Report of Technical Standards Committee
on
Technical Standards and Protocol for the Cold Chain in India

Control Atmosphere Cold Stores
(Technical Standards Number NHB-CS-Type 03-2010)

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Preface

A Task Force on development of cold chain in India had been set up by the Ministry of Agriculture vide its order dated 3rd May 2007. The said Task Force had recommended revised normative cost for cold storages and subsidy norms for ensuring technology up gradation in cold storages. It has, therefore, been felt necessary to define appropriate technical standards in respect of various components of cold storages without which exercise of quantification of revised normative cost, subsidy norms etc cannot be substantiated; nor can the desired results of effecting technology up gradation be achieved. Therefore, Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India, vide its communication No. 22011/5/2007-M-II dated 16th June 2009 constituted a Technical Standards Committee**.** *Terms of Reference* of the Technical Standards Committee **(TSC)** is to give recommendations on the following issues-

(i) Suitable technical standards and protocols for cold chain infrastructure in the Country
(ii) The mechanism of implementation of such standards and protocols
(iii) Any other issue that the Committee may consider important or relevant for the subject or may be assigned to it by the Government.

The Committee was given initial time frame of two months for submitting its recommendations. However, extension up to end of November 2009 was formally granted at a later stage.

The **TSC** has classified cold storages for fruits & vegetables in following three main categories as listed below.

(i) Cold storages for storage of fresh horticulture products which do not require pre-cooling ***(Technical Standards Number NHB-CS-Type 01-2010)***
(ii) Multi-commodity Cold storages for short term and long term storage of fresh horticulture products which require pre-cooling and varying storage requirements. ***Technical Standards Number NHB-CS-Type 02-2010)***
(iii) Control Atmosphere (**CA**) Storages. ***Technical Standards Number NHB-CS-Type 03-2010).***

These Standards cover **Cold Storage of Type-03** mentioned above and have three sections *viz. Technical Standards, Basic Data Sheet and Protocol for Implementation of the Prescribed Technical Standards.* While firming up its recommendations by **TSC**, emphasis is laid on optimum energy efficiency and overall performance and therefore *coefficient of performance* (**CoP**) is one of the determining criteria. In addition, *aspects of environmental and safety concerns and Human Resource Development* too have been taken in to account.

The Technical Standards have general information on the type of produce that can be stored in particular Type / module, their critical storage conditions, (as much compatible with the World standards as possible by relying on ISO Standards - ISO 6949:1988 (E) and *Word*

Food Logistic Organisation **(WFLO)** database in absence of research data for Indian conditions) in terms of temperature, humidity range, CO_2 level, loading rate, pull down time, air circulation and ventilation requirement etc. In order to facilitate improved design, there is a detailed **Basic Data Sheet** available in the **Section 2** of the Standards wherein plotting different specification data into a system shall lead to better coefficient of performance from energy efficiency point of view. **Section 3** deals with the **Protocol for Implementation of Technical Standards**, probably through Letter of Intent **(LoI)**, and system analysis of civil structure, thermal insulation and refrigeration.

These standards and recommendations are intended to serve as minimum requirement, and are not to be construed as limiting good practice. Wherever IS-Code is not available, relevant standard codes of ISO / ASME / ASHRAE / IIAR or other International Codes have been followed. The responsibility for deciding whether other requirements additional to the ones listed in the technical standard document are necessary to ensure system integrity, efficiency and overall safety, including operation, maintenance and servicing and/or the necessity to adopt additional requirements in the system design and construction to guarantee the overall performance, still rests with the supplier / manufacturer.

It is recommended that the suppliers / manufacturers shall furnish to the owner copies of instructions / manual which shall include operation & maintenance instruction, built drawings, wiring diagrams, recommended spare parts and replacement part list etc as recommended. It is also envisaged that the suppliers / manufacturers shall provide training for the plant and machinery installed including safety and emergency procedures. The supplier /manufacturer will follow all practices set forth by "G*ood Manufacturing Practices*" by various applicable Codes and Standards listed in this document and shall fully certify the equipment, plant and machinery supplied / installed in compliance to the relevant codes and standards.

Nonetheless, these also have provision for scope of variation, through a *Variation and Amendment Clause*, to take care of new concepts, innovations, and R&D in building design etc. so that improvements coming along the way are not stopped but analysed and incorporated in the design.

The notification constituting Technical Standards Committee is given in **Annexure-I.**

The Committee acknowledges the valuable contribution made by experts in firming up its recommendations whose particulars are listed in **Annexure-II** to the report; the list has special mention of non-member experts who have volunteered and spared their valuable time in giving their inputs from time to time. Relevant WFLO extracts have been annexed as **Annexure-III;** ISO Standards- ISO 6949:1988 (E) as **Annexure-IV** and List of relevant BIS and other Standards have been annexed as **Annexure-V** for ready reference to which investors, contractors and suppliers may refer to while designing and installing various components.

"The Technical Standards Committee" gratefully acknowledges the International Standard Organisation's source of information from ISO 6949:1988(E) and World Food Logistic

Organisation (GCCA) for critical storage conditions and disease control measures of various horticulture products, which are being referred to in the prescribed Standards.

Last but not the least, contribution made by Dr. R. K. Sharma - Senior Deputy Director NHB has been of immense value as he for all practical purposes functioned as Member- Secretary to the Committee.

(Bijay Kumar)
Chairman, TSC and Managing Director
National Horticulture Board
(Ministry of Agriculture, Govt. of India)

Dated- February 3, 2009

SECTION 1

Technical Standards

Section-1

Technical Standard for Controlled Atmosphere Cold Stores Storage for Fruits and Vegetables

1. Controlled Atmosphere Storage- General Description

Controlled Atmosphere (CA) storage uses oxygen and carbon dioxide concentrations of about 1% to 5% for each gas in most applications. Normal room air has an O_2 concentration of about 21% and CO_2 levels near 0.03%. Low O_2 and high CO_2 levels slow the ripening process, stop the development of some storage disorders such as scald in apples, and slows the growth of decay organisms. All of these effects increase storage life of fresh produce compared with conventional refrigerated stores. These facilities are recommended for long term storage of fruits and vegetables like Apples, Pears, kiwi, cabbage etc. for up to 10 months.

In Indian context, use of Controlled Atmosphere technology has increased steadily, contributing significantly to extending the post harvest life and maintaining the quality of apples during the past few years. This trend is expected to continue as technology advances are made in this field.

CA storages are generally multiple chambers with each chamber of capacity of 50-250 MT. However, it is expected that economically viable designs of small CA storages of single chamber and storage capacity of 50 MT or so may come up in near future. In CA stores produce is stored in large bins which are stackable up to 11 high (total chamber height up to 10 m) or in PVC crates which can be stacked in mild steel pallet frames up to 4 levels high (chamber height up to 8 m). Storage in CFB box may also be resorted to for short duration storage of fruits like strawberry. The refrigeration system is designed to maintain temperature of -1ºC with humidity of 90%-95% RH.

Recommended levels of O_2 and / or CO_2 are automatically regulated, measured and corrected during the storage period. Manual regulation supported by high precision analyser has been in use in some countries but are getting phased out. In spite of cost implication automatic regulation levels of O_2 and / or CO_2 is recommended to minimise possibility of storage disorders in high value produce stored in CA storages.

Several types of CA storage technology are available which include Ultra Low Oxygen Cold Store (ULO) for storage atmosphere below 2%, Low Ethylene CA storage, Rapid CA cold store for rapid establishment of optimal levels of O2 and CO2 levels and Programmed / Sequential CA storage.

Such facilities are recommended to be store under the desired storage and CA conditions within 5 to 7 days of harvest.

Method of Regulation of Atmosphere in CA cold stores.

It has been adopted from International Standards ISO 6949:1988 (E) which specifies the principals and techniques of controlled atmosphere storage for Fruits and vegetables. However the practice and specifications of controlled atmosphere cold stores as define in ISO 6949:1988 (E) are restricted to Type-2 of ISO codes for this purpose only. The techniques and requirements pertaining *to* method of regulation of atmosphere, gas tightness, equalization of pressure, testing for gas tightness, regulation of temperature, gas generator, maintenance and operation etc are suitably covered under the ISO code which is part of the Technical Standard Documents as Annexure-IV.

Critical Requirements for CA Cold Store

I. **Pre-cooling/ Rapid Cooling –** Controlling fresh produce temperature and reducing the amount of time the product is at less than optimal storage temperature are the most important methods of slowing quality loss in perishables. Pre-cooling or rapid cooling requirements will vary based on produce and method of cooling such as room cool, hydro cool, forced air cooling, evaporative forced air cooling and ice packaging. However, room cooling and forced air cooling may suffice for most of the produce and therefore, it is taken for recommending general technical standards for pre-cooling system. General recommendations in this regard for 7/8 cool for fruits and vegetable should be followed.

   For example apples, should be cooled as quickly as possible after harvest. Apples are not injured by rapid cooling. A delay of 1 day at 21°C after harvest takes 7 to 10 days off the potential storage life at 0°C. A delay of 3 days in the orchard or in a warm packing shed may shorten their storage life as much as 30 days, even if they are subsequently stored in CA at -1°C. Therefore, adequate refrigeration capacity to handle the maximum heat load is essential during room cooling. If adequate refrigeration and air circulation and not provided, apples may take several weeks to cool and thereby storage life is shorten. The desirable goal is for temperature of fruit in the centre of the stacks to drop to 0°C to 0.6°C in 2 to 4 days. Rapid cooling is also important to reduce water loss from the produce.

   The main advantage of room cooling is that the produce can be cooled and stored in the same room without the need of transfer but it requires that the rooms are properly designed with adequate refrigeration, air circulation and most importantly proper stacking of bins / storage arrangement.

II. **Quality of produce –** The storage life of produce varies widely with the quality of produce at the time of harvest and its preservation during post harvest. For example, apples, which is widely stored in controlled atmosphere cold stores all over the world should be harvested when mature but fully ripe for maximum

storage life. Immature apples have poor eating quality likely to shrivel in storage. They are also more susceptible to storage disorders. Therefore, good keeping quality of fresh produce to be stored must be not only sound at the right stage of maturity but also carefully handled in all operations including picking, grading and packaging. The main cause of rotten fruits in storage is rough handling or delay in pre-cooling to recommended storage conditions.

III. **Commodity Storage Conditions-** For designing a cold storage, product storage conditions must be defined in terms of critical storage conditions of temperature, relative humidity, presence of CO_2, ethylene, air circulation, light etc. In absence of research data for Indian conditions, it is recommended to adopt commodity storage conditions as prescribed by ***Commodity Storage Manual of WFLO*.**

a. Temperature and humidity range: The temperature in the CA cold store facility should be kept within $\pm 1^0$ C of the recommend temperature of the produce being stored. For storing at temperatures close to freezing point of the commodity, for increasing storage life, even a narrow range may be needed.

b. Humidity: The humidity (RH) in a long term CA cold store facility should be kept at 90% to 95%. The refrigeration system must be specially designed for maintaining high RH. Cooling Coils with large surface area and refrigerant controls maintain highest possible coil temperature reduce the amount of moisture from the CA cold store air and the produce. The coil should be large enough to operate at 2.2°C to 4.4°C[1] cooler than the room air temperature. Smaller coils result in un-acceptable moisture loss and further require to be supplemented with humidification equipment which result in un-controlled humidity levels and may cause growth of micro-organism, storage disorders like surface cracking etc.

c. CO_2 and O2 level: As per WFLO commodity storage recommendations refer **Annexure –II**, ISO refer to **Annexure -III**.

d. Loading Rate: To achieve good storage quality, the room should be small enough to be filled in 3 days or sooner with adequate refrigeration capacity and air circulation. As a guiding principle, loading rates may vary from 3% to 5% of the total cold store capacity and it is critical to sizing the chamber capacity of the Controlled Atmosphere store.

e. Air Circulation: CA cold store should be designed to provide an air flow of 165 cmh per MT of product, based on maximum amount of product that can be stored in each chamber. This is essential for rapid cooling of the produce.

[1] Design Essentials for Refrigerated Storage Facilities (2005). ASHRAE

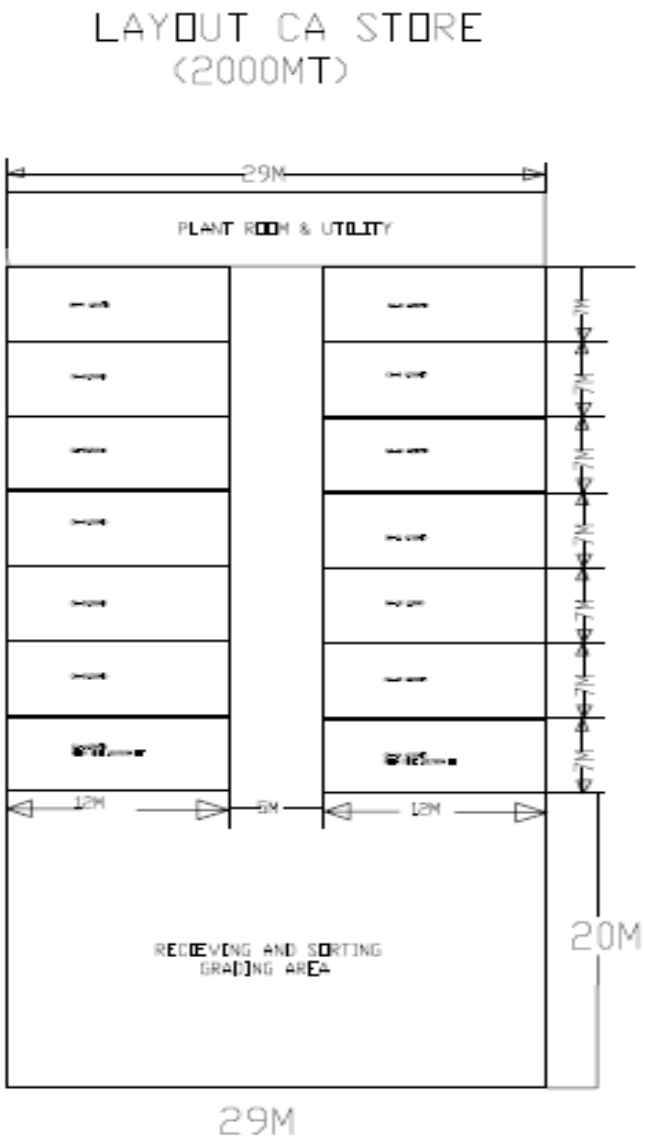
However the system should be designed to reduce air flow to 33 to 66 cmh/ MT after the produce has reached the storage temperature. This is achieved by variable frequency drive and control system. It is also recommended that once the core temperature is reached air flow is minimized by cycling evaporator fans automatically. During the winter storage period in temperate climates, most refrigeration load comes from heat rejected by the evaporative fans and motors. Therefore, optimizing fan operation time results in tremendous saving in electricity cost. It may also increase humidity in the storage and reduce product moisture loss.

f. Stacking: During room cooling, cold air from the coils flows past the produce bins/ crates thereby removing the product heat. For best result bins should be stacked so that the moving air can contact all the container surfaces for adequate and rapid cooling. Well ventilated bins/crates with vent alignment should be considered as they great speed-up the cooling rate by allowing the cooling air to uniformly flow. It is recommended that the bins / pallets must be stacked to form air channels 4 to 6 inches wide to direct air movement. They should also be space between the product and walls to allow refrigerated air to absorb the heat of conduction through the walls. Since, air takes the path of least resistant, in proper stacking in hips or partly filled rooms have poor air distribution and effect the cooling rate. However, there are reported instances of storing F & V in CFB cartons too but not recommended for long term storage.

