

# **Steps to build Modern & Efficient cold storage**

**By**

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**ASHRAE Distinguished fifty year service award-2020**

**Chairman ISHRAE Technical group –Refrigeration**

**Chairman AAR standards committee**

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**GREEN FIELD - NEW PROJECT**

**SESSION-I**

**BUILDING CONSRUCTION**

# **Cold Storage Owner's Expectations New Cold Storage –Green Field Project**

1. Minimum Capital Cost
2. Minimum Electricity Bill-Running Cost
3. No Weight Loss During Storage
4. Product Quality Does Not Deteriorate
5. Trouble Free/Ease of Operation

## To Meet Expectations

1. Discussions with customer- properties of various products, their shelf life and temperature, Humidity requirements
2. Construction of Building
3. Insulation selection
4. Product Handling/Loading Methods
5. Air Distribution
6. Refrigeration

PLAY GREAT ROLE

# Field of Applications

- **Positive Temperature Applications (+2 to +4°C)**

1. **Dairy Products**
2. **Fruits and Vegetables**
3. **Pharma**
4. **Hotel and Kitchen**
5. **Blood Storage**
6. **Floricultural**
7. **Horticultural**
8. **Fresh Meat and Fish**
9. **Miscellaneous, dry fruits, spices etc.**



- **Low Temperature Applications(-20 to -30°C/-35°C)**

1. **Frozen Meat and Fish**
2. **Ice Cream**

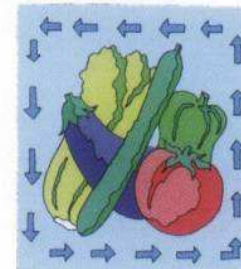
(Detail List ASHRAE – Refrigeration Volume 2018 or AAR book)



# Product Compatibility

- Having similar Characteristics to be stored together
  - Do not store
    1. Bread / Apple (Different Shelf Life)
    2. Onion / Mushroom (Different Humidity)
    3. Banana and Mango / Lemon and Orange (Different Temperature)
- Avoid cross contamination
  1. Garlic and Butter ???
  2. Fish and Milk ???
  3. Flowers with Dairy Products

Special care should be taken in the loading of fruit and vegetables.



## **Respiration only for – Fruits / Vegetables**

- **RESPIRATION – GROW – MATURE – DECAY STARTS WHEN HARVESTED**
  - **ROOTS – PROVIDE WATER / MINERALS**
  - **LEAVES – PROVIDE SUGAR – PHOTOSYNTHESIS**
- **ON HARVESTING - OWN INTERNAL SOURCES FOR METABOLISM FOR THE LIFE**

<b>COMMODITY</b>	<b>RATE OF RESPIRATION</b>	<b>STORAGE LIFE</b>
<b>POTATO / ONION / APPLES / CITRUS / FRUIT</b>	<b>LOW</b>	<b>LONG</b>
<b>LETTUCE / CAULIFLOWER / STRAWBERRY</b>	<b>MODERATE</b>	<b>SHORT – MODERATE</b>
<b>BRUSSELS / SPROUTS / SPINACH</b>	<b>HIGH</b>	<b>SHORT</b>
<b>ASPARAGOUS / MUSHROOM</b>	<b>VERY HIGH</b>	<b>VERY SHORT</b>

# COLD STORAGE CATEGORIES

- 1. Short Term-** 1-2 days, maximum-15 days-Retail
- 2. Long Term** -3-8 Months- Apples, potatoes, Chilies, Onions etc.
- 3. Frozen-** Long storage-Fish, Chicken, Meat, Ice Cream
- 4. CA-**Controlled Atmosphere cold storage

# CONTROLLED ATMOSPHERE (CA)

• **NORMAL AIR- 21 % OXYGEN + 78-79 % NITROGEN + 0.3 % CARBON DIOXIDE**

• **REDUCE OXYGEN - REDUCE RATE OF RESPIRATION**

• **INCREASE NITROGEN - REDUCE RATE OF RESPIRATION**

• **RISKS**

- **TOO LOW OXYGEN - SUFFOCATION**

- **TOO HIGH CARBON DIOXIDE - SUFFOCATION**

• **(CA) ATMOSPHERE - OXYGEN 3% (APPROX)**

- **CARBON DIOXIDE 3% (APPROX)**

• **(CA) UTILIZATION - EXTENSIVE – APPLE / PEAR / WHITE CABBAGE**

- **LONG STORAGE**

• **NOT USED – CITRUS FRUITS / GRAPE / MANGO / PAPAYA**

# **How To Design & Build Good Cold Store ?**

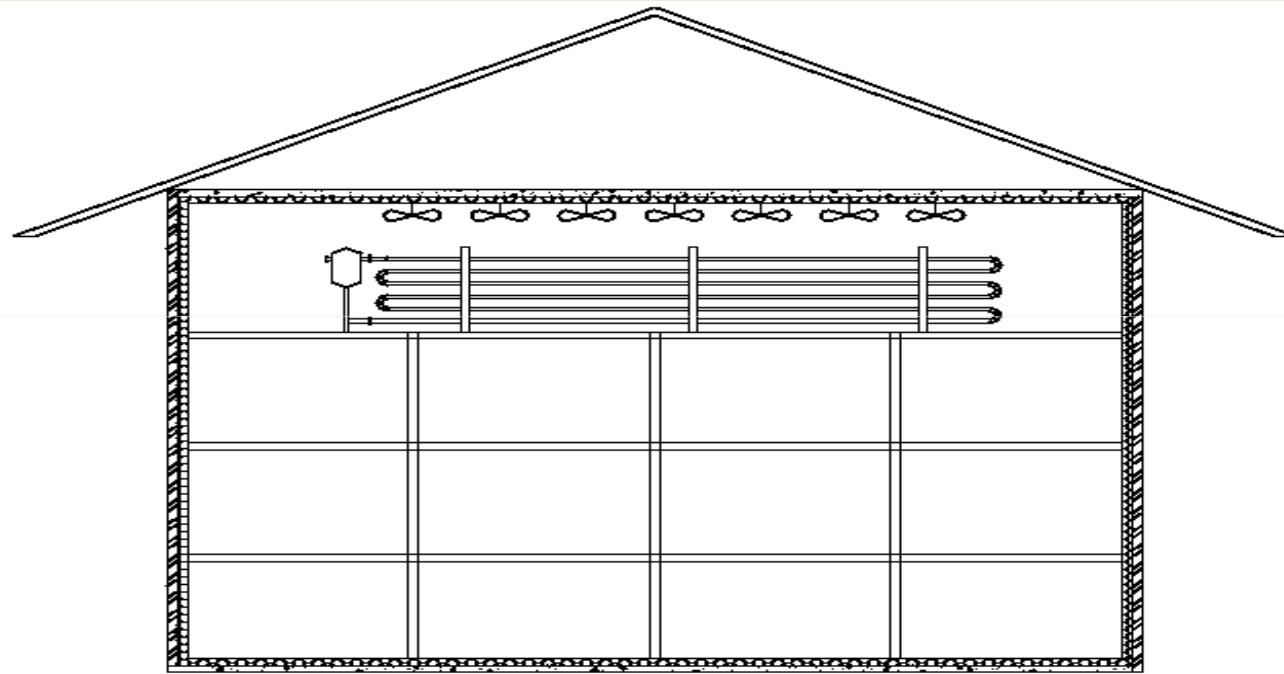
# Bulk Storage



# Bags Storage



# Old Units With Bunker Type Coils



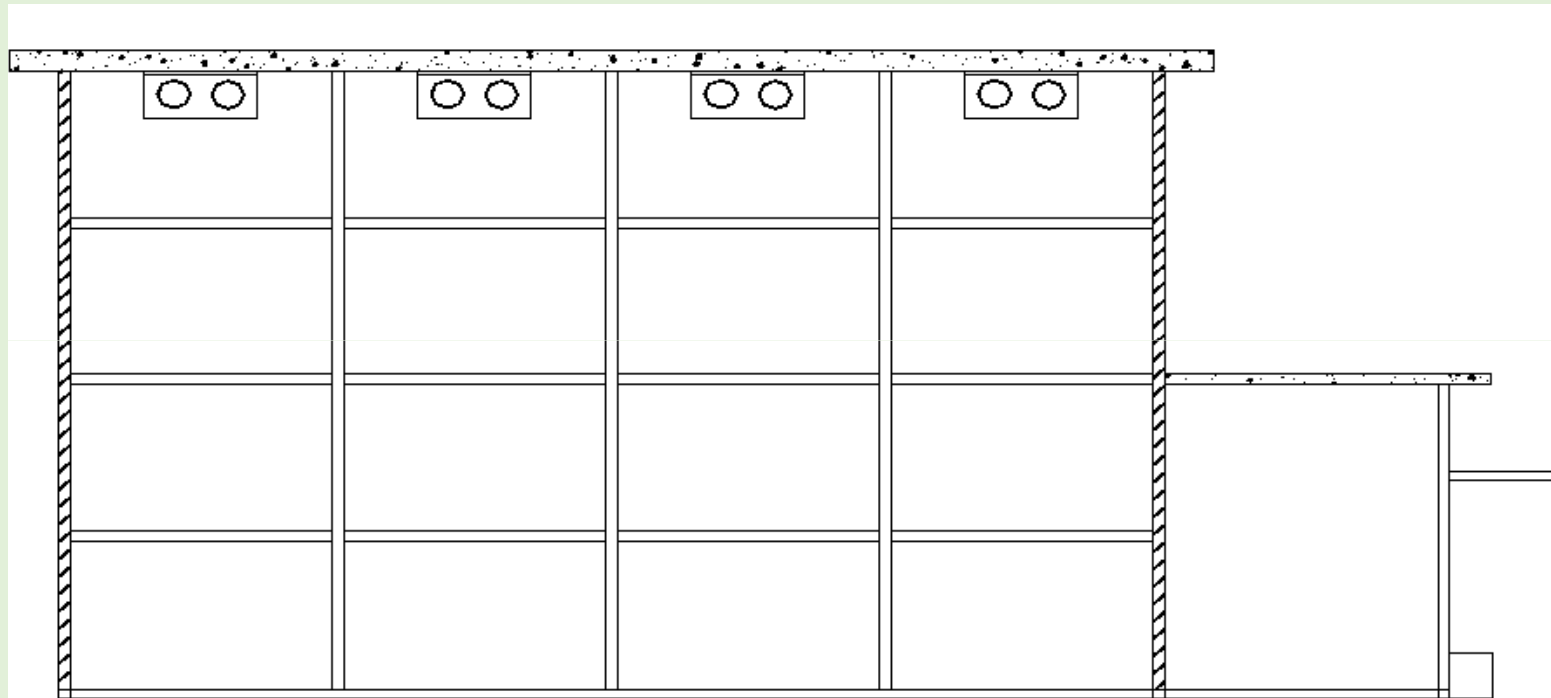
**TYPICAL OLD DESIGN OF COLD STORE WITH SHEET  
ROOFING & LARGE BUNKER TYPE COOLING COIL (SECTION)**

# Old Units With Diffuser Type Coils



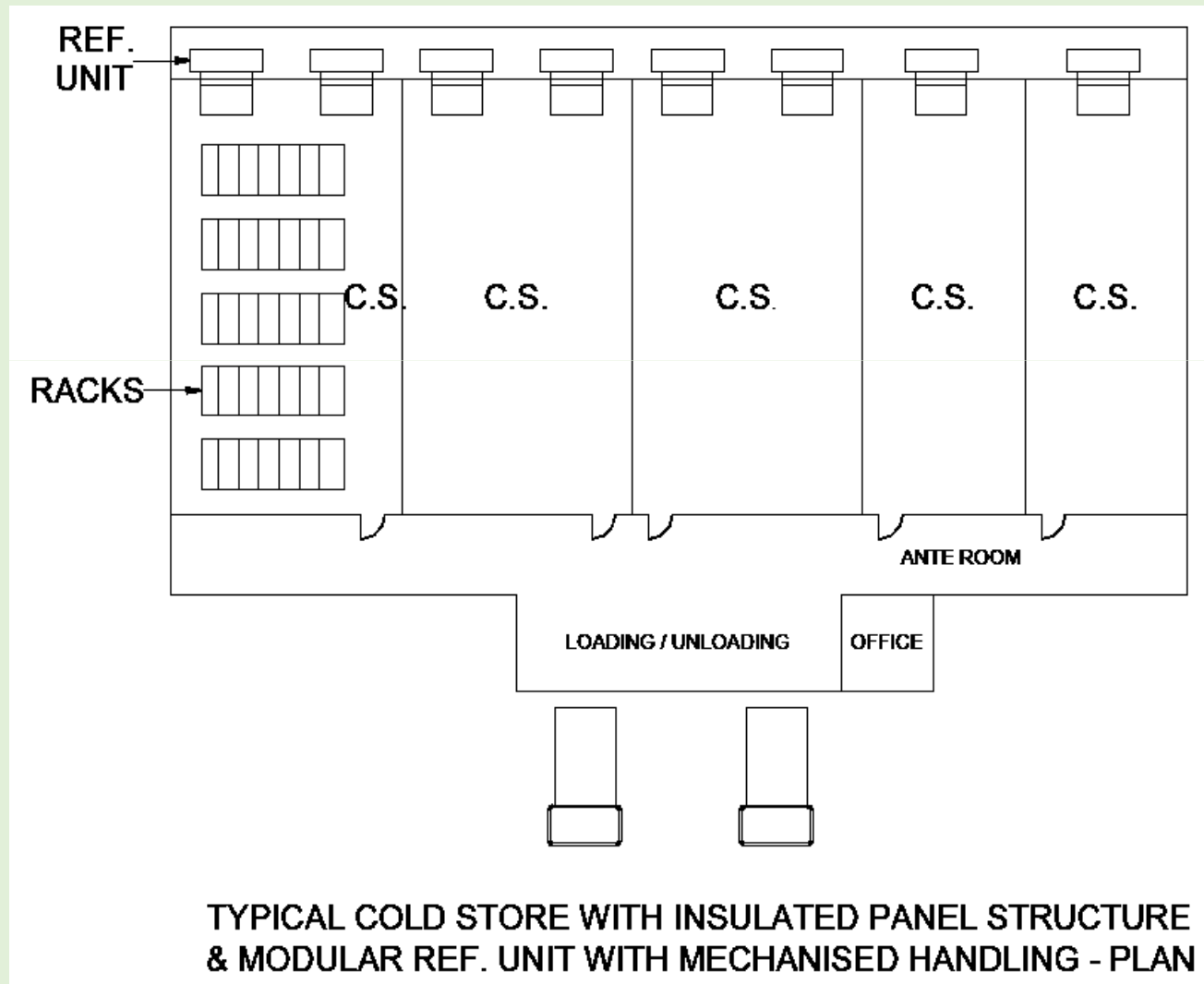
TYPICAL COLD STORE WITH R.C.C.SLAB ROOF  
& FLOOR MOUNTED AC UNIT WITH DUCTING

# Multipurpose Units With Conventional Construction & Ceiling Suspended Air Cooling units



TYPICAL COLD STORE WITH CEILING  
SUSPENDED AC UNIT

# Multipurpose Units With Sandwich Panel Construction



# DOCKS-Old Method



# DOCKING AREA-LATEST



# Conventional Construction - RCC



# Steel Structure-Old Design



# PEB STRUCTURES-LATEST

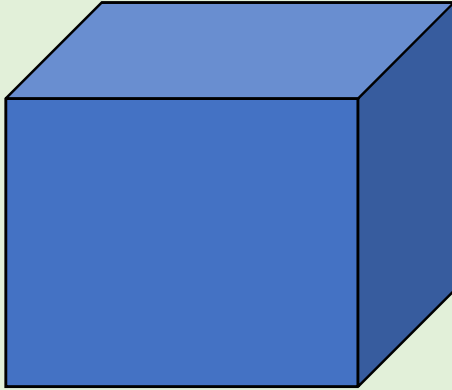


# EXTERIOR BUILDING CONSTRUCTION

- Tilt-up  
Construction at  
dock
- Insulated Panels



# SIZE AND SHAPE MATTERS



**Dimension 1m\*1m\*1m**  
**Surface Area : 6 Sq.m**  
**Floor Area 1 Sq.m**  
**Aspect Ratio 6**

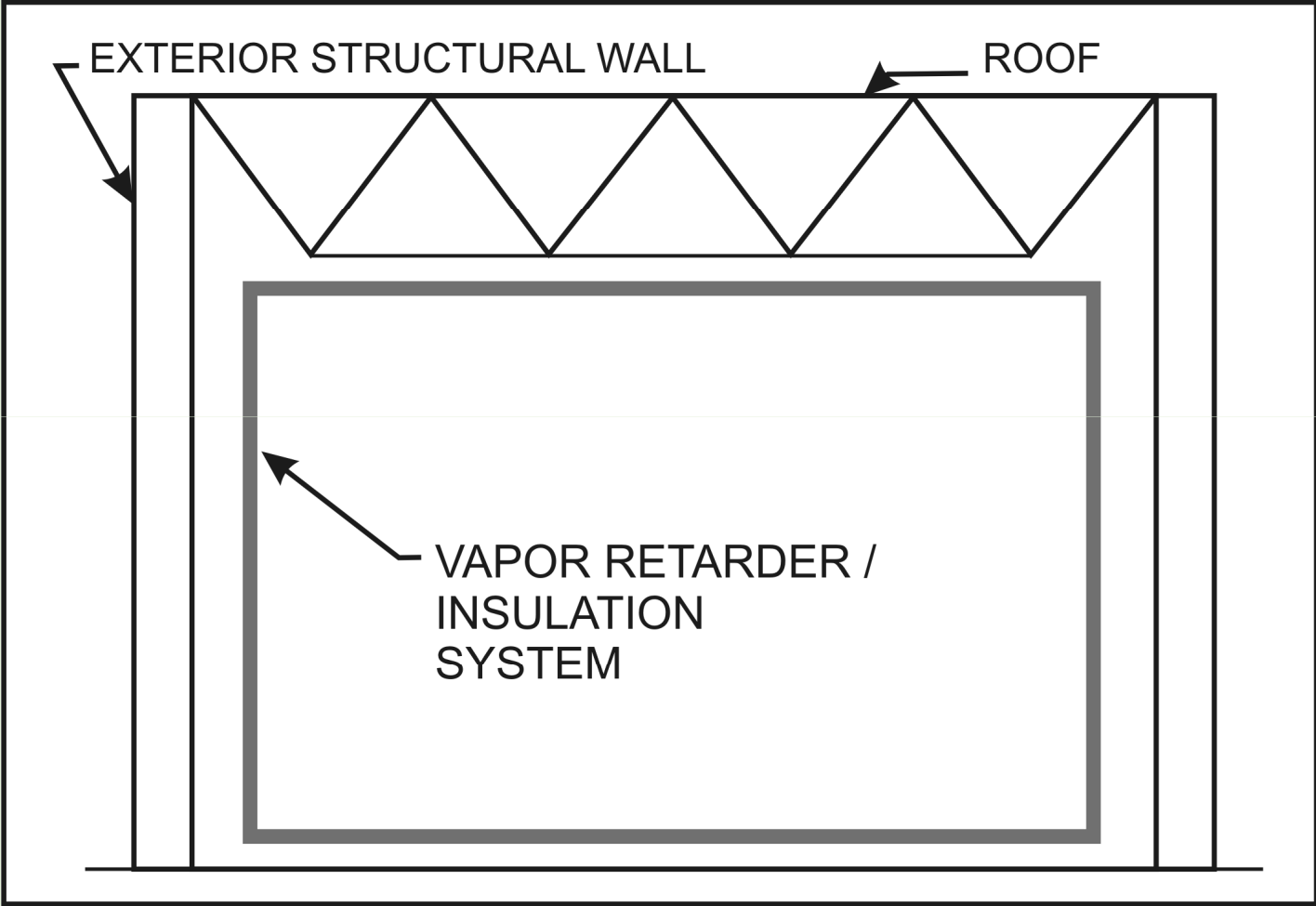


**Dimension 0.5m\*2m\*1m**  
**Surface Area :7.0 Sq.m**  
**Floor Area 1 Sq.m**  
**Aspect Ratio 7**

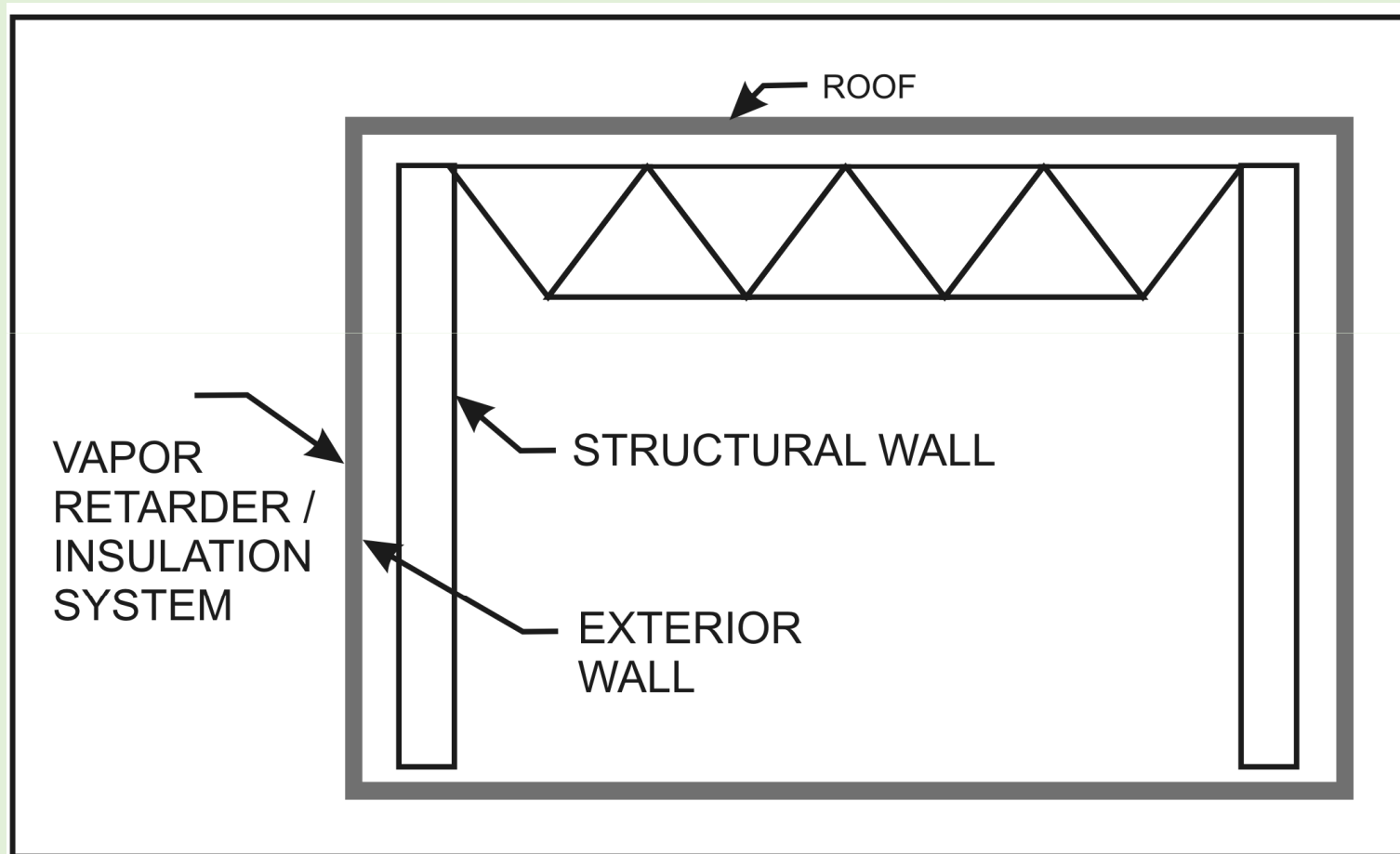
**Aspect Ratio = Surface Area / Floor Area**

**CUBICLE SHAPE PREFERRED**

# BOX IN DESIGN



# BOX OUT DESIGN



# THE BUILDING PLANNING

1. Roof type
2. Planning layout with Ante room to ensure outside air and cold room has in-between barrier
3. Office location
4. Room for expansion
5. Separate entrances?
6. Fire protection
7. Docks
8. Site – Parking
9. Space for vehicle movement
10. Waste material disposal area
11. Number , type and size of doors, these should be limited to minimum essential, limit use of strip curtains, use of single sliding doors, are suggested.
12. The liquid regulating stations should be outside the cold rooms and at convenient locations for adjustments

## **BUILDING FEATURES-PEB ?**

1. Minimize columns
2. High ceilings
3. Avoid Condensation
4. Provide Racking
5. Equipment/machinery-separate room
6. Minimize painting-use coated panels
7. Minimize flat edges and corners to avoid turbulence

# **MOISTURE-X**

Moisture is the greatest enemy

Temperature can be measured

Moisture in the air is invisible

## • **PROBLEM –MOISTURE PENETRATION**

- Ice formation, fogging, condensation on walls, ice around the doors
- Reasons-leakages,
- Infiltration-moisture migration from outside to inside due to vapour pressure difference,
- No proper vapour seals,
- Use of wrong insulation material etc.,

## LATENT HEAT V/S SENSIBLE HEAT

- To Cool one kg of dry air requires **1.006** kJ/kg<sub>da</sub>·K energy(0.24 Btu/lb)
- To condense one kg of Vapor requires **2500.77** kJ/kg<sub>da</sub>·k energy(1076Btu/lb.)
- To condense one lb. of air requires **970**Btu/Lb. whereas to cool one lb. air one requires only **0.24**Btu/b.(4041times more energy required to condense water )

## SPECIFIC HUMIDITY OR MOISTURE CONTENT G/KG- MORE IMPORTANT THAN R.H.

Sr. No.	Degree C	R.H. %	Moisture content g/Kg.da
1	5	90	0.6
2	15	90	1.2(Twice the amount of moisture compared to sr.no.1)

Sr.No.	Temperature	Moisture content- g/kgda	R.H.%
1	5-degree C	0.6	90
2	30-degree C	0.6	20

**R.H. only indicates ability to absorb additional moisture**

# VAPOUR BARRIER

The success or failure of insulation is dependent on effectiveness of vapour barrier in preventing vapour transmission through the insulation.

Outside air Temperatur e-°C	R.H.%	Moisture content- grams/kg	Vapour pressure- mmHg
40	30	13.968	16.6262
-40	95	0.0753	0.0915

A large difference in vapour pressures is a driving force for moisture ingress in the cold storages.

