ENGINEERING STANDARD

FOR

COLD STORES AND ICE PLANTS

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0. INTRODUCTION

This Engineering Standard covers the development and practical phase of refrigeration for those who are already familiar with these fundamentals.

The development phase embrace a brief study of the processes essential to the trouble-free operation of the refrigeration system, its load calculation, type, safety and other characteristics including controls, cooling fluids such as water, brine and refrigerants etc.

The practical phase is the study of the refrigerating priorities including compressor protection and compounding, compressor oil, heat transfer and the function, and operating principles of an overall system.

For the convenience of design engineer separate sections containing tables for load calculations and characteristics of refrigerants and other engineering tables are illustrated in the attachments.

1. SCOPE

This Engineering Standard provides for minimum requirements for commercial and industrial field-erected cold stores, pre-fabricated cold stores and ice making system (ice plants) covering the total refrigerating system complying with safety and automatic operation of the applied system.

The applicable refrigerants covered are the halocarbon and ammonia gas with commonly used brine coolant as secondary refrigerant.

For furthur information and coordination, this Standard shall be read in conjunction with IPS-M-AR-185.

This Standard does not cover hydrocarbon gasses required for the refrigeration system of oil, gas and petrochemical industries.

2. REFERENCES

Throughout this Standard the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Consultant.

ANSI / ASME B31.5-1987	"Pressure Code for Refrigeration Piping"
ANSI / ASHRAE 15-1989	"Safety Code for Mechanical Refrigeration"
ANSI / ASME A13.1-1981 (R 1985)	"Scheme for the Identification of Piping Systems"
ANSI / ARI 520-90	"Positive Displacement Refrigerant Compressors and Condensing Units"
ANSI / ARI 495-85	"Refrigerant Liquid Receivers"
ANSI / NFPA 214-1988	"Water Cooling Towers"
ASTM B42-88	"Specification for Seamless Copper Pipes Standard Sizes"
ARI 420-89	"Unit Coolers for Refrigeration"
ARI 510-87	"Ammonia Compressor Units"

3. DEFINITIONS & TERMINOLOGY

3.1 Absolute Zero

The zero point on the absolute temperature scale, 459.69 degrees below the zero of the Fahrenheit scale, (termed Rankine) 273.16 degree below the zero on the Centigrade scale (termed Kelvin).

3.2 Calibration

Process of dividing and numbering the scale of an instrument; also of correcting or determining the error of an existing scale, or of evaluating one quality in terms of reading of another.

3.3 Coefficient of Expansion

The change in length per unit length or the change in volume per unit volume, per degree change in temperature.

3.4 Compression, Ratio of

Ratio of absolute pressures after and before compression.

3.5 Critical Point

Of a substance, state point at which liquid and vapor have identical properties; critical temperature, critical pressure and critical volume are the terms given to the temperature or pressure and volume at the critical point. Above the critical temperature or pressure there is no line of demarcation between liquid and gaseous phases.

3.6 Cryohydrate

A frozen mixture of water and salt; a brine mixed in eutectic proportions to give the lowest freezing point.

3.7 Emissivity

The ratio of the total radiant flux emitted by a surface to that emitted by an ideal black body at the same temperature.

3.8 Eutectic Mixture (Solution)

A mixture which melts or freezes at constant temperature and with constant composition. Its melting point is usually the lowest possible for mixture of the given substances.

3.9 Extruded

Pushed out through a die. Bars of ice, metal rods, shapes and tubes are made by this method.

3.10 Flash Chamber

Separating tank placed between the expansion valve and evaporator in a refrigeration system to separate and bypass any flash gas formed in the expansion valve.

3.11 Flash Gas

The gas resulting from the instantaneous evaporation of refrigerant in a pressure-reducing device to cool the refrigerant to the evaporation temperature obtaining at the reduced pressure.

3.12 Flash Point

Temperature of combustible materials, as oil, at which there is a sufficient vaporization to ignite the vapor, but not sufficient vaporization to support combustion of the material.

3.13 Hydrolysis

The splitting up of compounds by reaction with water; e.g., reaction dichlorodifluoromethane or methyl chloroide with water, in which cases acid materials are formed.

3.14 Hydrometer

An instrument which, by the extent of its submergence, indicates the specific gravity of the liquid in which it floats.

3.15 Hygrometer

Instrument responsive to humidity conditions (usually relative humidity) of the atmosphere.

3.16 Lyophilization

The process of dehydrating a frozen substance under conditions of sublimation; e.g., vacuum-freeze drying.

3.17 Refrigerant

Refrigerants are heat carrying medium which during their cycle absorb heat at a low temperature level, are compressed by a heat pump to a higher temperature where they are able to discharge the absorbed heat together with that added during the compression to the condenser, cooling water or circulating air.

3.18 Thawing

Changing free water, or containing water as in foods, from solid phase to liquid phase by the addition of heat.

3.19 Vapor Lock

Formation of some vapor or all vapor in a liquid line reducing weight flow as compared to weight flow in liquid phase with the same pressure differential.

3.20 Vapor Pressure

The pressure exerted by the vapor released from any materials at given temperature, when enclosed in a vapor-tight container.

3.21 Volatile Liquid

One which evaporates readily at atmospheric pressure and room temperature.

4. UNITS

This standard is based on International System of Units, (SI) except where otherwise specified.

5. BASIC DESIGN REQUIREMENTS

5.1 General

To select a refrigeration equipment which will result in a balanced system, it is necessary to calculate the total refrigeration load of the space.

In general refrigeration loads can be grouped into five main categories:

1) Transmission Load (Heat gain through walls, roof and floors).
2) Infiltration (Air change Load).
3) Internal Load (Heat gain from people, lights, pallets, fork lift, electric motors etc.).
4) Product load (sensible and latent-below freezing or above freezing temperatures).
5) Safety Factor.

Note:

Each of these first four sources should be evaluated separately to determine the total load.

5.2 Transmission Load (Wall Heat Gain)

5.2.1 The heat gain through walls, ceiling and floor will vary with the following factors: type and thickness of insulation, construction, outside wall area and temperature difference between refrigerated space and ambient air.

5.2.2 Heat gain relative to various temperature differences shall be as indicated in the tables and charts provided in the ASHRAE Guide-book.

5.2.3 Cork insulation thicknesses given in Attachment 1 are those used for walls and vessels (the insulating influence of the masonary walls is not considered in this Attachment).

5.2.4 After the thermal transmission coefficient has been selected, the infiltration can be calculated from the formula:

$$Q = KS \times delta\ t$$

Where:

Q = Heat removed, kcal/hr;
K = Thermal conductivity, kcal/m^3/hr/°C
S = Surface area, m^2.

5.2.5 Solar radiation load shall be considered for walls exposed to sun. The overall coefficient of heat transfer for masonary or concrete walls shall be based on "K" factors indicated in Attachments 2. For practical purposes the temperature difference can be adjusted to compensate for the sun effect.

Note:

1) Table 3 in Attachment 1 represents the degrees centigrade which must be added to the normal temperature difference to compensate for the sun effect.

5.3 Infiltration (Air Change Load)

5.3.1 Air changes

The heat gain effected by the door openings is dependent upon the volume rather than the number of doors as indicated in Attachment 3. The heat removed to cool 1 cubic meter of air from outside conditions to the storage temperature is listed in Table 5 of Attachment 4.

5.3.2 Air-lock

5.3.2.1 Air lock shall be provided on doorways and vestibules which are subject to infiltration by air exchange. Depending upon traffic level and door maintenance, (strip doors or horizontal sliding doors) assumed effectivenes E for calculation purposes can range from 0.90 to 0.80 for freezer applications and from 0.95 to 0.85 for other applications.

5.3.2.2 The equation for heat gain through doorways from air exchanges is as follows:

$$q_t = q\ D_t D_f$$

Where:

q_t = Average hourly heat gain for the 24 hour or other period, kW.
q = Sensible and latent refrigeration load for fully established flow, kW.
D_t = Doorway open-time factor.
D_f = Doorway flow factor.

5.4 Internal Load (Heat Gain from People, Lights and Other Sources)

5.4.1 The calculated load shall represent the heat energy dessipated from these sources into the refrigerated space.

5.4.2 The heat equivalent factors of electric motors and people working in the refrigerated space shall be according to figures in Attachment 6.

5.5 Product Load

5.5.1 Products placed in a refrigerated room at a temperature higher than the storage temperature will lose heat until they reach the storage temperature.

5.5.2 The quantity of heat to be removed in such conditions may be calculated knowing the product, its state when entering the room, its final state, its weight, specific heat above and below the freezing point, its freezing temperature, latent heat and heat of respiration.

5.5.3 When a definite rate of product is required to be refrigerated the heat gain from product loading may consist of one or more of the following:

a) Heat removal from initial temperature, to a lower temperature, above freezing:

$$Q = P \times C_1 (t_1 - t_2)$$

b) Heat removal to freeze product (latent heat):

$$Q = P \times h_f$$

c) Heat removal from the initial temperature to freezing point of product:

$$Q = P \times C_1 \times (t_1 - t_c)$$

d) Heat removal to subcool the product from the freezing point to final temperature below freezing:

$$Q = P \times C_2 \times (t_c - t_3)$$

Where:

Q = Heat removed, kcal
P = Weight of product, kg
C_1 = Specific heat of product above freezing, kcal/kg/°C
t_1 = Initial temperature above freezing, °C
t_2 = Lower temperature above freezing, °C
t_c = Product freezing point, °C
C_2 = Specific heat of product below freezing, kcal/kg/°C
t_3 = Final product temperature below freezing, °C
h_f = Latent heat of fusion, kcal/kg

Note:

The product load shall be obtained through the sum of relevant formulas as mentioned above.

5.5.4 Should it be required to remove the heat from the product in a given number of hours, the equivalent load based on 24 hour shall be as follows:

$$\frac{\textbf{Product load} \times 24}{\textbf{required number of hours}} = \textbf{kcal/24 h}$$

5.5.5 Attachment 5 provides the values of specific heat above and below freezing and the latent heat of fusion for many products. Fresh fruits and vegetables give up heat while stored; such heat is due to product respiration (combination of oxygen of the air with the carbon of the plant tissue). The amount of heat liberated varies with the type and temperature of the product. The colder the product, the less the heat of respiration.

Notes:

1) Refer to ASHRAE guidebook for respiration factor relative to apples, pears and peaches.

2) For factors on various storage containers, pallets etc. refer to relevant ASHRAE guidebook.

5.5.6 Product cooling

Based on necessary pull down load for each chamber, the product cooling system can be accomplished by any or all of the following:

- Product chilling
- Product chilling and holding
- Product blast freezing
- Product storage

5.5.7 Product storage

For standard practice of product storage and the relevant chamber temperature, cold stores are classified in four class as illustrated in the foregoing table:

* CLASS	CHAMBER TEMP.	PRODUCTS TO BE STORED
F	-20°C OR BELOW	FROZEN FISH, MEAT, PACKED VEGETABLE AND FRUITS, FROZEN BUTTER, ICE CREAM, FROZEN FOOD IN GENERAL.
C1	-20°C TO -10°C	ICE CREAM (SHORT TERM STORAGE), FROZEN FISH AND MEAT, SHRIMP, PROCESSED FOOD.
C2	-10°C TO -2°C	PROCESSED FOOD IN GENERAL, DAIRY PRODUCTS (BUTTER, CHEESE ETC.) FROZEN EGGS, SMOKED FISH & MEAT,
C3	-2°C TO +10°C	VEGETABLE & FRUITS IN GENERAL, FRESH FISH AND MEAT, DATES, MILK, CANNED GOODS, TEA, NUTS ETC.

*** F represents freezing category.**

*** C represents cooling/chilling category.**

5.5.8 Product category

5.5.8.1 Generally classified by ASHRAE as follows.

Class 1:

Include products which require very high relative humidities in order to minimize moisture loss during storage. Examples of this category include unpackaged cheese or butter, eggs, and most vegetables if held for comparatively long periods.

Class 2:

Include products which require reasonably high relative humidities (but not as high as those included in class 1). Examples of this category include fruits, cut meats in retail storage. (Some supermarket fixtures for cut meat display may be designed to operate with lower temperature difference.)

Class 3:

Include products which require only moderate relative humidities, and includes such products as mushrooms, carcass meats, hides, smoked fish, and fruits such as melons having tough skins.

Class 4:

Include products which are either unaffected by humidity, or which require specialized storage conditions in which the maximum relative humidity is limited through use of a reheat system. Examples of the first group are furs, woolens, milk, bottled beverages, canned goods and similar products having a protective coating; nuts and chocolates are good examples of the second group.

5.5.8.2 For purposes of preservation, food products can be grouped into two general categories:

a) Those that are alive at the time of distribution and storage, such as fruits and vegetables.
b) Non living protein-rich food substances, such as meat, poultry, fish etc.

5.6 Safety Factor

Between 10% to 15% safety factor shall be applied to the calculated load to allow for possible discrepencies between the design criteria and actual operation. Safety factor should be selected in consultation with the facility user and be applied individually to the first four heat load segments.

5.7 Total Refrigeration Load

To properly size equipment selection, run a load diversification analysis, operate a trouble-free system and estimate operating costs, a correct calculation of the total refrigeration load shall be double checked.

6. REFRIGERATION

6.1 General

6.1.1 The essential parts of a refrigerating plant are the compressor, condenser, receiver, termed the 'Hi-side' with suitable pipe lines and necessary regulating valves connected together. A typical elementary diagram of a standard refrigerating cycle is illustrated in Attachment 7 (Exhibit A).

6.1.2 Refrigeration is the process of removing heat from a substance; the science of providing and maintaining temperatures below that of the surrounding atmosphere.

6.1.3 The operation of a standard compression system using R12 R22, ammonia, methyl chloride, CO_2 and other refrigerants all work on the same principle, but at different suction and discharge pressures. In the vapor compression system, refrigeration is produced by taking advantage of the latent heat necessary to evaporate a liquid.

6.1.4 In refrigeration it is not the volume of gas pumped nor the piston displacement of the compressor that determines the amount of cooling performed. Rather the amount of cooling depends on the weight of the gas condensed and evaporated. This would mean that the production of low temperature requires circulation of large quantities of low pressure gas.

Note:

For description of pressure-enthalphy diagram, reference is made to Attachment 8.

6.2 Functions

6.2.1 The function of refrigeration is:

- To reduce the temperature of substance (the act of cooling).
- To transform a substance from one state to another (as water to ice).
- To maintain substances in a desired state (as in the storage of ice or the preservation of food).

6.2.2 The mechanical refrigeration system comprises of four fundamental functions:

a) Evaporation of liquid-to form gas (function of evaporator).
b) Compression of gas-to increase pressure-to raise boiling point (function of a compressor).
c) Condensation of gas-to reconvert to liquid at higher pressure (function of condenser).
d) Pressure reduction of liquid to support evaporation by lowering boiling point (function of throttling device).

The action of the mechanical refrigeration system in completing each of its functions is known as the refrigeration cycle illustrated in Attachment 7 (Exhibit B).

6.2.3 The three basic factors involved in the refrigeration process are:

- Heat exchange.
- Pressure control.
- Liquid gas relationship.

6.3 System Types

The different types of industrial refrigerating system are:

1) Single stage compressor.
2) Multi-stage compressor.

a) Compound system employing either:

i) Booster system with a low stage compressor and a high stage compressor.
ii) Internally-compounded two-stage compressor.

b) Cascade system, wherein one refrigerant is used as the cooling media to condense the other refrigerant.

Note:

All ammonia compressors shall conform to ARI-510-87, and the positive displacement refrigerant compressors shall conform to ANSI / ARI 520-90.

6.4 Feed

6.4.1 The various feeds which are required for air cooler coil circuiting and commonly used in refrigeration systems are:

a) Direct expansion
b) Flooded operation
c) Liquid recirculation
d) Brine circulation

Note:

Coil capacities shall be based on sensible heat removal and frosted coil operation. Coil capacity shall be increased by 10% for wet operation.

6.4.2 The three types of feed recommended in a standard transfer system are as follows:

a) Dual drum transfer system.
b) Single drum transfer system.
c) Simple gravity system.

6.4.3 The three basic controls for both NH_3 and halocarbons used in a recirculation system (on liquid separators) are:

1) Top safety level (T.O.L).
2) Operating level (O.L).
3) Pump safety switch.

6.5 Refrigerating Machine Capacity

6.5.1 The capacity of a refrigerating machine depends upon the number and size of its cylinders, its speed when running, the efficiency of compression, the suction and discharge pressures and number of operating hours per day. The rated capacity shall be based on continuous operation of 24 hours.

6.5.2 Since the capacity of a compressor is dependent on operating pressures, the compressor capacities shall be considered at definite operating pressure as well as in terms of speed and compressor size. A compressor operated eight hours per day shall be required to deliver under best conditions just one third of its rated capacity.

6.5.3 ASHRAE adopts standard capacity conditions with different temperatures for suction and discharge and the pressures corresponding to these are different for each refrigerant.

6.5.4 Where refrigeration capacity data are based on an ambient temperature of 35°C (95°F) use of the following multipliers to the system capacities and delta T for other ambient temperatures are recommended for sites at sea level.

Ambient Temperature	Multiplier
32°C (90°F)	**1.04**
35°C (95°F)	**1.00**
38°C (100.4°F)	**0.97**
42°C (107.6°F)	**0.92**
48°C (118.4°F)	**0.86**
50°C (122°F)	**0.84**

6.6 Storage Temperature

6.6.1 In a cold store, storage of products at optimum temperature must be given due consideration. Normally the storage temperature should be slightly above the freezing point of the product.

6.6.2 Certain fruit and vegetables are very sensitive to storage temperatures, such as:

- Bananas suffer peel when stored below 13.3°C (56°F).
- Onions tend to sprout at temperatures above 0°C(32°F).
- Irish potatoes tend to become sweet at storage temperature greater than 4.4°C (40°F).
- Green beans, pepper develop pits on their surface at storage temperatures at or near 0°C(32°F).
- Different varieties of apples require different storage temperature (refer to Attachment 5).

6.6.3 Two basic types of storage facilities are:

- Cold storage above 0°C (32°F).
- Frozen stores at temperatures below 0°C (32°F), preferably minus-20°C to -29°C (-4°F to -20°F).

6.7 Temperature and Humidity Conditions

6.7.1 Maintaining the optimum relative humidity in a refrigerated space is as important as keeping the appropriate temperature. Since perishable products differ in their requirements for desired temperature and relative humidity, exact requirements should be determined before selecting the proper system.

6.7.2 Relative humidity control can be achieved by selecting a system with the right operating temperature difference between the room temperature and the evaporating temperature. The following table which has proved satisfactory in normal system (air cooler selection) application are recommended:

ROOM TEMP. RANGE	DESIRED R.H.	DELTA T
- 2°C (28.4°F)& above	**90% -----**	**4 - 6°C (7.2 to 11°F)**
- 2°C (28.4°F)& above	**85% -----**	**5 - 7°C (9 to 12.6°F)**
- 2°C (28.4°F)& above	**80% -----**	**6 - 9°C (11 to 16°F)**
- 2°C (28.4°F)& above	**75% -----**	**9 -11°C (16 to 20°F)**
- 10°C (14°F)	—	**8 & less (14°F)**

7. COLD STORAGE

7.1 General

7.1.1 A typical cold storage system can be divided into:

a) General cold store (commercial and industrial).
b) Freezing storage system.
c) Pre-fabricated cold stores.