For higher efficiency achieved by regulating the air flow by VFD and cyclic operation of the fans, The CA cold store stacking arrangement should be well designed to move the air uniformly through the stored produce. It is therefore recommended that CA cold store chamber / facility are designed for storage in Bins / PVC crates. The bins are of PVC / Treated wood and require to be handled with fork lift / stackers. Generally the PVC bins available in the country are of 300 Kg capacity each of size 1200 mm x 1000 mm x 780 mm which can be stacked up to 9 high.

g. Lighting Condition- Dark during storage

1. **Layout of a Typical CA Cold Store of Capacity 2000MT-**
(Indicative design only)



Typical Layout: CA cold stores will have multiple chambers each having capacity of 50 MT to 250 MT, anti rooms, docking area, grading/sorting area, grading /sorting line, Bins / palletized storage System & material handling system etc. The facility must be sized to handle peak amount of product. The floor area of each chamber can be calculated based on volume and weight of the produce in bins / pallets, its stackable height and considering floor area for aisle, fork lift manoeuvring and staging. The maximum storage height is limited by stackability of bin or / and Fork Lift reach. The storage chamber

should ideally have a floor perimeter in the shape of a square for optimum wall area per Sq. Ft. of floor area.

It is recommended that CA cold stores are of single storey design with individual rooms high enough to allow fruits to be stacked up to 11 bins high, including enough height between the bins and the ceiling to allow air from the cooling coils to mix with the room air and travel easily to far end and corners of the rooms. However, CA stores owned by producer farmer / farmers groups for his / their own farm product and up to storage capacity up to 50 MT may be allowed with mezzanine floor arrangement.

CA Cold Store with chamber layouts provided with an **interior corridor / ante room** offer better operating conditions and energy efficiency, than designs without interior **corridor / ante room**. The interior corridor allows easy access to pipe line and controls and protects the door and equipments. It also makes product observations easier and facilitates compliance with HACCP criterion.

Construction Features- The general construction recommendations are as follows:

Foundation:

Superstructure and Foundation (which may be conventional Footing Type, Pile Foundation, Raft Foundation etc) to be designed by qualified & licensed structural / civil engineer. The design shall meet the BIS standards and relevant seismic zone norms for earthquake proof designs.

Cold Store Building

The Building should be constructed as per approved drawings and dimensions indicated. It is recommended to construct such facility using steel construction / pre-engineered construction conforming to relevant BIS Codes for live load as per IS 875 Part-II, wind load as per IS 875 Part-III, seismic load as per IS 1893 and other codes and standards if applicable.

The steel structure components / construction sections are fabricated conforming to relevant codes and standards of ASTM/BIS as applicable.

The walls ceiling and partition are generally constructed of Insulated composite structural panels with core insulation of polyurethane. The insulation requirements or equivalent “U” values are mentioned in the subsequent para. The insulated panels are generally 1 to 1.2 Mtr. Wide and in single piece and are extended from floor to the ceiling and held together by fasteners and fixing system. All the joints are sealed with polyvinyl acetate co

polymer or latex emulsions sealer or similar sealing compound for achieving a total gas seal.

However, **in case of conventional civil construction** the general specifications are as under:

Walls Minimum 230 mm Brick walls / solid concrete blocks with sand- cement plaster. However, in RCC structure or pre-fabricated structure insulated panel boards may also be provided in place of masonry walls.

Roof RCC slabs or Truss Roof with G.S / Pre-coated G.S.Sheet cover. RCC slab to have proper water proofing with reflective colour paint / China mosaic finish. Slab to have proper slope for rain water drainage.

In case of truss roof, provision to be made for fixing insulated panels on the ceiling & supporting of cooling units from the trusses (alternatively cooling units can be supported on floor mounted frame structure on top floor).

Provision for FRP sheets for natural lighting to be made in roof sheeting at certain locations. For ventilation of attic, provision of ridge monitor or turbo ventilators (which require no electric power) can be made. Alternatively roof can also be designed by installing insulated roof panels with proper slope & sealing of longitudinal & lateral joints. The work to be handled by experienced agencies to ensure a trouble free roof structure. The roof may be kept walkable for maintenance.

Sealing In such conventional construction special consideration should be given to sealing of all joints for maintaining a gas tight enclosures. In this case also the walls and ceiling need to be provided with coatings of suitable sealing compounds / polymers.

Floor The floor comprises of base concrete, in cold stores with suitably lower levels in cold chambers. The level difference between cold chambers and ante room to be equal to the thickness of floor insulation plus the layer of PCC or tremix finish.

The floor should also be made gas tight by providing a gas seal of hot mopped asphalt roofing felt or equivalent materials in the sub floor. It can also be achieved by applying special materials such as chlorinated rubber compounds to the top surface of the floor. In both cases wall to floor sealing of joints are most likely to fail and should be given due consideration while designing and installation.

Ante Room The cold rooms should be provided with at least one common ante room area to avoid direct infiltration of warm ambient air into the cold rooms. The ante room also serves as warm-up chambers for produce stored so they do not get wet due to condensation on unloading for dispatch.

Process Grading and Sorting Area:- The process area will be suitable sized for sorting, grading, washing and packing line. The process area will be maintained at comfortable conditions by using evaporative cooling, particularly in dry areas. In High RH areas, cooling in the range of 20 ~ 24 deg C can be provided which would be suitable for handling of fresh fruit and vegetable produce. Dock shelters will be provided in the dispatch area of pre-cooled products.

Grading & Sorting Line- Suitable mechanized sorting; grading, washing and packing line should be provided. Washing facility should take care of water quality, waste water disposal in proper manner.

Bins, Palletization & Strapping Facility- Bins / Pallets / Rack system should be provided in CA cold store facilities.

Pallet Jack & Fork Lift- Fork lift if need to be provided for movement of Bins / palletized crates. High reach Stackers / pallet Jack are needed depending on height of stacking.

Bins, Crates, Pellets and Racks - These are required in sufficient numbers for storing and vertical stacking of produce. The Bins can be of food grade PVC or treated wood with suitable re-enforcement along the corners so that they can be stacked up to 11 levels high for optimal utilization of CA chamber space.

CA Cold Store Doors and Inspection windows – Different type of door designs can be used in CA facility. In all cases the doors are constructed of a solid frame which can be clamped tightly against the gasketed door frame without warping. They can be hinged / sliding type. In CA cold store using bin stacking with forklifts the doors are of size 2.4 M x 3.0 M High to allow fork lift movements. Each door is provided with a hatch window of size 0.6 M x 0.75 M which allow for entry for checking fruit and making repairs without opening the main door. Many CA Cold store also have clear acrylic windows near the top of the wall, in the attic area above the Ante room to allow the inspection of the fruit without entering the chambers. These windows are usually concave shaped allowing all areas of the chamber to be seen. In case of smaller capacity CA cold stores with tatal capacity upto 50MT with mezzanine floors, door size could be less.

Strip curtains for cold rooms and Air Curtains for external outlets/ inlets- Strip curtains are quite common for reducing infiltration of air during loading/ unloading. Air curtains need power for operation but are more effective if properly installed.

Rodent proof civil structure and proper drainage of water to be ensured.

Rooms for machines, Electricals etc.

Dock Loading & unloading dock shall be designed with RCC slab roof or sheet roofing. However the machine roof can have RCC slab-roof to accommodate the evaporative condensers, pump sets, water tank, water softener etc. The dock area to accommodate suitably sized office & toilet for staff & labour.

Ancillaries Underground fresh water storage, storage for fire fighting, water supply & sanitary arrangements, compound wall / fencing, main gate, security, small canteen / electrical sub-station & D.G. set platform, roads & parking place for vehicles etc. Green landscaping with benches for labourers is desirable.

4. Thermal Insulation:

It is recommended that appropriate BIS standards are adopted for selection of design parameters (IS 661:2000) and method of application of thermal insulation **(IS 661 & 13205).** For fresh F & V are stored at + 0^o C, it is recommended to design thermal insulation for (- 4^o C to + 2^o C) temperature condition to have lower heat load.

Materials of thermal insulation and its application-

Cold chambers have to be insulated on walls, ceilings / roofs & floors with proper insulating material of adequate thickness, with provision for vapour barrier on outer side & proper cladding/ cover on inner side. The commonly used insulation materials are:

a) Expanded polystyrene
b) Rigid Polyurethane foam
c) Rigid phenolic foam
d) Mineral wool in composite panel form
e) Extruded polystyrene

The ancillary materials to be used include:

a) Vapour barrier e.g. aluminium foil, polyurethane sheet, with bitumen / cold mastic adhesives
b) Teakwood batten pegs, Tees etc.
c) G.S. sheet runners (avoid wooden batten runners)

d) Cladding of profiled / pre-coated G.S. Sheets 0.5 / 0.6 mm thick / Fibre-glass sheets of suitable thickness

For Conventional Insulation

Walls & Ceiling

1. Primer Coat followed by two layers of bitumen
2. Fixing aluminium foil min. 50 microns
3. Fixing wooden pegs at suitable intervals
4. Fixing two layers of insulation with staggered joints
5. Fixing G.S sheet runners over the pegs in longitudinal & lateral directions
6. Fixing profiled & pre-coated g.s. sheets, 0.5 / 0.6 mm thick over the runners with proper finishing of joints. Alternatively FRP sheets can be used.

Floor

1. Laying of polythene sheet, min. 250 microns, as vapour barrier
2. Fixing insulation slabs in two layers with bitumen as adhesive for the first layer
3. Covering with tar felt
4. Laying PCC / tremix of 75 mm / 100 mm thickness

For Insulated Panel Structure

Walls & Ceiling

1. Perimeter of the plinth to be in level for panel installation
2. Panels to have cam lock or tongue / grove joints
3. Sheet metal flashing to be provided on all concrete / wall ceiling joints internally & externally. PVC coving or concrete curbing to be provided on wall - floor joints.
4. Horizontal Tie bracings to be provided between vertical wall panels & external columns, to take care of wind loads
5. Adequate numbers of Pressure relief ports to be provided on all chambers with electrical connection
6. Insulated doors shall be suitable for panel mounting

MINIMUM INSULATION THICKNESS FOR VARIOUS INSULATION MATERIALS BASED ON RECOMMENDED U VALUES FOR -4 TO +2 ° COLD STORAGE

Type of insulation	Material		Wall		Ceiling/ roof U value = 0.24 W/m^2K	Floor U value = 0.29W/m^2K
			External U value = 0.27W/m^2K	Partition U value = 0.58W/m^2K		
	ρ Density Kg/m^3	K (at 10 ^{0}C) W/mK	Thickness mm	Thickness mm	Thickness mm	Thickness mm
EPS	20	0.036	150	75	150	125
PUF	40)	0.023	100	50	100	100
XPS##	30-35	0.025	100	50	100	100
Phenolic foam ***	50	0.026	100	50	125	100
Mineral wool ***	48	0.033	125	50	125	100
Bonded fibre glass/ glass wool***	32	0.033	125	50	125	100

*** Recommended only with vapour barrier and metal or FRP cladding min 0.5 mm TCD

Recommended in conformance to ISO/FDIS 4898:2008(E) for properties of XPS used for thermal insulation of buildings, Categories II, III & IV only.

Notes-

- **K** values from IS661:2000.
- **U** values are the recommended heat transmission coefficients for cold storage temperature range -4 to 2°C by IS661:2000
- All values rounded off in multiples of inch (25 mm)

5. Total Refrigeration Load - Heat Load Calculation

➢ Procedure for load calculation

Procedures laid out by ASHRAE Fundamentals and Refrigeration handbooks may be followed. The current method prescribed by ASHRAE Fundamentals is RTS (radiant

time series) method in which room by room analysis for each hour is carried out. However, the assumptions used for the building envelope and the loads are very crucial. ASHRAE refrigeration handbook elaborates a more traditional approach. Thus, based on the overall impact/ sensitivity of important parameters, some estimates can be made. Designers also tend to take a safety factor of 5-10% on the estimated loads.

- **Ambient conditions**

0.4% annual design conditions of that location as per ASHRAE/ ISHRAE data may be used for holding period. For the loading and pull down periods, 0.4% design conditions for those months may be taken.

- **Product incoming temperature**

It varies with location and harvesting time. However, average value may be taken as shown in Typical Designs enclosed. For pre-cooling the initial product temperature and the final product temperature with the duration of the batch has to be considered to determine refrigeration capacity.

- **Capacity during loading, pull down, holding and lean periods**

Refrigeration capacities should be calculated at various operating conditions and necessary arrangements for capacity control be included in the equipments to be provided.

6. Refrigeration System & Equipment Selection

Vapour Compression systems are commonly used. However, absorption systems can also be used for cold storages, where heat is readily available instead of electricity e.g. solar, geothermal, waste heat etc. A 7.5TR ammonia-water absorption system was installed at Manikaran by IIT Delhi in 1980's. It worked on Geo-thermal energy.

Refrigerant issues – eco-friendly, safety, energy efficiency.

Ammonia seems to be the best refrigerant in terms of environment (being natural) and energy efficiency for this application. However, it is toxic and precautions should be taken in its handling. In case there is a restriction of using ammonia at certain locations, the refrigeration system can be designed to work on R134a, R404A etc.

- **Type of system – secondary brine system, direct expansion (in case of HFC and others) , liquid overfeed and gravity with a surge drum,**

Liquid overfeed systems force excess liquid through the evaporator to improve the system efficiency and reduce the operating costs. It becomes more favourable as the number of evaporators goes up. Details of a gravity feed system are included in

details on subsequent pages with list of additional equipment for a liquid overfeed system.

- **Compressor – reciprocating/ screw with capacity control**

In case separate pre-cooling chambers are provided for pre-cooling produce before transferring it to the CA cold store chambers, independent compressors shall be provided for each pre-cooling chamber or the refrigeration system suitably designed to accommodate such batch cooling process.. For cold stores, a common compressor system can be provided. Multiple multi-cylinder reciprocating compressors or screw compressors with appropriate capacity control may be used. Typically the holding capacity may just be 50% of the peak capacity during loading. So, it may be suitable to go for two same sized compressors each suitable for holding capacity at peak loads. A third compressor as standby compressor is recommended. Compressors should be able to deliver the desired capacity at worst conditions not at rated conditions. VFD's can also be used for closer control in some cases. Capacity of compressor shall be confirmed by data- sheet of manufacturer.

- **Condenser – atmospheric, evaporative, water cooled, air cooled in case of HFC**

Condensers can be air cooled with water spray or with provision of pre-cooling of condenser air in case of HFC / HCFC or water cooled with S&T condenser or Plate Heat Exchangers (PHE) with cooling tower arrangement in case of HFC / HCFC/Ammonia plant or of evaporative / atmospheric type or shell and tube water cooled type with cooling tower arrangement in case of ammonia plant. Capacity of condenser shall be confirmed by data- sheet of manufacturer. Coils with Aluminium tubes and Aluminium fins can also be used.

- **Cooling coils – ceiling / wall mounted**

Delta T (difference between evaporating and air inlet temperatures) should be kept low for higher humidity in the chamber. Typical values shall be 4.4 or less during holding period and can go up to 6 during peak loading period. This shall be confirmed by data sheet of manufacturer. This increases the coil surface substantially. The coils selected are kept on the higher side to keep higher humidity levels even during loading/ pull down periods. Ammonia coils are typically MS hot dip galvanised or SS/ aluminium tubes with Aluminium fins. The cooling units for other refrigerants have coils with copper tubes and aluminium fins.

- **Capacity control of fans**

Fans' operation can be cycled to save power during part load operation. VFD's *may* also be used on the fans to get good savings.

- **Air handlers for forced air pre-cooling**

Forced air pre-cooler is a separate room from the cold store chamber and is a much faster method of cooling fresh produce than room cooling because it causes cold air to move through the produce rather than around the containers. This is accomplished by producing a difference of pressure of opposite faces of stacks of ventilated containers. This pressure difference forces air through the stacks and carries the field heat away. Various air flow designs can be used depending on need and design of the facility such as Tunnel-Type, Cold Wall and Serpentine forced air cooling. The air handling units for pre-cooling shall be specially designed units for faster rate of cooling with high RH in the range of 96 ~ 98 %. The generally used design incorporates a DX cooling coil in case of HCFC/HFC refrigerants or a flooded ammonia cooling coil with adequate water circulation and spray system over the cooling coil and heat exchange surface deck and is provided with a high airflow & high static fan mounted on the unit.

- **Testing and Charging the system**

Installation, Testing & Commissioning should be carried out as per BIS (for standards available). ASHRAE standards may be referred to as guidelines but not mandatory.

- **Air purger (manual or automatic)**

It is desirable to remove air and other non condensable gases from the refrigeration circuit to keep the compressor head pressures lower and also improve heat transfer coefficients.