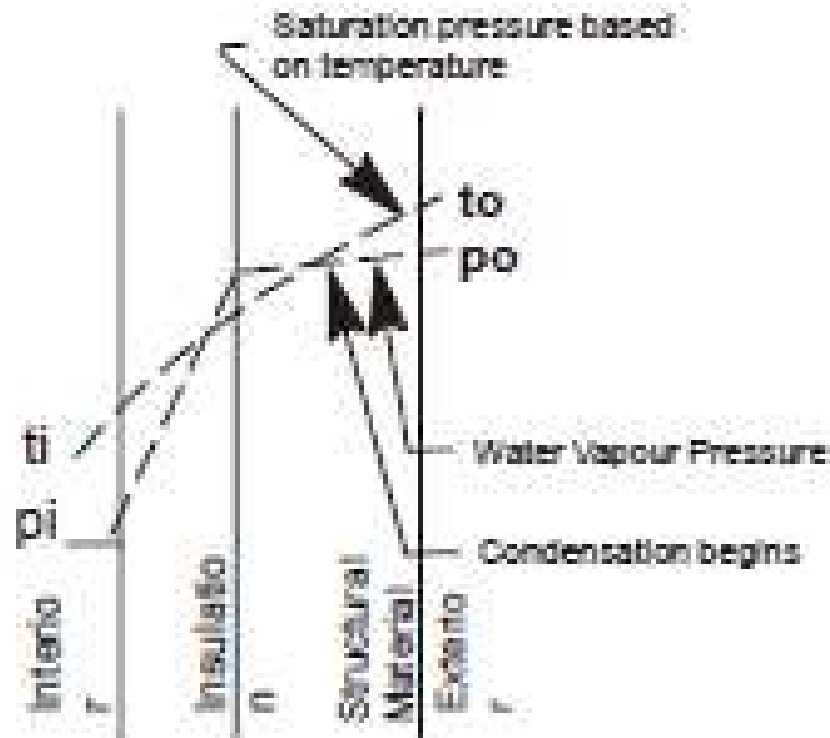
# PROPERTIES OF AIR

Temperature °C	Relative Humidity %	Absolute Humidity- gm/kg of dry air	Partial pressure of water vapour-Pa
40	25	11.59	13.86
5	85	4.6	5.56
-20	95	0.6	0.73
-40	95	0.075	0.019

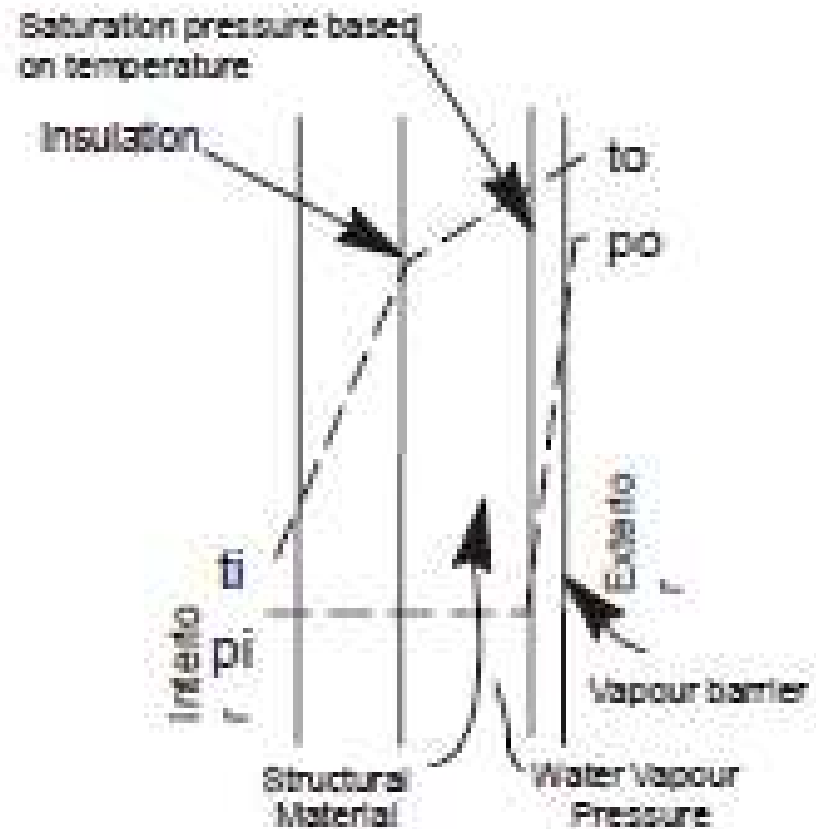
## Higher R.H. does not mean more moisture content-

1. 5°C & 85% R.H. has less moisture content 4.6 gm/kg<sub>da</sub> as against 40°C & 25% R.H.-11.59gm/kg<sub>da</sub> indicating that higher R.H. air has lower moisture content than air having lower R.H.
2. R.H is not correct indicator, find out g/kg for inside and outside conditions-or vapour pressure difference which is a driving force for moisture
- 3.The vapour pressure difference(13.86-5.56) is the driving force for moisture to enter the cold storage .
4. Lower the temperature of cold room more is the driving force for moisture

## VAPOUR PRESSURE /TEMPERATURE DIFFERENCES



(c)  
Water Vapour Pressure  
and Saturation Pressure



**Construct a vapour Tight moisture  
proof cold storage and not an ice  
factory-provide proper vapour  
barriers**



*"You can't solve a problem using the same knowledge that created it."  
-- Albert Einstein*









# DEFROST LOADS-LATENT LOADS-BTU/LB

<b>1</b>	<b>Latent Heat Condensation</b>	<b>1076 Btu/lb</b>
<b>2</b>	<b>Sensible Heat to reduce Vapour Temp. From 104°F to 32°F</b>	<b>40 Btu/lb</b>
<b>3</b>	<b>Sensible Heat (32°F to -15°F)</b>	<b>23 Btu/lb</b>
<b>4</b>	<b>Latent heat of Frost</b>	<b>144 Btu/lb</b>
<b>5</b>	<b>Heat reqd. to Defrost raise from -15 to 32</b>	<b>23 Btu/lb</b>
<b>6</b>	<b>Latent heat of Frost</b>	<b>144 Btu/lb</b>
<b>7</b>	<b>Assuming Defrost Efficiency 25%</b>	<b>576 Btu/lb</b>
<b>8</b>	<b>Raise temp. From 32 to 42 (room temp)</b>	<b>10 Btu/lb</b>
<b>9</b>	<b>Sublimation (Frost to Vapour) 16% (of 5+6+7)</b>	<b>120 Btu/lb</b>
<b>10</b>	<b>Evaporation loss 14% (of 5+6+7)</b>	<b>106 Btu/lb</b>
<b>11</b>	<b>Total Energy Required</b>	<b>2262 Btu/lb</b>
<b>12</b>	<b>Actual Energy lost 2262/0.7lb of ice</b>	<b>3232 Btu/lb</b>
<b>13</b>	<b>Power required to Defrost 1 lb</b>	<b>0.7 kW/lb</b>

# DEFROST LOADS-LATENT LOADS-BTU/0.7LB FROM COIL

		kWh
1	To produce Frost	0.21 kWh
2	To Defrost Frost	0.09 kWh
3	To remove Defrost Heat	0.16 kWh
4	Total power	0.46 kWh
6	Power required to remove 1 lb of Frost	$0.46/0.7=0.66$ kWh

# TRENDS IN THERMAL INSULATION PRACTICES

## ■ Old Units

- Rice husk used as Thermal Insulation
- Cheap but necessitated large thickness
- Lot of maintenance problems
- Walls and Ceiling finished with AC sheets
- Many units had cork as insulation

## ■ Last Three decades

- Expanded Polystyrene, Fiber glass on walls and ceilings with sand and cement plaster or Sheet metal cladding using Al. sheet or Pre coated G.S. sheet. Floor with EPS.

## ■ Latest

- Prefab Insulated Panel Structure (also called Sandwich Panel)
  - EPS Panels with EPS bonded to sheet metal skins using special glue
  - PUF Panels using Polyurethane as insulation material foamed between two metal skins

# INSULATED PANELS

## **Applications**

- Application right from small walk-ins to very large Cold Stores
- Gone beyond cold store construction –used for processing plants, prefabricated houses, ware houses etc.
- Also for doors for cold stores –light and simple construction

## **Highlights**

- Greater flexibility and faster construction
- Better isolation and better thermal insulation
- Brick Walls eliminated and therefore C.S. volume increases on a given floor area
- Modular construction feasible and offers advantage of addition / expansion as per requirement
- Some what more expensive and hence application was limited to small Cold Rooms , Walk-ins , Blast Freeze and Frozen Food Stores
- Now being used in many cold chain projects.

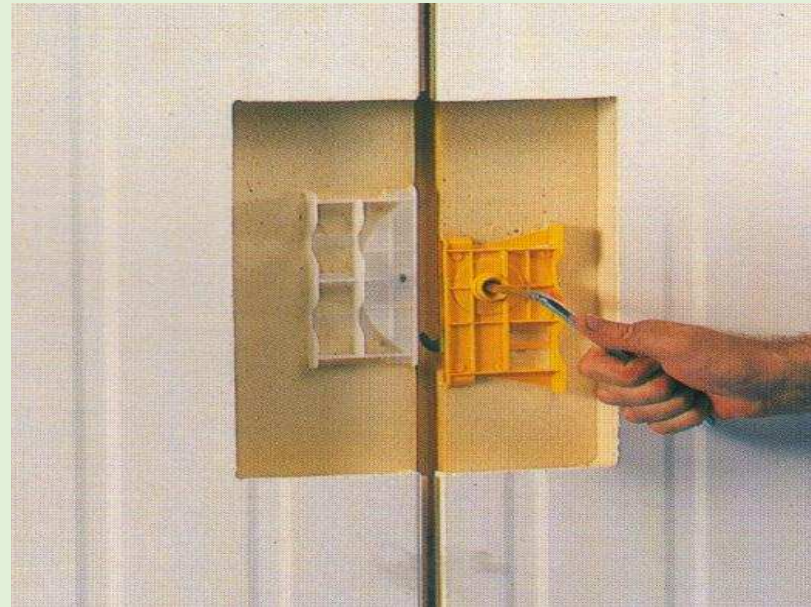
# INSULATION-RECOMMENDED

- Floor Insulation
  - Extruded polystyrene
- Wall panels
  - Polyurethane
- Roof Insulation
  - Polyisocyanurate

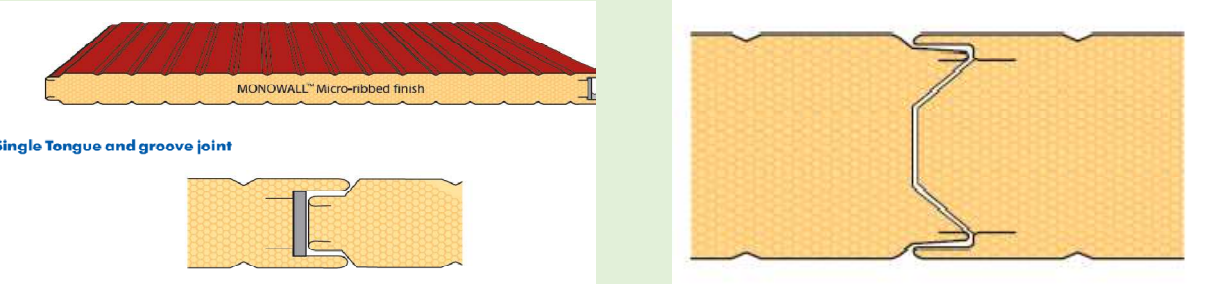


# CAM LOCK PANELS

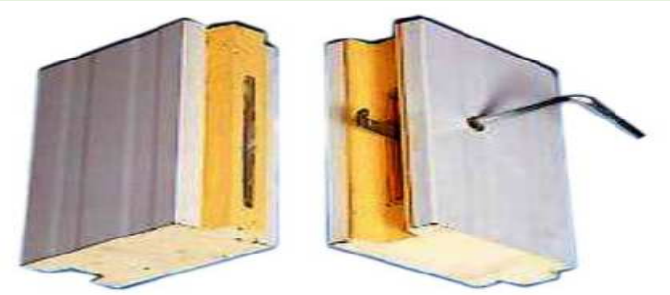
Camlocks with plastic hook



# PUR/PIR Panels



## TONGUE AND GROOVE JOINTS

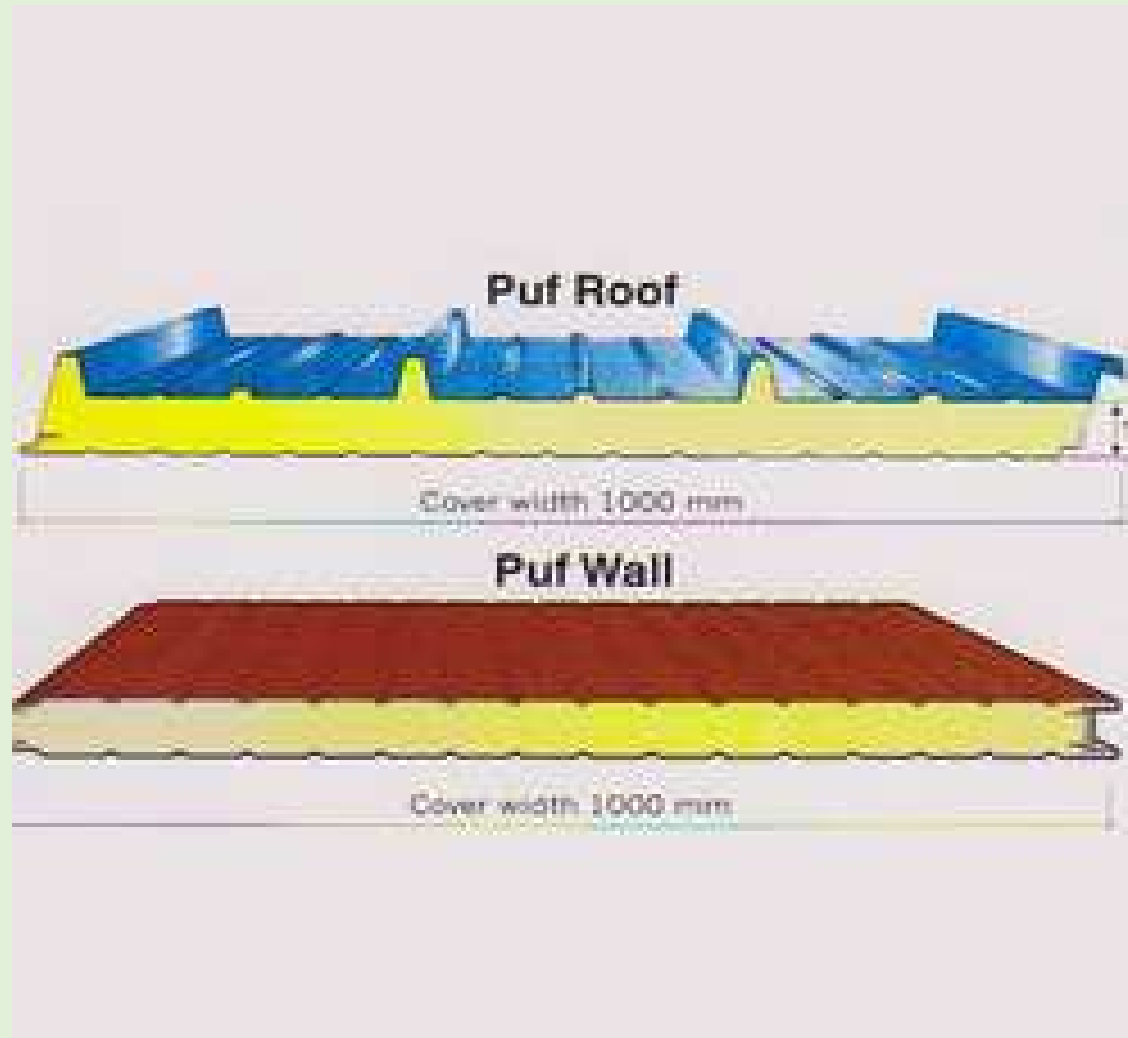


## CAM LOCK JOINTS

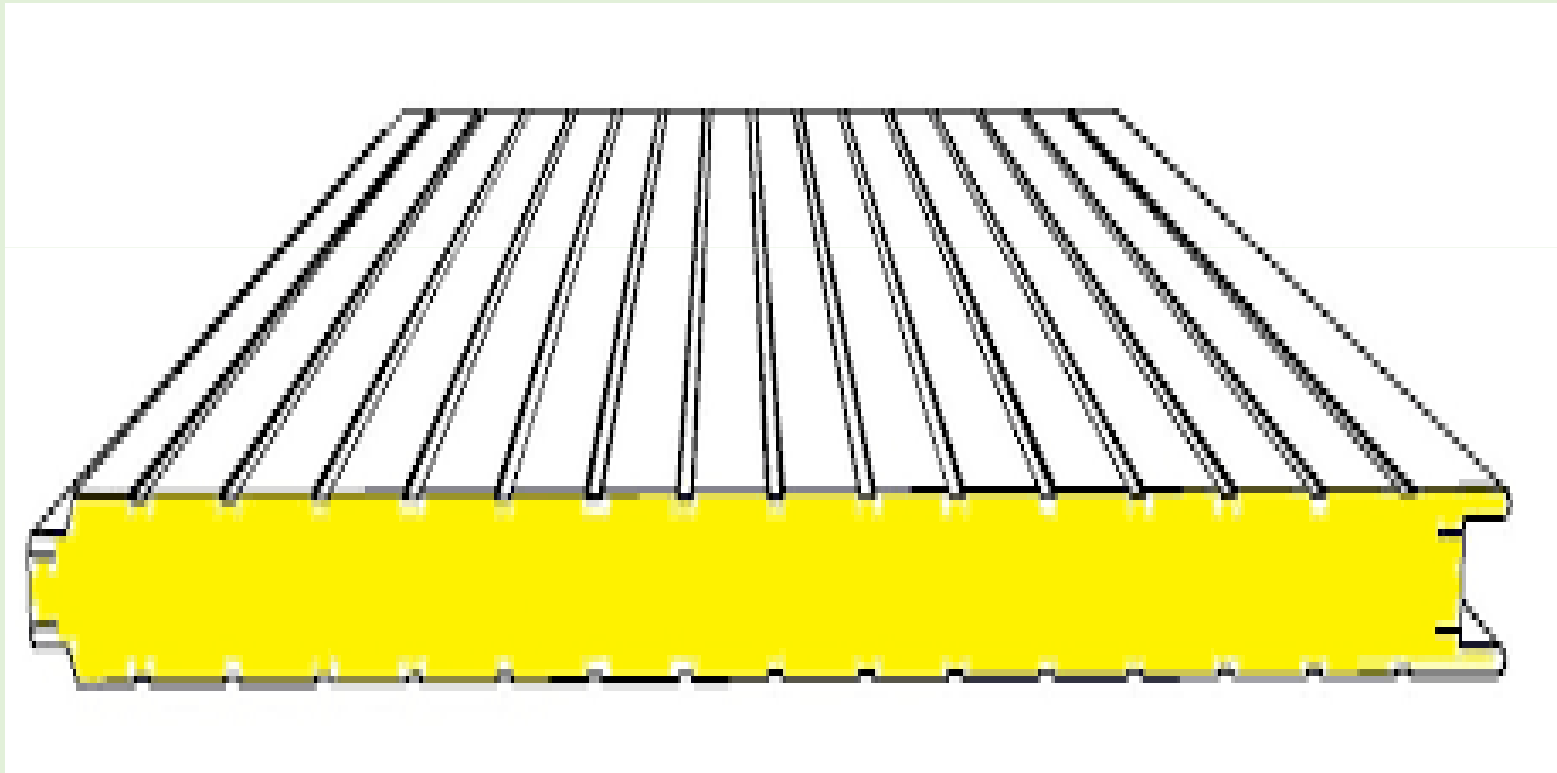
# EPS PANELS



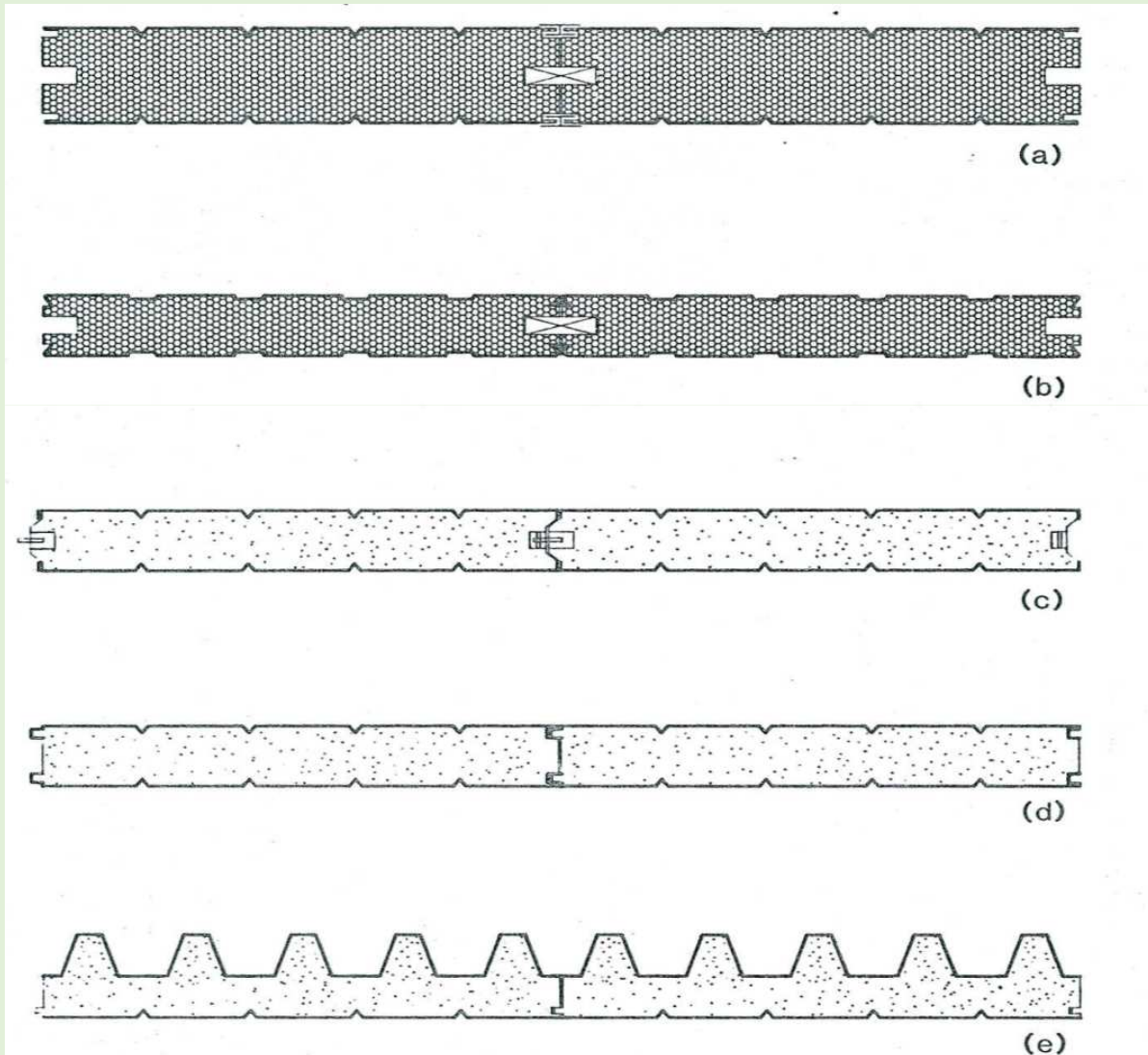
# PUF PANELS



# CONTINEOUS PANELS



# DIFFERENT TYPES OF INTERLOCKING FOR COLD ROOM PANELS



# SPRAY INSULATION



# MORE INSULATION MEANS LESS ENERGY AND MORE SAVINGS

	$Q = U \times A \times TD = U \times 2(21 \times 16 + 21 \times 13.7 + 16 \times 13.7) \times (45 - 3)$	
80mm	$U = 0.023 / 0.080 = 0.2875$	Q= 20.356 kW
100 mm	$U = 0.023 / 0.1 = 0.23$	Q= 16.284 kW
120mm	$U = 0.023 / 0.12 = 0.1976$	Q=13.57 kW
Savings	120mm instead 80 mm	20.356-13.57=6.786 kW/Room
Savings -4 Rooms	6.786 x4 =27.1 kW or 7.71 TR @ 1.1kW/TR=8.481 kW	
	8.481 kW x 8Rs/kW x 20 hrs/day x300 days = Rs. 4,07,088	

**K' Values for Various Material – (Btu/hr/sq.ft/Deg F /in OR W/m.k)**

**Polyisocyanurate Cellular Foam (R-141b expanded) Slabs – 0.16 / 0.027**

**Polyurethane Board Panels (R11-expanded) – 0.18 / 0.023 to 0.026**

**Polystyrene Extruded (R141b) – 0.24 / 0.035**

**Fiberglass – 0.24 / 0.035**

**Polystyrene Expanded (R141b) – 0.26 / 0.037**

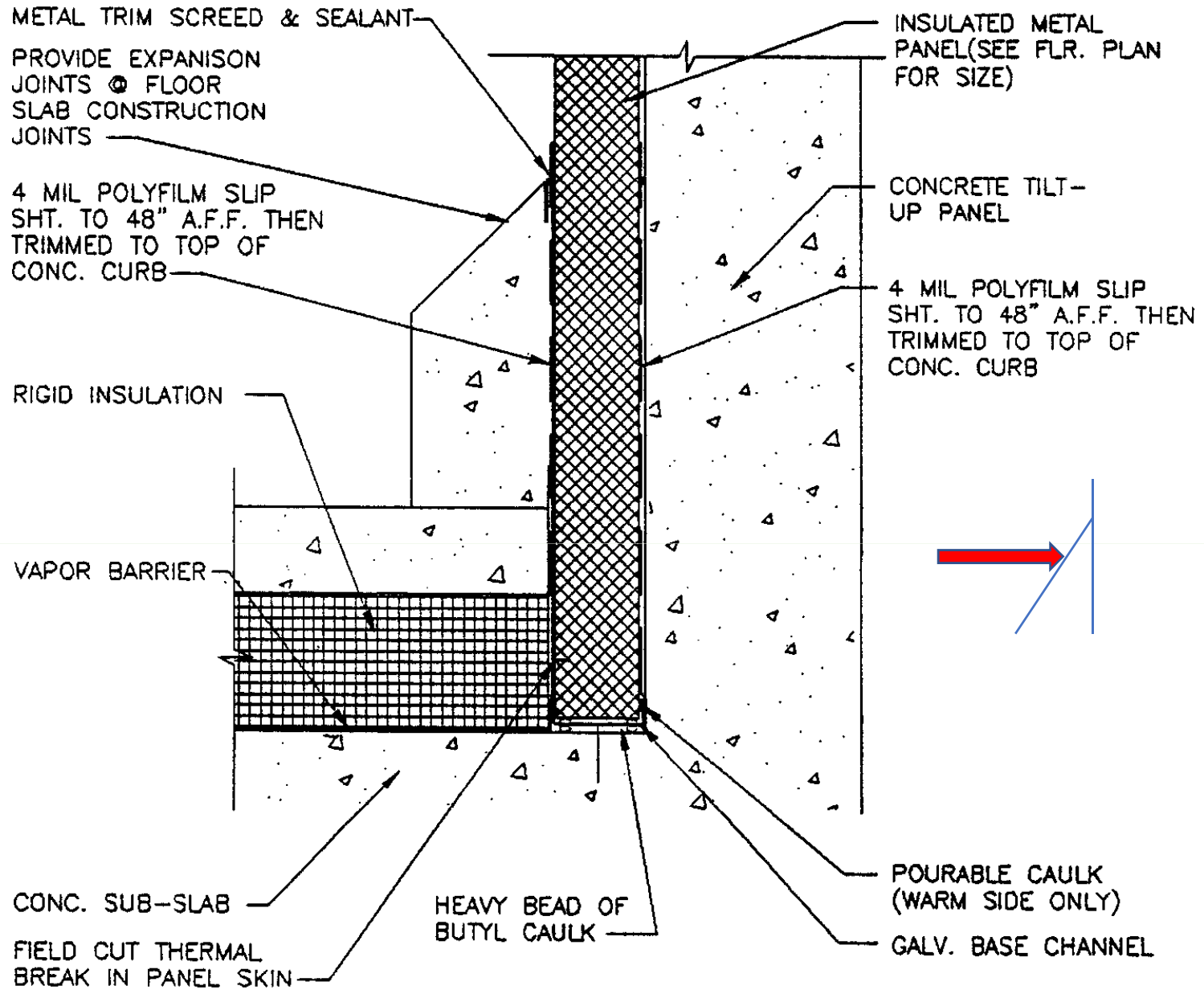
(Reference ASHRAE Refrigeration Volume 2014)

# RECOMMENDED INSULATION THICKNESS

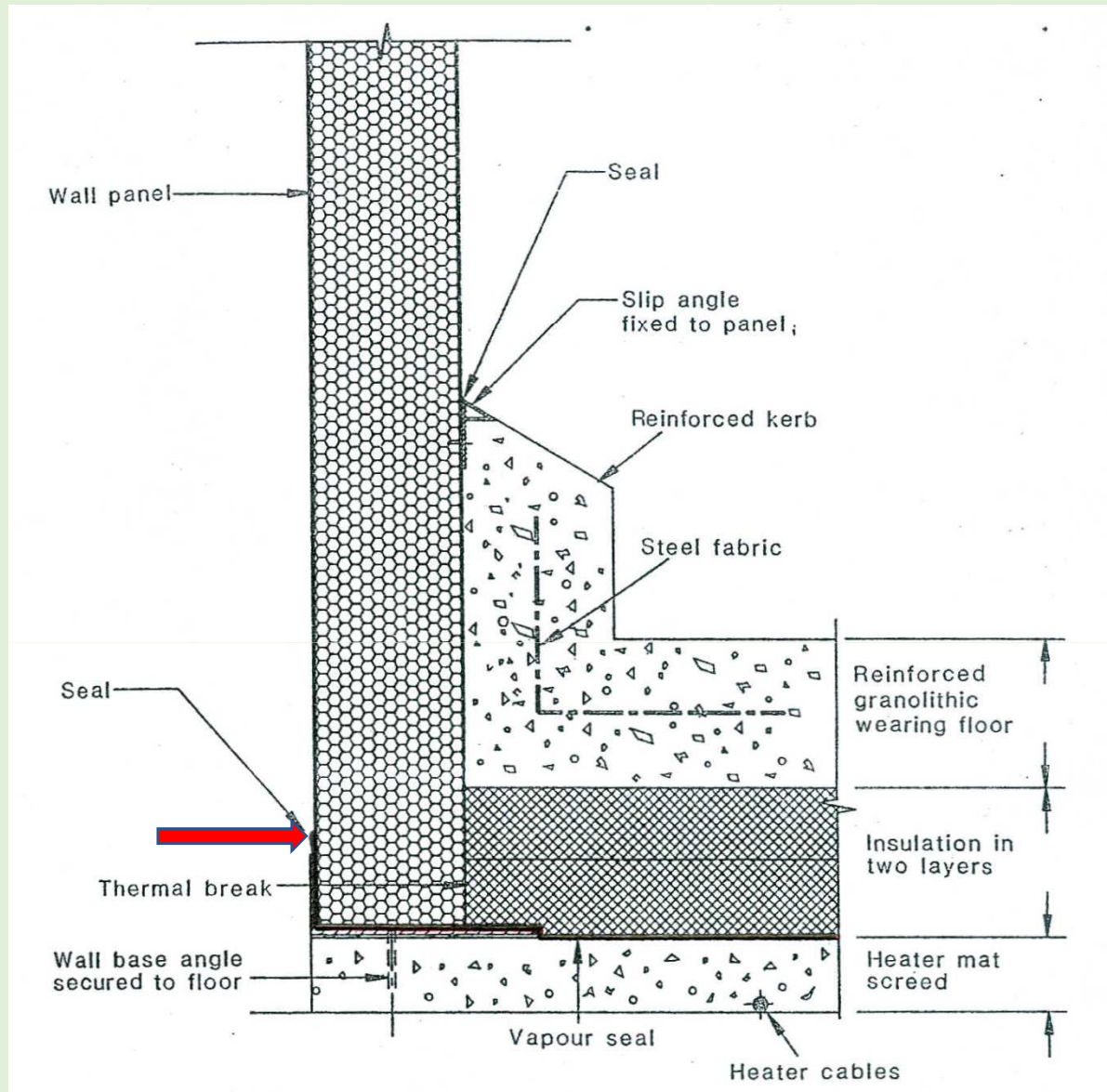
<b>Outside Temp Deg C / Deg F</b>	<b>Inside Temp Deg C / Deg F</b>	<b>Difference Deg C / Deg F</b>	<b>PUF/PIR Thickness (mm)</b>	<b>Polystyrene / Fiberglass</b>
<b>38 / 100.4</b>	<b>0 / 32</b>	<b>38 / 60.4</b>	<b>50</b>	<b>75</b>
<b>40 / 104</b>	<b>0 / 32</b>	<b>40 / 72</b>	<b>60</b>	<b>100</b>
<b>45 / 113</b>	<b>0 / 32</b>	<b>45 / 81</b>	<b>75</b>	<b>100</b>
<b>38 / 100.4</b>	<b>-23 / -9.4</b>	<b>61 / 91</b>	<b>150</b>	<b>200</b>
<b>40 / 104</b>	<b>-23 / -9.4</b>	<b>63 / 94.6</b>	<b>150</b>	<b>200</b>
<b>45 / 113</b>	<b>-23 / -9.4</b>	<b>68 / 104.6</b>	<b>150</b>	<b>200</b>

