000
Tube			180 000	280 000	460 000	740 000	1 300 000
Flake	20 000	40 000	160 000	270 000	420 000	720 000	1 280 000
Plate	15 000	30 000	140 000	240 000	400 000	700 000	1 240 000

Automatic operation and conveying is assumed on production of 10 t/24 h and above for tube, flake and plate. Manual operation and discharge is assumed for 2 and 5 t/24 h. Three days storage capacity is included for tube, flake and plate and two days for block. The figures represent a turnkey cost and are inclusive of plant, erection, delivery, soil investigations, commissioning, freight and insurance, etc., but exclusive of ground cost. The costs reflect a site that requires no exceptional civil works in piling or clearing with services near at hand.

As a rule of thumb the plant items (ice generators, refrigeration machinery, motors, conveying equipment, weighing equipment, etc.) for tube, flake and plate ice, plants over 10 t/24 h, amount to approximately 50 percent of the total cost.

4.7 Area Requirements

The required overall ground area for an ice plant will largely depend on the type of: ice-maker, condenser and store and the configuration of these units. It is usual in the case of plate and flake ice production that the ice-maker be located over the store enabling gravity feed of the ice to the store which results in a low ground area requirement overall. This is not feasible for the block type of plant because of the heavy loads imposed on the structure and unusual in the case of a tube plant because it would result in an excessively high building. Table 7 shows the area requirements of the ice-maker and refrigeration plant, not including storage, office accommodation, electrical sub-station or condensers.

Table 7 Area requirements for ice-maker and refrigeration plant (m²)

t	2	5	10	20	50	100	200
Block	-	-	100	200	450	800	1 500
Tube	-	-	30	35	60	92	160
Flake	7 <u>a/</u>	10 <u>a/</u>	20 <u>a/</u>	25	50	80	140
Plate	7 <u>a/</u>	8.5 <u>a/</u>	9 <u>a/</u>	12 <u>a/</u>	50	80	140

a/ Packaged units with allowance for access

4.8 Direct Running Costs

The direct running costs of labour, electricity, water and maintenance will largely depend on the type and size of plant, location and the degree of automation. As mentioned before, the design of plant should reflect the local capital and running costs such that the cost of ice per ton is minimized. In some instances there will be a trade-off of component costs. For example, the selection and design of the condenser requires a knowledge of local costs of electricity, water and labour (ignoring space as a cost). A shell and tube condenser using sea water which is dumped would have low water and electric costs in comparison to other condensers but higher labour costs due to the cleaning required. An air-cooled condenser would have no associated water cost but higher electric cost (particularly if it was silenced). An evaporative condenser or shell and tube with cooling tower, using fresh water would compromise the costs of electricity and water.

4.9 Power

In addition to the type of ice plant and its associated refrigeration machinery, the power consumption will depend on local ambient conditions and feed water temperatures. Table 8 shows the approximate electricity consumption per ton of ice produced for the icemaker and refrigeration plant for temperate and tropical areas. The figures do not include requirements for handling, crushing or storage.

Table 8 Approximate electricity consumption for ice production (kWh/t)

Type of ice	Climatic Zone	
	Temperate	Tropical
Flake	50-60	70-85
Plate	45-55	60-75
Tube	45-55	60-75
Block	40-50	55-70

The flake ice plant has a slightly higher overall requirement due to the low evaporation temperature used to produce subcooled ice even though it has no defrost load requirement. Large ice plants are often more efficient than smaller ones and are sometimes specified with precoolers particularly in tropical areas, which sometimes enables the use of a smaller icemaker. The precooler is specially designed to lower the temperature of the feed water to the ice-maker and does it more efficiently than the ice-maker. Automatic plants (flake, tube and plate) are better suited to take advantage of any tariff reductions for off-peak use of electricity. Where penalties are incurred for high peak demands such that occur on start-up, the plant can be supplied with a current-limiting device that will limit the power demanded.

4.10 Labour

Labour costs will depend on local rates of pay, social security payments, the degree of automation and the type and size of plant. Generally the automatic plants (flake, tube, plate) require far less labour than block plants, particularly for the larger capacities. The cycle and harvest of automatic plants requires little attention and it is possible for one man to discharge from the store a measured quantity of ice. Table 9 compares the labour requirements for different sizes of automatic and block type plants, but it must be stressed that in both cases the labour requirement will be dependent on design. No inclusion is made for trimming of vessels at the quayside and the block plant is assumed to be of the continuous harvest type. Twenty four hours availability of ice is assumed.

Table 9 Labour requirements (man hours/24 h)

t	10	20	50	100	200
<u>Automatic</u>					
Manager	8	8	8	8	8
Clerk/Tel./Rec.		8	8	8	8
Engine Room/Maintenance	8	24	32	32	32
Harvesting	-	-	-	-	-
Storing	-	-	-	-	-
Discharge	24	24	32	32	48
Total	40	64	80	80	96

Block

Manager	8	8	8	8	8
Clerk/Tel./Rec.		8	8	12	12
Engine Room/Maintenance	24	32	48	56	56
Harvesting	24	48	72	96	112
Storing					
Discharge					
Total	56	96	136	172	188

4.11 Water

The basic water requirement for ice making will be slightly more than the equivalent quantity of ice allowing for losses and bleeding to drain to prevent the build up of salts in circulated water systems. Additional water will be required for domestic purposes and for condenser cooling. The quantity required for condenser cooling depends on the amount of heat to be rejected, the temperature of cooling water and whether the system recycles the water or not. The requirements of a shell and tube condenser in tons of water per ton of ice produced is given in Table 10.

Table 10 Requirements of cooling water for a shell and tube condenser

Water temperature (°C)	Tons of water/t of ice
10	15
15	25
20	40
25	60
30	125

An evaporative condenser will use between 0.25 and 0.5 t/t of ice depending on design. Precise requirements can be calculated from manufacturer's figures making allowance for windage, evaporation and bleeding. Shell and tube condensers employing a water tower and recirculation will have similar requirements to the evaporative condenser.

Water used for ice making should meet microbiological standards of potable water and be free of excessive solids or salts, which may detract from the physical properties of the ice produced. Problems may also be experienced when using pure water for flake ice production as the ice produced adheres to the drum and is difficult to remove. This problem may be overcome by the addition of salt to the make-up water.

4.12 Maintenance

Although maintenance costs for financial planning are often budgeted as a fixed percentage of the capital cost the actual costs are obviously dependent on the type of ice plant, its delivery system, the quality of servicing it receives and the age of the plant. Maintenance costs are often higher in the very early life of a plant and in its later years. Between 2 and 5 percent of the capital cost is commonly allocated per annum but actual costs can vary greatly year to year. Block plants generally have higher maintenance costs due largely to repair or replacement of moulds which may have an average life of only a few years. The cost of replacing the moulds of a 100-t/d plant would be in the order of US\$ 60 000 to 100 000. Block plants also require more attention to the building structure due to evaporation of the brine and its effect on the steelwork although this can be reduced by the use of inhibitors.





4. ICE PLANTS

[4.1 Block Ice](#)

[4.2 Flake Ice](#)

[4.3 Plate Ice](#)

[4.4 Tube Ice](#)

[4.5 Selection](#)

[4.6 Capital Costs](#)

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Types

There are many methods of producing ice and the selection of the most suitable plant for a prospective buyer is not simple. The manufacturing process of one may involve efficiencies or advantages over another or the ice produced by one process may be better suited to the intended application than another. The plant types are usually referred to by the type of ice they produce; common examples being block, flake, plate and tube.

4.1 Block Ice

In the manufacture of block ice, tapered rectangular cans filled with water are immersed in a tank of refrigerated brine as shown in Figure 9.

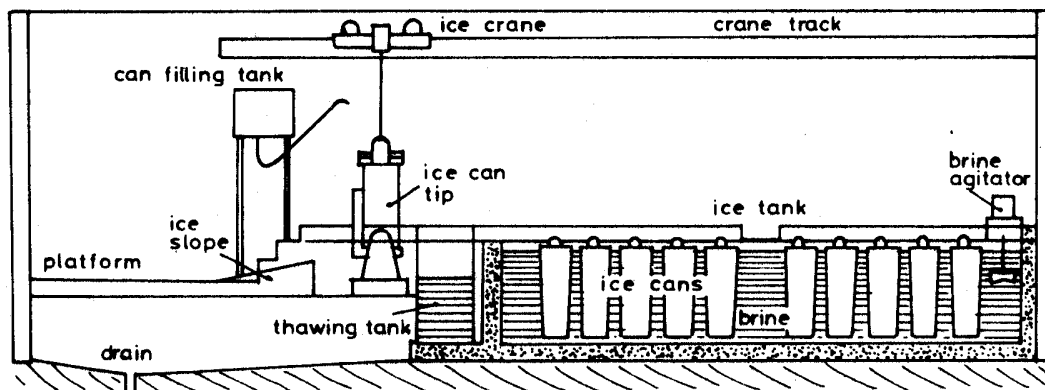


Figure 9. A brine type block ice plant

The brine which is cooled to about -5°C by a refrigeration process extracts the heat from the water and produces block ice within the can. The cans are then removed from the tank and thawed for a short time in a tank of water to release the block from the can. The blocks are then stored in a cold room and can be crushed on demand. The freezing period is typically between 16 and 24 h although plants known as rapid-block are available that have freezing periods of only a few hours. The quick freeze is achieved by the direct evaporation of the refrigerant in a jacketed mould fitted with finger evaporators. The blocks are released by a hot gas defrost and are subcooled to a temperature of -8°C . Rapid block plants require far less floor space than brine tank systems. Figure 10 shows a rapid block plant.

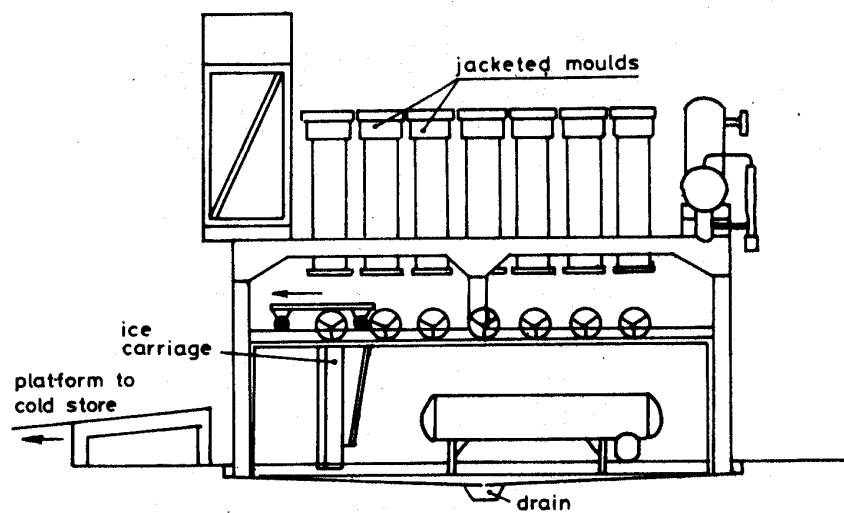


Figure 10. Rapid block plant

Typical block sizes and weights are given in Table 5.

Table 5 Block sizes and weights

Weight of block (kg)	Mould cross section		Length (mm)
	Top (mm)	Bottom (mm)	
25	270 x 140	240 x 114	1 025
25	190 x 190	160 x 160	1 105
50	408 x 184	378 x 154	1 000
136	560 x 280	535 x 254	1 220

4.2 Flake Ice

Flake ice is formed by spraying water over the surface of a refrigerated drum to freeze it and then mechanically removing it with a blade as shown in Figure 11 overleaf. In some models the drum rotates against a stationary scraper on its outer surface; in others the scraper rotates and removes ice from the inner double-walled stationary drum (as shown). No water is sprayed on the drum immediately in front of the scraper, so that the water is completely frozen and dry on removal. Ice produced by this method is commonly 2-3 mm thick.

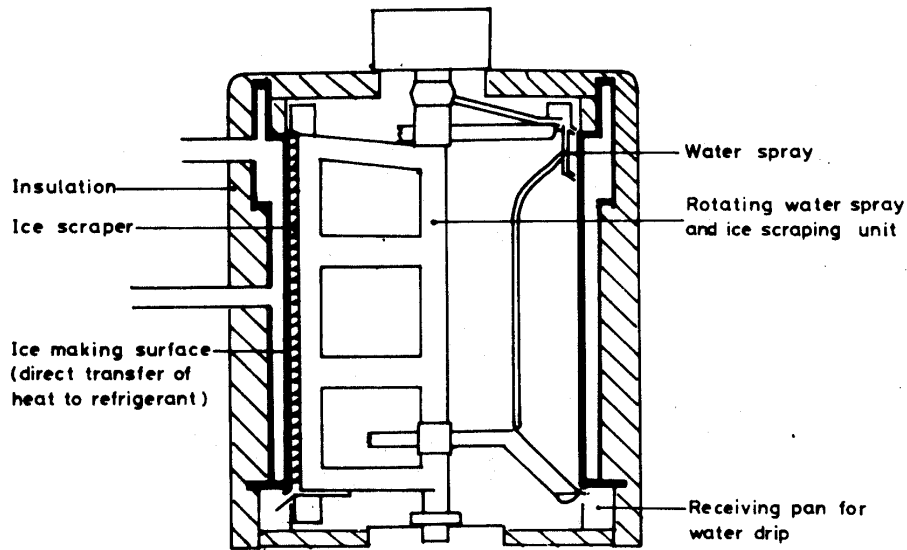


Figure 11. Flake ice plant

4.3 Plate Ice

In the manufacture of plate ice, water is sprayed and frozen onto the outer surface or surfaces of a refrigerated plate to form a sheet of ice which is usually

released by an internal hot gas defrost.

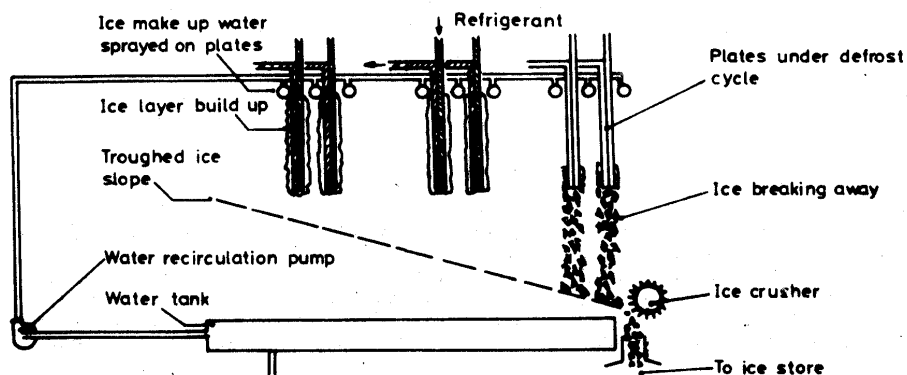


Figure 12. Plate ice plant

Thickness of the ice can be varied, within limits, by alteration of the defrost cycle, but is commonly set between 8 and 15 mm. To produce ice thinner than this would be inefficient due to the refrigeration energy required to repeatedly account for the heat of defrost. As the ice falls it is chopped by a rotating cutter. The process is automatic.

4.4 Tube Ice

Tube ice is formed in a vertical shell and tube vessel by passing water down the inside of tubes which are cooled by the circulation of refrigerant on the outer surfaces as shown in Figure 13.

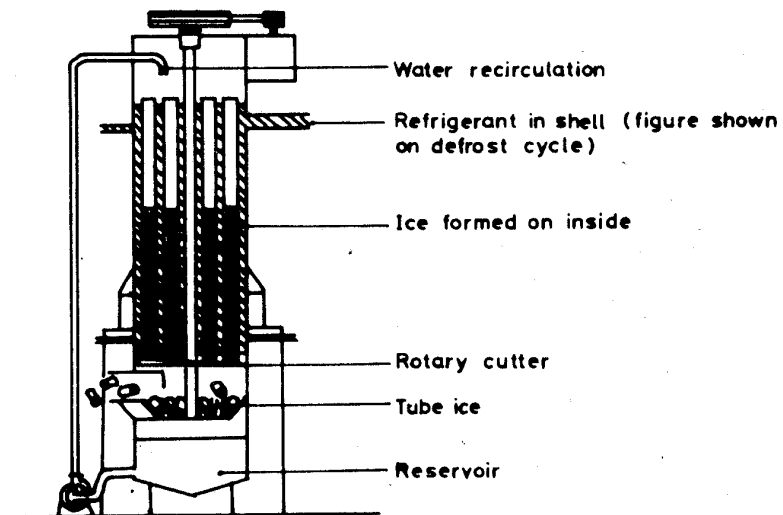


Figure 13. Tube ice plant

When the ice reaches the desired thickness the water flow is stopped automatically, the refrigerant is removed to a surge drum and hot gas is circulated around the tubes causing the ice tubes to melt and slide down. As the ice falls from the tubes it is broken by a rotating knife blade to a desired size. The ice tubes are about 50 mm in diameter with a wall thickness of 10-12 mm.

4.5 Selection

In the selection of an ice plant, many considerations need to be made relating to capital costs, running costs, availability of skilled servicing, water supply and the preferred type of ice. No plant is universally superior to all others and the selection of plant needs to be made with knowledge of local conditions and requirements. Manufacturers will meet a customer requirement from a given range of equipment and can manipulate specification to suit a particular market or to meet competition. In the selection of equipment or comparison of competitive tenders, it is essential to consider the total costs of production; both running and capital. It is possible that a plant of low capital cost could have high running costs resulting in a higher cost of ice than a plant of higher initial cost but lower running costs. It is essential to fully understand and appreciate a manufacturer's specification and exclusions.'

It is usual at the appraisal stage of an investment to prepare a technical/economic analysis based on estimated capital and running costs. The analysis should help not only in financial planning and pricing but in selection of plant as the relative local costs of electricity, water, finance and labour will influence the design specification.

As an example, the following analysis provides a cost estimate of ice production. The analysis is based on a flake ice factory of 150 t/24 h. The capital and running costs used are 1979 costs in the UK. The analysis assumes a location on the dockside and includes no allowance for distribution.

A Cost Estimate of Ice Production

Flake ice plant - 150 t/24 h

Total years production = 120 t/24 h x 5 d x 52 weeks = 31 200 t (at 91% capacity utilization)

Capital cost of plant = US\$ 1 000 000

Costs/year	US\$	% of annual cost
1. Labour (inc. of Soc.Sec. payments, etc.)	50 000	12.7
2. Electricity	68 000	17.0
3. Water	8 000	2.0
4. Office supplies	6 000	1.5
5. Depreciation (plant at 10 years, buildings at 15 years)	83 000	21.0
6. Capital interest at 10%	100 000	25.3
7 Maintenance	20 000	5.1
8. Land, rent, taxes and insurance	10 000	2.5
9. Audit, legal and bank charges	3 000	0.8
10. Taxes on profit	20 000	5.1
11. Dividend to shareholders	24 000	6.1
12. Miscellaneous (pension fund, bad debts, etc.)	<u>3 000</u>	0.8
Total annual costs	395 000	

US\$

Cost of ice/t	12.7/t
Assume sale price	17.0/t
Revenue from sales	530 400
Profit	135 400
Return of investment	13.54%

It is clear from the analysis that the correct selection of capacity of plant and store to meet the size and pattern of demand is of importance. If the plant is overspecified and underutilized the fixed overheads will be carried by a disproportionate volume of sales and the unit costs will be high.

The ice store should be sized according to both the volume and pattern of demands. Ice production and demand are seldom in phase and the store acts as a buffer helping to overcome daily fluctuations between production and demand. It also acts as a buffer in the event of a temporary breakdown of plant or interruption of services. Stores are commonly 2-4 times the daily production capacity.

To assist the supplier or refrigeration contractor in selection and design, the buyer should make available as much information as possible regarding local costs and site conditions, etc. The following lists the more important considerations:

- Production capacity desired under local ambient conditions
- Ice storage capacity desired
- Purpose for which ice is to be used
- Preferred type of ice, and in the case of block, the block size
- Maximum ambient temperature and humidity and annual fluctuations
- Cost and availability of local labour including skilled
- Temperature, pressure and purity of ice make-up water
- Cost of make-up water
- Temperature, pressure and type of condenser cooling water
- Cost of cooling water
- Information on electricity supply: voltage, cycles, phase, maximum installed power, maximum starting current allowable. Cost of electricity/unit and details of any reduced rate for off-peak use.
- Detail of any physical or planning restrictions of the intended site
- Detail of site soil tests
- Particulars of grant aid, or soft loans (if any) toward capital or running costs of plant and conditions attached to aid
- Cost of capital (interest)

From the information provided selection of plant can be made that will satisfy any site restrictions and produce ice at a minimum cost.

4.6 Capital Costs

It is often necessary for purposes of financial planning that budget costs are known before a detailed analysis is available. To assist in financial and technical planning the following tabulated data is an attempt to provide an order of costs and physical data for different types of ice plant inclusive of store. The figures shown in Table 6 are based on information provided by plant operators in the UK and assume UK cost levels (1979) and ambient conditions. It must be stressed most strongly that these figures cannot be used universally without considerations to local site conditions and costs, but they do provide a datum from which rough budget costings may be estimated given a general appreciation of local costs compared with those of the UK.

Table 6 Capital costs (US\$)

Type	t/24 h					
	2	5	10	20	50	100

Block (brine)			500 000	600 000	800 000	1 300 000	1 900 000
Tube			180 000	280 000	460 000	740 000	1 300 000
Flake	20 000	40 000	160 000	270 000	420 000	720 000	1 280 000
Plate	15 000	30 000	140 000	240 000	400 000	700 000	1 240 000

Automatic operation and conveying is assumed on production of 10 t/24 h and above for tube, flake and plate. Manual operation and discharge is assumed for 2 and 5 t/24 h. Three days storage capacity is included for tube, flake and plate and two days for block. The figures represent a turnkey cost and are inclusive of plant, erection, delivery, soil investigations, commissioning, freight and insurance, etc., but exclusive of ground cost. The costs reflect a site that requires no exceptional civil works in piling or clearing with services near at hand.

As a rule of thumb the plant items (ice generators, refrigeration machinery, motors, conveying equipment, weighing equipment, etc.) for tube, flake and plate ice, plants over 10 t/24 h, amount to approximately 50 percent of the total cost.

4.7 Area Requirements

The required overall ground area for an ice plant will largely depend on the type of: ice-maker, condenser and store and the configuration of these units. It is usual in the case of plate and flake ice production that the ice-maker be located over the store enabling gravity feed of the ice to the store which results in a low ground area requirement overall. This is not feasible for the block type of plant because of the heavy loads imposed on the structure and unusual in the case of a tube plant because it would result in an excessively high building. Table 7 shows the area requirements of the ice-maker and refrigeration plant, not including storage, office accommodation, electrical sub-station or condensers.

Table 7 Area requirements for ice-maker and refrigeration plant (m²)

t	2	5	10	20	50	100	200
Block	-	-	100	200	450	800	1 500
Tube	-	-	30	35	60	92	160
Flake	7 <u>a/</u>	10 <u>a/</u>	20 <u>a/</u>	25	50	80	140
Plate	7 <u>a/</u>	8.5 <u>a/</u>	9 <u>a/</u>	12 <u>a/</u>	50	80	140

a/ Packaged units with allowance for access

4.8 Direct Running Costs

The direct running costs of labour, electricity, water and maintenance will largely depend on the type and size of plant, location and the degree of automation. As mentioned before, the design of plant should reflect the local capital and running costs such that the cost of ice per ton is minimized. In some instances there will be a trade-off of component costs. For example, the selection and design of the condenser requires a knowledge of local costs of electricity, water and labour (ignoring space as a cost). A shell and tube condenser using sea water which is dumped would have low water and electric costs in comparison to other condensers but higher labour costs due to the cleaning required. An air-cooled condenser would have no associated water cost but higher electric cost (particularly if it was silenced). An evaporative condenser or shell and tube with cooling tower, using fresh water would compromise the costs of electricity and water.

4.9 Power

In addition to the type of ice plant and its associated refrigeration machinery, the power consumption will depend on local ambient conditions and feed water temperatures. Table 8 shows the approximate electricity consumption per ton of ice produced for the icemaker and refrigeration plant for temperate and tropical areas. The figures do not include requirements for handling, crushing or storage.

Table 8 Approximate electricity consumption for ice production (kWh/t)

Type of ice	Climatic Zone	
	Temperate	Tropical
Flake	50-60	70-85
Plate	45-55	60-75
Tube	45-55	60-75
Block	40-50	55-70

The flake ice plant has a slightly higher overall requirement due to the low evaporation temperature used to produce subcooled ice even though it has no defrost load requirement. Large ice plants are often more efficient than smaller ones and are sometimes specified with precoolers particularly in tropical areas, which sometimes enables the use of a smaller icemaker. The precooler is specially designed to lower the temperature of the feed water to the ice-maker and does it more efficiently than the ice-maker. Automatic plants (flake, tube and plate) are better suited to take advantage of any tariff reductions for off-peak use of electricity. Where penalties are incurred for high peak demands such that occur on start-up, the plant can be supplied with a current-limiting device that will limit the power demanded.

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Labour costs will depend on local rates of pay, social security payments, the degree of automation and the type and size of plant. Generally the automatic plants (flake, tube, plate) require far less labour than block plants, particularly for the larger capacities. The cycle and harvest of automatic plants requires little attention and it is possible for one man to discharge from the store a measured quantity of ice. Table 9 compares the labour requirements for different sizes of automatic and block type plants, but it must be stressed that in both cases the labour requirement will be dependent on design. No inclusion is made for trimming of vessels at the quayside and the block plant is assumed to be of the continuous harvest type. Twenty four hours availability of ice is assumed.

Table 9 Labour requirements (man hours/24 h)

t	10	20	50	100	200
<u>Automatic</u>					
Manager	8	8	8	8	8
Clerk/Tel./Rec.		8	8	8	8
Engine Room/Maintenance	8	24	32	32	32
Harvesting	-	-	-	-	-
Storing	-	-	-	-	-
Discharge	24	24	32	32	48
Total	40	64	80	80	96

Block

Manager	8	8	8	8	8
Clerk/Tel./Rec.		8	8	12	12
Engine Room/Maintenance	24	32	48	56	56
Harvesting	24	48	72	96	112
Storing					
Discharge					
Total	56	96	136	172	188

4.11 Water

The basic water requirement for ice making will be slightly more than the equivalent quantity of ice allowing for losses and bleeding to drain to prevent the build up of salts in circulated water systems. Additional water will be required for domestic purposes and for condenser cooling. The quantity required for condenser cooling depends on the amount of heat to be rejected, the temperature of cooling water and whether the system recycles the water or not. The requirements of a shell and tube condenser in tons of water per ton of ice produced is given in Table 10.

Table 10 Requirements of cooling water for a shell and tube condenser

Water temperature (°C)	Tons of water/t of ice
10	15
15	25
20	40
25	60
30	125

An evaporative condenser will use between 0.25 and 0.5 t/t of ice depending on design. Precise requirements can be calculated from manufacturer's figures making allowance for windage, evaporation and bleeding. Shell and tube condensers employing a water tower and recirculation will have similar requirements to the evaporative condenser.

Water used for ice making should meet microbiological standards of potable water and be free of excessive solids or salts, which may detract from the physical properties of the ice produced. Problems may also be experienced when using pure water for flake ice production as the ice produced adheres to the drum and is difficult to remove. This problem may be overcome by the addition of salt to the make-up water.

4.12 Maintenance

Although maintenance costs for financial planning are often budgeted as a fixed percentage of the capital cost the actual costs are obviously dependent on the type of ice plant, its delivery system, the quality of servicing it receives and the age of the plant. Maintenance costs are often higher in the very early life of a plant and in its later years. Between 2 and 5 percent of the capital cost is commonly allocated per annum but actual costs can vary greatly year to year. Block plants generally have higher maintenance costs due largely to repair or replacement of moulds which may have an average life of only a few years. The cost of replacing the moulds of a 100-t/d plant would be in the order of US\$ 60 000 to 100 000. Block plants also require more attention to the building structure due to evaporation of the brine and its effect on the steelwork although this can be reduced by the use of inhibitors.





5. ICE STORAGE

[5.1 Block Ice](#)

[5.2 Flake Ice](#)

[5.3 Plate Ice](#)

[5.4 Tube Ice](#)

[5.5 Simple Bin Stores Using Manual Discharge](#)

[5.6 Ice Store Costs](#)

[5.7 Ice Crushers](#)

The type and size of an ice store will depend upon the type of ice, the demand for ice and the patterns of demands. It is common for ice stores to be 2-4 times the daily production. Physical dimensions of stores of given capacities are included under the description of each type of store and are based on manufacturers published information. As a comparison Table 11 lists the volume and area requirements of different types of stores with the forms of ice commonly stored in them.

Table 11 Volume requirements of ice stores

Type of store	Type of ice	Volume (m ³) of store for given capacity			
		50 t	100 t	200 t	500 t
Silo a/	Flake	460	800	1 600	4 000
Rectangular bin	Flake	196	356	656	1 608
Rectangular bin	Plate	163	297	547	1 340
Rectangular bin	Tube	292	412	735	1 685
Block store	Block	150	300	600	1 500

Table 12 compares the area requirements of the types of store with different forms of ice commonly stored in them.

Table 12 Area requirements of ice stores

Type of store	Type of ice	Area (m ²) of store for given capacity			
		50 t	100 t	200 t	500 t
Silo a/	Flake	42	62	124	310
Rectangular bin	Flake	41	75	138	337
Rectangular bin	Plate	34	62	115	281
Rectangular bin	Tube	35	55	98	211
Block store	Block	36	75	150	375

a/ Inclusive of the air jacket space surrounding the silo

5.1. Block Ice

Block ice is usually stored in block form and crushed on demand. It is stored at temperatures between -4 °C and -2 °C and can be stacked one block upon another. Wooden battens can be used to separate blocks to prevent fusion but this is not normally a problem. Care should be taken when stacking tapered blocks which should be stacked to a maximum height of 2.2 m depending on block size or crushing of the lower blocks may result with danger to workers. The smaller sizes of block (e.g., 25 kg) may be stacked manually but larger sizes normally require some kind of lift or inclined conveyor to raise blocks one above another to a height at which they can be dragged using tongs. It is normal to base capacity upon a storage volume of 2-3 m³/t of ice stored.

5.2 Flake Ice

Flake ice is usually stored in silo or bin with the ice-maker located over the store. The silo system which is shown in Figure 14 usually requires slightly less ground area for a given storage capacity but will usually be taller than a bin system and will have a greater capital cost due to the civil work involved, particularly if the site has an exposed location where windage is an important design factor. The silo shown in Figure 14 is contained within an insulated jacket and cooled air passed between the jacket and silo to keep the ice in a subcooled and dry condition. To prevent bridging of the ice and to assist the flow of ice on discharge, an agitator rotates within the silo driven by an electric motor from above. The silo works on the first in-first out principle of storage but ice build-up can occur on the walls and requires occasional removal either by blows to the outside of the silo or by removal from the inside manually. Normally a trap door is provided in the top of the silo for access. The trap door is connected to a safety mechanism that isolates the agitator mechanism. The dimensions of the silo and building for given storage capacities are shown in Figure 14. The capital cost of the smaller capacities (40 t and below) are expensive compared with simple bin systems. For capacities much in excess of 100 t it is usual to install multiple units.

Bin store capacities and sizes are given in Figure 15. Many patented systems of handling and discharge exist but the mechanical rake and end gate system is common. The system operates on the first in-last out principle and requires emptying occasionally to remove stale and packed ice build-up at the bottom. To help overcome this problem the double bin system was developed which employs two bins and which enables one bin to be emptied while the other is filled. The triangular configuration shown in Figure 15 is less mechanically complicated than the rectangular system as the drive-end of the rake is fixed. It also discharges at a height convenient for loading but requires nearly twice the ground area of the rectangular bin and for this reason is rarely used for stores of large capacity. Other bin systems exist that operate on a first in-first out principle by removal of ice at the bottom of the store but the systems are expensive compared to the rake and end-gate systems and are more commonly used on large industrial application. Discharge of flake ice is usually by screw and/or belt conveyor. Pneumatic discharge systems need very careful design for application with flake ice or a pulverized soft and wet product will result

5.3 Plate Ice

Plate ice is usually stored in a bin system similar to that described above for flake and shown in Figure 15. The storage capacities given in Figure 15 which are for flake ice will be increased slightly for plate due to the higher packing density of plate compared to flake ice. A factor of 1.2 should be applied to the stated capacities when used for plate ice. Plate ice is commonly discharged by screw and pneumatic systems.