7.1.1 General cold stores

7.1.1.1 General

7.1.1.1.1 According to chamber temperature requirements, the general cold store can be classified into four groups as illustrated in clause 5.5.7. To indicate the capacity, each chamber shall consider the calculation of floor space (M^2) chamber volume (M^3) and product tonnage. (Reference is made to clause 5 of this Standard.)

7.1.1.1.2 The effective volume of the chamber shall be 90% of the volume obtained multiplying the floor space (measured wall to wall centers) by the inner height.

7.1.1.1.3 According to the type of items to be stored, the actual weight to be stored can be calculated in general by 350 kg for frozen products and 200 to 250 kg for vegetable and fruits per one cubic meter of effective space. Adequate isle space shall be provided for easy movement of fork lifts etc.

7.1.1.1.4 The products stored and piled over each other on box pallets or racks shall be such that a minimum space of 75 cm is maintained from the bottom of the air cooler.

7.1.1.1.5 Air curtain units shall be provided over cold store chambers with heavy traffic. These units shall be equipped with a limit switch and start operating as soon as the chamber or entrance door is opened, thus preventing the entering of hot outside air.

7.1.1.2 Refrigerated warehouse

7.1.1.2.1 A refrigerated warehouse can be any building or section used for storage controlled conditions, with refrigeration.

7.1.1.2.2 The warehouse handling method and storage requirements dictate design of refrigerated warehouses which are generally single-story structures. The Controlled Atmosphere (CA) storage rooms required for specialized storages, such as grapes and apples, fall in this category.

7.1.1.2.3 The five categories as recommended by ASHRAE for the classificatin of refrigerated storages for preservation of food quality, are:

a) Coolers at -2 to -3°C (28.4 to 26.6°F).
b) Coolers at temperatures of 0°C and above.
c) Controlled atmosphere for long-term storage of fruits and vegetables.
d) Low temperature storage rooms for frozen food products, usually maintained at -23 to 29°C (-9.4 to -21°F).
e) Low temperature storages at -23 to -29°C with a surplus of refrigeration for freezing products received above -18°C (-0.4°F).

7.1.1.2.4 Three types of refrigerated warehouses are:

a) Distribution warehouse:

Where turnover is high and involves more opening of doors with heavy traffic.

b) Storage warehouse:

Which has a rather slower turnover (half of item-a) of product. Generally about 35% of the total heat load are used on the products held.

c) Production warehouse:

It is a bit of both where lots of product may be out of freezing chambers. About 70% of the total heat load are generally utilized on the product itself. (In production warehouse the potential for profit is well worth and the return on investment can be substantially higher than for above warehouses.)

7.1.2 Freezing storage system

7.1.2.1 General

7.1.2.1.1 In order to keep freshness of products preventing shrinkage and dryness for a long period, freezing process shall be used on all protein-rich and agricultural products. (Reference is made to Attachment 5 for considering periods of long term and short term storage requirements of products).

7.1.2.1.2 For type and application of freezers, designs are dictated by:

- Wide range of product to be frozen.
- Wide range of capacities.
- Differing performance expectations/criteria.

7.1.2.2 Classification

According to the nature of its system, the freezing method may be classified into following categories.

a) By cooling system, which is furthur sub-divided into:

i) Air convection through:

- Natural convection.
- Forced convection.

ii) Contact system through:

- Horizontal type.
- Vertical type.

iii) Brine system through:

- Immersion system.
- Spray system.

b) By handling system, which is furthur sub-divided into:

i) Batch system through:

- Air blast freezing.
- Contact freezing.
- Brine immersion freezing.

ii) Continuous system or Individual Quick Freezing (IQF) through:

- Freezing tunnel system.
- Flow system.
- Belt spiral system.

Notes:

1) For brine immersion system, the type of brine shall preferably be either calcium chloride solution or propylene glycol.

2) Because of high cost of refrigerant and carbonic acid in water solution, the use of liquid nitrogen, and liquid CO_2 (particularly for continuous freezing method) are not permitted.

7.1.2.3 Economic considerations

7.1.2.3.1 Initial investment must be considered together with the operating cost. The cost are associated with:

- Downtime.
- Cleaning and risk of contamination.
- Freezing efficiency that is energy versus product dehydration.
- Expected life of material.

7.1.2.3.2 Since 40 to 50% of the total cost is in the form of electrical power expenses, an efficient energy management is the most important criteria while designing cold stores.

7.1.2.3.3 The chambers shall be well insulated and the product shall be stored and packed hygienically to meet appropriate standard requirements.

7.1.2.3.4 In order to provide savings in operation cost freezing procedures shall be suited for easy and mass handling of products.

7.1.3 Pre-fabricated cold stores

7.1.3.1 The types of prefabricated cold stores can be divided into two types:

a) The reach-in (installed indoors and may be stationary or portable). The reach-in type size shall be limited to small capacity upto 5 m^3 space.

b) The walk-in (installed indoors and outdoors).

The pre-fabricated walk-in with multi-chambers shall be limited to 1500 m^3 total space and suitable for locations that call for low population dwellings in rural areas, camp sites, drilling rigs, rest houses, hotels, commercial kitchens, motels etc., coast to coast. The selection of water-cooled or air cooled condensers shall depend on ambient temperatures and design engineer's discretion.

7.1.3.2 The cooler/freezer pre-fabs shall operate on direct expansion system with direct or belt-driven reciprocating compressors. The refrigerants used shall preferably be blended CFC-free halocarbon gasses.

Note:

Use of R502 refrigerant gas are not permitted.

7.1.3.3 System components

A typical prefab cooler/freezer units shall comprise of, but not limited to, the following:

a) Single stage reciprocating compressors (depending on the required freezer temperature).

b) Suspended air cooling units for the cooler rooms.

c) Suspended air cooling units for the freezer rooms.

d) Refrigerated doors

e) Controls for compressor, liquid line control together with thermostic expansion valve.

f) Inter-connecting copper pipes and fittings for proper hookup layout.

g) Halocarbon refrigerant charge of required capacity.

h) Pipe insulation material for suction line with suitable vapor proof arrangement.

i) Room insulating material together with necessary accessory items required for proper fastening to walls, floors and ceilings with suitable exterior surfaces.

j) Tunnel lights plus pertinent micro-switch with interconnecting electric wiring and connections.

k) Electric panel board comprising of all safety and automatic components suitable for proper interlocking.

Note:

For meat cold stores chromeplated hooks shall be provided and for fruits and vegetable cold store box pallet etc., shall be provided in required quantities. The box pallet shall be either galvanized steel or plastic type in standard size of 1M X1. 2M X1. 2M high.

8. ICE MAKING SYSTEM

8.1 General

8.1.1 Refrigeration system required to produce one ton of ice per day would require 6.3 kW (1.8 TR) of refrigerating capacity. This procedure requires water be cooled to the freezing point overcoming various other losses.

8.1.2 The ice generating units are used for commercial applications, fish trawlers, packing fresh protein products, dairy products, concrete cooling and chemical processing applications.

8.2 Block Ice System

8.2.1 The principle equipment representing a typical conventional block ice plant comprises of:

a) Single stage multi-cylinder reciprocating ammonia compressor with electric motor, starter and oil separator.

b) Condenser either shell and tube or evaporative condenser based on 3800 kcal per one TR of compressor capacity.

c) High pressure liquid receiver, calculated at approx 15 litres per 3300 kcal/hr of the compressor capacity, subject to minor fluctuations.

d) Freezing tank in which an ammonia evaporating coil is immersed in a brine solution comprising of brine agitator. The evaporating coil shall be with accumulator and line valves.

e) Harvesting equipment including cans placed in wooden frame, can grids etc.

f) Miscellneous items such as water pumps, can filling tank, dip tank (to thaw peripheral portion of ice in warm water) air blower with air receiver and core sucker pump, overhead crane and insulation material for the freezing tank.

8.2.2 A typical block ice plant producing 25 kg ice blocks shall preferably be inclusive of ice storage chamber, ice stacker (stationary or movable type) and a separate ice crusher unit of suitable capacity.

Note:

Package ice block plant shall be used where space is limmited and transparent ice are not required.

8.3 Fragmentary Ice Making Units

These shall be packaged machine and is used according to application requirements and can be of following types:

a) Flake ice unit

These are of two types; drum rotating and scraper turning type, where raw water is sprayed onto a freezing drum on which ice is formed. The drum is either vertical or horizontal and may be either stationary or fixed. The thickness of ice is in the range of 1 to 3 mm.

b) Plate ice unit

City water is sprayed on freezing plates and when predetermined (adjusted) ice thickness of 6 to 20 mm is reached, ice is removed by defrosting. Generally an ice crusher unit may be intergrated and placed below the plate.

c) Tube ice unit

City water is sprayed on the interior surfaces of number of tubes which may be cooled by refrigerant gas where ice is formed on preset thickness and falls down inside the tubes,the operation being controlled by a defrosting cycle. Generally ice in thicknesses of 8 to 15 mm may use an ice cutter unit.

Notes:

1) The ice producing method such as chipped ice, cube ice ,ribbon or slab ice are not covered in this Standard.

2) The ice storage rooms, to store ice in large volume, produced by above machines shall be held at -10°C (14°F) temperature to prevent sticking of ice into large pieces.

9. SELECTION METHOD

9.1 Compressor Selection Method

9.1.1 General

Since compressors are of vital importance for the plant management, in order to meet job requirements efforts shall be made to select the most suitable compressor unit.

9.1.2 Selection factors

The following factors shall govern compressor selection method:

a) Compression ratio, piston lineal speed and compressor displacement (swept volume in m^3/hr).
b) System size and capacity requirements.
c) Location such as indoor outdoor installation at ground level or on the roof.
d) Equipment noise criteria.
e) Part or full load operation.
f) Winter and summer operation.
g) Pull down time required to reduce the temperature to desired conditions for either initial or normal operations.
h) Availability of strategic items.

9.2 Air Cooler Selection Method

9.2.1 The selection of air coolers depend on the chamber dimensions and temperature, type of feed, type of refrigerant, type of defrost procedures, air circulations and product requirements.

9.2.2 The manufacturer's capacity ratings shall be in accordance with ARI standards, UL approved and listed and based on relevant ASHRAE testing procedures.

9.2.3 All air coolers shall conform to ARI 420-89 representing safety components covered under OSHA / UL requirements.

9.2.4 For proper selection of air cooling units the following guidelines on cooler configurations are recommended:

- Net rated capacity (after applying deration factors).
- Temperature difference between the room or return air temperature and the saturated evaporating temperature.
- Correct fin spacing.
- Coil face velocity.
- Air throw.
- External static pressure.
- Sound level.
- Refrigerant coil circuiting.
- Defrost and humidity control.
- Motor overload protection.
- Air unit location.

Note:

The use of explosion-proof air cooling units suited for walk-in coolers and freezers upto minus 15°C chamber temperature and maximum five meter ceiling height,shall be considerd for following application:

- Offshore oil platforms, Solvent & hazardous chemical storage, Peroxide catalyst storage buildings, Chemical processing areas, Laboratory sample storage, etc.

9.3 Walk-In Coolers/Freezers Selection Method

When selecting a walk-in cooler or freezer, following key factors shall be considered:

a) Overall quality of insulated panels and doors, with regard to insulation, steel cladding, and adhesion between the two.

b) Precision and effectiveness of panel connection system, that is, light-fitting panel joints, insulation to insulation contact, prevention of vapor transmission and/or cold conduction at the panel joint.

c) Flexibility of design, that is ability to meet specification requirements.

d) Speed of delivery, product efficiency and ease of installation.

e) Available parts and services of the refrigerating units and the insulation material.

f) Manufacturer and contractor's warranty along with their prior experience.

Note:

For selection of other components, vessels and equipment, reference is made to individual manufacturer's selection procedures.

10. COMPOUNDING

10.1 System

A refrigerating system consisting of more than one stage of compression is defined as a multi-stage system, to which the two specific types are compound and cascade. The compound system may further be divided into:

a) Booster system, consisting of separate booster (low-stage) and hi-stage compressors.
b) Internally compound system, when both stages of compression are handled by a 2-stage internally compounded (partitioned) compressors.

10.2 Reasons for Compounding

Factors which limit the use of single stage compression systems for production of low temperatures shall be as follows:

1) Compression Ratio (CR) may be defined as follows:(the under root of results obtained between the ratios below shall be considered as the acceptable limit.)

$$\mathbf{CR} = \frac{\textbf{Absolute discharge pressure (psia)}}{\textbf{Absolute suction presure (psia)}}$$

a) When the CR becomes too high, volumetric efficiency and compressor capacity decreases. If the compression ratio is high enough to result in very poor volumetric efficiency, it is possible that the total displacement for compound system operation may be less than the displacement that would be required for single-stage operation.

b) To allow for condenser scaling, noncondensable gases in system, oil in evaporators, and load surges, the CR shall be selected to below the maximum calculated value.

2) The pressure difference between the suction and discharge may exceed compressor limitations.

3) For some installations there may be an additional refrigeration load that requires an evaporating temperature equivalent to the intermediate pressure (the suction pressure of the high stage). The high stage shall be able to handle this additional intermediate temperature load.

4) In a compound system, opposed to a single-stage system, the following items play an important part in obtaining a greater refrigerating effect from a given power input and in providing possible savings in operating costs.

a) Improved volumetric efficiency by reduction of the compression ratio.
b) Subcooling of the liquid refrigerant,specially the liquid from the low temperature load.
c) Desuperheating of the low-stage discharge gas.

10.3 Economic Considerations

10.3.1 Careful economic evaluation shall be conducted when considering border line applications, initial system cost, installation cost, and operating costs. Generally the operating cost of a compound system are less as compared to single compression system of equal capacity.

10.3.2 Because of improved volumetric efficiency, in some cases it is more economical and recommended to incorporate two smaller compressors and drivers in place of one large compressor and driver.

Note:

Substantial savings on space and horse power per ton is achieved on two-stage internally compounded ammonia compressors operating at suction temperature minus 20°C (-4°F) and below.

10.4 Compounding Advantage

Basic gains on compounding systems are:

1) Improved volumetric efficiency.
2) Improved evaporator performance as volume to evaporate is reduced.
3) Improved overall reduction in horse power for the overall system.
4) System flexibility for continuous operation.

10.5 When to Compound

Compounding shall be considered when following conditions are met:

a) The overall maximum compression ratio shall be based on manufacturer's ratings not exceeding the following ratios:

For R12 CR = 10:1
For R22 CR = 12:1
For R502 CR = 14:1
For R717 CR = 8:1
For R290 CR = 10:1
For R717 CR = 18:1 (for screw compressors).

b) The BHP per ton of refrigeration is lower than the single stage.
c) When the system is operating preferably with ammonia gas.

Note:

Figures shown in item (a) are representative only and for execution purposes individual manufacturer's limitation shall be considered.

11. COMPRESSOR PROTECTION

11.1 Methods

11.1.1 Thought must be given relative to the continuous operational requirements, whether at full or part load, at conditions other than design, while maintaining:

- Adequate capacity control.
- Proper compressor lubrication.
- Guaranteed compressor protection.
- Sequencing of automatic controls.
- Proper design of gas lines.
- Proper selection and distribution of air coolers.
- Use of proper compressor oil.

11.1.2 The major cause of compressor problems relate to liquid slopover from the low side which tend to reduce compressor capacity, thereby causing damage not only to the compressor but at times to the whole system. In any system the booster compressor must be protected from liquid, the booster discharge gas must be desuperheated and the liquid to the low temperature load must be subcooled.

11.1.3 With proper compressor protection, care shall be taken to use correct grade oil for lubrication, basing selections on compressor type, refrigerant fluid and evaporating temperature. (Manufacturers' recommendation in this regard shall be strictly abided).

11.2 Protection Devices

11.2.1 The common device used for the protection of compressor in the ammonia system during slop over of liquid refrigerant from the evaporator is by trapping this liquid at various points of suction line and the devices for temperatures to -45°C (-50°F) are as follows:

a) Surge drum.
b) Suction trap (accumulator).
c) Suction knock out drum.
d) Oil return system.
e) Air purger.

11.2.2 The following are considered to be acceptable set of rules to follow as to systems requiring compressor protection from liquid surge:

a) A flooded or recirculation type of system.
b) Any system employing capacity control below 50%.
c) Any system employing hot gas defrost.
d) Any suction line length in excess of 20 meters.

Note:

For safety a suction pressure regulator shall be provided followed by a suction trap.

12. COMPRESSOR OIL

12.1 General

12.1.1 Selection of the proper refrigeration compressor lubricating oil is essential to assure efficient system service and maximum compressor life. Although the cost of oil is a small fraction of total system maintenance costs but incorrect lubricating oil substitution shortens wear life of moving parts, increases maintenance time and costs and compressor breakdown.

12.1.2 Oil being heavier than ammonia, density of oil being 899 kg/m^3(56 lbs/cuft) and that of ammonia is 642 kg/m^3 (40 lbs/cuft), i.e.,plant performance with ammonia system provide better efficiency.

12.2 Type of Oil

12.2.1 For proper lubrication of compressors, the most rigid specifications for the oils shall be maintained to meet lubrication requirements of all refrigeration applications. The method of testing the floc point of refrigeration grade oil shall conform to ANSI / ASHRAE 86-19830.

12.2.2 The most important characteristic in a refrigeration oil shall be its ability to reduce friction at all temperatures and pressures to assure trouble-free operation and long compressor life. A good and recommended compressor oil must posses the following qualities:

a) Chemically stable against reaction, at high or low temperature, with refrigerants or other equipment materials.

b) Thermally resistant to high temperature degradation, providing long service life.

c) Resistant to vaporization at working pressures and temperatures, due to high flash points. This prevents formation of insoluble deposits on working parts and also facilitates oil separation from discharge gas.

d) Low in carbon-forming tendencies, eliminating deposits at usual compressor hot spots, such as valves and discharge ports.

e) Free from corrosive acid-forming tendencies, even with extensive use.

f) Free of harmful moisture which, at low temperatures, causes clogged capillaries, valves and evaporator tubes and, at high temperatures, triggers chemical reactions leading to corrosion, copper plating and damage to refrigerant lines.

g) Formulated to the proper viscosities to insure good body at high operating temperatures and good fluidity under coldest operating conditions, thereby providing, to bearings and other wearing surfaces, a lubricating film at all times.

h) Resistant to congealing in condenser and evaporator lines, due to extremely low pour points.

i) Exceptionally wax-free, preventing flocculent separation of wax from oil-refrigerant mixtures even in the coldest parts of the refrigeration system.

j) Completely compatible with all common refrigerants, yet chemically inert so as not to form harmful by-products.

k) Treated with an anti-foam agent to reduce crankcase oil foaming on start-up.