(

HOW TO CONSTRUCT WALLS/PARTITION  
WALLS, CEILING & FLOORING SO THAT IT  
BECOMES MOISTURE PROOF BUILDING &  
WITH MINIMUM HEAT GAIN

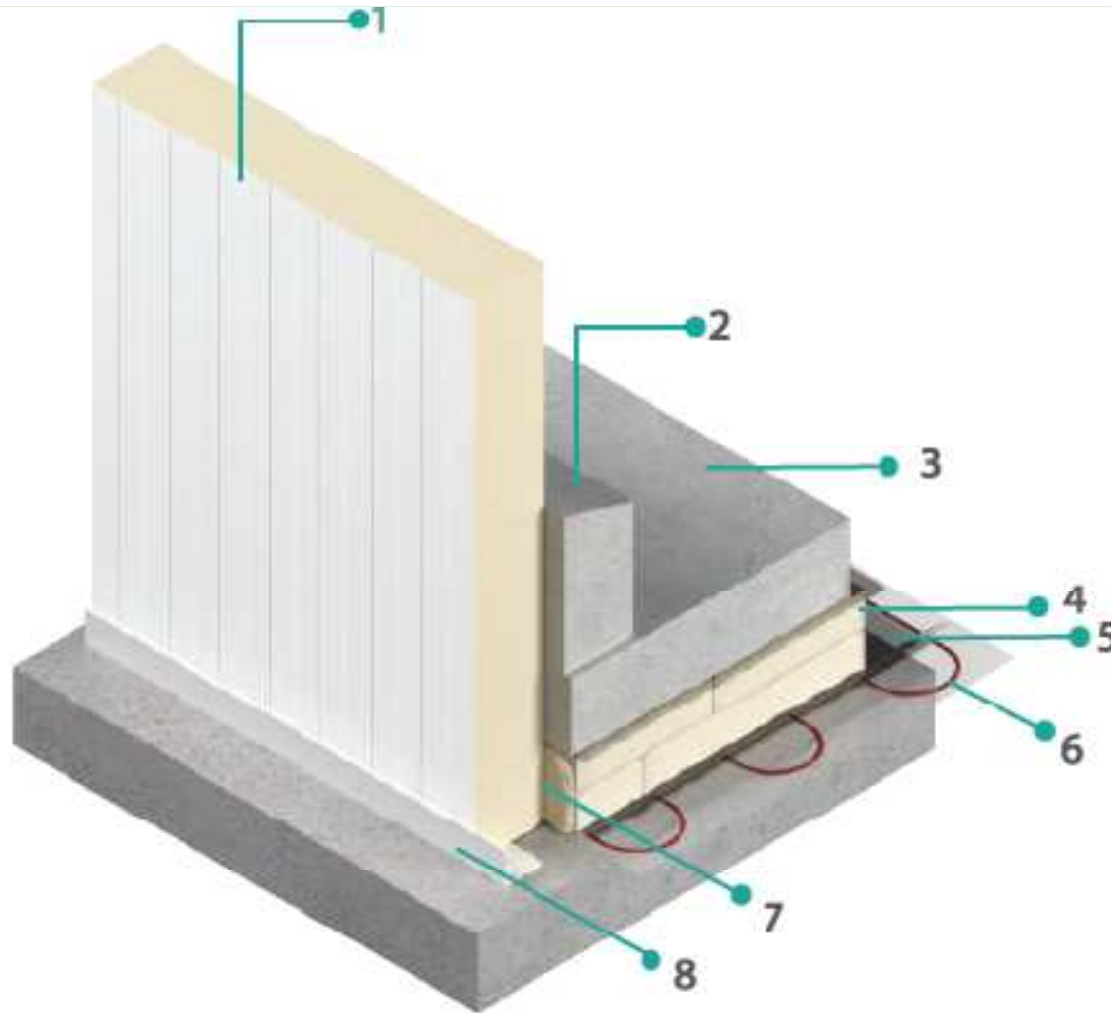


## EXTERIOR WALL AT FREEZERS



Vapour Sealing for Wall to Floor

## WALL TO FLOOR JOINT



1 Wall Panel

2 Concrete Upstand

3 Concrete Floor

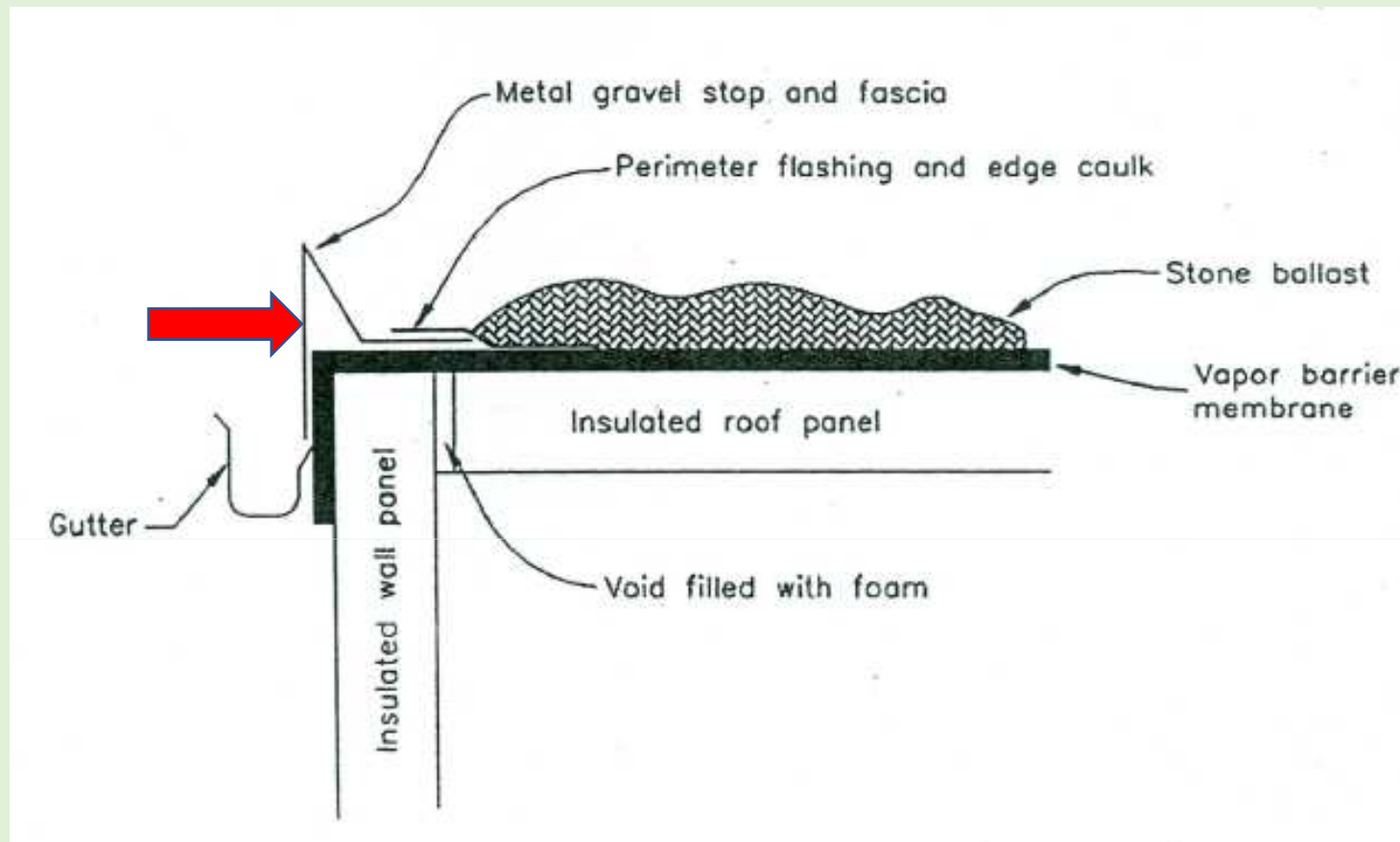
4 2 Layers of Floor Insulation

5 Vapour Barrier

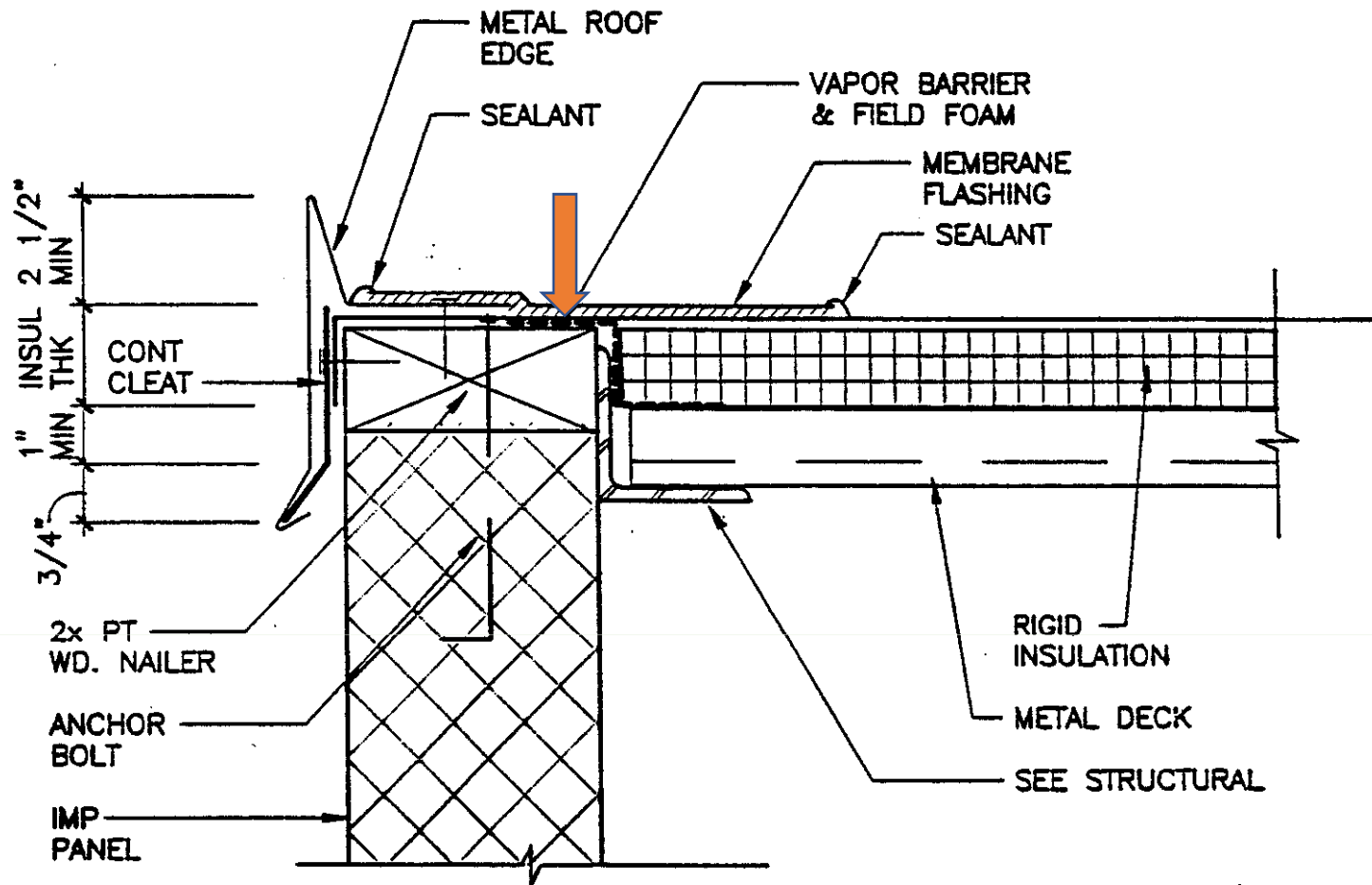
6 Floor Heater Cables

7 Spray Foam

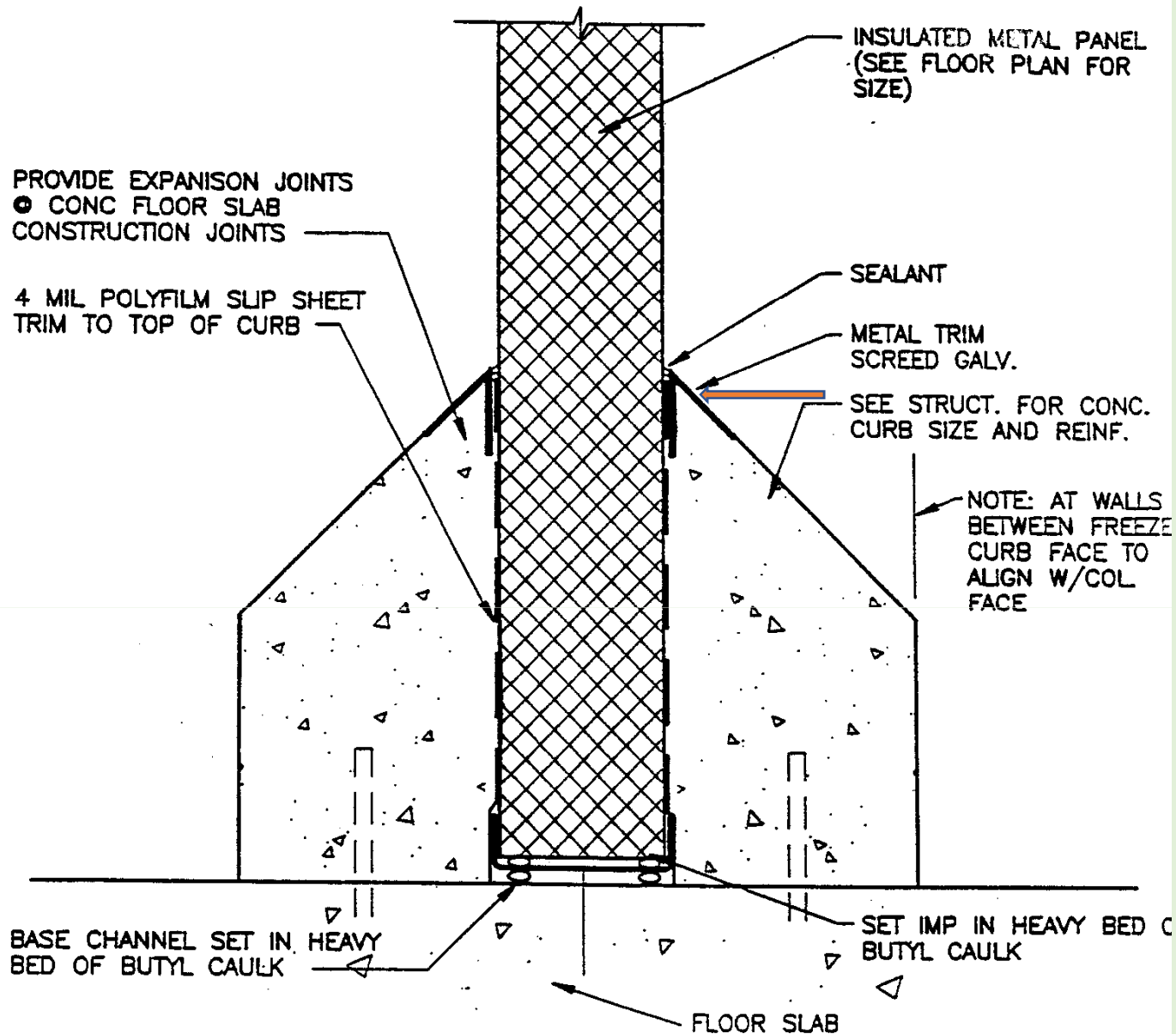
8 Floor Angle



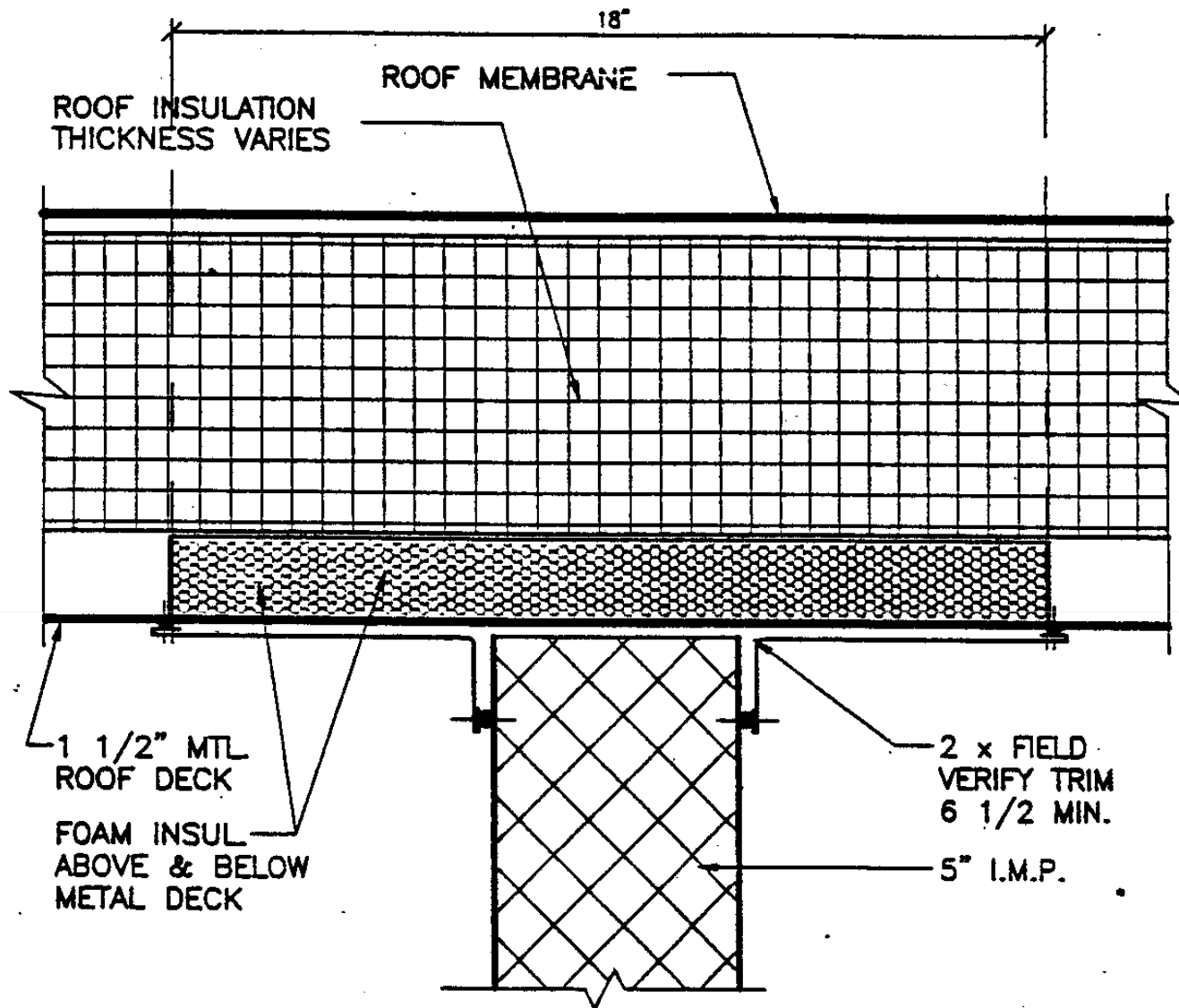
## Vapour Sealing for Roof



## FLASHING AT EXTERIOR INSULATED METAL PANEL WALL

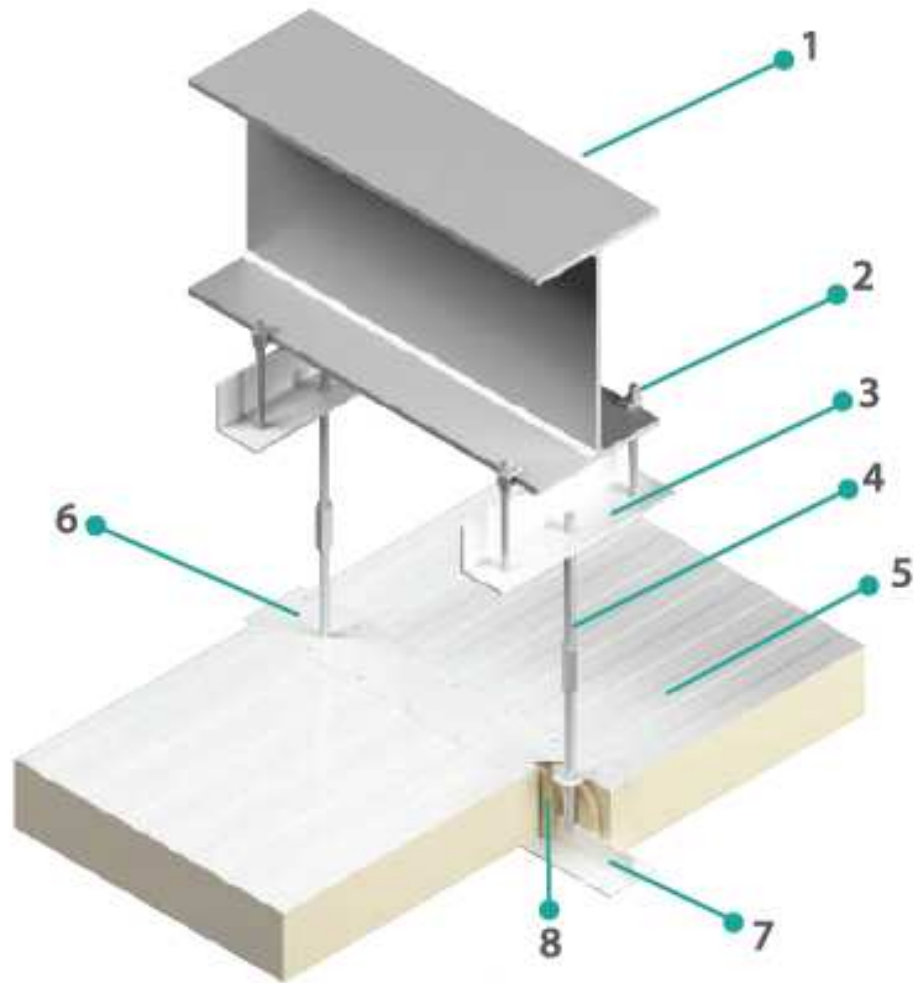


## INTERIOR WALL WITH CURBS



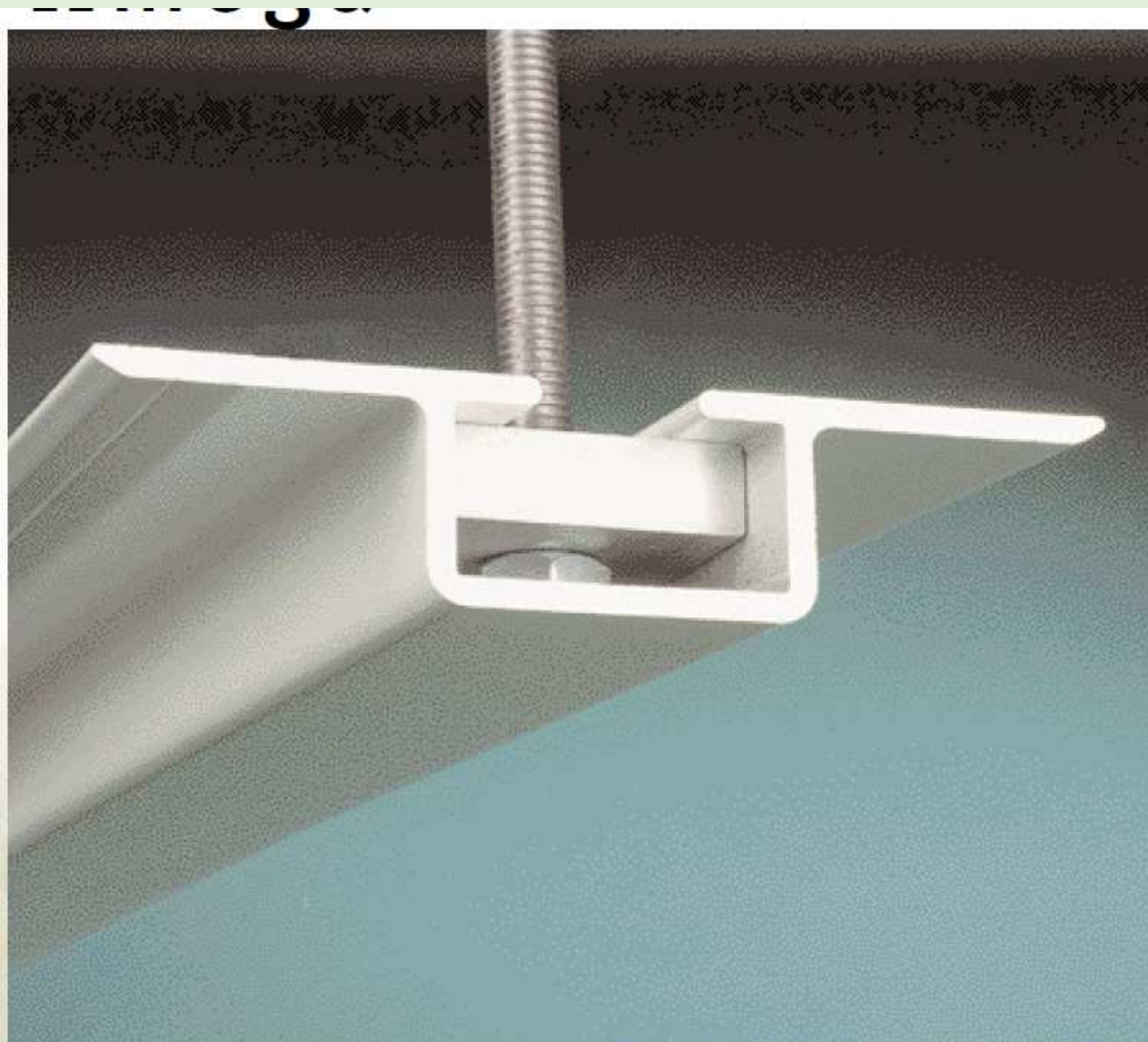
**IMP PERPENDICULAR TO ROOF DECKING**

## CEILING SUSPENSION



- 1 Rafter
- 2 Beam Clamp
- 3 Angle Support
- 4 Threaded Rod

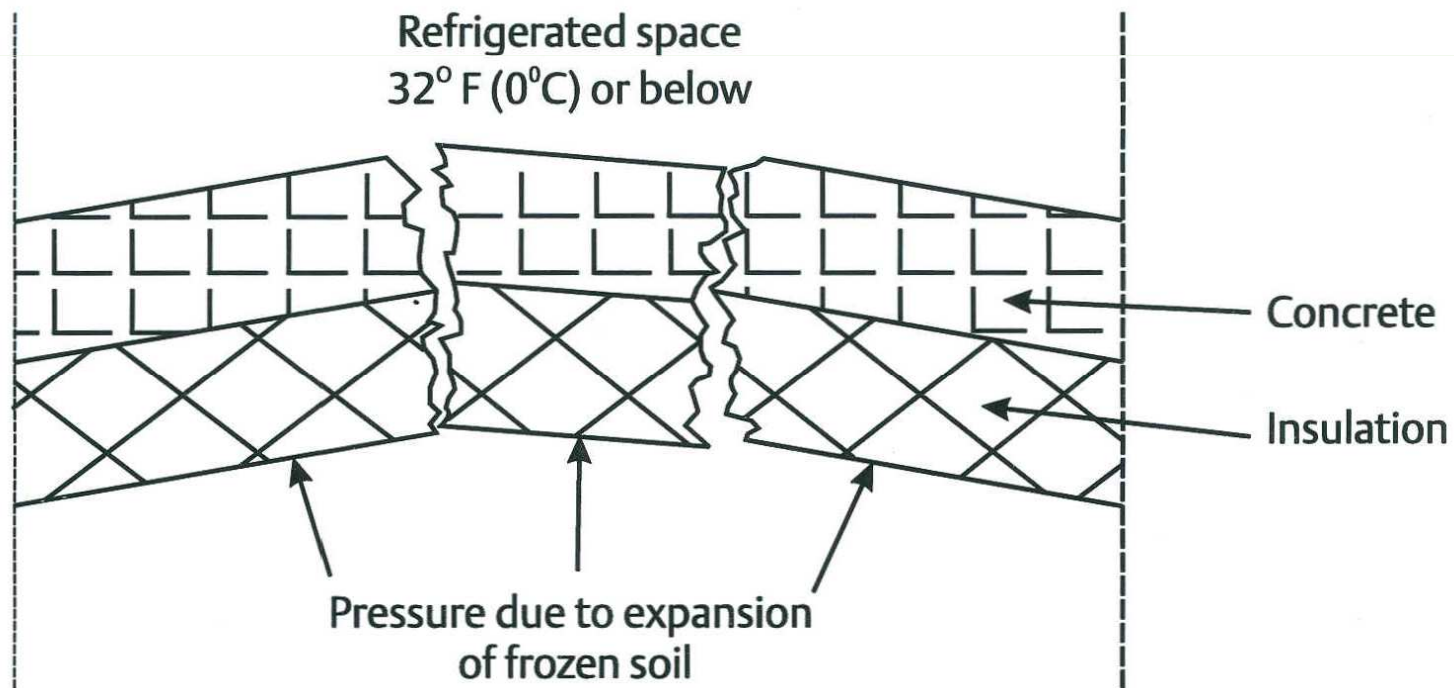
- 5 Ceiling Panel
- 6 Flat Flashing
- 7 Aluminium T-Suspension
- 8 Spray Foam