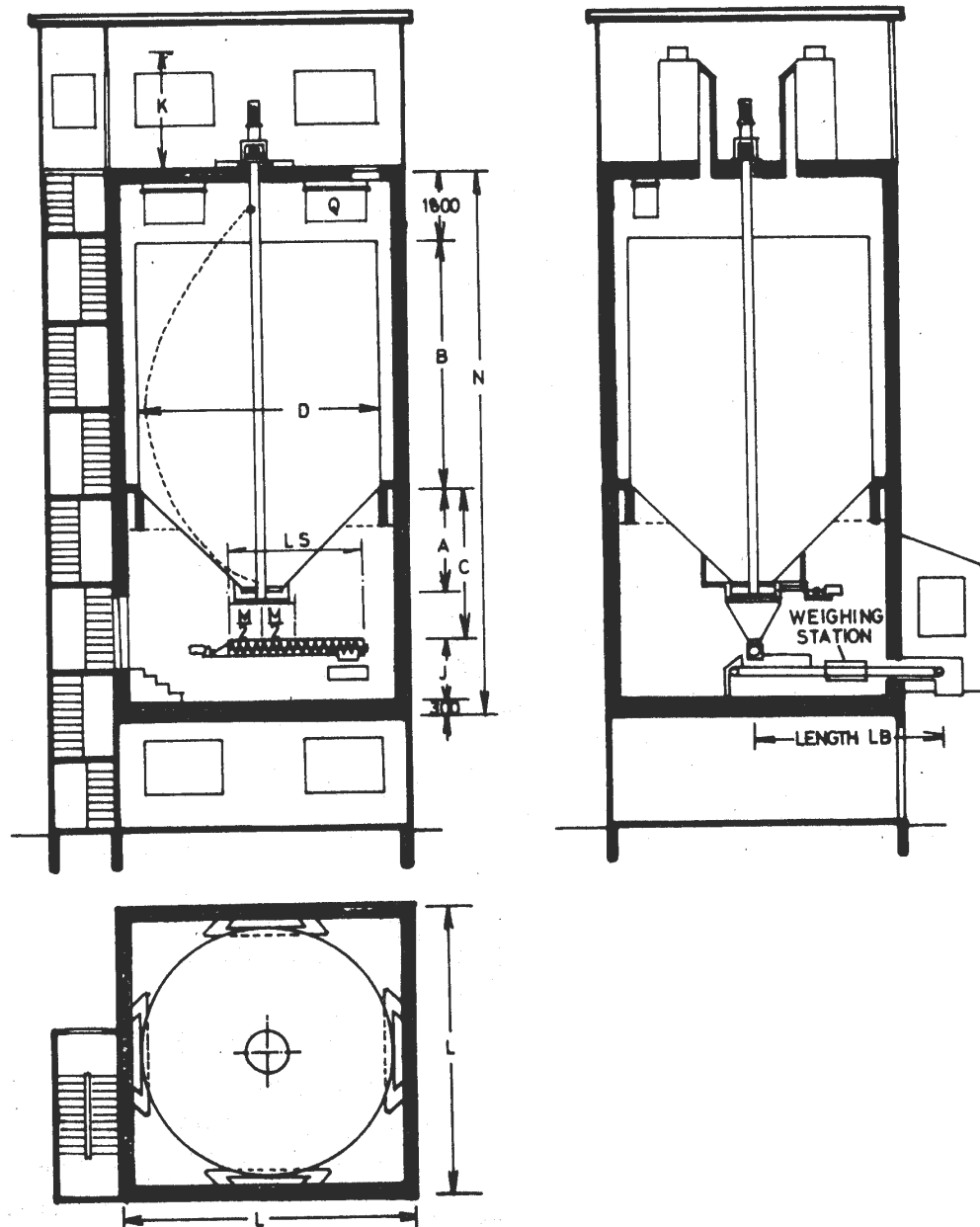
5.4 Tube Ice

Tube ice is commonly stored in bin systems similar to that shown in Figure 16 using a scraping bucket or grab device to handle the ice in the store. The operation is controlled from an observation platform with a

view through a window into the store. The walls and sometimes the floor are usually protected by timber planking to prevent damage by the bucket. The observation window is also suitably protected by a guard. The bucket or grab transfers the ice via a screw discharge conveyor to an automatic weighing device which can be read from the observation and control platform. Usually only small packaged units of up to 15 t/d (production) are located above the store and it is usual that the ice is delivered from the ice-maker at ground level to the store by vertical and horizontal screw conveyors. The ice is distributed within the store by a centrifugal or gated belt device. Storage capacities and dimensions of stores are given in Figure 16.

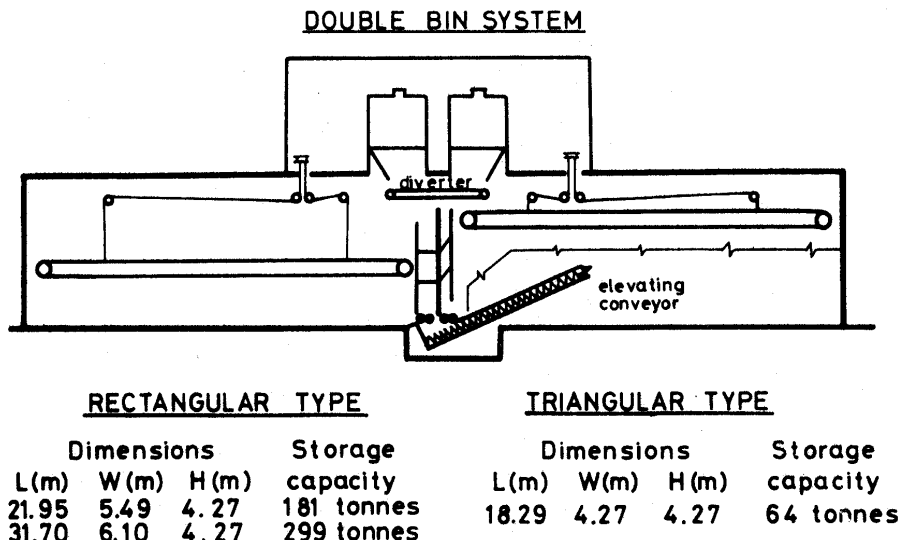
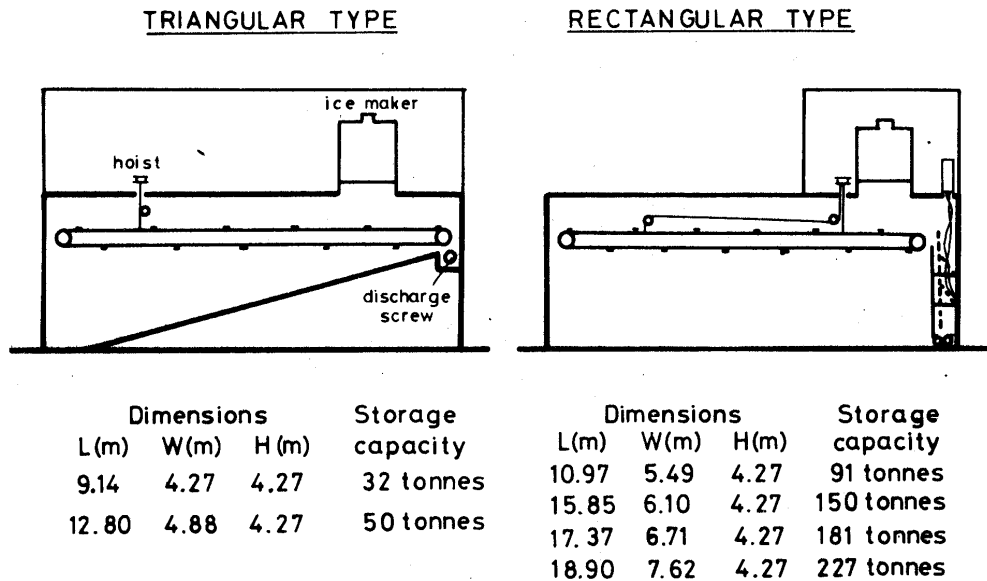
5.5 Simple Bin Stores Using Manual Discharge

Simple bin stores of capacity up to 50 t are available or can be made, without expensive weighing or automatic discharge systems, suitable for manual discharge. Figure 17. shows a timber framed and clad store suitable for small flake or plate ice-makers.



		CAPACITY OF SILO							
TONS		10	20	30	40	50	60	80	100
A	mm	1075	1445	1755	1870	1985	2135	2355	2660
B	mm	3350	4140	4120	4530	5140	5550	6365	6480
C	mm	2080	2475	2760	3080	3190	3340	3555	3860
D	mm	2870	3830	4465	5015	5260	5580	6060	6700
J	mm	1500	1550	1550	1550	1600	1600	1700	1700
K	depends on type of ice machine								
L	mm	4000	5000	5700	6200	6500	6800	7300	7900
M	mm	1000	1000	1700	1700	1700	1700	1700	1700
N	mm	8000	9100	9400	10100	10900	11400	12500	12950
LB	mm	3475	4150	4150	4500	4800	5175	5175	5175
LS	mm	2000	2000	2500	2500	2500	2500	3000	3000
Q	Kcal/h	4000	5500	7000	8000	9000	9500	11300	13000

Figure 14. Flake ice silo plant



Length	Width	Height	Capacity	Length	Width	Height	Capacity
21.95	5.49	4.27	181 tonnes	18.29	4.27	4.27	64 tonnes
31.70	6.10	4.27	299 tonnes				
34.75	6.71	4.27	363 tonnes	25.60	4.88	4.27	110 tonnes
37.80	7.62	4.27	454 tonnes				

Figure 15. Ice storage bins

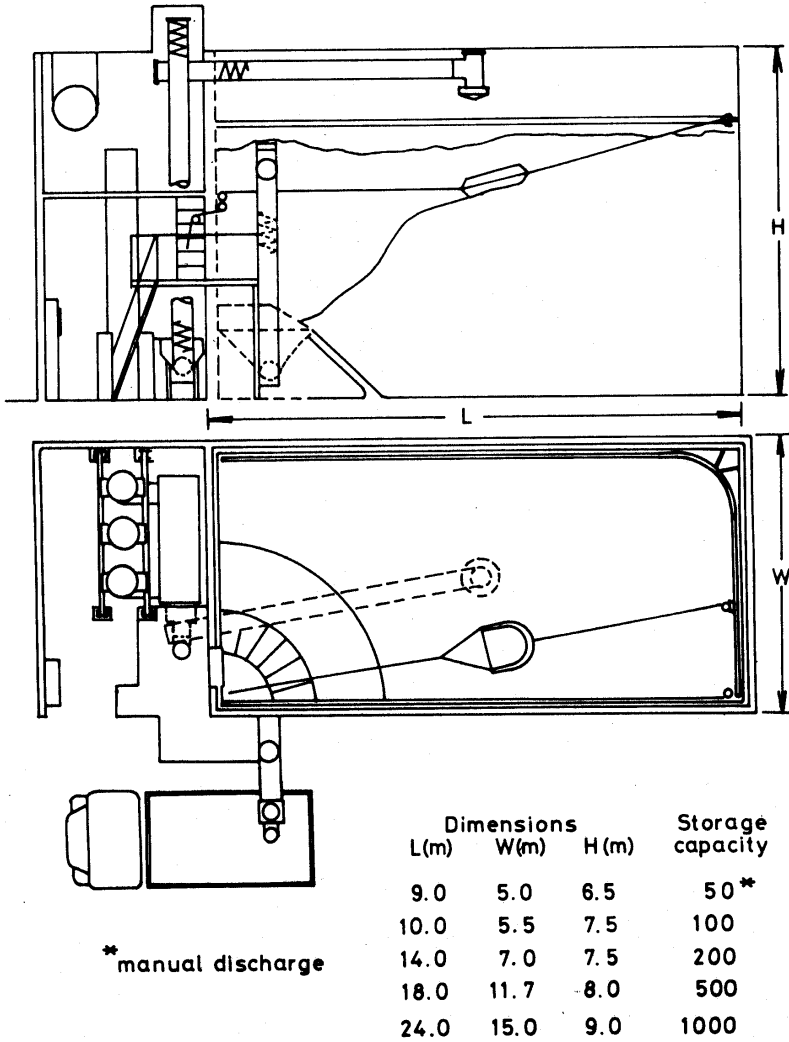


Figure 16. Tube ice bin with scraping bucket discharge system

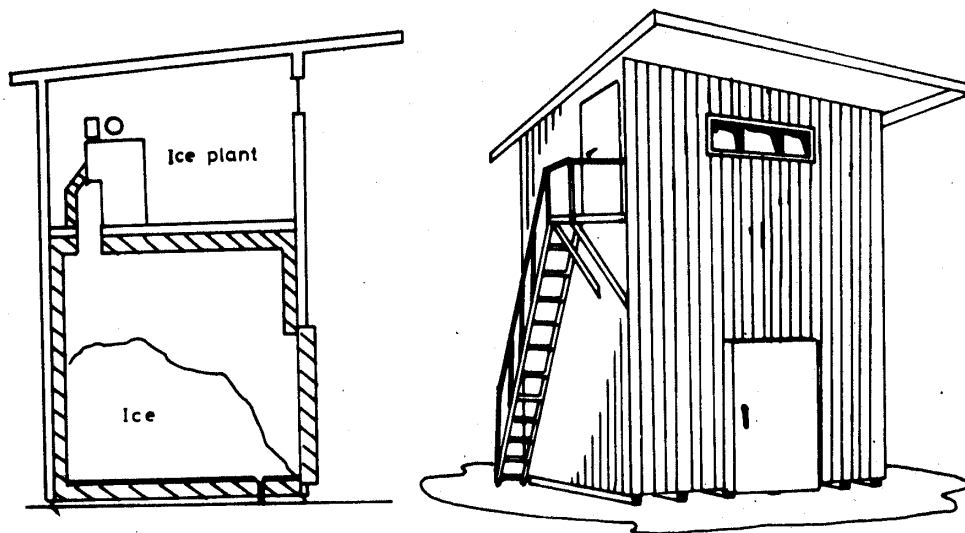


Figure 17. Simple bin store

Other bin stores are available that use modified insulated transport containers that require a minimum of site preparation and civil works. The stores can be purchased with ice-maker as a packaged unit. The plant can be considered as semi-permanent and should need arise it is possible to relocate it.

5.6 Ice Store Costs

The capital cost of ice stores will depend upon the type and capacity of the store, location and the specification or otherwise of associated equipment for refrigeration, handling, discharge and weighing, etc. The costs given in Section 4.6 for ice plants include stores but as a guide the following costs given in Table 13 apply to the store only. The costs are inclusive of steelwork, cladding, refrigeration plant (silo), piling and civil works, insulation, erection, automatic discharge (where stated) and weighing (where stated).

Table 13 Ice store costs

Type	Cost/t of store capacity (US\$)
Silo store with automatic discharge and weighing equipment (50 t plus)	2 000-3 000
Bin store with automatic discharge and weighing equipment (50 t plus)	1 400-2000
Refrigerated block store	700-1 000
Bin store with manual discharge	500-1 000

5.7 Ice Crushers

Mechanical ice crushers are available suitable for crushing block ice to a desired particle size within given limits. The loss on crushing is minimal (a fractional percentage), but loss on delivery will depend upon the distance involved and methods of delivery and may amount to more. If the factory is located some distance from the quay or from the point of usage then delivery in block form from the plant to a remote crusher may reduce loss during transit as loss is dependent on a surface heat transfer effect.

Crushing by hand, by ice pick and/or mallet is a laborious process that often leads to losses as high as 15-

20 percent and larger particle sizes which are less efficient for the rapid cooling of fish.

Table 14 gives details of capacity, size of blocks, particle size, installed power and costs for electrically driven mechanical crushers.

Table 14 Ice crushers

Capacity (t/h)	Block size - cross section	Particle size (cm)	Inst. power (kW)	Cost ex works (US\$)
2	25 x 11.5	3.75-7.5	1	3 500
6	25 x 20.3	1.9-6.5	3	5 000
10	50.8 x 20.3	3.0-6.5	7	7 300
40	81 x 30.5	3.75-7.5	10	15 300
90	167.5 x 30.5	3.75-7.5	20	20 500





5. ICE STORAGE

[5.1 Block Ice](#)

[5.2 Flake Ice](#)

[5.3 Plate Ice](#)

[5.4 Tube Ice](#)

[5.5 Simple Bin Stores Using Manual Discharge](#)

[5.6 Ice Store Costs](#)

[5.7 Ice Crushers](#)

The type and size of an ice store will depend upon the type of ice, the demand for ice and the patterns of demands. It is common for ice stores to be 2-4 times the daily production. Physical dimensions of stores of given capacities are included under the description of each type of store and are based on manufacturers published information. As a comparison Table 11 lists the volume and area requirements of different types of stores with the forms of ice commonly stored in them.

Table 11 Volume requirements of ice stores

Type of store	Type of ice	Volume (m ³) of store for given capacity			
		50 t	100 t	200 t	500 t
Silo a/	Flake	460	800	1 600	4 000
Rectangular bin	Flake	196	356	656	1 608
Rectangular bin	Plate	163	297	547	1 340
Rectangular bin	Tube	292	412	735	1 685
Block store	Block	150	300	600	1 500

Table 12 compares the area requirements of the types of store with different forms of ice commonly stored in them.

Table 12 Area requirements of ice stores

Type of store	Type of ice	Area (m ²) of store for given capacity			
		50 t	100 t	200 t	500 t
Silo a/	Flake	42	62	124	310
Rectangular bin	Flake	41	75	138	337
Rectangular bin	Plate	34	62	115	281
Rectangular bin	Tube	35	55	98	211
Block store	Block	36	75	150	375

a/ Inclusive of the air jacket space surrounding the silo

5.1. Block Ice

Block ice is usually stored in block form and crushed on demand. It is stored at temperatures between -4 °C and -2 °C and can be stacked one block upon another. Wooden battens can be used to separate blocks to prevent fusion but this is not normally a problem. Care should be taken when stacking tapered blocks which should be stacked to a maximum height of 2.2 m depending on block size or crushing of the lower blocks may result with danger to workers. The smaller sizes of block (e.g., 25 kg) may be stacked manually but larger sizes normally require some kind of lift or inclined conveyor to raise blocks one above another to a height at which they can be dragged using tongs. It is normal to base capacity upon a storage volume of 2-3 m³/t of ice stored.

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Flake ice is usually stored in silo or bin with the ice-maker located over the store. The silo system which is shown in Figure 14 usually requires slightly less ground area for a given storage capacity but will usually be taller than a bin system and will have a greater capital cost due to the civil work involved, particularly if the site has an exposed location where windage is an important design factor. The silo shown in Figure 14 is contained within an insulated jacket and cooled air passed between the jacket and silo to keep the ice in a subcooled and dry condition. To prevent bridging of the ice and to assist the flow of ice on discharge, an agitator rotates within the silo driven by an electric motor from above. The silo works on the first in-first out principle of storage but ice build-up can occur on the walls and requires occasional removal either by blows to the outside of the silo or by removal from the inside manually. Normally a trap door is provided in the top of the silo for access. The trap door is connected to a safety mechanism that isolates the agitator mechanism. The dimensions of the silo and building for given storage capacities are shown in Figure 14. The capital cost of the smaller capacities (40 t and below) are expensive compared with simple bin systems. For capacities much in excess of 100 t it is usual to install multiple units.

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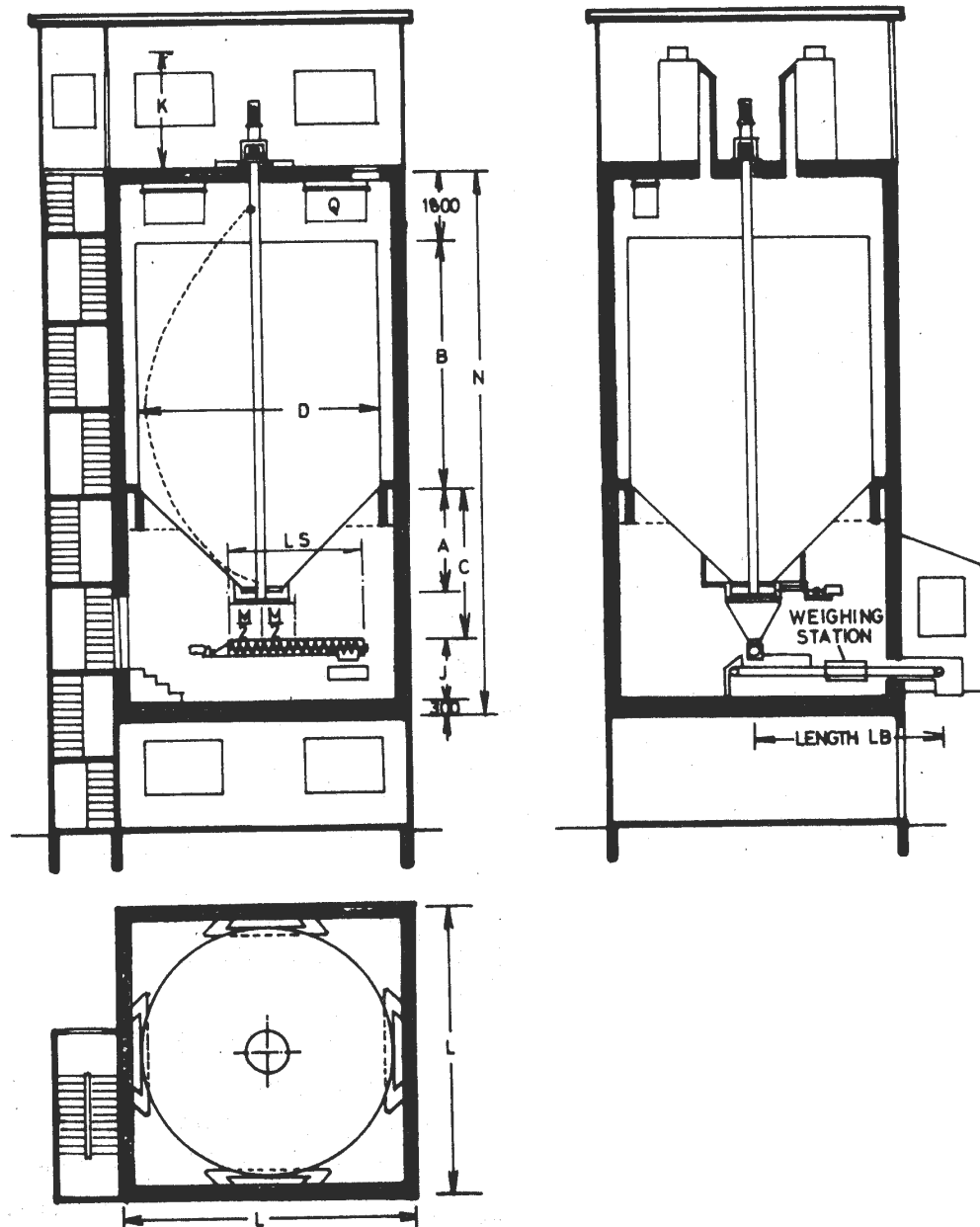
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Tube ice is commonly stored in bin systems similar to that shown in Figure 16 using a scraping bucket or grab device to handle the ice in the store. The operation is controlled from an observation platform with a

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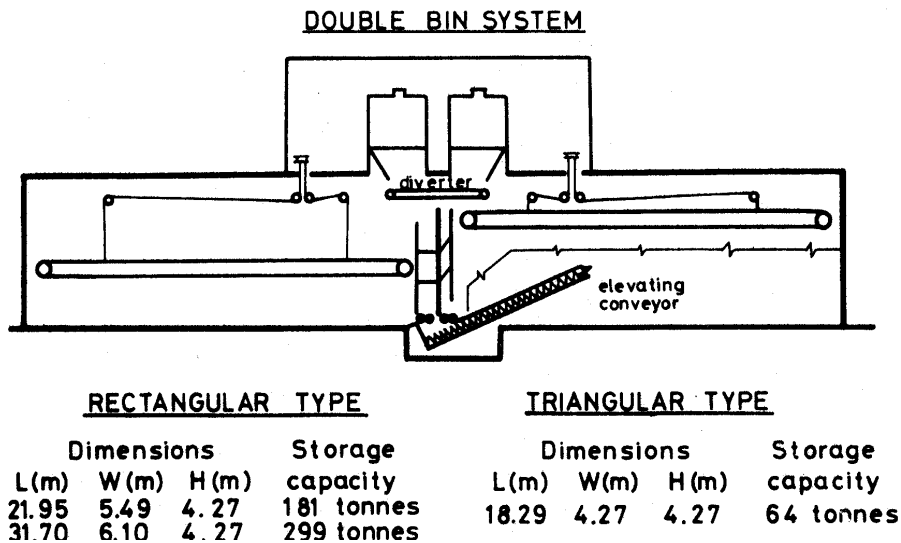
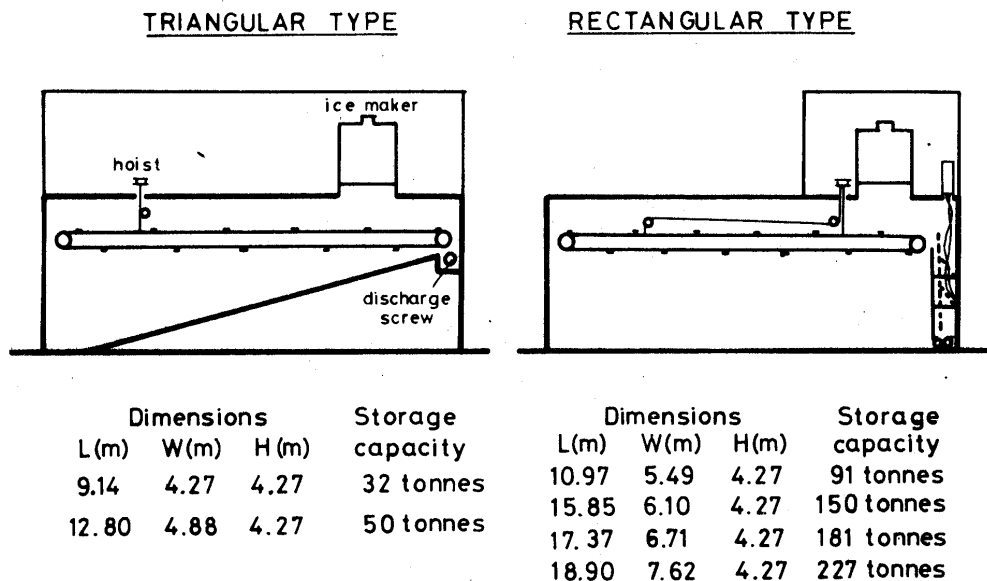
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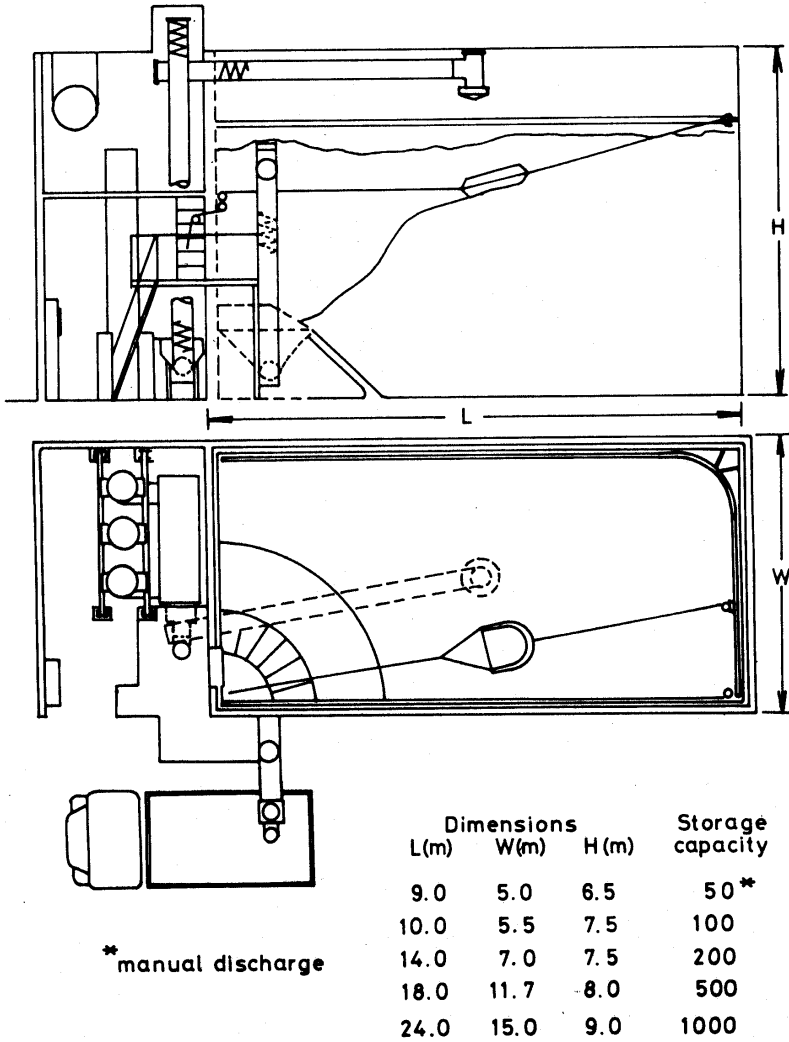


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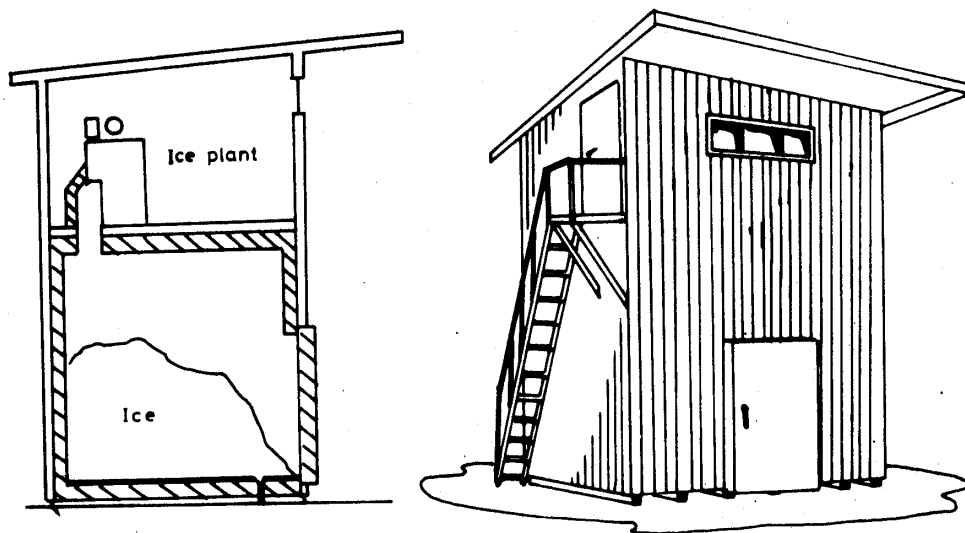


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6. ICING OF FISH

[6.1 At Sea](#)

- 6.1.1 Bulk stowage
- 6.1.2 Boxed stowage
- 6.1.3 Chilled sea water

[6.2 Ashore](#)

[6.3 Handling Ice](#)

- 6.3.1 Manual operation
 - 6.3.2 Conveyors
 - 6.3.3 Pneumatics
-

In order to maintain optimum fish quality, fish, once caught should be chilled to 0°C as quickly as possible. Ice chills fish by surface heat transfer either by direct contact between fish and ice or by cold melt water running over the fish surface. Therefore the more ice in contact with the fish the quicker the cooling rate. Even quicker cooling can be achieved by immersing the fish in a mixture of iced water which allows maximum surface heat transfer.

6. 1 At Sea

6.1.1 Bulk stowage.

Bulk stowage of fish is the stowage of iced fish in pounds usually formed by fitting portable pound boards into fixed vertical stanchions in the fish room. First a bed of ice is laid in the pound then a layer of fish, followed by further layers of ice and fish to a maximum depth of half a metre. A second platform is then formed of pound boards and the process repeated with generous applications of ice to the top, bottom and sides of each pound.