Notes:

1) Since few consumers have the necessary facilities to analyze the contents of oil, it is good engineering practice to use an oil which is backed by the experience of a reliable refrigeration equipment manufacturer.

2) Refer to individual compressor manufacturer's tables regarding oil properties, application and its recommended use with different refrigerants.

13. DEFROSTING

13.1 Types

In an air cooler, defrosting can be accomplished through:

a) Hot gas defrost.
b) Air defrost.
c) Water defrost.
d) Electric defrost.

Note:

The defrost kit shall preferably be purchased from the air cooler manufacturer.

13.1.1 Hot gas defrost

13.1.1.1 Chamber temperature from 1°C (33.8°F) and below shall be arranged for hot gas defrosting. It takes longer for coils with wider fin spacing to frost as the ice takes longer because of more surface to cover on say 4 or 3 fins per inch, (for example, if with 4 FPI, defrosting time may be every 4 hours, with 3 FPI, defrosting time may be every six to eight hours).

13.1.1.2 During defrost cycle the coil is isolated and high pressure vapor at approx 10°C (50°F) flows from top of receiver as hot gas, as it is 100% free from oil. During such defrosting, condensation of coil starts from top.

13.1.1.3 An acceptable defrost cycle may include a pumpdown cycle in which fans continue to run, a defrost period during which hot gas is supplied to the coil and drain pan, a fan delay period and pressure equilizing period.

13.1.1.4 It is recommended that no more than 1/3 rd of the total refrigeration system's capacity should be defrosted at one time. Also the drain pan must be heated.

13.1.1.5 Recommended hot gas line pipe sizing are as follows:

PIPE SIZE	MIN HIGH SIDE VOLUME	RECOMMENDED LIQUID RECEIVER VOLUME
	m^3 (cuft)	m^3 (cuft)
1"	0.34 (12)	0.24 (8.5)
1"	0.57 (20)	0.45 (16)
1"	0.90 (32)	0.72 (25.5)
1"	1.13 (40)	0.97 (32)
1¼"	1.47 (52)	1.13 (40)
1¼"	1.70 (60)	1.30 (46)
1¼"	2.26 (80)	1.78 (63)
1½"	2.94 (104)	2.26 (80)
2"	3.62 (128)	2.97 (105)

Notes:

1) Volume represent net volume of condenser (gas space) discharge line oil separator and liquid receiver (empty).

2) Recommended receiver volumes apply to arrangements where hot gas is obtained from liquid receivers

13.1.2 Air defrost

13.1.2.1 The air defrost shall be employed in rooms above 3.3°C (38°F) or warmer shutting off the refrigerant liquid line and allowing the fan run enough to defrost the frosted coil; the heat from the fan motor also helps speed the defrosting.

13.1.2.2 For air defrost it is recommended that the thermostat and solenoid be connected with compressor motor. All air defrost shall take place during off-cycle.

13.1.2.3 Defrost time can be reduced by increasing the pressure (and temperature) in the coil with an evaporator pressure regulator. Air units with low face velocities shall be considered to prevent water carry-over.

13.1.3 Electric defrost

Electric defrost shall be provided with defrost thermostat and insulated drain pan in areas where:

a) Voltage fluctuation is not severe.
b) The air cooling units are in wide spread quantity and capacity.
c) There are more than two refrigeration circuit in a cold store project.

13.1.4 Water defrost

13.1.4.1 Water defrost can be employed on industrial floor mounted units that require rapid defrost, wash down or in system without an adequate supply of hot gas.

13.1.4.2 Water defrost can be manually or automatically controlled and include water stop valves and vent to permit complete drainage. Additional controls can include relief pressure control to increase temperature in coil and bleed solenoid to provide compressor protection.

13.1.4.3 With water defrost big water volume is desirable using upto 21°C (70°F) water temperature where average coil is good for 45 to 68 litres (100 to 150 lbs) of water.

13.1.4.4 Proper slope for water header and bleedhole shall be provided for drainage. A suitable adjustable pressure operated valve shall be provided for ease of pressurizing the coil.

14. REFRIGERANTS

14.1 General

The importance of any refrigerant in a system can be observed from the general rule, that while water boils at a temperature of 100°C (212°F) in the open air, the refrigerant under atmosphere air will boil at 20 to 30 or more degrees below zero.

14.2 Desirable Properties

14.2.1 The ideal refrigerants would be one that could discharge to the condenser all the heat which it is capable of absorbing in the evaporator or cooler. All refrigerating mediums, however carry a certain portion of the heat from the condenser back to the evaporator and this reduces the heat absorbing capacity of the medium on the low side of the medium and system. For characterestic of different refrigerants, reference is made to Attachment 14.

14.2.2 The requirement of a good refrigerant for commercial/industrial applications shall be:

- Low boiling point.
- Safe and non-toxic.
- Easy to liquefy at moderate pressure and temperature.
- High latent heat value.
- Operate on a positive pressure.
- Have no effect on moisture and ozone.
- Miscible with oil.
- Non-corrosive to metal.

Note:

Use of liquid Nitrogen or Helium and Propane (R290) as refrigerants are not covered in this Engineering Standard.

14.3 Secondary Refrigerants

In large installations where distance of plant rooms are more than 20 meters from the cold chambers, a second refrigerant known as secondary refrigerant or brine are recommended. Brines can be made from:

a) Calcium chloride ($CaCl_2$).
b) Sodium chloride (NaCl).
c) Propylene glycol (HOC_3H_6OH) or $CH_3CH(OH)CH_2OH$.
d) Ethylene glycol (HOC_2H_4OH) or CH_2 $(OH)CH_2(OH)$.
e) Methanol (CH_3OH).
f) Ethanol (C_2H_5OH).
g) Methyl chloride (R40 or CH_3Cl).

14.4 Refrigerant Piping

14.4.1 Halocarbon piping

14.4.1.1 For halocarbon applications the following three refrigerant lines are used on pre-fab cold stores:

- Liquid line.
- Suction line.
- Discharge line.

1) Liquid line

The sizing of liquid lines is the least critical in a system, but proper selection is still necessary to avoid problems such as:

a) Flashing due to excessive pressure drop or lift.

b) Excessive velocities leading to hammer and shock. To avoid liquid flashing the liquid must remain subcooled, that it at a temperature (T_1) below its saturated temperature (Ts). The amount of subcooling is the difference expressed in degrees centrigrade (°C):

$$°C \ Subcooling = Ts - T_1$$

If the liquid refrigerant experiences a drop in pressure, its saturation temperatures (Ts) beomes lower, so if the actual liquid temperature T1 remains the same, some subcooling is lost due to the pressure drop. If all subcooling is lost, the liquid is at its saturated below which any further drop in pressure will cause a portion of the liquid to boil or flash off to a vapor. This vapor is known as flash gas, commonly observed as the bubbles in a refrigerant liquid sightglass. Since any fluid flowing through a pipe must experience a pressure drop to offset the inherent frictional forces resisting flow, the proper sizing of lines must account for some pressure loss in the lines, the related fitting, and various other components in the run.

Note:

For liquid line sizing reference is made to Attachment 9.

2) Suction line

The proper selection of a refrigerant suction line shall be generally based on following considerations:

a) Pressure drop.
b) Oil return.
c) Noise.

Pressure drop in a suction line increases the volume of the refrigerant vapor that enters the compressor suction port and causes an increase in the overall compression ratio the compressor must handle. This erodes system efficiency and should be addressed by the designer by minimizing pressure drop while insuring proper system operation.

Note:

For suction line sizing reference is made to Attachment 10.

3) Discharge line

Discharge lines, selection considerations are essential the same as with suction lines:

a) Pressure drop.
b) Oil return.
c) Noise.

Excessive line pressure drops cause higher operating discharge pressure at the compressor which can substantially increase power consumption and reduce system operating efficiency. As in suction line sizing, the pressure drop should be held to practical minimum, generally 7 to 20 kPa per 30 cm. Velocities necessary to entrain oil in discharge lines are the same as indicated for suction lines;that is 2.5 m/s and generally based on the following:

Horizontal Runs	**2.5 m/s (500 FPM)**	**Min.**
All	**20 m/s (4000 FPM)**	**Max.**
Risers	**5 m/s (1000 FPM)**	**Min.**

Note:

For discharge line sizes reference is made to Attachment 9.

14.4.1.2 For halocarbon refrigeration system, use of following pipes are recommended:

a) For commercial applications and installations type K copper pipes shall be used. These pipes shall preferably be seamless conforming to ASTM B42-88 Standard.

b) For industrial applications and installations, steel pipes as described in Clause 14.4.2 of this Standard shall be used.

14.4.1.3 For decision on proper pipe selection, the ANSI / ASME A13.1-1981 (R 1985) Standard on "Scheme for the Identification of Piping System" shall apply.

14.4.2 Ammonia piping

14.4.2.1 Ammonia refrigeration system require steel pipes. Systems using other refrigerants can and possibly may use welded steel pipe construction to create tighter, less leak prone systems.

14.4.2.2 All ammonia pipes shall be schedule 40 ASTM A-53 Grade B electric resistance welded (ERW) or seamless, or ASTM A-106 seamless. The A-53 Grade A is allowed by ANSI B31.5 Code for Refrigerant Pressure Piping but has a lower permissable stress than Grade B.

14.4.2.3 For low-temperature systems where pipes are to be used in the brittle region usually around -40°C and below ASTM A-333 Grade 6 (a nickel bearing steel with ductile characteristics) and ANSI B36.40 are recommended. All such pipes must be supported by the mill certification and test report. (Caution to all engineers not to use furnace butt welded A-120 or A-53 Grade F.)

14.4.2.4 The refrigeration piping covered in this Standard shall conform to minimum requirements of ASME / ANSI B31.5-1987 suitable for the material design, fabrication, assembly,erection test and inspection of refrigerant for the following pressure and temperature range:

a) 1034 kPa (150 Psi) maximum allowable working pressure for system low pressure side.
b) W2068 kPa (300 Psi) maximum allowable working pressure for system high pressure side with temperature range from -50°C (-58°F) to +149°C (300°F).

Notes:

1) Copper and brass must not be used with ammonia.

2) Cast iron, wrought iron or carbon steel fittings are not recommended for below minus 73°C (-100°F) temeprature lines.

14.5 Pipe Types

Description of pipe types for ammonia system as extracted from ASTM A53 and A106 specification shall be as follows:

14.5.1 Type F.-Furnace, butt-welded pipe, continuous-welded

Pipe produced by continuous lengths from coil skelp and subsequently cut into individual lengths, having its longitudinal butt joint forge welded by the mechanical pressure developed in rolling the hot-formed skelp through a set of round pass welding rolls.

14.5.2 Type E.-Electric resistance welded pipe

Pipe produced in individual lengths or in continuous lengths from coiled skelp and subsequently cut into individual lengths, having a longitudinal butt joint wherein coalescence is produced by the heat obtained from resistance of the pipe to the flow of electric current in a circuit of which the pipe is a part, and by the application of pressure.

14.5.3 Type S. Wrought steel seamless pipe

Wrought steel seamless pipe is a tubular product made without a welded seam. It is manufactured by hot working steel, and if necessary, by subsequently cold finishing the hot-worked tubular product to produce the desired shape, dimensions, and properties.

14.6 Refrigerant pipe sizing

14.6.1 While sizing the pipes for industrial refrigeration system, due consideration shall be given to plant efficiency and performance factors such as minimum velocities (to achieve adequate oil entrainment), height of various components (to prevent flash gas in liquid lines) and controls. The type and quantity of fittings play a crucial role in satisfactory operation of a refrigeration plant.

14.6.2 Refrigeration plants operate on 24 hrs non-stop bases as long as the chambers are stored with products. Therefore for proper sizing particularly in flooded system, following pressure and velocity limmitations shall be considered.

	R12 - 22 - 502	**R 717**
- Suction line PD/100 M@ - 40°C	**15.8 kPa (109 Psi)**	**9.06 kPa (62.5 Psi)**
- Discharge line PD/100	**45.113 kPa (311 Psi)**	**45.113 kPa (311 Psi)**
- Condenser to receiver velocity	**0.6 m/sec (120 Fpm)**	**0.5 m/sec (100 Fpm)**
- Receiver to system velocity	**1.5 m/sec (300 Fpm)**	**1.5 m/sec (300 Fpm)**
- Expansion valve to evaporator	**- per expansion valve size.**	

15. APPLICATION LIMITATIONS

15.1 General

Descriptions provided in this Standard pertain to stationery and land use of refrigerating system and does not cover for cascade and cryogenic system.

15.2 Compressors

Proposed application limitation for the vapor-compression type shall be as under:

a) For single stage application:

i) Compressors shall be reciprocating and installed on factory fabricated rigid steel base.
ii) Units upto 7.5 HP shall be semi-open or open type.
iii) Units 10 HP and above shall be open-type with OSHA approved belt-drive arrangements.

b) For hi-stage application:

i) 1st choice-heavy duty industrial type reciprocating units with lowest RPM available.
ii) 2nd choice-helical screw compressor (screw units shall preferably not be used for remote areas or areas subject to severe site and weather conditions).

c) For low-stage (booster) application:

i) 1st choice-slide vane rotary V-belt drive units with lowest RPM available. The compressor casing shall be cast Iron conforming to ASTM A278-75 and rotor shall be forged steel AISI C1045. Per design engineer's discretion reciprocating compressor may be used.

ii) 2nd choice-rotary screw compressor but with water-cooled compressor oil cooling. Use of liquid refrigerant, injection or thermosyphon compressor oil cooling system shall depend on job requirements and design engineers, choice. The casings shall be per ANSI / ASHRAE 15-1989 safety code and control system shall be per NEMA 4 or approved equal.

iii) 3rd choice-internally-compounded compressor units for dual or multi-stage application, where space in the plant room is limited.

d) Max allowable cylinders for reciprocating compressors shall be 12 and the minimum shall be two cylinders.

e) Maximum suction temperature for two stage compound application shall be limited to -50°C (-58°F).

f) Suction pressure limit for ammonia compressor shall not be taken below 20"Vacuum with reciprocating compressor, and below 30" Vacuum with screw compressor. (This may create difficulty to overcome valve spring and uplift the oil to the crankcase.)

Note:

Use of tandem arrangement compressors are not permitted.

15.3 Heat Rejection Units

a) For general cold store application the following limitations shall be considered:

- Evaporative condenser, blow through type shall be used for hot and moist regions,suitable for industrial application.

- Air-cooled condensers for central regions with high wet bulb conditions, suitable for pre-fab cold stores.

b) Use of water cooling towers particularly for industrial cold store applications shall be limited to engineer's choice, and job requirements. The cooling towers shall conform to ANSI / NFPA 214-1988.

c) Use of shell and tube condensers shall depend on the availability of adequate water at site.

d) Air cooled condensers shall not be used for industrial application, unless the site is located in areas with mild summers and high ambient wet bulb temperature.

Note:

Stand-by Diesel Generators shall be provided for all cold store project 1500 tons and over. However final decision shall depend on job requirements and budget allocation.

15.4 Air Coolers

Mentioned below are limitations recommended for ceiling suspended air coolers with generously sized coil surfaces and wide fin spacing:

- For small walk-in freezer/coolers low silhouette units shall be used for upto 3.5 meter ceiling height.

- Large floor mounted units shall be provided with extended goose-neck (site fabricated) ducting with adjustable louvres for uniform air throw.

- Depending on chamber temperature, the coil face velocity shall be from 2.5 m/s (500 fpm) minimum to 4 m/s (800 fpm) maximum.

- Electric defrost shall be used when too many air coolers are wide spread; on such cases, heaters for drain pan must be inclusive with the defrost kit.

- All fan motors shall be wired to a terminal in a common junction box.

- Depending upon installation and type of room the sound decibel level shall be maintained at maximum 'A' scale ratings.

- Air coolers 25000 kcal capacity and above shall be incorporated with pertinent side accesses for service and inspection purposes of electrical connections and refrigeration components.

- A separate electric disconnect switch shall be provided near each air cooler, unless it is a walk-in application.

- Components shipped loose such as fan motor contactor, heater contactor, defrost timer and clock shall be safely protected.

- For maximum heat transfer, minimum fin spacing of 8.5 mm (3 fins per inch) and maximum 4.2 mm (6 fins per inch) depending on chamber temperature, shall be considered.

- Casings of air coolers for industrial refrigeration shall be of heavy gage with stucco pattern aluminum sheets or hot dipped galvanized sheets with rust resistant hardwares.

- Unless otherwise mentioned, units operating with halocarbon gas, the cooling coil shall preferably be copper and those with ammonia gas or brine the coil shall be black carbon steel.

- When selecting air coolers following deration factors shall be considered on the manufacturer's net rating as required per job requirements

  - 50 Cycle rating (if at actuals or fan placed at a pitch no correction required).

  - Temperature difference (between room air and coil saturated refrigerant temperature) other than manufacturer's standard.

  - Fan motor heat (multiplied by 1134 kcal/hr factor for chambers below zero and by 1070 kcal/hr for chamber temperature zero or above).

  - Duration of defrost cycle (on the basis of 2-2 hours defrosting time).

- For freezers and freezing tunnel high volume air units with centrifugal blowers shall be provided (with flexible air louvre discharge arrangements).

- On liquid recirculation system the air cooler shall be provided with bottom feed of cooling coils for hot gas defrost system and top feed for air, water and electric defrost system.

- Unless otherwise mentioned fan motor electrical characteristics shall be 380 volt, three phase, 50 Hz AC supply. Where electric defrost system is required a 380 volt three phase AC supply shall be used.

- Chambers with temperatures below 1°C (inside room) shall have electric heating tracers on its drain (condensate) lines.

15.5 Liquid Refrigerant Pumps

Used for circulating ammonia or other refrigerants with normal viscosity for the following pressure-temperature limitations:

a) Pressure upto 16 kg/cm^2.
b) Temperature without consideration of lubricating oil from minus 90 upto +50°C (-130°F to +120°F).
c) In the normal delivery condition from -45 to +50°C (-49°F to +120°F).
d) At lower temperatures use of synthetic oil may be necessary.

15.6 Refrigerant

The standard acceptance for proper use of refrigerant in a typical cold store system shall be based on following limitations:

1) Commercial and pre-fab cold stores upto 750 product ton and 30 HP condensing units, halocarbon refrigerants shall be used.

2) Any cold store above 1000 ton shall be considered as industrial installations and all such installations shall use ammonia refrigerants.

3) The usage of brine shall be considered as secondary coolant on installations where the refrigeration plant room is a separate building located around 20 meters or more away from the closest cold store chamber. The type of brine, its availability and usage convenience shall depend on the design engineer's discretion.

15.7 General Limitations

a) Ceiling mounted cooling coils shall be used in projects where chamber ceilings provide clear access for pipe runs with no hindrances whatsover.

b) The closed circuit coolers shall be capable to provide means of cooling fluid within 2.8 °C (5°F) of the wet bulb and be used for industrial fluid cooling, process industries, printing and machine shop industries etc.

c) All outdoor mounted units shall be provided with adequate arrangement of shading protection.