**OMEGA profile** for ceiling suspension solutions.  
Made from GFK / Polyester ensuring **no condensation !**

# No proper Floor Construction & its vapour ceiling as well as its insulation

## Frost heaving and its prevention



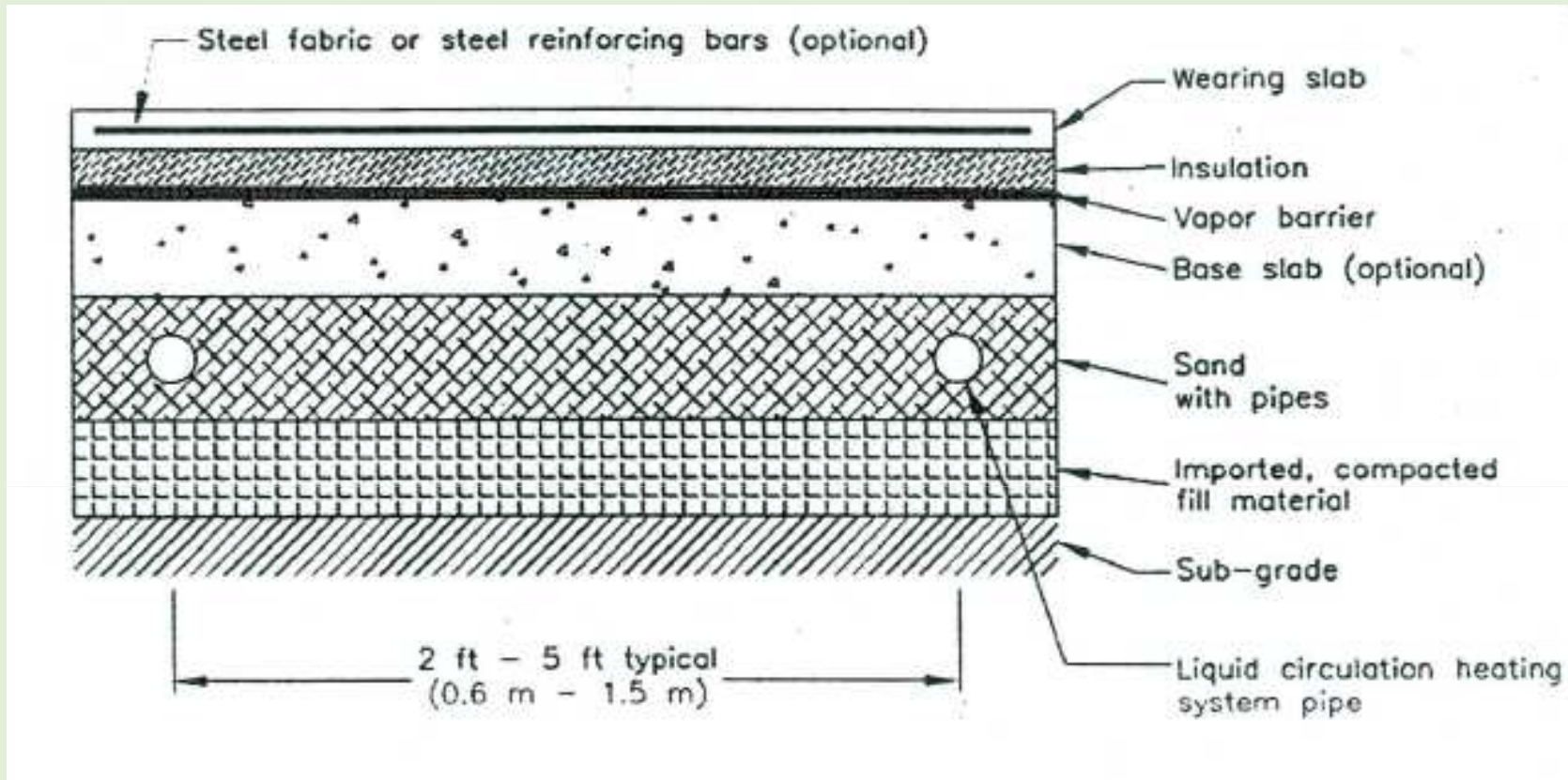
# FLOOR CONSTRUCTION

- Floors
  - Type of finish
  - Slope (  $1/8$  in. –  $1/4$  in. )
  - Drains  $1/400$  s.f.
- Floor insulation
- Vapor barrier

# FLOOR CONSTRUCTION

## Most Common Approach -

1. Under Floor Heat System –
2. Concrete Sub Slab
3. 10 mill Poly Vapor Barrier –
4. 2 Layers of Extruded Polystyrene(5”-6”-7”) –
5. 6 mill Poly Slip Sheet –
6. Concrete Finish Floor(5”-8”)



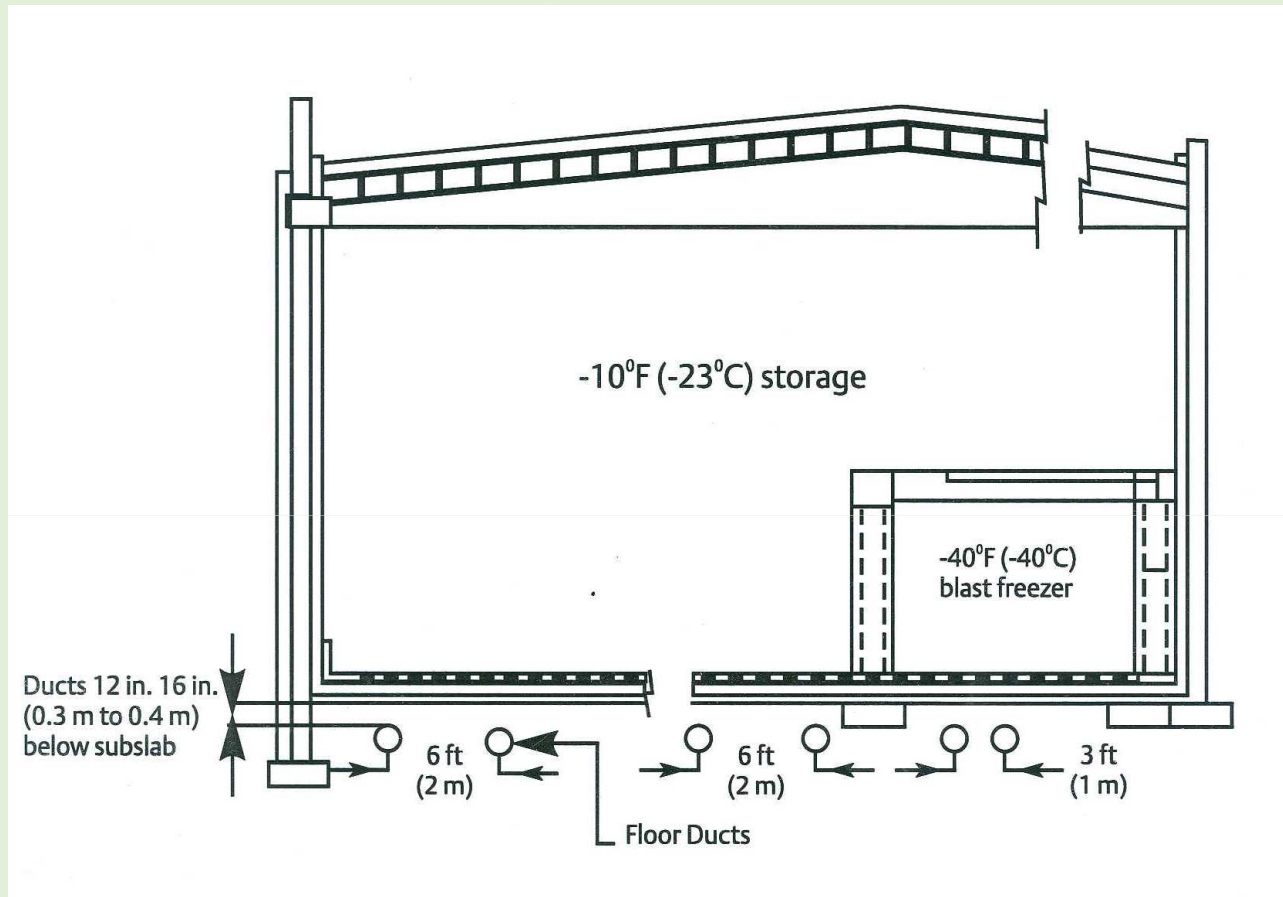
Vapour sealing & Glycol circulation system for Floor warming

# FLOOR WARMING

Any moisture in the sub soil freezes and causes floor frost heaving.

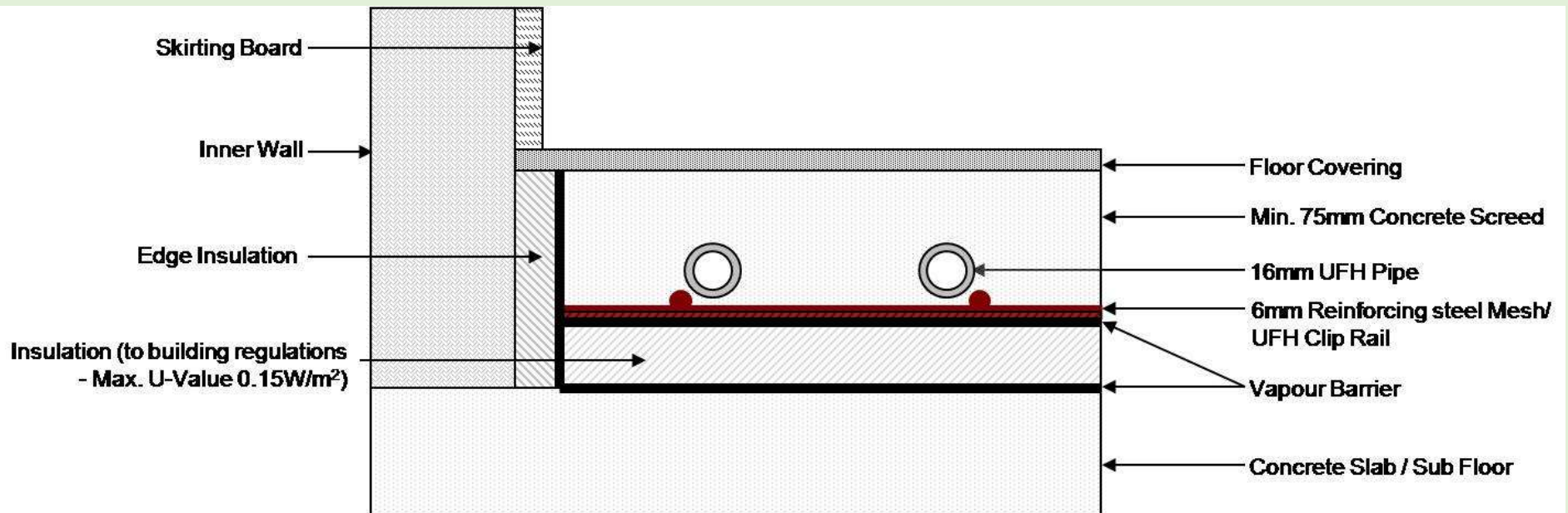
- There are methods to avoid these such as
  1. under floor tubes vented to atmospheric air
  2. Artificial heating by air circulated through under floor ducts
  3. Glycol circulated through plastic pipes
  4. Electric heating cables



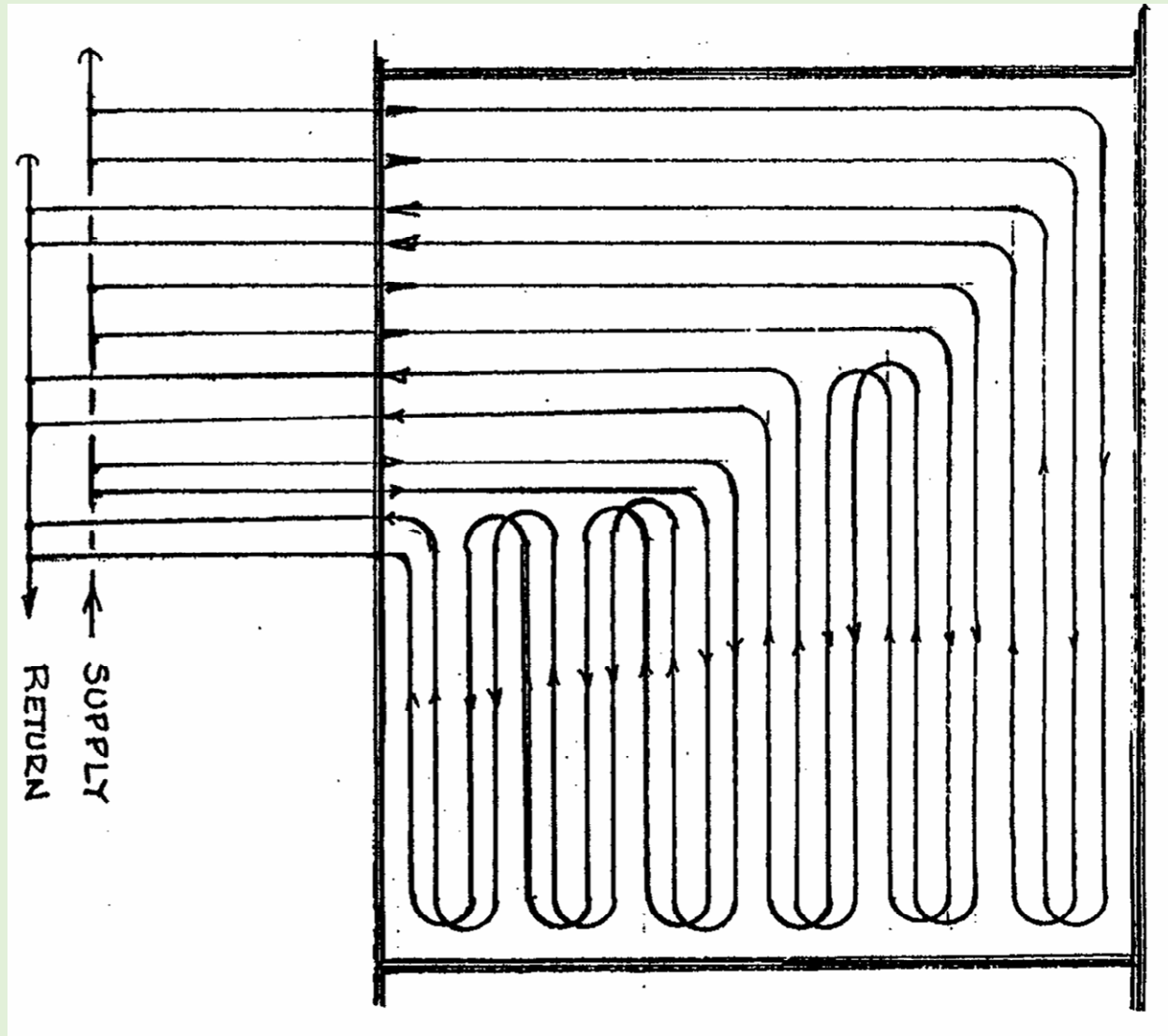


Ventilation Pipes to prevent frost heaving

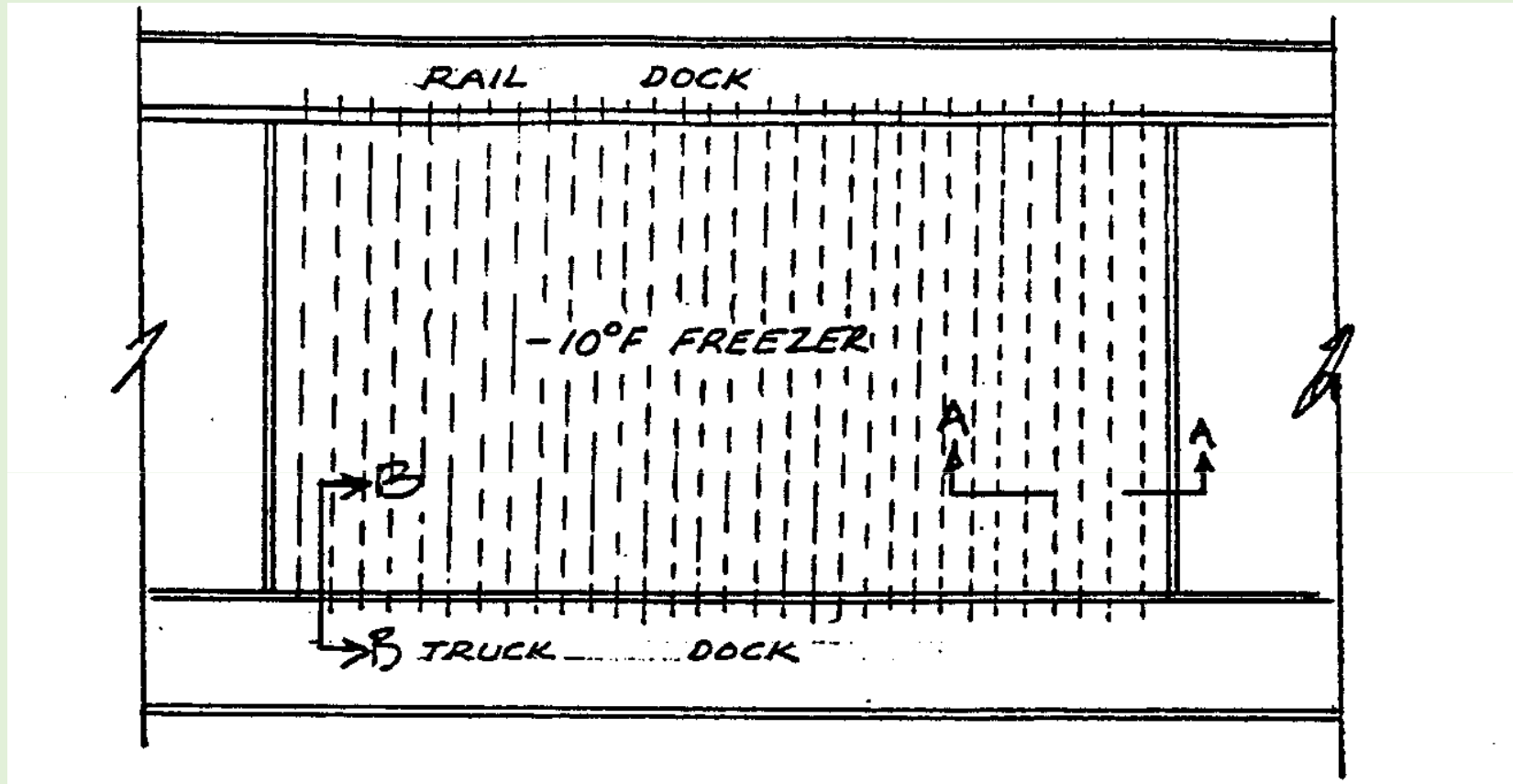
# FLOOR AIR VENTS



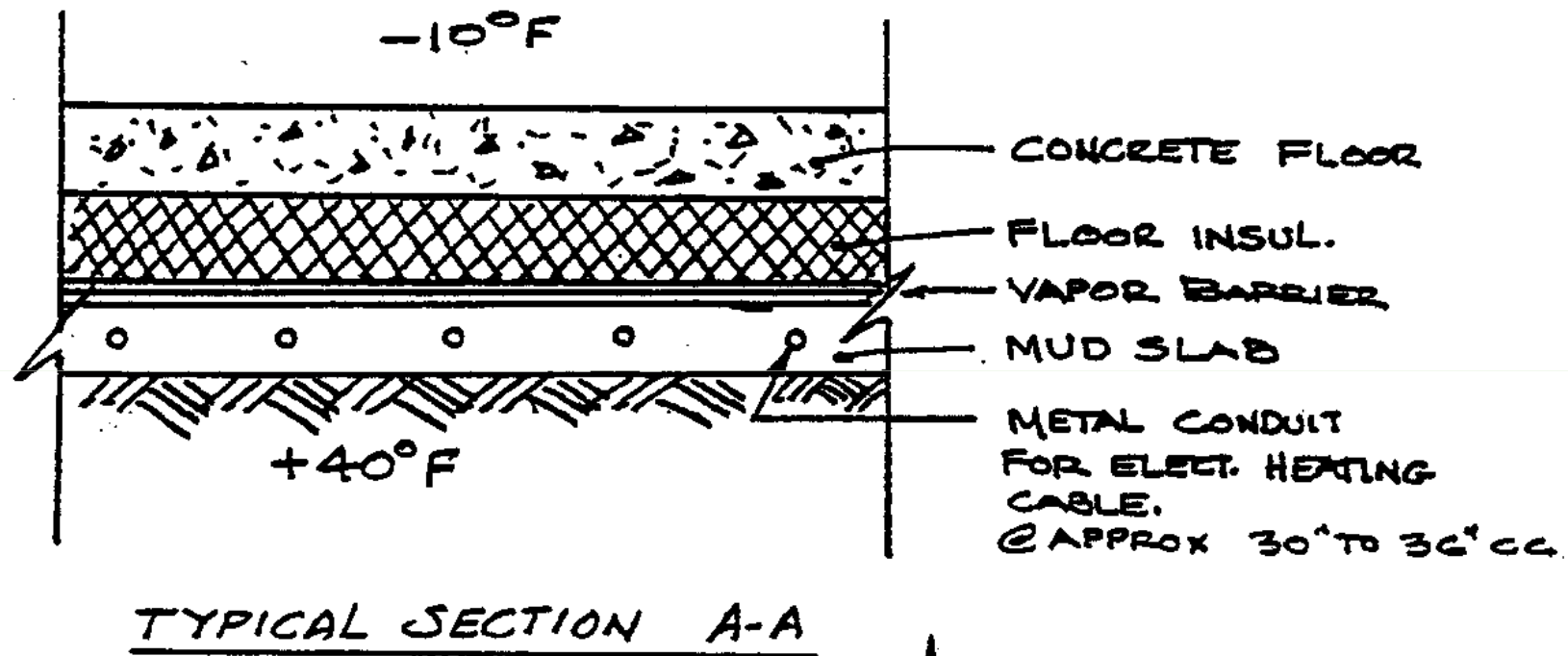
**GLYCOL  
FLOOR  
WARMING  
SYSTEM**



1000 ft maximum length  
No joints permitted under floor



## ELECTRIC FLOOR WARMING SYSTEM



## ELECTRIC UNDERFLOOR WARMING SYSTEM

# Electrical cable warming under the floor



# RACKS

- Structural Racks
- Double Deep
- Drive in Racks
- Select Racks
- Rack Uprights
- 10' - 12' aisles
- 35' Clear Height Minimum
- 34.0' Reach Height
- Convertible Rooms

