Interior of a modern refrigerated warehouse with a 40 ft. to 60 ft. wide area for staging or arranging in the proper place.

Design and Construction of Refrigerated Warehouses

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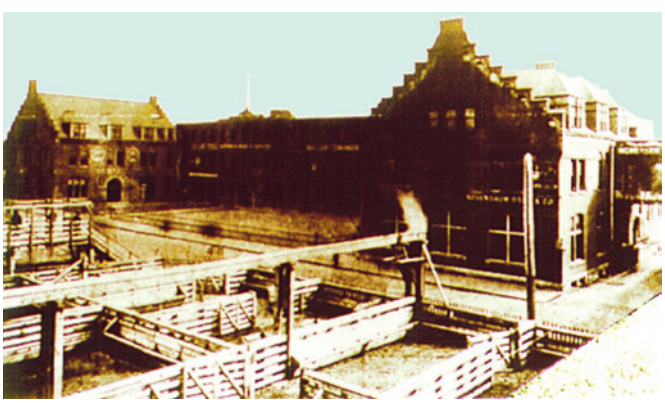
Trends

- Information Technology
- Operations
- Maintenance
- Project overview
- Change
- Factors that affect facility design
- Design
  - Preliminary design
  - Specific areas
  - Specific items

The Way it Was?



The Way it is Today

About the Author

Ron P. Vallort was President ASHRAE for 2004-2005. As a guest of ASHRAE Western India Chapter, he graced the COMFEX 2005 event in Ahmedabad in January 2005 and delivered two lectures in Pune. One of them based on his *Power Point* presentation is reproduced in this article. He can be contacted at *ronvallort@aol.com*

Factors That Affect Facility Design

- Customer requirements
- Requirements of operators
- Blast freezing
- Value added services
- Safety, OSHA, PSM
- Operating efficiency
- Energy costs
- Maintenance costs
- New technology
- Building Code requirements

Dialogue With Owner Is Very Important

- What works ■ What doesn't work
- What would you change?
- Changes you would make if money was no problem
- Discuss and integrate changes

The Design Phase

- Develop preliminary design
- Carefully review
- Produce final design
- Take input from operations

Issues To Be Decided

- Insulation ■ Clear heights desired
- Floor heating system ■ Doors ■ Charging room
- Roof system ■ Curbs and guards
- Storage rack configuration ■ Blast Cells

Goals

- Reduce cost of electrical energy consumption
- Improve layout efficiency and reduce labor
- Reduce maintenance costs
- Reduce risk of Ammonia releases (NH_3 usually used, is most efficient)

Flexibility Issues

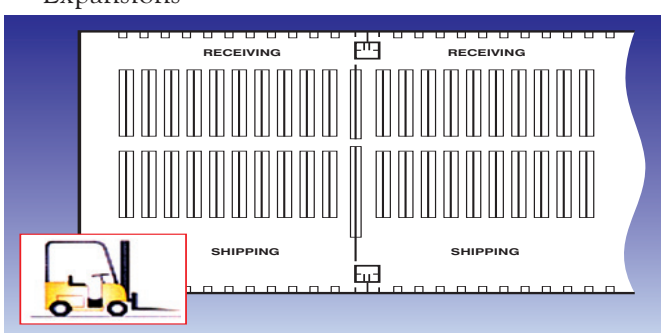
- Convertible rooms
  - –10°F to +35°F
- Usage change
- Process change
- Client requirements
- Government regulations
- Food safety issues

Expansion

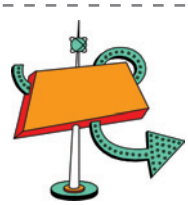
- Size: double? triple?
- Site: location near rail lines and roads
- Which areas?
- Initial layout with future in mind
- Non-load-bearing walls
- Use of panels
- Temperature – common temperatures together
- Location of plant room
- Electrical
- Refrigeration mains & vessels

Preliminary Design

- Most important phase (Rupee budget and makes)
- Rack plan
- Floor plan ■ Outline specifications ■ Flexibility
- Expansions



Basic Questions



- **Size** – 100,000 s.f. freezer
- **Number of rooms**
- **Dock**
  - Height
  - Staging 20ft., 40 ft., 60 ft.
  - Number and type of doors
  - Floor elevation (48" – 52")
  - Seals • Dock boards
  - Locking devices
- **Flow**
  - Straight through (best for expansion and cost)
  - L – shaped
  - U – shaped (most compact)
  - Door loops • Separate raw and cooked products
- **Office** • Over dock or on grade • 1 or 2 storey

Office

- Reception area
- Trucker's lounge
- General office
- Office for division manager
- Office for warehouse manager
- Cafeteria
- Locker rooms
- Rest rooms
- Conference room
- Future construction

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Site

- Designed for good traffic flow
- Drainage
- Truck apron-140 ft. minimum
- Trailer parking
- Auto parking
- Security
- Expansion

Energy Costs Drive The Need For More Insulation

	1988	2001	2006
Floors	5”	8”	?
Walls	8”	10”	?
Roofs	10”	13”	?