Pound boards are commonly made of aluminium, plastic or wood; the first two being preferable for reasons of hygiene and handling. Corrugated extrusions give strength to the boards and provide for better draining of contaminated melt water to the edges of the pounds.

As a guide to icing, an ice to fish ratio of 1:2 is commonly used in temperate climates for voyages up to 18 days and 1:1 for tropical climates. Ice requirements can be theoretically calculated from a knowledge of the thermal properties of the fishroom, the length of voyage and the ambient temperatures but in practice the requirements can only be realistically based on experience. At the end of the voyage at least a little ice should be remaining in each pound. It is better to use a little too much ice than not enough.

The stowage density of bulked fish is about 0.50 t/m³ of fishroom.

The major disadvantage of bulked stowage is the problem it presents on unloading. Digging out of the fish by hook and shovel is a laborious, slow and difficult process that results in a greater degree of damage than that

caused by unloading of boxed fish. It is also a common cause of industrial injury. The rate of unloading depends upon the method used, the vessel, quality and number of the work force and the size of the catch. As an example, 60 men (22 fishroom, 5 hatchway, 5 landing boards, 5 winch, 23 dragging baskets) can unload 125 t from a distant water vessel in 6 h using baskets on gin wires from a landing leg above the hatches. This does not include for setting-up or weighing, sorting or laying out on the market.

6.1.2 Boxed stowage.

Boxed stowage is similar in principle to bulk stowage except that instead of building up pounds in the fishroom the fish is mixed with ice in boxes. Similar quantities of ice are used for boxing as used for bulking except when the box is to be used for onward road transportation on landing without additional icing. In such cases extra ice is required to suit the onward journey. Types and costs of boxes are discussed in Section 8.

The stowage density of boxed and iced fish is in the order of 0.37 t/m³ depending on the size and design of the box. The advantages of boxed stowage are: easier and quicker unloading, reduced handling of the fish and reduction in the damage to fish. As an example of the unloading rate, 8 men (3 shore, 3 fishroom, 1 hatch, 1 winch) can unload 10 t of boxed fish from an inshore vessel, using a gin wire and hooks from the vessels derrick, in less than an hour.

6.1.3 Chilled sea water.

Stowage of fish in sea water chilled by ice and held in insulated fixed tanks offers several advantages over other methods of stowage, particularly for pelagic species not normally gutted at sea but which are caught in bulk and require rapid chilling.

Stowage in an ice-water mix minimizes crushing which causes damage and weight loss and rapidly cools the fish by efficient heat transfer. By design of the deck pounds and scuttles or pumping system the fish can be rapidly transferred from the deck or net to the tanks with the minimum delay and disruption to fishing effort.

The amount of Ice required to cool a tank of fish and water and maintain it in a chilled condition will depend upon the size of the tank, the effectiveness of the insulation, the ambient temperatures and the length of the trip. Allowance should also be made for ice loss during the outward passage to the fishing grounds. As a guide to icing a water: Ice: fish ratio of 1: 1: 4 is commonly used for 3-4 days stowage in insulated fixed tanks in temperate climates and 1: 2: 6 in tropical climates. For a given tank installation and prevailing conditions the quantity of Ice can be estimated in a similar manner to that of an insulated container for which an example calculation is given in Section 11. The calculation of the ice required to combat the heat gain to a fixed tank system is more complex and depends upon the method of construction of the tanks and particularly the way in which the tank lining is supported and insulated. The total heat gain to the tank is the sum of the heat gains through each tank surface and for each tank surface the gain must be calculated depending upon the conditions that exist on that surface. For example, if we consider an outer wing tank side, we must calculate for the transfer of heat through the tank surface and frames above the water line on the outer surface of the vessel, and the transfer through the surface and frames below the water line, as each surface area will be subject to different outer temperatures and will have different surface heat transfer coefficients. The overall heat transfer coefficient for a tank surface, or part of, is a function of the outside heat transfer coefficient, the inside heat transfer coefficient and the thickness and conductivity of the insulation, the tank lining and the outer steel surface, as given by:

$$\frac{1}{u} = \frac{1}{h_0} + \frac{x_1}{k_1} + \frac{x_2}{k_2} + \frac{x_3}{k_3} + \frac{1}{h_i}$$

where,

u = overall heat transfer coefficient (kcal/m² h deg C)

h_0 = outside heat transfer coefficient (Kcal/m² h deg C)

x_1 = thickness of plate, ship's side (m)

k_1 = conductivity. of plate, ship's side (kcal m/m² h deg C)

x_2 = thickness of insulation (m)

k_2 = conductivity of insulation (kcal m/m² h deg C)

x_3 = thickness of tank lining (m)

k_3 = conductivity of tank lining (kcal m/m² h deg C)

h_i = Inside heat transfer coefficient (kcal/m² deg C)

For each surface then or part of surface the heat transfer can be calculated through the surface, and frames, from the above given the temperatures that exist on each surface. From the total heat transfer to the tank the quantity of ice needed to offset the gain can be calculated from the latent heat of the ice. Examples of surface heat transfer coefficients for a typical steel tank installation are given in Table 15.

Table 15 Surface heat transfer coefficients

Surface	Heat transfer coefficient (kcal/m ² h deg C)
Deckhead, moving air outside	29.3
Tank floor, fresh water tanks beneath, gently agitated water	515.9
Engine room bulkhead, still air on engine room side	7.1
Ship's side above water, moving air outside	29.3
Ship's side below water, moving air outside	1 719.6
Tank inside, gently agitated water	515.9

Tank stowed fish for human consumption is usually unloaded by brail or by pump. Unloading rates of up to twenty t/h can be achieved using a brail of one t capacity. Rates of 30 t/h or more are possible with pump discharge but with a higher degree of damage to the fish, particularly if the fish has been previously pumped from the net.

6.2 Ashore

Upon landing the fish should be maintained at or as near as possible to its chilled temperature of 0°C through the market, processing and distribution chain.

If the fish is to be laid out on the market for display prior to sale additional ice or re-icing may be required to prevent the fish becoming warm and spoiling. This practice however is often ignored because of the problem it causes in viewing the fish on sale and checking the fish weight. This can be overcome by weighing the fish prior to icing if a market kit is used, or check weighing a small number of boxes if the vessels boxes are used for display. In any instance, the fish should be moved as quickly as possible and kept out of direct sunlight.

If the fish is to be re-iced at the market after sale for transport to the processing factory or secondary market the quantity of ice required will depend on the temperature of the fish, the length of the journey. The ambient temperature and the thermal protection given to the fish by the fish box and the transportation vehicle. The quantity of ice theoretically to chill the fish can be calculated from Table 16 which gives the weight of ice required to cool 1 kg of fish from selected temperatures. In practice more may be required.

Table 16 Quantity of ice theoretically required to cool 1 kg of fish to 0°C

Temperature (°C)	kg of ice to cool 1 kg of fish to 0°C

30	0.34
25	0.28
20	0.23
15	0.17
10	0.12
5	0.06

The quantity of ice required to maintain the fish in chill will depend on the ambient temperature, the insulative properties of the box and vehicle, and the position of the individual box within the load. A box in contact with the sides or base of the lorry will require more ice than a box in the centre of a stacked load which is protected from heat ingress by the boxes surrounding it, but it is not always practicable to ice boxes according to their later loading position within a lorry. In practice the amount of ice used on any given journey is based on experience but it can be estimated given the box and vehicle dimensions, thickness of insulation and thermal conductivities.

Typical conductivities of fish box materials are as follows:

Aluminium	172 kcal m/m ² h deg C
Wood (wet)	0.24 kcal m/m ² h deg C
Plastic	0.40 kcal m/m ² h deg C

Table 17 shows the quantity of ice required in practice to chill and maintain in chill boxed fish under selected surrounding temperatures, for both a single box and for a stack of 35 boxes.

Table 17 Ice requirements to chill and maintain in chill fish held in individual boxes and within a stack of boxes

	Melting of ice per box of 50 kg fish					
	1 box			35 boxes		
	+30	+20	+10	+30	+20	+10
Surrounding temperature (°C)	+30	+20	+10	+30	+20	+10
Fish chilling (kg)	21	14	7	21	14	7
Keeping (kg/h)	3	2	1	1	0.7	0.3

Not only is the quantity of ice of importance in a box, also the distribution of ice within a box.

If the fish is already chilled then the ice is required to combat the heat gain through the box and can be packed round the fish against the box surfaces, but if the ice has to chill the fish also then the ice should be well mixed with the fish.

If a box of fish was iced on the top only for example, even with the calculated and correct amount of ice for cooling and maintaining the fish in chilled condition. the fish would not be efficiently chilled even if the box was well insulated. This is because the cooling is largely achieved by surface heat transfer and if the bulk of the fish are not in contact with the ice, the transfer of heat through the bulk of the fish will require a considerably longer cooling period. (Some cooling may be achieved by the passage of melt water.) In effect the fish at the bottom of the box would be 'insulated' from the ice by the fish above them. For the same reason it takes a substantially longer time to cool a large fish of a given weight than to cool the same weight of smaller fish to a uniform chilled temperature.

6.3 Handling Ice

6.3.1 Manual operation.

The simplest form of delivery and icing system is a manual operation. Ice can be removed from bins using hand rakes and shovels and carried to the point of use in tubs, carts or box pallets. Such handling is satisfactory for

small operations. Icing at sea is still most commonly carried out with a shovel using an axe to break the surface crust. It is a laborious and physically exhausting job.

6.3.2 Conveyors.

Straight line fixed conveyor systems are the most common means of handling ice within the ice factory and for delivery of the ice to the fishing vessel or road vehicle. Where the ice factory is sited a long distance from the quayside specially designed tipping trucks or tow units can be used to deliver ice to petrol-driven inclined conveyors that deliver the ice through the fishroom hatch to the hold. Conveyors are normally supplied with galvanized finish and can be Insulated. Simple screw conveyors can act as elevators up to a maximum angle of approximately 30° to the horizontal depending on the type of ice although other types of screw conveyor will deliver vertically. Dished belt conveyors will handle ice horizontally and slated belt conveyors at inclinations up to approximately 40° or more depending on the design.

Screw conveyors should not be left with ice in them when stopped but should be run for a short period (depending on the length of the conveyor) after the supply of ice to them has been stopped to ensure that all the ice is discharged. Failure to do so can result in jamming the conveyor and burning out the drive motor. It is possible to fit an auto-delay to the conveyor motor to ensure this.

6.3.3 Pneumatics.

Pneumatic conveying of ice is often used to deliver ice from the ice factory to the fishing vessel or road carrier but can also be used for Icing of fish at sea. Pneumatic conveying on shore is more viable at greater distances (over 30 m), and when multiple stations are to be served. Delivery rates of 10-60 t/h are obtainable.

The system must be carefully designed for the handling of ice, particularly flake ice which can be reduced to a slush by impact at high velocity on the duct walls. To reduce the heating effect of the blown air it is usual to precool the air through a heat exchanger. Bends should be a minimum radius of 1.5 m.

At sea a pneumatic delivery system with flexible discharge hose greatly simplifies the task of icing fish in the hold. The hose has only to be directed at the fish and velocity of discharge throws the ice to the required box or pounds eliminating the laborious task of shovelling ice. In a large fishroom hold numerous coupling points can be provided for connexion of the discharge hose. Figure 18 shows a pneumatic distribution system for a distant water wet fish trawler fitted with its own ice plant.

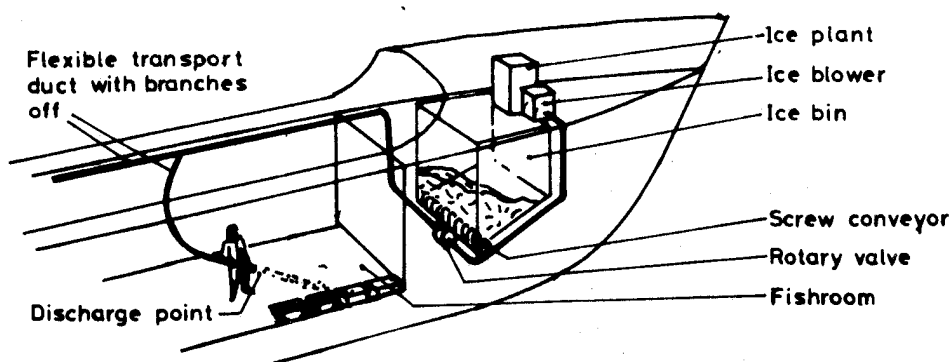


Figure 18. Pneumatic distribution system





6. ICING OF FISH

[6.1 At Sea](#)

- 6.1.1 Bulk stowage
- 6.1.2 Boxed stowage
- 6.1.3 Chilled sea water

[6.2 Ashore](#)

[6.3 Handling Ice](#)

- 6.3.1 Manual operation
 - 6.3.2 Conveyors
 - 6.3.3 Pneumatics
-

In order to maintain optimum fish quality, fish, once caught should be chilled to 0°C as quickly as possible. Ice chills fish by surface heat transfer either by direct contact between fish and ice or by cold melt water running over the fish surface. Therefore the more ice in contact with the fish the quicker the cooling rate. Even quicker cooling can be achieved by immersing the fish in a mixture of iced water which allows maximum surface heat transfer.

6. 1 At Sea

6.1.1 Bulk stowage.

Bulk stowage of fish is the stowage of iced fish in pounds usually formed by fitting portable pound boards into fixed vertical stanchions in the fish room. First a bed of ice is laid in the pound then a layer of fish, followed by further layers of ice and fish to a maximum depth of half a metre. A second platform is then formed of pound boards and the process repeated with generous applications of ice to the top, bottom and sides of each pound.

Pound boards are commonly made of aluminium, plastic or wood; the first two being preferable for reasons of hygiene and handling. Corrugated extrusions give strength to the boards and provide for better draining of contaminated melt water to the edges of the pounds.

As a guide to icing, an ice to fish ratio of 1:2 is commonly used in temperate climates for voyages up to 18 days and 1:1 for tropical climates. Ice requirements can be theoretically calculated from a knowledge of the thermal properties of the fishroom, the length of voyage and the ambient temperatures but in practice the requirements can only be realistically based on experience. At the end of the voyage at least a little ice should be remaining in each pound. It is better to use a little too much ice than not enough.

The stowage density of bulked fish is about 0.50 t/m³ of fishroom.

The major disadvantage of bulked stowage is the problem it presents on unloading. Digging out of the fish by hook and shovel is a laborious, slow and difficult process that results in a greater degree of damage than that

caused by unloading of boxed fish. It is also a common cause of industrial injury. The rate of unloading depends upon the method used, the vessel, quality and number of the work force and the size of the catch. As an example, 60 men (22 fishroom, 5 hatchway, 5 landing boards, 5 winch, 23 dragging baskets) can unload 125 t from a distant water vessel in 6 h using baskets on gin wires from a landing leg above the hatches. This does not include for setting-up or weighing, sorting or laying out on the market.

6.1.2 Boxed stowage.

Boxed stowage is similar in principle to bulk stowage except that instead of building up pounds in the fishroom the fish is mixed with ice in boxes. Similar quantities of ice are used for boxing as used for bulking except when the box is to be used for onward road transportation on landing without additional icing. In such cases extra ice is required to suit the onward journey. Types and costs of boxes are discussed in Section 8.

The stowage density of boxed and iced fish is in the order of 0.37 t/m³ depending on the size and design of the box. The advantages of boxed stowage are: easier and quicker unloading, reduced handling of the fish and reduction in the damage to fish. As an example of the unloading rate, 8 men (3 shore, 3 fishroom, 1 hatch, 1 winch) can unload 10 t of boxed fish from an inshore vessel, using a gin wire and hooks from the vessels derrick, in less than an hour.

6.1.3 Chilled sea water.

Stowage of fish in sea water chilled by ice and held in insulated fixed tanks offers several advantages over other methods of stowage, particularly for pelagic species not normally gutted at sea but which are caught in bulk and require rapid chilling.

Stowage in an ice-water mix minimizes crushing which causes damage and weight loss and rapidly cools the fish by efficient heat transfer. By design of the deck pounds and scuttles or pumping system the fish can be rapidly transferred from the deck or net to the tanks with the minimum delay and disruption to fishing effort.

The amount of Ice required to cool a tank of fish and water and maintain it in a chilled condition will depend upon the size of the tank, the effectiveness of the insulation, the ambient temperatures and the length of the trip. Allowance should also be made for ice loss during the outward passage to the fishing grounds. As a guide to icing a water: Ice: fish ratio of 1: 1: 4 is commonly used for 3-4 days stowage in insulated fixed tanks in temperate climates and 1: 2: 6 in tropical climates. For a given tank installation and prevailing conditions the quantity of Ice can be estimated in a similar manner to that of an insulated container for which an example calculation is given in Section 11. The calculation of the ice required to combat the heat gain to a fixed tank system is more complex and depends upon the method of construction of the tanks and particularly the way in which the tank lining is supported and insulated. The total heat gain to the tank is the sum of the heat gains through each tank surface and for each tank surface the gain must be calculated depending upon the conditions that exist on that surface. For example, if we consider an outer wing tank side, we must calculate for the transfer of heat through the tank surface and frames above the water line on the outer surface of the vessel, and the transfer through the surface and frames below the water line, as each surface area will be subject to different outer temperatures and will have different surface heat transfer coefficients. The overall heat transfer coefficient for a tank surface, or part of, is a function of the outside heat transfer coefficient, the inside heat transfer coefficient and the thickness and conductivity of the insulation, the tank lining and the outer steel surface, as given by:

$$\frac{1}{u} = \frac{1}{h_0} + \frac{x_1}{k_1} + \frac{x_2}{k_2} + \frac{x_3}{k_3} + \frac{1}{h_i}$$

where,

u = overall heat transfer coefficient (kcal/m² h deg C)

h_0 = outside heat transfer coefficient (Kcal/m² h deg C)

x_1 = thickness of plate, ship's side (m)

k_1 = conductivity. of plate, ship's side (kcal m/m² h deg C)

x_2 = thickness of insulation (m)

k_2 = conductivity of insulation (kcal m/m² h deg C)

x_3 = thickness of tank lining (m)

k_3 = conductivity of tank lining (kcal m/m² h deg C)

h_i = Inside heat transfer coefficient (kcal/m² deg C)

For each surface then or part of surface the heat transfer can be calculated through the surface, and frames, from the above given the temperatures that exist on each surface. From the total heat transfer to the tank the quantity of ice needed to offset the gain can be calculated from the latent heat of the ice. Examples of surface heat transfer coefficients for a typical steel tank installation are given in Table 15.

Table 15 Surface heat transfer coefficients

Surface	Heat transfer coefficient (kcal/m ² h deg C)
Deckhead, moving air outside	29.3
Tank floor, fresh water tanks beneath, gently agitated water	515.9
Engine room bulkhead, still air on engine room side	7.1
Ship's side above water, moving air outside	29.3
Ship's side below water, moving air outside	1 719.6
Tank inside, gently agitated water	515.9

Tank stowed fish for human consumption is usually unloaded by brail or by pump. Unloading rates of up to twenty t/h can be achieved using a brail of one t capacity. Rates of 30 t/h or more are possible with pump discharge but with a higher degree of damage to the fish, particularly if the fish has been previously pumped from the net.

6.2 Ashore

Upon landing the fish should be maintained at or as near as possible to its chilled temperature of 0°C through the market, processing and distribution chain.

If the fish is to be laid out on the market for display prior to sale additional ice or re-icing may be required to prevent the fish becoming warm and spoiling. This practice however is often ignored because of the problem it causes in viewing the fish on sale and checking the fish weight. This can be overcome by weighing the fish prior to icing if a market kit is used, or check weighing a small number of boxes if the vessels boxes are used for display. In any instance, the fish should be moved as quickly as possible and kept out of direct sunlight.

If the fish is to be re-iced at the market after sale for transport to the processing factory or secondary market the quantity of ice required will depend on the temperature of the fish, the length of the journey. The ambient temperature and the thermal protection given to the fish by the fish box and the transportation vehicle. The quantity of ice theoretically to chill the fish can be calculated from Table 16 which gives the weight of ice required to cool 1 kg of fish from selected temperatures. In practice more may be required.

Table 16 Quantity of ice theoretically required to cool 1 kg of fish to 0°C

Temperature (°C)	kg of ice to cool 1 kg of fish to 0°C

30	0.34
25	0.28
20	0.23
15	0.17
10	0.12
5	0.06

The quantity of ice required to maintain the fish in chill will depend on the ambient temperature, the insulative properties of the box and vehicle, and the position of the individual box within the load. A box in contact with the sides or base of the lorry will require more ice than a box in the centre of a stacked load which is protected from heat ingress by the boxes surrounding it, but it is not always practicable to ice boxes according to their later loading position within a lorry. In practice the amount of ice used on any given journey is based on experience but it can be estimated given the box and vehicle dimensions, thickness of insulation and thermal conductivities.

Typical conductivities of fish box materials are as follows:

Aluminium	172 kcal m/m ² h deg C
Wood (wet)	0.24 kcal m/m ² h deg C
Plastic	0.40 kcal m/m ² h deg C

Table 17 shows the quantity of ice required in practice to chill and maintain in chill boxed fish under selected surrounding temperatures, for both a single box and for a stack of 35 boxes.

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6.3.3 Pneumatics.

Pneumatic conveying of ice is often used to deliver ice from the ice factory to the fishing vessel or road carrier but can also be used for icing of fish at sea. Pneumatic conveying on shore is more viable at greater distances (over 30 m), and when multiple stations are to be served. Delivery rates of 10-60 t/h are obtainable.

The system must be carefully designed for the handling of ice, particularly flake ice which can be reduced to a slush by impact at high velocity on the duct walls. To reduce the heating effect of the blown air it is usual to precool the air through a heat exchanger. Bends should be a minimum radius of 1.5 m.

At sea a pneumatic delivery system with flexible discharge hose greatly simplifies the task of icing fish in the hold. The hose has only to be directed at the fish and velocity of discharge throws the ice to the required box or pounds eliminating the laborious task of shovelling ice. In a large fishroom hold numerous coupling points can be provided for connexion of the discharge hose. Figure 18 shows a pneumatic distribution system for a distant water wet fish trawler fitted with its own ice plant.

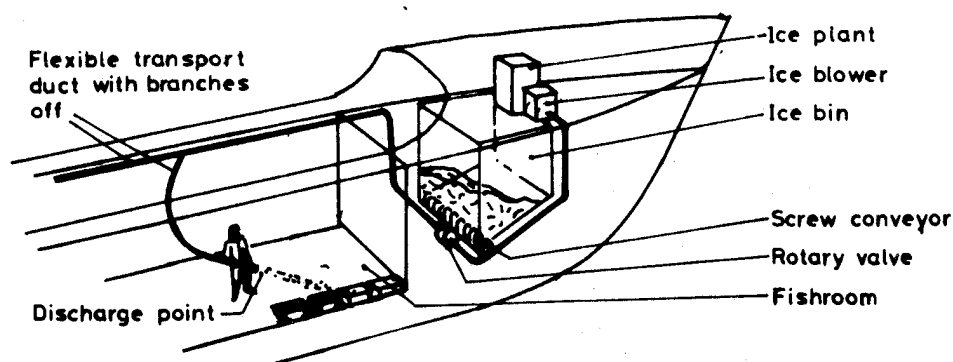


Figure 18. Pneumatic distribution system





7. CHILL STORES

[7.1 Design and Construction](#)

[7.2 Physical Parameters](#)

[7.3 Technical Parameters](#)

[7.4 Costs](#)

7.1 Design and Construction

Chill stores suitable for holding fresh fish should operate in the range 0-4 °C in order that the fish, which should always be stored in ice, is not frozen or partially frozen. In this range the fish is efficiently cooled by ice melt water and thereby kept moist. Each store should be specifically designed or selected for the operating conditions.

It is not the intention here to describe the detail design of a store but to discuss the operating conditions will effect the design and costs.

In the design of the store the refrigeration engineer will require to know the total weight of product, the turnover of product, the handling methods, the temperature of the fish going into store, ambient temperature, water cooling temperature (if water cooled) and The cost/availability of electricity, water, labour and space. The refrigeration duty will be based upon:

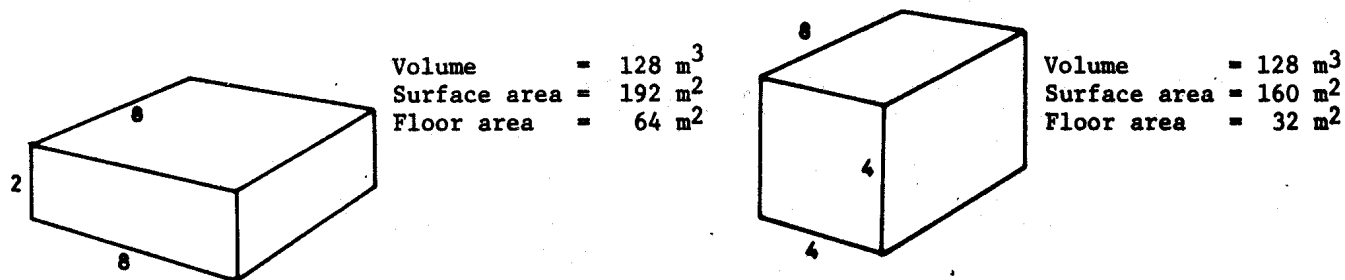
- the heat entering through the insulated structure
- the heat from the incoming fish
- the heat from electrical equipment (including lights)
- the heat from men working in the store
- the heat from air exchange

Methods of estimating these loads are available in refrigeration manuals.

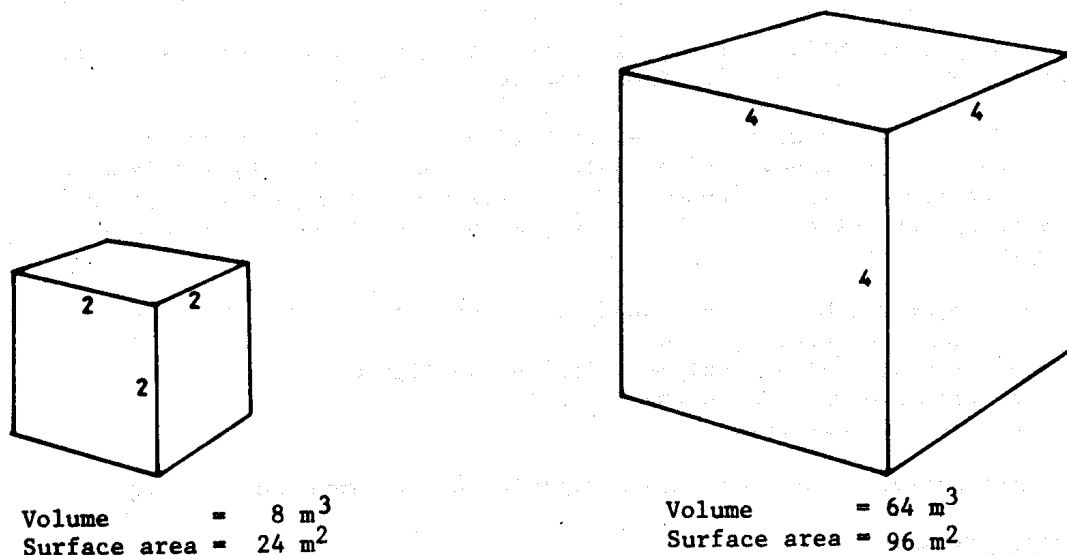
7.2 Physical Parameters

For a given weight of fish the physical size of the store will depend greatly upon the handling and stowage methods and the requirement

for access and withdrawal of stock. For small stores manual loading and unloading is quite feasible and often the cheapest solution but may not be economic for larger stores where large volumes of fish need to be moved quickly. Mechanical handling offers advantages in quicker and cheaper movement of stock and in some cases lower capital and running costs. Fork lift trucks for example enable higher stacking of fish in the chill room and it is therefore possible to design the room to take advantage of this. Consider for example the two following rooms of the same internal volume.



The first store has a total surface area (including floor) of 192 m² and the second only 160 m². Now the heat gain through the surfaces of the store is proportional to the surface area so the running cost of the first will be higher than that of the second. Additionally, the capital costs of construction will also be higher for the first store as the higher surface area will require extra insulation and floor surfacing. Considering also two stores of the same form but of different sizes as shown below:



The volume per unit surface area in the first case is 0.33 and in the second case 0.66 which illustrates the economy of scale with increasing size. The cost per unit volume, both capital and running, will be lower for larger stores. An important consideration in the sizing of a store is the requirement for access and withdrawal of stock. Consider the stowage of small pelagic species stored in ice at a fish: ice ratio of 3:1 in a box of dimensions 600 x 368 x 214 mm. Each box will contain approximately 25 kg of fish which represents a

stowage volume of about 2 m³/t with no allowance for internal clearance, access or handling and evaporator. In practice a minimum of 3 m³/t should be allowed for storage where internal access is not important. This might be the case, for example, where fish is to be unloaded from a fishing vessel one afternoon, held overnight and brought out for sale on the market the following morning. It would not matter that the first fish into the store was the last to be brought out (FILO).

Where access is required for selective withdrawal of stock, possibly of different species or ages, the stowage volume required will depend on the degree of selection required and the methods of handling. Between 4 and 8 m³/t is commonly used and provides sufficient access for most situations. Figure 19 shows the floor plan of a store designed to hold 5 t of boxed fish, handled manually, based on a design figure of 4 m³/t. The plan assumes a box of dimensions 600 x 368 x 214 mm loaded with 25 kg of iced fish. The boxes are stacked nine high (1.93 m). The internal dimensions of the store are 3.50 x 2.50 x 2.30 m (high).

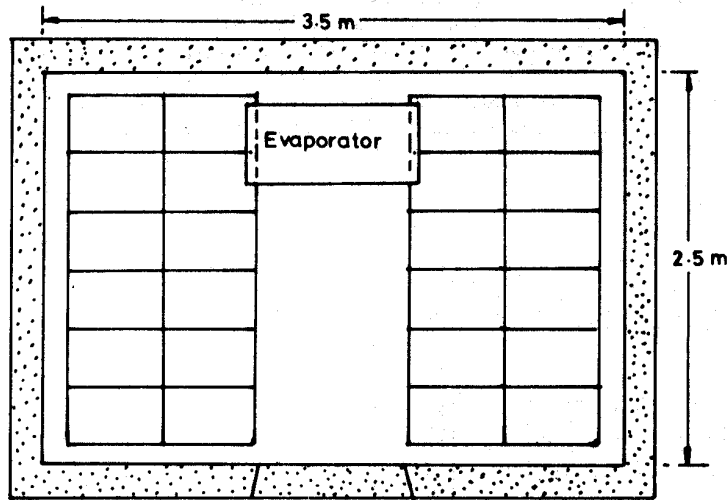


Figure 19. Floor plan of a 5-t chill store

Mechanical handling of stock in a chill store is unlikely to reduce the required floor plan area or volume required per t of fish if access is required for selective withdrawal of stock, as the aisles required for access and manoeuvring of a standard fork lift truck will be far in excess of that required for manual handling, and will not be compensated by the extra height of stacking. If selective withdrawal is not necessary then mechanical handling will enable a smaller ground area particularly for larger stores (over 30 t). The width required for a 90° stacking aisle for a standard fork lift (1-1 1/2 t capacity) will vary depending on manufacturer and pallet size, but for a 1 200 x 1 200 mm pallet it is approximately 3.25 m. Special aisle trucks are available, designed for warehouse operation that will turn in a much narrower aisle width but are seldom used in the fish processing industry, Probably because the standard fork lift is better suited to other duties that it may have to perform in addition to work in the chill store. As further examples of storage arrangements, Figures 20, 21 and 22 show the floor stacking plan and elevation of stock within three chill stores. Figure 20 shows a store designed for 25 t of boxed and iced fish to be handled manually. The plan assumes a stack-only box of dimensions 600 x 368 x 214 mm using a fish: ice ratio of 3:1 and holding 25 kg of fish. The boxes are shown stacked to a height of nine boxes. The aisles (1.2 m) between boxes provide access for selective withdrawal from any box column. The internal volume per t of fish stored is 7.0 m³/t.

Figure 21 shows a store designed for 25 t of fish handled by fork lift truck. The plan assumes a pallet size of 1 200 x 1 200 m with 24 boxes per pallet (6 boxes per layer x 4 layers). The pallets are shown stacked three high. The layout allows access to any pallet stack. The floor plan area is less than that required for manual handling but the volume . required per t of fish is greater at 8.0 m³/t.