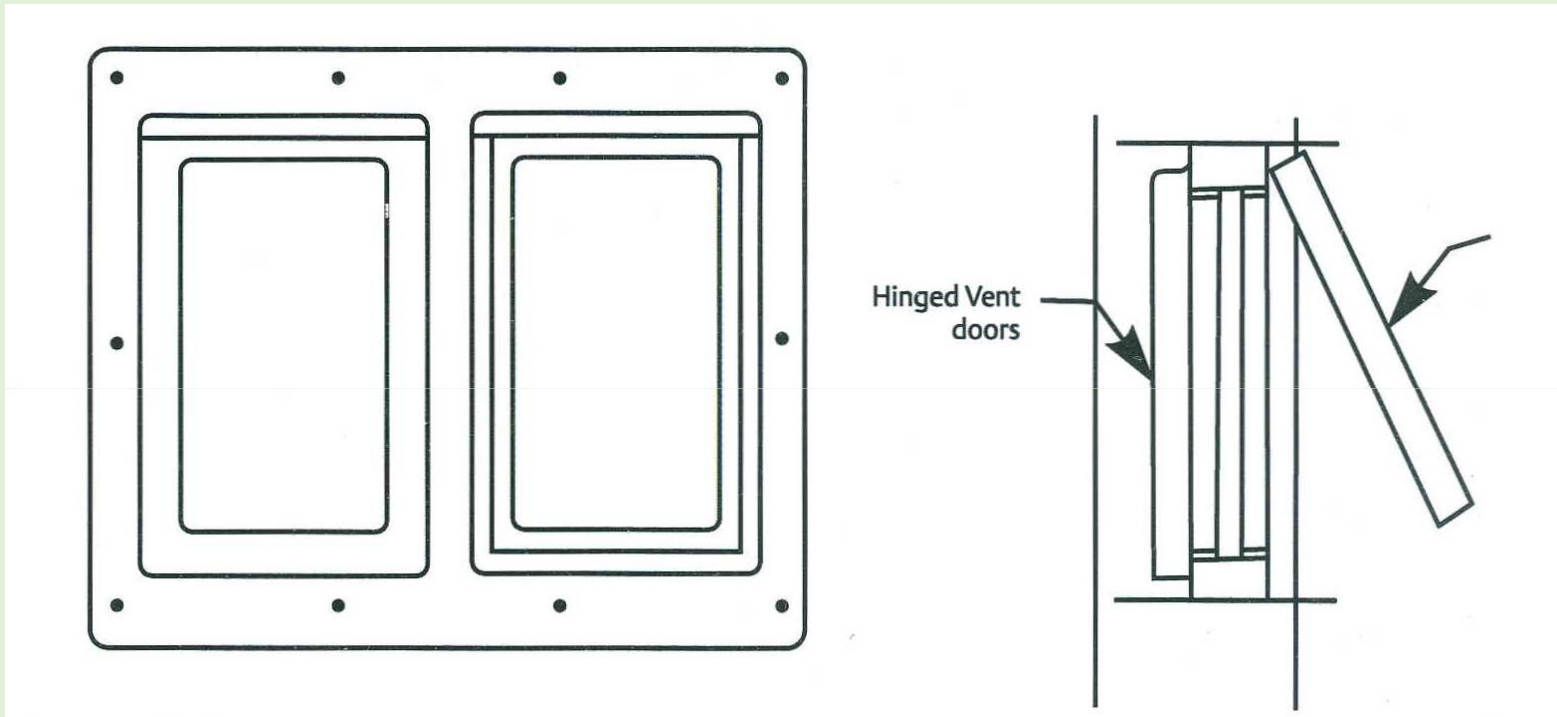


# RACKING SYSTEM



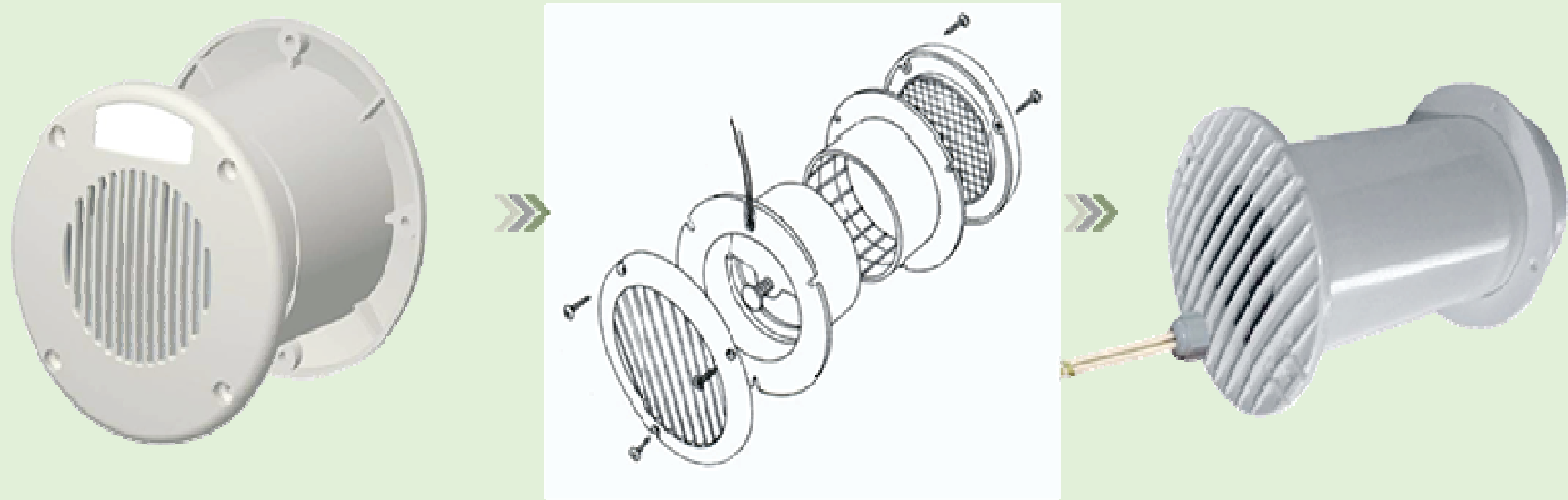


**RACKING SYSTEM**



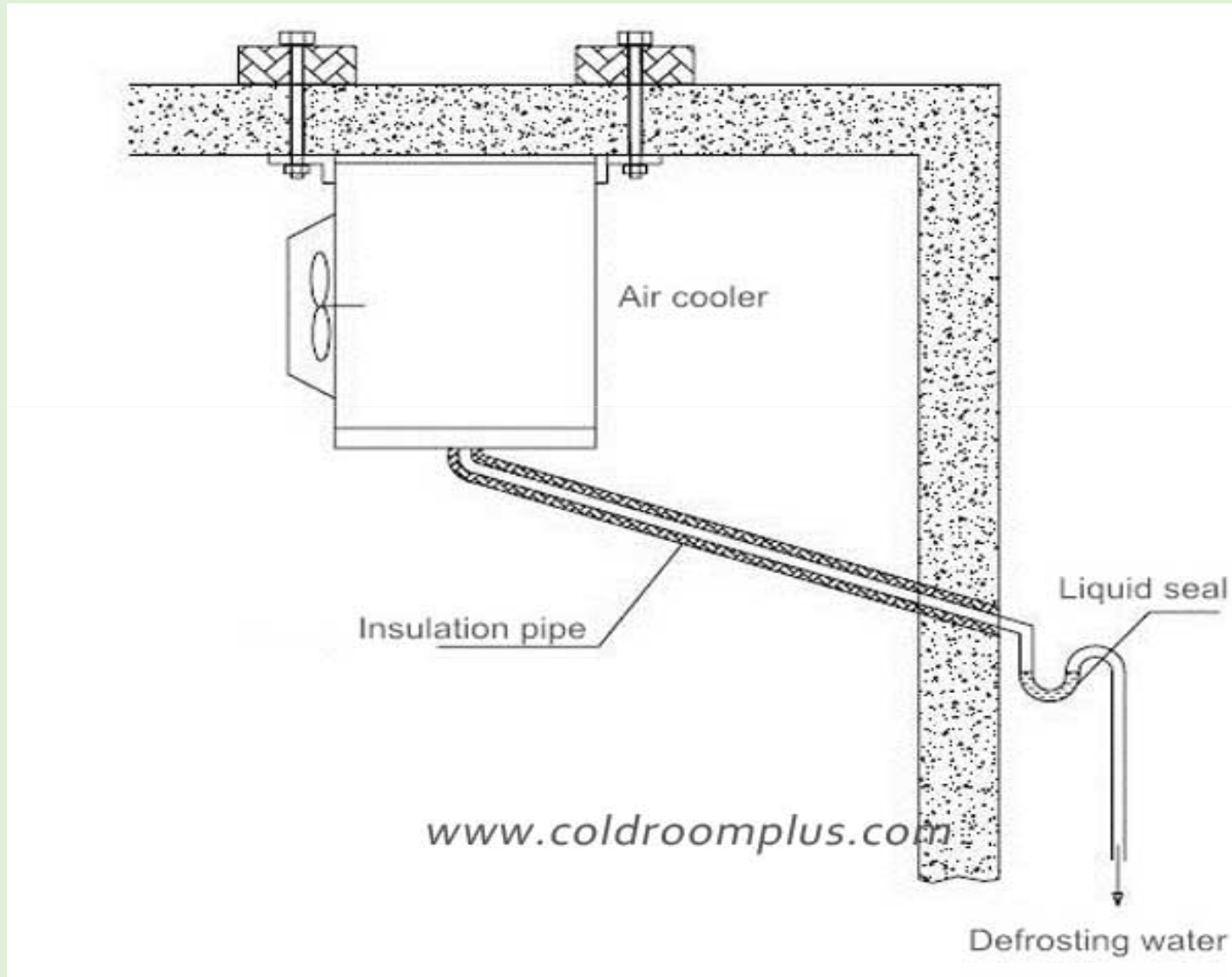
Pressure Equalization Vent flaps

# Pressure Equalizing Valves



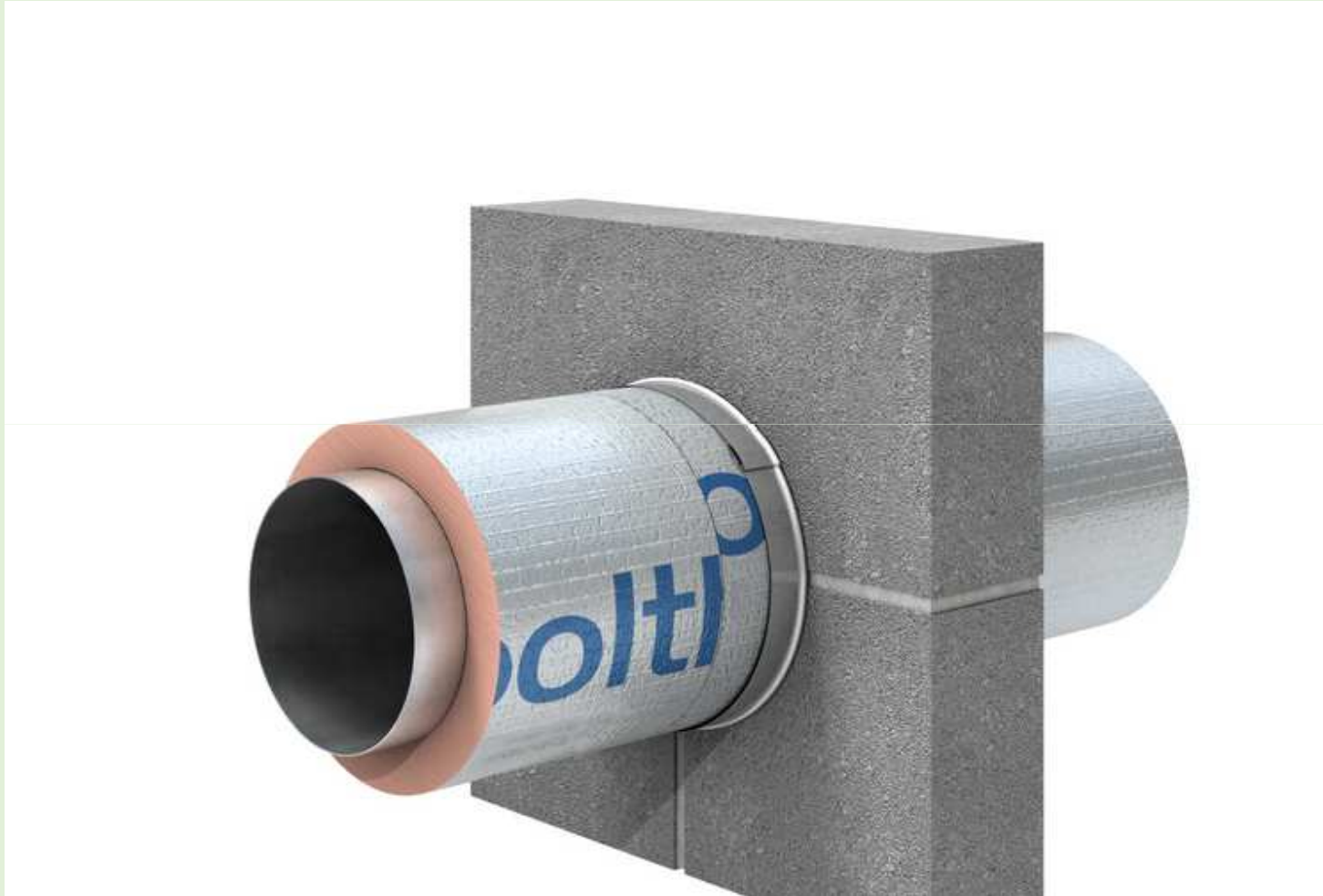
When air is cooled, its density increases and internal pressure reduces, if no equalizing valves are provided, the panels distort or collapse.

# AIR COOLER DRAIN PIPING WITH LIQUID SEAL





# Wall Penetration of pipe fitting



26<sup>th</sup> June 2020

# Wall Penetration of pipe fitting



26<sup>th</sup> June 2020

**Sliding doors with Electronic sensors to ensure the door opening time is kept minimum, helps in saving energy to large extend**

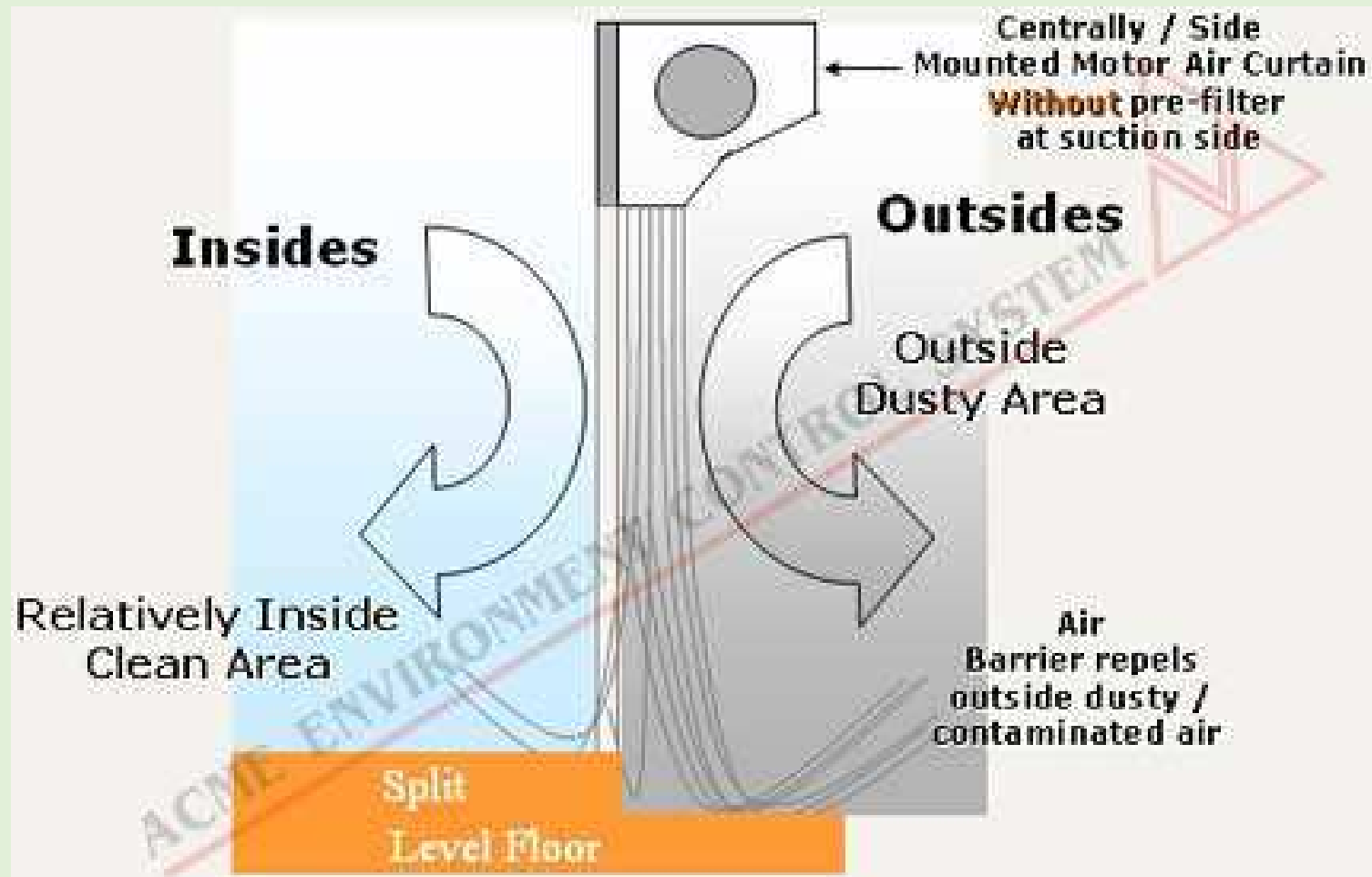


## **PVC DOOR CURTAINS**

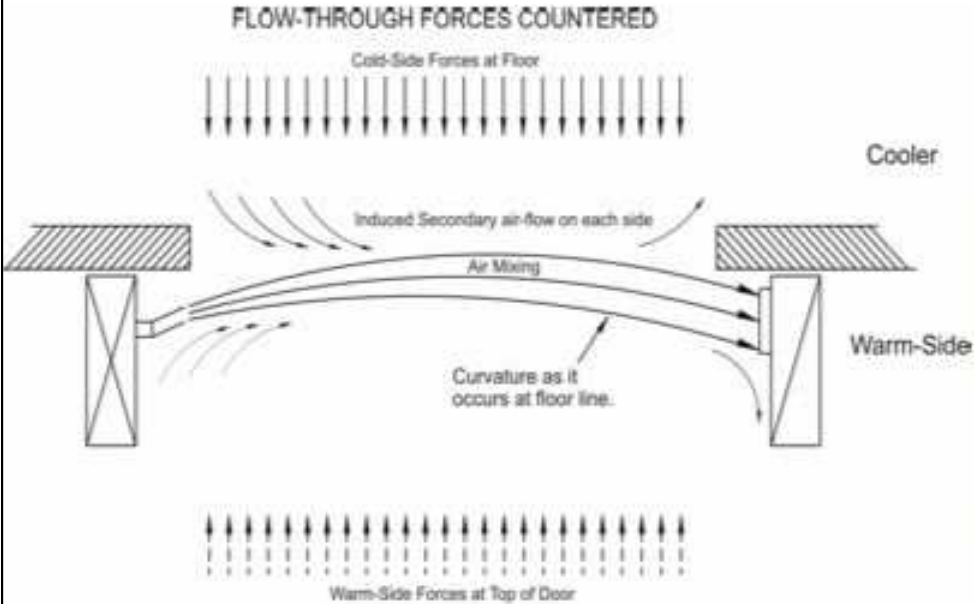
PVC 2mm thick, strip curtains are often used in cold storages. They are preferred to prevent the cold air escaping from the room when the door is opened. Because the most heat loss is experienced when the doors remain open. In addition to cold storage, PVC curtains are also preferred for the outside doors of factory and hangars.

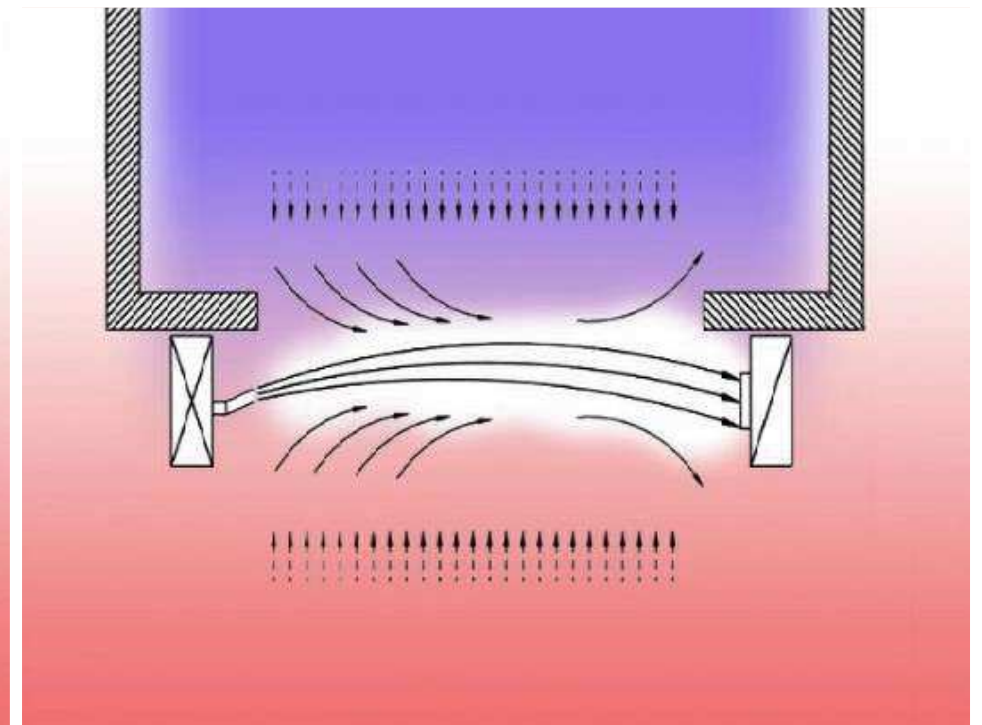
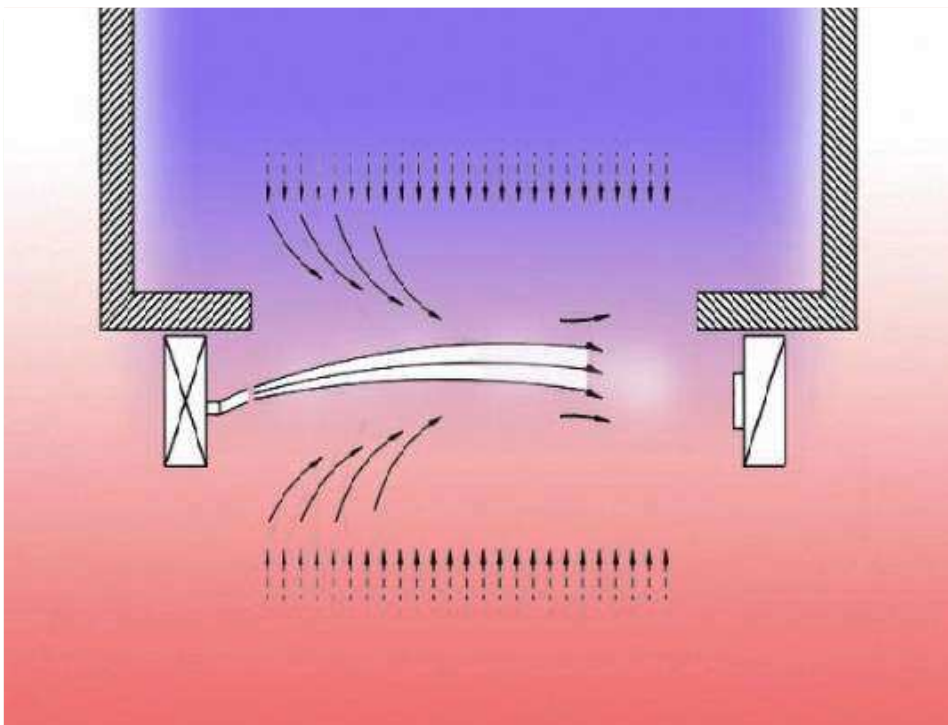
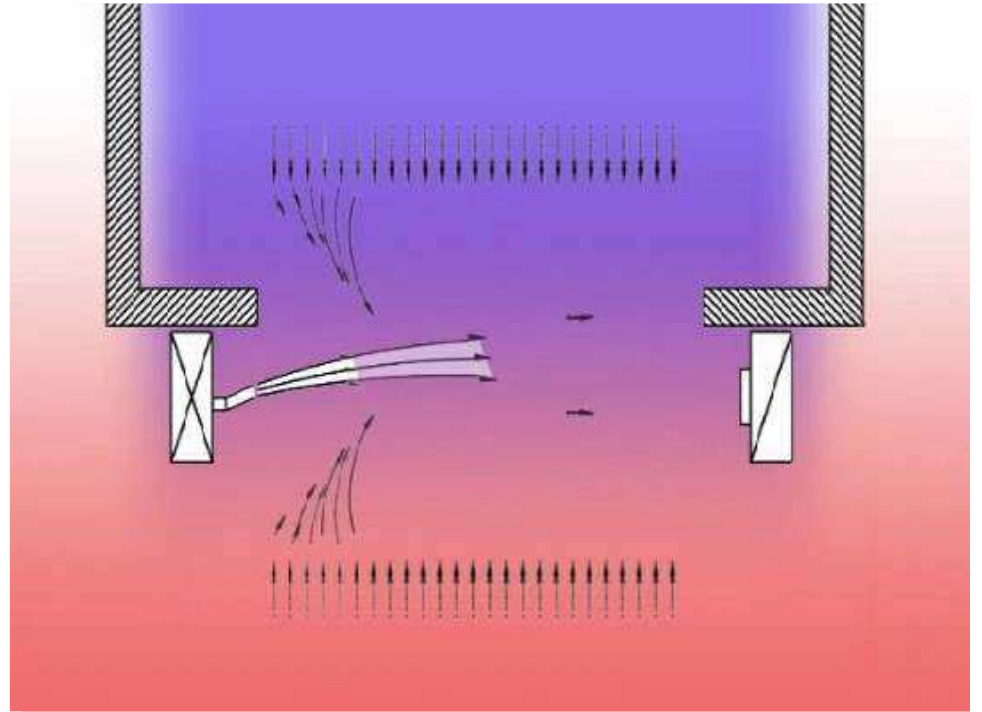
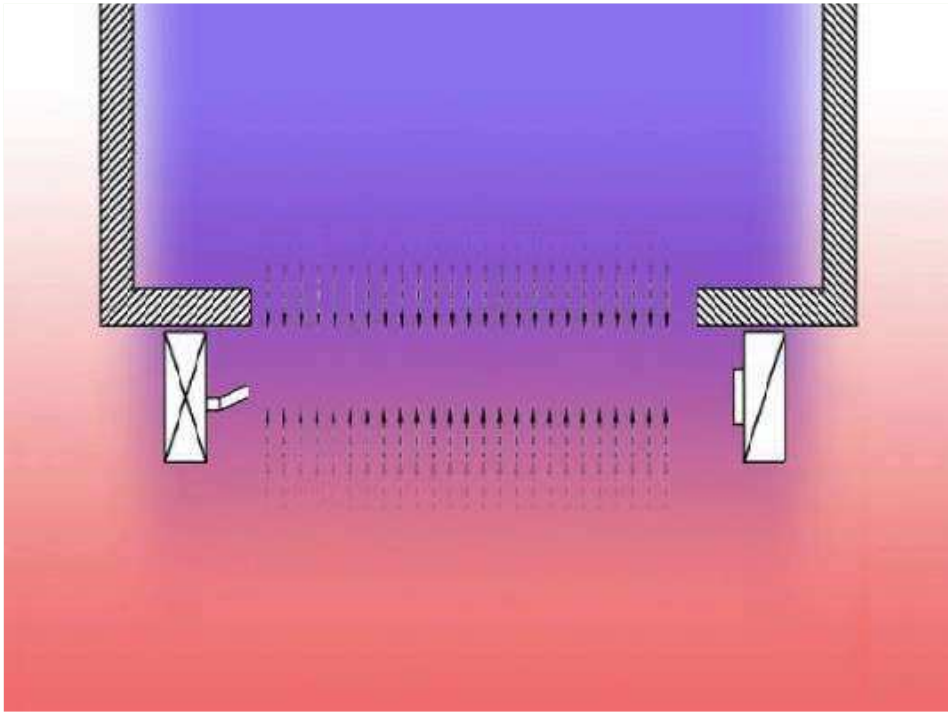


# AIR CURTAINS



# HCR Model AC Air Curtain

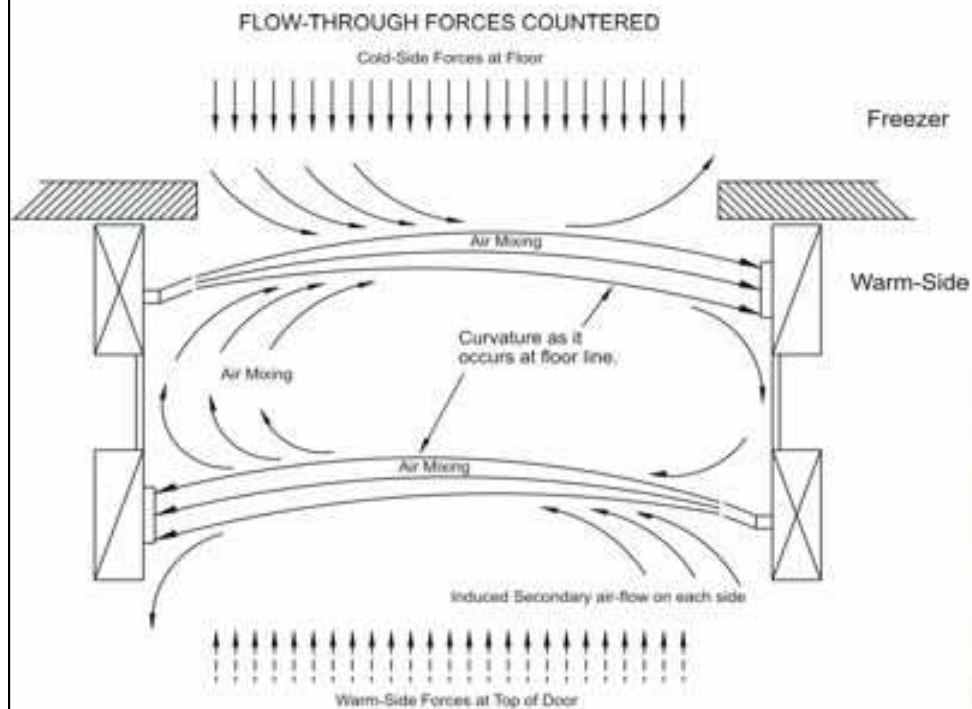






# HCR Model DCAV

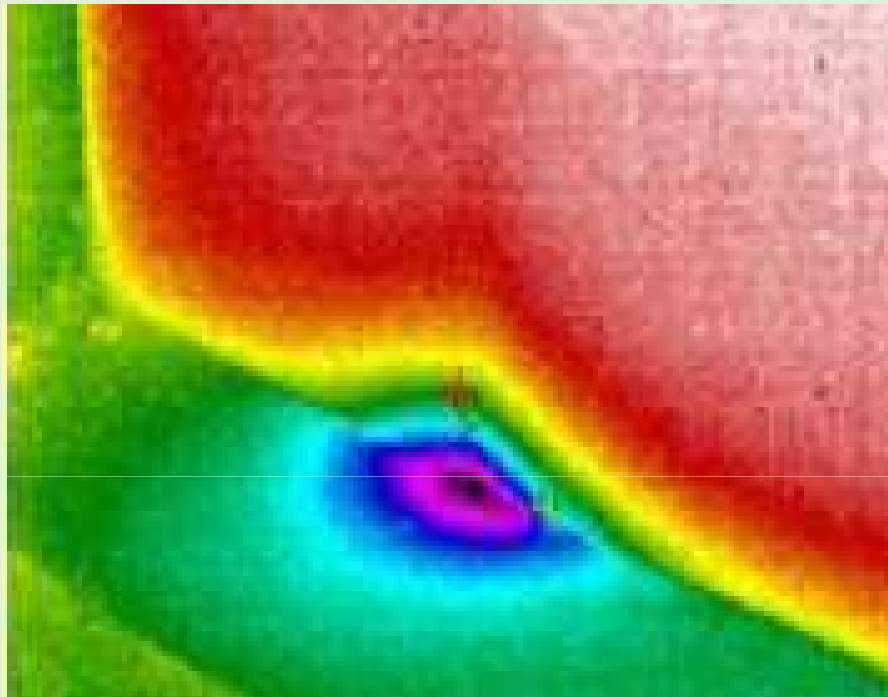
## Double Conditioned Air Vestibule



# **INSULATION LEAKAGE TEST- THERMOGRAPHY**

## SITE AND MEASURING PARAMETERS

OBJECT PARAMETER	LOCATION	DISTANCE	CONDITIONED PREMISE TEMP.	OUTSIDE AMBIENT TEMP.	EMISSIVITY
Value	Outdoor	05 FT	-21 C	23 C	0.95