16. THERMAL INSULATION

16.1 General

16.1.1 The three main function of an insulation envelope shall be to reduce economically the refrigeration requirements for the refrigerated space (i.e., reduction of heat gain from exterior surfaces), to prevent consdensation on the exterior (be moisture proof) and to provide frost heave protection.

16.1.2 The primary concern in the design of a low temperature facility is the vapor barrier system which must be 100% effective. The success or failure of an insulation envelope depends entirely on the vapor barrier systems used to prevent water vapor transmission into and through the insulation.

16.2 Types

Whether pre-moulded, rigid, block or panel flat type, the insulating material for ducting, pipes, equipment, pressure vessels, wall, floor and ceilings of cold store chambers shall be suitable for operating temperatures from -100°C to +200°C and represented by any of the following types:

a) Cellular glass insulation.
b) Expanded polystyrene.
c) High density fibreglass insulation material.
d) Corkboard-expanded pure agglomerated.
e) Polyurethane insulation, factory molded or foamed-in place or site injection.
f) Synthetic vinyl rubber insulation, preformed or blanket type.

16.3 Features

1) A typical insulating material shall be light weight material composed of closed-cell structures capable to provide the following benefits:

a) Constant insulating efficiency.
b) Moisture and fungus resistant.
c) Fire protection.
d) Corrosion resistant.
e) Long term dimensional stability.
f) Physical strength.
g) Vermin resistant.
h) High compressive strength.

2) Maximum acceptable coefficient of thermal conductivity (K factor) for temperaturre at 23.9°C (75°F) for different insulating materials shall be:

- Cellular glass	0.040 kcal/m/hr/°C (0.323 Btu-in/ft^2/hr/°F)
- Polyurethane	0.017 kcal/m/hr/°C (0.137 Btu-in/ft^2/hr/°F)
- Fibreglass (high density)	0.032 kcal/m/hr/°C (0.26 Btu-in/ft^2/hr/°F)
- Polystyrene (expanded)	0.035 kcal/m/hr/°C (0.280 Btu-in/ft^2/hr/°F)
- Corkboard (expanded)	0.033 kcal/m/hr/°C (0.266 Btu-in/ft^2/hr/°F)
- Synthetic vinyl rubber	0.029 kcal/m/hr/°C (0.234 Btu-in/ft^2/hr/°F)

Note:

The R-value (m^2- k/w) or insulation thickness required varies at conditions surrounding the room. Consult ASHRAE or insulation supplier in obtaining the R-value required for different types of facilities.

16.4 Insulation Material and Thickness

16.4.1 For refrigerated space

16.4.1.1 The basis of selection insulation thickness for cold store chambers (walls, floor and ceiling) depend on the following factors:

- The ambient temperature.
- Chamber temperature.
- High compressive strength.
- Thermal conductivity based on its density, specific heat and mean temperature.

16.4.1.2 To maintain minimum requirements of chamber insulation thickness the following table can be considered as a general rule for standard condition of thermal conductivity at 0.45 Kcal/m/hr/°C.

TEMPERATURE RANGE	CEILING (mm)	FLOOR (mm)	OUTER WALL (mm)	PARTITION (mm)
- 20°C OR BELOW	175	175	175	125
- 20°C TO - 10°C	150	150	150	100
- 10°C TO - 2°C	125	125	125	75
- 2°C TO + 10°C	100	100	100	75

16.4.2 For pipes, vessels and equipment

16.4.2.1 The type and thickness on insulation material and its vapor barier on low temperature pipes, pressure vessels and equipment shall be given priority consideration, as the smallest leak in the vapor barrier can allow ice to form inside of insulation destroying the integrity of the insulation system.

16.4.2.2 The following preferred insulation material shall be considered for pipes, vessels and equipment:

a) A pre-formed or pre-moulded insulation of either cellular glass, synthetic vinyl rubber, high density fibreglass or activated poly-urethane material, with a "K" value of 0.5 W/m°C (0.35 Btu-in/ft^2/hr/°F) shall be used as follows:

i) Cut sectional type for pipes;
ii) Block type for vessels and equipment.

b) Insulation bands shall be stainless steel, 19 mm (¾") wide × 0.51 mm (0.020") thick with seals for vessels.

c) The wire-stainless steel, wire gages shall be as follows:

- Pipe 12" and under 16 gage (1.5 mm)
- Vessel & Pipe 12" and larger 14 gage (2.0 mm)

d) Weather-proofing jackets shall preferably be as follows:

i) Aluminum jacketing conforming to BS 1470 SIC $½H_4$ or approved equal with vapor retarder supplied as follows:

- 0.23-0.25 mm (0.010") thick × 5 mm (3/16") corrugated for piping 6" diameter and smaller.

- 0.50 mm (0.020") thick × 5 mm (3/16") corrugated for piping over 6" diameter, and vessels and equipment 30" diameter and smaller.

- 0.88 mm (0.031") thick × 32 mm (1¼") corrugated for vessels and equipment larger than 30" diameter.

- 0.5 mm (0.020") thick × flat for vessel and equipment heads and transition.

ii) Galvanized metal jacketing for vessles and tanks conforming to ASTM A575 commercial grade G90 and related standard, to thickness of 0.5 mm (26 gage) for all applications.

e) Bands for jacket shall preferably be as follows:

i) For aluminum covering on pipe at 13 mm (½") wide × 0.38 mm (0.015") stainless steel with seals.
ii) For metal covering on vessels at 19 mm (¾") wide × 0.51 mm (0.020") stainless with seals.

f) Approved quality of adhesive compound on insulating material and metal surfaces shall be provided. Manufacturer's recommendation shall be given priority consideration.

g) The joint sealer for the two ends of insulating material shall be a non-setting and non-shrinkable type of approved quality.

16.4.2.3 For recommended thickness of insulating material and the corresponding operating temperature reference is made to Attachment II. The thickness shall be determined by lowest temperature at which the piping, vessel and equipment normally operate.

Notes:

1) The thicknesses shown in cleuse 6.4.1.2 shall be increased according to the ambient temperature,required storage temperature and the thermal conductivity of insulation materials to be used.

2) Economic parameters demand that correct thickness be specified, as with smaller thickness material the initial investment may be low, but power consumption and operating cost increases and vice-versa.

16.5 Frost Heave Protection

To prevent freezing of soil under chambers with below freezing temperature, any of the following method for frost heave protection shall be applied:

a) An adequate air space shall be provided between the chamber floor and grade level.

b) Pipes with available heating medium shall run under chamber floor with provision for proper drainage, where necessary.

c) Insulation thickness shall be moisture-proof with increased thickness.

17. SAFETY PROVISIONS

17.1 Handling Refrigerant Control Valves Safely

17.1.1 General

For proper performance, refrigerant control valves used in large commercial and industrial systems must be well designed and well built to withstand the extreme conditions they are regularly subjected to.

Safety, is always a primary concern for all personnel working on such valves be qualified to work on refrigeration systems. The following safety procedures shall be considered for both halocarbon system and those using ammonia refrigerant.

a) Avoid altering or modifying any refrigerant valves or regulators without checking such changes with the manufacturer. Threaded parts should not be over torqued by using over-sized wrenches, wrench extensions, or by hammering the wrench handle. It is important to follow torque requirements for bolts, screws, and other threaded parts.

b) All spare parts for corrosion shall be checked before installation. Spare part numbers should also be checked against current valve assembly literature to make sure the parts are up to date.

c) Liquid shock can cause tremendous pressure increase in liquid lines that end in solenoid valves or regulators with electric shutoffs, especially in long runs of pipe sized 1½ inch and up.

d) Suction shock can occur when there is a sudden large-volume release of defrost pressure into a low pressure suction line. This can cause even large pipe lines to shake and bend. If such shocks repeatedly occur, they can lead to failure at the piping system’s weakest point.

17.1.2 Liquid expansion precautions

17.1.2.1 In liquid lines or other lines that may contain substantial amounts of liquid refrigerant, take care to avoid damage because of liquid expansion when a section of line is isolated by positive shut off valves. This condition may occur whenever the ambient temperature is higher than the liquid temperature. This can happen in liquid lines, and other refrigerant or oil lines.

17.1.2.2 When low temperature lines are used, as in a liquid over-feed (recirculation) system, and if these lines or control valves become exposed to warm ambient conditions, extra care shall be provided because liquid expansion can occur very rapidly.

17.1.2.3 Check valves should never be installed at the inlet of either a solenoid valve or a regulator that has electric solenoid pilot shut-off features.

Check valves should also never be installed at the inlet of an outlet regulator in a system where liquid may be trapped between the two valves. When needed, check valve shall be installed on the outlet side of such valves.

17.1.2.4 Any hand valves in a system that could trap liquid when closed, should be marked with a warning against accidental closing.

17.1.2.5 Liquid refrigerant must be removed before closing hand valves on both sides of a control valve or any other component. Liquid must also be removed before closing a hand valve at the inlet of a solenoid valve or regulator with positive electric shut-off, or some outlet pressure regulators, or at the outlet of a check valve, unless these valves are manually open.

17.1.2.6 To protect personnel, product, and plant, all liquid from the section to be isolated shall be removed before closing hand valves. Control valves shall remain open when removing liquid. Manufacturer's service and maintenance instructions shall be checked before trying to dismantle a valve.

17.1.2.7 Relief devices or methods shall be used in all parts of a system where liquid can become trapped and liquid expansion can occur. These valves shall be installed in accordance to all applicable safety standards and codes, in compliance to the manufacturer's instructions and generally known safety practices.

17.1.3 Mounting the valves

17.1.3.1 When installing a valve, ample space shall be allowed around it. Valves should not be used to stretch or align piping. Using flange bolts to close large gaps can distort the valve or cause it undue stress which could possibly make it malfunction.

17.1.3.2 Avoid locating valves where trapped ice can build up. Provide adequate access to control valves in easy reach for maintenance.

17.1.3.3 Mount flow switches to minimize the effects of vibration on the switch mechanism. Otherwise the switch could fail prematurely from excessive vibration.

17.1.3.4 When it becomes necessary to insulate control valves, insulation shall be applied so valves can operate properly and their manual and adjustable stems applied are readily accessible.

17.1.3.5 Construct insulation so sections can be easily removed and replaced to allow disassembly of the valve. Strainers shall be so insulated to allow accessibility for cleaning.

17.1.3.6 Because most maintenance problems cused by dirt happen at system start-up, insulating control valves should be delayed until the system has been operating for a few days. During that time, strainers shall be checked for dirt and cleaned as necessary.

17.1.3.7 Provisions shall be made for pumping out or safely purging refrigerant from individual control valves or control stations.

17.1.3.8 After installing a system section and prior to operating it, the system shall be charged with proper refrigerant or inert gas to prevent internal corrosion.

17.1.4 Pressure testing

17.1.4.1 Every segment of a refrigeration system, including control valves, should be field pressure tested before being insulated or put into operation. Correct high and low side pressures and proper refrigerant or gas for pressure testing shall be used.

17.1.4.2 Use of halocarbons or CO_2 to test an ammonia system or ammonia to test a halocarbon system, or use of system's compressor to build up test pressures shall not be permitted.

17.2 Safety Relief Valve

17.2.1 General

The safety relief valves can be single or dual valves with manifold and shall be constructed of cast iron body, teflon seat, stainless steel trim capable to withstand upto 150°C (302°F) maximum temperature. It shall have a standard drain plug and be unaffected by vibration.

17.2.2 Application

17.2.2.1 Used with ammonia and halocarbon refrigerant in non-corrosive environments relief valves protect each refrigeration system pressure vessel that can be isolated by valves. They are patterned after the ASME boiler and pressure vessel code and the ANSI / ASHRAE 15-1989 safety code for mechanical refrigeration.

17.2.2.2 The safety relief valve shall be intended to prevent the pressure of the vessel from rising more than 10% above:

1) The design working pressure (DWP) of the vessel, or
2) The pressure setting of the relief device.

17.2.2.3 Whenever conditions permit, it is advisable to have the relief valve pressure setting at least 25% higher than the normal operating pressure for the system. The relief valve pressure setting should however not exceed the design working pressure of the vessel.

17.2.3 Selection data

17.2.3.1 On positive displacement compressor systems, pressure limiting devices-such as high pressure cutouts, must stop the action of the pressure imposing element at no higher than 90% of the pressure setting of the pressure relief device.

17.2.3.2 On non-positive displacement compressors, pressure limiting devices-such as a high pressure cut-out, may be set at the design working pressure (DWP) of the high side, provided:

1) The low side is protected by a properly sized pressure at the low side DWP; and
2) There are no stop valves in the system that isolate the high side from the low side.

17.2.3.3 Discharge piping from relief devices must not exceed lengths specified in ANSI / ASHRAE 15-89 with discharge to atmosphere.

17.2.3.4 Per ANSI / ASHRAE 15-89, the formula for determining the minimum required discharge capacity of a pressure relief device or fusible plug for each pressure vessel where the vessel is valved off from the refrigerating systems, is: $C = FDL$.

Where:

C = Minimum required charge capacity, kg/s (lb/min air);
F = A factor from the table below;
D = Outside diameter of the vessel in meters (feet);
L = Length of vessel in meters (feet).

REFRIGERANT	VALUE OF F	
R - 717	0.041	(0.5)
R - 12, 22, 500	0.130	(1.6)
R - 13, 13B1, 14, 502	0.203	(2.5)
ALL OTHERS	0.082	(1.0)

Note:

For control valve symbols and function, reference is made to Attachment 12.

18. COLD STORAGE DOORS

18.1 General

General recommended guidelines to follow in selecting the cold storage doors best suited to meet job requirements shall be based on cold storage capacity, chamber dimensions and storage period. The inner and outer material shall be constructed of suitable thickness with either galvanized sheets, aluminum sheets or stainless steel.

18.2 Types

a) Single door

The single leaf insulated swinging door are generally specified for personnel passage and hand cart traffic, and may also be used separately or in multiple door "fronts". Larger than standard sizes shall require strong structural support.

b) Double door

Double leaf insulated swinging doors shall be used where wider doorways and space restrictions do not permit use of a single leaf or other types of doors. They are used on loading docks and where large equipment must be moved. Personnel traffic through these doors requires the use of only one leaf at most times.

c) Track door

The single leaf insulated swinging track doors used where an overhead track rail passes through a doorway.

d) Vestibule door

The single leaf insulated swinging door with double batten door hung in the same frame forms a vestibule unit. The insulated door can remain open and the batten doors will serve as an air barrier. Vestibule units can also be formed with double doors or track doors.

e) Double acting batten doors

Noninsulated doors shall be used with all types of insulated doors to prevent excessive loss of refrigeration when the insulated doors must remain open for loading or unloading.

f) Double acting batten track doors

These doors shall be available with either track port equipped frames or battens notched for the meat track rail. Track frames shall have height in clear 15 cm less than top of rail height, notched battens shall have height in clear of 20 cm greater than top of rail height.

g) Bi-Parting horizontal sliding

Used where space limitations rule out single doors and are preferred where power operation is desired. In the power version these doors should be capable to provide the fastest operation with a minimum loss of refrigeration.

h) Single horizontal sliding

These shall be used for both personnel and truck traffic, especially where space restricts use of swinging doors. It can be either manual or power operation.

i) Horizontal sliding track doors

These doors shall be used where restricted space does not permit use of swinging track doors. They can be manual or power operation, single leaf (with a head frame member) or bi-parting, (notched for the track trail).

j) Overhead rolling (roll-up) doors

These doors shall be used for refrigerated shipping and loading docks where openings are close together and ceiling height is limited. Suitable for power or manual operation.

k) Vertical sliding doors

These doors shall be used on exterior walls of refrigerated shipping and loading docks where openings are close together and there is ample ceiling height, suitable for power or manual operation. They may also be used in package passing sizes for pass-through or conveyer operation.

l) Bi-Passing vertical sliding doors

These doors are designed for locations where headroom is not sufficient for a single leaf vertical sliding door, and where overhead obstructions prevent use of an overhead rolling door. They are suitable for either manual or power operation.

Notes:

1) Reference is made to Attachment 13 for illustrations on cold storage doors.

2) Protective bollards for protection of door frame and door leaf shall be provided on horizontal sliding doors.

3) Power operation would mean either electric or hydraulic.

18.3 Sizes

Door sizes provided below are approximate and may be different with different manufacturers. (Deviations upto 20% shall be acceptable in order to support local fabricators).

a) Package passing

Sizes may range from 45 × 45 cm to 120 × 120 cm. Openings should preferably be 15 cm wider and higher than largest package going through opening.

b) Personnel

Sizes may range from 75 × 135 cm to 105 × 135 cm, except where combined with hand cart and truck traffic.

c) Hand truck

Sizes may range from 105 × 135 cm to 150 × 210 cm. Openings should preferably be 30 cm minimum wider and 15 cm minimum higher than widest object going through doorway.

d) Forklift truck

Sizes may range from 150 × 210 cm (walk-behind) through 300 × 360 cm; 180 × 240 for regular stacker, and 240 × 300 cm for high stacker being common sizes. About 30 cm minimum clearance shall be allowed on each side of widest load and 15 cm minimum head clearance.

e) Meat rail

USDA requires 150 × 255 cm top of rail for beef quarters as minimum; 135 × 330 cm top of rail for whole beef. Wherever carts also pass through doorway, width must be 150 cm minimum. Intermediate rail heights can be 240, 270, and 300 cm. Height in clear shall be about 15 cm less than top of rail height.

f) Double acting battens

Frame openings should preferably be about 10 cm wider and 30 cm higher than largest load or object going through doorway.

18.4 Insulation

18.4.1 Cold storage doors shall be insulated with either expanded polystyrene or polyurethane insulation doors with 5 cm of insulation shall have an approximate R value of 15 at 25°C, 10 cm of insulation an R value of 30, and 15 cm of insulation an R value of 45.

18.4.2 Insulation thickness for cooler doors for service in chamber temperature +1°C and above shall be 10 cm for swinging doors, and 5 or 10 cm for sliding doors, depending upon construction and panel size. For a temperature difference over 28°C, a 10 cm door is recommended.

18.4.3 Insulation thickness for freezer doors, for service at +32°F and below is 10 to 15 cm, depending upon the temperature difference between one side of the doorway and the other. For a temperature difference of 55°C, a 10 cm door is recommended; for a difference of 83°C a 15 cm door (with maximum warm side temperature of 66°C) is recommended.

18.4.4 Insulation for high temperature doors, such as somkehouse doors, shall preferably be high density fiberglass insulation.

Note:

Thickness of insulation shall vary depending upon type and insulation material used.

18.5 Type of Operation

a) Manual operation

Are recommended on swinging doors in most operations, and on horizontal sliding, vertical sliding, and overhead doors where traffic is light, such as for loading and unloading truck and railroad cars.

b) Hydraulic operation

Shall be suitable for roll-up or sliding movements.

c) Power operation

Recommended for horizontal sliding overhead, and vertical sliding doors where traffic is heavy or where automatic conveyer operation is used. Swinging doors can also be power operated, but this may create a hazard for unwary personnel. Motor operation should be 220 volt, single phase, 50 Hz.