Figure 22 shows a store designed for 100 t of iced fish held in 1 200 x 1 200 x 750 mm (high) box pallets handled by fork lift truck. The pallets are stacked four high and it is assumed that they each hold 450 kg of iced fish. Access is available to any box pallet stack. The internal volume required per t of fish stored is 9 m³/t.

In each of the foregoing examples the capacity is greatly increased if selective with drawal is not required.

The examples assume the storage of small pelagic species in a stack only box at a fish: ice ratio of 3: 1. Different fish species, box sizes and designs and fish: ice ratios will effect the space requirement for storage. For larger species such as cod, the volume should be increased by as much as 16 percent depending on size of fish. If a stack-nest type of box is used the volume should be increased by as much as 18 percent depending on size and design. At a 2:1 fish: ice ratio it should be increased by 20 percent, and at 4:1 decreased by 12 percent.

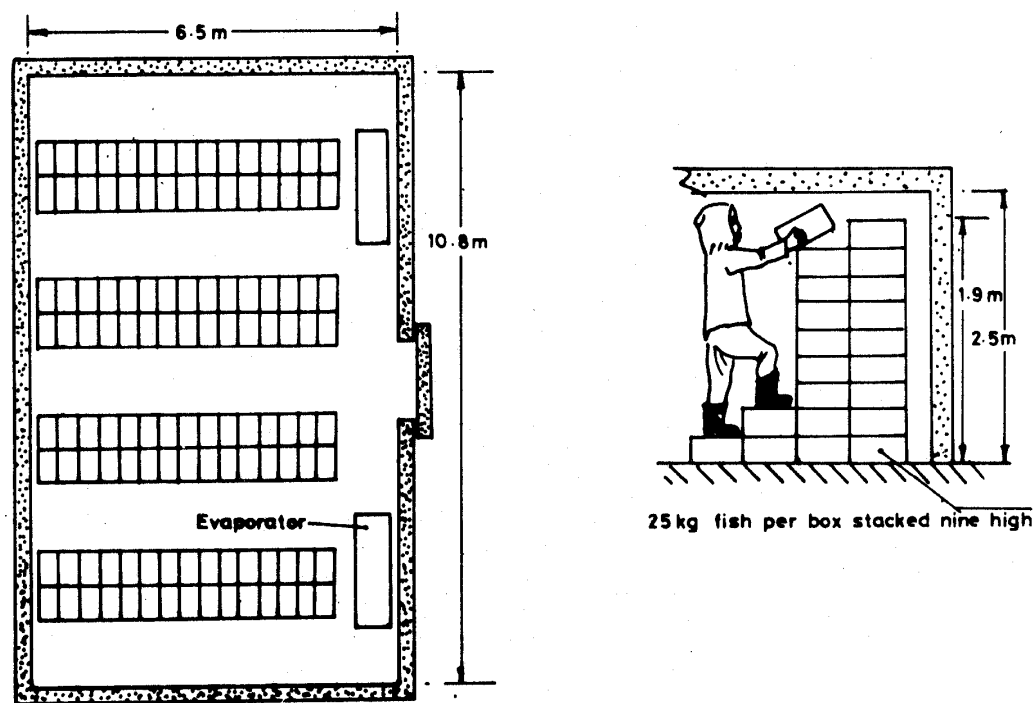


Figure 20. 25- t chill store manual operation

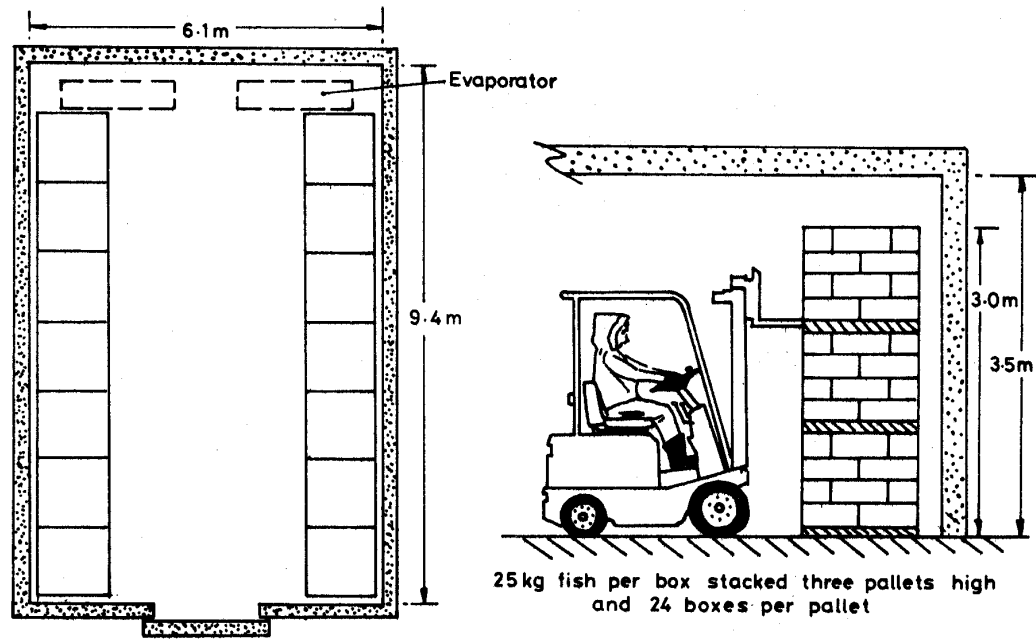


Figure 21. 25-t cold store-fork lift operation

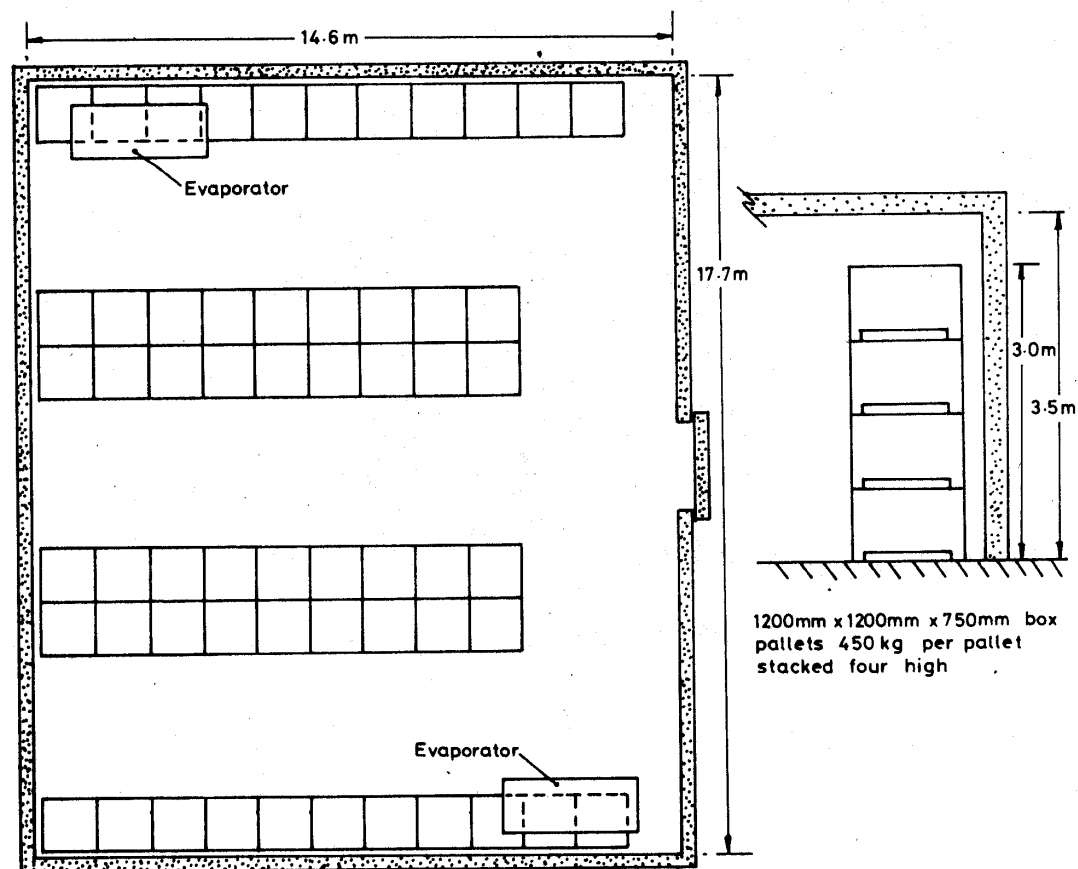


Figure 22. 100-t chill store-fork lift operation

7.3 Technical Parameters

As previously stated, it is not the intention here to describe the detail calculation of technical parameters such as optimum insulation thickness, refrigeration duty, etc., and selection of equipment which is the province of the refrigeration engineer and must be determined for each case in point. However, it is often necessary for purposes of feasibility study or planning to have some estimation of the consumption of electrical and water services and the size and connexion of installed electrical machinery. To this end the following three cases serve as examples which by interpolation might, for the purposes stated, be used in the planning of chill stores.

Three sizes of store are considered: 5 t, 25 t and 100 t (assuming a design factor of 4 m³/t) under increasingly adverse (higher)

conditions of ambience, water temperature and product temperature. In each case a daily product loading of half the capacity of store is assumed. The 5-t store operates under an ambient air temperature of 20 °C with mains water supply (for cooling) at 15 °C and with incoming fish at a temperature of 5 °C. The 25-t store is assumed to operate under an ambient air temperature of 30 °C with mains water supply at 25 °C and with incoming fish at a temperature of 10 °C. The 100-t store is assumed to operate at an ambient air temperature of 40 °C with mains water supply at 30 °C and with incoming fish at a temperature of 20 °C. The refrigeration duty is respectively: 2 654 kcal/h, 11 335 kcal/h and 75 113 kcal/h. Note that the difference in power consumption between air cooled and water cooled in Cases I and II is small, but in Case III it is significant (103.5 cf. 79 kW). The installed power rating of the compressor for Cases 1 and II is the same, but for Case III is only 55 kW for water cooled compared with 90 kW for air cooled. For Case III it is assumed that the motor is star delta connected, whereas for Cases I and II the motors might be connected direct on line. There is a slight difference in the compressor running times: Case I - 18 h; Case II - 19 h; and, Case III - 20 h.

7.4 Costs

The capital costs of the three chill stores considered in Section 7.3 and specified in Table 18 are shown in Table 19. The total capital cost is given for stores with air- and water-cooled condensers, and broken down into component costs of the store and fittings (insulation, surface finishes, doors and floor), refrigeration equipment (air and water cooled) and erection (including electrical wiring).

Analysis of the costings illustrates the economy of scale mentioned in Section 7.2 with the cost per unit volume of store dropping from US\$ 600/m³ for Case I, the 5-t store, to less than US\$ 300/m³ for Case III, the 100-t store (which operates under higher ambient conditions).

For the smaller stores the difference in capital costs between the air and water-cooled plants is not significant and might well depend on the manufacturer's product range as to which works out the cheaper. In Case III (100 t) the water-cooled plant works out to be nearly US \$ 6 000 cheaper (5 percent less than air cooled), but again could be influenced by the manufacturer's product range or actual site conditions. The question of choice between an air-cooled or water-cooled condenser would normally be made on running costs depending on the relative costs (or possibly availability) of electricity and water. Note the difference in power consumption given in Table 18 between air-cooled and water-cooled plants and the water consumption in the case of the water-cooled condenser.

Table 18 Wet fish chill rooms - specification and utilities consumptions

	Case I	Case II	Case III
Storage capacity	5 090 (5t)	25 454 kg (25 t)	101 818 kg (100 t)
Approx. room sizes (internal)	2.44 W x 3.66 D x 2.28 m H (8 ft W x 12 ft D x 7 ft 6 in H)	4.487 W x 6.09 D x 3.5 m H (16 ft W x 20 ft D x 11 ft 6 in H)	6.09 W x 15.54 D x 4.50 m H (20 ft W x 51 ft D x 14 ft 9 in H)
Room volume	20.39 m ³ (720 ft ³)	104.2 m ³ (3 680 ft ³)	426 m ³ (15 045 ft ³)
Thickness and type of insulation walls and ceiling	75 mm (3 in) foamed polyurethane	100 mm (4 in) foamed polyurethane	125 mm (5 in) foamed polyurethane
Floor insulation	75 mm (3 in) foamed polyurethane	100 mm (4 in) foamed polyurethane	125 mm (5 in) foamed polyurethane

Thickness and type granolithic cement on floor	50 mm (2 in)	75 mm (3 in)	100 mm (4 in)	
Means of handling	Manual	Manual	Fork lift	
Ambient air temperature	20°C (68°F)	30°C (86°F)	40°C (104°F)	
Mains water temperature	15°C (59°F)	25°C (77°F)	30°C (86°F)	
Condensing temperature: Air cooled Water cooled	32.2°C (90°F) 30°C (86°F)	43.3°C (110°F) 45°C (113°F)	54.4°C (130°F) 41.1°C (116°F)	
Fish entering temperature	5°C (41°F)	10°C (50°F)	20°C (68°F)	
Design room temperature	0-3°C (32-37°F)	0-3°C (32-37°F)	0-3°C (32-37°F)	
Maximum daily product load to be cooled in 24 h	2 545 kg (5 599 lb)	12 727 kg (27 999 lb)	50 909 kg (111 999 lb)	
Number and size of door	one - 0.762 W x 1.92 m H (2 ft 6 in W x 6 ft 3 in H)	one - 0.90 W x 1.92 m H (2 ft 11 in W x 6 ft 3 in H)	one - 2 W x 3 m H (6 ft 6 in W x 9 ft 10 in H)	
Refrigerant	R12	R12	R12 Air; R22 Water	
Number of air coolers	one	Two	Four (electrical defrost alternated)	
approx. compressor speed (rpm)	1 450	1 450	1 540 air 1 050 water	open type
Refrigeration duty	2 654 kcal/h (10 500 Btu/h)	11 335 kcal/h (45 000 Btu/h)	75 113 kcal/h (298 200 Btu/h)	
Compressor (kW): Air cooled (kW) Water cooled (kW)	1.1 (1 1/2 hp) D.O.L. 1.1 (1 1/2 hp) D.O.L.	5.5 (7 1/2 hp) D.O.L. 5.5 (7 1/2 hp) D.O.L.	90 (125 hp) S.D. 55 (75 hp) S.D.	
Approx. compressor running time	18 h	19 h	20 h	
Total power absorbed: Air cooled (kW) Water cooled (kW)	5.1 (6.84 hp) 4.85 (6.5 hp)	11.9 (15.95 hp) 11.44 (15.34 hp)	103.5 (138.8 hp) 70 (93.87 hp)	
Water consumption (shell and tube condenser)	772 litres/h (170 g.p.h.)	4 654 litres/h (1 025 g.p.h.)	23 154 litres/h (5 100 g.p.h.)	

Table 19 Chill store costs (US\$)

Case	Cold store and fittings	Refrigeration equipment		Erection inc. electrical	Total capital cost	
		Air cooled	Water cooled		Air cooled	Water cooled

I	4 200	6 100	6 920	1 500	11 800	12 620
II	9 120	17 820	18 300	4 200	31 140	31 620
III	34 600	72 200	64 400	10 300	117 100	111 300





7. CHILL STORES

[7.1 Design and Construction](#)

[7.2 Physical Parameters](#)

[7.3 Technical Parameters](#)

[7.4 Costs](#)

7.1 Design and Construction

Chill stores suitable for holding fresh fish should operate in the range 0-4 °C in order that the fish, which should always be stored in ice, is not frozen or partially frozen. In this range the fish is efficiently cooled by ice melt water and thereby kept moist. Each store should be specifically designed or selected for the operating conditions.

It is not the intention here to describe the detail design of a store but to discuss the operating conditions will effect the design and costs.

In the design of the store the refrigeration engineer will require to know the total weight of product, the turnover of product, the handling methods, the temperature of the fish going into store, ambient temperature, water cooling temperature (if water cooled) and The cost/availability of electricity, water, labour and space. The refrigeration duty will be based upon:

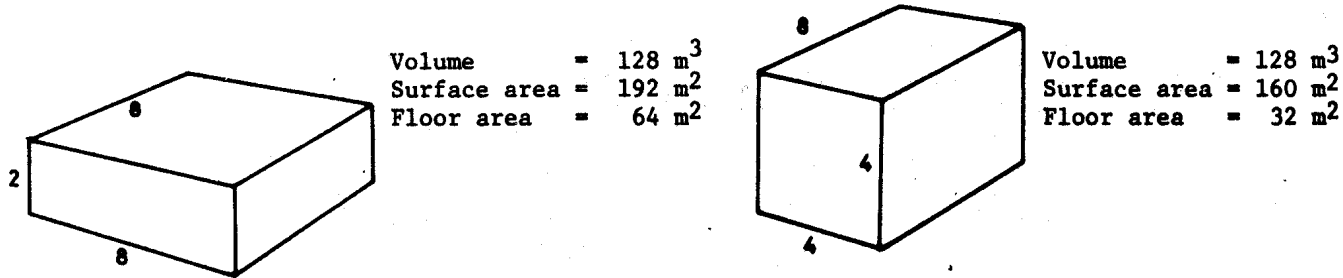
- the heat entering through the insulated structure
- the heat from the incoming fish
- the heat from electrical equipment (including lights)
- the heat from men working in the store
- the heat from air exchange

Methods of estimating these loads are available in refrigeration manuals.

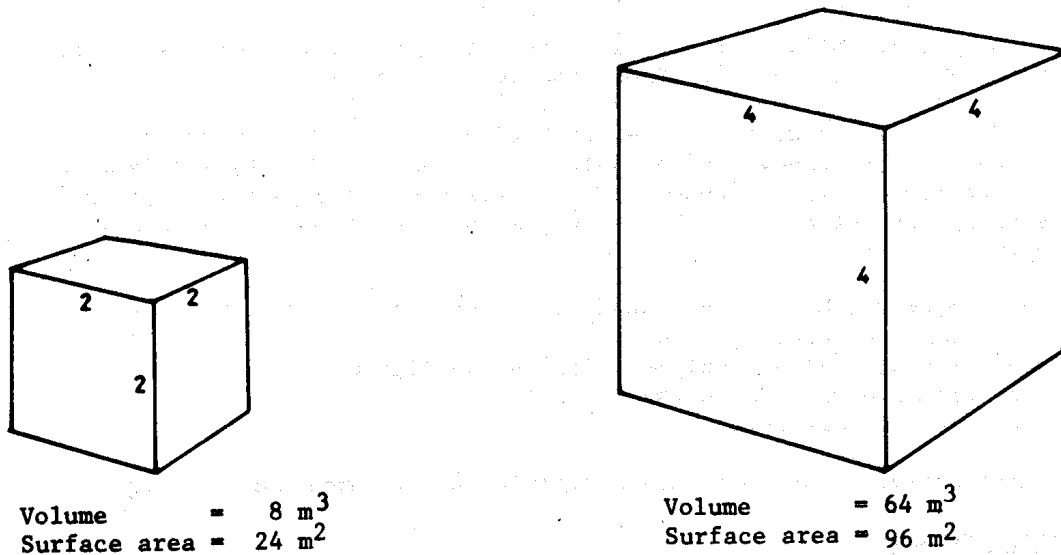
7.2 Physical Parameters

For a given weight of fish the physical size of the store will depend greatly upon the handling and stowage methods and the requirement

for access and withdrawal of stock. For small stores manual loading and unloading is quite feasible and often the cheapest solution but may not be economic for larger stores where large volumes of fish need to be moved quickly. Mechanical handling offers advantages in quicker and cheaper movement of stock and in some cases lower capital and running costs. Fork lift trucks for example enable higher stacking of fish in the chill room and it is therefore possible to design the room to take advantage of this. Consider for example the two following rooms of the same internal volume.



The first store has a total surface area (including floor) of 192 m² and the second only 160 m². Now the heat gain through the surfaces of the store is proportional to the surface area so the running cost of the first will be higher than that of the second. Additionally, the capital costs of construction will also be higher for the first store as the higher surface area will require extra insulation and floor surfacing. Considering also two stores of the same form but of different sizes as shown below:



The volume per unit surface area in the first case is 0.33 and in the second case 0.66 which illustrates the economy of scale with increasing size. The cost per unit volume, both capital and running, will be lower for larger stores. An important consideration in the sizing of a store is the requirement for access and withdrawal of stock. Consider the stowage of small pelagic species stored in ice at a fish: ice ratio of 3:1 in a box of dimensions 600 x 368 x 214 mm. Each box will contain approximately 25 kg of fish which represents a

stowage volume of about 2 m³/t with no allowance for internal clearance, access or handling and evaporator. In practice a minimum of 3 m³/t should be allowed for storage where internal access is not important. This might be the case, for example, where fish is to be unloaded from a fishing vessel one afternoon, held overnight and brought out for sale on the market the following morning. It would not matter that the first fish into the store was the last to be brought out (FILO).

Where access is required for selective withdrawal of stock, possibly of different species or ages, the stowage volume required will depend on the degree of selection required and the methods of handling. Between 4 and 8 m³/t is commonly used and provides sufficient access for most situations. Figure 19 shows the floor plan of a store designed to hold 5 t of boxed fish, handled manually, based on a design figure of 4 m³/t. The plan assumes a box of dimensions 600 x 368 x 214 mm loaded with 25 kg of iced fish. The boxes are stacked nine high (1.93 m). The internal dimensions of the store are 3.50 x 2.50 x 2.30 m (high).

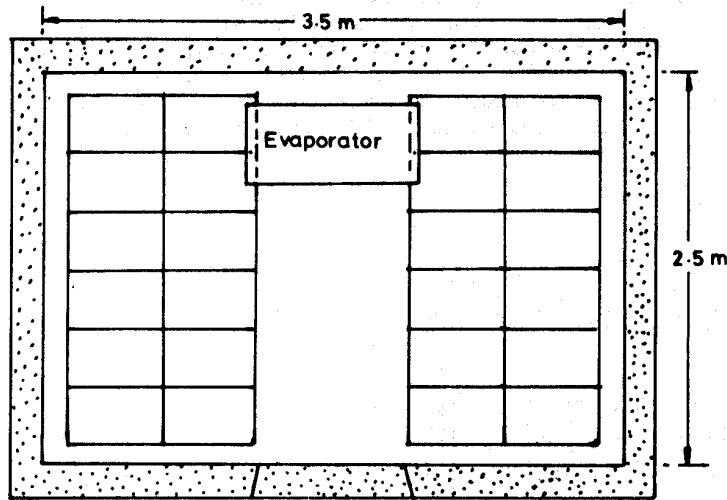


Figure 19. Floor plan of a 5-t chill store

Mechanical handling of stock in a chill store is unlikely to reduce the required floor plan area or volume required per t of fish if access is required for selective withdrawal of stock, as the aisles required for access and manoeuvring of a standard fork lift truck will be far in excess of that required for manual handling, and will not be compensated by the extra height of stacking. If selective withdrawal is not necessary then mechanical handling will enable a smaller ground area particularly for larger stores (over 30 t). The width required for a 90° stacking aisle for a standard fork lift (1-1 1/2 t capacity) will vary depending on manufacturer and pallet size, but for a 1 200 x 1 200 mm pallet it is approximately 3.25 m. Special aisle trucks are available, designed for warehouse operation that will turn in a much narrower aisle width but are seldom used in the fish processing industry, Probably because the standard fork lift is better suited to other duties that it may have to perform in addition to work in the chill store. As further examples of storage arrangements, Figures 20, 21 and 22 show the floor stacking plan and elevation of stock within three chill stores. Figure 20 shows a store designed for 25 t of boxed and iced fish to be handled manually. The plan assumes a stack-only box of dimensions 600 x 368 x 214 mm using a fish: ice ratio of 3:1 and holding 25 kg of fish. The boxes are shown stacked to a height of nine boxes. The aisles (1.2 m) between boxes provide access for selective withdrawal from any box column. The internal volume per t of fish stored is 7.0 m³/t.

Figure 21 shows a store designed for 25 t of fish handled by fork lift truck. The plan assumes a pallet size of 1 200 x 1 200 m with 24 boxes per pallet (6 boxes per layer x 4 layers). The pallets are shown stacked three high. The layout allows access to any pallet stack. The floor plan area is less than that required for manual handling but the volume . required per t of fish is greater at 8.0 m³/t.

Figure 22 shows a store designed for 100 t of iced fish held in 1 200 x 1 200 x 750 mm (high) box pallets handled by fork lift truck. The pallets are stacked four high and it is assumed that they each hold 450 kg of iced fish. Access is available to any box pallet stack. The internal volume required per t of fish stored is 9 m³/t.

In each of the foregoing examples the capacity is greatly increased if selective with drawal is not required.

The examples assume the storage of small pelagic species in a stack only box at a fish: ice ratio of 3: 1. Different fish species, box sizes and designs and fish: ice ratios will effect the space requirement for storage. For larger species such as cod, the volume should be increased by as much as 16 percent depending on size of fish. If a stack-nest type of box is used the volume should be increased by as much as 18 percent depending on size and design. At a 2:1 fish: ice ratio it should be increased by 20 percent, and at 4:1 decreased by 12 percent.

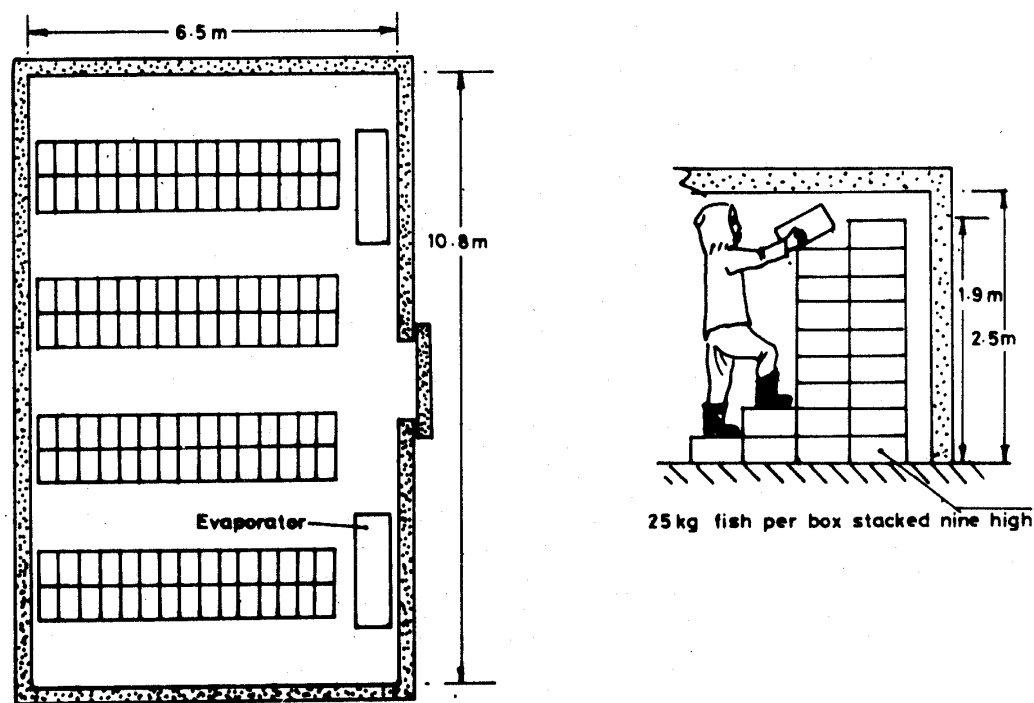


Figure 20. 25- t chill store manual operation

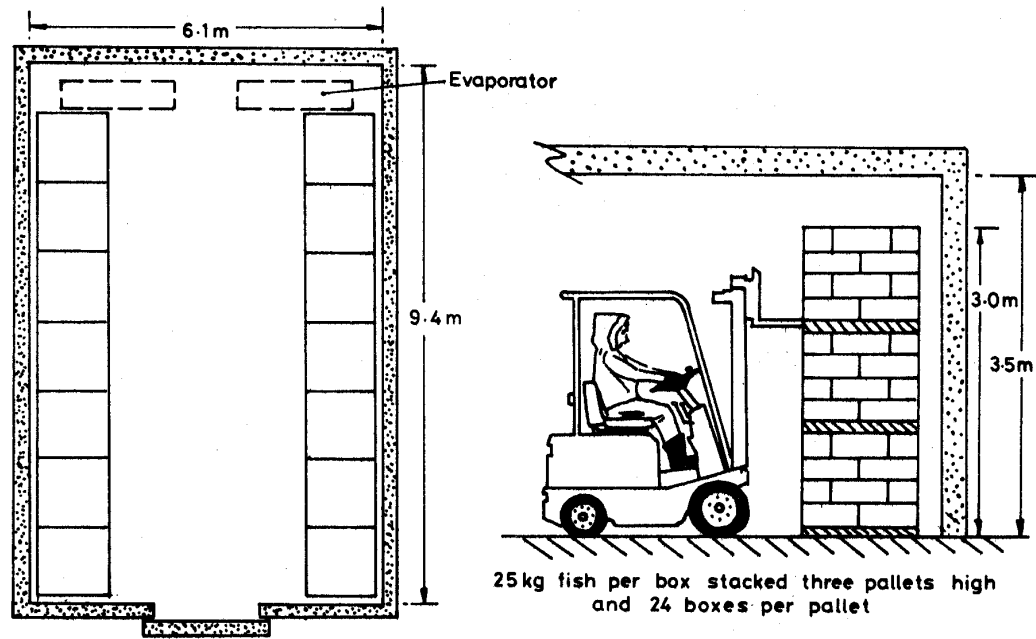


Figure 21. 25-t cold store-fork lift operation

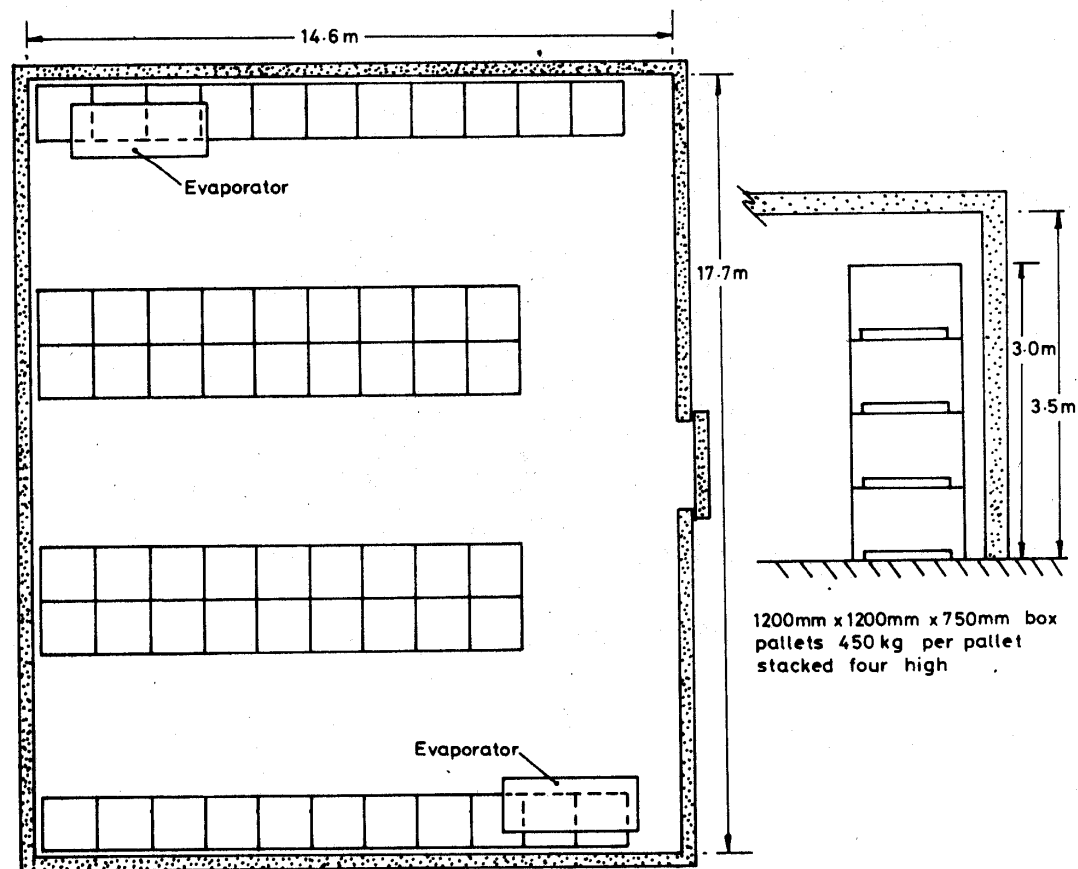


Figure 22. 100-t chill store-fork lift operation

7.3 Technical Parameters

As previously stated, it is not the intention here to describe the detail calculation of technical parameters such as optimum insulation thickness, refrigeration duty, etc., and selection of equipment which is the province of the refrigeration engineer and must be determined for each case in point. However, it is often necessary for purposes of feasibility study or planning to have some estimation of the consumption of electrical and water services and the size and connexion of installed electrical machinery. To this end the following three cases serve as examples which by interpolation might, for the purposes stated, be used in the planning of chill stores.