- **Defrosting method – water/ hot gas/electric/air etc.**

Water defrosting is a simple method and can be done manually or through a timer.

- **Humidification system**

Although higher humidity levels of 85-90% can be achieved by keeping low delta T in the cooling coil. But during loading periods and for RH>90%, humidification system may be used. Several techniques are available, but it should preferably be done using water mist with 2- 10 micron and uniformly distributed all over the chamber ensuring that the product does not get wet.

- **Equipment de-rating at higher ambient**

A designer should match the loads with the de-rated equipment capacity at higher ambient conditions.

7. GENERAL SPECIFICATIONS FOR REFRIGERATION SYSTEM

(Typical Designs Enclosed Separately)

Brief Specifications for Equipment / Materials / Services

Brief Specifications for Equipment / Materials / Services

i. Refrigeration Compressors & Motors

Quantity	For pre-cooling, one compressor shall be provided for each chamber to facilitate independent operation of the batch. For Cold stores, 3 No. each of 50% capacity (*one preferred as standby)* can be provided in case of ammonia. In case of HFC / HCFC, individual condensing units or rack system can be provided.
Type	For ammonia as refrigerant, reciprocating, multi cylinder complete with water-cooled head / jackets, with accessories like oil separators, capacity control & unloaded start. Alternatively screw compressor, open type with accessories can be provided. For HCFC / HFC, reciprocating. / scroll / screw can be provided..
Capacity at critical operating conditions	*To be configured in kW*
Estimated Motor rating	*To be configured in kW, RPM, type of insulation, Input AC power supply*

ii. Evaporative Condenser for Ammonia:-

Coil section	Hot dip galvanised M.S. pipes CDW Boiler quality tubes / ASTM A 214 or S.S.304 tubes,
Fan section	With 2 / 3 Axial Flow Fans with Cast Aluminium OR S.S impellers, complete with TEFC Sq. cage motors, Class F insulation & IP-55 protection
Water sump tank	S.S.304 or M.S. Epoxy coated with necessary connections
Other provisions	Water spray arrangement, air inlet grilles, eliminators of suitable design
Unit casing	with removable G.S sheet panels & inspection windows etc.

Estimated Heat rejection capacity at 38 deg C condensing & and applicable WB temp	*To be configured in KW*
Suggested Standard	ARI Std 490

Air cooled / water cooled condenser for HFC / HCFC.

Capacity	*To be configured in KW*
Size	To be furnished

iii. **H.P. Receiver for Ammonia:-**

Horizontal Ammonia receiver complete	With necessary connections, reflex type level gauge etc.
Capacity	To be configured
Material of Construction	Boiler quality steel plates
Quantity	2 Nos. (Two no's are suggested in case some States' regulations call for Pressure testing of high pressure vessels on a periodic basis)
Suggested Standard	ANSI / ARI 495/ BIS Code IS 2825

iv. **Air Cooling Units**

a) Finned cooling coil	Coil design to be suitable for gravity feed / pump circulation for ammonia & DX operation for HCFC / HFC as per design
M.O.C	Hot dip galvanised coil with M.S. pipes CDW Boiler quality tubes – ASTM A 214 with MS fins or S.S.304 tubes & Aluminium fins OR Aluminium tubes & Aluminium fins with proper bonding system with bullet drawn expansion / equivalent expansion for

	Ammonia For HFC / HCFC coils with copper tubes & aluminium fins or aluminium tubes with aluminium fins.
Fin spacing	*(3-4) FPI* [2]
b) Axial Flow fans	With cast aluminium / S.S. / FRP impellers, with variable pitch, TEFC Squirrel cage motors with class F insulation, IP-55 protection
c) Accumulator	Vertical / horizontal with necessary connections (in case of gravity feed units) for Ammonia
d) Unit casing	G.S. sheet duly painted, drain pan of G.S / M.S with epoxy paint
d) Defrosting arrangement	Water
Unit capacities	
Number per chamber	To be configured
Estimated capacity each at critical operating conditions	*To be configured*
Estimated coil surface area	*To be configured*
Estimated air flow capacity each	To be configured

For Fruits & Vegetables requiring higher humidity, lower delta T, higher flow rates of air and higher coil surface areas need to be used.

For 1 no. F & V cold store	one or more number per chamber; generally 3 *to 4 nos. to ensure uniform air distribution; as per configuration*
Estimated capacity each at critical operating condition	*To be configured*

[2] Design Essentials for Refrigerated Storage Facilities (2005). ASHRAE

Estimated coil surface area	*To be configured*
Estimated air flow capacity each	*To be configured*
Suggested Standard	ARI Std. 420

Notes:

a) Number of ACUs may vary from 2 to 4 per chamber, in which case the capacity parameters shall be increased or decreased proportionally
b) The ranges in capacities have been mentioned considering the possibility of higher cooling capacity requirement if incoming product temperatures are around 30 deg C, mostly in western & southern zones

v. **Refrigerant Piping, Fittings & Valves**

Piping	M.S. black piping conforming to IS-1239 / ASTM A Gr.106B for 40 NB & smaller sizes / ASTM A Gr.53B for 50 NB & larger sizes. For HFC / HCFC, hard Copper piping type L
Interconnecting piping between compressor, condenser, receiver and cooling units	Piping as per. ANSI guidelines and pressure vessels as per BIS Code IS 2825). Reference to ASHRAE B-31.5 recommended.

vi. **Water Piping, Fittings & Valves**

Piping shall be used for a. Condenser water circulation b. Compressor cooling c. Defrosting d. Drain lines	Piping to be G.I class B or sizes up to 65 NB & M.S. black pipe conforming to IS-1239. Valves up to 40 NB to be Gate / Globe type. Valves 50 NB / larger to be butterfly type.

vii. **Water Pump sets**

Water flow capacity to take care of condenser water flow & compressor head / jacket cooling	2 nos. (one standby)
Capacity	To be configured

viii. **Thermal insulation for refrigerant piping etc.**

Material for insulation for refrigerant suction line, accumulators etc.	a. EPS pipe section b. PUF pipe section With 0.6 mm Aluminium or 0.5 mm G.S. pre-coated sheet cladding c. Nitrile Rubber / EPDM / chemically cross linked polyethylene pipe section / other acceptable materials with woven glass cloth with UV treated pigmented epoxy Coating

xii. **Controls**

CA Monitoring Equipment	Oxygen and Carbon Di-oxide must be monitored daily or more frequently to ensure they are within the prescribed limit. Automatic gas analyser and monitoring equipment is more accurate and widely used. This is further connected to a controller to automatically maintain proper gas concentration.
Pressure Equalization	Changes in pressure difference between the cold rooms and outside can damage the gas seal. Therefore suitable equalization system is necessary. This can be achieved by using breather bags which have the advantage of capturing the gas mixture and allowing it to re-enter the room at a later stage when the pressure drops.
Temperature control	Temp Indicators cum controllers for individual chambers. Temperature scanners and a centralized temperature indication in machine room. The thermostat sensors are usually placed 1.5 Mtr above the floor and should not be placed near

	source of heat like door openings, walls or exterior surface. Neither they should be placed near the cooling coil discharge. The thermometer / thermostat should be collaborated and periodically check for accuracy.
RH control	RH indicator & controller
CO_2 control	CO_2 sensors for regulation of ventilation system. Automatic regulation is recommended
Refrigerant flow controls	Liquid level controls, solenoid valves etc.
PLC control systems	For overall control of various parameters

Note. Location for installing the sensors will depend on site conditions and stacking pattern etc. However, facility for recording temperatures and RH at various locations on hourly basis and displayed in the plant room is desirable. Therefore Programmable Logic Controllers (PLC) is recommended with the display point in the manager's cabin.

xiii. **Installation, Testing & Commissioning**

Installation	The plant shall be installed, tested & commissioned as per IS 660 / ASHRAE. Std 15.

General Notes:

a. The above design recommendations are based on Ammonia as refrigerant & the system designed for gravity feed for air cooling units. It is also possible to use pump circulation system (overfeed system) requiring following components :
b. Centralised ammonia L.P receiver
c. Ammonia pumps – 2 nos
d. Refrigerant flow & safety controls
e. Interconnecting piping – both supply & return lines shall be insulated. In this case the individual accumulators for AC units & level controls etc. are not required.
f. In case of palletized cold store, it is recommended that in order to prevent damages to the walls from the pallet movement etc., strong GI Pipe/tubing should be laid out to create a barrier.
g. The docks should ensure that dimensions of the dock should commensurate with the dimensions of the containers to avoid hot air entering the inside of the bay.

Further, dock cushioning and shock absorber should be installed to avoid damage by the impact of container adjustment on the docking bay.

8. ELECTRICAL INSTALLATIONS

- Power Factor – not less than 0.95
- Transformer of minimum required capacity

ELECTRICAL INSTALLATION

i. Substation

Substation with a rating of about 200kW	a. Step down transformer suitable for incoming H.T. voltage / 433 V as per IS-2026 / other applicable standards b. Two pole / four pole structure as per local requirements c. Outdoor type metering cubicle with approved meter, CTs / PTs etc. d. Earthling station as per requirement e. Switchyard fencing with gates as per Electrical Board requirements

ii. D.G. Set for standby power

D.G. set complete with accessories and with *weather-proof* and noise-proof canopy *as per local pollution control norms*	Estimated Rating: *as per design. One big for pull down period and one small for holding period may be used.*

iii. Main power distribution panel

Main power distribution panel with changeover facility for normal electric supply & D.G. set supply. With ongoing feeders for various electrical panels.

iv. Electric panels

Electric panels for	a. Refrigeration b. Lighting, Electric hoist, Fans c. APFC (automatic power factor correction) panel d. Water supply, fire fighting etc.

v. Power & Control cabling etc

Power and Control cabling, earthing etc for various electrical circuits	Aluminium armoured conductors for main power lines & equipment lines & copper conductors for lighting, control wiring etc.

vi. Lighting

Lighting in a. cold stores, ante room b. other areas c. outside areas	The light fittings (with non glass covering) should be energy efficient eg. CFL (with vapour proof casing) fittings for cold chambers. A central switch should be provided outside each chamber. Typical installations for lights may be 2 to 3 W / m^2 of floor area. **(IS 15111)**

9. Safety-

SAFEETY MEASURES

CA Safety Considerations	No person should be allowed inside the chamber when the CA is in operation.
Provision for handling accidental leakage of ammonia	Ammonia sensors in cold chambers near ACUs & machine room Emergency ventilation for machine room Safety release of refrigerant to water sump Ammonia masks First aid kit Instructions for handling emergencies
Fire protection	Fire sensors in cold chambers & machine room. Dry & water based fire fighting systems as per

	specs below. Sprinklers for high pressure receivers
Emergency lighting system	May be solar PV cells with batteries & controller
Emergency alarm system	To be provided with switches near all cold store doors and alarms located in common public areas
Lightning arrestors for the building as per local regulations	

i. Fire Fighting

a. Dry Type

Fire fighting equipment necessary for extinguishing liquid, solid and electrical fire :	i) Dry chemical powder type 5.0 Kg Cap with ISI Mark Fire Extinguisher complete with wall mounting bracket. ii) Carbon Di-Oxide (CO_2) type 4.5 Kg. capacity Fire Extinguisher complete with wall mounting bracket. iii') G.I. Fire Buckets iv) M.S. Stand for Fire Buckets

b. **Water based** (mandatory if local code so prescribes)

System shall comprise of	i) 2 sets of Water supply pumps. ii) 2 sets Fire fighting pumps iii) G.I. piping, class C with necessary fittings & valves iv) Rubber Hose reel v) Canvas Hose pipe vi) M.S. Fabricated hose box with key

10. **Coefficient of Performance (CoP) -** Optimum energy efficiency should be determining criteria for CoP. ***It may be noted that CoP will be different for Brine based secondary cooling, Dx Freon, and overfeed ammonia systems – However, design CoP value should be indicated in the project.***

11. Operation & Maintenance- CA Cold storage design must be accompanied by Operation & Maintenance Manual for cold storage operator which should cover following points in English as well as Hindi languages-

- No. of operating hours
- Training of operators
- Monitoring & control – temperature, humidity, CO_2
- Door seals – checking methods
- Maintenance of equipment / cold store
- Hygiene issues

12. Variation / amendment Clause-

The standards prescribed above are not intended to prevent or discourage variations arising out of new concepts, innovations and R & D in building design & construction, thermal insulation and cooling & refrigeration technology etc. However, any variations or deviations from the above prescribed standards must be supported by scientific / technical details for prior approval of the competent authority, on the basis of merit who may decide the proposal in view of relevant technical details including critical storage requirements, energy efficiency (coefficient of performance), availability of *Standards*, environmental concerns, safety etc. Similarly, periodic amendment of standards for general application may also be undertaken by the National Horticulture Board; in consultation with a committee of subject matter experts duly constituted for this purpose.

SECTION 2

Basic Data Sheet

Section-2

Data Sheet for Controlled Atmosphere (CA) Cold Stores

A. Identification

Name of Cold Storage			
Location of Cold Storage	Area / Village	Town	
	District	State	
Name of Promoter Company / Owner			
Type of company (Proprietorship / Partnership / Pvt. Ltd / Ltd)			
Postal address of Promoter			
	Tel / Fax	Mob. No	E-mail
Present activity in brief			
Name of CEO / MD			
Name of Manager / Contact Person		Phone / Mobile No	

B. CA Cold Store Design Considerations

i) Commodity Storage Requirements (Apple, Pears & Others)

Type of Commodities/Produce		
Ideal / Recommended Storage Conditions – Temperature (DB in ^{O}C) – Humidity RH (%) Range – CO2 Percentage – O2 Percentage – O2 Pull down duration (hrs) – Cooling Rate (Product Temp Pull Down duration in hrs) – Air Circulation (CMH/MT of Produce) – Produce Freezing Point ^{O}C – Others		
CA Chamber Dry bulb (DB in ^{O}C)		
CA Chamber RH (%)		
Max Storage period (months)		
Max product temp (^{O}C) – at the time of loading		
Daily loading rate (MT/day) – in each cold chamber		

Loading Period (months)		
Temperature Pull down rate (^{O}C / day)		
Unloading Period (months)		
Daily unloading rate (MT/day) – from each cold chamber		
Ante Room Conditions (T ^{O}C & RH %)		
Sorting & Grading Area (T ^{O}C & RH %)		
Special Provisions – Ethylene Control – Air Purification – Sanitation		

ii) Storage System (Bins, Crates with/without Pallets)

Brief Description of Storage System	
Bins/ Crates – Size of Bin – Material of Construction – Storage Capacity (Kg/Bin) – Stack ability (Bins High)	Plastic/Wood

iii**) CA Cold Store Chamber Sizing and Capacity**

- No. of chambers: *(based on 3 day fill-up*)
- Type : Bins/Crates/ Palletized
- Max Height of Building

Details	**CSC 1**	**CSC 2**	**CSC 3**	**CSC 4**
Total Capacity of Each Cold Store Chamber (MT)				
Internal Chamber Dimensions L x B x H (m)				
No. of mezzanine floors X Height (m) per floor				
Size &Weight of Bins/Pallets being stored				
Total number of Bins/Pallets stored in each Cold Store Chamber				

Note. Use extra sheet for additional chambers

iv) Ante Room & Process Areas

Details	**Length (m)**	**Width (m)**	**Height (m)**
Ante Room			
Sorting & Grading Area			

Loading / Unloading dock			

v) Machine Room & Utility Areas

Details	**Length (m)**	**Width (m)**	**Height (m)**
Machine Room			
Office Area			
Toilets & Changing rooms			
Any other			

vi) Building & Construction Details

- **Type of construction :** Pre-engineered Building /Civil

Type of External walls of cold chambers	
Type of Internal / Partition walls	
Type of Roof / Ceiling	
Type of Flooring for forklift/stacker movement	
Type of Gas Tightness / Sealing Methodology to maintain minimum gas tightness requirements as per ISO Code 6949:1988 (E)	
Types of Lighting fixtures in cold Chambers	

Types of Lighting fixtures in Process & Other Areas	

vii) Insulation and Vapor Barrier

- **Type of Insulation :** Insulating Sheets / Metal Skin Composite panels

Type of Insulation	**Wall**		**Ceiling / Roof**	**Floor**
	External	**Internal**		
Type of material EPS / Metal Skin PUF Composite Panels / XPS/ PUR, Others				
Relevant IS Code				
Density (kg/m^3)				
Thermal Conductivity at +10°C k value (W/m.K)				
Thermal diffusivity m2/h				
Water vapour transmission rate, ng/Pa.sm, Max.				
Water absorption after 24h immersion, percentage by mass.				
Relevant IS Code of Practice for Thermal Insulation of Cold Store				
Total Insulation Thickness (mm)				
No. of layers & Thickness / layer (mm)				

Type of vapor barrier & thickness (microns)				
Type of Bituminous/Sticking Compound				
Type of Cladding / Covering/External Finish				
Locking/Fixing & Sealing System in case of Metal Skin Composite Panels				
Any other info				

viii) Cold Store Doors & Air Curtains

Type of Insulation	**Details**
No. of Insulated CA doors	
Type hinged / sliding	
Insulation Material EPS / PUF / Others	
Thickness of Insulation (mm)	
Type of cladding	
Size of door opening	
Provision of Inspection Windows & Size	
Air curtains, if any	

Others type of doors for ante room and process area	

ix) Material Handling

- **Proposed Practice :** Manual / Electric Fork Lift /Stacker

Procedure	**Brief Description**
Material Handling Procedures & Equipments	
Any other device	

x) Grading, Sorting, Washing, Waxing & Packing Line

- **Proposed Practice :** Manual / Semi Automated /Automated

Procedure	**Brief Description**
Process Line	
Total Connected Load (kW)	

Please attach a Plan & Layout of the proposed Cold Store unit in accordance to the Statutory Building By-Laws and BIS Building Codes & Standards duly approved by a Registered Architect and Structural Engineer. The drawings should detail out insulation type, thickness, and fixing methodology in sectional details.