Exterior Building Construction

- Tilt-up construction at dock and office
- Insulated panels

Insulation

- Floor insulation – Extruded polystyrene
- Wall panels – Urethane
- Roof insulation – Poly-isocyanurate

Building Features

- Minimize columns
- High ceilings • Avoid condensation • Racking
- Minimize painting
- Minimize flat edges
- No bar joists overhead if open product
- Open lunch room / locker room design
- Walls • Smooth • Impervious
  • Washable • Seal openings

Maintenance Reduction

- Limit use of strip curtains
- Single slide manual doors ■ Concrete truck paving
- Hydraulic “Clean Pit” dock levelers
- Structural steel storage racks ■ Single ply EPDM roofs

Building

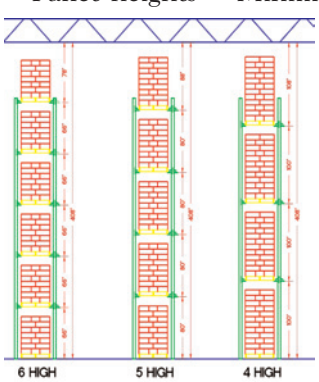
- Floors
  • Type of finish • Slope (1/8” – 1/4”)
  • Drains 1/400 s.f.
- Floor insulation – Extruded polystyrene
- Vapor barrier
- Single ply roof • Ballasted
  • Mechanically fastened

Decisions

- Insulation
- Clear heights desired
- Doors
- Roof system
- Curbs & guards
- Blast cells
- Battery charging room
- Floor heating system
- Storage rack configuration

Clear Heights

- Storage areas • MHE capabilities
  • Pallet heights • Minimize columns



34 feet Clear Height plus Refrigeration Units

Racks

Racks

- Structural racks ■ Double deep ■ Drive in racks
- Select racks ■ Rack uprights @ 105” on centres.
- Use additional beam to protect in-rack sprinklers
- 10 ft. - 12 ft. aisles

Storage Rack System Details

Front to back aisles	120”
Front cross aisle	144”
Rack to wall	
Front	24”
Others	16”
Bays	
Clear width	52”
Depth	50”

Drive in Rack Characteristics

- Fair density
- Cost
- Labor intensive
- Damage factors
- Less selective
- Honeycombing
- Poor order selectivity
- Human errors

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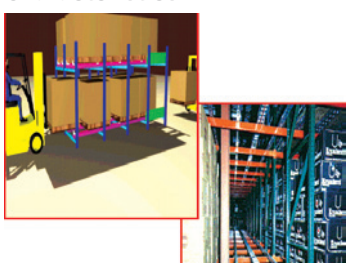
Push Back Rack

Characteristics

- Good density
- Cost
- Labor intensive
- Damage factors
- Less selective
- Difficult order selectivity
- Human errors

Deep Lane Gravity Flow Rack

Characteristics

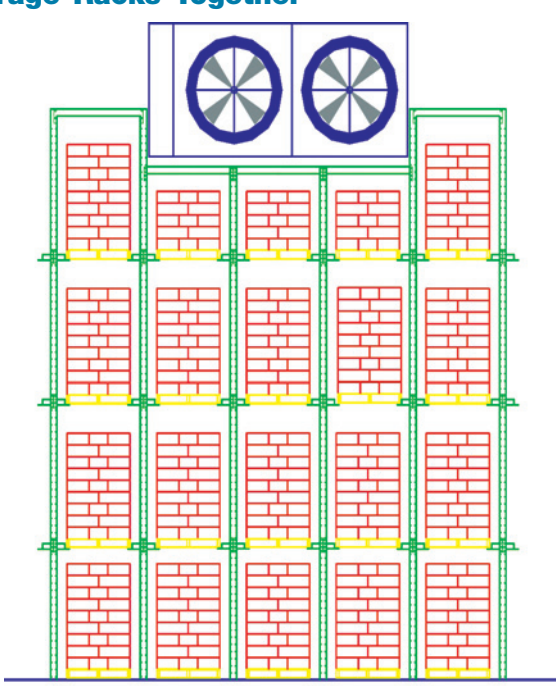


- Excellent density
- Cost
- Labor intensive
- Damage factors
- Poor order selectivity
- SKU proliferation
- Maintenance
- Human errors

Freezer

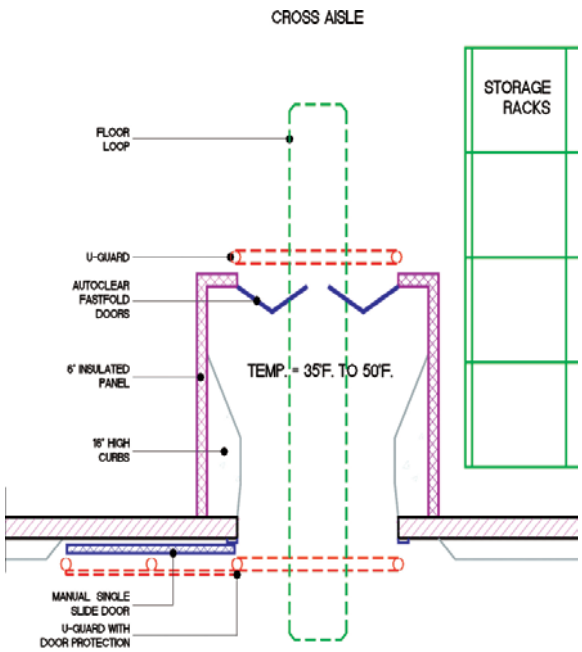
- Temperature
- Penthouses
- 35' clear height minimum
- 29' reach height
- Convertible rooms