Controls for power doors shall be adapted to conform to special activation systems and may include any of the following:

- Pull cord switches; sensitive edges on sliding doors;
- Pedestrian switches; photoelectric cell control; time delay closing when used with a safety device; two or more door interlock switch controls; air curtain switch;
- Radio control and special push-button switches.

18.6 Heating Devices (applied to freezer doors only)

18.6.1 Heater cables shall be applied to doors and frames to prevent (1) doors from freezing shut, (2) condensation from forming on doors and frames, and (3) power operator systems from freezing fast.

18.6.2 Freezer doors designed for installation in warm room shall be with temperatures 0°C (+32°F) and above. Freezer doors for rooms 0°C and below should be mounted on the warmer side of the wall. Where freezer doors are mounted in freezer rooms (0°C and below), fabrications shall proceed after drawings are approved.

18.6.3 Where cold room temperature is below -30°C (-22°F) and/or the relative humidity is greater than 80% on the warm side, especially designed heater cables should be added to the frame/gasket assembly.

Note:

Hot oil piping systems are not recommended for use as heating devices.

18.7 Moisture Protection

18.7.1 Metal cladding exterior doors should have all exposed surfaces of door and frame metal clad with special seam and caulking or flashing on exterior frame perimeter. Small canopies to protect exterior doors should be erected wherever possible.

18.7.2 For interior doors which are subject to high humidity and frequent washdown, metal cladding should be applied to all surface of doors and frames including back surfaces of frames, with vapor tight seams. This is especially desirable in meat packing plants and food processing and service facilities.

Note:

Special overhead rainscreen shall be provided for doors mounted exterior of the building.

18.8 Cleansing Agents

The harsh detergents or similar cleansing agents shall be used for protection of stainless steel metal cladding and chromeplated hardware may be called for. For polyester plastic doors, use liquid soaps and wax, but use of chemical solvents, or continuous live steam shall be avoided. Acrylic doors should not be cleaned with cleansers containing granular agents.

19. ELECTRICAL REQUIREMENTS

19.1 General

19.1.1 The refrigeration plant control and protection parts shall be placed in safety applied areas. The panel board shall contain the apparatus for protection of the refrigeration equipment. All components shall be installed in enclosures and properly supported.

19.1.2 The main control and signalling equipment shall be positioned on the front side of multi-cubicle panel boards.

19.2 Feeding Cable

19.2.1 The electric feeding system for the various utilizing equipment shall be realized by electric cables sized on the basis of the maximum capacity allowed and according to the specific laying and ambient conditions.

19.2.2 The cables feeding the electric motors will be sized for 115% of the rated load of the motors. The maximum voltage drops allowed shall be as follows:

a) A maximum total of 4% on the electric motor feeding lines, with a maximum of 15% during start-up.
b) A maximum total of 3% on feeding lines, on the lighting circuits and on all utilizing equipment, except for the electric motors.

19.2.3 The lines coming from the panel boards shall be made of fixed set cables, three-pole and monopolar, rubber insulated type, internal layer in PVC, having insulation Class 4.

19.2.4 All wiring in suitable sizes shall be installed in conduit. The wiring or cable connections shall be applied to all electrical gadgets, viz:

a) Electric motors & starters of compressors.
b) Electric motors & starters of air coolers.
c) Electric magnetic solenoid valves on liquid line.
e) Electric motors & starters for fan and pump of evaporative condenser.
f) Electro-magnetic solenoid valves on compressor crankcase heater & compressor water jacket circuits.
g) Electric wiring for flow recorders installed (presumably) over each chamber door.
h) Electro-magnetic controls of suction lines.
i) Electric motors & starter of secondary oil pump
j) Room thermostats and refrigerated door heaters.

Note:

Necessary interlocking with auxilliary contacts of units required to co-ordinate its operation through load demand for efficient and automatic operation shall be made.

19.3 Electric Cable Holder Raceway

19.3.1 The raceways and main accessories shall be realized in hot galvanized steel (sendzimized), sized and anchored to support 130% of the weight of the cables guaranteeing a free space of at least 15% of the total occupied section.

19.3.2 The cables shall be fixed to the raceways at regular distance intervals and properly anchored. The cables coming out of raceways shall be adequately protected & supported up to the coupling of the utilizing equipment.

Note:

The passes through the cold room walls shall be closed and subsequently insulated with expanded polyurethane to avoid as much as possible thermal dispersions and formation of condensate.

19.4 Internal Lighting

19.4.1 The lighting plan shall be sized to perform the following intensities:

Cold rooms	**150 Lux**
Anteroom	**200 Lux**

19.4.2 Lighting shall be carried out with waterproof ceiling lamps with IP 54 protection complete with fluorescent tubes.

19.4.3 In office areas and processing room, the ceiling lamps shall be installed on the ceiling through prefabricated and self-supporting ducts complete with all accessories.

19.4.4 Lighting in cold rooms shall be through waterproof ceiling lamps, mercury-vapor flourescent type, fixed directly to the ceiling with feeding from the top of the room through holes in the panels subsequently closed with foamed polyurethane. The lamps shall be provided with waterproof switches installed outside each chamber.

19.5 Man-in-Room Alarm Station

19.5.1 The control station shall be preferably composed of a panel board, with a suitable structure placed in the refrigeration plant room, suitable to contain the control equipment (relay, etc.), with visual and acoustic signals also indicating persons locked in cold rooms.

19.5.2 The signal to the refrigeration plant shall be given by a button placed in a waterproof safety box on the inside of the cold room.

19.5.3 The lines from the station in refrigeration plant room to the safety boxes shall be made with fixed set cables, four-pole rubber insulated type, in preferably PVC sheathing and Class 4 insulation.

19.5.4 The station shall be fed preferably from a source of continuous current of nickel batteries coupled to continuous current with rectifiers.

19.6 Earthing System

The equipment connections shall be earthed between the refrigeration equipment and the main low voltage refrigeration panel board. The earthing conductor shall be included in the feeding cables.

19.7 Performance and Design

19.7.1 The quality of material, design, manufacturing, painting, galvanizing, etc. shall be according to the valid IEC Standards.

19.7.2 The enclosures of all electrical equipment shall have a degree of protection in accordance with IEC 529 classified for various areas as follows:

- Wet areas (process, service)	IP 54
- Mostly dry areas (machinery room)	IP 32
- Dusty areas (process, storage)	IP 54
- Cold store chamber	IP 54
- Control rooms	IP 21

19.8 Regulation and Norms

The equipment and material of the relevant IEC Standards shall apply to the following publications.

a) Publication 34:	Rotating electrical motors.
b) Publication 529:	Degrees of protection for enclosures.
c) Publication 364:	Electrical installations.
d) Publication 439:	Factory built assemblies of low voltage switch gears and control gears.

ATTACHMENTS

(THE ATTACHMENTS ARE FOR INFORMATION PURPOSES AND DOES NOT FORM PART OF THIS STANDARD)

ATTACHMENT 1

TABLE - 1

INSULATION	TEMPERATURE DIFFERENTIAL (ambient temp. - room temp.) °C														
Thickness of cork or equivalent material mm	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70
60	14.7	73.5	147	222	294	368	444	515	590	660	735	810	888	960	1030
80	11.0	55.0	110	156	220	274	330	385	440	495	550	605	680	715	770
100	8.8	44.0	86.0	132	176	220	264	308	352	396	440	485	530	572	618
120	7.3	36.5	73.0	110	146	182	219	256	292	328	365	402	439	475	512
140	6.3	31.5	63.0	94.5	126	157	190	220	252	284	315	348	379	410	441
160	5.5	27.5	55.0	82.5	110	138	165	193	220	248	275	303	330	358	386
180	4.9	24.5	49.0	73.5	98.0	123	147	172	196	220	245	270	294	318	344
200	4.4	22.0	44.0	66.0	88.0	110	122	154	176	198	220	242	264	286	309
220	4.0	20.0	40.0	60.0	80.0	100	120	140	160	180	200	220	240	260	280
240	3.65	18.3	36.5	54.6	73.0	91.5	109	128	146	164	182	201	219	238	256
260	3.38	16.9	33.8	51.0	67.6	85.0	103	118	135	152	170	186	205	220	236
280	3.14	15.7	31.4	47.3	62.8	78.5	94.0	110	126	142	157	173	189	204	220
300	2.92	14.6	29.2	44.0	58.5	73.0	87.5	104	117	131.5	146	162	175	190	206
320	2.75	13.8	27.5	41.3	55.0	69.0	82.5	96.5	110	124	138	152	165	179	193
340	2.58	12.9	25.8	38.8	51.5	64.5	77.5	90.0	103.5	116	129	142	155	167	180
Plain glass	132	660	1320	2000	2640	3300	3960	4620	5300	5950	6600	7260	7900	8600	9260
Medium thick glass	54	270	540	810	1080	1350	1620	1890	2160	2430	2700	2980	3240	3510	3800
Thick glass	34.2	172	340	510	685	855	1025	1200	1370	1540	1720	1885	2030	2220	2400

Note: Calories multiplier for expanded polystyrene is 0.96

TABLE - 2

Minimum recommended thickness of cork or equivalent material - cm

Room temp. °C	North	South
10 ÷ 15	5	7.5
4.5 ÷ 10	7.5	10
- 4 ÷ 4.5	10	12.5
- 10 ÷ - 4	12.5	15
- 10 ÷ - 18	15	17.5
- 18 ÷ - 26	17.5	20
- 26 ÷ - 40	22.5	25

TABLE - 3

Conventional temperature differential increase to compensate for sun effect

Δt °C

Exposition Color	East	South	West	Flat Roof
Dark color	4.5	2.6	4.5	11
Medium color	3.3	2.2	3.3	8.6
Light color	2.2	2.1	2.2	5

Note: Soil temperature to be considered equal to 12°C

ATTACHMENT 2

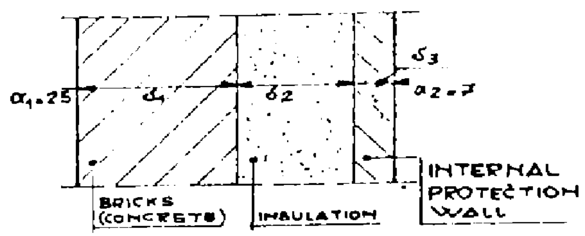
OVERALL COEFFICIENT OF HEAT TRANSER, OR
" K " FACTOR FOR MASONRY OR CONCRETE WALLS INSULATED WITH EXPANDED CORK
NOTE. FOR EXPANDED POLYSTYRENE USE a 0.96 multiplier

Insulation thickness (cm)	BRICK MASONRY wall thickness cm							CONCRETE wall thickness cm						
	6.5	12	25	38	51	64	77	5	10	15	20	30	40	50
3	1.15	1.06	0.90	0.78	0.58	0.61	0.56	1.20	1.15	1.09	1.04	0.95	0.88	0.81
4	0.94	0.88	0.76	0.68	0.60	0.54	0.50	0.97	0.93	0.89	0.86	0.80	0.75	0.70
5	0.78	0.74	0.66	0.59	0.54	0.49	0.45	0.81	0.79	0.76	0.73	0.69	0.65	0.61
6	0.68	0.65	0.58	0.53	0.48	0.44	0.41	0.70	0.68	0.66	0.64	0.60	0.57	0.54
8	0.53	0.51	0.47	0.44	0.40	0.38	0.36	0.55	0.53	0.52	0.51	0.49	0.47	0.45
10	0.44	0.42	0.40	0.37	0.35	0.33	0.31	0.45	0.44	0.43	0.42	0.41	0.39	0.38
12	0.37	0.36	0.34	0.32	0.31	0.29	0.28	0.38	0.37	0.37	0.36	0.35	0.34	0.33
14	0.33	0.32	0.30	0.29	0.27	0.26	0.25	0.33	0.33	0.32	0.32	0.31	0.30	0.29
16	0.29	0.28	0.27	0.26	0.25	0.24	0.23	0.29	0.29	0.28	0.28	0.27	0.27	0.26
20	0.23	0.23	0.22	0.21	0.21	0.20	0.19	0.24	0.23	0.23	0.23	0.22	0.22	0.22
24	0.20	0.19	0.19	0.18	0.18	0.17	0.17	0.20	0.20	0.20	0.19	0.19	0.19	0.18

Note: For partition walls ($\lambda_1 = 7$) reduce K values found on the table by 5%

This table gives the values of the overall coefficient of heat transfer, or " K " factor, Kcal/sq. m./h/ C relative to bricks or concrete walls, insulated with expanded cork or polystyrene. These values have been obtained by the theoretical formula that takes into consideration the insulating effected of the whole wall being considered, main wall insulation and internal protection wall.

CROSS . SECTION OF INSULATED WALL



$\lambda_1 = 0.76$ (1.1) $\quad \lambda_2 = 0.05 \quad \lambda_3 = 0.75$

$$K = \frac{1}{\frac{1}{\alpha_1} + \frac{\delta_1}{\lambda_1} + \frac{\delta_2}{\lambda_2} + \frac{\delta_3}{\lambda_3} + \frac{1}{\alpha_2}}$$

PHYSICAL DIMENSIONS OF K FACTOR

$$[K] = \left[\frac{Kcal}{mq.\ h.\ ^\circ C} \right]$$

ATTACHMENT 3

TABLE - 4 NUMBER OF AIR CHANGES PER 24 HOURS DUE TO COLD ROOM DOOR OPENING

Room volume cu. m.	Heavy usage	Normal usage	Room volume cu. m.	Heavy usage	Normal usage
8.5	34.7	26.2	140	7.3	5.6
11	29.5	22.4	170	6.6	5.1
14	26	13.8	225	5.6	4.3
17	23.5	17.9	283	5	3.9
23	20.1	15.3	425	4	3.1
28	17.7	13.5	563	3.4	2.6
34	16	12.2	700	3	2.3
45	13.7	10.4	850	2.7	2.1
57	12	9.1	1130	2.3	1.8
70	10.6	8.2	1410	2	1.6
83	9.6	7.4	2100	1.6	1.3
113	8.2	6.3	2830	1.4	1.1

Note:

1) Heavy usage examples are restaurants or supermarkets.

2) Ante-room, reduce the values to 50%.

3) As a minimum 1 air change per 24 hours.

ATTACHMENT 4

HEAT TO BE REMOVED FROM OUTSIDE AIR ENTERING INTO COLD ROOMS (kcal cu. m.)

Room Temp. °c	AMBIENT TEMPERATURE							
	29.4°C		32.2°C		35°C		37.8°C	
	PERCENT RELATIVE HUMIDITY							
	50	60	50	60	50	60	50	60
18.3	5.8	7.6	8.3	10.4	11	13.7	14	17.4
15.6	7.6	9.2	10.1	12.2	12.8	15.5	15.8	13.2
12.8	10	12	12.6	14.8	15.3	17.9	18.3	21.7
10	11.8	13.7	14.4	16.7	17.2	19.8	20.3	13.6
7.2	13.4	15.4	16	18.4	19.8	21.5	22	25.4
4.4	15	17.1	17.8	20.1	20.6	23.3	23.8	27.2
1.7	16.6	18.6	19.4	21.6	22.1	24.8	25.4	28.8
1.1	17.8	20	20.2	22.5	23.5	26.2	26.2	29.8

Room Temp. °c	AMBIENT TEMPERATURE							
	4.4°C		10°C		32.2°C		37.8°C	
	PERCENT RELATIVE HUMIDITY							
	70	80	70	80	50	60	50	60
- 1.1	2.14	2.58	5.15	5.9	20.1	22.5	26.2	29.8
- 3.9	3.65	4	6.7	7.4	21.7	24.1	28	31.5
- 6.7	5	5.5	8.1	8.8	23.4	25.8	29.6	33.2
- 9.4	6.3	6.7	9.4	10.1	25	27.3	31.2	34.8
- 12.2	7.6	7.9	10.3	11.3	26.1	28.5	32.4	35.9
- 15	8.7	9.2	11.9	12.7	27.8	30.2	34.2	38
- 17.8	10	10.4	13.2	13.9	29.2	31.7	35.7	39.4
- 20.6	10.9	11.4	14.1	14.9	30.4	32.8	37	40.7
- 23.3	12	12.5	15.4	16.1	31.7	34.2	38.4	42.2
- 26.1	13.4	13.6	16.5	17.1	32.7	35.2	39.4	43.2
- 28.9	14.5	15	17.9	18.6	34.6	37.2	41.5	45.4
- 31.7	15.8	16	18.9	19.7	15.6	38.3	42.5	46.4
- 34.4	17	17.4	20.4	21.2	37.6	40.2	43.6	48.4

ATTACHMENT 5

COMMODITY	SHORT TIME STORAGE		LONG TIME STORAGE		APPROX. MAX. STORAGE LIFE	RESPIRATION Kcal/ton of product/24h	APPROX. WATER CONTENT %	SPEC. HEAT kcal/kg/°C		LATENT HEAT kcal/kg	FREEZING POINT °C	SENSIBLE HEAT %	
	D.B. TEMP. °C	R.H. %	D.B. TEMP. °C	R.H. %				ABOVE FREEZING	BELOW FREEZING			PRECOOLING	HOLDING
DAIRY PRODUCT													
butter	5÷7	60÷80	-23	65÷85	12 Mos.	—	15	0.64	0.34	8.2	-18÷-35	87÷91	95÷98
cheese, cream	4	70÷80	0	70÷80	1÷2 Wks.	—	55	0.64	0.36	44	—	87÷91	80÷83
cheese, emmental	—	—	1.5÷4	60÷70	4÷5 Mos.	—	—	—	—	—	—	—	—
cheese, fresh	4.5	85÷90	—	—	30÷45 Days		55	0.64	0.36	44	—	87÷91	80÷83
cheese, hard	—	—	16÷18	80	12 Mos.	—	55	0.65	0.32	44	-15	87÷91	80÷83
eggs, fresh	4.5	70÷85	-1	70÷85	9 Mos.	—	73	0.76	0.40	55	-2.8	87÷91	83÷87
eggs, frozen	—	—	-18	60÷80	12÷18 Mos.	—	73	0.76	0.40	55	-2.8	-	91÷95
ice cream	-18	60÷80	-24	60÷80	2 Wks.	—	60	0.78	0.45	27	-18÷-33	93÷98	93÷98
milk, fresh	4	60÷70	0	60÷80	5 Days	—	88	0.94	0.49	70	-1	83÷91	83÷91
yoghurt	2÷5	—	—	—	2÷3 Days	—	85	0.90	0.50	68	—	—	—
VEGETABLES													
artichokes, clobe	4.4	80÷89	-0.5	80÷89	1÷2 Wks.	400	84	0.90	0.49	67	-1.7	80÷83	72÷77
artichokes, jerusalem	4.5	80÷89	-0.5	80÷89	2÷5 Mos.	400	84	0.90	0.49	67	-1.7	80÷83	72÷77
asparagus	4.5	80÷89	0	80÷89	3÷4 Wks.	400	94	0.95	0.40	75	-1	80÷83	72÷77
broccoli	4.5	80÷89	1.5	80÷89	7÷10 Days	400	90	0.90	0.45	74	-7	80÷83	72÷77
brussel sprouts	4.5	80÷90	0	80÷90	3÷4 Wks.	400	95	0.91	0.40	74	-1	80÷83	72÷77
cabbage	1.7	80÷90	0	80÷90	3÷4 Mos.	390	92	0.93	0.47	74	-0.6	80÷83	72÷77
carrots, bunch	1.7	80÷95	0	80÷95	10÷14 Days	725	88	0.86	0.45	70	-1.1	80÷87	72÷77
cauliflower	1.7	80÷90	0	80÷90	2÷3 Wks.	390	92	0.91	0.46	75.5	-0.6	80÷83	72÷77
corn, dried	10	60÷70	1.7	60÷70	12 Mos.	—	11	0.29	0.24	8.3	—	—	87÷91
corn, green	1.7	80÷89	0.5	80÷90	1÷4 Wks.	1060	74	0.86	0.38	60.5	-1.7	80÷83	72÷77
cucumbers	10	80÷85	7.2	80÷85	10÷14 Days	206	96	0.93	0.48	76	-0.6	83÷87	77÷80
agg plant	10.6	80÷90	7.2	80÷90	7÷10 Days	159	93	0.91	0.45	73.5	-1.1	83÷87	77÷80
endive	1.7	80÷90	0	80÷90	2÷3 Wks.	2060	89	0.90	0.46	75.5	-0.6	80÷83	71÷77