C. Control Atmosphere Equipment

Conforming to ISO 6949:1988(E), Type 2

Type/Make/ Model	Description/Capacity
Carbon Dioxide Absorber System & Accessories	
Nitrogen Generator System & Accessories	
Pressure Equalization System & Accessories	
Regulation & Control System & Accessories	
Gas Analyzer & Calibration System & Accessories	
Ethylene Scrubber System	
Air Purifier (optional)	
Others	

D. Heat Load Calculation of Cooling System – Summary

Ambient Conditions	Summer	Monsoon	Winter
Dry Bulb Temperature (°C)			
Wet Bulb Temperature (°C)			

Refrigeration Load	During Loading (kW)	During Pull Down (kW)	During Holding (kW)
Transmission Load			
Product Load			

Internal Load	Lighting load			
	Occupancy load			
Infiltration Load				
Ventilation/ Fresh Air Load				
Equipment Load - Fan motors etc.				
Total Load (kW/24 hrs)				

Compressor Operation **Hours/Day**	Loading Period	
	Pull Down Period	
	Holding period	

Multipliers	Safety Factor	
	Defrost Period	

Total Refrigeration Load	**Peak Period**	**Holding Period**	**Lean Period**
Total Load (KW)			

Please attach detailed heat load calculation sheets of the proposed cold store unit in accordance to the prescribed Technical Standards and Guidelines duly approved by a Qualified Engineer.

E. Cooling System Design & Equipment Selection

i) Cooling System Configuration

Type of Refrigerant	Ammonia /Freon /Others
Type of System	**Secondary Brine System** / Direct Exp / Gravity Feed / Overfeed
Type of compressor	Reciprocating / Screw / Scroll / Others
Type of capacity control	Automatic In steps / Step less
Type of condenser	Atmospheric / Evaporative / Shell & Tube / Plate Heat Exchanger / Other
Cooling Towers (if applicable)	FRP Induced Draft / Others
Type of cooling coil	Ceiling suspended / Floor Mounted / Others
Type of defrosting	Air / Water / Electric / Hot gas
Humidification System & Control (Brief Description)	

ii) Compressor Detail

Compressor Make & Model	Nos.	Comp. RPM	Operating Parameters Evap. SST. / Cond. Temp (^{O}C)	Refrigeration Capacity (KW)	Motor Rating. (KW)	Total Electric Power. (BkW)	Remarks Working /Standby

iii) Secondary Brine System

Make & Model	Nos.	Operating Parameters inlet/outlet (^{O}C) &flow (lps)	Chiller Capacity (kW)	Recirculation Pump Motor Rating (kW)	Total Electric Power (BkW)	Remarks Working /Standby

iv) Condenser Details

Condenser Make & Model	Nos.	Operating Parameters Cond.Temp.(SDT)/ in/out water temp(^{O}C) &flow (lps)	Condenser Capacity (kW)	Electric Fan /Pump Motor Rating (kW)	Total Electric Power (BkW)	Remarks Working /Standby

v) Cooling Tower Details (if applicable)

Cooling Tower Make & Model	Nos.	Operating Parameters DB & WB Temp, in/out water temp(^{O}C)	Cooling Tower Capacity(KW)	Fan & Pump Capacity (CMH/LPS) & Motor (kW)	Total Electric Power (BkW)	Remarks Working /Standby

vi) Air Cooling Units (ACU)

ACU Make & Model	Nos.	Operating Parameters Evap. (SST)/ inlet-outlet & TD* (^{O}C)	Cooling Capacity (kW)	Air Flow (CMH) & Face Velocity (M/S)	Material of Coil Tubes & Fins	Fin pitch (mm)	Total Fan Electric Power (BKW)

(*) TD – Temperature difference between Evap. (SST) ^{O}C & Return Air (at coil inlet).

Please attach Technical Data Sheets of each equipment namely Compressors, Condensers, Cooling Towers, Air Cooling Units giving General Layout, Dimensions, Material of Construction, Rated Capacity, Operating Parameters and COP (please note that the Air Cooling Unit data sheet should include heat transfer area, fin spacing, no. of rows, air flow, face velocity, fan static, air throw, Fan Motor BKW/KW, fin spacing, etc) duly Certified by the respective equipment manufacturers with reference to the Relevant Codes & Standards. In case, equipment selection is in process, then data sheet for options being tried be provided and range of design values be indicated in data sheet.

E. Electrical Instillation

Total Connected load (kW)	
Estimated power requirement at Peak Load Period (BkW)	
Estimated power requirement at Holding Load Period (BkW)	
Estimated power requirement at Lean Load Period (BkW)	
Capacity of Transformer (KVA) (proposed)	
Size of Capacitor for power factor correction & their operation	
Make & Capacity of standby D.G. Set (KVA)	

F. Safety Provisions

Details of Fire Fighting equipment	Dry	
	Water based	
Handling Refrigerants & Leaks	Leak Detection	
	Handling measures	
Safety devices – LP/HP cutouts, safety valves, shut off valves etc.		
Details of Emergency alarm system & push button system in cold chambers		
Emergency lighting in Cold chambers & other areas		
Lightening arrestors		
Any other safety provisions		

G. Codes & Standards Followed

Building Design & Structure	
Construction Materials	
Thermal Insulation & Application	
Refrigeration Equipment & Systems	
Electrical & Mechanical Systems	
CA Storage Systems	
Food Safety	

Others - CA Safety Considerations for Operators	

H. Energy Saving Equipment & Measures

Details of Energy Saving devices	Brief Description and Savings
Light Fixtures CFL/LED	
Natural Lighting for general areas	
VFD for fans / compressors	
Refrigerant Controls and Automation	
Air Purger	
Power Factor Controller	
Renewable/ Solar Energy e.g. PV lighting	
PLC Control, & Data Acquisition	
Any other features e.g. water recycling, rain water harvesting …	

I. Operation & Maintenance

Description	Nos. / Details
Proposed staff for Operation & Maintenance	
Proposed Annual Maintenance Contracts (if any)	
Training & Preventive Maintenance procedures	

Sanitation & Hygiene practice	
Pollution Control	

J. Estimated Performance Parameters of Proposed CA Cold Store

Parameters	**Peak Period**	**Holding Period**	**Lean Period**
Coefficient Of Performance (COP) Of the Cold Store Unit			
Power Consumption (KWH/Day)			
Total Electricity Cost (Rs/Day)			
Electricity Cost towards Storage (Rs/ MT /Day)			

K. Other Information

Place
Date

Signature and
Name of Applicant with seal

SECTION 3

Protocols for Implementation of Technical Standards

Section-3

Protocol for Implementation of Technical Standards

Subject to provisions of *Variation Clause*, only those cold storage projects that are in conformity with the prescribed technical standards will be eligible for Central Government Subsidy. In order to verify this, following mechanism needs to be put in place-

A. System of *Letter of Intent* (LoI)- LoI to be obtained by the promoter prior to undertaking construction of cold storage needs to be introduced. An application for Letter of Intent must be accompanied by following documents, in addition to any other documents prescribed-

i. A copy of the detailed project report
ii. Information in prescribed Basic Data Sheet accompanied by requisite documents

Technical scrutiny of the above documents will be undertaken to ensure that the project is in conformity with the prescribed technical standards or any variation is fully justified keeping in view the product to be stored, prescribed storage conditions, energy efficiency and environmental and safety concerns.

B. Civil Structure- Following documents must be submitted by the promoter in respect of civil construction

i. Certificate of approval of the building plan by local planning authority,
ii. Certificate issued by registered civil design engineer about conformity with relevant BIS Standards and prescribed standards and safety concerns,
iii. Certificate by site engineer / architect to the effect of construction of the civil structure as per approved building plan and design and completion of the civil components accordingly in all respects as per prescribed plan and standards,

C. Thermal Insulation & Refrigeration System, Control and Safety Devises

i. The components of insulation and refrigeration system should be certified in form of a technical data sheet by the manufacturer confirming the rating and performance as per prescribed standards.
ii. Further, site inspection at appropriate stages of construction / erection and commissioning may be undertaken by an inspection team constituted by competent authority for this purpose.
iii. Finally, the manufacturer/refrigeration contracting agency will issue a certificate of satisfactory commissioning of the cooling system in conformance to the performance indicators as per prescribed standards.
iv. The manufacturer/refrigeration contracting agency will also provide “as built drawings”, including cold store layout, P&I and electrical drawing and an operation & maintenance manual along with a list of essential spare parts.

A set of above documents along-with the refrigeration system performance certificate issued by the refrigeration company / contracting agency, duly signed by an authorized graduate engineer of the company/agency, must be submitted to competent authority for record and a copy of the same must be issued to the promoter / owner of the project.

Annexure - I

No. 22011/5/2007-M-II
Government of India
Ministry of Agriculture
Department of Agriculture & Cooperation

Krishi Bhavan, New Delhi.
Dated the 16th June, 2009

A Task Force on development of cold chain in India had been set up by Ministry of Agriculture vide its order dated 3rd May, 2007. One of the recommendations of the Task Force, which submitted its report in 2008, is development of standards and protocols for the cold chain system in India so that a standardized infrastructure and service pertaining to the cold chain can be promoted in India.

Now it has been decided with the approval of the competent authority to constitute a Technical Standards Committee for recommending the technical standards and protocols for the cold chain in India with the following composition:-

1.	Managing Director, National Horticulture Board, DAC :	Chairman.
2.	Shri Daljit Mirchandani, Chairman CII Cold Chain Initiative.	:Member
3.	A representative of Secretary, Ministry of Food Processing Industries (not below the rank of Dy. Secy.)	:Member
4.	A representative of Secretary, Department of AHD&F (not below the rank of Dy. Secy.).	:Member
5	A representative of Chairman. Railway Board	:Member.
6	Joint Secretary and Mission Director (NHM), DAC or his representative.	:Member
7	A representative of Chairman, APEDA	:Member
8.	A representative of DG, ICAR (not below the rank of ADG)	:Member
9	A representative of Principal Secretary(Horticulture),Govt. of Uttar Pradesh	Member
10.	A Representative of Principal Secy.(Agriculture), Govt. of Maharashtra.	:Member
11	A Representative of Principal Secy.(Hort.), Govt. of Himachal Pradesh	:Member
12.	A representative of Vice-Chancellor, G.B. Pant University of Agriculture & Technology, Pant Nagar, Uttarakhand	:Member
13	A representative of Bureau of Indian Standards -Dy. D.G.(Technical)	:Member
14.	A representative of Chairman & Managing Director, Central Warehousing Corporation.	:Member

15. Shri Sanjay Agarwal, CMD, Dev Bhumi Cold Chain Prvt.Ltd. :Member
16. Shri S.K. Sharma, MD, Global Agri System Pvt. Ltd. :Member
17 Shri P.K. Swain, Director (Marketing), DAC :Member-Secy.

National Horticulture Board, DAC will provide the secretarial assistance to the committee. The Technical Standards Committee shall give recommendations on the following issues:-

(i) Suitable technical standards and protocols for cold chain infrastructure in the country.
(ii) The mechanism of implementation of such standards and protocols.
(iii) Any other issue that the Committee may consider important or relevant to the subject or may be assigned to it by the Government.

The Committee will submit its recommendations within a period of two months.

16.6.07

(Rajendra Kumar Tiwari)
Joint Secretary (Marketing)

To

1. Shri S.K. Pattanayak, JS (NHM), DAC, Krishi Bhavan, New Delhi.
2. Shri Bijay Kumar, MD, NHB, 85, Institutional Area, Sector – 18 Gurgaon – 122 015(HARYANA).
3. Shri B.B. Patnayak, CMD, CWC, 4/1, Siri Institutional Area, August Kranti Marg, New Delhi.
4 Shri Daljit Mirchandani, Confederation of Indian Industries (CII), India Habitat Centre, Core 4A, 4th Floor, Lodi Road, New Delhi.
5. Shri Gokul Patnaik, Chairman, Global AgriSystem Pvt. Ltd., K-13A, Hauz Khas Enclave, New Delhi.
6. Shri V.K. Dutt, Additional Member Electrical, Railway Board, Rail Bhavan, New Delhi.
7. Shri Rajiv Agarwal, MD, National Cooperative Development Corporation, 4- Siri Institutional Area, Hauz Khas, New Delhi.
8. Mrs. Madhulika Prakash, DDG, Bureau of Indian Standards, Manak Bhavan, 9, Bahadur Shah Zafar Marg, New Delhi – 110 002.
9. Joint Secretary, Ministry of Food Processing Industries, Panchsheel Bhavan, New Delhi.
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Annexure - II

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Annexure - III

Apples, Controlled Atmosphere Storage
[as mentioned in WFLO]

Revised 2000	
• Lowering the Oxygen Concentration	• Precautions
• Maintaining the Desired Gas Concentrations	CA Storage Disorders
• Technology	

Introduction

Controlled atmosphere (CA) storage may he used to extend the storage life of apples. Varieties such as Mclntosh are CA stored at 36°F (2°C) to control flesh browning and physiological flesh breakdown caused by chilling injury which develops in storage. Chilling insensitive varieties, such as Delicious and Rome, are CA stored at 30 to 32°F (-1 to 0°C). State Agricultural Experiment Station or cooperative extension specialists should be consulted for recommended concentrations of carbon dioxide (1 to 5%) and oxygen (1 to 3%) because recommended gas mixtures vary with the variety and the geographic area in which the variety is grown. In general, temperatures are increased 1-2°F or oxygen is decreased. CA recommendations for apples grown in one area may cause injury to the same variety grown in another area.

Lowering the Oxygen Concentration

An air-tight door is sealed in place after the air-tight CA room has been filled with apples. The oxygen in the room is lowered to the desired concentration generally by flushing the room with nitrogen gas from an external tank or from an air separator (hollow-fiber-membrane or pressure-swing-adsorption), which separates the oxygen from the nitrogen air. Most apple growing areas report that the more quickly the low oxygen atmosphere is attained after harvest and cooling, the better will be the condition of the CA apples after storage. Rarely, oxygen is lowered by fruit respiration by a fossil fuelled atmosphere generator.