Three sizes of store are considered: 5 t, 25 t and 100 t (assuming a design factor of 4 m³/t) under increasingly adverse (higher)

conditions of ambience, water temperature and product temperature. In each case a daily product loading of half the capacity of store is assumed. The 5-t store operates under an ambient air temperature of 20 °C with mains water supply (for cooling) at 15 °C and with incoming fish at a temperature of 5 °C. The 25-t store is assumed to operate under an ambient air temperature of 30 °C with mains water supply at 25 °C and with incoming fish at a temperature of 10 °C. The 100-t store is assumed to operate at an ambient air temperature of 40 °C with mains water supply at 30 °C and with incoming fish at a temperature of 20 °C. The refrigeration duty is respectively: 2 654 kcal/h, 11 335 kcal/h and 75 113 kcal/h. Note that the difference in power consumption between air cooled and water cooled in Cases I and II is small, but in Case III it is significant (103.5 cf. 79 kW). The installed power rating of the compressor for Cases 1 and II is the same, but for Case III is only 55 kW for water cooled compared with 90 kW for air cooled. For Case III it is assumed that the motor is star delta connected, whereas for Cases I and II the motors might be connected direct on line. There is a slight difference in the compressor running times: Case I - 18 h; Case II - 19 h; and, Case III - 20 h.

7.4 Costs

The capital costs of the three chill stores considered in Section 7.3 and specified in Table 18 are shown in Table 19. The total capital cost is given for stores with air- and water-cooled condensers, and broken down into component costs of the store and fittings (insulation, surface finishes, doors and floor), refrigeration equipment (air and water cooled) and erection (including electrical wiring).

Analysis of the costings illustrates the economy of scale mentioned in Section 7.2 with the cost per unit volume of store dropping from US\$ 600/m³ for Case I, the 5-t store, to less than US\$ 300/m³ for Case III, the 100-t store (which operates under higher ambient conditions).

For the smaller stores the difference in capital costs between the air and water-cooled plants is not significant and might well depend on the manufacturer's product range as to which works out the cheaper. In Case III (100 t) the water-cooled plant works out to be nearly US \$ 6 000 cheaper (5 percent less than air cooled), but again could be influenced by the manufacturer's product range or actual site conditions. The question of choice between an air-cooled or water-cooled condenser would normally be made on running costs depending on the relative costs (or possibly availability) of electricity and water. Note the difference in power consumption given in Table 18 between air-cooled and water-cooled plants and the water consumption in the case of the water-cooled condenser.

Table 18 Wet fish chill rooms - specification and utilities consumptions

	Case I	Case II	Case III
Storage capacity	5 090 (5t)	25 454 kg (25 t)	101 818 kg (100 t)
Approx. room sizes (internal)	2.44 W x 3.66 D x 2.28 m H (8 ft W x 12 ft D x 7 ft 6 in H)	4.487 W x 6.09 D x 3.5 m H (16 ft W x 20 ft D x 11 ft 6 in H)	6.09 W x 15.54 D x 4.50 m H (20 ft W x 51 ft D x 14 ft 9 in H)
Room volume	20.39 m ³ (720 ft ³)	104.2 m ³ (3 680 ft ³)	426 m ³ (15 045 ft ³)
Thickness and type of insulation walls and ceiling	75 mm (3 in) foamed polyurethane	100 mm (4 in) foamed polyurethane	125 mm (5 in) foamed polyurethane
Floor insulation	75 mm (3 in) foamed polyurethane	100 mm (4 in) foamed polyurethane	125 mm (5 in) foamed polyurethane

Thickness and type granolithic cement on floor	50 mm (2 in)	75 mm (3 in)	100 mm (4 in)	
Means of handling	Manual	Manual	Fork lift	
Ambient air temperature	20°C (68°F)	30°C (86°F)	40°C (104°F)	
Mains water temperature	15°C (59°F)	25°C (77°F)	30°C (86°F)	
Condensing temperature: Air cooled Water cooled	32.2°C (90°F) 30°C (86°F)	43.3°C (110°F) 45°C (113°F)	54.4°C (130°F) 41.1°C (116°F)	
Fish entering temperature	5°C (41°F)	10°C (50°F)	20°C (68°F)	
Design room temperature	0-3°C (32-37°F)	0-3°C (32-37°F)	0-3°C (32-37°F)	
Maximum daily product load to be cooled in 24 h	2 545 kg (5 599 lb)	12 727 kg (27 999 lb)	50 909 kg (111 999 lb)	
Number and size of door	one - 0.762 W x 1.92 m H (2 ft 6 in W x 6 ft 3 in H)	one - 0.90 W x 1.92 m H (2 ft 11 in W x 6 ft 3 in H)	one - 2 W x 3 m H (6 ft 6 in W x 9 ft 10 in H)	
Refrigerant	R12	R12	R12 Air; R22 Water	
Number of air coolers	one	Two	Four (electrical defrost alternated)	
approx. compressor speed (rpm)	1 450	1 450	1 540 air 1 050 water	open type
Refrigeration duty	2 654 kcal/h (10 500 Btu/h)	11 335 kcal/h (45 000 Btu/h)	75 113 kcal/h (298 200 Btu/h)	
Compressor (kW): Air cooled (kW) Water cooled (kW)	1.1 (1 1/2 hp) D.O.L. 1.1 (1 1/2 hp) D.O.L.	5.5 (7 1/2 hp) D.O.L. 5.5 (7 1/2 hp) D.O.L.	90 (125 hp) S.D. 55 (75 hp) S.D.	
Approx. compressor running time	18 h	19 h	20 h	
Total power absorbed: Air cooled (kW) Water cooled (kW)	5.1 (6.84 hp) 4.85 (6.5 hp)	11.9 (15.95 hp) 11.44 (15.34 hp)	103.5 (138.8 hp) 70 (93.87 hp)	
Water consumption (shell and tube condenser)	772 litres/h (170 g.p.h.)	4 654 litres/h (1 025 g.p.h.)	23 154 litres/h (5 100 g.p.h.)	

Table 19 Chill store costs (US\$)

Case	Cold store and fittings	Refrigeration equipment		Erection inc. electrical	Total capital cost	
		Air cooled	Water cooled		Air cooled	Water cooled

I	4 200	6 100	6 920	1 500	11 800	12 620
II	9 120	17 820	18 300	4 200	31 140	31 620
III	34 600	72 200	64 400	10 300	117 100	111 300





8. FISH BOXES

- [8.1 Material](#)
- [8.2 Strength](#)
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- [8.7 Useful Life](#)
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- [8.9 Fish Box Washing](#)

- 8.9.1 Hose wash
- 8.9.2 High pressure cleaning
- 8.9.3 Box washing machines

8.1 Material

Fish boxes are commonly made of wood, aluminium or plastic. Wood was the traditional material for fish boxes but is being increasingly replaced now by plastic for reasons of cost and problems of usage. Wood is extremely difficult to clean properly, has a short life compared to plastic and requires frequent repair. Aluminium is easier to keep clean but is prone to damage by rough handling making them difficult to stack. Aluminium boxes are also very noisy to handle on a concrete market surface. Plastic (thermoplastic high density polyethylene) is easy to clean, will withstand rough handling and allows detail design requirements to be incorporated in the mould.

8.2 Strength

Boxes used in the fishing industry are often subjected to abuse by rough handling and should be designed to withstand such treatment. At sea they are often subjected to fierce gravitational forces caused by vessel motion. Particular attention should be given to the design of the handles or recesses for lifting, which should be strong enough to carry the load of three full boxes as vessels often discharge this many boxes using hooks to the handles of the bottom box of three. A stack formed from loaded boxes should be rigid and not tend to flex.

8.3 Weight

The tare weight of plastic and aluminium boxes is constant and not subject to age or environmental conditions. Wooden boxes will absorb water and can almost double in weight when saturated making accurate weighing of fish in the wooden boxes difficult and increasing transport costs. Typical box weights are given in Table 20.

8.4 Drainage

Fish boxes should be designed to have good drainage in order that the melt water, which contains bacteria from the fish, is allowed to drain away. Some designs enable the melt water to drain through the box so that melt water from one box will then pass through the box beneath it thereby providing the maximum cooling effect from the cold water. The disadvantage of this design is said to be cross contamination by bacteria carried by the water from box to box. Other designs prevent this by drainage to the outside of the box but

with the loss of the cooling effect of the water.

8.5 Nesting

The ability of a box to nest when not in use is very useful when storing empty boxes, particularly for applications within fish markets and box pools. Nesting boxes will give a reduction in storage volume of up to 60 percent depending on design compared to stack-only types. The nesting type of box does however suffer the following drawbacks, particularly for use at sea:

- i. nesting boxes can only be safely stacked one directly above another which results in a poor utilization of fish room space on fishing vessels which have curved sides;
- ii. the tapered sides required for nesting result in a poorer volumetric efficiency (capacity) compared to a stack only box;
- iii. the boxes are more difficult to stack and unstack manually as they require lifting out or into position. Care also has to be taken to ensure the box is right way round or damage to fish by crushing will result and the stack becomes unstable;
- iv. the reduced base area of a nesting box produces a stack that is less stable than stack only boxes with interlocking grips.

An advantage of some nesting designs is the ability to lift boxes by the lips by a modified fork lift or pallet truck which eliminates the need of pallets. Figure 23 shows the stack/ nest box.

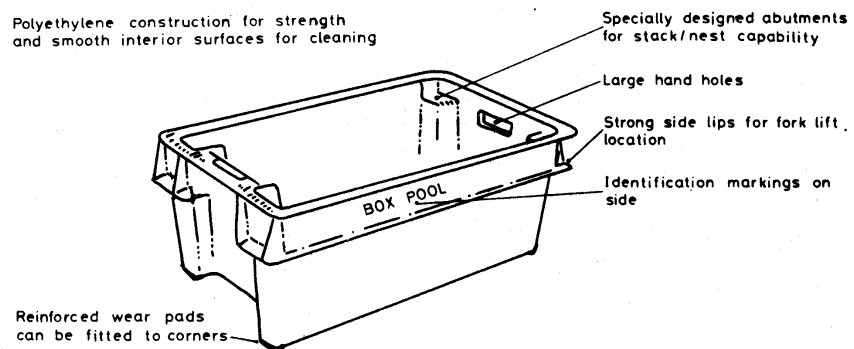


Figure 23. Stack/nest box

8.6 Stacking

Boxes that stacking only should incorporate interlocking grips between boxes to prevent sideways movement of boxes in the fish room at sea or during transportation on shore as shown in Figure 24. Plastic and aluminium boxes can be designed with this facility but not wooden boxes. The grips should allow staggered patterns of stacking for better utilization of fish room space. Stack only boxes are volumetrically more efficient than nesting boxes but require far greater storage volume when empty.

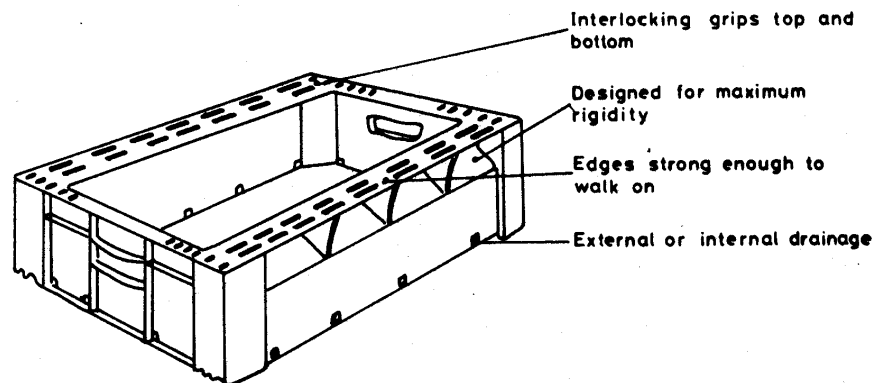


Figure 24. Stack only box

8.7 Useful Life

The life of any box is plainly dependent on factors of design, material, construction, degree of use and methods of handling but as a comparison aluminium and plastic boxes might last 6-10 years, respectively, whereas a wooden box might last only 2 years and require repair during that period. In the calculation of requirements of boxes over a period, pilfering and loss should be accounted for, and in this respect, plastic boxes offer an advantage over wooden or aluminium inasmuch as the material is of little use for alternative purposes.

8.8 Dimensions and Capacities

The dimensions and capacity of a fish box should reflect factors of fish size, packing density of fish and ice, use of mechanical handling equipment and whether a one-or two-man lift is desirable. It may also need to be compatible with existing boxes, possibly wooden, and of a capacity that is a traditional unit of sale. The length should be such that fish will not overhang the boxes or have to be forced into it and the depth should be such as to allow for fish and ice without crushing. If the box is to be used on a roller conveyor care must be taken to ensure a continuous bearing surface along the base of the box in the direction of intended motion. The volumetric capacities and dimensions of different types of boxes are given in Table 20.

Table 20 Dimensions, capacities and costs of fish boxes

Type	Material	Volume (1)	Cost <u>a/</u> (US\$)	External Dimensions (mm)	Tare weight (kg)	Capacity of fish (kg) <u>d/</u>
Stack nest	Plastic	30	9.80	800 x 450 x 150	2.5	17
	Plastic	60	11.50	800 x 450 x 270	3.7	35
	Plastic	100	17.70	900 x 495 x 355	5.0	56
Stack	Plastic	42	6.90	600 x 368 x 214	2.6	25
	Plastic	60	12.00	813 x 480 x 178	3.5	35
	Plastic	70	12.00	844 x 514 x 190	5.0	40
	Plastic	90	18.00	850 x 515 x 260	6.0	50
	Aluminium	76	29.80	832 x 370 x 260	6.0	43
	Wood	60	5.00	812 x 470 x 178	7.0 <u>b/</u>	35
Stack <u>c/</u>	Plastic	25	6.90	560 x 415 x 150	1.6	20 fillets
	Plastic	42	7.40	650 x 400 x 200	2.3	30 fillets

a/ Individual box cost based on an order of 1 000 boxes ex-works (1979)

b/ Dry weight which can almost double when water-logged

c/ Fillet boxes for use in the processing factory

d/ Approximate capacity of fish assuming a 2:1 fish: ice ratio (crushed block ice)

8.9 Fish Box Washing

It is essential that after use fish boxes should be thoroughly cleaned of all dirt, fish slime and scales. The method of cleaning to be employed will depend on the number of boxes involved and whether or not the debris has been allowed to dry onto the box.

8.9.1 Hose wash.

With small numbers of boxes, a simple cold water wash may be all that is required but if the debris has been allowed to dry on the boxes then an overnight soak in a detergent solution with scrubbing and hosing the following day will be necessary. Such treatment is not suitable for wooden boxes which cannot be satisfactorily cleaned.

8.9.2 High pressure cleaning.

Portable high pressure cleaners can be used effectively to clean plastic and aluminium boxes but should not be used on wooden boxes. The units are available with cold or hot systems operating at pressures, typically in the order of 70 kg/cm². Water consumption is about 12 litres/min and fuel consumption (hot water models) between 7-11 litres/h depending on temperature. Installed power is typically 2-3 kW. Approximate cost of cold water unit is US\$ 1 500 and for a hot water unit US\$ 3 500 (1979).

8.9.3 Box washing machines.

Box washing by machine is by far the most efficient and quickest method of handling large numbers of boxes with capacities in the range of 800-1 200 boxes/h. Boxes are normally fed through the machine hung on a monorail conveyor or upside down on a roller or mesh belt conveyor. The machines are typically made up of three sections having a cold or warm water pre-rinse followed by a hot water detergent wash and finally a cold water rinse. A pre-wash is necessary to remove salt from the boxes as it reduces the effectiveness of the detergent. The washes are performed under pressures of 4.6-5.6 kg/cm² if the debris is dried on, or slightly less if not. Fresh water consumption for a unit of 1 000 boxes/h capacity would be about 5 t/h. This can be reduced by using pumped sea water for the pre and post-wash rinses but is not recommended because of possible contamination. Power consumption will depend on throughput and water pressures involved, but is typically in the range 15-30 kW for a 1 000 box/h unit. Boiler oil consumption for heating water will be about 40 litres/h for a throughput of 1 000 boxes/h with a wash temperature of 70 °C in a temperate climate. A mildly alkaline detergent should be used for wood, aluminium or plastic boxes at a concentration of 1-2 percent solution. For the 1 000 box/h machine a minimum labour force of four men will be required; two feeding the machine and two removing boxes plus additional labour depending on distances involved fetching and stacking boxes. Price for complete unit, 1 000 boxes/h, including boiler and installation would be in the order of US\$ 50 000-60 000 ex-works. The space required for the machine is not large (10 m long x 3 m wide x 2 m high), but relatively large areas must be allowed for handling of the boxes which will be dependent upon the type of box and maximum height. Stack/nest boxes in this situation have a big advantage.





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with the loss of the cooling effect of the water.

8.5 Nesting

The ability of a box to nest when not in use is very useful when storing empty boxes, particularly for applications within fish markets and box pools. Nesting boxes will give a reduction in storage volume of up to 60 percent depending on design compared to stack-only types. The nesting type of box does however suffer the following drawbacks, particularly for use at sea:

- i. nesting boxes can only be safely stacked one directly above another which results in a poor utilization of fish room space on fishing vessels which have curved sides;
- ii. the tapered sides required for nesting result in a poorer volumetric efficiency (capacity) compared to a stack only box;
- iii. the boxes are more difficult to stack and unstack manually as they require lifting out or into position. Care also has to be taken to ensure the box is right way round or damage to fish by crushing will result and the stack becomes unstable;
- iv. the reduced base area of a nesting box produces a stack that is less stable than stack only boxes with interlocking grips.

An advantage of some nesting designs is the ability to lift boxes by the lips by a modified fork lift or pallet truck which eliminates the need of pallets. Figure 23 shows the stack/ nest box.

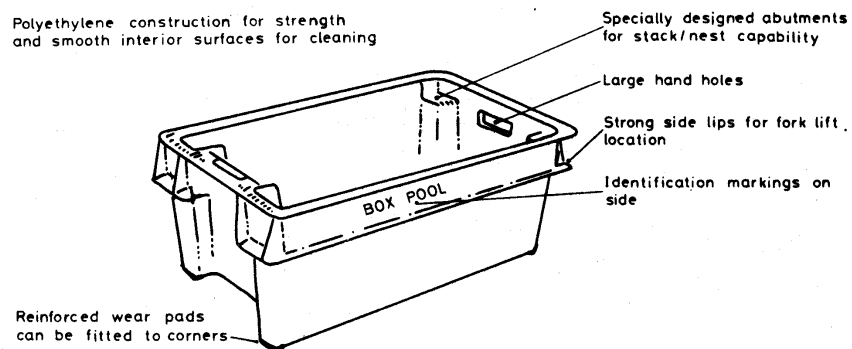


Figure 23. Stack/nest box

8.6 Stacking

Boxes that stacking only should incorporate interlocking grips between boxes to prevent sideways movement of boxes in the fish room at sea or during transportation on shore as shown in Figure 24. Plastic and aluminium boxes can be designed with this facility but not wooden boxes. The grips should allow staggered patterns of stacking for better utilization of fish room space. Stack only boxes are volumetrically more efficient than nesting boxes but require far greater storage volume when empty.

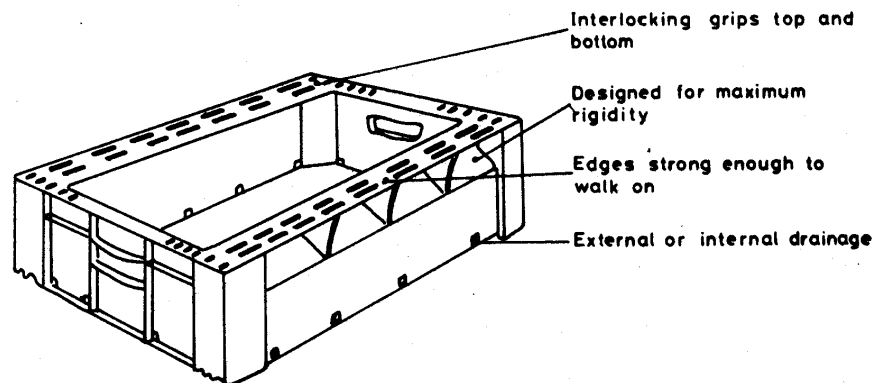


Figure 24. Stack only box

8.7 Useful Life

The life of any box is plainly dependent on factors of design, material, construction, degree of use and methods of handling but as a comparison aluminium and plastic boxes might last 6-10 years, respectively, whereas a wooden box might last only 2 years and require repair during that period. In the calculation of requirements of boxes over a period, pilfering and loss should be accounted for, and in this respect, plastic boxes offer an advantage over wooden or aluminium inasmuch as the material is of little use for alternative purposes.

8.8 Dimensions and Capacities

The dimensions and capacity of a fish box should reflect factors of fish size, packing density of fish and ice, use of mechanical handling equipment and whether a one-or two-man lift is desirable. It may also need to be compatible with existing boxes, possibly wooden, and of a capacity that is a traditional unit of sale. The length should be such that fish will not overhang the boxes or have to be forced into it and the depth should be such as to allow for fish and ice without crushing. If the box is to be used on a roller conveyor care must be taken to ensure a continuous bearing surface along the base of the box in the direction of intended motion. The volumetric capacities and dimensions of different types of boxes are given in Table 20.

Table 20 Dimensions, capacities and costs of fish boxes

Type	Material	Volume (1)	Cost <u>a/</u> (US\$)	External Dimensions (mm)	Tare weight (kg)	Capacity of fish (kg) <u>d/</u>
Stack nest	Plastic	30	9.80	800 x 450 x 150	2.5	17
	Plastic	60	11.50	800 x 450 x 270	3.7	35
	Plastic	100	17.70	900 x 495 x 355	5.0	56
Stack	Plastic	42	6.90	600 x 368 x 214	2.6	25
	Plastic	60	12.00	813 x 480 x 178	3.5	35
	Plastic	70	12.00	844 x 514 x 190	5.0	40
	Plastic	90	18.00	850 x 515 x 260	6.0	50
	Aluminium	76	29.80	832 x 370 x 260	6.0	43
	Wood	60	5.00	812 x 470 x 178	7.0 <u>b/</u>	35
Stack <u>c/</u>	Plastic	25	6.90	560 x 415 x 150	1.6	20 fillets
	Plastic	42	7.40	650 x 400 x 200	2.3	30 fillets

a/ Individual box cost based on an order of 1 000 boxes ex-works (1979)

b/ Dry weight which can almost double when water-logged

c/ Fillet boxes for use in the processing factory

d/ Approximate capacity of fish assuming a 2:1 fish: ice ratio (crushed block ice)

8.9 Fish Box Washing

It is essential that after use fish boxes should be thoroughly cleaned of all dirt, fish slime and scales. The method of cleaning to be employed will depend on the number of boxes involved and whether or not the debris has been allowed to dry onto the box.

8.9.1 Hose wash.

With small numbers of boxes, a simple cold water wash may be all that is required but if the debris has been allowed to dry on the boxes then an overnight soak in a detergent solution with scrubbing and hosing the following day will be necessary. Such treatment is not suitable for wooden boxes which cannot be satisfactorily cleaned.

8.9.2 High pressure cleaning.

Portable high pressure cleaners can be used effectively to clean plastic and aluminium boxes but should not be used on wooden boxes. The units are available with cold or hot systems operating at pressures, typically in the order of 70 kg/cm². Water consumption is about 12 litres/min and fuel consumption (hot water models) between 7-11 litres/h depending on temperature. Installed power is typically 2-3 kW. Approximate cost of cold water unit is US\$ 1 500 and for a hot water unit US\$ 3 500 (1979).

8.9.3 Box washing machines.

Box washing by machine is by far the most efficient and quickest method of handling large numbers of boxes with capacities in the range of 800-1 200 boxes/h. Boxes are normally fed through the machine hung on a monorail conveyor or upside down on a roller or mesh belt conveyor. The machines are typically made up of three sections having a cold or warm water pre-rinse followed by a hot water detergent wash and finally a cold water rinse. A pre-wash is necessary to remove salt from the boxes as it reduces the effectiveness of the detergent. The washes are performed under pressures of 4.6-5.6 kg/cm² if the debris is dried on, or slightly less if not. Fresh water consumption for a unit of 1 000 boxes/h capacity would be about 5 t/h. This can be reduced by using pumped sea water for the pre and post-wash rinses but is not recommended because of possible contamination. Power consumption will depend on throughput and water pressures involved, but is typically in the range 15-30 kW for a 1 000 box/h unit. Boiler oil consumption for heating water will be about 40 litres/h for a throughput of 1 000 boxes/h with a wash temperature of 70 °C in a temperate climate. A mildly alkaline detergent should be used for wood, aluminium or plastic boxes at a concentration of 1-2 percent solution. For the 1 000 box/h machine a minimum labour force of four men will be required; two feeding the machine and two removing boxes plus additional labour depending on distances involved fetching and stacking boxes. Price for complete unit, 1 000 boxes/h, including boiler and installation would be in the order of US\$ 50 000-60 000 ex-works. The space required for the machine is not large (10 m long x 3 m wide x 2 m high), but relatively large areas must be allowed for handling of the boxes which will be dependent upon the type of box and maximum height. Stack/nest boxes in this situation have a big advantage.





9. INTERNAL TRANSPORTATION

[9.1 Sack or Case Truck](#)

[9.2 Jak-tug](#)

[9.3 Hand-drawn Truck](#)

[9.4 Electric Tow and Platform Trucks](#)

[9.5 Hand Pallet Truck](#)

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[9.8 Roller Conveyors](#)

[9.9 Powered Belt Conveyors and Elevators](#)

[9.10 Flumes](#)

The following range of machines or devices are commonly used as handling aids in the fishing industry. The range is wide and the use of a particular type will depend upon the total load to be carried, the unit load, cost of labour/machine, the distances involved, the floor surface and consideration of maintenance, etc. A brief description of types is given followed by Table 21 which gives prices and capacities.

9.1 Sack or Case Truck

A very simple manually operated two-wheel unit suitable for handling individual or small numbers of stacked fish boxes. Of limited capacity and normally used only over short distances.

9.2 Jak-tug

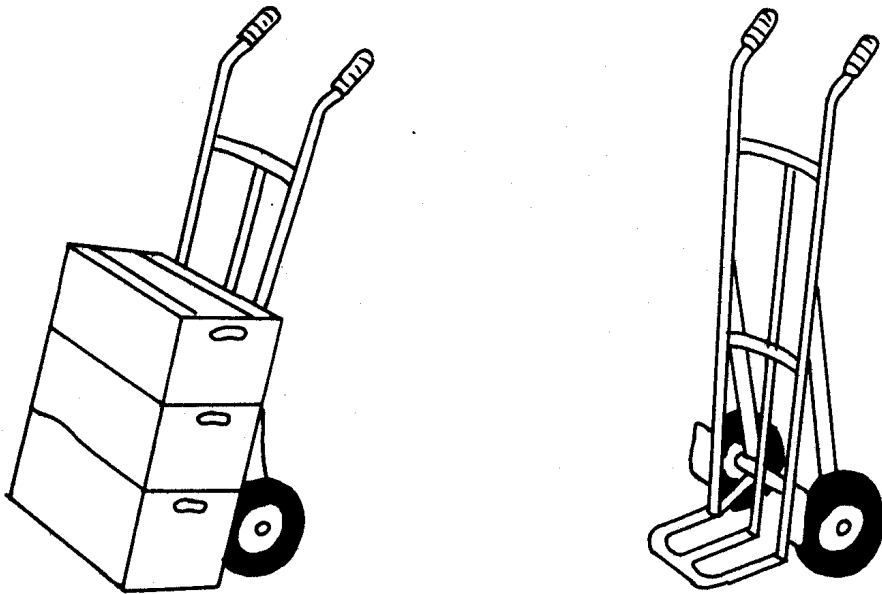


Figure 25. Sack or case truck

A rigid platform with wheels at one end which can be manouvered manually by the use of a towing unit that lifts and supports the other end. Restricted to use on more or less level floor.

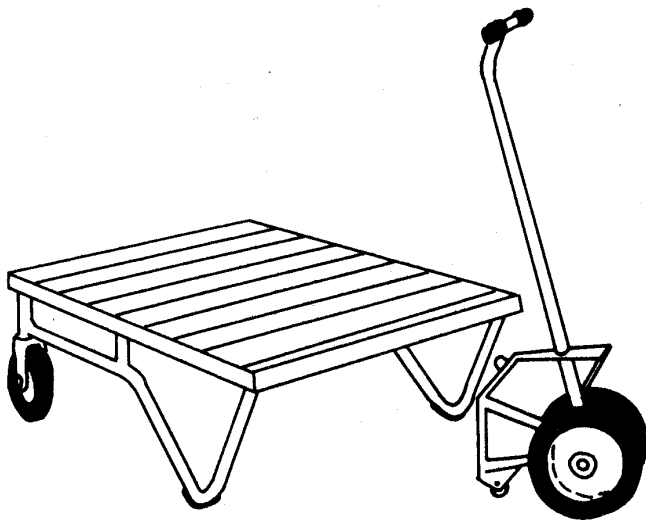


Figure 26. Jak-tug

9.3 Hand-drawn Truck

A four-wheeled manually operated truck suitable for loads of up to 1 t. Steering is either by means of a turntable assembly or by a central pivot connected to the steering wheels by track rods. The track rod type of truck is preferred as the wheels remain under and give support to their respective corners on turning. The turntable type has a tendency to tip when negotiating sharp turns if unevenly loaded.

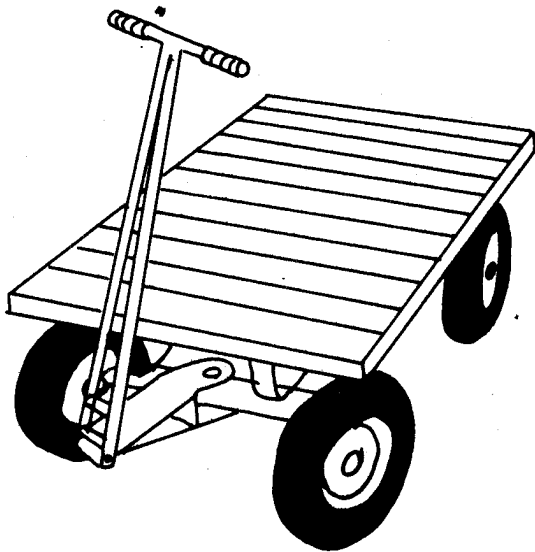


Figure 27. Hand-drawn truck

9.4 Electric Tow and Platform Trucks

They are basically battery-operated versions of the manual equivalent, which are better suited for handling greater loads over longer distances. Diesel versions are also available but should not be used in markets or processing factories where fumes and oil spillage can lead to contamination of product or be a hazard to operators. Gradients of 1:10 can be negotiated under load on floors that need not be smooth. Facilities are required for re-charging of batteries.