Alternate Method of Fitting Air Units and Storage Racks Together



STORAGE RACK/AIR UNIT FIT

Provide Vestibule To Avoid Infiltration



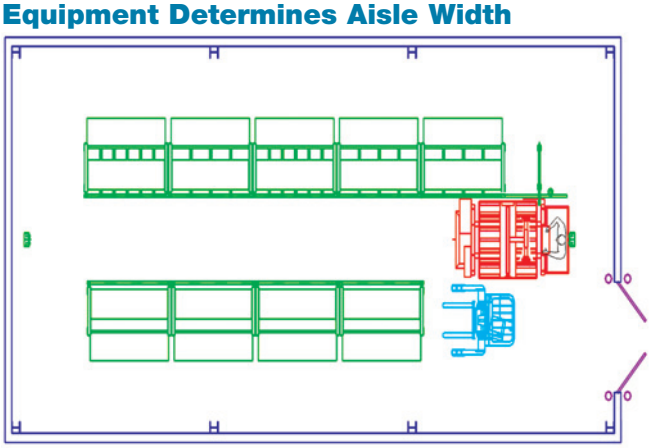
TYPICAL URS VESTIBULE

Note : Quality of doors has improved considerably now, so vestibule may not be required.

Fork Lift Maintenance/ Battery Charging Room

- Convenient location off the dock
- 3 ton overhead crane
- Engineer's office
- Ventilation
- Hydrogen detector (actuates fan)

Equipment Determines Aisle Width



TYPICAL URS BATTERY ROOM - FLOOR PLAN.

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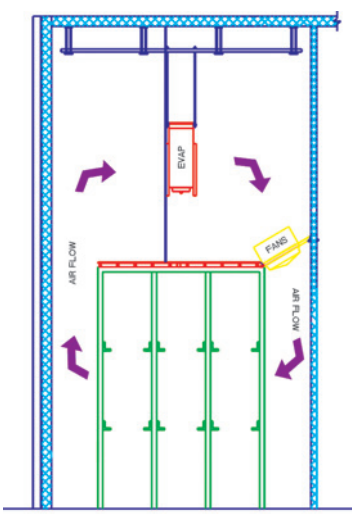
Blast Cells

- Near machine room
- Adjacent to dock wall
- Air flow
- Doors
- Maintenance access doors (3 ft. x 4 ft.)
- Ammeters at MCC
- Condensate drain lines heating cable inside pipe).

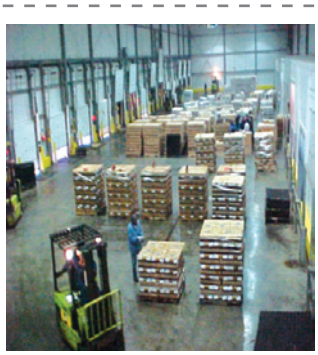
Typical Blast Cell – Elevation



Docks

- Truck and Rail Docks • Vertical doors • Overhead pallet storage • Air unit protection • Roof mounted controls and piping.

Truck Docks



- Temperature
- Width
- Ceiling height
- Number of doors
- Local trucks/ramp
- Trash compactor
- Stretch wrap
- Tilt table
- Overhead pallet storage

Dock Doors

- For 35°F and above, good quality sectional door
- For below freezing, vertical lift low temp doors
- Dock seals
- Dock locks

Dock Equipment

- Mechanical dock levelers
- Hydraulic vertical dock levelers
- Limit switches
- Guard posts

Overhead Door Improvements

- Tracks guarded
- Heavy duty tracks and hardware
- Smart design features
- Bottom panel guard

Curbs & Guards

- Reduces costs/year in repairing damages
- Greater efficiency makes increased damage more likely
- Panels and doors are damage prone

Penetrate Walls, Not Roof !

Mechanical, Electrical, Plumbing (MEP)

- **Temperature**
- **Verify utilities' entry**
- **Standby power, double feed**
- **Fire protection**
  - Well • Tank storage • Sprinklers
  - Wet or dry (less than 32°F)
  - In rack
  - Fire pumps.

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Lighting

- Inspection area : 50 – 100 f.c.
- Processing area : 30 f.c.
- General area : 20 f.c.
- Storage area : 10 f.c. (*f.c.: foot candles)*
- Piping, conduit and fixtures: 1" off wall or seal
- New fixtures
- Fluorescent with stepped dimming (saves on wiring)
- Programmable Logic Controller systems

Floor Warming

- Glycol
- Vent tubes
- Electric

Fire Protection

- Overhead sprinklers
- In-rack sprinklers
- Heat detection

Machine Room

- Designed for good maintenance access
- Epoxy coating on floor
- Electrical switch gear and MCC panels
- Good ventilation

Refrigeration

- IBM compatible computerized control system
- Rotary screw compressors
- Exterior piping and valve groups (rust inhibitor on piping)
- Pipe insulation and vapor barrier
- Isolation valves
- Ammonia detectors/room
- Condenser water treatment

Typical Project

The client initiates the first contact...

"As we had discussed recently and also on the telephone yesterday, Best Built Warehouse would like to open discussions with you and your company concerning the design/build of a new cold storage facility in Western Pennsylvania. General details are as follows:

1. 3,000,000 cubic feet
2. Two (2) blast cells each capable of holding 40,000 lbs.
3. If possible, rooms convertible from –10° to + 35° F
4. One freezer to maintain –5° to –15° F
5. Engine room to be designed to double size of building for future expansion

Dan, could you give me an approximate idea about how much the building will cost?