Maintaining the Desired Gas Concentrations

The desired oxygen concentration is maintained by adding some air to the CA room each

day, if the atmosphere is analyzed manually, or several times each day if atmospheres are automatically analyzed and controlled by a computer. Excess carbon dioxide is removed from the atmosphere by chemical reaction with lime, adsorption onto activated carbon, permeation through silicone elastomer or hollow fiber membranes, or by slow flushing of the CA room with nitrogen gas. Removal of ethylene gas from the storage atmosphere by chemisorption or by catalytic oxidation has found limited commercial application for firmness retention of Empire apples and control of storage scald on Bramley's Seedling apples.

Technology

The technology for establishing and maintaining the desired atmospheres is changing rapidly. There has been a rapid increase in the use of air separators for quick establishment of the low oxygen atmosphere. Systems for automatic analysis and computer control of oxygen and carbon dioxide are currently (1998) in use in North America, Europe and elsewhere. Before proceeding with construction of a new CA warehouse facility, the latest advances in CA technology should be appraised by visiting the nearest state-of-the-art CA facility.

Precautions

Only apples of good quality and long storage potential should be cold-stored in controlled atmospheres. Immature or over mature apples should not be held in this manner. Rapid cooling and quick filling of the room are essential. Use storage scald control methods practiced in your area. The atmospheres used in CA apple storage will not support human life. If inspection or repair is needed, aerate the room and then quickly reestablish the atmosphere after making the inspection and/or repairs.

CA Storage Disorders

C02 Injury	Irregular, sunken, dry, pebbly patches of brown on the green skin of apples indicates the carbon dioxide was too high early in the CA season. This skin injury is aggravated by the presence of water on the fruit. There are also three forms of flesh carbon dioxide injury. One often begins as a discrete milk-chocolate browning between the core and the skin. The brown tissue is firm, but not necessarily moist. Another form of carbon dioxide injury appears as cavities, sometimes surrounded by patches of discolored tissue. Finally, in Delicious apples there is often very premature mealiness without tissue browning. **Control:** Follow recommendations of the local State Agricultural

	Experiment Station because varietat susceptibility to carbon dioxide injury varies with the fruit growing region and the recommended oxygen concentration used in CA.
Low Oxygen Injury	Symptoms of low oxygen injury include: skin lesions which are similar in appearance to soft scald; a purplish or bluish cast to red areas of the skin; clearly defined chocolate brown areas in the flesh; apples become very soft and split open. If the tainted flavor associated with low oxygen injury is not present, it may be difficult to distinguish low oxygen injury from high carbon dioxide injury. Control: Follow recommendations of the local State Agriculture! Experiment Station because varietal susceptibility to low oxygen injury varies with the fruit growing region and the recommended CA temperature.

NOTE: CO2-related disorders have caused severe commercial losses in Braeburn and Empire apples when kept under poor circulation (e.g., in packed cartons) within a few days.

Storage Conditions

Temperature	30-32°F (-1 to 0°C), with exceptions
Relative Humidity	90% - 95%
Freezing Point	Approximately 29°F (-1.7°C)

Most apples maintain their quality best when held between 30 and 32°F (-1.8 and 0°C), although some varieties are cold-sensitive at this lower temperature and have to be held at 38 to 40°F (3.3 to 4.4°C). Internal browning of the flesh is the most common indication of cold sensitivity. The local State Agricultural Experiment Station will usually have data on what varieties in the area are cold-sensitive.

Maintaining the proper relative humidity around stored apples is very important. Apples have approximately 84% moisture at the time of harvest, and to maintain this water content and prevent shriveling of the skin, the storage relative humidity should be 90% or higher. With good air circulation, a higher relative humidity (95 to 98%) may be maintained without mold formation.

The freezing point of apples varies considerably, but most types will not freeze until the flesh is below 29°F (-1.7°C). Freezing discolors the surface and browning can occur internally. To prevent unnecessary injury, apples should not be handled while frozen.

Storage with Other Commodities

Other temperate climate tree fruits can be stored with apples if they have the same temperature requirements. Odor from celery, cabbage, carrots, potatoes and onions will be absorbed by apples and should therefore not be stored in the same room with apples. Also, odors from apples are readily absorbed by meat, eggs and dairy products, which should be stored in other rooms.

Apples produce ethylene gas as a natural product. Commodities sensitive to ethylene at 32° F (0°C) should not be stored with apples. Commodities that are adversely affected by ethylene at 32°F (0°C) include: asparagus, cabbage, carrots, lettuce and other salad greens, watermelons, kiwifruit, nursery stock, and some kinds of cut flowers, potted plants and florist greens. When an apple storage room and other storage rooms holding ethylene sensitive commodities open onto a common corridor, it may be necessary to continuously flush the corridor with outside air to prevent transfer of the ethylene from the apple storage room to the other rooms.

Ammonia Damage

Ammonia fumes that have escaped from the refrigeration plant can cause damage to apples exposed to a low concentration foe a long time or a high concentration for a short time. The first visible symptoms occur at the lenticles (dots) on the skin. Red changes to blue-black and yellow or green changes to brown. Normal skin color will be restored when the ammonia has been removed from the room, if the exposure has not been long and the concentration of ammonia has not been high. Prolonged exposure to low concentrations or short exposure to high concentrations will cause death of the tissue adjacent to the lenticles (dots). The dead tissue turns brown, becomes sunken and is likely to be infected with fungus diseases.

The human nose is very sensitive to ammonia. It detects less than 20 ppm (ul/1) ammonia in the air. 100 ppm (ul/1) ammonia is hazardous to humans exposed for 8 hours or longer. More than 8 hours is required for permanent damage to apples to occur when exposed to 500 ppm (ul/1) ammonia.

Electronic ammonia detectors should be installed in warehouses which use ammonia as the refrigerant, if 24-hour human surveillance is not practiced.

An ammonia leak should be isolated by shutting valves and then the escaped ammonia fumes can be removed from the building by aeration and water washing of the ammonia

from the air. Refrigeration coils should be deiced, because ammonia dissolved in ice will be slowly released into the room over a long period of time.

Storage Period

The good quality storage life of apples is influenced by fruit maturity when picked, delays before cold storage, storage temperature, and the presence of other foods in the room. Varieties differ widely in their inherent length of keeping. Some, such as Mclntosh, ripen quite rapidly at 32°F (0°C) and therefore have a relatively short storage life. Others, such as Rome, ripen more slowly at 32°F (0°C) and therefore keep longer. Some varieties are susceptible to storage diseases and disorders and therefore have a short storage life.

Orchard culture and climate influence storage "life. Less than ideal soil conditions influence the composition of apples and thus their storage life. Cool, cloudy growing seasons result in a shorter life.

Fruit size and prehandling procedures also influence storage life. Large, over-sized fruit have a shorter life than normal ones. Rough handling shortens the expected storage period.

Storage Period in Air

Variety	Potential months of storage — 32°F (0°C) Air	Potential months of storage — CA*
Cortland	2 to 3	4-6
Delicious	3	8-12
Empire	2 to 3	5-10
Fuji	4	8-10
Gala	2 to 3	5-6
Golden Delicious	3 to 4 1	L 8-10
Ida red	3-4	7-9
Jonagold	- 2	1 5-7
Jonamac	2	3
Law Rome	3-4	7-9
Macoun	3	1 5-7
Mclntosh	1 • 2-3	5-7
Mutsu	1 3-4	1 6-8
Spartan	1 ^{3}-^{4}	1 6-8
Stayman	11 2-3	1 5-7

***The potential months for storage are for <u>rapid CA</u>** and range from those obtained with standard CA to those obtained with low oxygen storage.

Prestorage Treatment

Apples may be stored "orchard run" or packed in boxes or cartons. Some storages supply a service of treating the orchard run apples with diphenylamine for prevention of storage scald. This is done by drenching bulk bins with the storage scald inhibitor. Packed boxes or cartons should have already had some such treatment if the variety is scald susceptible.

Some varieties, such as Golden Delicious, are very subject to water loss. The fruit boxes or bulk bins may be covered with polyethylene film. These covers should not be sealed or the fruit may develop an off flavor. The tops of bins should be covered with film *after* field heat has been removed. Many apples are waxed after storage and before packing for market. The wax is applied to improve the cosmetic appeal of the apples.

Diseases, Disorders, and Injuries

Diseases in stored apples are caused by fungi, which penetrate the fruit in the orchard and/or after harvest. Diseases may frequently be distinguished from disorders and injuries by the presence of fungal spores which usually develop on the surface of the fruit at the center of the lesion. **Disorders** develop over a period of time when the normal biological processes are changed by conditions which may be present in the orchard or in storage. **Injuries** are caused by a single traumatic event in the orchard or after harvest. Colored pictures of many apple diseases, disorders, and injuries have been printed in two publications. *Market Diseases of Apples, Pears, and Quinces,* Agricultural Handbook No. 376, may be obtained from the Superintendent of Documents, US Government Printing Office, Washington, DC 20402. *Postharvest Disorders of Apples and Pears*, Publication 1737/E, may be obtained from Communications Branch, Agriculture Canada, Ottawa, K1A OC7, Canada.

Diseases

Alternaria Rot	Universal, small, firm, slightly sunken spots, brown around the edges but mostly with a rough black rust. At higher temperatures, spots may enlarge to brown or grayish rotted areas. Often develops by mid-season in cold storage on apples showing sun-scald, bruising or chemical injury and frequently follows storage scald, soft scald and Jonathan Spot. Rot does not spread from one fruit to another. **Control:** Careful handling and prevention of mechanical injury or storage disorders; prompt cooling and storage.
Bitter Rot	Occurs in areas east of Great Plains, especially in hot, humid districts. Appears in orchard but may also affect apples in storage and after removal. Firm and uniform brown color, somewhat sunken and often shows wet pink or cream-colored spores; does not spread from one fruit to another, dormant below 50°F (10°C). **Control: Nothing that a warehouseman can do. Orchard control involves** removing old bitter rot mummified apples and spray program; cold storage at 32°F (0°C) will check, but rot resumes growth on removal.
Black Rot	East of Rocky Mountains. Brown, irregular spots, later dark brown or black, firm with scattered black pimples containing spore masses; on removal from storage rotted areas become soft and mushy. **Control:** Nothing that a warehouseman can do. Spray program in orchard. Prevention of insect and mechanical injuries to fruit and proper storage and transit refrigeration will hold it in check.
Blotch	Middle West. Mostly on Mclntosh, Maiden, Blush, North-Western Greening, Rome Beauty, Yellow Newtown and Yellow Transparent; light-brown fan-shaped areas with fringed margins, later nearly black and markedly sunken, subsequently cracking. C**ontrol:** Nothing that a warehouseman can do. Spray program in orchard.
Blue Mold Rot	Universal and very common: soft watery spots sharply defined from sound tissue, rotted portion can readily be scooped from sound tissue; in a moist environment white fungus and later blue spore masses appear, accompanied by musty odor and flesh tastes musty. **Control:** Nothing that a warehouseman can do except maintain proper

	storage temperatures, careful handling, packinghouse sanitation, avoiding chemical injury during washing, use of approved fungicides such as benomyl or thiabendazole (TBZ) in wash water, and prompt refrigeration.
Bull's Eye Rot	Primarily in the Pacific Northwest. Rot develops slowly in cold storage from spores on apples when harvested, does not spread from one fruit to another; most frequent on Winesap, Yellow Newtown, and Delicious. Spots of various sizes, singly or in groups, may be pale yellowish or brown, but often spot is brown with a pale center. Rotted tissue is firm and somewhat mealy and does not separate readily from healthy tissue, shallow or deep. **Control:** Usually worse after rainy harvest period and if fruit cooling is delayed. Best control is orchard spray.
Core Rot	Sometimes apples that seem sound externally are found to be internally decayed, following infection through an open calyx tube. This infection may occur in the orchard and has been known to occur when apples were submerged during washing. **Control:** Nothing that a warehouseman can do.
Fisheye Rot	In Pacific Northwest, resembles Bull's Eye Rot, spongy and stringy; infected tissue does not separate easily from healthy tissue. This disease is associated with wet harvest seasons. It can develop at 30 to 32°F (-1 to 0°C) but is usually found late in season in stored apples; does not spread. **Control:** Nothing that a warehouseman can do.
Brooks Fruit Spot	Usually in Northeast United States. Deep red or black on red areas and dark green on green or yellow areas; spot later becomes black in center; later slightly sunken and in over-ripe fruit, surrounded by brown band. Fruit looks speckled. Affected areas are shallow, change little in cold storage. **Control:** Nothing that a warehouseman can do. Controlled by spray program.
Gray Mold Rot	Quite universal. Initially pale, translucent, watery appearing but firm with light brown to brown areas; later softening and with freckled appearance. Spreads from decayed to healthy apples, causing "nests" in stored fruit. Gray mold develops faster in cold storage than any other decay. **Control:** Source of infection is in the orchard. Orchard sanitation and fungicides like benomyi or thiabendazole (TBZ) in fruit wash or drencher

	help control.
Scab	Occurs widely in areas where there is considerable rainfall during growing season. Development in storage is due to large infections in orchard. Irregular circular dark spots with definite borders, sometimes smooth, but also roughened or russeted surface; can enlarge slightly in cold storage. Control: Nothing that a warehouseman can do. Controlled by spray program in orchard.
Flyspeck	Appears as clusters of small, slightly raised, black specks on the fruit surface, This superficial fungus disease is present on the fruit at harvest. Control: Controlled by orchard sprays, only.
Sooty Blotch	Common in Central and Eastern United States. Irregular sooty patches or spots, easily removed by scraping or moistening and wiping fruit; does not develop or spread in transit or storage. **Control:** By orchard spray program.

Orchard Related Storage Disorders

Bitter Pit	Sunken spots often distributed over calyx end of apple, resembling small bruises or hail injury, initially appearing water-soaked, with intensified green or red color, finally becoming brown, gray or sometimes black. When fruit is peeled or cut, numerous brown areas appear, mostly just beneath skin but also may be deep in flesh. Affected tissue sometimes has a bitter taste. Appearance varies somewhat on different varieties. Spots may increase in numbers and intensity upon removal from cold storage. Worse on large fruit from light crops and young trees. **Control:** Related to orchard practices, especially irregular heavy irrigation or rainfall or heavy nitrogen fertilization. Calcium deficiency, light cropping and early harvest aggravate it. A prestorage drench with 2 to 4% calcium |chloride will reduce its development during storage.
Cork Spot	Widely distributed and often confused with other disorders producing corky spots. Due to boron deficiency in soil; usually fruit lacks characteristic shape, ripens earlier with dull color. Irregular corky spots frequently in core tissue. Present on fruit at harvest. Any corky-type disorder on apples should be diagnosed by a fruit specialist if there is any

	claim against the warehouse **Control:** Nothing that a warehouseman can do.
Water Core	Water-soaked areas in flesh, more often near core and around core "dots. When only core area is involved, disorder cannot be detected without cutting fruit. Visible water often accompanies sunburn, caused by high heat and intense sunshine. Does not develop or spread in transit or storage and if slight in degree, may actually disappear in apples while in storage. When large portions of apple are involved, especially in Delicious, Jonathan, Rome Beauty and Stayman, internal breakdown may follow. Fuji appears relatively resistant to damage from water core. **Control:** Harvest before extensive water core develops. Most susceptible varieties are Delicious, Fuji, Winesap, and Stayman.
Water Core Breakdown	If water core in apples is serious it may eventually cause breakdown of the flesh. With this type of breakdown remnants of the severe water core or water soaked flesh can often be seen. However, some studies indicated that water core breakdown may appear even though the water cored areas have disappeared. Slight water core usually, if not always, disappears in storage. In the late stages of this breakdown, affected fruit may have a dull skin and the fruit is spongy. Severely affected fruits may smell and taste fermented. When the breakdown is near the surface of the fruit, the soft area can be detected by touch of the points at the calyx end of Delicious. **Control:** It is-worse in large, late picked fruit and is aggravated by delayed storage. The problem is delayed by CA storage. Among the susceptible cultivars are: Delicious, Stayman, Jonathan, Winesap, Cox's Orange Pippin, Miller's Seedling, James Grieve, Bramley Seedling, Worcester, Braeburn and Holstein Cox.