(to be continued)

ATTACHMENT 5 - (continued)

COMMODITY	SHORT TIME STORAGE		LONG TIME STORAGE		APPROX. MAX. STORAGE LIFE	RESPIRATION kcal/ton of product/24h	APPROX. WATER CONTENT %	SPEC. HEAT kcal/kg/°C		LATENT HEAT kcal/kg	FREEZING POINT °C	SENSIBLE HEAT %	
	D. B. TEMP. °C	R. H. %	D. B. TEMP. °C	R. H. %				ABOVE FREEZING	BELOW FREEZING			PRECOOLING	HOLDING
lettuce	1.7	80÷90	0	80÷90	2÷3 Wks.	1640	95	0.90	0.45	75.5	-0.6	80÷87	71÷77
mushrooms	—	—	0	80÷85	2÷3 Days	—	90	0.90	0.45	72	-1.1	80÷83	71÷77
onions	10	75÷80	0	75÷80	5÷6 Mos.	305	89	0.90	0.51	71	-1.1	83÷87	77÷80
peas, dried	10	60÷70	1.7	60÷70	12 Mos.	—	10	0.28	0.23	77	—	—	87÷91
peas, green	1.7	80÷90	0	80÷90	1÷2 Wks.	750	74	0.85	0.45	60	-1.1	83÷87	77÷83
peppers, chili (dry)	—	—	0	70÷80	6÷9 Mos.	—	—	—	—	—	—	—	83÷87
peppers, sweet	4.4	80÷85	0	80÷90	4÷5 Wks.	422	85	0.90	0.46	—	-1.1	80÷87	77÷81
potatoes, irish	4.4	80÷90	2.2	80÷90	6 Mos.	472	79	0.86	0.47	62	-1.7	87÷91	83÷87
potatoes sweet	10	80÷85	10	80÷85	4÷6 Mos.	472	78	0.80	0.46	57	-1.7	87÷91	83÷87
radishes	4.4	80÷90	0	80÷95	2÷4 Mos.	158	91	0.90	0.50	74.5	—	87÷91	83÷87
tomatoes (green)	12.8	80÷85	12.8	80÷85	1÷5 Wks.	390	95	0.92	0.46	73.3	-0.6	83÷87	77÷80
tomatoes (ripening)	18.3	80÷85	18.3	80÷85	—	1055	95	0.92	0.46	73.5	-0.6	80÷83	71÷77
tomatoes, ripe	4.4	80÷85	4.4	80÷85	7÷10 Days	158	95	0.92	0.46	73.5	-0.6	80÷83	71÷77
turnips	1.7	80÷95	0	80÷95	4÷5 Mos.	159	90	0.90	0.45	71	-0.6	83÷87	77÷80
vegetables, frozen pack	—	—	-23.3	80÷85	6÷12 Mos.	—	—	—	—	—	—	—	95
<u>FRUITS AND FRUIT JUICES</u> apples, dried	—	—	-3.3	60÷65	9÷12 Mos.	—	30	0.47	0.32	24	—	91÷94	87÷91
apples, fresh	1.7	80÷88	-1.1	80÷88	2÷7 Mos.	245	84	0.90	0.49	68	-2.2	80÷83	74÷80
apples, cider	7.8	80÷85	-1.7	80÷85	3÷4 Wks.	—	87	0.95	0.50	72	-3.9	87÷91	83÷87
apricots, dried	—	—	-3.3	65÷70	9÷12 Mos.	—	30	0.47	0.32	24	—	91÷95	87÷91
apricots, fresh	1.7	80÷85	-0.6	80÷85	1÷2 Wks.	244	85	0.92	0.50	68	-2.2	80÷83	74÷80
avocados	7.2	80÷90	4.4	80÷90	4÷6 Wks.	244	—	0.91	0.49	76	-2.8	83÷87	77÷80
bananas, green	13.3	80÷85	13.3	80÷85	—	915	75	0.90	0.36	—	-1.1	77÷83	71÷77

(to be continued)

ATTACHMENT 5 - (continued)

COMMODITY	SHORT TIME STORAGE D.B. TEMP. °C	SHORT TIME STORAGE R.H. %	LONG TIME STORAGE D.B. TEMP. °C	LONG TIME STORAGE R.H. %	APPROX. MAX. STORAGE LIFE	RESPIRATION kcal/ton of product/24h	APPROX. WATER CONTENT %	SPEC. HEAT kcal/kg/°C ABOVE FREEZING	SPEC. HEAT kcal/kg/°C BELOW FREEZING	LATENT HEAT kcal/kg	FREEZING POINT °C	SENSIBLE HEAT % PRECOOLING	SENSIBLE HEAT % HOLDING
bananas, ripening	17.8	80÷85	17.8	80÷85	—	2330	75	0.90	0.36	—	-1.1	—	67÷71
bananas, ripe	13.3	80÷85	13.3	80÷85	7÷10 Days	915	75	0.90	0.36	—	-1.1	77÷83	71÷83
berries, general	1.7	80÷85	0	80÷85	10÷14 Days	—	84	0.90	0.49	67	-1.7	77÷80	74÷80
blackberries	6.1	80÷85	-0.6	80÷85	7÷10 Days	1835	85	0.90	0.47	67	-2.2	80÷83	71÷77
cherries	2.2	80÷85	-0.6	80÷85	10÷14 Days	490	84	0.92	0.46	67	-2.2	80÷83	74÷80
cherry juices	2.2	80÷85	2.2	80÷85	12 Mos.	—	90	0.95	0.50	72	-3.9	87÷91	83÷87
cranberries	2.2	80÷85	2.2	80÷85	1÷3 Mos.	490	87	0.91	0.46	70	-2.8	83÷87	77÷83
currants	2.2	80÷85	0	80÷85	10÷14 Days	490	85	0.95	0.50	72	-3.9	80÷83	74÷80
dates, cured	1.7	60÷70	-4.4	60÷70	12 Mos.	—	18	0.35	—	14.4	-20	87÷91	83÷87
dates, non cured	-17.8	70÷80	-17.8	70÷80	12 Mos.	—	18	0.35	—	14.4	-20	—	95
dates, dried	4.4	60÷70	4.4	60÷70	9÷12 Mos.	—	30	0.47	0.32	24	—	91÷95	87÷91
dates, fresh	4.4	75÷80	0	60÷75	15 Days	245	80	0.88	0.48	61	-2.2	80÷83	74÷80
dewberries	1.7	80÷85	-0.6	80÷85	7÷10 Mos.	1840	—	—	—	—	—	77÷80	71÷77
figs, dried	4.4	60÷65	4.4	60÷65	9÷12 Mos.	—	30	0.47	0.32	24	—	91÷95	87÷91
figs, fresh	4.4	70÷75	0	65÷70	5÷7 Days	225	80	0.88	0.48	64	-2.2	93÷96	86÷93
fruit, frozen pack	—	—	-23.3	70÷85	6÷12 Mos.	—	—	—	—	—	—	—	96
grapes, american type	1.7	80÷85	-0.6	80÷85	3÷8 Wks.	367	82	0.85	0.45	62	-2.2	80÷83	74÷80
grapes, europian type	1.7	80÷85	-0.6	80÷85	3÷6 Mos.	367	82	0.85	0.45	62	-2.2	80÷83	74÷80
grapefruit	15.6	80÷88	15.6	80÷88	6÷8 Wks.	770	88	0.91	0.49	71	-1.7	77÷80	71÷77
lemons	14.4	80÷88	14.4	80÷88	1÷4 Mos.	625	88	0.91	0.49	70	-2.2	77÷80	71÷77
limes	7.2	80÷88	7.2	80÷88	6÷8 Wks.	690	88	0.91	0.49	70	-1.7	77÷80	71÷77
logan berries	1.7	80÷85	-0.6	80÷85	7÷10 Days	1835	83	0.92	0.48	74	-1.1	71÷80	71÷77
melons, cantaloupe	10	80÷85	2.2	80÷85	3÷4 wks.	193	81	0.92	0.52	64	-0.6	83÷87	77÷80
melons, casabas	10	80÷85	2.2	80÷85	4÷6 Wks	193	92	0.90	0.46	73	-1.1	80÷87	77÷80
melons, honey dew	10	80÷85	2.2	80÷85	2÷4 Wks.	193	80	0.90	0.50	64	-1.7	83÷87	77÷80

(to be continued)

ATTACHMENT 5 - (continued)

COMMODITY	SHORT TIME STORAGE D.B. TEMP. °C	SHORT TIME STORAGE R.H. %	LONG TIME STORAGE D.B. TEMP. °C	LONG TIME STORAGE R.H. %	APPROX. MAX. STORAGE LIFE	RESPIRATION kcal/ton of product/24h	APPROX. WATER CONTENT %	SPEC. HEAT kcal/kg/°C ABOVE FREEZING	SPEC. HEAT kcal/kg/°C BELOW FREEZING	LATENT HEAT kcal/kg	FREEZING POINT °C	SENSIBLE HEAT % PRECOOLING	SENSIBLE HEAT % HOLDING
melons, watermelon	4.4	80÷85	2.2	80÷85	2÷3 Wks.	193	92	0.90	0.46	—	-1.7	80÷87	77÷80
oranges	4.4	80÷85	0	80÷85	6÷10 Wks.	388	86	0.90	0.47	69	-2.2	80÷83	74÷80
peaches, fresh	1.7	80÷85	-0.6	80÷85	1÷4 Wks.	550	88	0.92	0.48	71	-1.1	80÷83	74÷80
peaches, dried	—	—	-3.3	65÷70	9÷12 Mos.	—	30	0.47	0.32	43	—	91÷95	87÷91
pears, fresh	1.7	80÷88	-0.6	80÷88	1÷4 Wks.	244	84	0.91	0.49	68	-1.7	80÷83	74÷80
pineapples, green	15.6	80÷88	10	80÷88	3÷4 Wks.	244	88	0.90	0.50	71	-2.2	80÷83	74÷80
pineapples, ripe	7.2	80÷88	4.4	80÷88	2÷4 Wks.	141	88	0.90	0.50	71	-2.2	80÷83	74÷80
plums, dried	—	—	4.4	65÷70	9÷12 Mos.	—	30	0.47	0.32	24	—	87÷91	83÷87
plums, fresh	1.7	80÷85	-0.6	80÷85	3÷8 Wks.	244	86	0.90	0.49	67	-2.2	80÷83	74÷80
pomegranates	4.4	80÷85	0.6	80÷85	1÷3 Wks.	244	77	0.87	0.48	62	-2.2	80÷83	74÷80
prunes, dried	—	—	4.4	65÷70	9÷12 Mos.	—	30	0.47	0.32	43	—	87÷91	83÷87
prunes, fresh	1.7	80÷85	-0.6	80÷85	3÷8 Wks.	244	30	0.88	0.48	64	-2.2	80÷83	74÷80
quinces	1.7	80÷85	-0.6	80÷85	2÷3 Wks.	244	85	0.90	0.49	68	-2.2	80÷85	74÷80
raisins, dried	—	—	4.4	60÷70	9÷12 Mos.	—	30	0.47	0.32	43	—	87÷90	79÷83
strawberries, fresh	1.7	80÷85	-0.6	80÷85	7÷10 Days	1835	91	0.92	0.48	73	-11	77÷80	71÷77
MEAT, MEAT PRODUCTS, POULTRY, GAME AND FOWL													
beef, edible offal	2.2	80÷85	-0.6	80÷85	—	—	—	0.72	0.40	52	—	67÷71	80÷87
beef, dried	7.2	65÷70	2.2	65÷70	6 Mos.	—	15	0.34	0.26	—	—	87÷91	91÷95
beef, fresh	1.7	80÷87	0	80÷87	1÷6 Wks.	—	68	0.75	0.40	54	-2.8	67÷71	80÷87
fowl, fresh goose	1.1	80÷85	-2.2	80÷85	10 Days	—	47	0.57	0.34	52	—	67÷71	80÷87
fowl, fresh turkey	1.1	80÷85	-2.2	80÷85	10 Days	—	56	0.64	0.37	37	—	67÷71	80÷87
game, fresh	1.1	80÷85	-5.6	80÷85	—	—	—	0.80	0.42	64	—	67÷71	80÷87
hides and pelts	—	—	-3.9	60÷70	—	—	—	—	—	—	—	87÷91	87÷91

(to be continued)

ATTACHMENT 5 - (continued)

COMMODITY	SHORT TIME STORAGE		LONG TIME STORAGE		APPROX. MAX. STORAGE LIFE	RESPIRATION kcal/ton of product/24h	APPROX. WATER CONTENT %	SPEC. HEAT kcal/kg/°C		LATENT HEAT kcal/kg	FREEZING POINT °C	SENSIBLE HEAT %	
	D.B. TEMP. °C	R.H. %	D.B. TEMP. °C	R.H. %				ABOVE FREEZING	BELOW FREEZING			PRECOOLING	HOLDING
lamb and mutton, edible offal	2.2	80÷85	-0.6	—	—	—	—	0.72	0.40	52.0	-1.7	67÷71	80÷87
lamb and mutton, fresh	2.2	80÷85	0	80÷85	5÷12 Days	—	58	0.67	0.30	46.5	-1.7	67÷71	80÷87
lard	7.2	70÷80	0	70÷80	4÷8 Mos.	—	20	0.52	0.31	50	—	87÷91	83÷87
mince meat	1.7	70÷80	-1.1	70÷80	10 Days	—	—	—	—	—	—	87÷91	82÷87
oleo (oil)	—	—	4.4	60÷80	—	—	—	—	—	—	—	87÷91	82÷87
oleo margarine	7.2	60÷80	-23.3	65÷85	—	—	15	0.48	0.34	8.3	-2.2	87÷91	92.5÷98
pork, cured bacon	—	—	15.6	70÷85	4÷6 Mos.	—	38	0.50	0.39	28	-2.8	—	83÷87
pork, cured ham	—	—	15.6	70÷80	3 Years	—	51	0.61	0.35	40.5	—	—	83÷87
pork, edible offal	2.2	70÷85	-0.6	70÷85	—	—	—	0.72	0.40	52	—	67÷71	80÷87
pork, fresh	1.7	70÷87	0	70÷87	3÷7 Days	—	60	0.68	0.32	48	—	67÷71	80÷87
poultry, fresh chicken	1.1	80÷85	-2.2	80÷85	10 Days	—	75	0.80	0.4	59.5	—	83÷87	87÷91
sausage, casings	—	—	4.4	80÷85	—	—	—	—	—	—	—	—	83÷87
sausage, franks	4.4	80÷85	-0.6	80÷85	2 Days	—	60	0.88	0.56	45	-1.7	87÷91	83÷87
sausage, fresh	1.7	80÷85	0	80÷85	15 Days	—	48	0.89	0.56	51.6	-3.3	83÷87	83÷87
sausage, smoked	7.2	70÷80	0	70÷80	6 Mos.	—	60	0.86	0.56	48	-3.9	91÷95	87÷91
veal, edible offal	2.2	80÷85	-0.6	80÷85	—	—	—	0.72	0.40	52	—	66÷71	80÷87
veal, fresh	1.1	80÷87	0	80÷87	5÷10 Days	—	63	0.71	0.93	50	-1.7	66÷71	80÷87
<u>FISH AND SEA FOODS</u> caviar	4.4	80÷85	1.1	80÷85	15 Days	—	—	—	—	—	—	80÷83	80÷83
clams, in shell	1.7	80÷90	0	80÷90	15 Days	—	80	0.84	0.44	64	-2.8	80÷83	80÷83
clams, shucked	1.7	60÷70	0	60÷70	10 Days	—	87	0.90	0.46	—	—	83÷87	83÷87
crabs, alive	3.9	70÷85	2.2	70÷85	—	—	79	0.83	0.44	63	—	80÷83	80÷83
crabs, boiled	1.7	80÷85	-3.9	80÷90	—	—	—	—	—	—	—	87÷91	83÷87

(to be continued)

ATTACHMENT 5 - (continued)

COMMODITY	SHORT TIME STORAGE		LONG TIME STORAGE		APPROX. MAX. STORAGE LIFE	RESPIRATION kcal/ton of product/24h	APPROX. WATER CONTENT %	SPEC. HEAT kcal/kg/°C		LATENT HEAT kcal/kg	FREEZING POINT °C	SENSIBLE HEAT %	
	D.B. TEMP. °C	R.H. %	D.B. TEMP. °C	R.H. %				ABOVE FREEZING	BELOW FREEZING			PRECOOLING	HOLDING
fish, fresh	1.7	80+85	0.6	80+90	15 Days	—	70	0.80	0.41	56	-2.2	83+87	80+83
fish, smoked	—	—	4.4	50+70	6+8 Mos.	—	—	—	—	—	—	87+91	87+91
fish, brine salted	—	—	4.4	80+90	10+12 Mos.	—	—	—	—	—	—	87+91	87+91
fish, milk cured	—	—	-2.2	70+80	4+8 Mos.	—	—	—	—	—	—	87+91	87+91
lobster, alive	3.9	70+85	2.2	80+85	—	—	—	—	—	—	—	80+83	80+83
lobster, boiled	1.7	80+85	-3.9	80+90	—	—	79	0.83	0.44	63	—	87+91	87+91
oysters, in shell	1.7	80+90	0	80+90	15 Days	—	80	0.84	0.44	64	-2.8	80+83	80+83
oysters, shucked	1.7	80+70	0	80+70	15 Days	—	87	0.90	0.46	69.5	—	83+87	83+87
<u>MISCELLANEOUS</u> beer, wood kegs	1.7	60+70	1.1	60+70	6 Mos.	—	92	1.00	0.47	72	-2.2	—	87+91
beer, steel kegs	1.7	75+85	1.1	75+85	6 Mos.	—	92	1.00	0.47	72	-2.2	—	83+87
bulbs	1.7	—	-1.1	70+80	3+6 Mos.	—	—	—	—	—	-2.2	83+87	77+80
cereals	—	—	4.4	50+60	—	—	—	—	—	—	—	—	83+87
chocolate	15.6	50+55	15.6	50+55	6 Mos.	—	30	0.48	0.56	22	32.2	—	83+87
cut flowers	4.4	80+90	1.7	80+90	1 Wks.	—	—	—	—	—	-1.7	—	71+77
furs	—	—	2.2	40+60	—	—	—	0.40	—	—	—	—	87+91
furs, moth killing	—	—	-9.4	40+60	—	—	—	—	—	—	—	—	89+92
ferns	-4.4	60+70	-4.4	60+70	—	—	—	—	—	—	—	—	77+83
honey	4.4	60+70	-0.6	60+70	12+18 Mos.	—	2	0.35	0.26	15	—	—	87+91
hops	1.7	60+65	1.7	60+65	6 Mos.	—	—	—	—	—	—	—	87+91
ice	-3.9	60+80	-6.7	60+80	—	—	100	1	0.50	80	0	—	83+91
malt	10	70+80	8.9	70+80	6 Mos.	—	—	—	—	—	—	—	80+87
maple sugar	7.2	60+70	-0.6	60+70	6 Mos.	—	5	0.24	0.21	—	—	—	87+91
maple syrup	7.2	60+70	-0.6	60+70	—	—	36	0.49	0.31	29	—	—	87+91