Thanks,
John J. Owner

The design firm replies with the rough scope of the facility and some rough numbers…

- 100,000 s.f. of freezer space
- 8,000 s.f. of dock
- 4,000 s.f. of office
- 5,000 s.f. of engine room
- Building will have a 4 ft. dock height.
- All necessary earth work and paving…
- Structural steel frame building w/ single-ply EPDM roof and required insulation.
- Eight dock doors.
- All utilities to 5 ft. outside the building.
- 27 ft. clear height inside.
- Insulated metal wall panels for exterior walls.
- All required refrigeration and electrical work

The design firm zeroes in on scope of work and facility needs...

- Concrete slab-on-grade (6" thick)
- Interior fire sprinkler system
- Ammonia refrigeration system

Design Project

- 100,000 s.f. freezer
- 13,500 s.f. dock at 40° F
- Office
- Engine room

Freezers

- 25,000 s.f. – 25° F ice cream
- (3) 25,000 s.f. – 10 / + 28° F poultry
- (2) 40,000 lb. – 30° F blast cells

Location

- Pittsburgh, PA
- O.A.T. 91° F dry bulb / 71° F wet bulb
- Altitude 1137 ft.

Information

- 40°F dock • 335 ft. × 40 ft. × 25 ft. high
  - People/ motors / lights / fork lifts • Infiltration
  - No product load
  - Little or no staging of product
  - –25° F freezer • 10 lb. product / s.f.
  - Pull down 15°F in 18 hr. (*ice cream*)
  - 300 ft. × 83 ft. × 40 ft. high • 3 aisles

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- People / motors / lights/ fork lifts
- Infiltration.

- (3) – 10° / +25°F freezers
  - 10 lb. product / s.f. • Pull down 10°F in 24 hr. (*chicken*) • 300 ft. × 83 ft. × 40 ft. high • 3 aisles • People / motors / lights/ fork lifts • Infiltration
- – 30° F blast freezer • 40,000 lb. product • Pull down –30°F in 24 hr. (*chicken*) • Infiltration

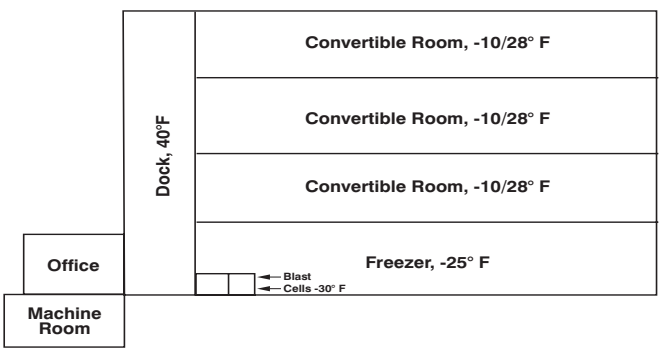


Figure 1 : Floor Plan of a typical 100,000 s.f. Freezer.

Design Data

Best Built Warehouse Pittsburgh, PA

General Characteristics and Geographical Information

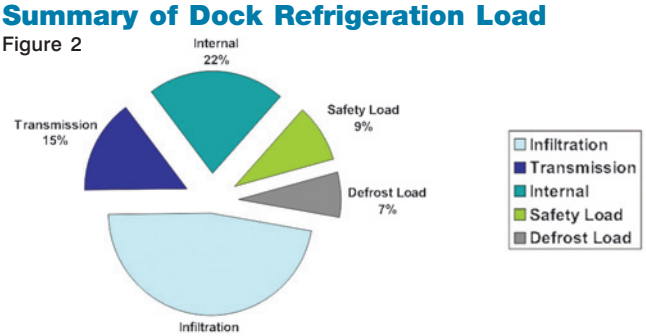
- Outdoor design conditions • Altitude 1137 feet • Outdoor design dry bulb: 91°F • Outdoor design wet bulb: 71°F • Infiltration air dry bulb: 91°F • Infiltration air wet bulb: 71°F.

+ 40°F Truck Dock

- Box dimensions: 335 x 40 x 25 feet
- Refrigerated dock dry bulb temp: 40°F
- 10 dock doors
- 3 doors to each 3 freezers
- 2 doors to –25°F / blast freezer
- Approximately 72 tons of refrigeration
- 6 Evaporators

Summary of Dock Refrigeration Load

Figure 2

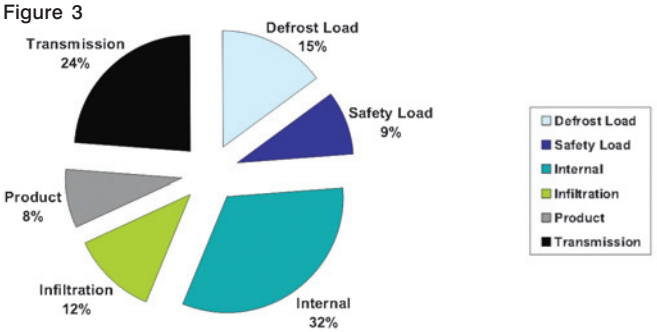


NH_3 Refrigeration System

- (1) 25,000 s.f. freezer • –25°F • 35 ft. clear height • 83 tons of refrigeration • 4 evaporators.