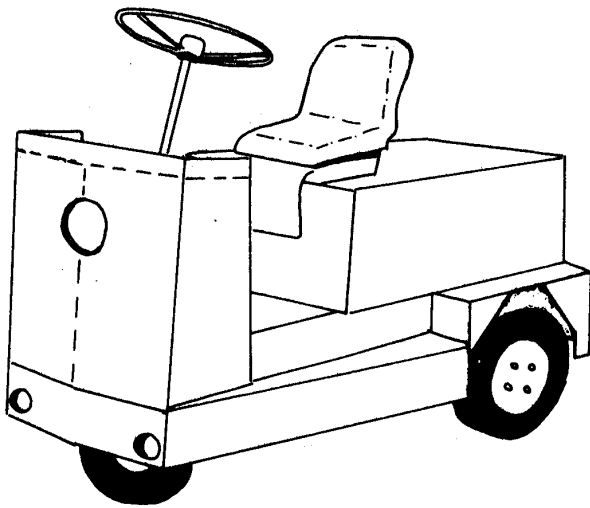


Figure 28. Electric tow tractor unit

9.5 Hand Pallet Truck

A manually operated truck for use with palletized loads. It consists of two forks and a steering unit. The forks are entered into the pallet which is raised by a hand-operated hydraulic pump, until the load is clear of the ground. Because of the relatively small wheels required for entry into the pallet the floor needs to be smooth and fairly level. Simple modification by means of a frame fitted over the forks makes it suitable for transport of stack/nest types of fish box. It is particularly useful in box, pool or factory operations and eliminates wear caused by dragging or pushing boxes over concrete surfaces.

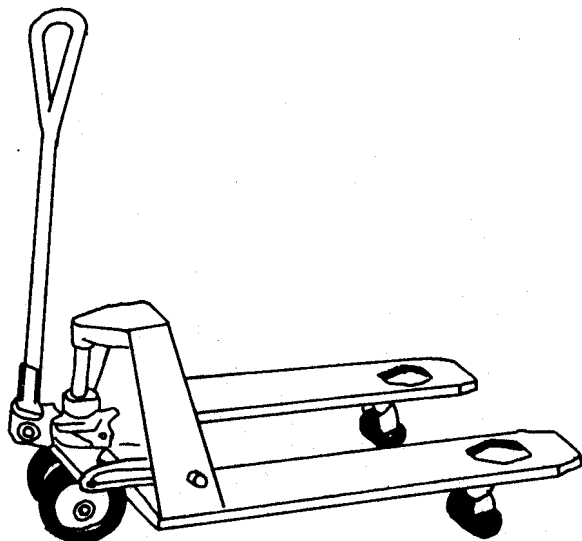


Figure 29. Hand pallet truck

9.6 Powered Pallet Truck

An electrically powered truck similar to the hand pallet truck which can be pedestrian or rider-operated depending on design. Quicker in operation than the hand pallet truck and more suited to greater loads and distances. inclines. Can be operated on fairly uneven surfaces and inclines.

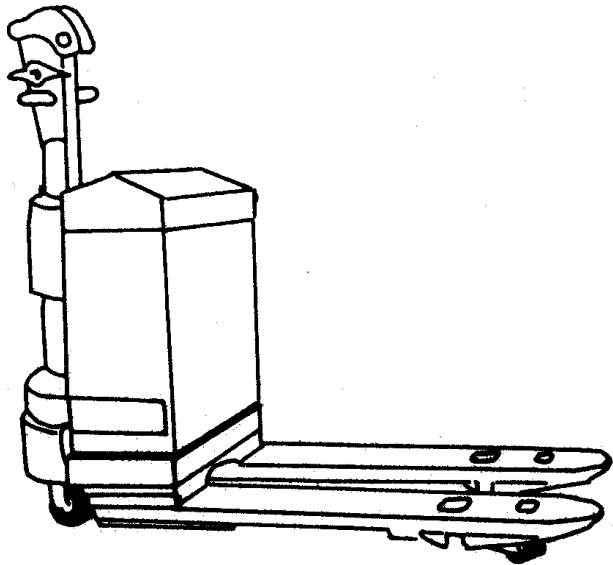


Figure 30. Powered pallet truck

9.7 Fork Lift Trucks

Similar to the pallet truck but with the capacity of lifting the load much higher. The forks do not contain the wheels and the load is balanced by the weight of the truck. They can be pedestrian or rider-operated depending on design, and are particularly useful for loading and unloading of road transport, stacking within chill stores and movement of processing machinery.

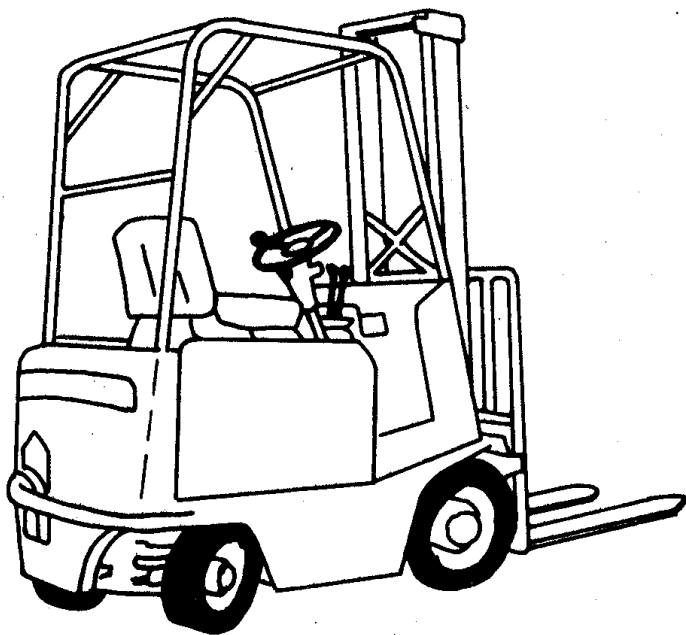


Figure 31. Rider electric fork truck

9.8 Roller Conveyors

Gravity roller conveyors are commonly used for the handling boxes or cases 'horizontally' over short distances. Powered rollers can be used over greater distances. Roller conveyors are available in unit lengths both straight or curved sections or can be specifically designed for intended application if the scale warrants it. Portable and expandable units are also available which can be removed or contracted to save space when not in use. Electrically powered units should be fitted with waterproof motors. Both powered and gravity rollers should allow efficient cleaning.

9.9 Powered Belt Conveyors, and Elevators

Belt conveyors and elevators are commonly used for transportation of whole fish, fillets offal and other fish products. Wherever the product comes into contact with the belt then the belt used must be of food quality grade and should not contain metal fasteners but be of the continuous type. Smooth finish PVC type belts are restricted to horizontal applications for the transportation of fish but rough top belts can be used up to a maximum inclination of 150 to horizontal if dry or 200 if wet for most species of fish. The belt should be fitted with a brush and/or wire to clean the returning belt surface. Variable speed belts are often a great asset where manual operations are performed along the belt length allowing the speed to be varied to suit the number or capability of the operatives. Stop or emergency buttons should be clearly seen and easily reached. For inclinations greater than the above slated-belt elevators are commonly used for transport of fish and offal. In a continuous process the speed of the elevator and design and spacing of the slats should be such as to deliver the required volume of fish.

9. 10 Flumes

Water flumes are often used for the transport of fish or removal of offal within a processing factory as an alternative to a conveyor and can be built in the case of offal removal beneath the floor provided easy access to the flume is allowed for. The degree of inclination and volume of water flow required is dependent on the fish size and type and the cross section and material of the flume. Trials have shown that for a 'U' section flume of 46 cm width, using

15 litres/min water flow, inclinations of between 5-10° to the horizontal were required depending on the size and type of fish.

Table 21 In plant transportation capacities/prices

Type 1	Characteristics	Capacity a/ (kg)	Price b/ (US\$)
Case truck	Can be made to suit box	200	70
Jak-tug	Platform 1 200 x 800 mm	500	140
Hand-drawn truck	Platform 2 000 x 1 000 mm	1 000	360

Electric platform truck	Platform 2 000 x 1 500 mm 2 kW motor 24 V battery 292 Ah at 5 h rate, 7.0 kWh Battery charger	Carry 1 000 and tow 1 000	5 500 750
Electric tow truck	1 kW motor 24 V battery 235 Ah at 5 h rate, 5.6 kWh Battery charger	Tow 3 000	3 500 700
Pallet truck	Width over fork 500-700 mm Fork length 800-1 200 mm Lifting height from 80-200 mm	2 000 (1 000-2 500)	400
Pallet truck (powered)	As for pallet truck Lift motor 0.35 kW drive 0.75 kW 16 V battery 216 Ah at 5 h rate, 3.5 kWh Battery charger	2 000 (1 000-2 000)	5 700 620
Pedestrian fork lift truck	Fork spread 260-800 mm Lift 3 300 mm Drive 1.0 kW Lift 2.0 kW 48 V battery 85 Ah at 5 h rate, 4.1 kWh Battery charger	1 000 (750-1 500)	10 500 680
Rider electric fork truck	Fork spread 260-900 mm Lift height 3 300 mm Drive 5.6 kW Lift 6.3 kW 72 V battery 235 Ah at 5 h rate, 16.9 kWh Battery charger		18 500 860
Roller conveyer (gravity)	35 mm roller; 180 mm pitch 600 mm wide point finish 3 000 mm length		100
Powered belt conveyer (food quality belt)	3 000 mm length 200 mm wide belt Drive 1.5 kW		1 600
Powered belt conveyer (standard belt)	3 000 mm length 600 mm wide Drive 2.0 kW		1800

a/ The capacity given is for the unit described under characteristics. The capacity range given below this is the range of units

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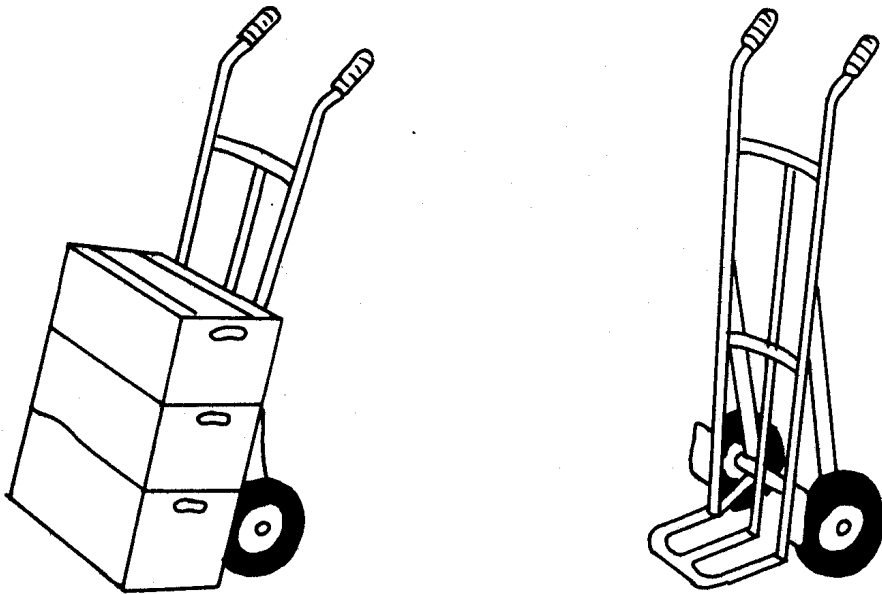


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A rigid platform with wheels at one end which can be manouvered manually by the use of a towing unit that lifts and supports the other end. Restricted to use on more or less level floor.

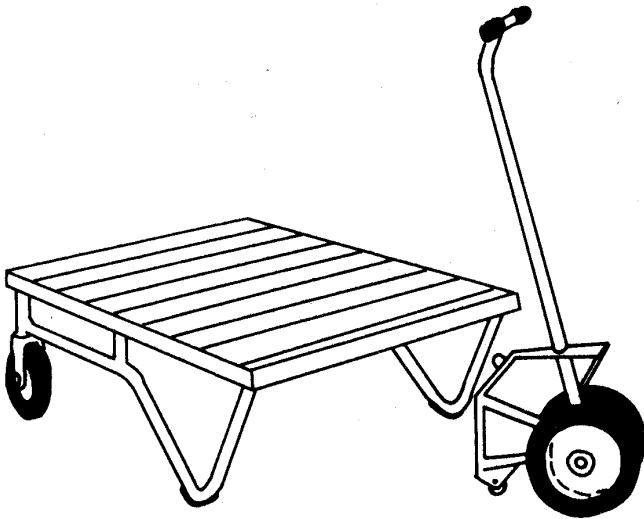


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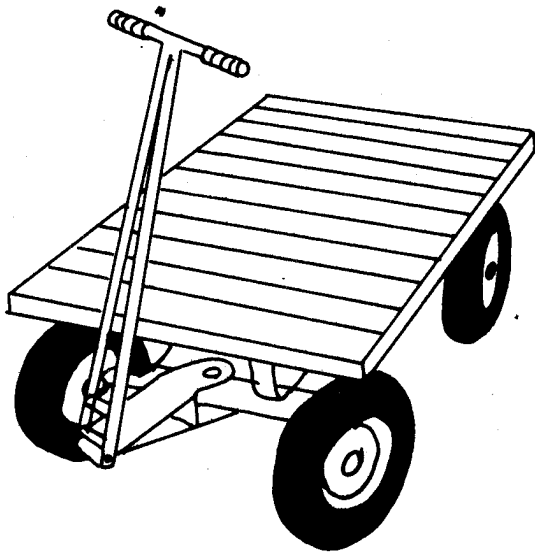


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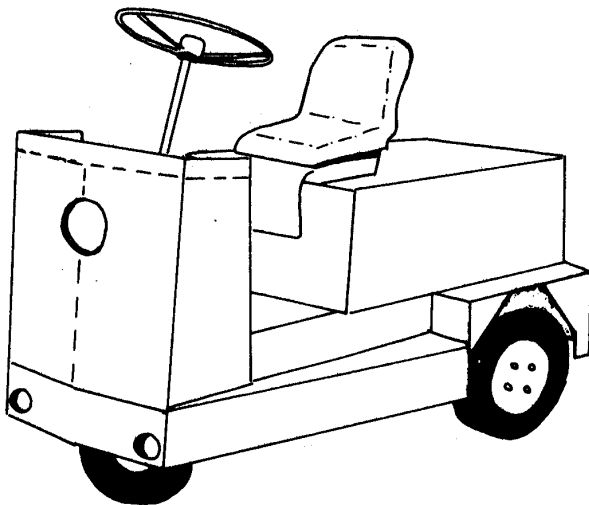


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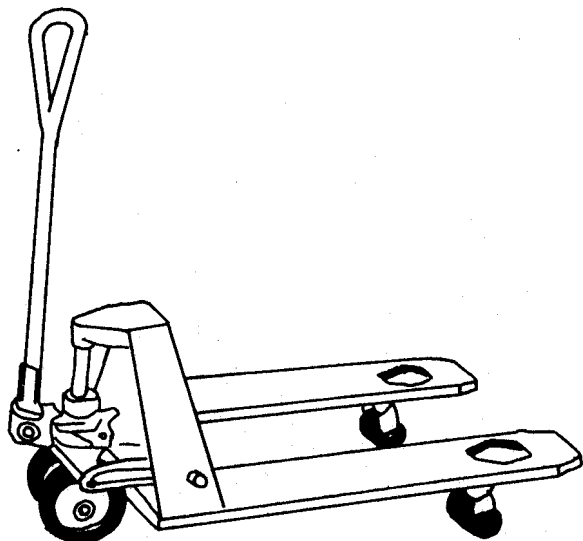


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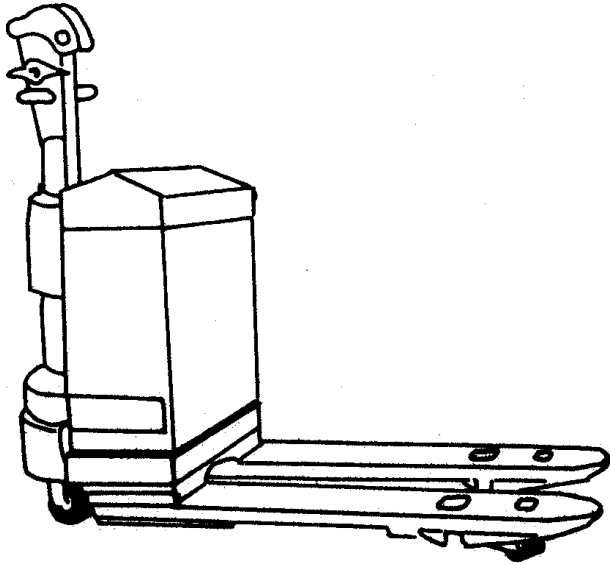


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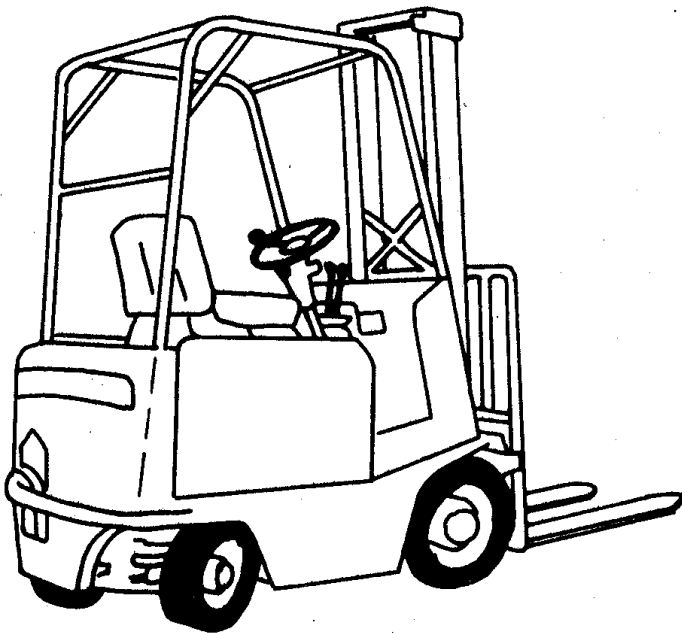


Figure 31. Rider electric fork truck

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10. PALLETS

[10.1 Types](#)

[10.2 Materials](#)

[10.3 Costs](#)

10.3.1 Life

10.3.2 Specification

[10.1 Types](#)

A pallet forms the base structure for a load in order that it may be handled by a fork lift or pallet truck. A unit load may be built up of a number of smaller unit loads, for example, fish boxes, on a pallet and transported and handled as a single load making the handling much simpler. They are particularly useful with regular shaped loads such as fish boxes when they can be stacked one upon another. If the loads are irregular, or if damage could occur due to crushing, post or box pallets can be used to stack one upon another as shown in Figures 32 and 33.

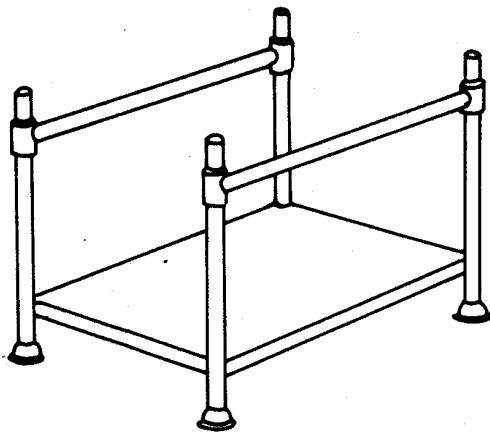


Figure 32. Post pallet

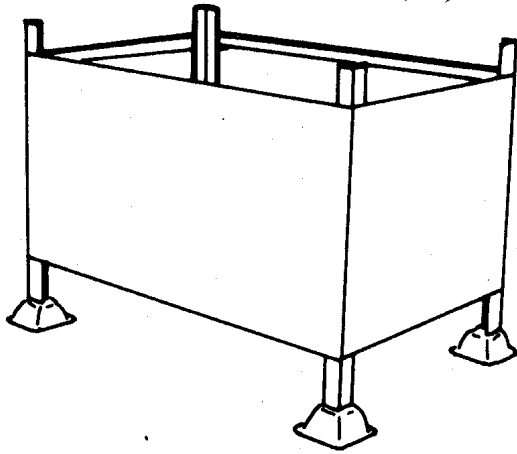


Figure 33. Box pallet

A pallet converter, shown in Figure 34, is used with an ordinary flat pallet to achieve the same purpose as a post or box pallet.

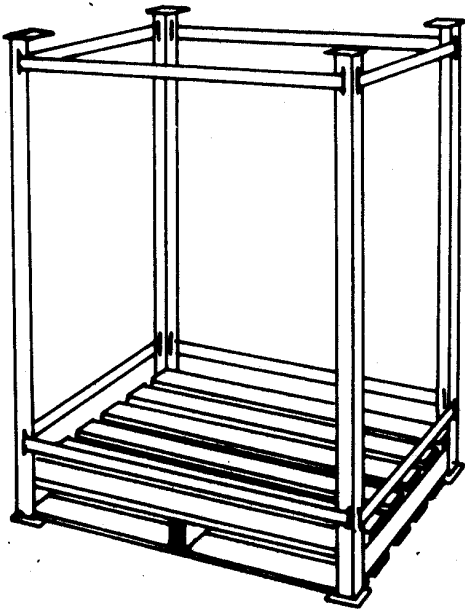


Figure 34. Pallet converter .

The flat pallet is the most common type of pallet in general use in the fishing industry and can be of reversible or non-reversible type and of two-way entry or four-way entry. The reversible pallet shown in Figure 35 has identical top and bottom decks either of which can be load bearing and is of strong construction. It is not suitable for use with pallet trucks and is of two-way entry. The non-reversible pallet has only a load bearing top deck and is suitable for use with pallet and fork lift trucks. The two-way entry pallet consists of a top deck, three full length bearers and a suitably spaced bottom deck as shown in Figure 36.

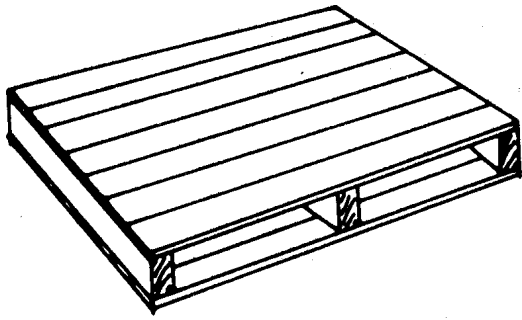


Figure 35. Two-way entry reversible

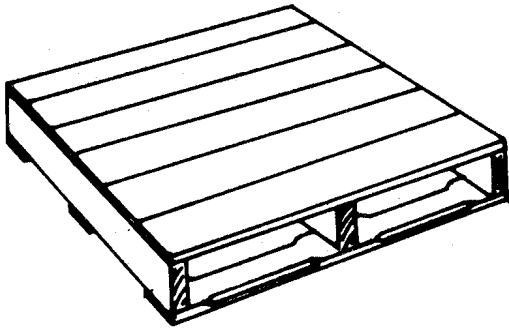


Figure 36. Two-way entry non-reversible

The four-way entry pallet which has advantages in handling consists of a top deck, 9 spacing blocks and 3 transverse stringers as shown in Figure 37. It is not as strong as a two-way entry pallet but may be strengthened by additional slats to the base to form a perimeter base or cruciform base pallet as shown in Figure 38.

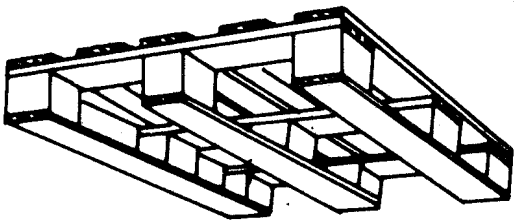
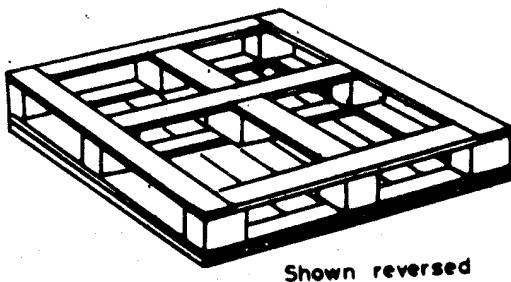


Figure 37. Four-way entry pallet



Shown reversed

Figure 38. Four-way entry pallet with cruciform perimeter base

Winged pallets are pallets designed with decks that extend beyond the outer bearers for lifting by crane with spreader bar slings.

Wooden pallets may be specified in hardwood, which is better suited to rough handling or softwood and may have an unplaned or planed deck of open-boarded or close-boarded construction.

For use with pallet trucks the edge to the bottom deck may be chamfered to facilitate the passage of the load wheels of the truck.

10.2 Materials

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Type	Material	Size (mm)	Cost (US\$)
Non-reversible flat	Timber	800 x 1 200	8.80
Non-reversible flat	Timber	1 000 x 1 200	10.60
Non-reversible flat	Timber	1 200 x 1 200	12.00
Non-reversible flat	Timber	1 800 x 1 200	16.80
Reversible flat	Timber	800 x 1 200	10.80
Reversible flat	Timber	1 000 x 1 200	13.60
Reversible flat	Timber	1 200 x 1 200	15.60
Reversible flat	Timber	1 800 x 1 200	21.80
Non-reversible flat	H D polyethylene	1 000 x 1 200	30.00
Box with lid and drain <u>a/</u>	H D polyethylene	800 x 1 200 x 825	200.00
Box with lid and drain <u>a/</u>	H D polyethylene	930 x 1 250 x 720	280.00
Box with lid and drain <u>a/</u>	H D polyethylene	1 120 x 1 530 x 885	393.00
Box with sheet sides	Steel with painted finish	1 000 x 1 200 x 850	110.00
Box with sheet sides	Steel with galvanized finish	1 000 x 1 200 x 850	176.00

Post	Steel with painted finish	1 000 x 1 200 x 850	80.00
Post	Steel with galvanized finish	1 000 x 1 200 x 850	128.00

a/ Suitable for iced fish or ice chilled water and fish

10.3.1 Life

The working life of a pallet depends entirely on its usage, the degree of rough handling it receives and its likelihood of loss. The life of a plastic pallet will be many times that of a timber pallet justifying its high first cost if loss is not a serious problem.

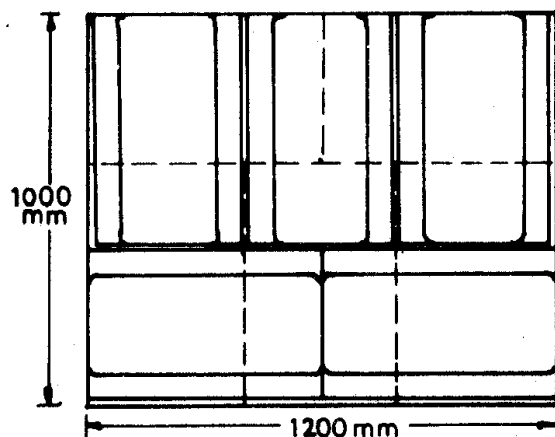
Metal pallets will have a life between that of wood and plastic.

Plastic pallets can be distinctively coloured or permanently marked for identification to assist recovery and have little alternative use unlike the timber pallet that can be burnt for firewood or used for other purposes.

10.3.2 Specification.

The International Organization for Standardization has recommended the following plan dimensions for standard pallets: 800 x 1 200, 1 000 x 1 200, 1 200 x 1 200, 1 200 x 1 600 (maritime use) and 1 200 x 1 800 mm. Each pallet can be specified for loading of 1 000, 1 500 or 2 000 kg.

The standard plan sizes are designed for loading of transport vehicles for industry in general and unfortunately are not always well suited for handling of fish in boxes. If standard flat pallets are to be used for handling fish in boxes consideration should be given in selection of pallet size to the stacking plan on the pallet for optimum utilization. For example the 600 x 368 x 214 mm plastic box commonly used for small pelagic species fits well on the 1 000 x 1 200 (as shown in Figure 39), 1 200 x 1 200 and the 1 200 x 1 800 mm pallets.



Standard fish box shown stacked on pallet (dotted line shows alternate layer stacking with some types of box)

Figure 39. Pallet stacking plan for fish boxes

Some manufacturers of plastic boxes produce pallets and stillages not necessarily to ISO specification to suit their range of fish boxes.

Depending on the base design of the box subsequent layers of boxes may be repeated on the same plan or 'mirror imaged' as shown dotted in Figure 39 to give better stability.

For handling of fish in bulk particularly from the market box pallets often offer advantages in handling and storage.





10. PALLETS

[10.1 Types](#)

[10.2 Materials](#)

[10.3 Costs](#)

10.3.1 Life

10.3.2 Specification

[10.1 Types](#)

A pallet forms the base structure for a load in order that it may be handled by a fork lift or pallet truck. A unit load may be built up of a number of smaller unit loads, for example, fish boxes, on a pallet and transported and handled as a single load making the handling much simpler. They are particularly useful with regular shaped loads such as fish boxes when they can be stacked one upon another. If the loads are irregular, or if damage could occur due to crushing, post or box pallets can be used to stack one upon another as shown in Figures 32 and 33.

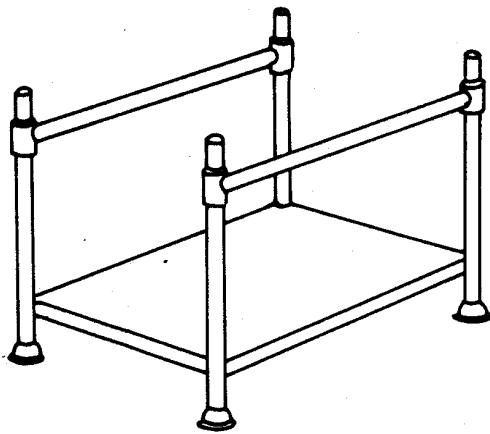


Figure 32. Post pallet

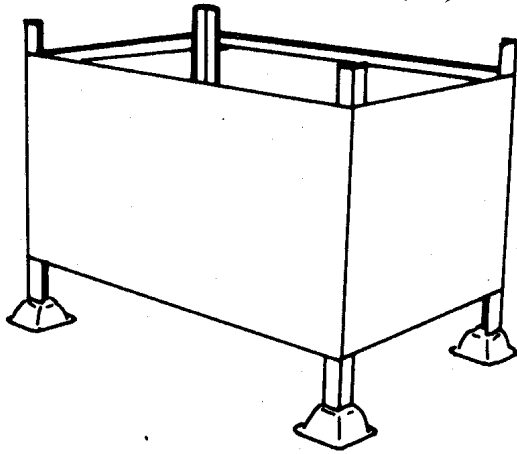


Figure 33. Box pallet

A pallet converter, shown in Figure 34, is used with an ordinary flat pallet to achieve the same purpose as a post or box pallet.

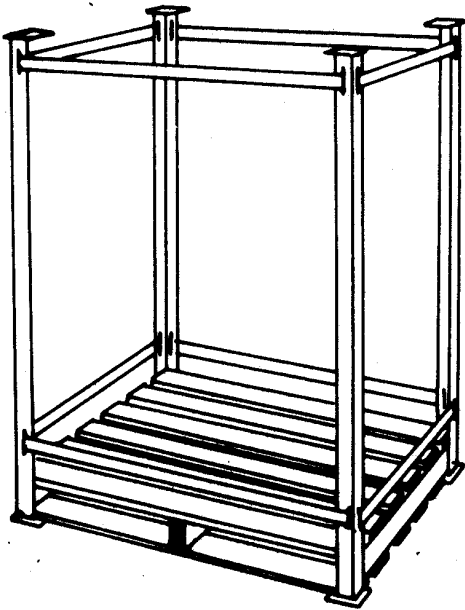


Figure 34. Pallet converter .

The flat pallet is the most common type of pallet in general use in the fishing industry and can be of reversible or non-reversible type and of two-way entry or four-way entry. The reversible pallet shown in Figure 35 has identical top and bottom decks either of which can be load bearing and is of strong construction. It is not suitable for use with pallet trucks and is of two-way entry. The non-reversible pallet has only a load bearing top deck and is suitable for use with pallet and fork lift trucks. The two-way entry pallet consists of a top deck, three full length bearers and a suitably spaced bottom deck as shown in Figure 36.