(to be continued)

ATTACHMENT 5 - (continued)

COMMODITY	SHORT TIME STORAGE		LONG TIME STORAGE		APPROX. MAX. STORAGE LIFE	RESPIRATION kcal/ton of product/24h	APPROX. WATER CONTENT %	SPEC. HEAT kcal/kg/°C		LATENT HEAT kcal/kg	FREEZING POINT °C	SENSIBLE HEAT %	
	D.B. TEMP. °C	R.H. %	D.B. TEMP. °C	R.H. %				ABOVE FREEZING	BELOW FREEZING			PRECOOLING	HOLDING
nuts, dried	1.7	60+75	-1.1	60+75	3+12 Mos.	—	10	0.29	0.24	7.8	—	—	87+91
plants, potted	1.7	70+85	1.7	70+85	—	—	—	—	—	—	—	—	77+83
rose bushes	—	—	-2.8	75+80	—	—	—	—	—	—	—	—	87+91
seeds	7.2	70+85	5	70+85	—	—	—	—	—	—	—	—	87+91
tobacco and cigars	1.7	85+90	1.7	85+90	—	—	25	—	—	—	—	—	87+91
vaccines and serums	5.6	60+70	5.6	60+70	4 Mos.	—	—	—	—	—	—	—	87+91
yeast	7.2	80+85	4.4	80+85	—	—	—	—	—	—	—	—	83+87

(to be continued)

ATTACHMENT 5 - (continued)

COMMODITY	STORAGE CONDITIONS DRY BULB °C	STORAGE CONDITIONS R.H. %	APPROX. MAX. STORAGE LIFE	% SENSIBLE LONG STORAGE	WATER CONTENT LARGE PIECES	WATER CONTENT SMALL PIECES	SPECIFIC HEAT LARGE PIECES ABOVE FREEZING	SPECIFIC HEAT LARGE PIECES BELOW FREEZING	SPECIFIC HEAT SMALL PIECES ABOVE FREEZING	SPECIFIC HEAT SMALL PIECES BELOW FREEZING	FREEZING POINT °C	LATENT HEAT kcal/kg LARGE PIECES	LATENT HEAT kcal/kg SMALL PIECES
MEAT AND MEAT PRODUCTS GAME AND FOWL Beef brisket, medium fat	-23.3	80-90	9-12 Mos.	95	92	55	0.53	0.32	0.64	0.36	-2.8	32.7	43.4
ribs, lean	-23.3	80-90	9-12 Mos.	95	53	68	0.62	0.36	0.74	0.41	-2.8	41.6	54
round. lean	-23.3	80-90	9-12 Mos.	95	64	70	0.72	0.39	0.76	0.41	-2.8	51.5	55.6
rump, lean	-23.3	80-90	9-12 Mos.	95	57	66	0.55	0.37	0.73	0.40	-2.8	45	52
fat, clear	-23.3	80-90	9-12 Mos.	95	13.4		0.31	0.24			-2.8	19	41
Veal fresh leg, hind medium fat	23.3	80-90		95		63			0.70	0.39	-1.7		50
Lamb fresh leg, hind medium fat	23.3	80-90	8-10 Mos.	95	53	64	0.62	0.36	0.71	0.39	-1.7	42	51
pork fresh	23.3	80-90	4-8 Mos.										
loin, chops, lean	-23.3	80-90	4-8 Mos	95	46	60	0.57	0.34	0.68	0.38	-1.7	35.7	47.6
loin, tenderloin	-23.3	80-90	4-8 Mos	95		67	0.73	0.40			-1.7	52.8	
shoulder	-23.3	80-90	4-8 Mos	95	45	51	0.56	0.32	0.61	0.35	-1.7	35.5	40.5
bacon				95		20			0.36	0.26	-2.8		15.5
POULTRY, GAME AND FOWL chicken broilers	-23.3	80-90		95	44	75	0.55	0.32	0.80	0.42	-1.1	34.5	59
fowl	-23.3	80-90		95	47	64	0.57	0.34	0.72	0.39	-1.1	37.2	51
game	-23.3	80-89	9-12 Mos	95					0.80	0.42	-1.1		64
goose	-23.3	80-90		95	39	47	0.51	0.31	0.57	0.34	-1.1	30.5	37
turkey	-23.3	80-90		95	42	56	0.54	0.33	0.64	0.37	-1.1	34	44

(to be continued)

ATTACHMENT 5 - (continued)

COMMODITY	STORAGE CONDITIONS DRY BULB °C	STORAGE CONDITIONS R.H. %	APPROX. MAX. STORAGE LIFE	% SENSIBLE LONG STORAGE	WATER CONTENT LARGE PIECES	WATER CONTENT SMALL PIECES	SPECIFIC HEAT LARGE PIECES ABOVE FREEZING	SPECIFIC HEAT LARGE PIECES BELOW FREEZING	SPECIFIC HEAT SMALL PIECES ABOVE FREEZING	SPECIFIC HEAT SMALL PIECES BELOW FREEZING	FREEZING POINT °C	LATENT HEAT kcal/kg LARGE PIECES	LATENT HEAT kcal/kg SMALL PIECES
SEAFOOD, SHELLFISH													
clams	-17.8	80-90	4 Mos.	95	28	86	0.42	0.28	0.89	0.46		22	69
lobster	-17.8	80-90	4 Mos.	95	31	79	0.45	0.29	0.83	0.44		24.4	62.9
oyster, in liquid	-17.8	80-90	4 Mos.	95	16	87	0.33	0.25	0.90	0.46	-2.2	12.8	69.5
oyster, in shell	-17.8	80-90	4 Mos.	95		80			0.84	0.44			64
bass,striped	-17.8	80-90	8-10 Mos.	95	35	78	0.48	0.30	0.82	0.43	-2.2	27.8	61.6
black fish	-17.8	80-90	8-10 Mos.	95	31	79	0.45	0.29	0.83	0.44	-2.2	25	62.6
blue fish	-17.8	80-90	8-10 Mos.	95		79			0.83	0.43	-2.2		62.4
butter fish	-17.8	80-90	8-10 Mos.	95	43	70	0.54	0.33	0.76	0.41	-2.2	34	55.5
cat fish	-17.8	80-90	8-10 Mos.	95	52	64	0.61	0.35	0.71	0.39	-2.2	41	51
cod	-17.8	80-90	8-10 Mos.	95	39	83	0.51	0.31	0.86	0.45	-2.2	30.6	65
eels (salt water)	-17.8	80-90	8-10 Mos.	95		72			0.77	0.41	-2.2		56.5
flounder	-17.8	80-90	8-10 Mos.	95	33	84	0.46	0.30	0.87	0.45	-2.2	26	66.5
haddock	-17.8	80-90	8-10 Mos.	95		82			0.85	0.44	-2.2		65
hake	-17.8	80-90	8-10 Mos.	95		83			0.86	0.45	-2.2		66
halibut (steaks)	-17.8	80-90	8-10 Mos.	95		75			0.80	0.42	-2.2		60
herring	-17.8	80-90	8-10 Mos.	95	42	73	0.53	0.32	0.78	0.42	-2.2	33.2	57.7
king fish	-17.8	80-90	8-10 Mos.	95	34	79	0.47	0.30	0.83	0.44	-2.2	27	52.6
lamprey	-17.8	80-90	8-10 Mos.	95	39	71	0.51	0.31	0.77	0.41	-2.2	30.5	56
mackerel	-17.8	80-90	8-10 Mos.	95	40	73	0.52	0.32	0.70	0.42	-2.2	32	58
mullet	-17.8	80-90	8-10 Mos.	95	32	75	0.45	0.29	0.80	0.42	-2.2	25	59.5
perch (white)	-17.8	80-90	8-10 Mos.	95	28	76	0.42	0.29	0.80	0.43	-2.2	22.8	60
pickerel (white)	-17.8	80-90	8-10 Mos.	95	42	80	0.54	0.33	0.84	0.44	-2.2	33.3	64
pike (grey)	-17.8	80-90	8-10 Mos.	95	30	41	0.44	0.30	0.85	0.44	-2.2	23.9	84.4

(to be continued)

ATTACHMENT 5 - (continued)

COMMODITY	STORAGE CONDITIONS		APPROX. MAX. STORAGE LIFE	% SENSIBLE LONG STORAGE	WATER CONTENT		SPECIFIC HEAT				FREEZING POINT °C	LATENT HEAY kcal/kg	
							LARGE PIECES		SMALL PIECES				
	DRY BULB °C	R. H. %			LARGE PIECES	SMALL PIECES	ABOVE FREEZING	BELOW FREEZING	ABOVE FREEZING	BELOW FREEZING		LARGE PIECES	SMALL PIECES
pollack	-17.8	80-90	8-10 Mos.	95	54	76	0.63	0.36	0.81	0.44	-2.2	43.4	60.5
porgy	-17.8	80-90	8-10 Mos.	95	30	75	0.44	0.20	0.80	0.42	-2.2	23.9	59.5
salmon	-17.8	80-90	8-10 Mos.	95	41	65	0.53	0.32	0.72	0.39	-2.2	32.8	51
salmon (land locked)	-17.8	80-90	8-10 Mos.	95	42	78	0.54	0.33	0.82	0.43	-2.2	33.4	61.5
shad	-17.8	80-90	8-10 Mos.	95	35	71	0.48	0.30	0.76	0.41	-2.2	27.8	56
shad roe	-17.8	80-90	8-10 Mos.	95		71			0.77	0.41	-2.2		56
skate, lobe of body	-17.8	80-90	8-10 Mos.	95	40	82	0.52	0.32	0.86	0.44	-2.2	31.6	65
smelt	-17.8	80-90	8-10 Mos.	95	40	79	0.57	0.34	0.83	0.44	-2.2	36.7	62.8
spanish mackerel	-17.8	80-90	8-10 Mos.	95	45	68	0.56	0.33	0.74	0.44	-2.2	35.6	54
trout, brook	-17.8	80-90	8-10 Mos.	95	40	78	0.52	0.32	0.82	0.43	-2.2	32.2	61.6
trout, salmon. lake	-17.8	80-90	8-10 Mos.	95	37	71	0.49	0.31	0.76	0.41	-2.2	29	61.6
turbot	-17.8	80-90	8-10 Mos.	95	37	71	0.5	0.31	0.77	0.41	-2.2	29.5	61.7

ATTACHMENT 6

TABLE 7 - HEAT EQUIVALENT OF ELECTRIC MOTORS

CONNECTED LOAD IN REFRIGERATED SPACE		MOTOR LOSSES OUTSIDE REFRIGERATED SPACE	CONNECTED LOAD OUTSIDE REFRIGERATED SPACE
MOTOR KW	KW/KW	KW/KW	KW/KW
0.1 TO 0.4	1.8	1.0	0.8
0.4 TO 2.2	1.5	1.0	0.5
2.2 TO 15	1.3	1.0	0.3

TABLE 8 - HEAT EQUIVALENT OF OCCUPANCY

EQUIVALENT HEAT	ROOM TEMP.		Kcal/h PER PERSON	WATTS PER PERSON
	°F	°C		
OF PEOPLE	50	10	180	210
	40	4,4	210	240
kcal/h/ PERSON OR WATTS PER PERSON	30	-1,1	240	270
	20	-6,7	260	300
(NORMALLY 8 HOURS/DAY)	10	-12,2	300	330
	0	-17,8	325	360
	-10	-23,3	350	390

ATTACHMENT 7

EXHIBT A:

TYPICAL DIAGRAM OF THE STANDARD REFRIGERATING CYCLE, SHOWING MAIN PARTS OF THE SYSTEM

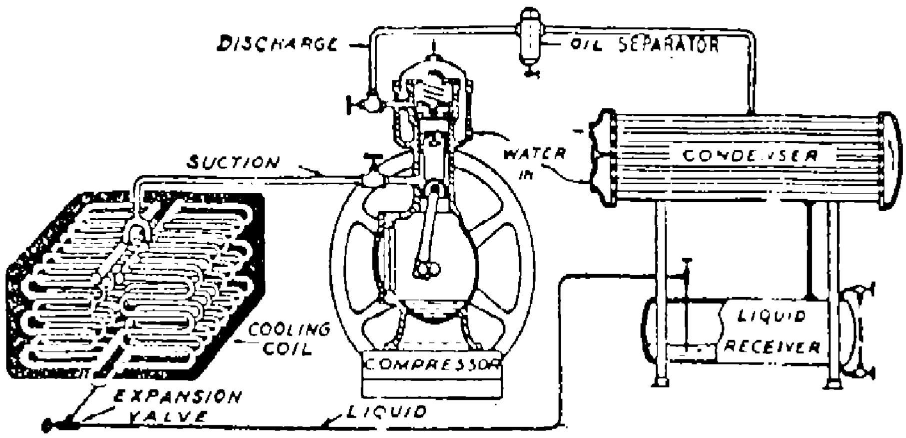
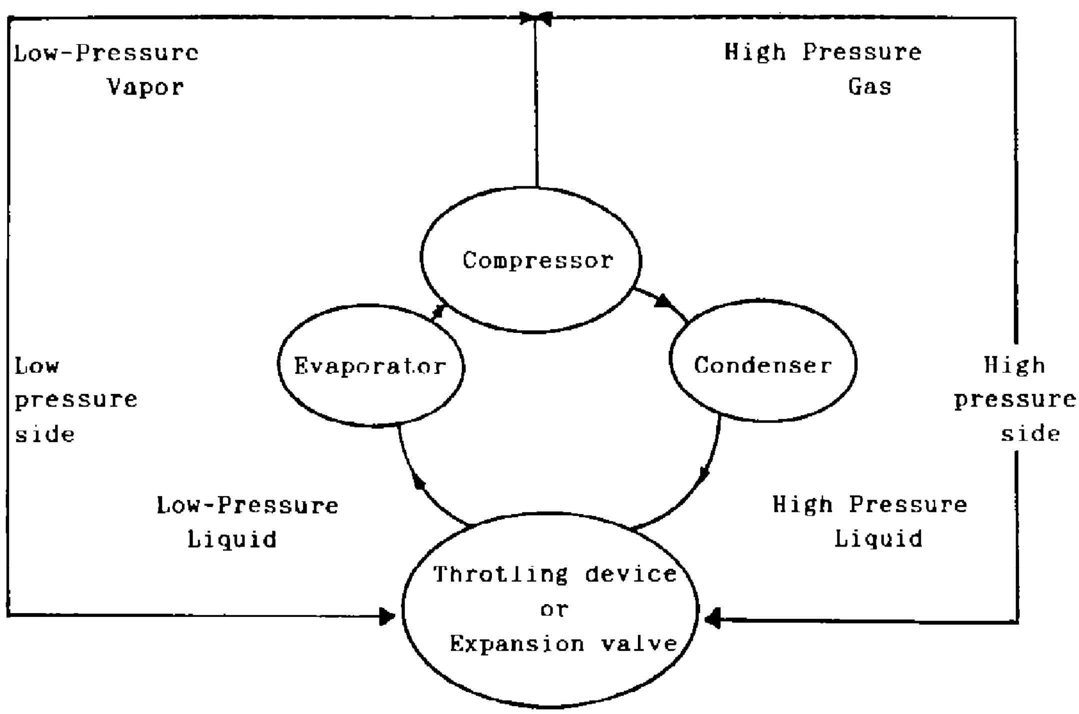


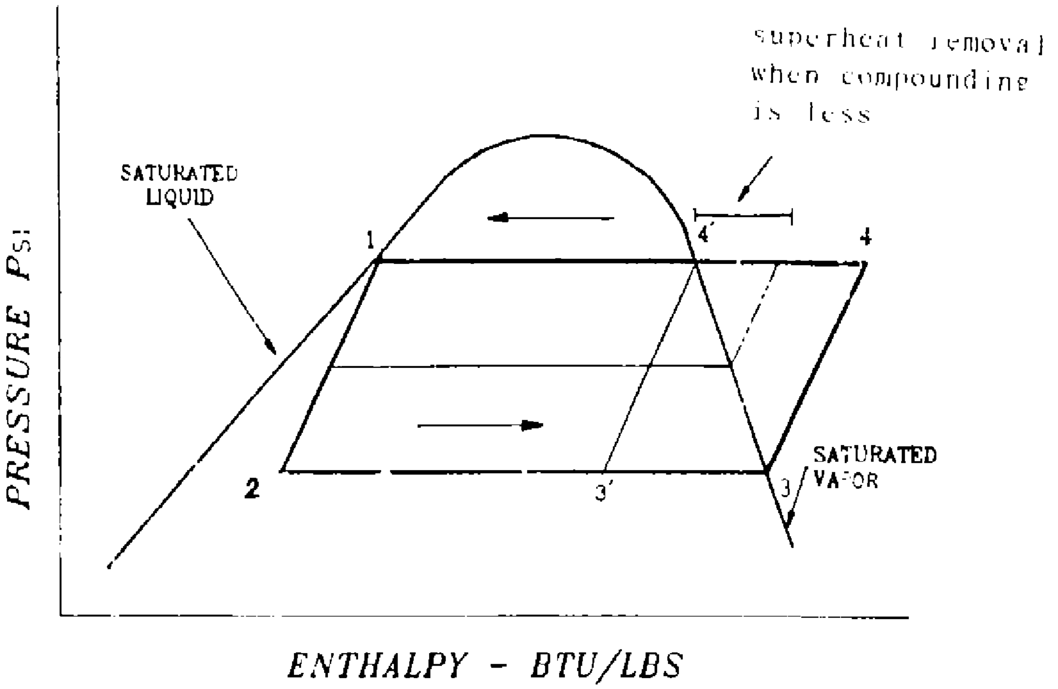
EXHIBIT B:

A SCHEMATIC DIAGRAM OF A SIMPLE MECHANICAL REFRIGERATION SYSTEM



ATTACHMENT 8

PRESSURE-ENTHALPY DIAGRAM DESCRIPTION



1 - 2	THROTTLING OR EXPANSION.
2 - 3	EVAPORATION IN COOLING COIL.
3 - 4	COMPRESSION (DRY).
4'- 1	CONDENSATION IN CONDENSER COIL.
3'- 4'	COMPRESSION (WET).
4 - 4'	SUPERHEAT REMOVAL.
3'- 3	HEAT PICKED UP IN SUCTION PIPING FROM EVAPORATOR BACK TO COMPRESSOR.