Summary of Refrigeration Load of – 25°F Freezer

Figure 3

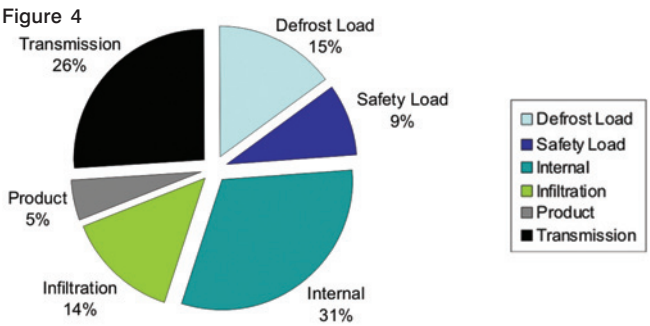


NH_3 Refrigeration System

- (2) –30° F blast cells • 40,000 pounds of product • Entering temperature +40°F • Product pull down to –10°F in 24 hours • 20 tons of refrigeration each • 1 evaporator each
- (3) 25,000 s.f. convertible freezers • –10°F or 28°F • 35 ft. clear height • 75 tons of refrigeration each • 4 evaporators each.

Summary Of Refrigeration Load of –10°F / +28°F Convertible Freezer

Figure 4

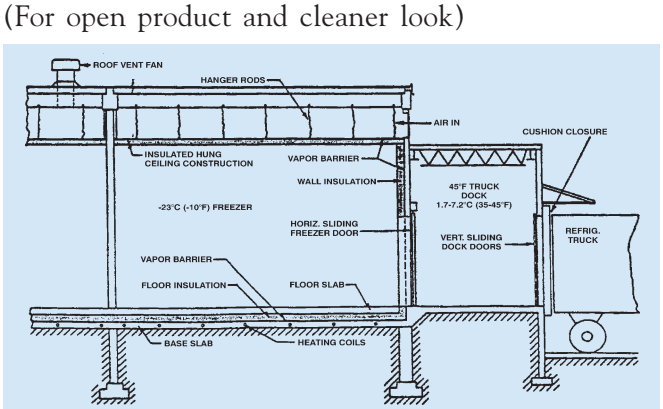


NH_3 Refrigeration System

- (1) Refrigerated machine room • Vented as per code • Condenser placed on the roof
- Water will drain back to an internal water sump

Freezer Section With Suspended Ceiling

(For open product and cleaner look)



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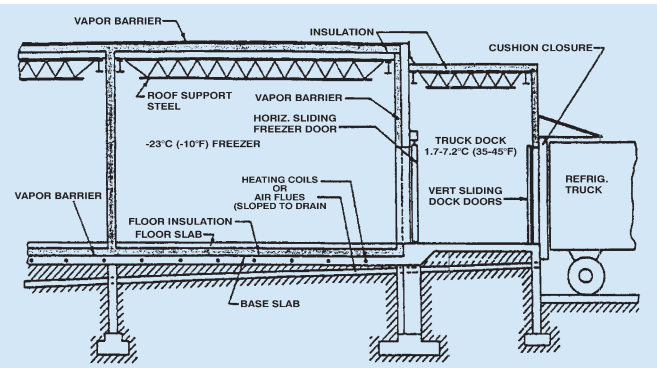
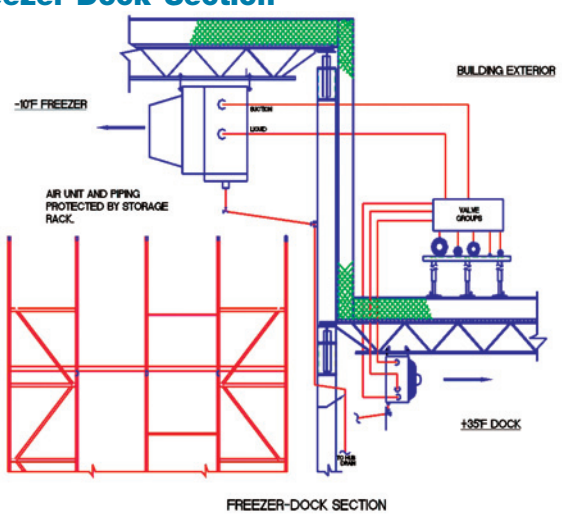
Freezer Section With Bar Joist Construction