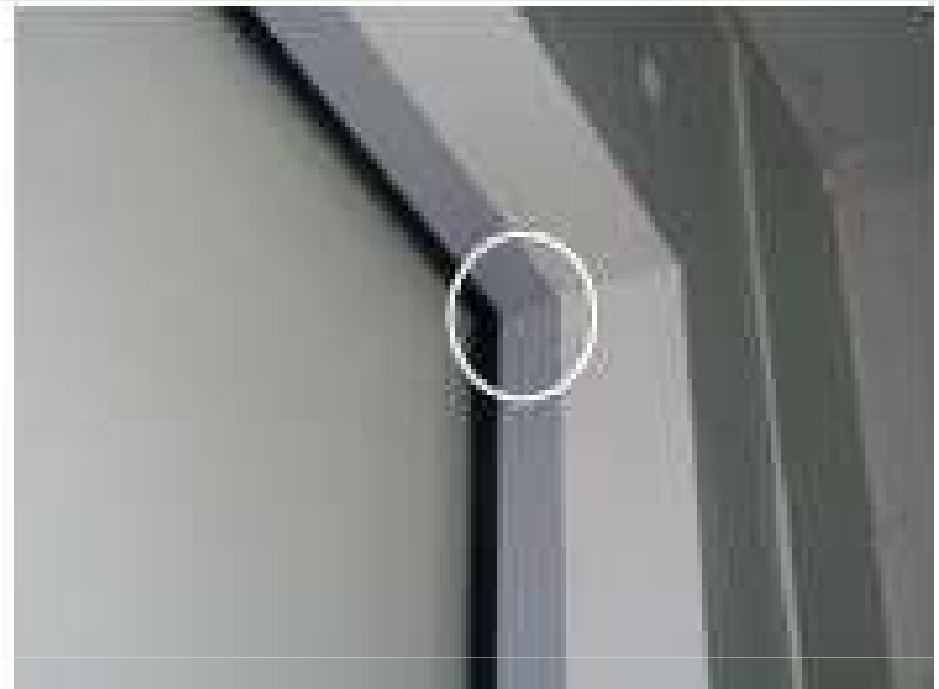
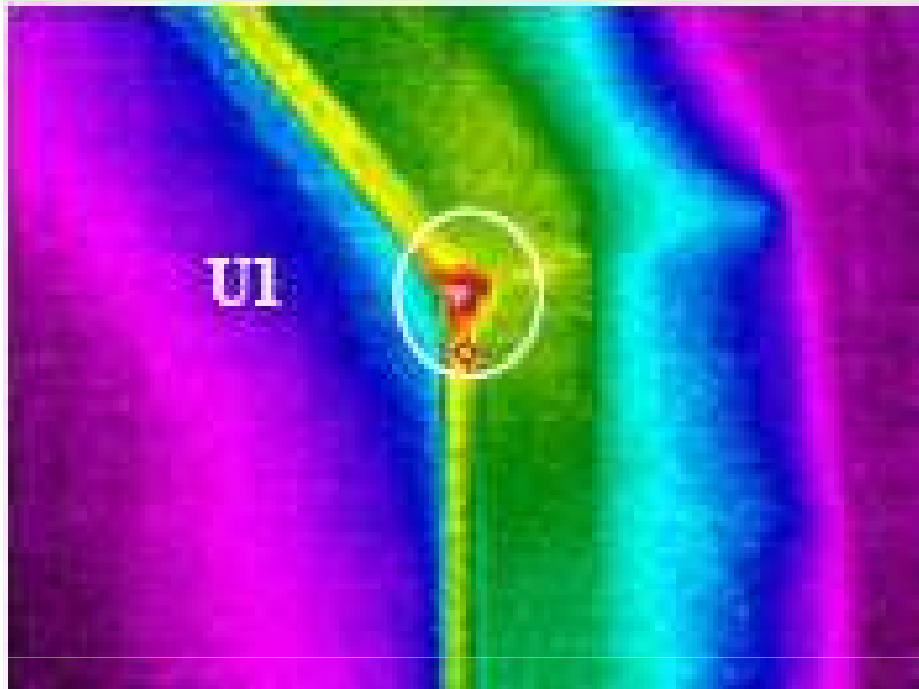


## TEMPERATURE MEASUREMENTS

LABEL	RATED VALUE (°C)	TEMP. DECREASED BY (AS PER MIN) (°C)	OUTLINED AREA TEMP.		
			MIN. (°C)	AVG. (°C)	MAX. (°C)
U1	23	9.7	13.3	17.1	21.8

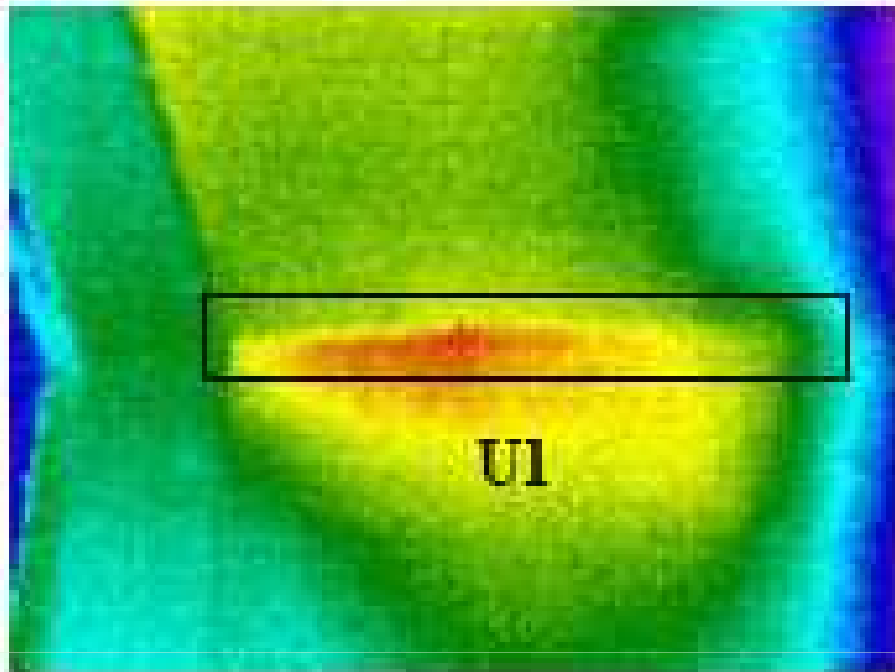
### **Recommended Action:**

Temperature at highlighted area in the real image is 9 C less than the ambient outside temperature. A panel joint at bottom has not been done properly. By injecting silicon sealant at mentioned area will maintained the temperature.



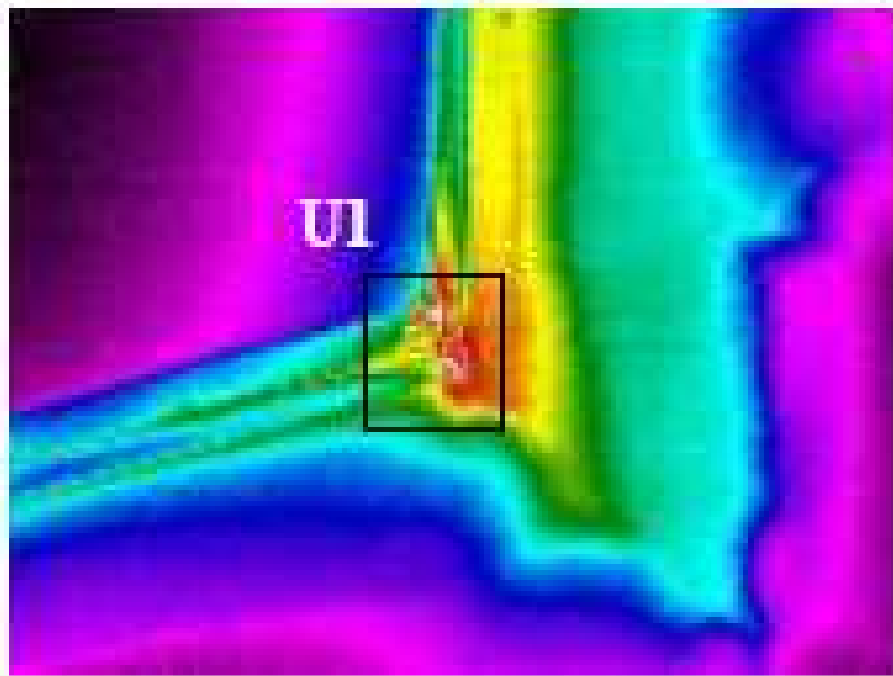
### TEMPERATURE MEASUREMENTS

LABEL	RATED VALUE (°C)	TEMP. INCREASED BY (°C)	OUTLINED AREA TEMP.		
			MIN. (°C)	AVG. (°C)	MAX. (°C)
U1	0	10	2.2	5.8	10.0



**TEMPERATURE MEASUREMENTS**

LABEL	RATED VALUE (°C)	TEMP. INCREASED BY (°C)	OUTLINED AREA TEMP.		
			MIN. (°C)	AVG. (°C)	MAX. (°C)
U1	5	7.9	8.8	11.4	12.9



### TEMPERATURE MEASUREMENTS

LABEL	RATED VALUE (°C)	TEMP. INCREASED BY (°C)	OUTLINED AREA TEMP.		
			MIN. (°C)	AVG. (°C)	MAX. (°C)
U1	0	21.4	7.2	15.6	21.4







# WALL PENETRATIONS (NOT ROOF)









# Dock Equipment

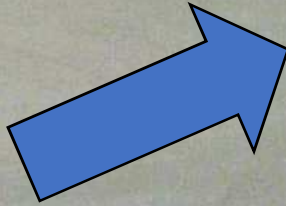
- Mechanical Dock levelers
- Hydraulic vertical dock levelers
- Limit Switches
- Guard Posts







THIS DOOR  
TO REMAIN OPEN  
WHEN THIS BUILDING  
IS OCCUPIED







# Electrical

- Switch Gear
- MCC Panels



# LED LIGHTING IN COLD STORAGE

**Programmable  
Logic Controller  
Systems  
Lighting Levels  
Inspection  
Processing  
General  
Storage**



# **MATERIAL HANDLING**

## **Conventional Handling Practices**

- Manual loading & unloading

## **Recent Development**

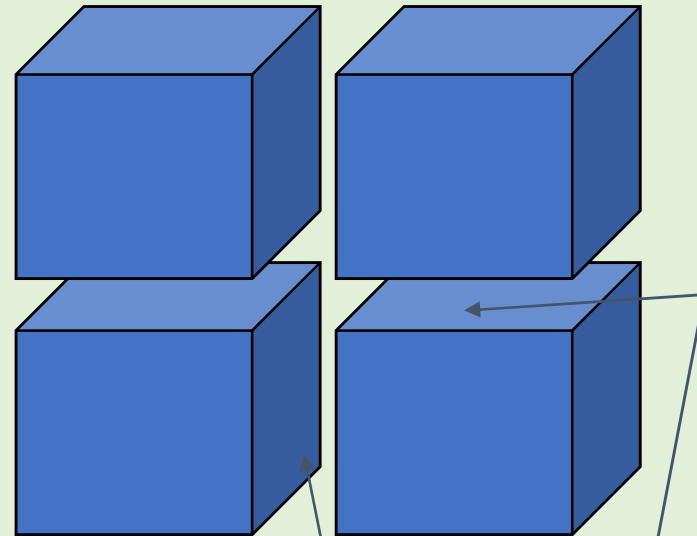
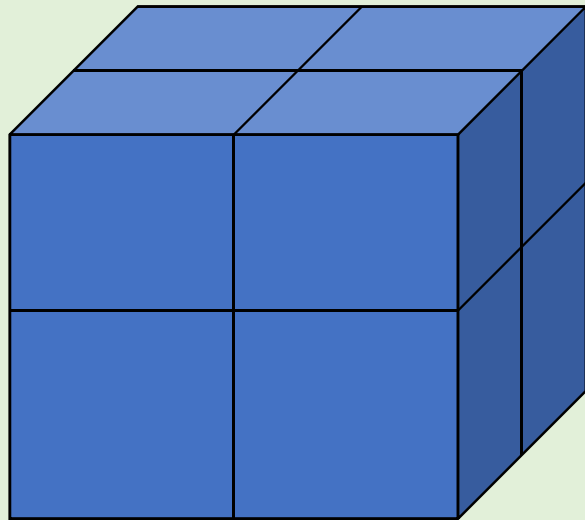
- Use of electrical hoists / lifts / fork lift trucks / conveyors
- Rack structures in chambers for storing
- Use of Pallets & Bins
- Use of computers for maintaining record of loading / unloading & stocks

## Care while Loading / Unloading

**Loading/unloading work should be done quickly.**



# AIR SPACES BETWEEN PACKAGES



Air Spaces

## INCORRECT USE OF SPACE



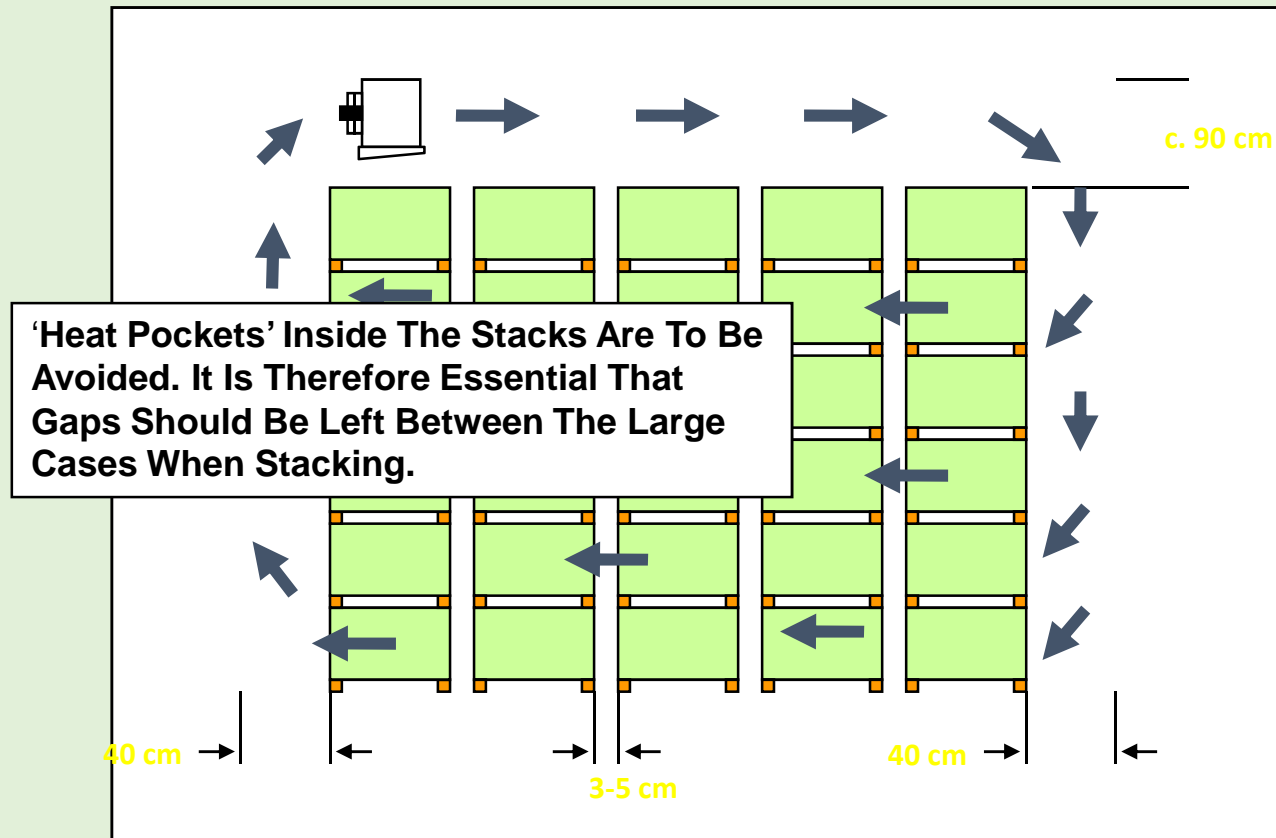
*Product stacked haphazardly in aisles due to a lack of suitable racking space.*

# NO PROPER AIR CIRCULATION ON PRODUCT



**X**

# AIR CIRCULATION IN THE COLDROOM



# AIR MOVEMENT DUCTS



# COLD STORES



# MULTIPURPOSE COLD STORE



# INSIDE VIEW OF SANDWICH PANEL CONSTRUCTION



# LED LIGHTING IN COLD STORAGE

**Programmable Logic  
Controller Systems  
Lighting Levels  
Inspection  
Processing  
General  
Storage**



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

**Cold Storage  
For  
Fresh Horticulture Produce Not Requiring Pre-cooling Before Storage  
(Technical Standards Number NHB-CS-Type 01-2010)**



Agency  
Cold Chain Development Centre  
National Horticulture Board  
Department of Agriculture & Cooperation,  
Ministry of Agriculture, Govt. of India  
85, Institutional Area, Sector 18, Gurgaon-122 015  
(Haryana)

These standards are  
available at  
<http://nhb.gov.in>

**Technical Standards  
and  
Protocol for the Cold Chain in India**

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

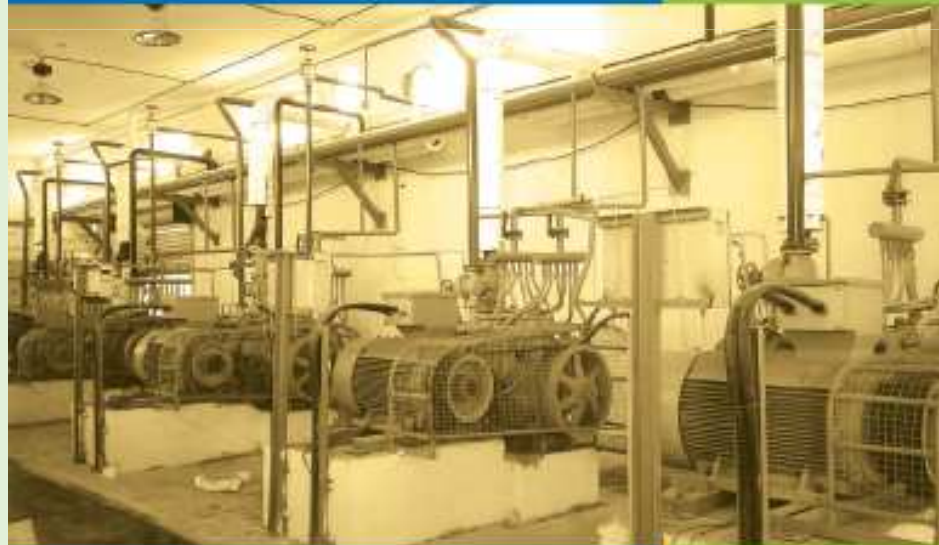
**Control Atmosphere Cold Stores  
(Technical Standards Number NHB-CS-Type 03-2010)**



Agency  
Cold Chain Development Centre  
National Horticulture Board  
Department of Agriculture & Cooperation,  
Ministry of Agriculture, Govt. of India  
85, Institutional Area, Sector 18, Gurgaon-122 015  
(Haryana)



**SUGGESTED INSTALLATION /  
OPERATION / MAINTENANCE  
PRACTICES FOR CLOSED CIRCUIT  
FIELD ERECTED AMMONIA  
REFRIGERATION SYSTEMS**





Association of  
AMMONIA REFRIGERATION

# **COLD STORAGE**

DESIGN &  
SELECTION OF EQUIPMENT

**THANK YOU**  
**Questions?**

**Ramesh Paranjpey**  
**Fellow Life member ASHRAE**  
**[ramesh.paranjpey@gmail.com](mailto:ramesh.paranjpey@gmail.com)**

**Cell No. 9822398220**

**Web: <http://ramesh-paranjpey.com>**

# Designer's Responsibilities

- Selection of Refrigerant
- Efficient equipment selection
- Advanced Heat Exchangers
- Proper Air Circulation
- Minimum weight Loss
- Precise Temperature Control-variation not more than 2<sup>0</sup>C
- Quick Pull Down Rate
- Reduced Maintenance Cost

## **Load Estimation-DBR--Use of software only after you learn basics**

1. Essential to understand and discuss and educate the customer regarding pros or cons of his views
2. Come to common understanding as what finally needs to be done
3. Prepare Joint signed statement before starting load calculations
4. High temperature & Low temperature cold rooms have different requirements
5. Multi Temperature-multiproduct cold storages have different requirements

## **Load Estimation-DBR--Use of software after you learn the basics**

6. Refrigerant Selection-Ammonia preferred
7. Load estimation
8. Construction with Insulation & it's application technology
9. Importance of avoiding moisture penetration
10. Equipment Selection based on Load pattern
11. Load diversity factor-0.7 to 0.85 for multi room
12. Evaporator-Selection-Air quantity required
13. Product loading practices
14. Defrost load & its effects

# Components Contributing Heat Load

## 1. Input Data

1. Location
2. Qty to be stored
3. Type of Product to be stored
4. Frequency of Door Opening
5. Duration of Storage expected
6. Type of Insulation and Thickness
7. Product Loading Rate & Cool Down Period
8. Method of Internal/ External Packaging and Storage

## 2. Product Load - Sensible + Latent Heat Load-Respiration

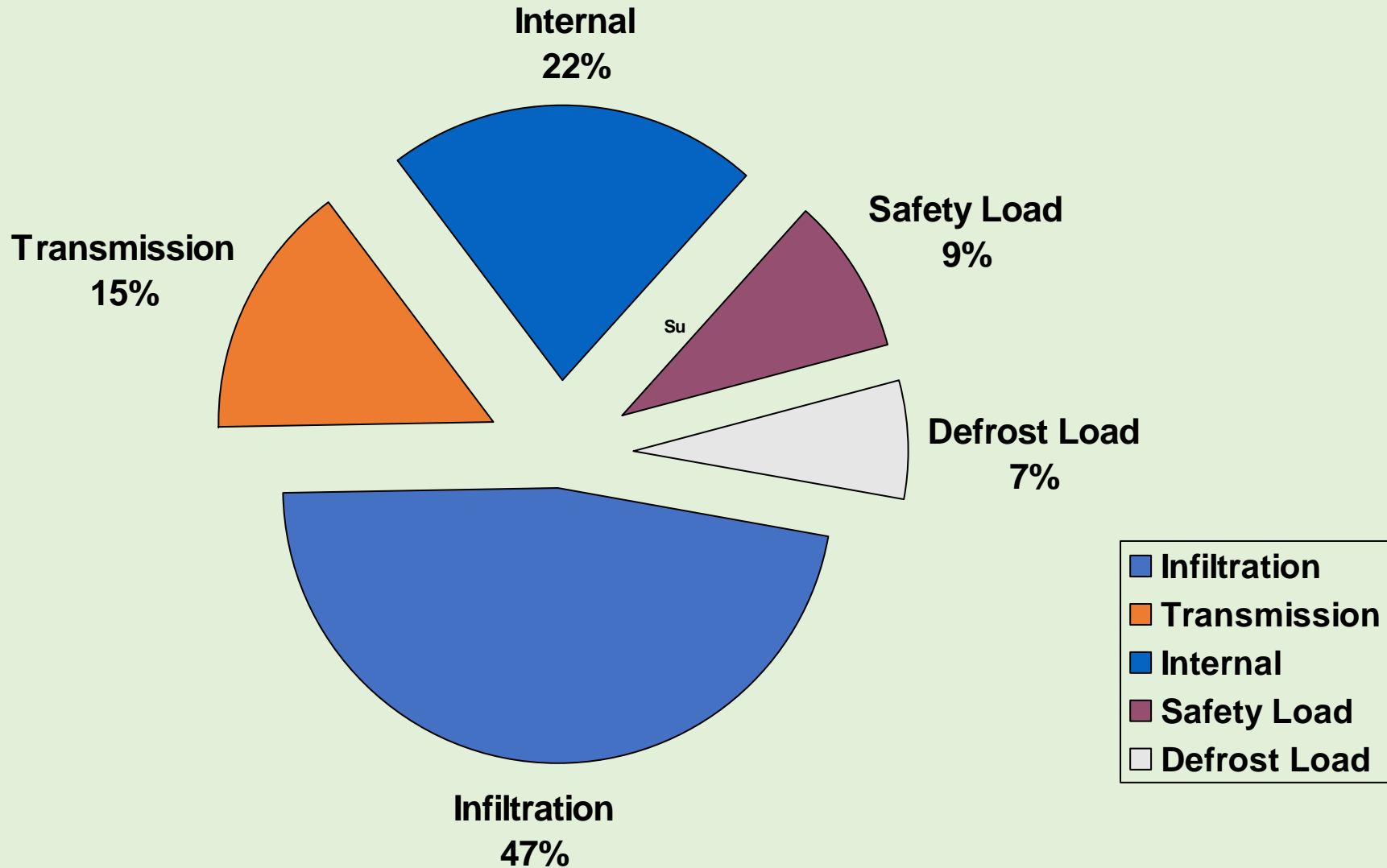
## 3. Transmission Load

## 4. Air Change Load-by design or by default-air leakage

## 5. Other Loads – Lighting / Fan Motors/Occupancy

# Summary Refrigeration Load

(ONCE PRODUCT REACHES DESIRED TEMPERATURE)



# Pack House

A Pack House consists of: -

- Grading & Packing Hall
- Pre Cooling Chamber
- Ripening Chambers
- Cold Stores

# Grading & Packing Hall



# HEAT GAIN REDUCTION POSSIBILITIES

---

- 1. Exterior Surfaces- Light Colour**
- 2. Exterior surfaces- Reflective finish**
- 3. East/West -Shaded to avoid direct Solar Radiation**
- 4. Tall Trees Planted to Provide shading effect**
- 5. Roof exposed to Sun should be covered**
- 6. Attic places should be ventilated**

## Floor construction

Most Common Approach –

1. Under Floor Heat System –
2. Concrete Sub Slab
3. 10 mill Poly Vapor Barrier –
4. 2 Layers of Extruded Polystyrene(5”-6”-7”)
5. 6 mill Poly Slip Sheet –
6. Concrete Finish Floor(5”-8”)

# CONCLUSION

1. **Make a joint agreement-as to what is required and what needs to be done**
2. **Construct building taking into account-accessibility-Disposal of waste-Ease of loading/unloading**
3. **Calculate proper load ensuring-not more than 4% loading per chamber and do loading in the evening or at night time**
4. **Select different compressors for base load and peak load**
5. **Check the quality of product for core temperature for frozen products and freshness for fresh products- cold storage does not improve quality**
6. **Install efficient equipment to ensure minimum power consumption**
7. **Install automation and controls for adjusting plant performance to respond and to match the load**
8. **Provide P & ID and electrical diagram on the wall**
9. **Employ trained refrigeration operator to manage the operation**
10. **Maintain log book, with all readings, daily input/out put and energy consumption**

## **PART-II**

- 1. PRIORITY-SOLVING EXSISTING PROBLEMS**
- 2. HOW TO IMPROVE PERFRMANCE OF EXSISTING COLD STORAGE**

## Problems ?

---

1. Ice formation inside cold room/Floor/doors
2. Condensation on walls/ceiling
3. Room Fogging-Misting
4. Product not uniformly cooling
5. Foul or Bad Smell in cold room
6. Product weight loss
7. Product shrinking/shriveling/rotting

## Problems ?

---

8. Product good during loading but deteriorates during storage
9. Temperature colder than required
10. Temperature higher than required
11. Temperature not uniform/Fluctuating
12. Panels distorted/collapsed