ATTACHMENT 9

DISCHARGE AND LIQUID LINE CAPACITIES

COMMODITY	STORAGE CONDITIONS		APPROX. MAX. STORAGE LIFE	% SENSIBLE LONG STORAGE	WATER CONTENT		SPECIFIC HEAT				FREEZING POINT °C	LATENT HEAY kcal/kg	
							LARGE PIECES		SMALL PIECES				
	DRY BULB °C	R.H. %			LARGE PIECES	SMALL PIECES	ABOVE FREEZING	BELOW FREEZING	ABOVE FREEZING	BELOW FREEZING		LARGE PIECES	SMALL PIECES
pollack	-17.8	80-90	8-10 Mos.	95	54	76	0.63	0.36	0.81	0.44	-2.2	43.4	60.5
porgy	-17.8	80-90	8-10 Mos.	95	30	75	0.44	0.20	0.80	0.42	-2.2	23.9	59.5
salmon	-17.8	80-90	8-10 Mos.	95	41	65	0.53	0.32	0.72	0.39	-2.2	32.8	51
salmon (land locked)	-17.8	80-90	8-10 Mos.	95	42	78	0.54	0.33	0.82	0.43	-2.2	33.4	61.5
shad	-17.8	80-90	8-10 Mos.	95	35	71	0.48	0.30	0.76	0.41	-2.2	27.8	56
shad roe	-17.8	80-90	8-10 Mos.	95		71			0.77	0.41	-2.2		56
skate, lobe of body	-17.8	80-90	8-10 Mos.	95	40	82	0.52	0.32	0.86	0.44	-2.2	31.6	65
smelt	-17.8	80-90	8-10 Mos.	95	40	79	0.57	0.34	0.83	0.44	-2.2	36.7	62.8
spanish mackerel	-17.8	80-90	8-10 Mos.	95	45	68	0.56	0.33	0.74	0.44	-2.2	35.5	54
trout, brook	-17.8	80-90	8-10 Mos.	95	40	78	0.52	0.32	0.82	0.43	-2.2	32.2	61.6
trout, salmon, lake	-17.8	80-90	8-10 Mos.	95	37	71	0.49	0.31	0.76	0.41	-2.2	29	61.6
turbot	-17.8	80-90	8-10 Mos.	95	37	71	0.5	0.31	0.77	0.41	-2.2	29.5	61.7

Note:

These capacities are based on fluid flow at 32.2°C (90°F) saturated condensing temperature and -6.7°C (20°F) saturated condensing temperature.

ATTACHMENT 10

SUCTION LINE CAPACITIES IN THOUSAND OF Frig/h

LINE SIZE (inches)	Saturated Suction Temperature -°C e °F																
	-34.4°C (-30°F)				-28.9°C (-20°F)			-17.8°C (0°F)			-6.7°C (20°F)			4.44°C (40°F)			
	Pressure Drop in kg/sq. cm. per 30.5 m (psi/100ft)																
kg/sq. cm	0.035	0.07	0.141	0.035	0.07	0.141	0.035	0.07	0.141	0.035	0.07	0.141	0.211	0.035	0.07	0.141	0.211
psi	½	1	2	½	1	2	½	1	2	½	1	2	3	½	1	2	3
½	1.3	1.9	2.7	1.5	2.2	3.1	2.0	2.8	4.0	2.5	3.6	5.2	7.3	3.1	4.4	6.3	8.9
¾	2.9	4.2	6.0	3.4	4.8	6.8	4.4	6.3	8.9	5.5	7.9	11.4	15.8	6.9	9.8	14.0	19.7
1	5.8	8.3	11.3	6.5	9.2	12.8	8.3	11.6	16.9	10.6	15.1	21.4	26.3	13.1	18.5	26.7	22.7
1¼	14.5	21.0	29.8	16.4	23.6	33.6	21.4	30.6	43.2	27.2	39.2	56.0	69.0	33.8	48.8	70.0	85.5
1½	22.1	31.8	45.2	25.0	36.2	51.0	32.4	47.0	66.5	44.0	59.5	84.0	107	51.7	73.0	109	128
2	42.7	62.0	87.1	48.2	72.5	98.5	63.5	89.5	129	80.0	115	162	203	93.0	142	198	248
2½	69.0	98.5	139	76.6	109	158	102	145	206	128	182	259	310	159	227	222	290
3	121	174	246	137	196	277	179	255	366	226	323	456	567	280	396	575	705
4	253	360	512	282	396	563	366	520	738	463	660	923	1145	575	815	1155	1420
5	453	647	916	508	720	1030	660	945	1340	835	1190	1583	2070	1035	1470	2090	2570
6	737	1040	1470	830	1175	1670	1070	1530	2160	1350	1930	2720	3360	1690	2390	3400	4170
8	1530	2150	3025	1690	2410	3410	2200	3140	4440	2780	3960	5500	6860	3440	4880	6940	8500
10	2730	3870	5480	3060	4330	6100	3950	5630	8000	4970	7120	10000	12400	6170	8760	12500	15300
12	4400	6200	8800	4900	7000	9900	6350	8400	12900	8100	11600	16400	20000	10100	14300	20200	26000

Note:

These capacities are based on fluid flow at 32.2°C (90°F) saturated condensing temperature.

ATTACHMENT 11

A. INSULATION THICKNESS CHART FOR PIPING

PIPE SIZE	INSULATION THICKNESS				
	25 mm (1")	38 mm (1½")	51 mm (2")	64 mm (2½")	76 mm (-3")
½"	+ 7.5°C (+45°F)	- 12.5°C (+10°F)	- 31.5°C (-25°F)	—	—
¾"	+ 10.0 (+50)	- 4.0 (+25)	- 23.5 (-10)	—	—
1"	+ 10.0 (+50)	- 4.0 (+25)	- 23.5 (-10)	—	—
1½"	+ 10.0 (+50)	- 1.0 (+30)	- 9.5 (+15)	- 26.0°C (-15°F)	—
2"	+ 10.0 (+50)	- 1.0 (+30)	- 9.5 (+15)	- 26.0 (-15)	—
3"	+ 10.0 (+50)	- 1.0 (+30)	- 9.5 (+15)	- 23.5 (-10)	—
4"	+ 10.0 (+50)	- 1.0 (+30)	- 6.5 (+20)	- 17.5 (0)	- 34.5°C (-30°F)
6"	+ 10.0 (+50)	+ 7.5 (+45)	- 4.0 (+25)	- 17.5 (0)	- 31.5 (-25)
8"	—	+ 7.5 (+45)	- 4.0 (+25)	- 17.5 (0)	- 26.0 (-15)
10"	—	+ 7.5 (+45)	- 1.0 (+30)	- 12.5 (+10)	- 23.5 (-10)
12"	—	+ 7.5 (+45)	- 1.0 (+30)	- 9.5 (+15)	- 20.5 (-5)
14"	—	+ 7.5 (+45)	- 1.0 (+30)	- 9.5 (+15)	- 17.5 (0)
16"	—	+ 7.5 (+45)	- 1.0 (+30)	- 6.5 (+20)	- 17.5 (0)
18"	—	+ 7.5 (+45)	- 1.0 (+30)	- 6.5 (+20)	- 17.5 (0)
20"	—	+ 10.0 (+50)	- 1.0 (+30)	- 6.5 (+20)	- 17.5 (0)
24"	—	+ 10.0 (+50°F)	- 1.0 (+30)	- 6.5 (+20)	- 17.5 (0)

B. INSULATION THICKNESS CHART FOR VESSELS AND EQUIPMENT

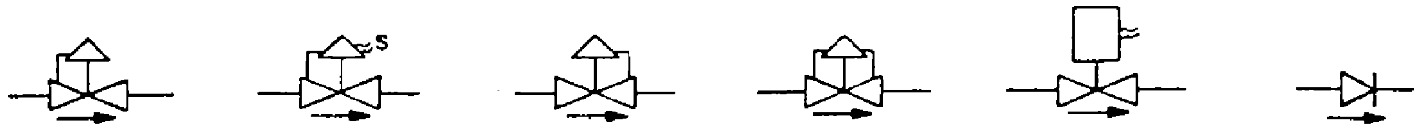
SIZE	INSULATION THICKNESS				
	38 mm (1½")	51 mm (2")	64 mm (2½")	76 mm (3")	89 mm (3½")
0.9 m (3’-0") & under	+ 10.0°C (+50°F)	- 1.0°C (+30°F)	- 6.5°C (+20°F)	- 12.5°C (+10°F)	- 20.5°C (-5°F)
1.2 m (4’-0")	+ 10.0 (+50)	- 1.0 (+30)	- 4.0 (+25)	- 12.5 (+10)	- 20.5 (-5)
1.5 m (5’-0")	+ 10.0 (+50)	- 4.5 (+40)	- 4.0 (+25)	- 12.5 (+10)	- 20.5 (-5)
1.8 m (6’-0")	+ 10.0 (+50)	- 4.5 (+40)	- 4.0 (+25)	- 12.5 (+10)	- 17.5 (0)
2.4 m (8’-0")	+ 10.0 (+50)	- 4.5 (+40)	- 4.0 (+25)	- 12.5 (+10)	- 17.5 (0)
3.0 m (10’-0")	+ 10.0 (+50)	- 4.5 (+40)	- 4.0 (+25)	- 12.5 (+10)	- 17.5 (0)
3.7 m (12’-0)	+ 10.0 (+50)	- 4.5 (+40)	- 4.0 (+25)	- 12.5 (+10)	- 17.5 (0)
over 3.7 m (12’-0") to flat	+ 10.0 (+50)	- 4.5 (+40)	- 4.0 (+25)	- 9.5 (+15)	- 17.5 (0)

Note:

Minimum operating temperature shown for given insulation thickness. For additional informations on operating temperatures and insulation thickness reference is made to ASHRAE FUNDEMENTAL GUIDEBOOK.

ATTACHMENT 12

CONTROL VALVE SYMBOLS and FUNCTIONS



INLET PRESSURE REGULATOR
(Opens on a rise in inlet pressure. Closes when inlet pressure is below set-point.)

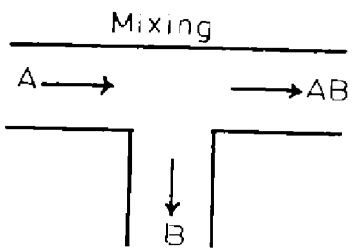
INLET PRESSURE REGULATOR WITH ELECTRIC SHUT-OFF
(Opens on a rise in inlet pressure when energized. Closes when inlet pressure is below set-point or when de-energized.)

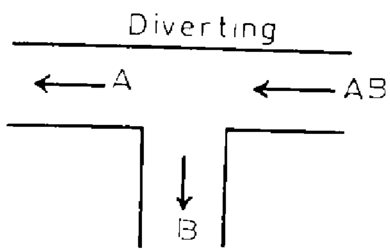
OUTLET PRESSURE REGULATOR
(Opens on a drop in outlet-pressure. Closes when outlet pressure is above set-point.)

DIFFERENTIAL PRESSURE REGULATOR
(Opens on a rise in pressure difference. Closes when pressure difference is below set-point.)

SOLENOID VALVE
(Opens when energized; closes when de-energized.)

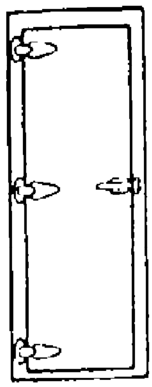
CHECK VALVE
(Permits flow in one direction only.)



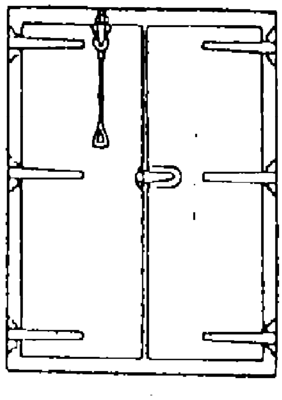


ATTACHMENT 13

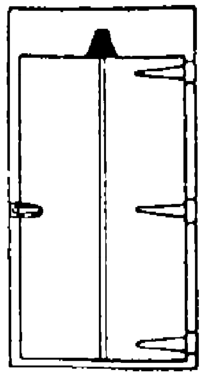
TYPE OF COLD STORE DOORS



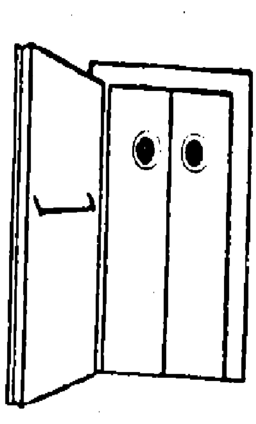
SINGLE DOORS



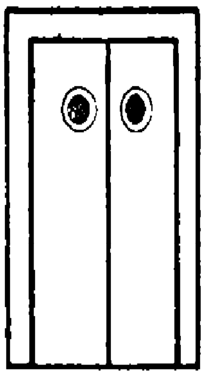
DOUBLE DOORS



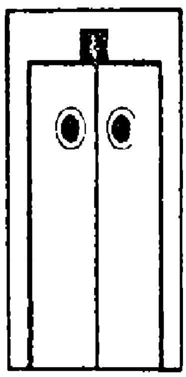
TRACK DOORS



VESTIBULE DOORS



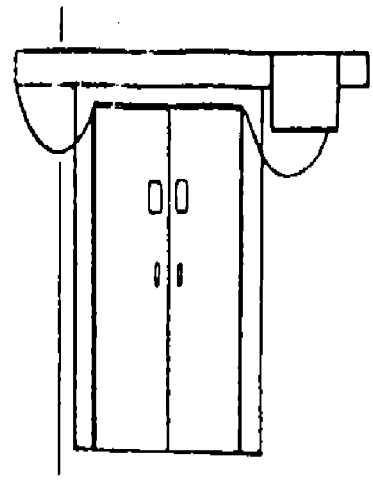
DOUBLE ACTING
BATTEN DOORS



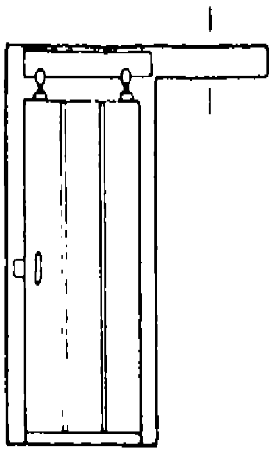
DOUBLE ACTING
BATTEN TRACK
DOORS

(to be continued)

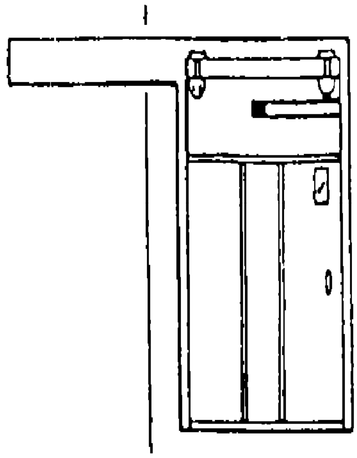
ATTACHMENT 13 - (continued)



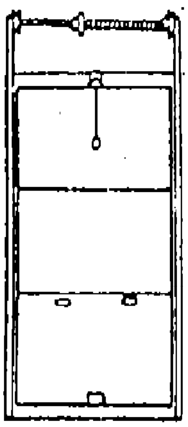
BI-PARTING HORIZONTAL SLIDING DOORS



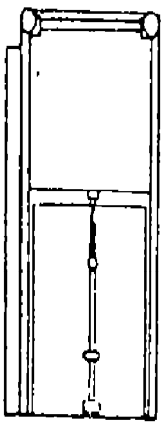
SINGLE HORIZONTAL SLIDING DOORS



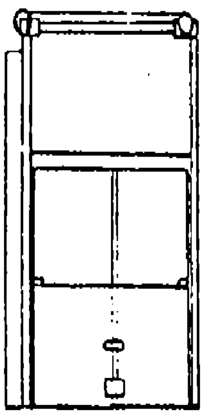
HORIZONTAL SLIDING TRACK DOORS



OVERHEAD ROLLING DOORS



VERTICAL SLIDING DOORS



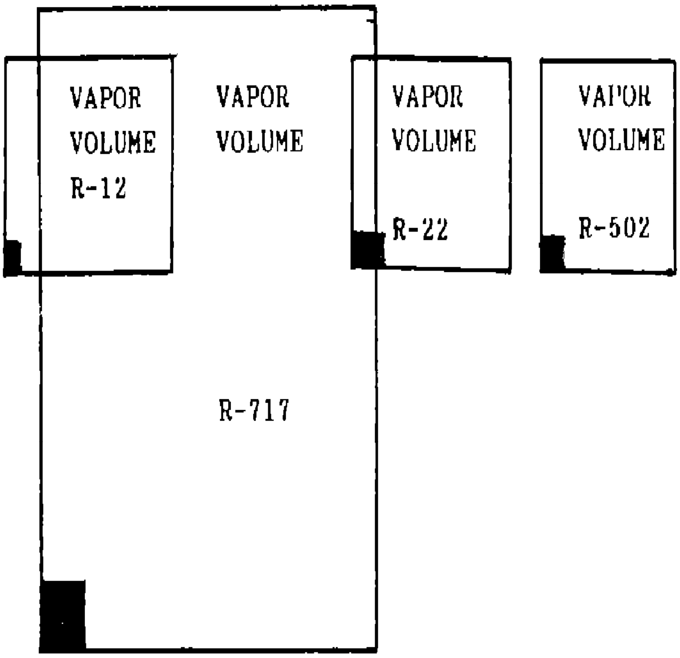
B1 PASSING VERTICAL SLIDING DOORS

ATTACHMENT 14

REFRIGERANT CHARACTERISTICS
AT - 6.7°C (20°F) EVAP. TEMP. AND 35°C (95°F) CONDENSING TEMP (NO LOSSES CONSIDERED)

RELATIONSHIP OF LIQ TO VAPOR VOLUME FOR I TR

REFRIGERANT		AMMONIA	R-12	R-22	R502
EVAP PRESS	PSIG	33.50	21.04	43.28	52.45
	PSIA	48.21	35.73	57.98	67.14
COND PRESS	PSIG	181.10	108.25	183.70	199.70
	PSIA	195.80	122.95	198.40	214.40
COMPRESSION RATIO		4.06	3.44	3.42	3.19
lbs/min/TON REF'G		0.42	4.05	2.95	4.48
CUFT/min. PER TR	LIQ	0.0104	0.0457	0.0362	0.0524
	VAPOR	2.475	4.4500	2.760	2.920
RATIO OF VOLUME LIQ. TO VAPOR		1:238	1:97.5	1:76.3	1:53.9



Note:

Shaded areas indicate typical liquid volume.