Storage Chilling Disorders

Brown Core	Occurs principally on apples from New York and New England. Most serious on Mclntosh, but also found on Empire, Idared, and others. No external symptoms. When fruit is cut, core is first brown between seed cavities, then in whole core area and brown streaks may extend into flesh. Associated with too low storage temperature, appearing late in season and increases after fruit is removed from storage. Tendency to brown is in fruit before it is stored. Cloudy, rainy weather, when apples are maturing, aggravates disorder. Control: Hold apples with brown core tendency at 36°F (2°C) and market in 2-3 months, or put them in controlled atmosphere storage at 36°F (2° C).

Internal Browning	Affects only certain apples ir; certain regions, notably Yellow Newtown and Bellflower grown where weather is cool and foggy, as in the Watsonville area of California. Detected only by cutting fruit. Mostly browning in the core; worse on larger fruit; tendency is inherent in fruit but is aggravated by storage at 30 to 32°F (-1 to 0°C) and increases with longer storage period. Control: Store at 38 to 40°F (3 to 4°C) in CA storage.
Low Temperature Breakdown	(Tissue affected by this disorder is likely to be firmer and more moist than tissue affected by senescent breakdown. In the earlier stages fruit must be cut for the discolored areas to be seen. There are a variety of symptoms, even in one sample of fruit. The normal syndrome is markedly brown vascular bundles ("core dots"), browning of the flesh and a clear halo of unaffected tissue beneath the skin. Low temperature breakdown develops before the apples are senescent. Jonathan may show the trouble within 12 weeks at 30°F (-1°C) and Cox's Orange Pippin sooner at 32°F (0°C). The disorder is found in Twenty Ounce, Northern Spy, Jonathan, Cox's Orange Pippin and Bramley Seedlingand several others. **Control:** Store at 38 to 40°F (3 to 4°C) in CA. With Jonathan it has been reduced by postharvest calcium treatments.
Soft Scald	Distinguished by roundish or ribbon-like browned areas of skin and possibly underlying flesh with sharp line of separation of healthy and diseased tissue. Becomes progressively worse when apples removed from storage. Most common on Jonathan, but also on other varieties, such as Honeycrisp; favored by storage below 36°F (2°C) during early part of storage season. Possibly an expression of Soggy Breakdown. **Control:** Avoid storage at low temperatures (30-32°F/-1 to 0°C) during first 2 months of storage.
Soggy Breakdown	Different from internal breakdown. Light brown areas in outer fleshy part of apple, sharply defined from healthy tissues, initially moist and soggy. Adjacent sound areas have fermented taste, fruit may seem to be spongy, more prevalent in apples stored at 30 to 32°F (-1 to 0°C), generally increased greatly by delaying storage of fruit. **Control:** Store at 36 to 40°F (2 to 4°C) or store at 32°F (0°C) in CA storage. Varieties most susceptible are Golden Delicious, Grimes Golden, Jonathan, Northwest Greening and Wealthy. Soggy breakdown doesn't appear in CA storage with Jonathan even when the temperature is this low.

Senescent Breakdown Disorders

Senescent Breakdown	With slight variations among varieties, symptom development is usually: flesh becomes very soft, first on one side then on entire fruit; apple is easily punctured with thumb and is easily bruised; flesh becomes dry, mealy and lacks aroma and flavor; browning of the fruit flesh and vascular strands in the flesh; skin becomes dull, dark, or water-soaked in appearance; fruit splits open. Although it is most common on Mclntosh, almost all apple varieties are susceptible to some type of senescent breakdown. Senescent breakdown has been aggravated by low calcium levels in the fruit, very hot and dry weather before harvest, delayed harvest, slow cooling in storage, delayed establishment of low 02 in CA, high storage temperature, prolonged storage, and for Mclntosh, CA. storage with low C02 (1% or lower). **Control:** Senescent breakdown can be controlled or alleviated by drenching the apples with 2 to 4% food grade calcium chloride, rapid cooling, rapid establishment of the proper CA atmosphere, and sale of the apples soon after CA rooms have been opened.

Other Storage Disorders

Superficial Scald **(syn. Storage Scald**	Very common, widespread and serious disease, affects the skin of the apple, mostly on the green side. Superficial browning of skin, but in severe cases, decay follows. Usually not severe while apples are in storage. When moved out of storage, scald develops rapidly. Worse on fruit that was immature at harvest and after a warm harvest period. **Control:** Prestorage drenching of bins of apples with diphenylamine. Varieties most seriously affected are Cortland, Delicious, Law Rome, Granny Smith, Stayman, Winesap, and York Imperial. Mclntosh develops scald in some seasons.
Jonathan Spot	Initially appears as bluish-black circular spots in the skin, then becomes brown and sharply sunken, later becoming lobed and more sunken. Spots may be irregular in outline on Idared. Tends to develop in transit or storage on fruit that seemed to be sound when shipped. It is aggravated by late harvest, delayed storage, high storage temperature, and C02 levels below 1% in CA.

	Control: Prompt refrigeration after harvest, avoiding delays at ordinary temperatures. Store in CA with adequate C02.

Injuries

Braising	Bruises on fruit at harvest time, in the packing operation and in transit, may influence adversely the storage life of apples. While the warehouseman has no control over such bruising, he should be aware of the significance of mechanical injury on the ripening and deterioration of apples in storage, especially if some claim is made regarding the condition of the apples while in storage. One of the types of bruises that may be confused with freezing injury is that found in apples at the lower side of the **bottom layer of boxes** in a reefer car or trailer. If such bruises are not detected when the fruit is accepted for storage, claims may be made later that the apples were frozen in the warehouse. This type of bruise **is** flat, water-soaked and darkened in appearance, generally firm. In cross section, the bruise is usually water-soaked and glassy and may be shallow or deep and wedge-shaped. Hence, a glassy, water-soaked bruise is not necessarily a sign that freezing has occurred. The transit bruises are caused by pressure and the jolting of the transport vehicle in motion. Bruise breakdown, which is seen as brown tissue radiating into the flesh from a bruise may develop on any apple variety, but is most common on soft fleshed varieties as Mclntosh and Golden Delicious.
Chemical Injury	Reference will be made merely to the fact that chemical injury may occur from orchard sprays, postharvest drenches with storage scald inhibitors and calcium chloride, during the washing of apples before packing, and when fruit comes in contact with salt or fertilizer. If fruit delivered to the warehouse is suspected to be chemically injured, the diagnosis is best made by a fruit inspector or qualified pathologist.
Freezing Injury	Slight freezing injury may not be noticeable externally, or even internally, although such apples will be softer and not keep as well after defrosting. But, if severe, the surface is discolored and darkened in irregular-shaped areas, and is water-soaked. In frozen condition, apple skins show network of wrinkles and, of course, apple has "hard feel." Best indication of freezing found is when defrosted apples are cut. Core "dots" will be brown as well as strands in flesh if freezing has been severe. In extreme cases, flesh has solid discoloration, shades of brown or even black with water-soaked appearance. Frozen apples usually decay if left in storage. Slightly frozen apples will defrost with no apparent after-effect except slight softening, if thawed slowly. It is best not to move or handle apples when frozen because bruising

	injures frozen apples severely. Sometimes internal breakdown is mistaken for freezing injur.'. If there is any question about cause where claims are made, a fruit inspector or qualified pathologist should diagnose the problem. **Control:** Prevent cold "pockets" in storage by air movement and do not allow temperature to drop below 30°F (-1°C).
Hail Injury	Usually on one side of fruit, sunken spots with brown, corky, dry tissue beneath which do not tend to decay. Fruit may grow distorted. Injury near harvest may result in increased decay incidence. **Control:** None.
Heat Injury	On slightly injured apples, isolated spots of brown spongy tissue; if severe, whole apple may seem to be baked due to excessively high temperatures in orchard. Skin may look sunburned, even if not brown, with collapsed tissue beneath, which may lead to fruit becoming distorted. Sun scald cannot be controlled by diphenylamine. **Control:** Surround™ is being used in the northwest to reduce sun scald.

Pears
[as mentioned in WFLO]

Storage Conditions

	Temperature			**Freezing**	**Point**
	°F	**°C**	**Relative Humidity**	**°F**	**°C**
Storage	30-32	-1to0	90-95%		
Ripening	60-72	16-22	85-95%	29	-1.5

Storage Period***

Anjou	6-7 month
Bartlett	2-3 month
Bosc	3-4 month
Cornice	4-5 months
Hardy	2-3 months
Kieffer	2-3 months
Packham's Triumph	5-6 months
Seckel	3-3.5 months
Winter Nelis	7-8 months

*** These storage times allow for additional time for transportation and subsequent marketing. The storage life ofAnjou, Cornice, and Bosc can be extended 1-2 months by packaging in polyethylene liners or storage in controlled atmospheres (1-2% oxygen + less than 1% carbon dioxide, balance nitrogen).

For best storage quality, pears should be cooled rapidly after harvest. Fruit temperatures should be brought down to 32°F (0°C) within 48 hours. The storage life may be 33% longer at 30°F (-1.1°C) than at 32°F (0°C). At 30°F (-1.1°C), precise temperature control is needed to prevent freezing. Pears low in solids may be damaged by freezing when

stored below 30°F (-1°C). Intermediate temperatures of 36.5-50°F (2.5-10°C) are harmful to some cultivars of pears; Bartletts stored in this temperature range are dry textured.

The time that pears can be held safely in storage at 30-32°F (-1.1 to 0°C) varies with cultivar as shown above. If held beyond their normal storage life, some cultivars may not ripen properly and attain good flavor. Even though they may appear in good condition, the flesh will not soften, the skin "scalds" or turns brown, and breakdown occurs.

Pears lose weight rapidly by evaporation, so relative humidity in storage rooms should be carefully maintained. When weight loss is a problem in the top bins of a stack in a commercial storage, the addition of polyethylene covers will reduce weight loss and visible shrivel. Most pears for long storage are packaged in folded-over polyethylene liners with needle point or 1/4 inch (6 mm) perforations. The liners are opened when pears are removed from cold storage. For ripening purposes, the relative humidity can be lower, at 85-90%. Some winter pears require a period of cold storage before they will ripen normally at room temperature. Anjou, for example, need to be held at 30-31°F (-1 to -0.6°C) for at least 30 days before they will ripen with good quality.

Pears are good candidates for controlled atmosphere (CA) storage (1.0-2.0% 02 + less than 1.0% C02). Storage period of some varieties can be extended by several months with CA storage. However, fruit maturity and growing district are important factors in determining storage potential.

Disorder and Diseases

Superficial Scald (Anjou Scald)	This brown to black discoloration of the skin of Anjou and Packham's [Triumph pears does no harm other than marring appearance. It may occur even in fruit held under good refrigerated storage conditions for long durations. **Control:** Ethoxyquin (antioxidant) applied as dip, spray, or wrap.
Alternaila Rot	Occurs usually late in the storage season, usually at punctures. Decayed tissue is gray to black, dry in center, gelatinous at edge, and easily removable as a core from surrounding flesh. Control: Prevent skin breaks and remove from storage promptly when noted.
Blue Mold Rot	Frequently appears on pears as scattered spots. This is the most common and most destructive rot of pears in storage. Affected areas have a straw to brown color and soft, watery tissues. One phase of the disease develops when the fungus *[Penicillium expansum)* grows

	down the stem and rots the tissues of the neck. **Control:** Prevent skin breaks and lower fruit temperature to 30-31°F (-1 to -0.5°C). Use of approved fungicides, along with good housekeeping practices to prevent infection during packing.
Core Breakdown	Often accompanies pear scald. Soft, brown breakdown in core area, accompanied by disagreeable odor. Due primarily to over-maturity before harvest, or to holding pears too long at low storage temperatures. **Control:** Harvesting at optimum maturity should largely eliminate this problem.
Cork Spot	Primarily on Anjou pears. Has small, brown corky regions in the flesh which cause surface pitting if near the skin. **Control:** It is due to growing conditions, not storage conditions, although it may first be observed in storage. Fruit with cork spot can be stored almost as long as normal fruit, although market value is depreciated.
Gray Mold Rot	Characterized by firm, dull brown, water-soaked decay with bleached borders and, when more advanced, by dirty white to gray masses or "nests" of decayed fruits. **Control: Use approved fungicides; cool promptly to 30-31°F (-1.0 to -0.5°** C)
Senescent Scald	This brown to black discoloration of the skin, which is frequently accompanied by softening of the underlying tissues, is associated with fruit that is not fully mature at harvest and is stored at temperatures above optimum. Control: Harvest at optimum maturity for long storage and cool promptly to desired storage temperature.
Freezing Injury	Symptoms are a glassy, water-soaked external appearance, with a tan, pithy region around the core. Pears frozen severely may break down completely or show marked sunken areas where slightly bruised while frozen.

	Control: For pears with low soluble solids content, hold at 30-31°F (-1 to -0.5°C). Even severely frozen pears will recover if thawed gradually at temperatures not exceeding 36°F (2°C).

* Commodity storage manual published by World Food Logistics Organization, 1500 King Street, Suite 201, Alexandria, VA 22314. **Revised 2000**

** The potential months for storage are for rapid CA and range from those obtained with standard CA to those obtained with low oxygen storage.

Annexure- IV

INTERNATIONAL STANDARD **ISO 6949:1988 (E)**

Fruits and vegetables — Principles and techniques of the controlled atmosphere method of storage

1 Scope

This International Standard specifies the principles and techniques of controlled atmosphere storage for fruits and vegetables.

It applies to various kinds of fruits and vegetables (notably apples, pears and bananas). The application of this method is specific to each product; in addition to maintaining the optimum limits of temperature and of relative humidity, the oxygen content should also be reduced from 21 % (*VI V)* (the normal level); this means that the partial pressure of this gas is also reduced.

However, oxygen contents below 1,5 % < *VI V)* are not recommended since, in the absence of sufficient oxygen, fermentation processes take place (intracellular respiration) and a brownish discoloration of the fruits and vegetables may appear.

At the same time, the atmosphere is enriched in carbon dioxide; however, too high a carbon dioxide content [for example exceeding 8 % (*VI V)* to 10 % (*VI V}*\ can in most cases cause various physiological diseases (carbon dioxide injuries) resulting in a reduction in quality as well as quantitative losses.

2 Types of controlled atmosphere

In practice two types of controlled atmosphere can be distinguished.

2.1 Type 1 (Not Applicable to this Standard)

Atmosphere with slightly reduced oxygen content [from 18 % *(VI V)* to 11 % *{VI V)}* and more or less enriched in carbon dioxide [from 3 % *{VI V)* to 10 % *(VI V)}* in such a way that the sum of the oxygen and carbon dioxide contents is 21 *%(VIV).*

EXAMPLE

8 % *(VIV)* **CO;; 13** % *(VIV)* **0;; 79** % *(VIV)* **N:,**

This type of atmosphere, also called a modified atmosphere, is brought about by the increase in the carbon dioxide content during the natural respiration of the product and is thus not preferred. The level of carbon dioxide can only be decreased by ventilation with outside air, with a consequential increase in the oxygen level.

This type of controlled atmosphere is recommended for apples and may be beneficial in the tropics for short-term storage of fruits such as bananas.**2.2 Type 2**

Atmosphere with

- — an oxygen content of 2 % (*VI V)* to 4 % (*VI V)* [mean, 3 % (*VI V)}* and a carbon dioxide content of 3 % (*VI V}* to 5 % *(VIV),* or with
- — a greatly reduced oxygen content [1 % *{VIV}* to 2 % (*VI V)}* and a carbon dioxide content of 1 % (*VI V)* to 2% *(VIV},* so that the sum of the oxygen and the carbon dioxide contents is below 21 % *(VIV}.*

EXAMPLE

3 % (*VI V)* COz; 3 % (*VI V)* Oz; 94 % (*VI V)* IM;, Special equipment is necessary to obtain these concentrations.

This is the type of controlled atmosphere most often used. In general, it is necessary to vary the gas mixture according to the type of product to allow for

- — sensitivity to carbon dioxide concentrations which are too high or to lack of oxygen;
- — the degree of ripening;
- — the storage period.

