Section-I

Technical Standard No. NHB-Cold Storage-Type 01-2009

1. Cold Storage Type :

For fresh fruits and vegetables and other horticulture products which do not require pre-cooling but there is crop specific rate of pull down and storage conditions,

a. Fresh Potato Tubers for following purposes

i. Early Crop (pre mature)

ii. Seed Potato

iii. Table Potato

iv. Process Potato

- French Fries
- Chipping

b. *Onion, garlic, tamarind etc.*

2. Critical Storage Conditions :

i. Quality of produce - Curing & pre-conditioning for about 7 to 10 days in the fields for skin set/ proper handling/ Application of CIPC.

For example- it is recommended that potatoes are harvested at temps not lower than 8° C and not higher than 20° C and harvested potatoes are cured by keeping at 15° C to 20° C and 90% to 95 % RH for 5 to 10 days before placing them into cold storage, allowing the surface wounds to heal, thereby preventing water loss and protection from decay.

ii. 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* in absence of research data from Indian Institutions. Example - Design conditions for Irish Potatoes which are adopted, in absence of data for Indian potatoes are as given below.

a. Temperature, storage period, relative humidity etc.

Fresh Potato	Temperature	Storage Period	Relative Humidity
Early Crop	4 – 10°C	0 – 3 months *	95%
Seed Potato	3°C @	5 – 10 months	90 – 95%
Table Potato	4°C	5 – 10 months	90 – 95%
For French Fries	7.2 – 10°C	1 – 10 months **	90 – 95%
For Chipping	7.2–10°C #	1 – 8 months **	90 – 95%

(*) If cured / wounds healed before storage.

(**) Sprout suppressors must be used for long-term storage.

(#) Generally stored between 9 - 13°C as per WFLO manual whereas CPRI recommends 11°C

@ Based on expert advice of CPRI, which is firmed up by TSC after analysis of the same, critical storage temperature for seed potato is taken as 3°C ±1° C. Moreover, one of the following two critical storage conditions for table potatoes may be taken into account after evaluating their implications on consumer preference for stored potatoes and cost of storage; firstly as critical storage conditions of potatoes for processing purposes and secondly, the critical storage conditions recommended for seed potatoes.

a. 24 hours cooling to 15°C followed by pull down rate of 0.5°C per day till holding temperature of 11°C ± 1°C with CIPC application after first 30 days of storage; in this case stored potatoes may not turn sweet due to separation of sugar, however, storage cost will be higher due to CIPC application.

b. 24 hours cooling to 10°C, pull down to holding temperature of 3°C ± 1°C within 8 to days; in which case, starch accumulation will take place but storage cost may be lower,

c. **Temperature and humidity range:** +/- 1°C for temperature and humidity range as given.

d. **CO_2 level:** Not more than 4000 ppm during loading and 2000 ppm during holding (source: industry).

e. **Loading Rate:** 4% (at 25°C) to 5% (at 20°C) of the total storage capacity (equally split into chambers) per day so that total loading period is about 20 days. Temperature during loading to be maintained at 15° C which should be brought down to holding temperature @ 2° to 3° C per week; subject to choice of adopting CPRI recommendations as mentioned above.

f. **Pull-down time:** 24 hours for pull down to 15° C and @ 20 - 30 C per week for pull down to holding temperature. CPRI recommends that seed potatoes should be cooled to 10° C within 24 hours of arrival at cold store and its temperature should be further pulled down to holding temperature of 3° C ±1° C within 8 to 10 days as sugar separation due to rapid cooling is not a matter of concern for seed potatoes.

g. **Air Circulation:** Minimum 50 CFM/MT of Potato (85 CMH/ MT of Potato) during the loading and pull-down period. However, during the holding period fan power is optimized by fan speed reduced to almost 70% by VFD control (which will reduce fan motor power consumption to 34%) and thereafter automatic control will maintain temperature variation within each chamber at less than +/- 1 °C throughout the storage period.

h. **Ventilation requirements in cold storage:** it may range between 2 to 6 air changes per day to maintain CO_2 less than 4000 ppm. It is recommended to opt for mechanical CO_2 extractor with energy recovery system. It is a much better option than the present practice of opening the cold stores doors & hatch windows to ventilate and remove the CO_2 build-up as the later practice results in loss of energy, inability to maintain temperature variation range of ± 1°C, wetting of product leading to product loss.

i. **Lighting Condition: Dark**

j. **CIPC application:** For processing potatoes in general and for table potatoes if critical storage conditions equivalent to processing potatoes are adopted. CPRI recommends that due to slow pull down of temperature (0.5° C per day) in these situations, high holding temperature is built up which in turn accelerates germination of potatoes immediately after its dormancy period; therefore, CIPC application is recommended immediately after first 30 days of arrival of potatoes in cold storage. He further cautioned that rapid cooling should not be carried out for potatoes for processing purposes.