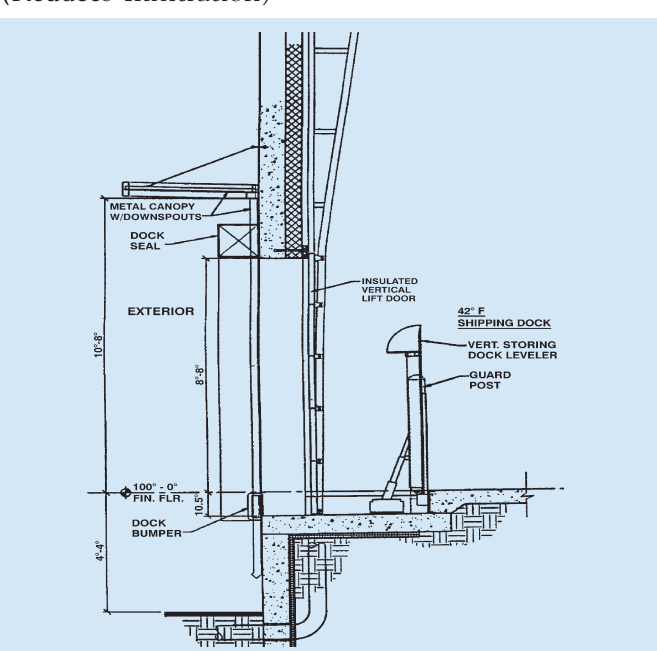
Freezer-Dock Section



FREEZER-DOCK SECTION

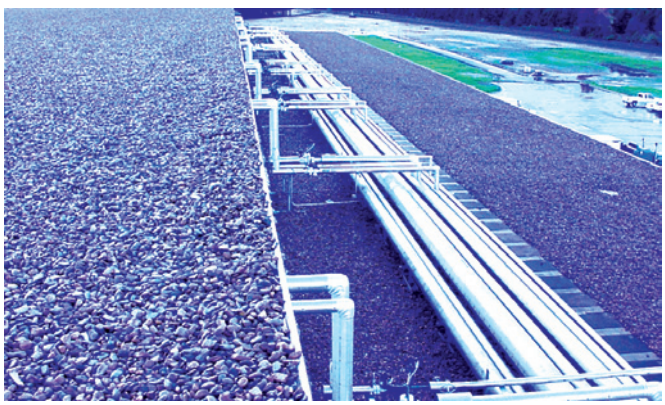
Vertical Storing Dock Leveler

(Reduces Infiltration)

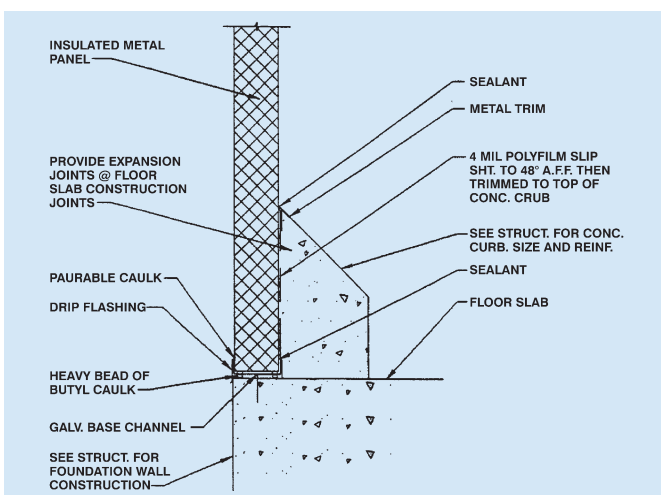


Reduce Ammonia Risks

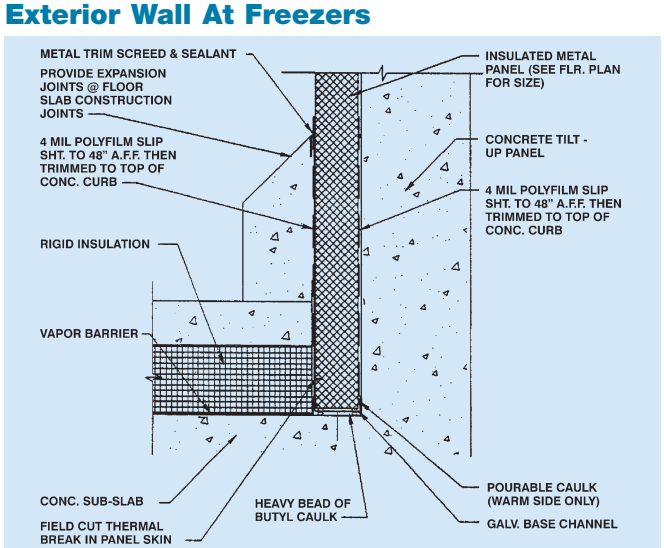
- Exterior piping
- No threaded fittings inside
- Protect system from fork lift damage
- Ammonia detection system