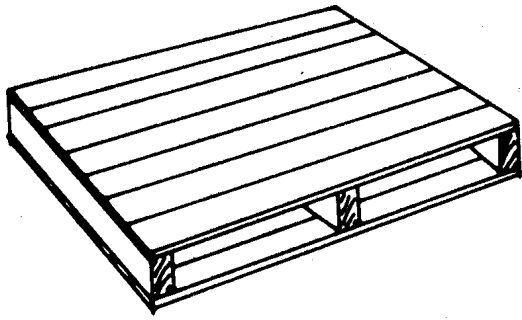


Figure 35. Two-way entry reversible

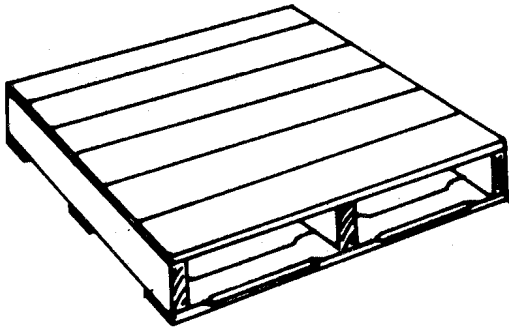


Figure 36. Two-way entry non-reversible

The four-way entry pallet which has advantages in handling consists of a top deck, 9 spacing blocks and 3 transverse stringers as shown in Figure 37. It is not as strong as a two-way entry pallet but may be strengthened by additional slats to the base to form a perimeter base or cruciform base pallet as shown in Figure 38.

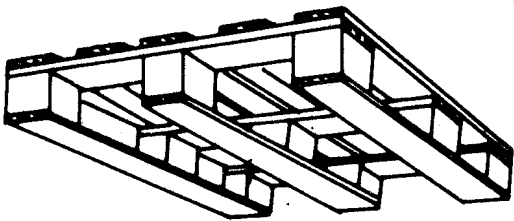
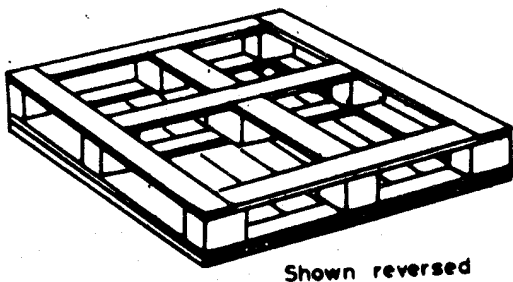


Figure 37. Four-way entry pallet



Shown reversed

Figure 38. Four-way entry pallet with cruciform perimeter base

Winged pallets are pallets designed with decks that extend beyond the outer bearers for lifting by crane with spreader bar slings.

Wooden pallets may be specified in hardwood, which is better suited to rough handling or softwood and may have an unplaned or planed deck of open-boarded or close-boarded construction.

For use with pallet trucks the edge to the bottom deck may be chamfered to facilitate the passage of the load wheels of the truck.

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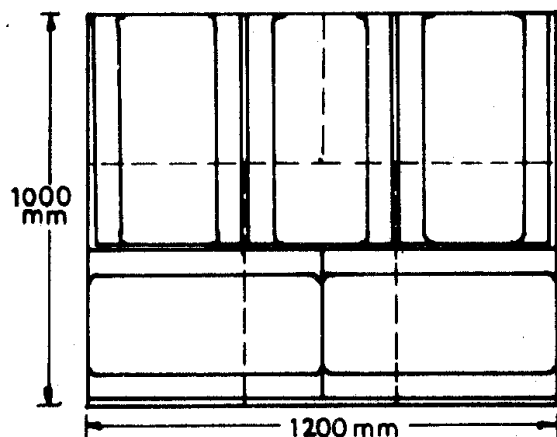
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11. INSULATED CONTAINERS

[11.1 Description](#)

[11.2 Calculation of Fish, Ice and Water Quantities](#)

The use of insulated containers for stowage and transport of fish in iced sea water offers several advantages over traditional boxed and iced practises. It is particularly suited to small pelagic species that are not normally gutted at sea but which are caught in bulk and require rapid chilling because of their high fat content.

Advantages:

1. Fish can be transferred rapidly from deck to the containers (by careful arrangement of the deck pounds and scuttles) with minimum delay and with minimum disruption to fishing effort.
2. Improvements in quality of the fish can be achieved due to the nature of stowage and to the reduction in handling of catch.
3. Rapid unloading of the vessels by removal of containers by crane and refitting with clean iced containers enables a quick turn about of the fishing vessel in port and substantially reduces the labour required for unloading.

Disadvantages:

1. The major disadvantage of the portable insulated container is the reduction of carrying capacity of both the fishing vessel and road transport.
2. For efficient operation of a container system the fishing vessel needs to be designed for the purpose. (Particularly scuttles, chutes, fishroom floors and unloading hatches.)
3. Fishing vessels are restricted to ports that can provide a change of containers.
4. A slight uptake of salt in fish flesh occurs with stowage in sea water.
5. Containerized catches are a less attractive proposition if the fish is to be sold through a traditional market of small unit sale and are better suited for sale direct to the processing factory.

11.1 Description

The following specification relates to a container developed for use in the UK for stowage and handling of herring and is shown in Figure 40. For similar use in tropical areas the insulation thickness should be increased to a minimum of 75 mm.

Container dimensions:	1 170 mm wide x 1320 mm deep x 1950 mm high
Insulation:	50 mm rigid foam polyurethane
Construction:	Aluminium inner skin with GRP outer skin; hinged lid at top and drain at bottom
Capacity:	2.1 m ³
Empty weight:	175 kg
Aeration:	By means of an aluminium lance, built into the container with coupling at top to manifold

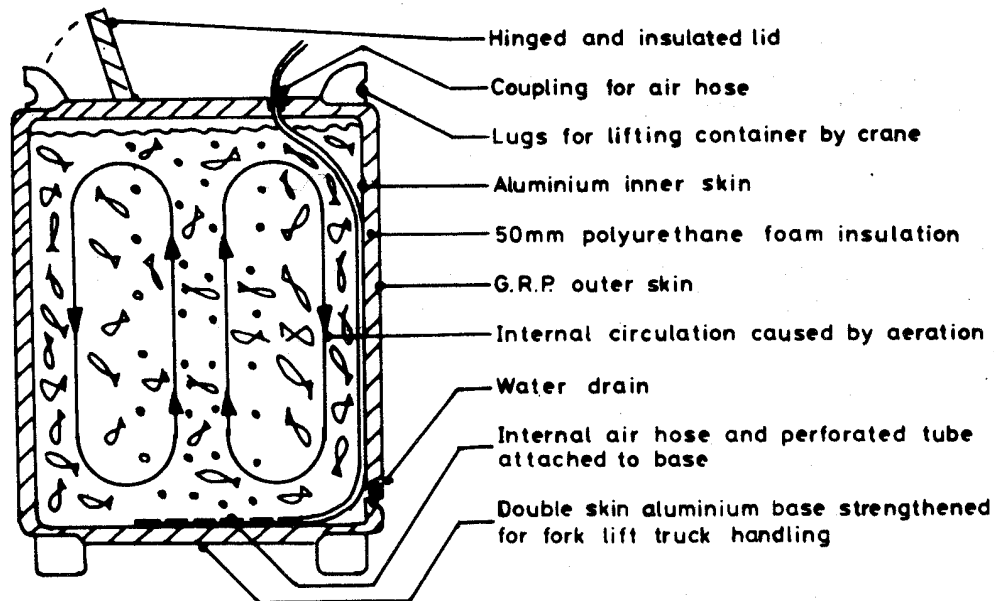


Figure 40. Chilled sea water container

11.2 Calculation of Fish, Ice and Water Quantities

For any given container, the ice:water:fish ratios can be calculated from a knowledge of ambient temperature, sea water temperature, the insulative properties of the container and the period of holding. The requirement of the ice is to cool the sea water and fish to 0°C, to counter the heat input from aeration and to counter the heat gain through the container.

The requirement for water is to provide a medium that will enable rapid heat transfer from the fish and to hold the fish such that they are not subject to crushing.

Table 16 (Section 6.2) shows the weight of ice required to cool, one kilogramme of fish or water to zero degrees centigrade, over a range of temperatures. It is assumed for the purposes of estimation that the specific heats are equal. Table 23 shows the weight of ice required to offset the heat gain through the container previously specified. It assumes a figure of 0.085 kg of ice loss per degree centigrade above zero per hour based on trials with the container.

Table 23 Ice required for each day of stowage to counter heat gain through the walls of the container specified

Ambient temperature (°C)	kg of ice/24h of stowage
35	72
25	51
15	31
5	10

Example calculation

The following example calculation of ice:water:fish ratios assumes ambient temperature of 20°C, sea water temperature of 15°C, a holding period of three days and a container as previously specified.

Assume 1/5 volume of container for water

$$0.2 \times 2.1 = 0.42 \text{ m}^3.$$

Ice required to cool 0.42 m³ of sea water at 15°C from Table 16

$$= 420 \times 0.17 \text{ kg} = 71.4 \text{ kg}$$

which occupies a volume of 0.08 m³ according to Table 3.

Ice required to counter heat gain through container for 3 days from Table 23

$$= 123 \text{ kg}$$

which occupies a volume of 0.13 m³.

For purposes of estimation the heat input by aeration will be assumed negligible.

Volume of remaining space within container

$$V_r = 2.1 - 0.42 - 0.08 - 0.13 = 1.47 \text{ m}^3.$$

This volume will be the volume of fish plus the volume of ice required to cool the fish from 15°C to 0°C.

From Table 16 the ratio of fish:ice is approximately 1:0.17

$$\text{volume of fish} = 1.47 \times 1/1.17 = 1.26 \text{ m}^3. \text{ and}$$

$$\text{volume of ice} = 1.47 \times 0.17/1.17 = 0.21 \text{ m}^3.$$

$$\text{Total volume water} = 0.42 \text{ m}^3$$

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$$\text{Total volume fish} = 1.26 \text{ m}^3$$

From this follows:

$$\text{Ratio fish:ice:water} = 3:1:1 \text{ (by volume).}$$

For higher conditions of ambience and sea water temperatures the above calculation can lead to unacceptably low carrying capacities and in these circumstances what is done in practice is to put in less ice and water initially than calculated but to later drain off some of the water and re-ice. It is important when doing this not to drain off all the water or the fish will no longer be floating in an ice water mix but subject to its dead weight

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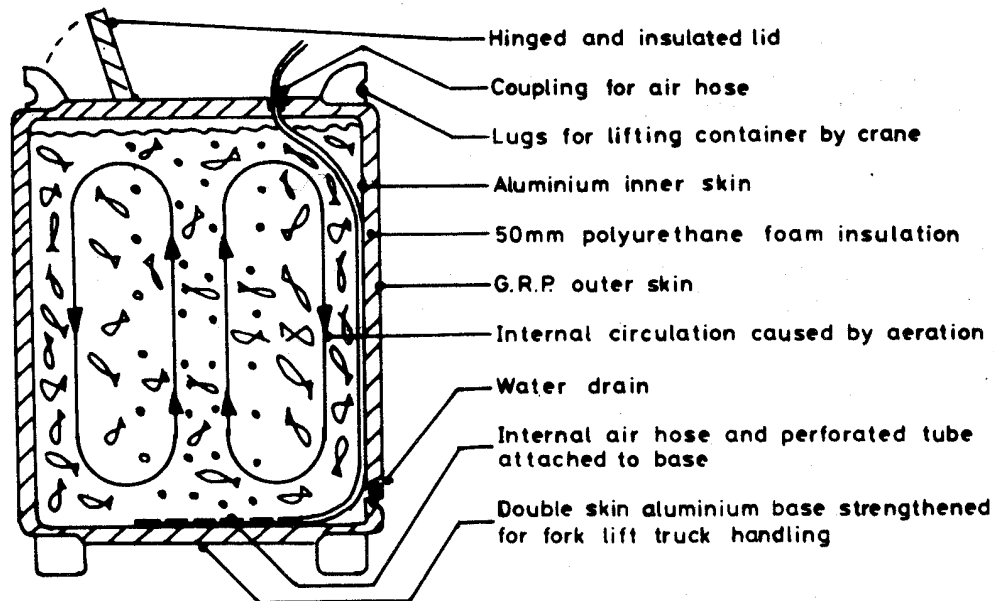


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12. FISH WORKING PREMISES

[12.1 Location](#)

[12.2 Design](#)

- 12.2.1 Basic shape
- 12.2.2 Floors
- 12.2.3 Drains
- 12.2.4 Walls, ceilings and fittings
- 12.2.5 Plant and equipment
- 12.2.6 Area requirements

[12.3 Costs](#)

[12.1 Location](#)

Perhaps the most important decision in the planning of a new processing plant or fish market is the selection of location. which is often critical to the success or otherwise of the venture. Once established it is most disruptive an costly to move site.

In evaluation of a site the following factors should be considered:

- a. supply of raw materials (availability and distance from)
- b. supply of labour
- c. supply of services (electricity, water, sewerage)
- d. disposal of effluents, offal, etc.
- e. proximity to sales area or public
- f. adverse factors effecting neighbours amenity (smell, noise, traffic)
- g. civil costs of site development (clearing, levelling, etc.)
- h. possibility of future expansion
- i. access to good road/rail linkage or to vessel docking

[12.2 Design](#)

The initial cost of a building is only the first of a series of costs which will arise throughout its life. The building will require regular maintenance, heating and lighting, and cleaning and servicing rates and insurance will be incurred. Over the life of a building these running expenses will amount to two or three times its cost of construction and their incidence will depend on its planning and design.

The inclusion of running costs as well as initial costs within the costing concept considerably increases the value of cost analysis of the building design. There is often conflict between the effects of a design feature on capital and running costs, but the long-term nature of the investment necessitates a long-term evaluation of the effect of design on costs. As examples the amount of insulation specified will effect the heat gains or losses to or from a building, the use of natural lighting will influence power consumption and materials of construction will effect life, cost of insurance and the cost of maintenance and cleaning.

It is often helpful at the planning stage to draw up a process flow diagram showing the sequence of operations, proposed equipment, service requirements (water, electricity, steam) and the need for removal of wastes. This will assist in planning of layout and in assessment of total service requirements. Modelling techniques can also be usefully employed in planning layout.

The very diverse nature of fish processing operations, local practices and material availability make it impossible to describe within this text universal detail designs of fish working premises but the following notes relating to the principles of design, construction and materials are relevant.

12.2.1 Basic shape

The basic shape or configuration of a building will be influenced by the nature of the process, the installed equipment and cost considerations. It may also be influenced by site restrictions or planning regulations. Most fish processing buildings and markets are single story or of a hybrid configuration with offices or stores above part of the processing area. In the design of a floor plan particular attention should be paid to product and materials handling; a through-flow design often being the simplest and most economical to operate.

Wholesale fish markets for example are often long narrow structures running the length of and a short distance from, the landing quay. Such a shape enables the maximum number of vessels to simultaneously unload at the market with the minimum handling of fish along the quay for market display. It also enables the maximum number of road vehicles access to the rear of the market for loading. The narrow width of building means reduced handling from vessel to road transport.

12.2.2 Floors

Floors should be hard-wearing, non-porous, washable, well-drained, non-slip and resistant to possible attack from brine, weak ammonia, fish oil and offal. Granolithic concrete is attacked by the continued action of strong brine and acids and accelerated by wear or damage of the surface. Nonetheless it is a popular and reasonably cheap surface for fish working premises. Clay tiles are more expensive than concrete but are harder wearing and less susceptible to attack by brine or acid. Care should be taken that they are laid level. Asphalt is not resistant to oils and is rather soft but is waterproof, fairly hard-wearing and less slippery when wet.

Areas subject to extra traffic may require metal tiles and the exposed edges of loading bays or steps may require some form of metal protection to the edge.

Fish working floor surfaces should be well drained and not allow the formation of water pools. A slope of 1:100 is usually sufficient for drainage but should not be greater than 1:40 which can be dangerous.

12.2.3 Drains

Where possible three drainage systems should be provided, one for domestic foul sewage, for storm water and surface drains, and the main drainage system for handling liquid wastes. Main drains should not connect directly to a sewer without an intermediate trap, and should be sufficiently barge to carry away all waste water without backing up or flooding. Floor drainage channels should have easily removable gratings which can be simply cleaned. It should not be possible for rodents to enter the building via the drainage system.

12.2.4 Walls, ceilings and fittings

The prime requirement of walls, ceilings and fittings in general is that they are easily cleanable. Walls should be smooth and waterproof and ideally surfaced with ceramic tiles to a height of at least 1 m. Pipe runs and electrical cables should be recessed into the wall or boxed in. If brine, salt or acids are used in processing special attention should be paid to protection of the steelwork or use of alternative materials.

12.2.5 Plant and equipment

Again a prime requirement of plant and equipment is that it is readily accessible for easy cleaning. Preferably all plant should be raised off the floor on plinths. Electric motors and starters should be water (pressure) proof and good lighting should be provided where cutting, strapping or similar operations are undertaken. Copper and bronze are not suitable metals when in direct contact with food products; stainless steel or aluminium being preferable.

12.2.6 Area requirements

The floor area requirements for fish handling operations depend on the throughput, the nature of the operation and methods of handling and storage. Within the building adequate space must be left for access and movement of fish, offal, ice, packaging materials, etc. Area requirements for ice and chill stores are given in Sections 5 and 7 and fish box dimensions and capacities in Section 8. Careful consideration should also be given in the planning stage as to the requirements of access to the building and parking in its vicinity particularly in the case of fish markets. As an example, Figure 41 shows the plan of a wet fish (filleting) operation designed for a maximum throughput of 5t (whole gutted fish input) per day. It is typical of many small concerns operating on or near wholesale fish markets supplying a wet fish trade. It is assumed in this case that centralised facilities of canteen, toilets, etc., are available to staff.

The second example shown in Figure 42 is of a wholesale fish market designed for a maximum landing (mostly by vessel) of 200 t per day. The design assumes that a11 fish is laid out for display and that only one auction round is conducted each day. A boxed display is assumed with no stacking of boxes. The design makes allowance for storage of unloading and grading equipment, box cleaning and storage, and washroom facilities. Other facilities such as canteen, ice supply, banking and other offices are assumed to be available.

12.3 Costs

The capital cost of buildings suitable for fish processing or handling will vary enormously depending on location, design, materials of construction and size but as an indication of UK cost levels the following table gives the cost per square metre for three classes of building (excluding ground cost) .

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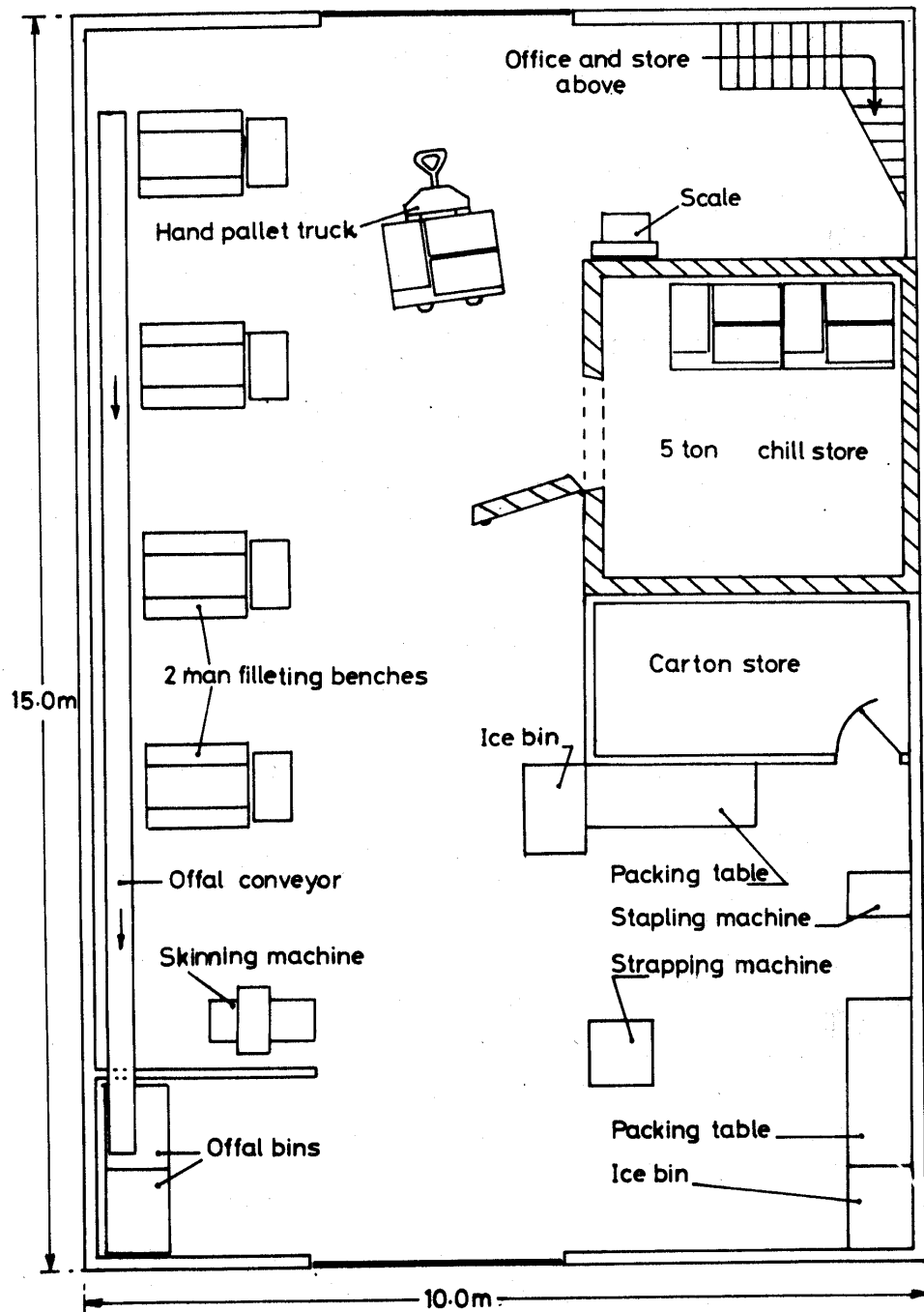


Figure 41. Wet fish processing unit -5 t/d

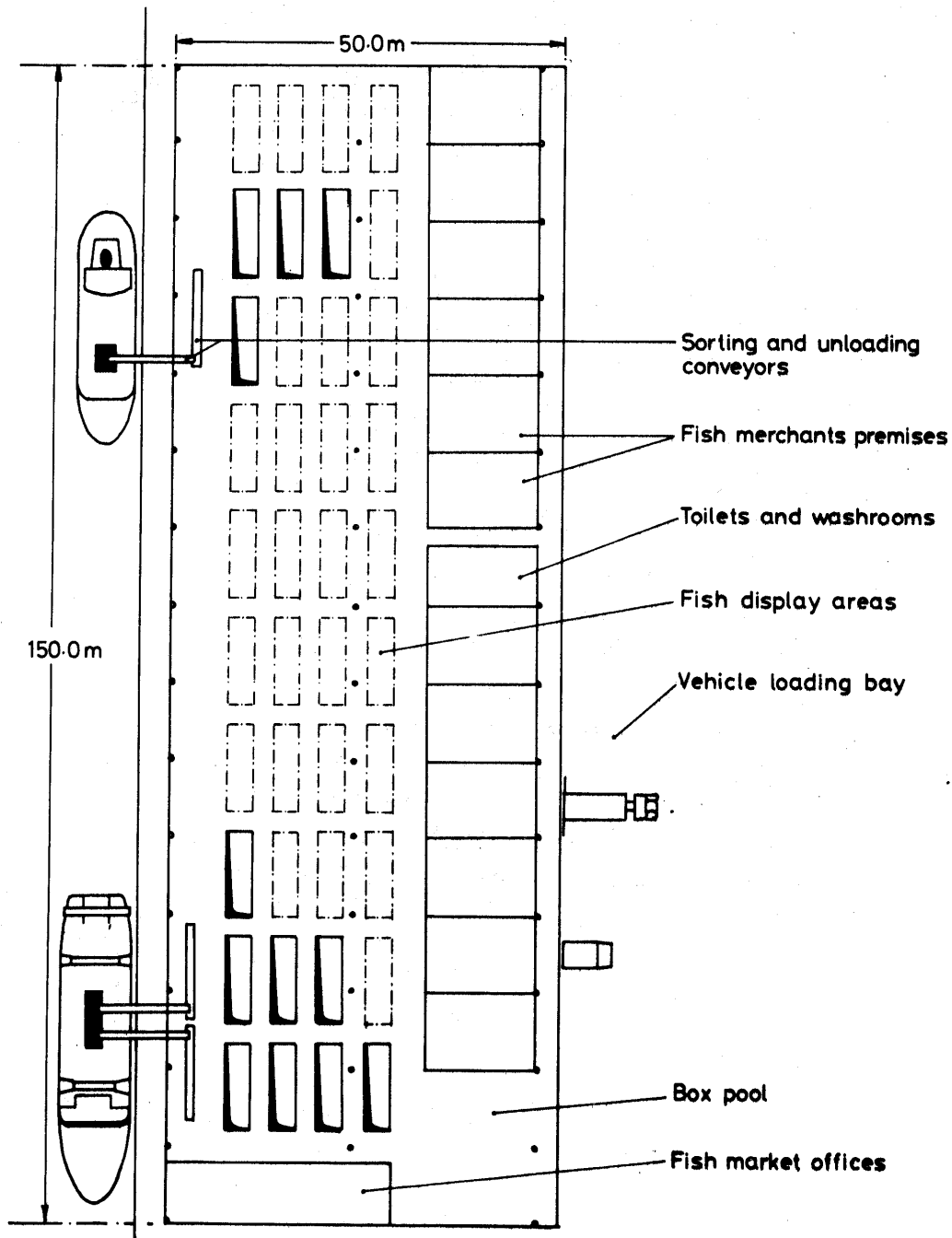


Figure 42. Wholesale fish market - 200 t/d





12. FISH WORKING PREMISES

[12.1 Location](#)

[12.2 Design](#)

- 12.2.1 Basic shape
- 12.2.2 Floors
- 12.2.3 Drains
- 12.2.4 Walls, ceilings and fittings
- 12.2.5 Plant and equipment
- 12.2.6 Area requirements

[12.3 Costs](#)

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- g. civil costs of site development (clearing, levelling, etc.)
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The inclusion of running costs as well as initial costs within the costing concept considerably increases the value of cost analysis of the building design. There is often conflict between the effects of a design feature on capital and running costs, but the long-term nature of the investment necessitates a long-term evaluation of the effect of design on costs. As examples the amount of insulation specified will effect the heat gains or losses to or from a building, the use of natural lighting will influence power consumption and materials of construction will effect life, cost of insurance and the cost of maintenance and cleaning.

It is often helpful at the planning stage to draw up a process flow diagram showing the sequence of operations, proposed equipment, service requirements (water, electricity, steam) and the need for removal of wastes. This will assist in planning of layout and in assessment of total service requirements. Modelling techniques can also be usefully employed in planning layout.

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Wholesale fish markets for example are often long narrow structures running the length of and a short distance from, the landing quay. Such a shape enables the maximum number of vessels to simultaneously unload at the market with the minimum handling of fish along the quay for market display. It also enables the maximum number of road vehicles access to the rear of the market for loading. The narrow width of building means reduced handling from vessel to road transport.

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Floors should be hard-wearing, non-porous, washable, well-drained, non-slip and resistant to possible attack from brine, weak ammonia, fish oil and offal. Granolithic concrete is attacked by the continued action of strong brine and acids and accelerated by wear or damage of the surface. Nonetheless it is a popular and reasonably cheap surface for fish working premises. Clay tiles are more expensive than concrete but are harder wearing and less susceptible to attack by brine or acid. Care should be taken that they are laid level. Asphalt is not resistant to oils and is rather soft but is waterproof, fairly hard-wearing and less slippery when wet.

Areas subject to extra traffic may require metal tiles and the exposed edges of loading bays or steps may require some form of metal protection to the edge.

Fish working floor surfaces should be well drained and not allow the formation of water pools. A slope of 1:100 is usually sufficient for drainage but should not be greater than 1:40 which can be dangerous.

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12.2.4 Walls, ceilings and fittings

The prime requirement of walls, ceilings and fittings in general is that they are easily cleanable. Walls should be smooth and waterproof and ideally surfaced with ceramic tiles to a height of at least 1 m. Pipe runs and electrical cables should be recessed into the wall or boxed in. If brine, salt or acids are used in processing special attention should be paid to protection of the steelwork or use of alternative materials.

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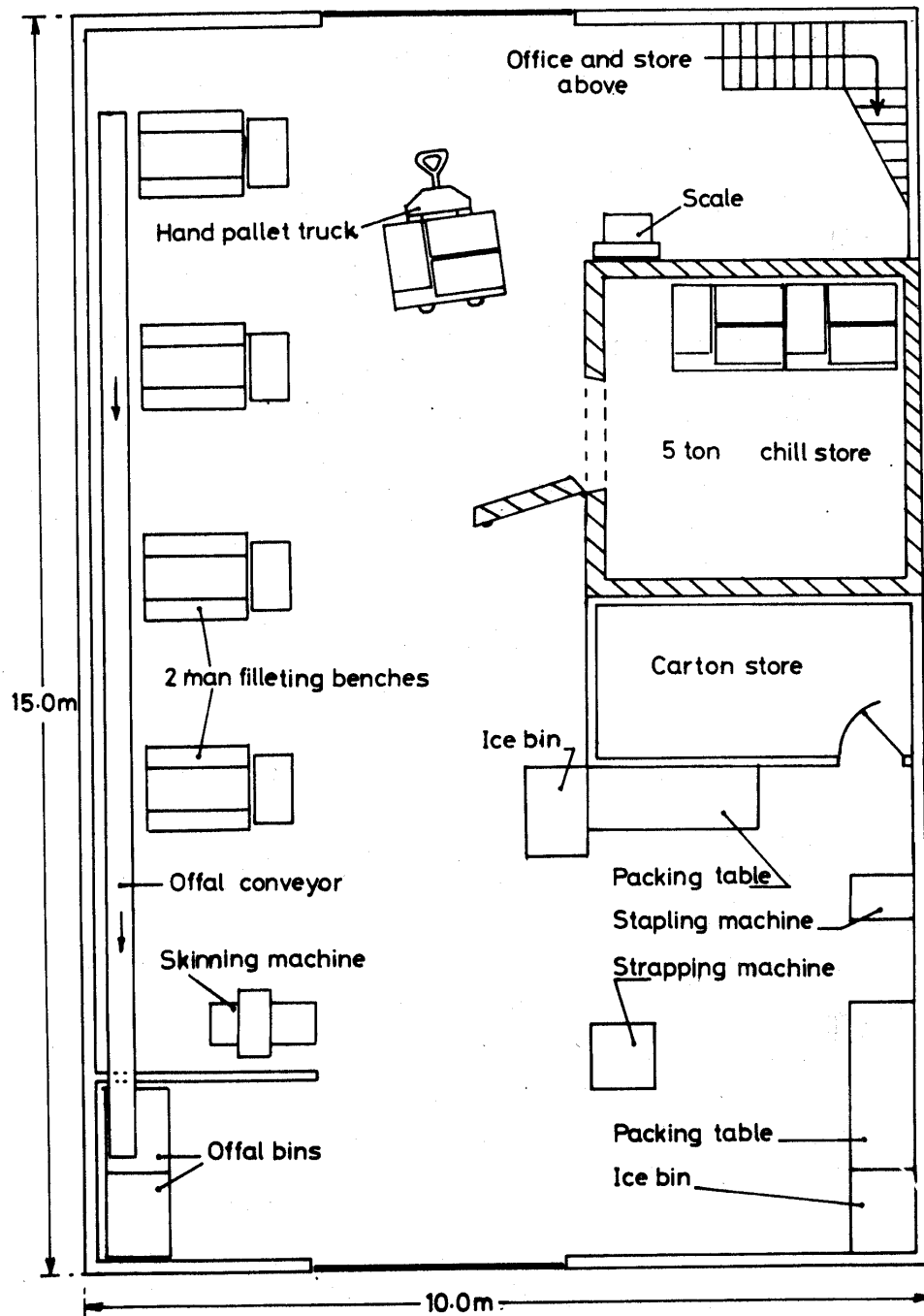


Figure 41. Wet fish processing unit -5 t/d

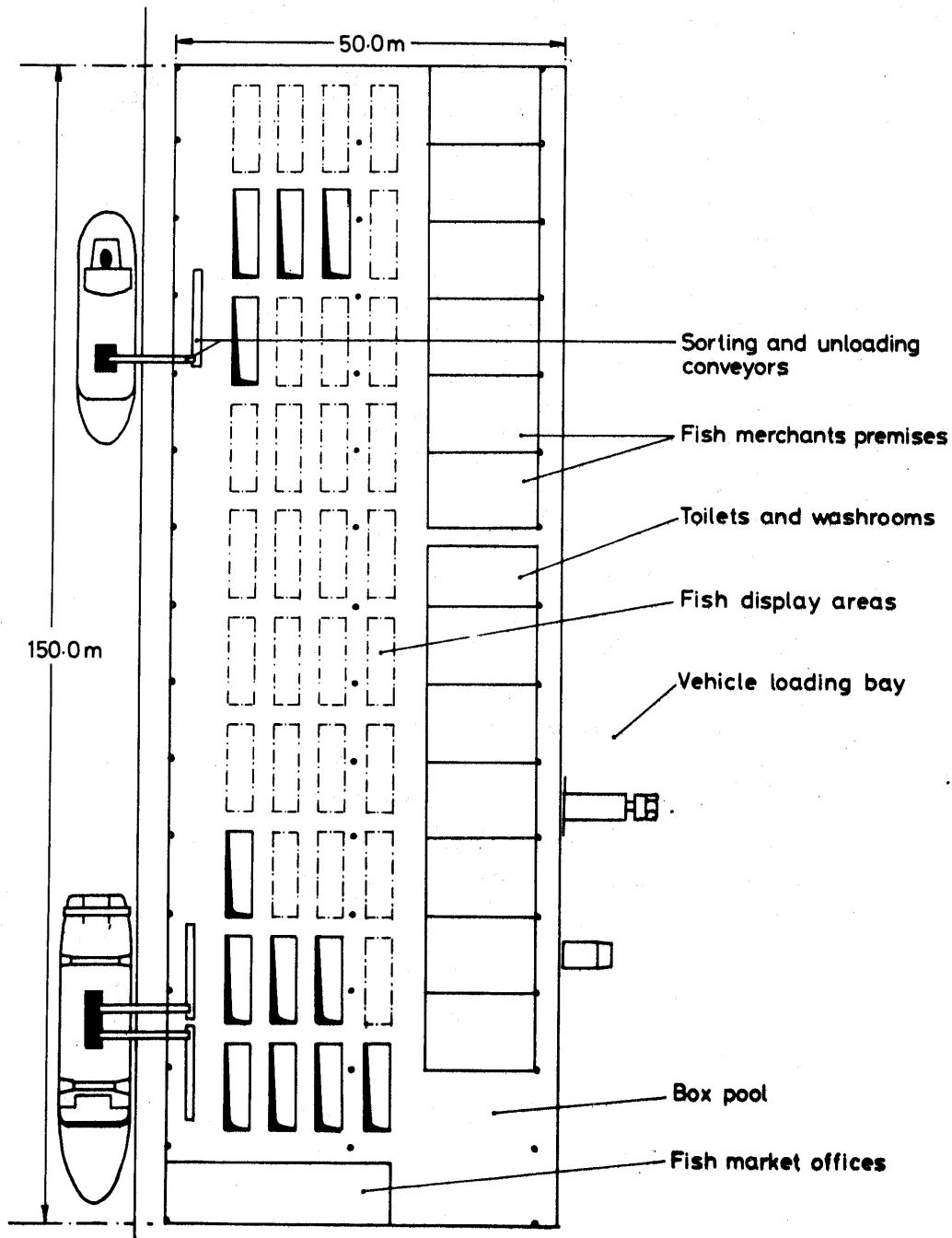


Figure 42. Wholesale fish market - 200 t/d





13. UNITS

[13.1 Selected Conventional Metric Units](#)

[13.2 Selected International System Units](#)

The units of measurement used throughout the text are the conventional metric units, supplemented on a few occasions by the British units. However, for the convenience of the readers who may have familiar with the new International System of Units their conversion factors into the conventional units, and vice-versa, are given below for all the units that are not identical in the systems and that have been used in the text.