3 Method of regulation of atmospheres

Atmospheres of composition different to that of the normal atmosphere can be prepared in specially fitted-out storage chambers, or exceptionally in so-called physiological packing-cases, the permeability of which is designed to give an oxygen-carbon dioxide mixture of specified composition. The storage of products in sacks or in chambers provided with semi-permeable membranes made of silicone plastics of the Marcellin and Letenturier types represents an application of this system.

The specially fitted-out storage chambers and the use of adequate equipment and installations allows a controlled atmosphere of characteristic oxygen and carbon dioxide contents to be produced for the products to be stored. Short-term high-carbon-dioxide treatments may be applied to specific products (e.g. Golden Delicious).

ISO 6949 : 1988 (E) 4 Chambers for controlled atmosphere storage

4.1 Capacity

The capacity of the chambers is in general from several hundred tonnes up to 1 000 t of the product.

4.2 Gas-tightness

The construction of chambers for controlled atmosphere storage is designed to obtain an appropriate gas-tightness to allow the composition of the desired atmosphere inside to be maintained. In practice, it is not possible to make chambers absolutely gas-tight; gas exchange between the interior and the exterior is unavoidable. However, the chamber should Therefore, it is important to know the maximum permissible leakage rate and to have available a method to check whether the construction satisfies this criterion. (The rate of entry of oxygen into the chamber is directly proportional to the leakage rate.)

4.2.1 Minimum gas-tightness

In theory, the inflow of oxygen into the chamber has to remain lower than the respiratory consumption by the products stored. Thus the acceptable inflow depends on the product stored, its temperature, the gas mixture sought and the ancillary equipment which may be deployed to control it (e.g. oxygen absorbers or expansion sacks).Actual inflow into the chamber in operation is caused by diffusion, resulting from the difference in concentration of the gases, and by convection, resulting from the difference in pressure.

It is particularly the exchange by convection which should be eliminated. During storage, the controlled atmosphere chambers should function under the most difficult circumstances, e.g. storage of apples, at 0 °C, in an atmosphere of type 2. Therefore, the criteria of gas-tightness are defined for this case, but are suitable for other uses.

4.2.2 Construction

The gas-tightness of the chambers is achieved by covering the walls, the floor and the ceiling with aluminium sheathing, prefabricated steel sheathing, polyester resins, epoxy resins or polyamide resins, reinforced with glass fibre, etc. The thickness of insulation required depends, amongst other things, on the exterior temperature, the storage period and cost factors.

An advantageous and technically better solution is the use of sandwich panels mounted on metal frames which ensure simultaneously thermal insulation and gas-tightness. The sandwich panels are constructed of a metal, wooden or plastic plate? on the outside, a polyurethane layer in the middle and a layer of polyester resin on the interior (a total thickness up to about 10 cm is advisable).

In the case of constructions with concrete walls, as in the case of the use of sandwich panels, the gas-tight layer serves equally as a barrier against vapours. In order to make repairs easier, for example if cracks appear, the gas-tight layer is generally applied on the internal surface of the wall. In order to ensure gas-tightness, plastic-resin-based paints, pitch, asphalt-lined paper. etc. can also be used. In all cases, the materials for gas-tightness should

— be gas-tight,
— not give off odours,
— be resistant to the action of micro-organisms and humidity,
— be easy to install and repair,
— be resistant to mechanical shock,
— be fire-proof,
— retain their properties during variations in temperature, relative humidity and pressure within the chamber.

The gas-tightness is considered to be suitable when the ratio between the quantity of oxygen getting into the chamber and that consumed by the products stored is approximately unity.

It is necessary to improve the gas-tightness of a chamber when

— it is used at a lower temperature,
— it is partially loaded with products,
— it contains products whose respiration rate is particularly low.

The closure of the storage chambers is ensured by thermo-insulating doors with rubber trimming, and with a sliding hermetic closure or other hermetic systems. The doors are fastened by means of bolts or any other system of closure which ensures that the trimming on the door touches the metal frame in the wall, thus forming a gas-tight seal. The doors may be fitted with portholes allowing the inside of the chamber to be seen and with smaller doors giving access to the chamber.

However, inspection windows placed at a level above that of the contents of the store may be more useful. They are hinged to allow entrance above the level of the contents for inspection of the product, evaporators and cooling apparatus.

A warning sign signalling the presence of a low-oxygen atmosphere should be placed at the entrance of the chamber and at other appropriate places.

4.3 Equalization of pressure

Between the chamber and the exterior, differences in pressure are created by fans, cooling equipment, appliances for regulating the composition of the atmosphere, as well as fluctuations in exterior atmospheric pressure. A sudden drop in the gas pressure in the chamber

can cause the gas-tight layer on the walls and ceiling to become detached, thereby destroying the gas-tightness of the chamber. It follows that drops in pressure should be not greater than 1 mm *Hyp* (9,8 Pa). In order to avoid great fluctuations in pressure, the doors of controlled atmosphere chambers should be hermetically sealed only when the storage temperature has been attained.

To the same end, pressure valves are fixed in each controlled atmosphere chamber. These consist of pipes of appropriate diameter which link the interior of the chamber to the exterior.

The exterior part is bent and penetrates about 4 mm into a vessel containing water and possibly antifreeze. For example, for a storage chamber of capacity 2 000 m^3, it is necessary to have two valves having a tube of diameter 15 cm.

Siphon-type pressure valves ensure equalization of pressure. If the exterior pressure is lower, some of the gas mixture leaves the chamber without modifying the composition of the atmosphere inside, while, if the exterior pressure is higher, air enters the chamber until equilibrium is reached, modifying the composition of the atmosphere in the chamber.

To avoid pressure fluctuations in small stores, impermeable plastic sacks (breather bags) of gas having a volume of 5 % to 7 % of the volume of the free gas in the chamber (or a corresponding percentage of the volume of the chamber) may be used. The sacks, which are connected to the chamber by a pipe of large diameter, expand with increasing pressure and contract with decreasing pressure thereby regulating the pressure in the chamber.

Sacks require a great deal of space and they may deteriorate, producing an additional source of leakage.

Pipes for refrigeration, for sampling the air, for regulation of the gas-composition, for electric circuits, etc. pass through the walls of the chamber. The points where cables and pipes pierce the gas seal must be sealed very carefully.

4.4 Testing for gas-tightness

Checking of the gas-tightness of the chambers is carried out when the chambers are first put into service and then every year, before the start of storage, to discover any cracks.

The following methods (4.4.1 and 4.4.2) may be used to test for gas-tightness.

4.4.1 Convection method based on the study of pressure variation

The test is carried out in an empty chamber at constant temperature, with the fans not operating. Close the doors hermetically and increase the pressure to 15 mm *HyO* to 25 mm H;0 (147 Pa to 245 Pa) above atmospheric, using independent air pumps or air pumps built into the installation for regulating the composition of the atmosphere. Measure the time of the chambers is very good, good or insufficient.

A variant of this method is to estimate the gas-tightness as a function of the minimum time necessary for the excess pressure created to dissipate. The time varies between 10 min and 70 min as a function of the dimensions of the chamber and the product stored.

Another variant of this method is to measure the time necessary for the initial excess pressure in the chamber to fall by half. This time (under appropriate constant temperature conditions) should exceed 10 min to 12 min for the chamber to be acceptable.

In practice, it is recommended that the gas-tightness be estimated **as a** function of the pressure reached after 30 min from an initial pressure of 10 mm H^O (98,1 Pa).

The result of the estimate may be used to classify the chamber as

— very good [increase in pressure of 3,4 mm *Hyp* (33,3 Pa)]
— good [increase in pressure of 1 mm *HyO* to 3,4 mm H^O (9,8 Pa to 33,3 Pa)]
— insufficient [increase in pressure of 1 mm *HyO* (9,8 Pa)].

The convection method can also be used for measuring the gas-tightness of chambers employing gas-filled sacks if the gas-filled sacks can be shut off with a valve.

4.4.2 Diffusion method based on the diffusion of carbon dioxide from a previously cooled chamber

This method is particularly appropriate to chambers with gas-filled sacks where the convection method cannot be used. A known carbon dioxide content is established in the chamber. The changes in the levels of carbon dioxide and oxygen are then determined continuously.

For example, a carbon dioxide content of 15 % *(VIV)* is produced in the chamber [giving an oxygen content of 6 % *(VIV}* in the chamber].

If, in the course of 24 h, the carbon dioxide content does not decrease by more than 1 % *(VIV)* and the oxygen content does not increase more than 0,25 % (*VI V)* with the fans operating, the gas-tightness is considered to be suitable.

4.5 Detection of faults in gas-tightness

In order to detect cracks or areas of insufficient gas-tightness, proceed as follows.

Increase or decrease the pressure in the chamber by about 10 mm *HyO* (98,1 Pa) with the doors hermetically sealed and the fans not operating. Instruct a person inside or outside the chamber to locate the point through which the gas is moving by observing whether

— smoke generated in the chamber flows in a particular direction,
— there is any whistling noise indicating air movement into or out of the chamber,

— when a solution of soapy water is applied with a paint brush to suspicious areas, air bubbles are formed,
— when a lighted candle is placed in the suspicious area, the passage of air makes the flame longer.

4.6 Repair

Chambers having unsatisfactory gas-tightness should be repaired before any products are stored in them.

In the areas having gas-tightness faults, apply silicone or polyurethane mastics.

Eliminate the faults by replacing the sheathing which lines the walls (steel, aluminium, etc.). When polyester resins are used for insulation, stick together webs of glass-fibre and apply two or three coats of resin on top.

After reparation, it is recommended that the gas-tightness of the chamber be checked again.

5 Regulation of the temperature and the atmosphere

5.1 Regulation of temperature

Pre-cool the product immediately after harvest. The time of filling and the rate of cooling determine the maximum size of the controlled atmosphere chamber.

5.2 Regulation of the atmosphere

The regulation of the atmosphere follows immediately the regulation of the temperature.

In order to produce, maintain and check the controlled atmosphere in the storage chambers, different methods may be used according to the equipment available (converters, scrubbers, controlled atmosphere generators, analysers, etc.).

5.2.1 Regulation of the oxygen content

The oxygen content of the atmosphere [21 % (*VI V}}* may be reduced because of the respiration of the product, or by using special installations, in controlled atmosphere storage chambers.

5.2.1.1 Reduction in the oxygen content by respiration (Not Applicable to the Standard)

During respiration, oxygen is consumed and carbon dioxide, water and heat are given off. The reduction in the oxygen content is therefore determined, in this case, by the respiration rate of the products stored, the capacity of the storage chamber, its degree of loading, etc. In a chamber of capacity 300 t of apples, an oxygen level of 2 % (*VI V)* to 3 % (*VI V)* can be obtained in about 20 days. During the storage period, the opening of the doors is not advisable, given that a longer period of time would be necessary to reattain the oxygen content and that variations in the chemical composition of the gas would be unfavourable to the products stored.

5.2.1.2 Reduction in the oxygen content by means of converters

Converters are used to reduce the oxygen content to 2 % I *VI V)* to 4 % (*VI V)* in 2 days to 3 days. They work on the principle of consumption of oxygen by combustion of hydrocarbons or by combination of the oxygen with hydrogen which is produced by the decomposition of ammonia (Nl-y (reduction of the oxygen takes 2 days or 3 days).

The consumption of oxygen by the combustion of hydrocarbons takes place according to the reaction

CyHs + 5 Oz - 3 COz + 4 H:>0

The combustion takes place at high temperature, then the atmosphere enriched in carbon dioxide is cooled and passed through a carbon dioxide absorber or is introduced directly into the chamber. These installations function generally in closed or open cycle; atmosphere taken from the chamber or from the exterior is passed over the heated catalyst and, now impoverished in oxygen, is pumped back into the interior. In practice, different types of converters are used.

5.2.2 Regulation of the carbon dioxide content

During the keeping period, as a result of the respiration process of the products, carbon dioxide accumulates in the chambers. To maintain this content constant at an optimum value, different types of apparatus named "adsorbers" or "scrubbers" allowing the carbon dioxide content to be reduced to the desired value are used.

These appliances work on the principle of physical adsorption or chemical absorption of carbon dioxide.

5.2.2.1 Physical adsorption

For physical adsorption, active carbon, zeolites, etc., whose effectiveness depends on the capillarity, the porosity and the nature of the adsorbent and on the activation method, are used as adsorbents. The adsorbers work in two stages, i.e.

— adsorption:- The atmosphere taken from the chamber is fed through a space where the carbon dioxide is retained by the adsorbent. After diminution of the carbon dioxide content, the atmosphere is returned to the storage chamber.

— regeneration:- Regeneration of the adsorbent is carried out by passing a current of air, through the adsorbent, which picks up the carbon dioxide and drives it out to the exterior.

These two stages take place during well-determined periods; the passage from one to the other is controlled by a temporizing relay. Some zeolite adsorbers have a molecular sieve.

5.2.2.2 Chemical absorption-

Various chemical substances (potassium carbonate, sodium hydroxide, ethanolamine, calcium hydroxide, etc.) are used to remove carbon dioxide. However, their limited effectiveness and precision restrict their use.

The following types can be distinguished:

— (mono-, bi-, or tri-) ethanolamine scrubber: The absorption of carbon dioxide is achieved by chemical as well as physical processes. Solutions of carbonates and hydrogen carbonates are obtained, which on heating release carbon dioxide and regenerate themselves.
— potassium carbonate scrubbers, based on the principle of the reversibility of the reaction of the product with carbon dioxide: In a first compartment, the formation of potassium hydrogencarbonate is carried out by the capture of carbon dioxide from the gas passing through the chamber, then the solution is regenerated in another compartment by liberation of carbon dioxide to the exterior. The process is continuous.
— scrubber in which dry calcium hydroxide reacts with carbon dioxide to produce calcium carbonate or bicarbonate : When the calcium hydroxide no longer reacts, it is replaced with fresh material.

5.2.3 Gas generators

These are installations made up of an oxygen converter and a scrubber. These devices work simultaneously during the keeping period; a carbon dioxide scrubber alone can also be used.

The catalytic combustion of oxygen takes place in the converter and the gas mixture obtained (rich in nitrogen and carbon dioxide) is cooled and then sent on to the scrubber which absorbs the carbon dioxide. The gas mixture which results is pumped into the chamber.

NOTE —*catalytic combustion of oxygen may also result in a decrease in the ethylene content of the atmosphere*,

The atmosphere generated contains 1 % *(VI V)* to 1,5 % *{V/V}* oxygen, 2 % *{VIV* to 5 % *[VIVl* carbon dioxide, the rest being nitrogen. The carbon dioxide and oxygen contents can be regulated, if necessary.

There are two types of generators:

a) open-cycle generators use air from the exterior; after the combustion and fixation of the carbon dioxide, the gas mixture is pumped by a fan into the chamber, which creates a pressure excess thereby displacing some of the atmosphere in the chamber;
b) closed-cycle generators which recycle the air in the storage chamber, lower the oxygen content gradually, remove the carbon dioxide and circulate the effluent through the chamber until the desired composition is obtained.

5.2.4 Production of controlled atmospheres by exchanger-diffuse rs

Exchanger-diffusers may be used for the regulation of the composition of the atmosphere, based on the principle of the difference in the diffusion speeds of oxygen, carbon dioxide and nitrogen across a silicone plastic membrane with selective properties for the gases.

Passage of air through the exchanger-diffuser favours diffusion and automatically allows fixed proportions of carbon dioxide and oxygen concentrations to be obtained according to the silicone plastic membrane used [for example 5 % *(VI V)* carbon dioxide, *2%(VIV)* to *3%(VIV)* oxygen, and 92 % (*VI V)* to 93 % I *VI V)* nitrogen]. In this case, the desired concentrations in the atmosphere are obtained after a longer period of time as a consequence of normal metabolic processes. These membranes are bags of various capacity which can be fitted inside or outside the chambers, or linked to the exterior by means of pipes. The surface area of the membrane depends on the volume of the gas in the chamber.

6 Maintenance of the composition of the controlled atmosphere

Once the required oxygen or carbon dioxide contents have been obtained, recourse has to be made to various procedures to maintain the composition constant. Owing to the different factors causing variation in the oxygen and carbon dioxide contents (delivery of carbon dioxide gas during ventilation, diffusion of oxygen) specific intervals are needed to control and maintain the required level of each of the gas components.