# Evaporation – Water Loss

- Main Cause For Deterioration
- Weight Loss – Revenue Loss

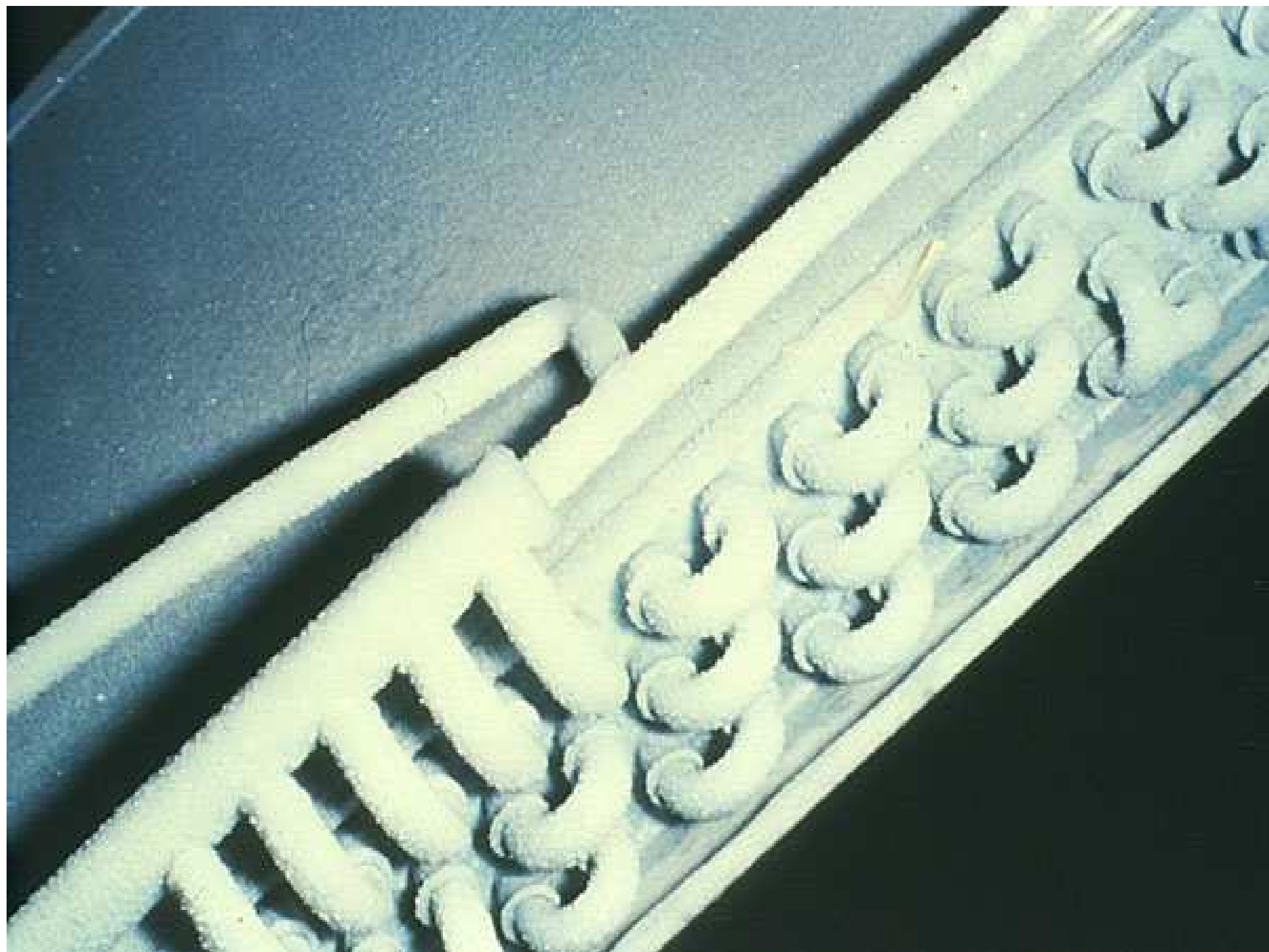
## **To Reduce Water Loss**

- Maintain High Humidity & Ideal Temperature
- Rapid Pre-cooling
- Observe Specific Humidity And Not RH

# Evaporator Coil Icing –Excessive Condensate removal

- Coils running at much lower temperature than designed
- Defrost system defective
- Storage R.H. is much higher than designed
- Inadequate air flow
- Coil design incorrect -high fin density, small tubing, more than required depth leading to removal of excess moisture than necessary
- Too high fin density

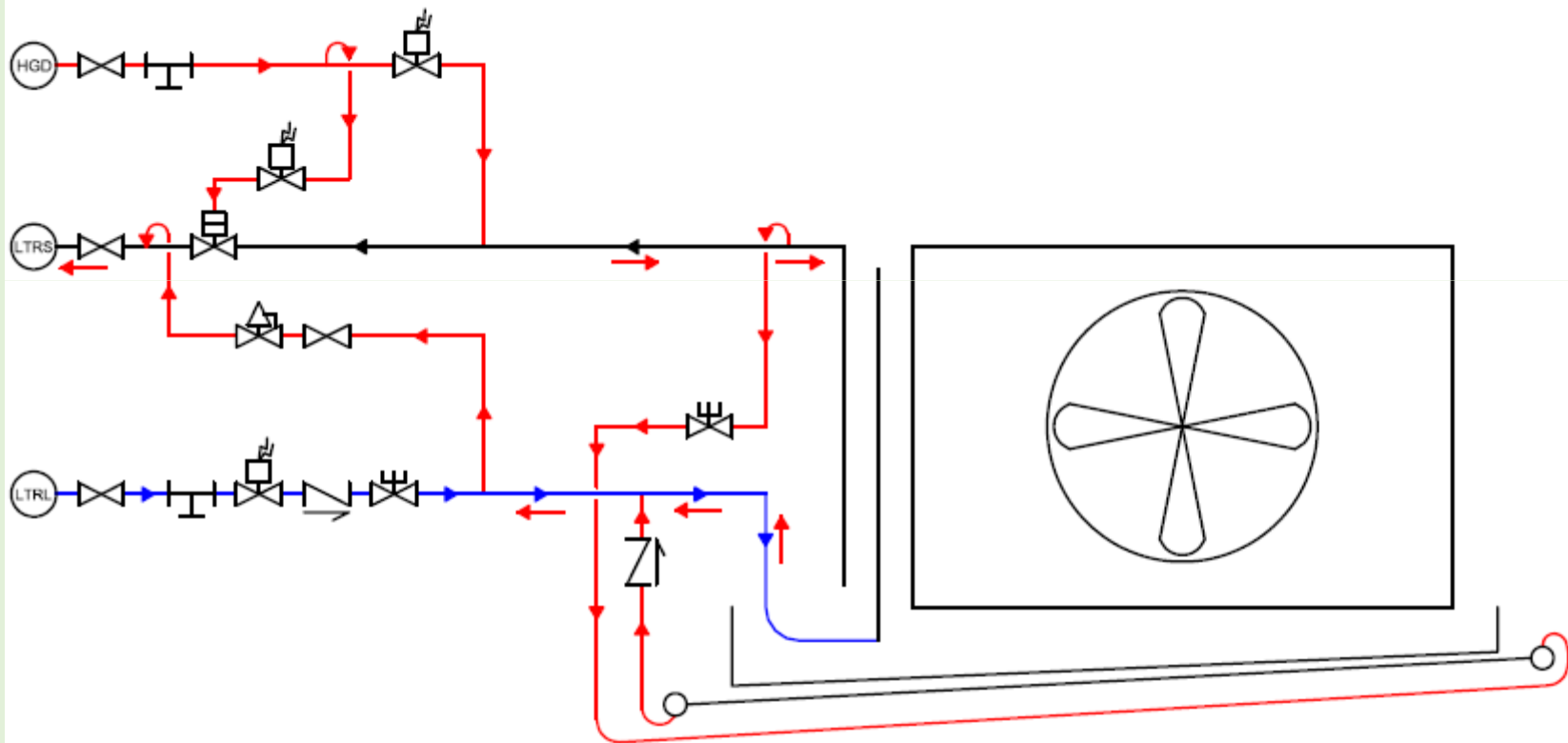
# **COIL DEFROST**



# Evaporator Coil Icing – Excessive Condensate removal

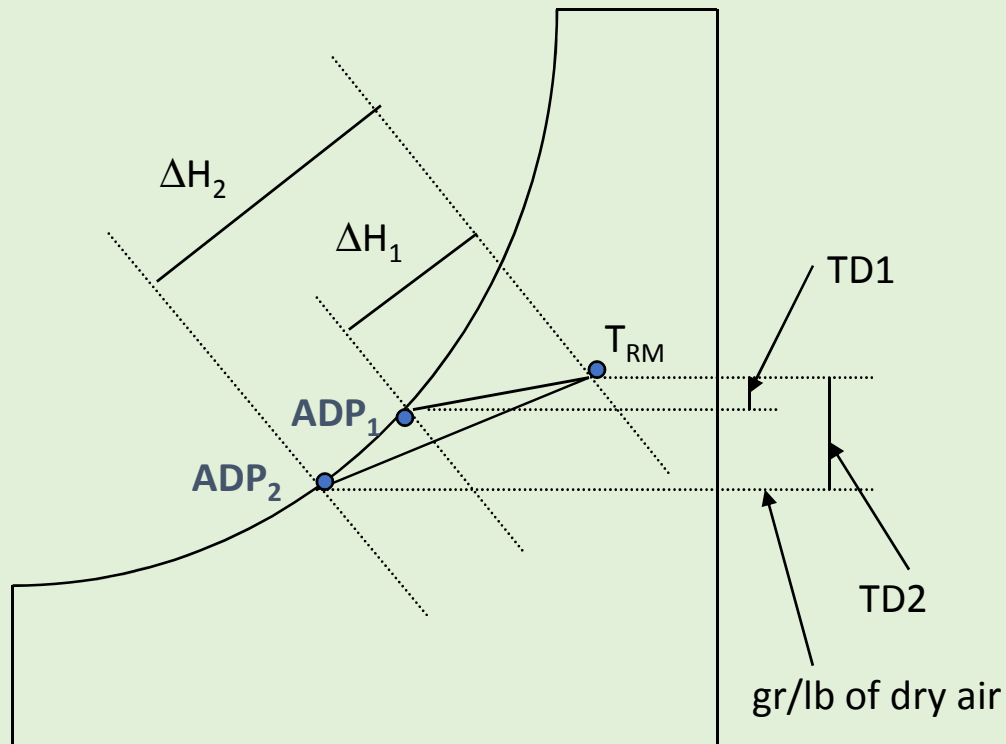
- **Coils running at too low a temperature**
- **Defrost system defective**
- **Storage RH is too high**
- **Inadequate air flow**
- **Coil design incorrect -high fin density, small tubing, more than required depth leading to removal of excess moisture than necessary**

**RECIRCULATED BOTTOM FEED  
2-PIPE HOT GAS DEFROST  
VERTICAL HEADERS  
1-PASS PAN LOOP**



**PRODUCT DRYING-WEIGHT LOSS-  
PRODUCT APPEARECE NOT FRESH**

# Psychrometric Analysis



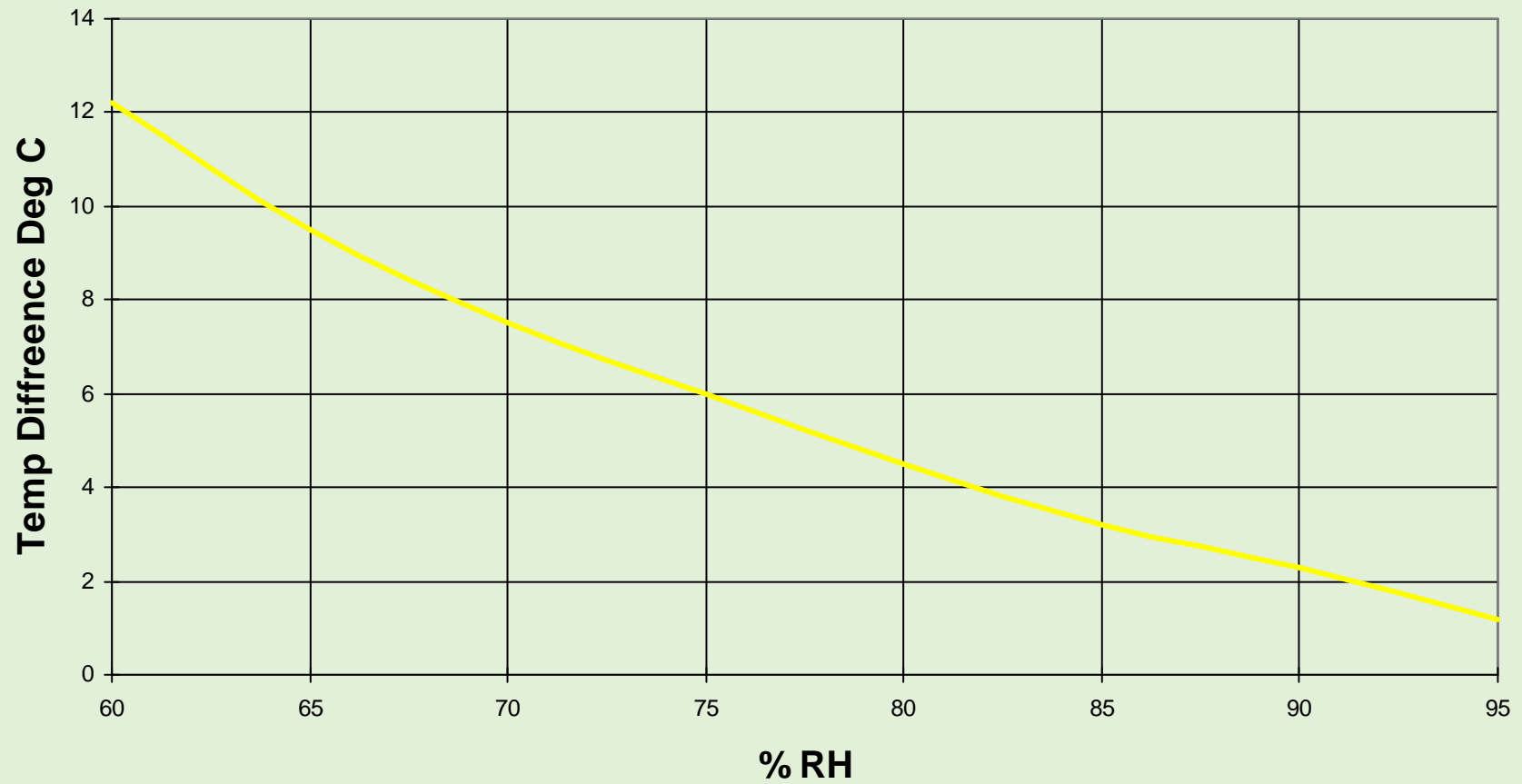
$$Q = U \times A \times \Delta T$$

$$Q = 4.5 \times \text{cfm} \times \Delta H$$

$$TD = T_{RM} - T_{ADP} (T_{\text{evap}})$$

- Smaller TD less weight loss / Less Moisture Removed  $TD1 < TD2$
- For same heat removal  $Q$ , smaller TD - More area, bigger Coil
- For same Heat Removal  $Q$ , smaller  $\Delta H$  - More cfm - Bigger fan
- Smaller TD, More expensive Initial cost - but lower power consumption & running cost

# Coil Selection – TD vs %RH



Ref : ISHRAE Journal Jan-Mar 2007

## Empirical values

cold room temperature	evaporating temperature	TD-temperature difference- $\Delta T$	rel. air humidity measured values
<b>+1 °C</b>	<b>-7 °C</b>	<b>8 °C</b>	<b>85-92 %</b>
<b>+1 °C</b>	<b>-4 °C</b>	<b>5 °C</b>	<b>92-94 %</b>
<b>+1 °C</b>	<b>-3 °C</b>	<b>4 °C</b>	<b>97-98 %</b>

- The smaller the temperature difference, the lower the dehydration rate and the higher the air humidity. A temperature difference of 4 °C can only be achieved with an electronic expansion valve.
- Caution: Make sure that the cooling capacity is designed to match this low temperature difference !!!

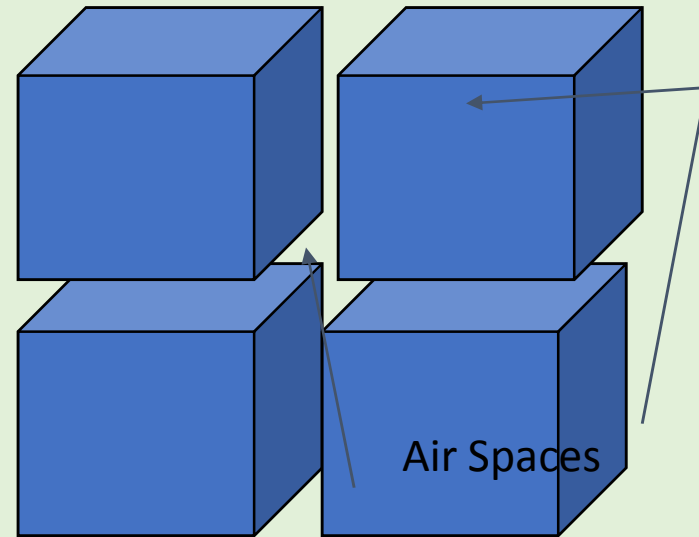
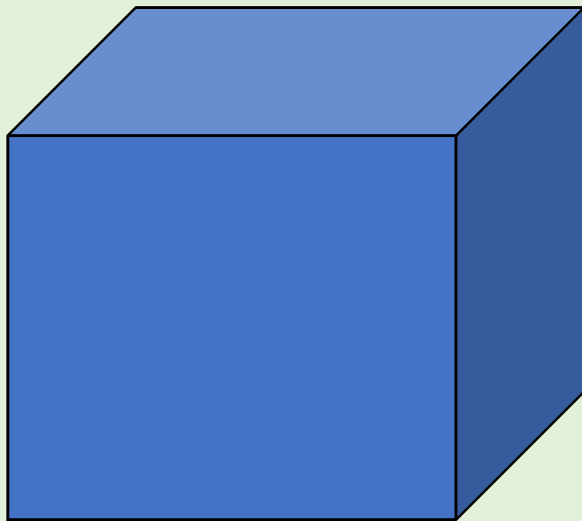
**PRODUCTS NOT COOLING  
UNIFORMLY, TEMPERATURE  
VARIATION HIGH**

## Care while Loading / Unloading

**Loading/unloading work should be done quickly.**



# Air Spaces between packages



Air Spaces

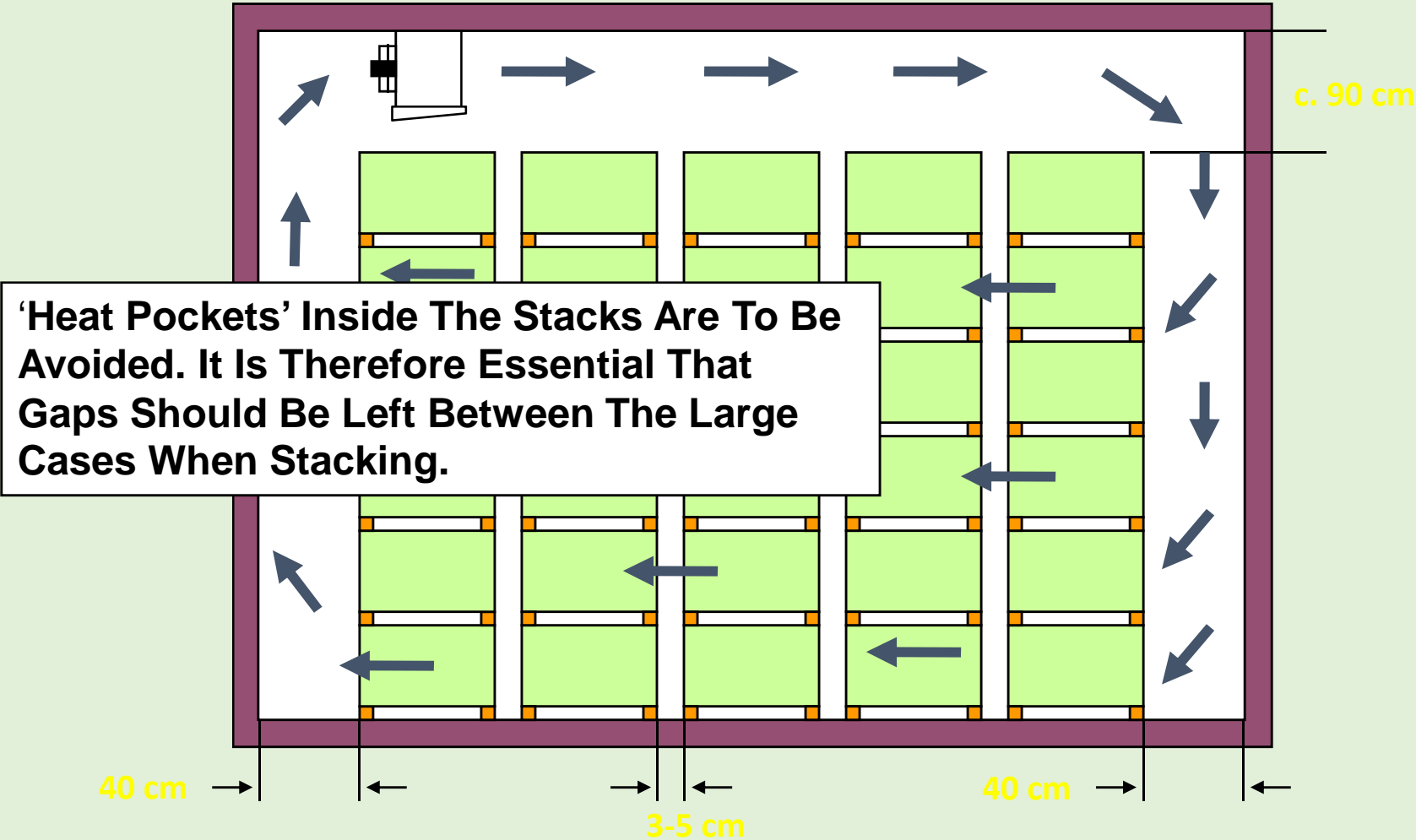
# No Proper Air Circulation on Product



# Air Movement



# Air Circulation In The Coldroom



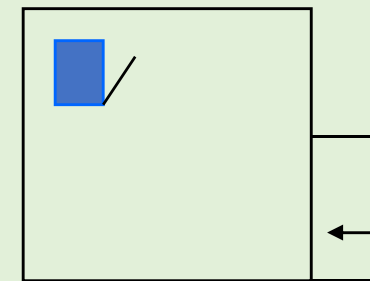
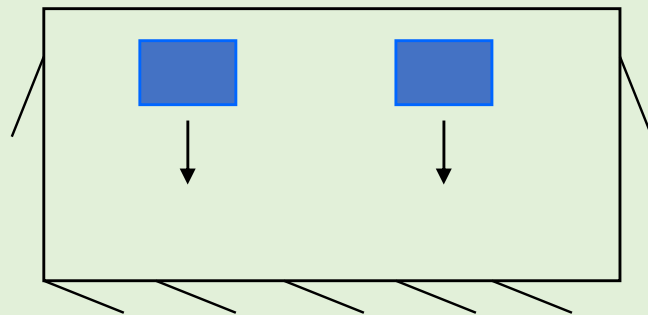
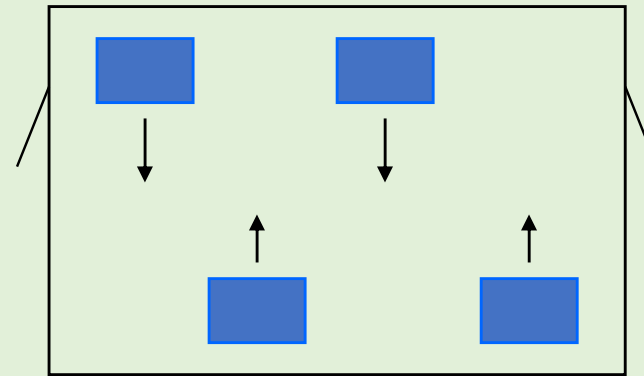
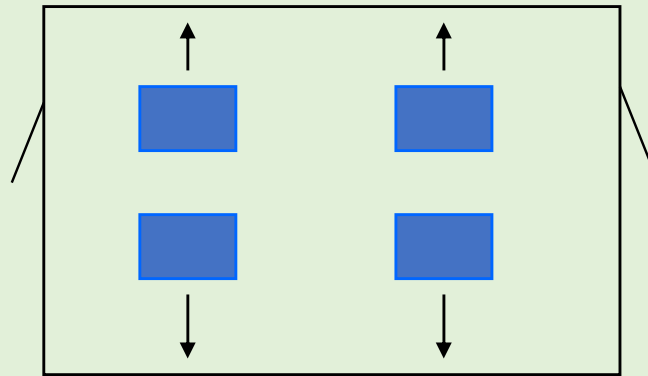
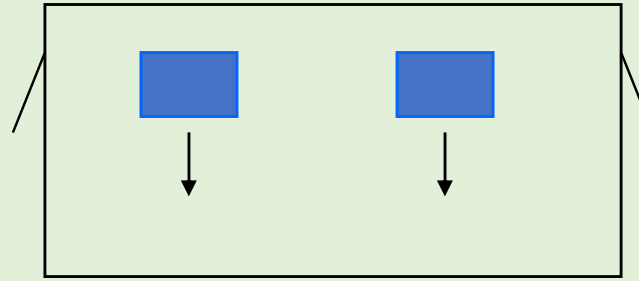
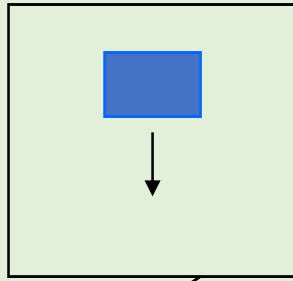
# FAN LAWS

➤ As per Affinity Law:-

$$\frac{H_2}{H_1} = \left[ \frac{N_2}{N_1} \right]^2, \quad \frac{P_2}{P_1} = \left[ \frac{N_2}{N_1} \right]^3, \quad \frac{Q_2}{Q_1} = \frac{N_2}{N_1}$$

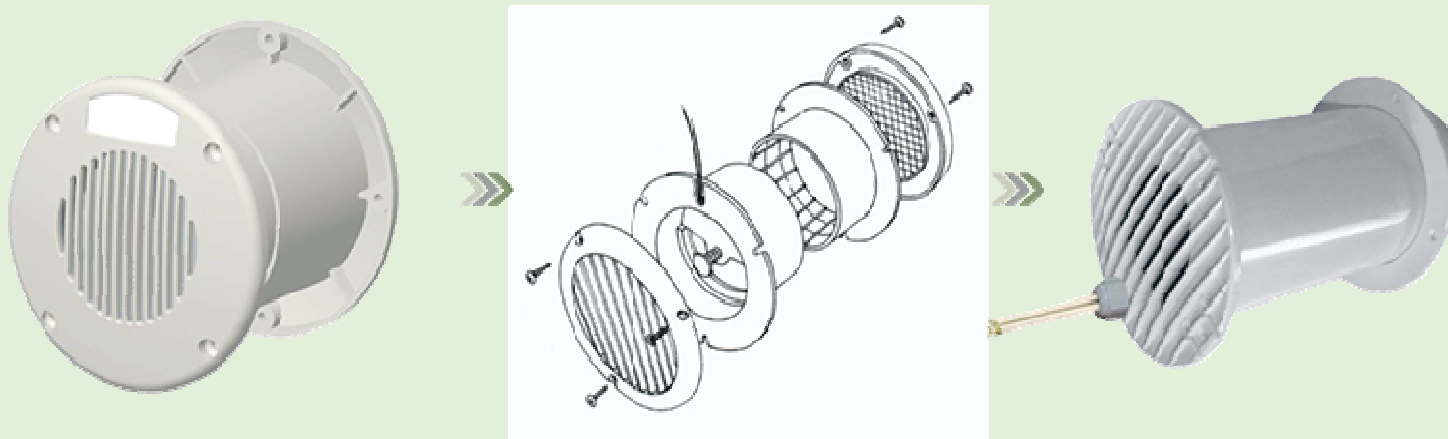
- ❖ H = Pressure or head developed by fan (eg. Pascal)
- ❖ N = Shaft Rotation Speed (eg. rpm)
- ❖ P = Shaft Power (eg. W)
- ❖ Q = Volumetric flow rate (eg. CFM)

# Recommended Cooler Placement



# **AUTOMATION-CONTROLS**

# Pressure Equalizing Valves



When air is cooled, its density increases and internal pressure reduces, if no equalizing valves are provided, the panels distort or collapse.

# System Capacity

1. The overall capacity depends on the weakest component in the system.
2. Individual component may influence the system performance.
3. Balancing of all components is therefore essential.

# Causes High Discharge Pressure-Water Cooled

1. Overcharged Systems
2. Non Condensable gases in System
3. Inadequate Water supply-Flow/Pressure
4. Bad water quality-Tube well make up water
5. Choke/Obstructions in Circulation System
6. High Cooling Water Temperature
7. Condenser Tubes Fouling
8. Cooling Tower Fills damaged/choked
9. Water Spray on Tubes/fills improper
10. Inadequate Ventilation-for condensers

# **Is your cold storage consuming more power than expected and designed?**

1. Recheck design parameters and find out the areas where the readings are not as per design
2. Check Insulation leak performance
3. Check whether ice or frost is accumulating in the cold room
4. Check whether product quality is not being achieved-whether fresh product is drying
5. Check Selection of air coolers
6. Check whether capacity controllers, thermostats etc. are working properly
7. Install additional controls if necessary to improve performance
8. Make the plant operation automatic as much as possible
9. Check log book readings and History of maintenance
10. Check oil charging and oil drained balance and additional gas charging quantity
11. Check whether there is excess moisture and non condensable accumulated in the system
12. Install water rectifier and automatic air purger
13. Visual checks and operational checks
14. Install pressure relief valve on panels so panels won't distort

# CONTROLS

Controls are one of the most critical elements for improving efficiency/reliability/Safety of any Refrigeration system.

A good control system can make a marginally designed installation operate satisfactorily while a poor control system cannot make the best designed installation operate satisfactorily.