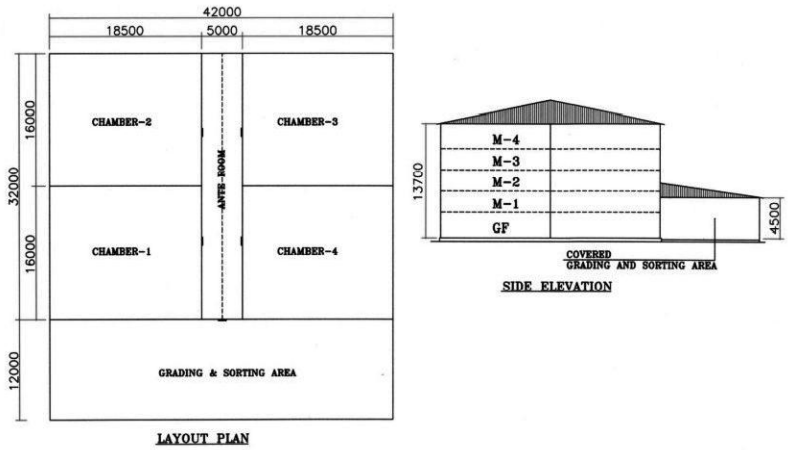
3. Layout of a Typical Cold Store for Products Identified

It is recommended to have multi commodity cold stores for better capacity utilisation. For example - a solely potato based cold storage may be designed for storage of seed potato and table potato or processing potato etc. Similarly, for energy efficiency, cold stores have to be multi chamber. It is recommended to have at least two chambers and chamber size should be of the capacity range of 1,000 MT to 1,500 MT for ensuring uniform storage condition, proper capacity utilization, and energy efficiency. This is not possible in single chamber / larger chamber cold storages. Cold stores for of this type are generally with mezzanine floors, which must be provided with anteroom of adequate dimensions. Having staircase inside the chamber may reduce storage space and restrict possibility of having elevators and fire escape. Layouts with staircase in anteroom facilitate better space utilisation; higher efficiency of workmen, providing for elevators and fire escape but construction cost may be higher due to multiple doors etc. If CIPC is to be used as sprout-suppressor for certain products, then other chambers having products to be used as seed must be adequately separated by having separate anti chamber. Two typical layouts are given below.

TYPE LAYOUT - OPTION - A

FOUR CHAMBER POTATO BASED COLD STORE

(With staircase inside chambers, common entry and exit at ground floor for all floors of a chamber, no provision for elevators and fire escape route)

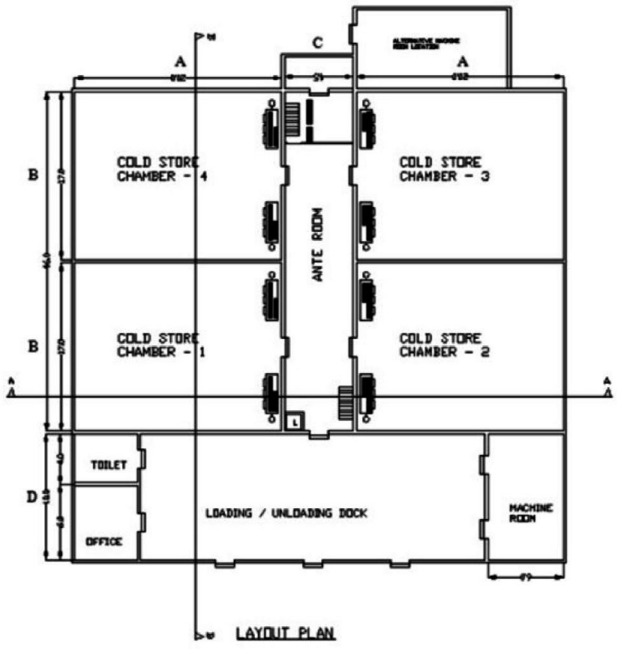


TYPE LAYOUT - OPTION - B

FOUR CHAMBER POTATO BASED COLD STORE

(With provision for staircase outside chambers, doors for each chamber at each floor, elevator and fire escape route etc)