Stabilization systems for controlled atmospheres are as follows:

— a periodic and careful input of gas for atmospheres of type 1; (Not Applicable to the Standard)

a periodic and careful input of fresh air and removal of carbon dioxide combined with the use of scrubbing and diffusion equipment for atmospheres of type 2.**7 Checks during the keeping period**

Check the keeping factors (temperature, relative humidity and gas composition) twice-daily initially and then every day, using direct reading or recording equipment. Check the quality of the products stored periodically.**8 Operations at the end of controlled storage**

When it is desired to end controlled atmosphere storage, open the doors of the cells and leave the fans operating for 1 h or 2 h. Excess carbon dioxide is thus dispersed and the oxygen content is equilibrated with the ambient levels, making it safe for workers to enter without a protective mask.

Annexure – V

List of Relevant BIS and Other Standards

The Codes and Standards listed in this annexure represent practices and methods published by Bureau of Indian Standards (BIS) and other International Organizations applying to design and construction of Cold Stores, Pack House, Ripening Chambers, and Food Processing Facilities etc. They are valuable guides for the practicing engineer in determining test methods, rating, performance requirement and limits applying to design construction and equipments used.

The codes and standards listed are intended to serve as minimum requirement, and are not to be construed as limiting good practice. Wherever IS-Code is not available, relevant standard codes of ASME / ASHRAE / IIAR or other International Codes are to be followed. Latest revisions will be followed in all cases.

The responsibility for deciding whether other requirements additional to the ones listed in this document are necessary to ensure system integrity, efficiency and overall safety, including operation, maintenance and servicing and/or the necessity to adopt additional requirements in the system design and construction to guarantee the overall performance, still rests with the supplier / manufacturer. The suppliers / manufacturers shall furnish to the owner copies of instruction manual which shall include operation & maintenance instruction, as built drawings, wiring diagrams, recommended spare parts and replacement part list.

The suppliers / manufacturers shall provide training for the plant and machinery installed including safety and emergency procedures. The supplier /manufacturer will follow all practices set forth by "good manufacturing practices" by various applicable Codes and Standards listed in this document and shall fully certify the equipment, plant and machinery supplied / installed in compliance to the relevant codes and standards.

Where there is a requirement for deviation, the difference(s) must be brought to the intention of the regularity body and the customer in writing.
All "exceptions/deviations" to the codes and standards for the plant and machinery including civil works and design shall be identified and detailed in the proposal / bid documents to the customers /owner and his specific approval in writing will be taken before commencement of supply/work.

The supplier / manufacturer/contractor should be fully aware of all details in his scope etc, and it is imperative that all work performed shall be done by personnel trained and skilled in the installation of plant and machinery.

CODES AND STANDARDS

A. Electrical
Bureau of Indian Standards (BIS)

S. No.	Title	Reference
1.	PVC Insulated cables (light duty) for working voltage up to 1100 volts	IS 694-1977 Part I & II
2.	PVC Insulated cables (heavy duty) for working voltage up to 1100 volts	IS 1554-1976 Part-I
3.	PVC Insulated cables for voltage 3.3 KV to 11 KV	IS 1554-1976 Part-II
4.	Specification of Polyurethane insulated PVC sheeted heavy duty electrical cables, voltage not exceeding 1100 V	IS 5959-1970 Part-I
5.	Specification of Polyurethane insulated PVC sheeted heavy duty electrical cables, voltage 3.3 KV to 11 KV	IS 5959-1970 Part-II
6.	Guide for making of insulated conductors	IS 5578-1970
7.	Code of practice for installation and maintenance of paper insulated power cables	IS 1255-1967
8.	Code of practice for earthling	IS 3043-1966
9.	Guide of practice for installation and maintenance of induction motors	IS 5216-1969
10.	Code of practice for installation and maintenance of AC induction motor starters	IS 5214-1969
11.	Code of practice for installation and maintenance of AC induction motors	IS 900-1965
12.	Code of practice for installation and maintenance of switchgears	IS 372-1975
13.	Code of practice for installation and maintenance of transformers	IS 1886-1967
14.	Code of practice for electrical wiring installation, voltage not exceeding 650 V	IS 732-1963
15.	Code of practice for electrical wiring installation (system voltage exceeding 650 V)	IS 2274-1963
16.	Guide for testing three-phase induction Motor	IS 4029-1967
17.	Three Phase induction Motors	IS 325
18.	Electrical measuring instruments and there accessories	IS 248
19.	Current transformers	IS 2705
20	Dimensions of slide rails of electric motors	IS 2968
21.	Flexible Steel conduits for electric wiring	IS 3480

22.	Air-Break Switches	IS 4064
23.	Motor Starters for voltage not exceeding 1000 Volts	IS 8544
24.	Conduits for electrical installation	IS 9537
25.	Selection, installation & maintenance of Transformers	IS 10028
26.	Selection, installation & maintenance of switch gear and control gear	IS 10118
27.	National Electrical Codes	SP: 30

B. Mechanical

Bureau of Indian Standards (BIS)

S. No.	Title	Reference
1.	Safety cods for Mechanical Refrigeration	IS 660
2.	Code of practice for thermal insulation of cold storages	IS 661
3.	Code of practice for application of polyurethane insulation by in-situ pouring method	IS 13205
4.	Rigid phenolic foams for thermal insulation	IS 13204
5.	Application for spray applied insulation code of practice – Polyurethane / Poly-isocyanurate	IS 12432 Part-III
6.	Specifications for preformed rigid polyurethane (Pur) and poly isocyanurate (Pir) foams for thermal insulation	IS 12436
7.	Expanded polystyrene for thermal insulation	IS 4671
8.	Code for practice for fire safety of industrial buildings: General Storage and warehousing including cold storage	IS 3594
9.	Anhydrous ammonia	IS 662
10.	Industrial Bitumen	IS 702
11.	Gunmetal gate, globe and check valve for general purpose	IS 778
12.	Ball Valves including floats for water supply purposes	IS 1703
13.	Mild Steel Tubes, tubular and other wrought steel pipes fittings	IS 1239
14.	Steel Plates for pressure vessels used at moderate and low temperature	IS 2041
15.	Color code for identification of pipe lines	IS 2379
16.	V-belts for industrial purposes	IS 2494
17.	Hot dip galvanizing of iron and steel	IS 2629
18.	Code for unfired pressure vessels	IS 2825
19.	Glossary of terms for safety and relief valves	IS 3233
20	Steel for pressure vessels and welded structures	IS 3503
21.	Steel tubes for mechanical and general engineering purposes	IS 3601

22.	Steel for general structural purposes	IS 2062
23.	Steel tubes for structural purposes	IS 1161
24.	Specifications for steel doors, windows and ventilators	IS 1038
25.	Code of practice for design loads (other than earthquake) for building and structures	IS 875 Part I to V
26.	Criteria for earthquake resistant design of Structures	IS 1893
27.	Specifications for cold formed light gauge structural steel sections	IS 811
28.	Code of practice for use of Steel Tubes in general building construction	IS 806
29.	Code of practice for use of cold form light gauge steel structural members in general building construction	IS 801
30.	Code of practice for general construction in steel	IS 800
31.	Glossary of terms used in refrigeration and air-conditioning	IS 3615
32.	Pressure and vacuum gauges	IS 3624
33.	Safety Codes for scaffolds and ladders	IS 3696
34.	Formed ends for tanks and pressure vessels	IS 4049
35.	Shell an tube type heat exchangers	IS 4503
36.	Code of safety for ammonia	IS 4544
37.	Expanded polystyrene for thermal insulation purposes	IS 4671
38.	Hot-dip Zinc coating on steel tubes	IS 4736
39.	Units and symbol for refrigeration	IS 4831
40.	HDPE pipes for potable water supplies, sewage and industrial effluents	IS 4984
41.	Gauge glasses	IS 5428
42.	Specification for sprayed aluminum and zinc coating on iron and steel surfaces	IS 5905
43.	Steel Pipe flanges	IS 6392
44.	Injection molded HDPE fittings for portable water supplies	IS 8008
45.	Vertical steel ladders	IS 8172
46.	Treatment of water for industrial cooling systems	IS 8188
47.	Nominal sizes of valves	IS 9520
48.	Selection, use and maintenance of respiratory protective devices	IS 9623
49.	Polythene floats for ball valves	IS 9762
50.	General purpose ball valves	IS 9890
51.	SI units	IS 10005
52.	Recommendations for general pipeline welding	IS 10234
53.	Ammonia valves	IS 11132
54.	Finned type heat exchanger for room air conditioner	IS 11329
55.	Refrigeration oil separators	IS 11330
56.	MS tubes for vertical condenser	BS 3059
57.	Specification for metal air duct	IS 655

58.	Specification for galvanized steel sheet	IS 227
59.	Specifications for Performed Rigid Polyurethane	IS 12436 - 1988
60.	Glossary of Terms used in Refrigeration& Air conditioning	IS 3615: 2007
61.	Code of Practice for Fire Safety of Ware housing including cold storages	As per Relevant IS specification
62.	Food Hygiene – General Principle – Code of Practice	IS 2491-1998
63.	Self blasted lamps for general lighting service	IS 15111 Part 1 and 2

C. Publication by International Societies and Associations
Pre Engineered Building

S. no.	Title	Reference
1.	Building Code	IBC 2006
2.	Design Code	AISC 2005
3.	Tolerance Code	MBMA 2002
4.	Purlin Code	AISI 2001
5.	Welding Code	ANS 2006
6.	Wind Load & Seismic Load	IS 875 & IS A893-2002& Relevant Codes

D. European Organization for Technical Approvals (EOTA)

S. no.	Title	Reference
1.	External Thermal Insulation Composite Systems with Rendering	ETAG 004
2.	Cold Storage Premises Kits Part-1: Cold Storage Room Kits	ETAG 21
3.	Cold Storage Premises Kits Part-2: Cold Storage Building Envelope and building its	ETAG 021

American Society of Heating, Refrigeration and Air Condition Engineers, Inc ASHRAE

Refer to REFRIGERATION - Systems and Applications, Handbook

Chapter – 51 Codes and Standards,

International Standard (ISO)

Standard and/or project
ISO 873:1980 Peaches -- Guide to cold storage
ISO 874:1980 Fresh fruits and vegetables -- Sampling
ISO 931:1980 Green bananas -- Guide to storage and transport
ISO 949:1987 Cauliflowers -- Guide to cold storage and refrigerated transport
ISO 1134:1993 Pears -- Cold storage
ISO 1212:1995 Apples -- Cold storage
ISO 1673:1991 Onions -- Guide to storage
ISO 1838:1993 Fresh pineapples -- Storage and transport
ISO 1956-1:1982 Fruits and vegetables -- Morphological and structural terminology
ISO 1956-2:1989 Fruits and vegetables -- Morphological and structural terminology
ISO 1990-1:1982 Fruits -- Nomenclature -- First list
ISO 1990-2:1985 Fruits -- Nomenclature -- Second list
ISO 1991-1:1982 Vegetables -- Nomenclature -- First list
ISO 1991-2:1995 Vegetables -- Nomenclature -- Part 2: Second list
ISO 2165:1974 Ware potatoes -- Guide to storage
ISO 2166:1981

Carrots -- Guide to storage
ISO 2167:1991 Round-headed cabbage -- Guide to cold storage and refrigerated transport
ISO 2168:1974 Table grapes -- Guide to cold storage
ISO 2169:1981 Fruits and vegetables -- Physical conditions in cold stores -- Definitions and measurement
ISO 2295:1974 Avocados -- Guide for storage and transport
ISO 2826:1974 Apricots -- Guide to cold storage
ISO 3631:1978 Citrus fruits -- Guide to storage
ISO 3659:1977 Fruits and vegetables -- Ripening after cold storage
ISO 3959:1977 Green bananas -- Ripening conditions
ISO 4125:1991 Dry fruits and dried fruits -- Definitions and nomenclature
ISO 4186:1980 Asparagus -- Guide to storage
ISO 4187:1980 Horse-radish -- Guide to storage
ISO 5524:1991 Tomatoes -- Guide to cold storage and refrigerated transport
ISO 5525:1986 Potatoes -- Storage in the open (in clamps)
ISO 6000:1981 Round-headed cabbage -- Storage in the open
ISO 6477:1988 Cashew kernels -- Specification
ISO 6478:1990 Peanuts -- Specification
ISO 6479:1984 Shelled sweet kernels of apricots -- Specification

ISO 6479:1984/Cor 1:1999
ISO 6659:1981 Sweet pepper -- Guide to refrigerated storage and transport
ISO 6660:1993 Mangoes -- Cold storage
ISO 6661:1983 Fresh fruits and vegetables -- Arrangement of parallelepipedic packages in land transport vehicles
ISO 6662:1983 Plums -- Guide to cold storage
ISO 6663:1995 Garlic -- Cold storage
ISO 6664:1983 Bilberries and blueberries -- Guide to cold storage
ISO 6665:1983 Strawberries -- Guide to cold storage
ISO 6755:2001 Dried sour cherries -- Specification
ISO 6756:1984 Decorticated stone pine nuts -- Specification
ISO 6757:1984 Decorticated kernels of mahaleb cherries -- Specification
ISO 6822:1984 Potatoes, root vegetables and round-headed cabbages -- Guide to storage in silos using forced ventilation
ISO 6882:1981 Asparagus -- Guide to refrigerated transport
ISO 6949:1988 Fruits and vegetables -- Principles and techniques of the controlled atmosphere method of storage
ISO 7558:1988 Guide to the pre packing of fruits and vegetables
ISO 7560:1995 Cucumbers -- Storage and refrigerated transport
ISO 7561:1984 Cultivated mushrooms -- Guide to cold storage and refrigerated transport

ISO 7562:1990 Potatoes -- Guidelines for storage in artificially ventilated stores
ISO 7563:1998 Fresh fruits and vegetables -- Vocabulary
ISO 7701:1994 Dried apples -- Specification and test methods
ISO 7702:1995 Dried pears -- Specification and test methods
ISO 7702:1995/Cor 1:2001
ISO 7703:1995 Dried peaches -- Specification and test methods
ISO 7703:1995/Cor 1:2001
ISO 7907:1987 Carob -- Specification
ISO 7908:1991 Dried sweet cherries -- Specification
ISO 7910:1991 Dried mulberries -- Specification
ISO 7911:1991 Unshelled pine nuts -- Specification
ISO 7920:1984 Sweet cherries and sour cherries -- Guide to cold storage and refrigerated transport
ISO 7922:1985 Leeks -- Guide to cold storage and refrigerated transport
ISO 8682:1987 Apples -- Storage in controlled atmospheres
ISO 8683:1988 Lettuce -- Guide to pre-cooling and refrigerated transport
ISO 9376:1988 Early potatoes -- Guide to cooling and refrigerated transport
ISO 9719:1995 Root vegetables -- Cold storage and refrigerated transport
ISO 9833:1993 Melons -- Cold storage and refrigerated transport

ISO 9930:1993 Green beans -- Storage and refrigerated transport
ISO 23391:2006 Dried rosehips -- Specification and test methods
ISO 23392:2006 Fresh and quick-frozen maize and peas -- Determination of alcohol-insoluble solids content
ISO 23393:2006 Pomegranate fruit -- Specification and test methods
ISO 23394:2006 Dried oleaster -- Specification and test methods

Other Standards and References

There is sufficient data available on design of energy efficient cold stores and commercial storage practices of fresh fruits and vegetables and other perishable commodities from various publications by organizations such as:

1. International Association of Refrigerated Warehouses (IARW) and World Food Logistics Organizations,
   a) Commodity Storage Manual
   b) Crisis Management Manual
   c) Guide to Effective Ware House Operations
   d) Maintenance and Modernization Manual

2. American Society of Heating, Refrigeration and Air Condition Engineers, Inc - ASHRAE Handbooks

   a) REFRIGERATION – Systems & Applications
   b) FUNDAMENTALS
   c) HVAC Systems and Equipment
   d) HVAC Applications

3. The International Institute of Refrigeration (IIR),
4. International Institute of Ammonia Refrigeration (IIAR),
5. United States Department of Agriculture (USDA),
6. Post-harvest Technology-Research & Information Center UC DAVIC