Exterior Wall At Dock



Exterior Wall At Freezers



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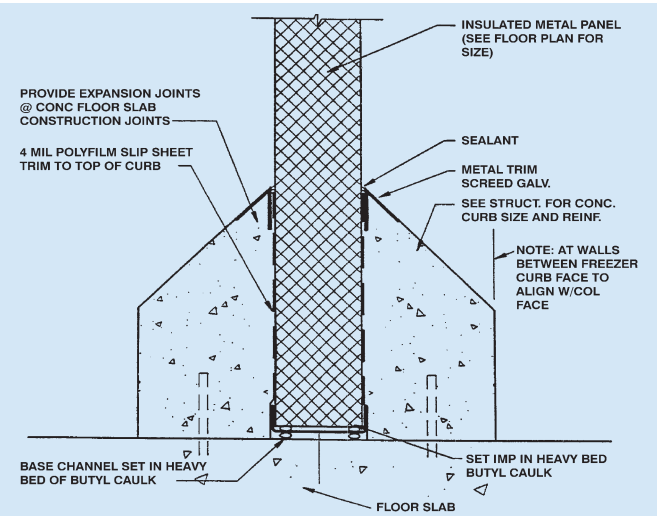
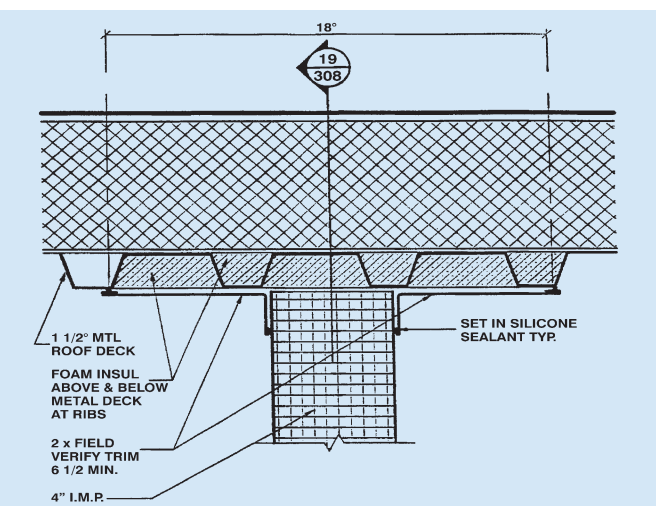
Interior IMP Wall With Curbs

(Versus top of curb) IMP : Insulated Metal Panel

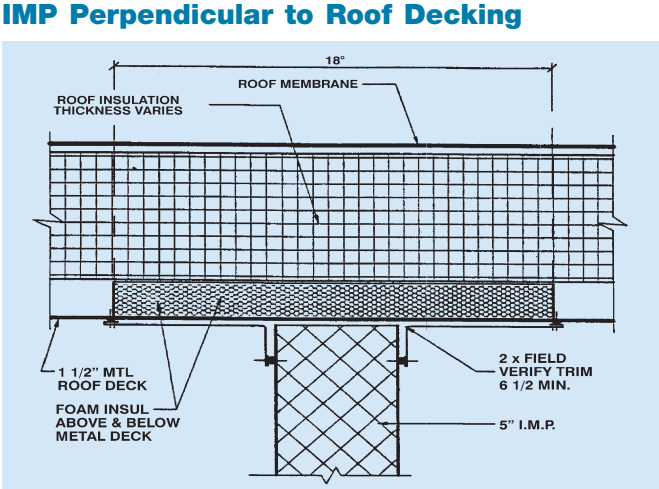


IMP Parallel to Roof Decking

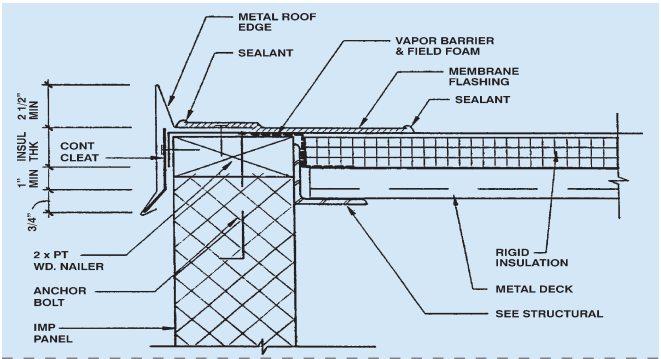
(IMP: Insulated Metal Panel)



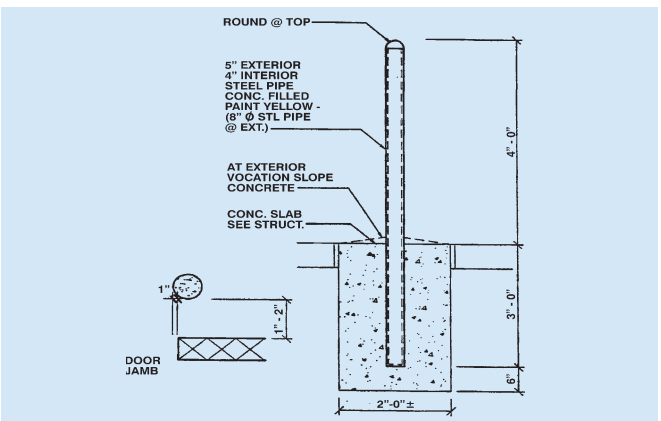
IMP Perpendicular to Roof Decking



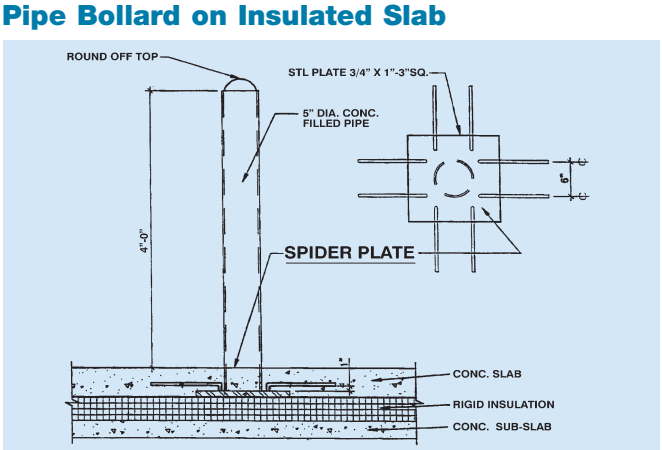
Flashing at Exterior Insulated Metal Panel Wall