# CONTROLS

## IMPOTRANCE OF EVAPORATOR PRESSURE CONTROL

1. Maintains constant temperature in the room irrespective of Load
2. Reduces Product Weight Loss
3. Leads to energy saving operation by compressor
4. Reduces Defrost frequency and energy

## WHAT VLTs CAN ACHIEVE

**Save Overall System Cost (DG Size/ Compressor Size/ Cables etc.)**

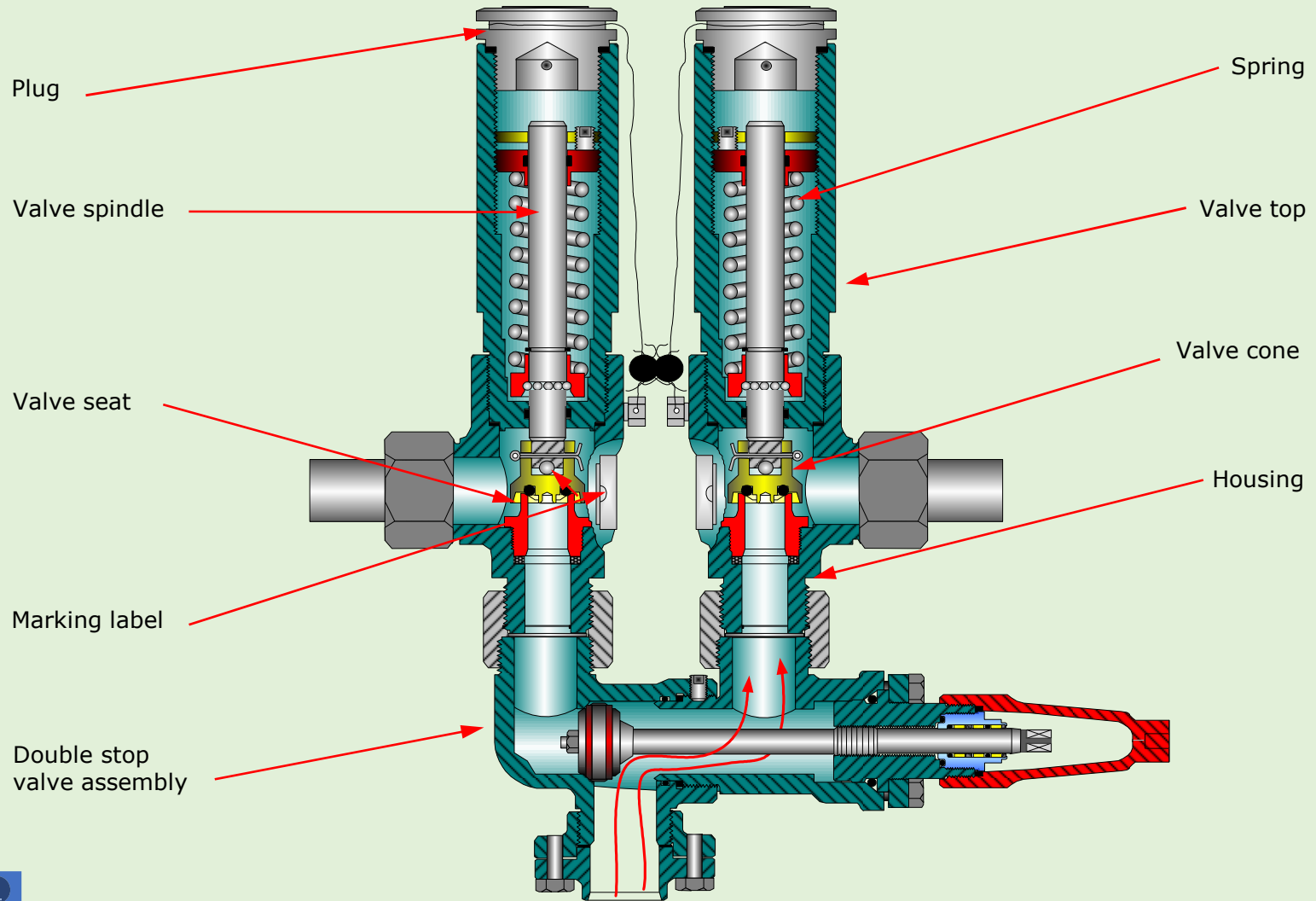
**Save Energy (Run Your system at Part Loads)**

**Reduce System Complexity**

**Increase Profitability**



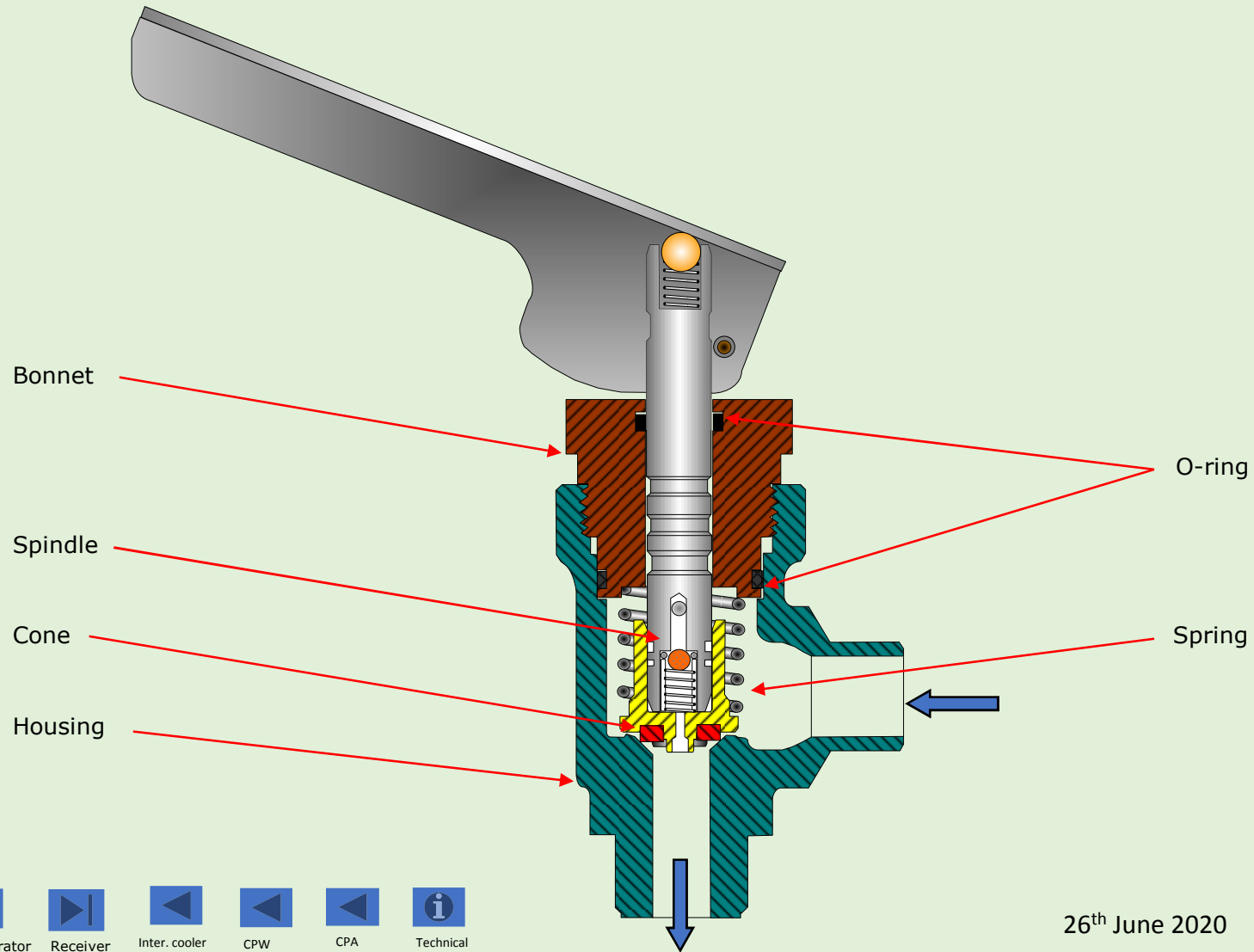
# Double Stop Valve - type DSV and Double Safety Valve - type SFV



Technical  
brochure

26<sup>th</sup> June 2020

# Quick closing oil drain valve – type QDV 15

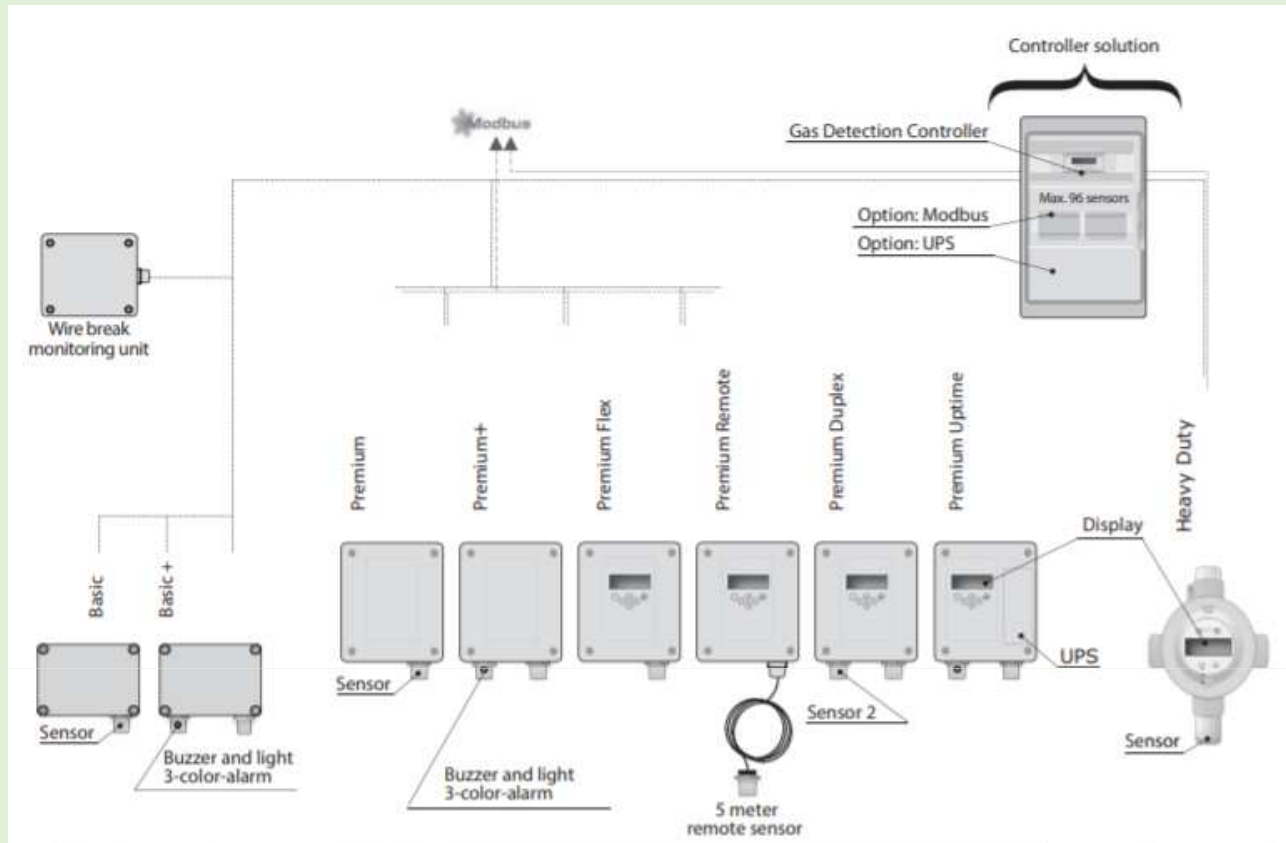


To build and install valve station takes hours



Same job using ICF takes just minutes

# GAS DETECTION



Fail safe ammonia leak detection and its upkeep is key in securing refrigeration plant safety and initiating necessary containment action in case of leak.

- Electro chemical models are highly accurate, senses only target gas and compensated for wide temperature range compared to semiconductor models thus avoiding false / missed alarms.
- Digital solution offers simple plug and play option with simplified field wiring and faster installation & start up.
- Digital gas detection systems ensures two way communication between sensors and controller. It also offers pre-alarms in case of end of sensor life, calibration reminders etc., through visual interface ensuring high reliability by avoiding manual check and upkeep.
- Digital solutions offer faster calibration through digital interface avoiding use of potentiometers / screw drivers as in case of analog models. Generation of field calibration reports is possible using dedicated tool.

# Automatic Liquid Flow Regulating Valve



# MONITORING DASHBOARD

Kunal Cold Storage



Settings



Reports

Digital Display OFF

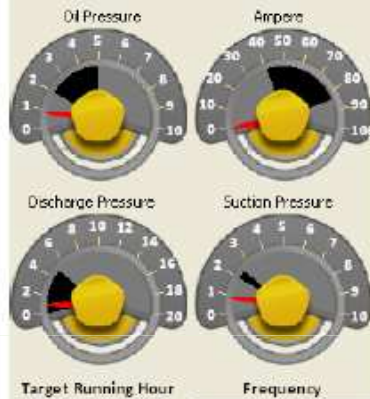
Alarm **ON**



0°C

13/01/2013 09:59:00

## COMPRESSOR



Target Running Hour: 8  
Frequency: Not to Run

Actual Running Hours: 00:00  
Unit Consumed: 0.00

COMPRESSOR OFF  
WATER PUMP OFF

Alerts

Alerts

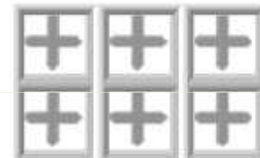
## CHAMBER 1

EXPANSION VALVE

OFF



FAN 1 FAN 2 FAN 3



K-01 CLOSE  
K-02 CLOSE  
K-03 CLOSE  
K-04 CLOSE  
K-05 CLOSE  
K-06 CLOSE

Alerts

Temp. more, start Expansion valve & Compressor.

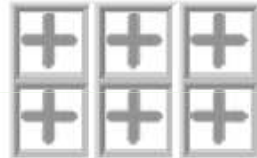
## CHAMBER 2

EXPANSION VALVE

OFF



FAN 1 FAN 2 FAN 3



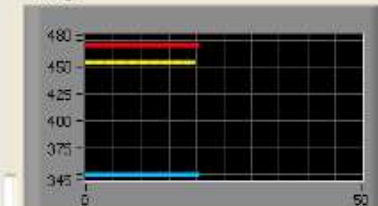
K-07 CLOSE  
K-08 CLOSE  
K-09 CLOSE  
K-10 CLOSE  
K-11 CLOSE  
K-12 CLOSE

Alerts

Temp. more, start Expansion valve & Compressor.

## POWER

Voltage



Ampere



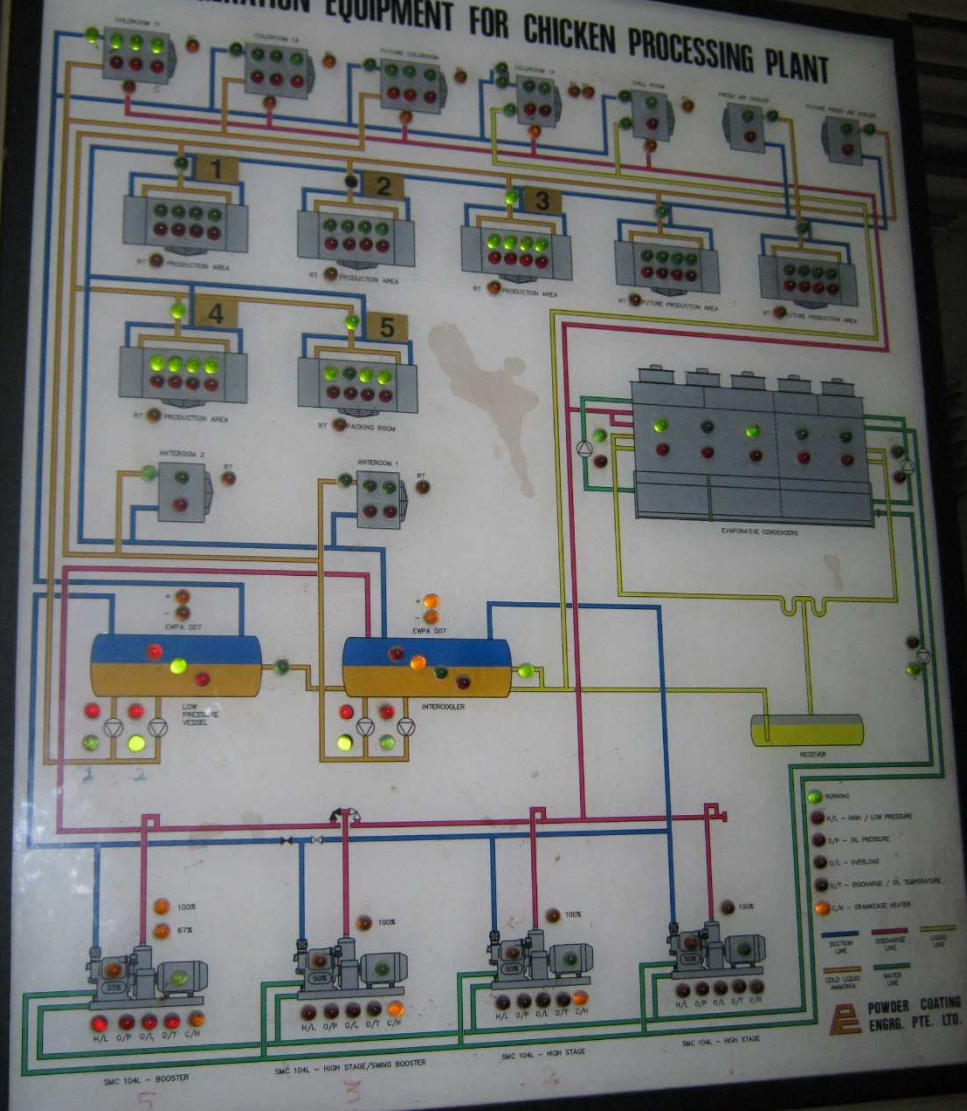
Power Factor



Total Unit Consumed

2.35

# REFRIGERATION EQUIPMENT FOR CHICKEN PROCESSING PLANT



- RUNNING
  - H/L - HIGH / LOW PRESSURE
  - O/P - OIL PRESSURE
  - O/L - OVERLOAD
  - O/T - DISCHARGE / OIL TEMPERATURE
  - C/W - DEBRIDATE HEATER
- SUCTION LINE  
— DISCHARGE LINE  
— LIQUID LINE  
— WATER LINE  
— COLD LIQUID AMMONIA

**POWDER COATING ENGRS. PTE. LTD.**



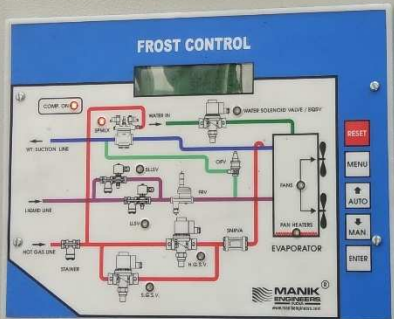
### DEFROST CONTROLLER - 1



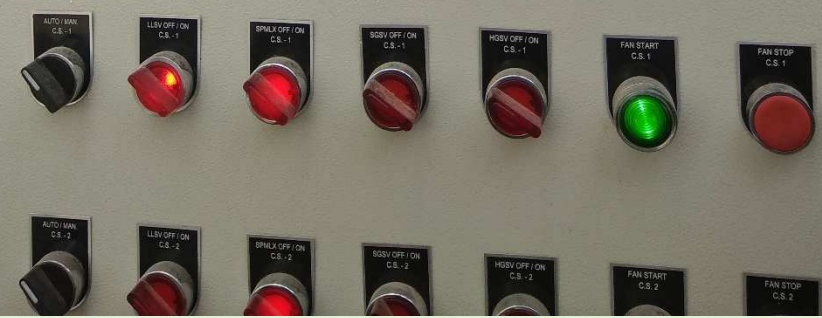
### TEMP. CONTROLLER - 1



### DEFROST CONTROLLER - 2



### TEMP. CONTROLLER - 2



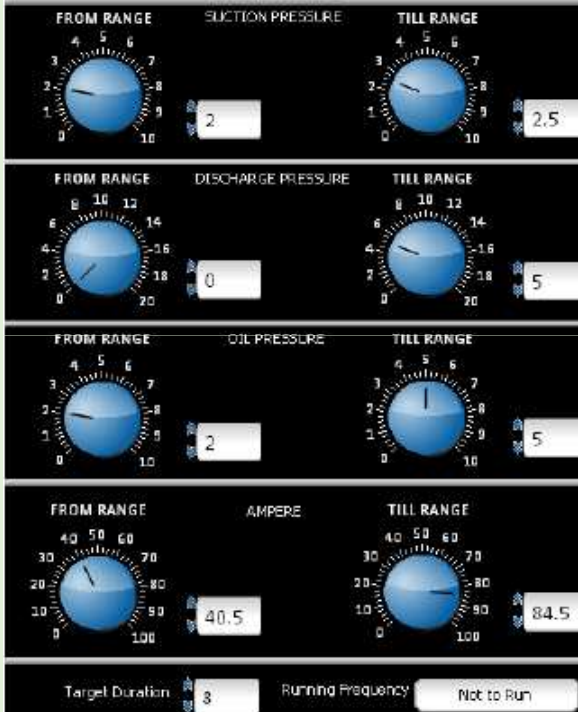
# PARAMETER SETTING SCREEN

## PARAMETER SETTINGS

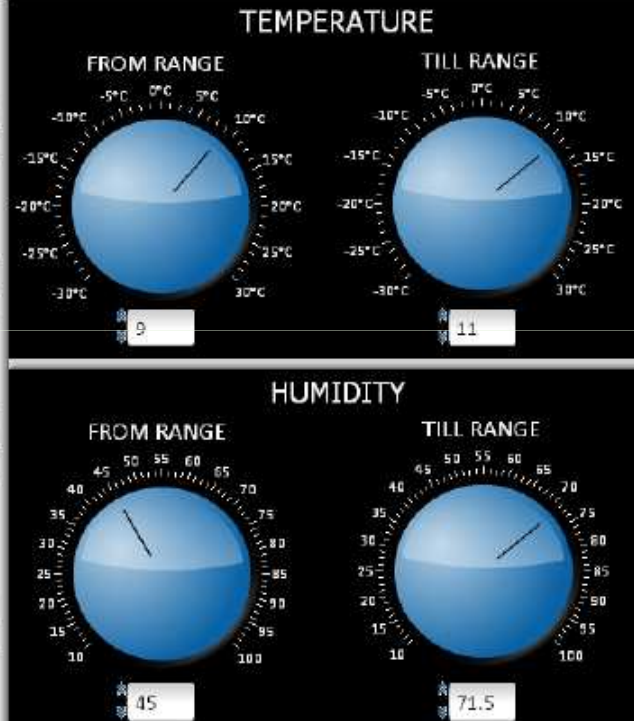


Current Setting OFF

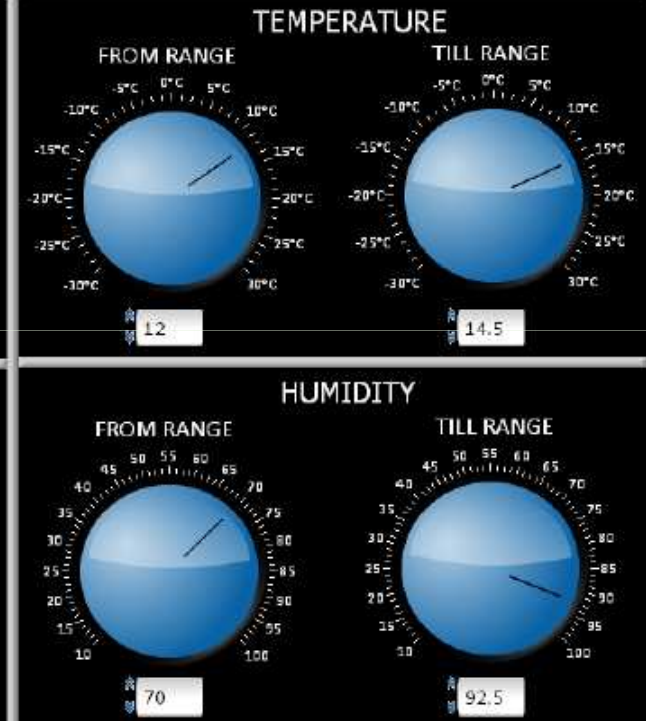
### COMPRESSOR SETTINGS



### CHAMBER 1 SETTINGS



### CHAMBER 2 SETTINGS

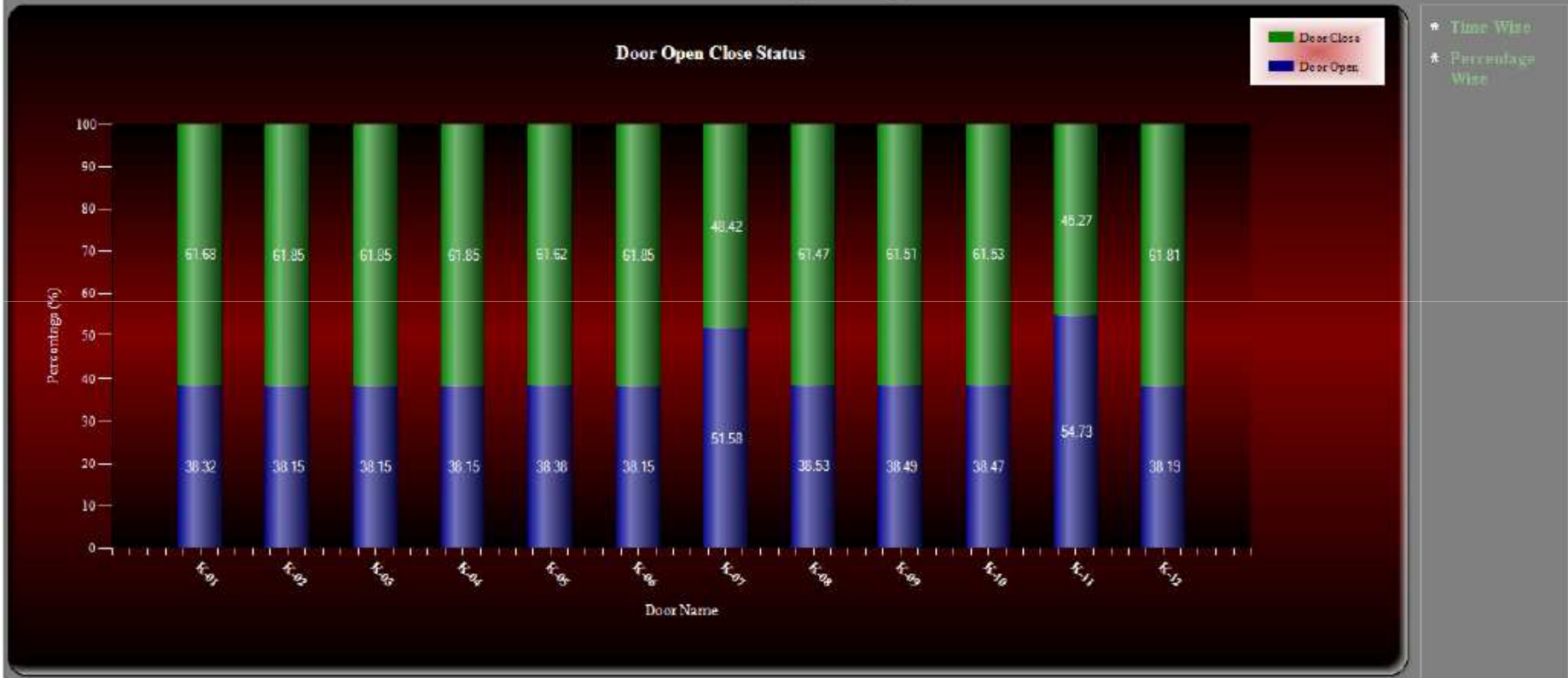


# DOOR OPEN/CLOSE GRAPHICAL REPORT

Cold Storage Name : Eland Cold Storage  
Parameter Name : Door Open Close Status  
Period : 16/01/2013 - 17/01/2013



Percentage Wise Graph



## **Areas for improvement**

- Standard vapor-compression cycle
- Heat exchangers
- Frequency controlled fans
- Adjustable speed drives
- Automatic air purgers & oil recovery units
- Water rectifier
- Computers and electronics
  - System design-capacity controller for compressor to match load
  - Monitoring all parameters & comparing with design values

# LOG SHEET RECORD

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1. Cold Room Temperature-daily loading and unloading quantity
2. Cold Room Relative Humidity
3. Compressor Discharge Pressure
4. Compressor Suction Pressure
5. Compressor Oil Pressure
6. Compressor Discharge Temperature
7. Compressor current consumption- Each separately-energy meter for complete plant
8. Condenser water inlet temperature
9. Condenser water outlet temperature
10. Condenser Pump-Amps
11. Oil charged if any –frequency and quantity
12. Record of oil removed-Quantity
13. Ammonia charged –Quantity
14. Product loading/unloading –if done- Duration & Quantity & Temp.

# CONCLUSION

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- 1. Keep discharge Pressure Low**
- 2. Keep Suction Pressure High**
- 3. Keep Superheat Minimum**
- 4. Maximize Subcooling**
- 5. Use VFD, where ever possible**
- 6. Use Water Cooled Condenser**
- 7. Electronics - Continuous Response and Modulation to Load Fluctuations**

# CONCLUSION

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**8. Keep Layout Compact**

**9. Do Not Over Design Equipment**

**10. Size Refrigerant Piping –Minimum pressure Drop**

**11. Ensure Proper Oil Management**

**12. Do Not Over Select Pumps/Motors**

**13. Keep Water side Pressure Drops Minimum**

**14. Remove Non Condensable Periodically**

**15. Keep Water Lines Clean-De-scale**

**16. Keep Filters/Coils Clean**

**17. Ensure daily /Weekly/Monthly/Yearly Maintenance Schedule**

**18. Follow Preventive Maintenance Practices**

**SAVE 20%-30% POWER**

**THANK YOU**  
**Questions?**

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