A = 20 – 21 m
B = 15 – 18 m
C > 3 m
D = 10 – 12 m

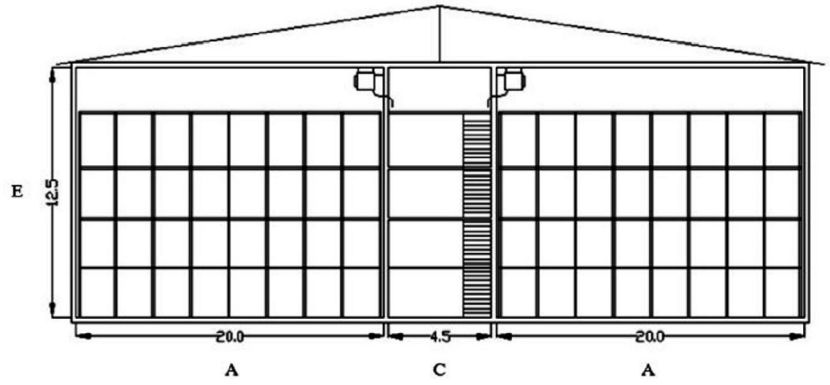


OTHER ANCILLARY WORKS

1. ELECT. SUBSTATION & METERINGROOM.
2. UNDERGROUND WATER STORAGE TANK/ FIRE FIGHTING STORAGE TANK / OVERHEAD TANK.
3. DRAINAGE LINES. STORM WATER DRAINAGE & SEPTIC TANK (IF REQUIRED).
4. FENCING & ROADS.
5. MAIN GATE & SECURITY CABIN.

NOTE -

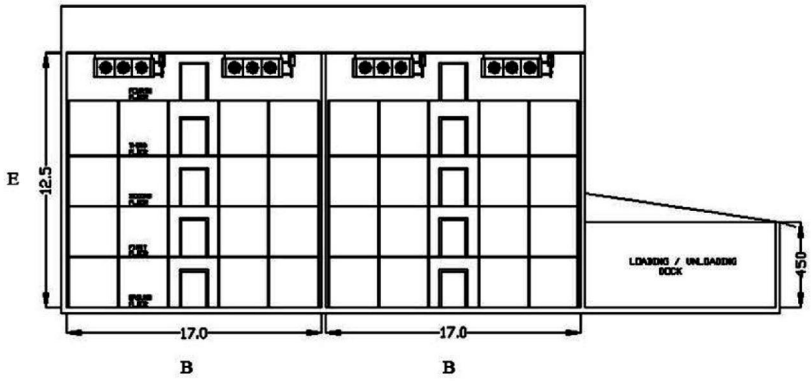
- NO OF INTER FLOORS IN COLD STORE - 5
- TOTAL HEIGHT OF COLD STORE CHAMBER - 12.5m
- P.L.S. REFER TO SECTION ON DRG NO CS GEN 09.09A & CS GEN 10.10A .
- ALL DIMENSIONS IN METERS



SECTION – AA
ALTERNATIVE – 1 (WITH TRUSS ROOF)

COLD STORAGE PLANT - SECTION FOR ALT - I

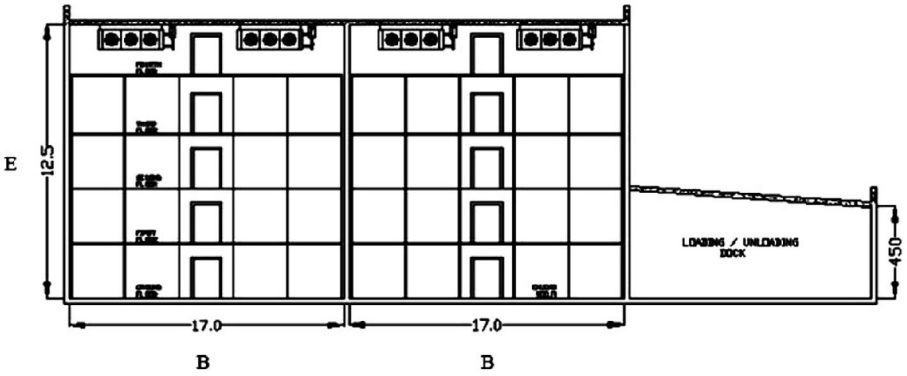
A = 20 – 21 m
C > 3 m
E = 12 – 14 m



SECTION – BB
ALTERNATIVE – 1 (WITH TRUSS ROOF)

COLD STORAGE PLANT - SECTION FOR ALT - I

B = 15 – 18 m
E = 12 – 14 m



SECTION – BB
ALTERNATIVE – 2 WITH CONVENTIONAL
CONSTRUCTION WITH R.C.C SLAB ROOF

COLD STORAGE PLANT - SECTION FOR ALT - I

B = 15 – 18 m
E = 12 – 14 m

Construction Features : The general convention of conventional construction is 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 Chamber:

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.