13.1 Selected Conventional Units

Power:	1 horsepower (hp) = 0.7457 kW
Specific energy:	1 kilocalorie per kilogramme (kcal/kg) = 4.187 kJ/kg
Heat flow rate:	1 kilocalorie per hour (kcal/h) = 1.163 W 1 British thermal unit per hour (Btu/h) = 0.2931 W
Specific heat capacity, mass basis:	1 kilocalorie per kilogramme, degree Celsius (kcal/kg deg C) = 4.187 J/g deg C
Thermal conductivity:	1 kilocalorie metre per square metre hour degree Celsius (kcal m/m ² h deg C) = 1.163 W m/m ² deg C 1 kilocalorie per metre hour degree Celsius (kcal/m h deg C) = 1.163 W/m deg C

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Power:	1 kilowatt (kW) = 1.341 hp
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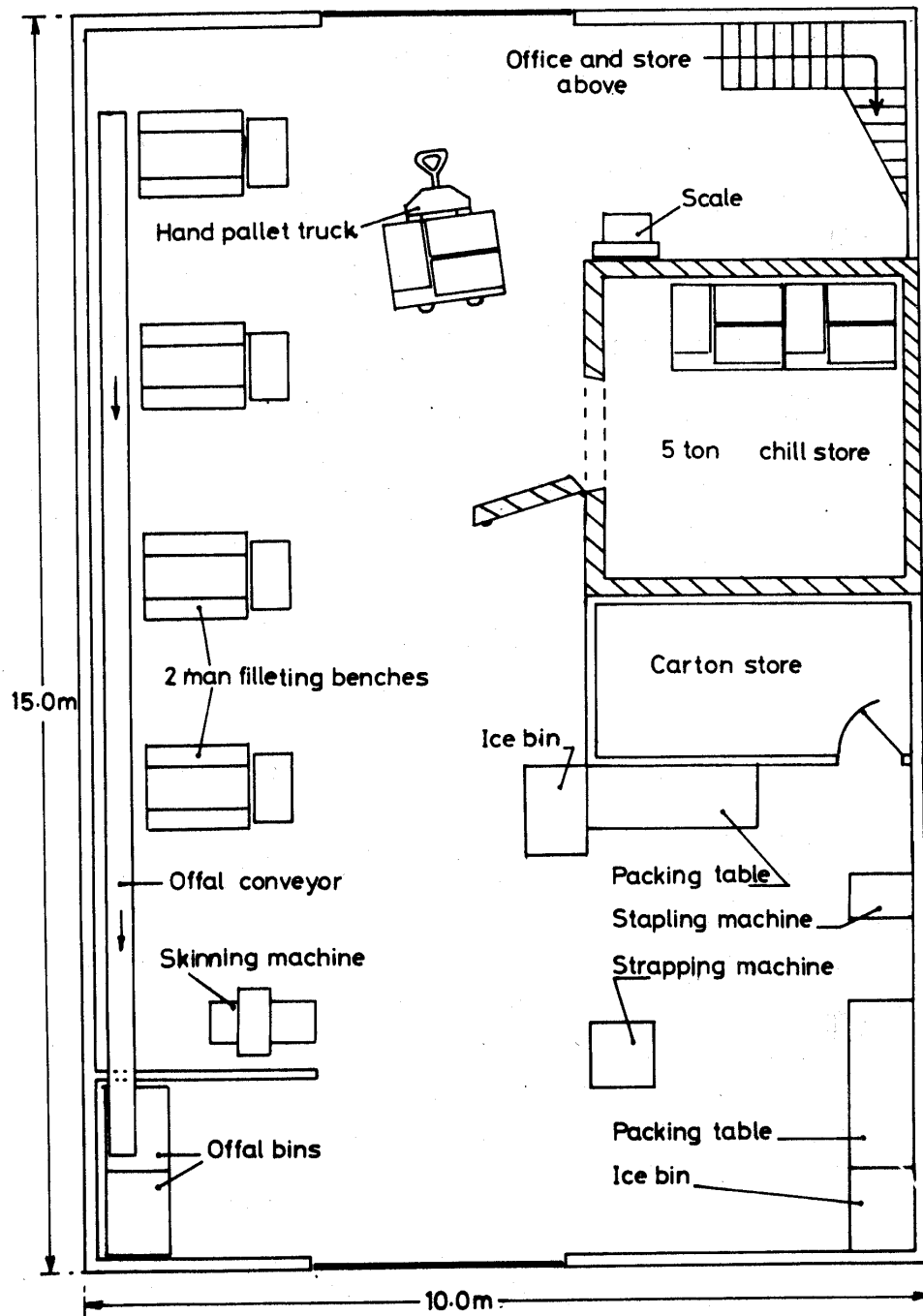


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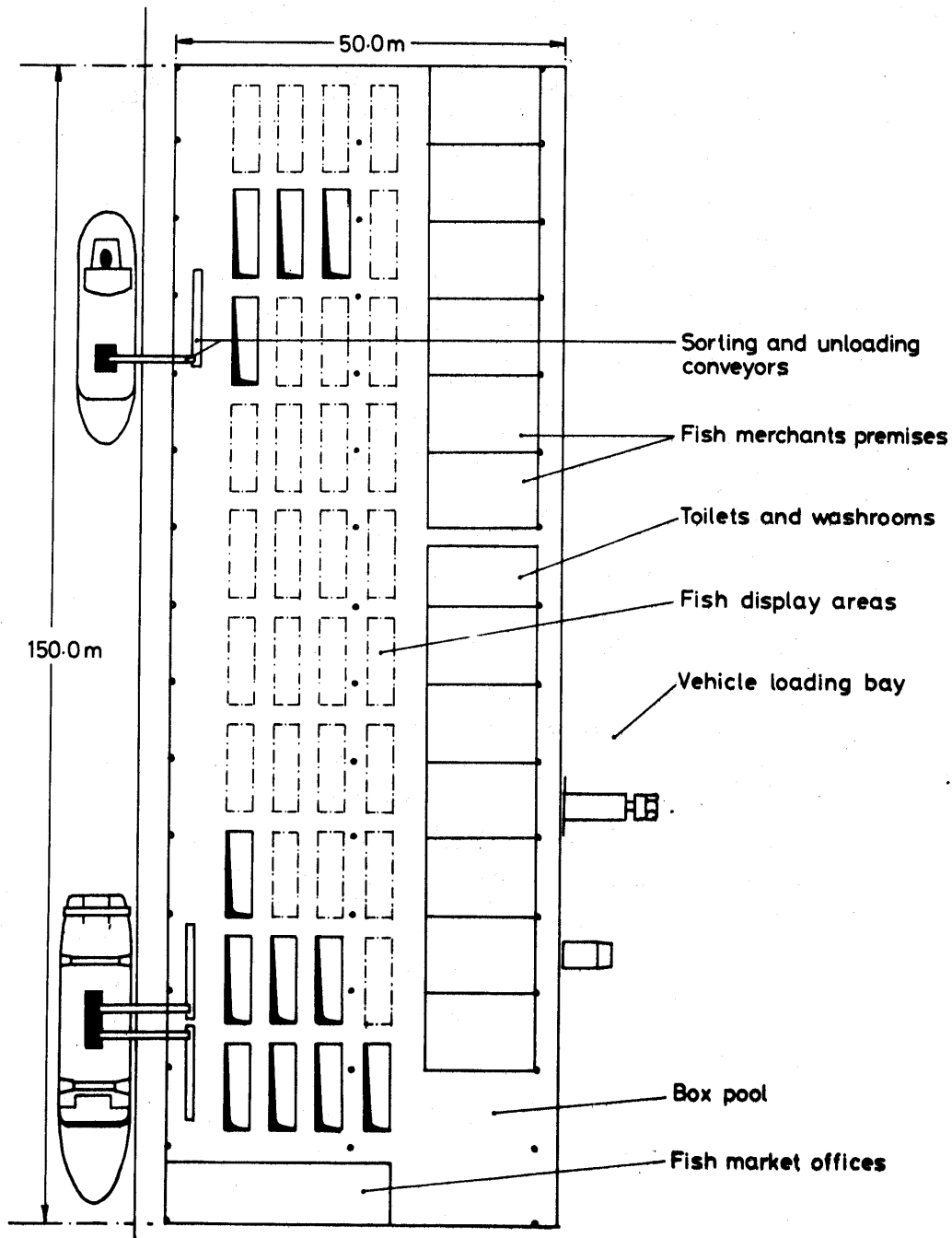


Figure 42. Wholesale fish market - 200 t/d





10. PALLETS

[10.1 Types](#)

[10.2 Materials](#)

[10.3 Costs](#)

10.3.1 Life

10.3.2 Specification

[10.1 Types](#)

A pallet forms the base structure for a load in order that it may be handled by a fork lift or pallet truck. A unit load may be built up of a number of smaller unit loads, for example, fish boxes, on a pallet and transported and handled as a single load making the handling much simpler. They are particularly useful with regular shaped loads such as fish boxes when they can be stacked one upon another. If the loads are irregular, or if damage could occur due to crushing, post or box pallets can be used to stack one upon another as shown in Figures 32 and 33.

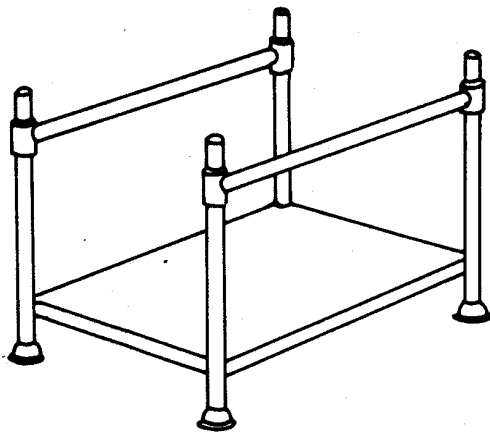


Figure 32. Post pallet

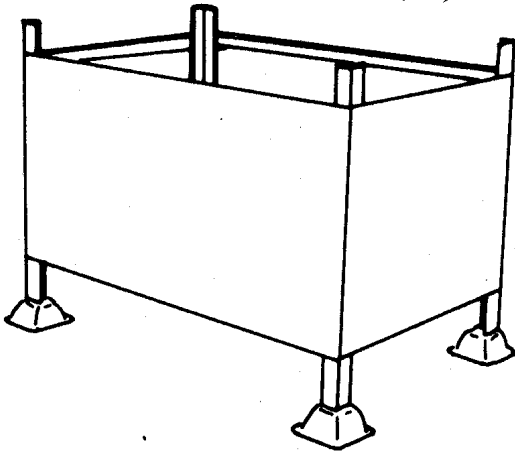


Figure 33. Box pallet

A pallet converter, shown in Figure 34, is used with an ordinary flat pallet to achieve the same purpose as a post or box pallet.

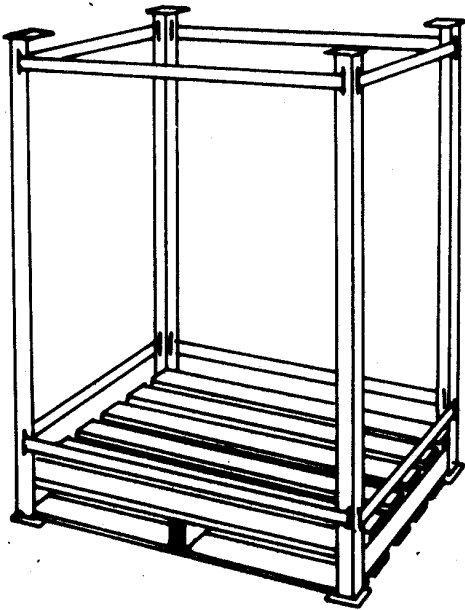


Figure 34. Pallet converter .

The flat pallet is the most common type of pallet in general use in the fishing industry and can be of reversible or non-reversible type and of two-way entry or four-way entry. The reversible pallet shown in Figure 35 has identical top and bottom decks either of which can be load bearing and is of strong construction. It is not suitable for use with pallet trucks and is of two-way entry. The non-reversible pallet has only a load bearing top deck and is suitable for use with pallet and fork lift trucks. The two-way entry pallet consists of a top deck, three full length bearers and a suitably spaced bottom deck as shown in Figure 36.

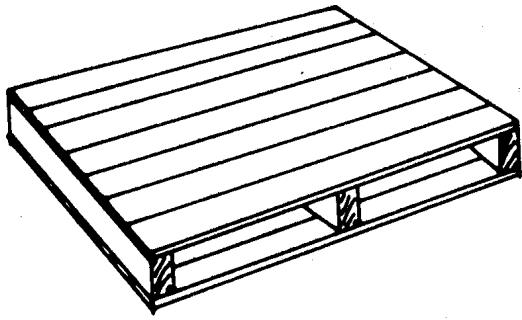


Figure 35. Two-way entry reversible

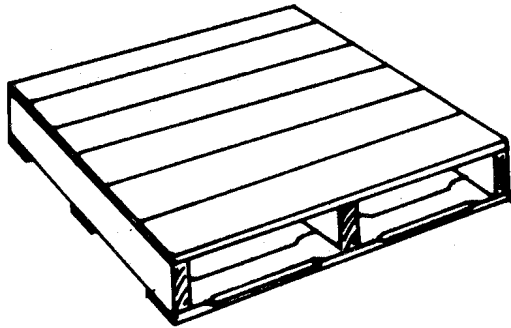


Figure 36. Two-way entry non-reversible

The four-way entry pallet which has advantages in handling consists of a top deck, 9 spacing blocks and 3 transverse stringers as shown in Figure 37. It is not as strong as a two-way entry pallet but may be strengthened by additional slats to the base to form a perimeter base or cruciform base pallet as shown in Figure 38.

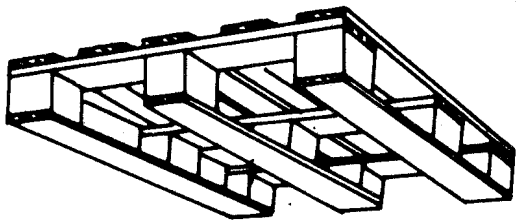
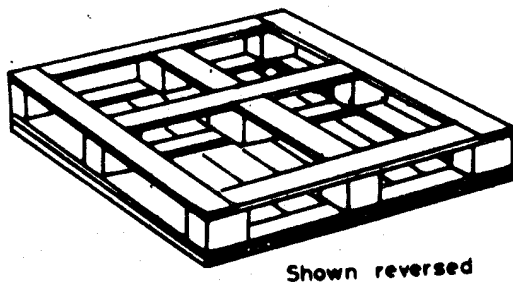


Figure 37. Four-way entry pallet



Shown reversed

Figure 38. Four-way entry pallet with cruciform perimeter base

Winged pallets are pallets designed with decks that extend beyond the outer bearers for lifting by crane with spreader bar slings.

Wooden pallets may be specified in hardwood, which is better suited to rough handling or softwood and may have an unplaned or planed deck of open-boarded or close-boarded construction.

For use with pallet trucks the edge to the bottom deck may be chamfered to facilitate the passage of the load wheels of the truck.

10.2 Materials

Timber pallets may be of soft or hardwood but must be of good commercial quality that complies with international standards in respect to grain, knots, resin, splits and bark pockets. If screws are used in the manufacture they should not be hammered in and if nails are used they should be of the annular ring type.

As with fish boxes, timber is not well suited for applications in a wet environment as the pallets absorb water which can weaken and damage them as well as making them difficult to clean. The low first cost compared with other materials however has resulted in its continued use in the processing industry.

Plastic pallets are available which have many advantages over the timber pallet baring first cost. Plastic pallets are smooth, do not absorb water (and hence have a constant tare weight), are easy to clean and have longer life. Unfortunately the high first cost and the requirement frequently to leave the factory and be possibly lost has restricted its use.

Other than that it is ideally suited for use in the processing industry.

Metal pallets are available suitable for use in a wet environment if properly protected, and designed so as not to damage tiled floors. Neither mechanical fasteners nor welding, fillets should project above the deck surface to an extent greater than the thickness of the deck materials. If the pallet is galvanized the surface should not be excessively rough.

10.3 Costs

The following table lists the ex-works cost of four-way entry pallets based on an order of 100 pallets. A slight reduction would be available in most cases for larger orders.

Table 22 Four-way pallet costs

Type	Material	Size (mm)	Cost (US\$)
Non-reversible flat	Timber	800 x 1 200	8.80
Non-reversible flat	Timber	1 000 x 1 200	10.60
Non-reversible flat	Timber	1 200 x 1 200	12.00
Non-reversible flat	Timber	1 800 x 1 200	16.80
Reversible flat	Timber	800 x 1 200	10.80
Reversible flat	Timber	1 000 x 1 200	13.60
Reversible flat	Timber	1 200 x 1 200	15.60
Reversible flat	Timber	1 800 x 1 200	21.80
Non-reversible flat	H D polyethylene	1 000 x 1 200	30.00
Box with lid and drain <u>a/</u>	H D polyethylene	800 x 1 200 x 825	200.00
Box with lid and drain <u>a/</u>	H D polyethylene	930 x 1 250 x 720	280.00
Box with lid and drain <u>a/</u>	H D polyethylene	1 120 x 1 530 x 885	393.00
Box with sheet sides	Steel with painted finish	1 000 x 1 200 x 850	110.00
Box with sheet sides	Steel with galvanized finish	1 000 x 1 200 x 850	176.00

Post	Steel with painted finish	1 000 x 1 200 x 850	80.00
Post	Steel with galvanized finish	1 000 x 1 200 x 850	128.00

a/ Suitable for iced fish or ice chilled water and fish

10.3.1 Life

The working life of a pallet depends entirely on its usage, the degree of rough handling it receives and its likelihood of loss. The life of a plastic pallet will be many times that of a timber pallet justifying its high first cost if loss is not a serious problem.

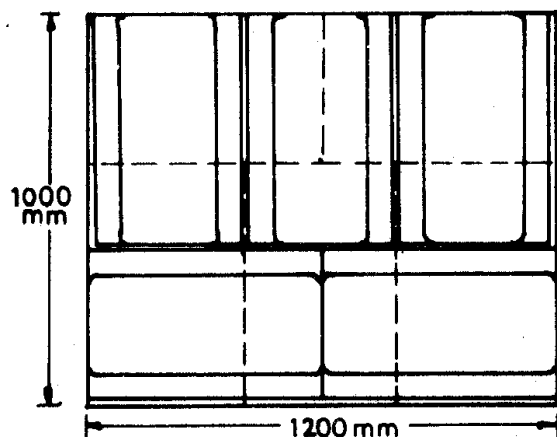
Metal pallets will have a life between that of wood and plastic.

Plastic pallets can be distinctively coloured or permanently marked for identification to assist recovery and have little alternative use unlike the timber pallet that can be burnt for firewood or used for other purposes.

10.3.2 Specification.

The International Organization for Standardization has recommended the following plan dimensions for standard pallets: 800 x 1 200, 1 000 x 1 200, 1 200 x 1 200, 1 200 x 1 600 (maritime use) and 1 200 x 1 800 mm. Each pallet can be specified for loading of 1 000, 1 500 or 2 000 kg.

The standard plan sizes are designed for loading of transport vehicles for industry in general and unfortunately are not always well suited for handling of fish in boxes. If standard flat pallets are to be used for handling fish in boxes consideration should be given in selection of pallet size to the stacking plan on the pallet for optimum utilization. For example the 600 x 368 x 214 mm plastic box commonly used for small pelagic species fits well on the 1 000 x 1 200 (as shown in Figure 39), 1 200 x 1 200 and the 1 200 x 1 800 mm pallets.



Standard fish box shown stacked on pallet (dotted line shows alternate layer stacking with some types of box)

Figure 39. Pallet stacking plan for fish boxes

Some manufacturers of plastic boxes produce pallets and stillages not necessarily to ISO specification to suit their range of fish boxes.

Depending on the base design of the box subsequent layers of boxes may be repeated on the same plan or 'mirror imaged' as shown dotted in Figure 39 to give better stability.

For handling of fish in bulk particularly from the market box pallets often offer advantages in handling and storage.





11. INSULATED CONTAINERS

[11.1 Description](#)

[11.2 Calculation of Fish, Ice and Water Quantities](#)

The use of insulated containers for stowage and transport of fish in iced sea water offers several advantages over traditional boxed and iced practises. It is particularly suited to small pelagic species that are not normally gutted at sea but which are caught in bulk and require rapid chilling because of their high fat content.

Advantages:

1. Fish can be transferred rapidly from deck to the containers (by careful arrangement of the deck pounds and scuttles) with minimum delay and with minimum disruption to fishing effort.
2. Improvements in quality of the fish can be achieved due to the nature of stowage and to the reduction in handling of catch.
3. Rapid unloading of the vessels by removal of containers by crane and refitting with clean iced containers enables a quick turn about of the fishing vessel in port and substantially reduces the labour required for unloading.

Disadvantages:

1. The major disadvantage of the portable insulated container is the reduction of carrying capacity of both the fishing vessel and road transport.
2. For efficient operation of a container system the fishing vessel needs to be designed for the purpose. (Particularly scuttles, chutes, fishroom floors and unloading hatches.)
3. Fishing vessels are restricted to ports that can provide a change of containers.
4. A slight uptake of salt in fish flesh occurs with stowage in sea water.
5. Containerized catches are a less attractive proposition if the fish is to be sold through a traditional market of small unit sale and are better suited for sale direct to the processing factory.

11.1 Description

The following specification relates to a container developed for use in the UK for stowage and handling of herring and is shown in Figure 40. For similar use in tropical areas the insulation thickness should be increased to a minimum of 75 mm.

Container dimensions:	1 170 mm wide x 1320 mm deep x 1950 mm high
Insulation:	50 mm rigid foam polyurethane
Construction:	Aluminium inner skin with GRP outer skin; hinged lid at top and drain at bottom
Capacity:	2.1 m ³
Empty weight:	175 kg
Aeration:	By means of an aluminium lance, built into the container with coupling at top to manifold

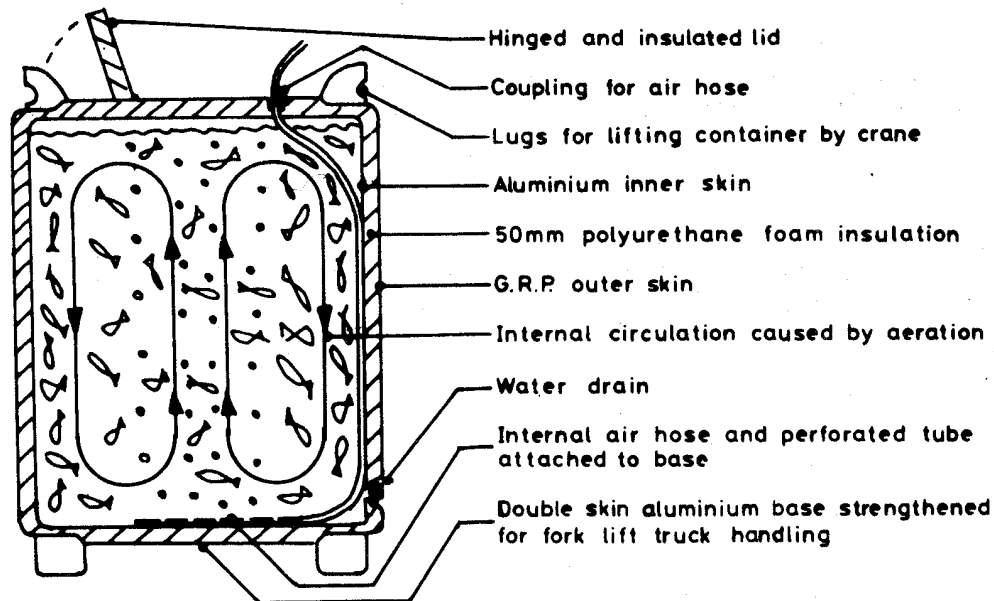


Figure 40. Chilled sea water container

11.2 Calculation of Fish, Ice and Water Quantities

For any given container, the ice:water:fish ratios can be calculated from a knowledge of ambient temperature, sea water temperature, the insulative properties of the container and the period of holding. The requirement of the ice is to cool the sea water and fish to 0°C, to counter the heat input from aeration and to counter the heat gain through the container.

The requirement for water is to provide a medium that will enable rapid heat transfer from the fish and to hold the fish such that they are not subject to crushing.

Table 16 (Section 6.2) shows the weight of ice required to cool, one kilogramme of fish or water to zero degrees centigrade, over a range of temperatures. It is assumed for the purposes of estimation that the specific heats are equal. Table 23 shows the weight of ice required to offset the heat gain through the container previously specified. It assumes a figure of 0.085 kg of ice loss per degree centigrade above zero per hour based on trials with the container.

Table 23 Ice required for each day of stowage to counter heat gain through the walls of the container specified

Ambient temperature (°C)	kg of ice/24h of stowage
35	72
25	51
15	31
5	10

Example calculation

The following example calculation of ice:water:fish ratios assumes ambient temperature of 20°C, sea water temperature of 15°C, a holding period of three days and a container as previously specified.

Assume 1/5 volume of container for water

$$0.2 \times 2.1 = 0.42 \text{ m}^3.$$

Ice required to cool 0.42 m³ of sea water at 15°C from Table 16

$$= 420 \times 0.17 \text{ kg} = 71.4 \text{ kg}$$

which occupies a volume of 0.08 m³ according to Table 3.

Ice required to counter heat gain through container for 3 days from Table 23

$$= 123 \text{ kg}$$

which occupies a volume of 0.13 m³.

For purposes of estimation the heat input by aeration will be assumed negligible.

Volume of remaining space within container

$$V_r = 2.1 - 0.42 - 0.08 - 0.13 = 1.47 \text{ m}^3.$$

This volume will be the volume of fish plus the volume of ice required to cool the fish from 15°C to 0°C.

From Table 16 the ratio of fish:ice is approximately 1:0.17

$$\text{volume of fish} = 1.47 \times 1/1.17 = 1.26 \text{ m}^3. \text{ and}$$

$$\text{volume of ice} = 1.47 \times 0.17/1.17 = 0.21 \text{ m}^3.$$

$$\text{Total volume water} = 0.42 \text{ m}^3$$

$$\text{Total volume ice} = 0.08 + 0.13 + 0.21 = 0.42 \text{ m}^3$$

$$\text{Total volume fish} = 1.26 \text{ m}^3$$

From this follows:

$$\text{Ratio fish:ice:water} = 3:1:1 \text{ (by volume).}$$

For higher conditions of ambience and sea water temperatures the above calculation can lead to unacceptably low carrying capacities and in these circumstances what is done in practice is to put in less ice and water initially than calculated but to later drain off some of the water and re-ice. It is important when doing this not to drain off all the water or the fish will no longer be floating in an ice water mix but subject to its dead weight

which can lead to damage by crushing.





13. UNITS

[13.1 Selected Conventional Metric Units](#)

[13.2 Selected International System Units](#)

The units of measurement used throughout the text are the conventional metric units, supplemented on a few occasions by the British units. However, for the convenience of the readers who may have familiar with the new International System of Units their conversion factors into the conventional units, and vice-versa, are given below for all the units that are not identical in the systems and that have been used in the text.

13.1 Selected Conventional Units

Power:	1 horsepower (hp) = 0.7457 kW
Specific energy:	1 kilocalorie per kilogramme (kcal/kg) = 4.187 kJ/kg
Heat flow rate:	1 kilocalorie per hour (kcal/h) = 1.163 W 1 British thermal unit per hour (Btu/h) = 0.2931 W
Specific heat capacity, mass basis:	1 kilocalorie per kilogramme, degree Celsius (kcal/kg deg C) = 4.187 J/g deg C
Thermal conductivity:	1 kilocalorie metre per square metre hour degree Celsius (kcal m/m ² h deg C) = 1.163 W m/m ² deg C 1 kilocalorie per metre hour degree Celsius (kcal/m h deg C) = 1.163 W/m deg C

Thermal conductance:	1 kilocalorie per square metre hour degree Celsius (kcal/m ² h deg C) = 1.163 W/m ² deg C
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13.2 Selected International System Units

Power:	1 kilowatt (kW) = 1.341 hp
Specific energy:	1 kilojoule per kilogramme (kJ/kg) = 0.239 kcal/kg
Heat flow rate:	1 watt (W) = 0.86 kcal/h 1 watt (W) = 3.412 Btu/h
Specific heat capacity, mass basis:	1 joule per gramme degree celsius (J/g deg C) = 0.239 kcal/kg deg C
Thermal conductivity:	1 watt metre per square metre degree celsius (W m/m ² deg C) = 0.86 kcal m/m ² h deg C 1 watt per metre degree celsius (W/m deg C) = 0.86 kcal/m h deg C
Thermal conductance:	1 watt per square metre degree celsius (W/m ² deg C) = 0.86 kcal /m ² h deg C