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,

Inter-floors : The basic structure can be RCC columns & beams or steel columns & steel beams

Grating : Wooden batten grating or steel grating using flats / square tubes etc. The inter-floors have to be designed for a product loading of 900 kg/m^2 min. Where AC units are located on top floor, the structure has to be suitable for the unit static & dynamic loads.

Ante Room : This should preferably be designed to accommodate staircase, electrical hoist cage and have wider doors. Provision for fire escape stair & exits to be made as per local norms. The inter-floors in ante room to have doors to each cold room on each floor.

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).**Though fresh F & V are stored at + 0° C, it is recommended to design thermal insulation for (- 4° C to + 2° 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 / glass wool

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 and 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/m²K	Floor U value = 0.29W/m²K
			External U value = 0.27W/m²K	Partition U value = 0.58W/m²K		
	p Density Kg/m³	K (at 10 °C) W/mK	Thickness mm	Thickness mm	Thickness mm	Thickness mm
EPS	15	0.036	150	75	150	125
PUF	32	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 TCT

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).
- **Radiant barrier.** This could be an option which the promoters can use for energy saving. However, the minimum thickness of insulation and the method of fixing will remain as specified in the standards.

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.

- **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 - direct expansion (in case of HFC and others), liquid overfeed and gravity with a surge drum in case of ammonia:**

  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**

  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**

  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 and Plate Heat Exchanger (PHE) with cooling tower arrangement in case of HFC / HCFC / Ammonia plant or of evaporative / atmospheric type in case of ammonia plant. Capacity of condenser shall be confirmed by data-sheet of manufacturer.

- **Air Cooling Unit - ceiling / wall mounted- for cold stores**

  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. Coils with Aluminium tubes and Aluminium fins can also be used.

- **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.

- **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 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 is a must. 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 derating 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

(May refer to the Type Designs given in Section 4)

Brief Specifications for Equipment / Materials / Services

i. Refrigeration Compressors & Motors

Quantity	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 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 re-circulation/overfeed system 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 with bullet drawn expansion may be used.
Fin spacing	*6.25 to 8.5 mm (3 to 4 FPI)*
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 F & V cold store	One or more nos. per chamber depending on chamber size and capacity; generally 3 to 4 nos. to ensure uniform air distribution, as per configuration
Estimated capacity each at critical operating condition	*To be configured*
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 Interconnecting piping between compressor, condenser, receiver and cooling units	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 in case of ammonia plants. For HFC / HCFC, hard Copper piping type L 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	At least 2 nos. operational during peak load and 1 no 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

ix. Duct Mouthpieces

To be provided on each fan outlet for uniform distribution of air at the topmost level	G.S. sheet ducting as per IS 655

x. Ventilation for cold chambers

System to be designed for providing adequate air changes / day	Axial flow / Inline duct fans with cleanable inlet filters, G.S sheets / Aluminium / PVC ducting up to cold chambers and ducting for exhaust from cold chambers to outside Heat exchanger with energy recovery wheel or heat pipe can be used for cooling the incoming air from the exhaust air. Typical efficiencies of heat exchangers are 70% or higher for achieving desired CoP.

xi. Humidification

External humidification for 90 to 95 % RH	Fogger type external humidification system with 2 to 10 micron particles with automatic regulation

xii. Controls : One sensor per 100 ton of storage is suggested as good (Univ. of Idaho study).

Temperature control	Temp Indicators cum controllers for individual chambers. Temperature scanners and a centralized temperature indication in machine room
RH control	RH indicator & controller
CO_2 control	CO_2 sensors for regulation of ventilation system
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 for large cold stores (3,000 MT and above) 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.

h. All cold store doors should be constructed to be airtight and weather-proof, to suitable to the cold store specific applications.

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. The use of Diesel engines on compressors is left to the promoter to assess but keeping in view overall CoP of the plant.*

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)**

vii. Electrical hoist

Electric hoist	With wire ropes, steel fabricated cage with guides & openable doors for material movement, product lifting
Capacity	2 MT of product

9. SAFETY

Safety Measures

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

- Provision of lifts/ material handling equipments - no. of doors (one on GF or on each floor)

Improper handling may cause injury to the potatoes. As labour is cheap in India and power is not reliable, lifts/ mechanized handling is not common but may be useful in some cases. Palletization; wherever feasible and economical would maintain the quality of potato.

10. Coefficient of Performance (CoP)

Optimum energy efficiency should be determining criteria for CoP. However, for the instant type of cold storage CoP of minimum 3.6 at peak load condition, 3.3 for holding period and about 2.5 during lean period is recommended.

11. Operation & Maintenance

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.