Pipe Bollard



Pipe Bollard on Insulated Slab



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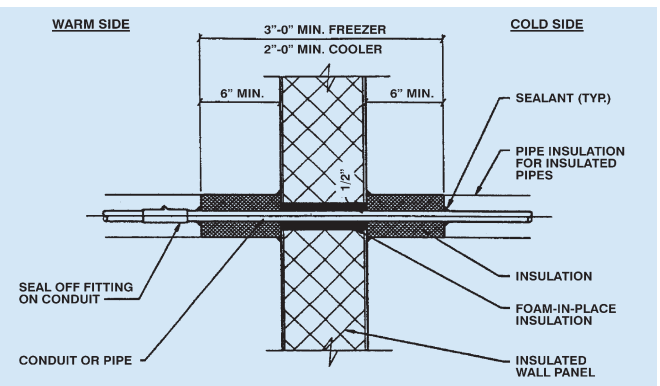
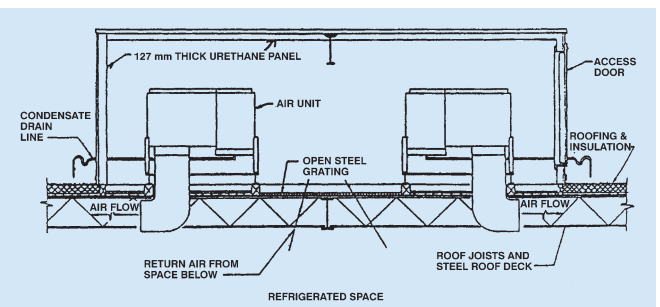
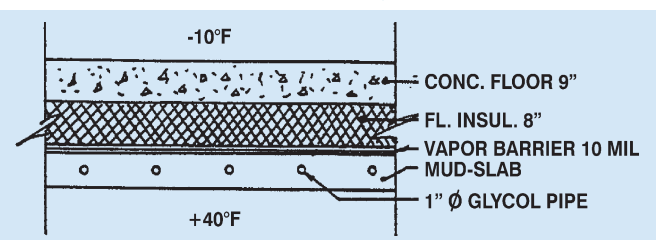
Insulated Metal Panel (Wall Penetration Detail)



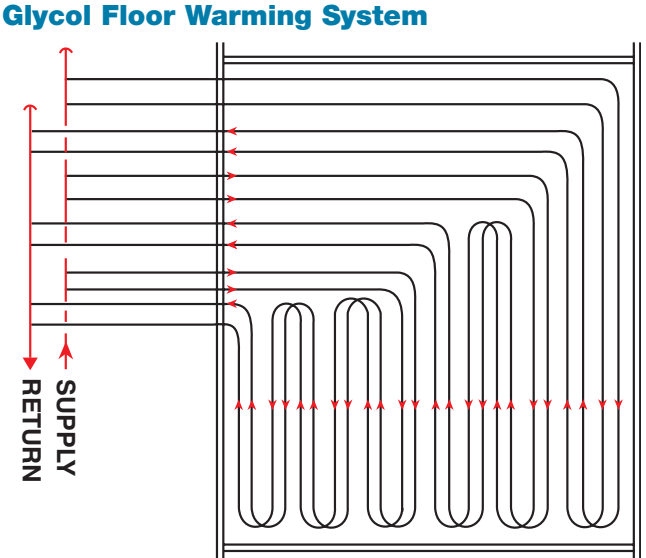
Penthouse Application of Refrigeration Units



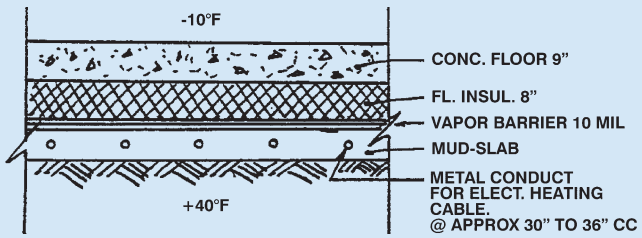
Glycol Underfloor Warming System



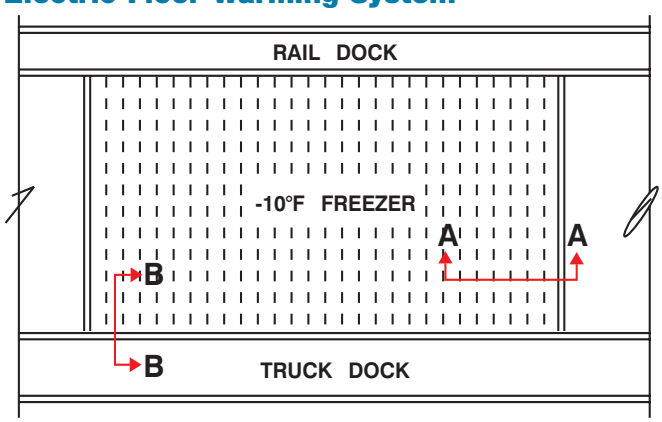
Glycol Floor Warming System



Electric Underfloor Warming System



Electric Floor Warming System



Reaching Goals

- Improve energy efficiency
- Improve operating efficiency

Improve Energy Efficiency

- Items regularly reviewed
- Insulation type and thickness
- Better doors/vestibules
- Efficient refrigeration system and controls

Improve Operating Efficiency

- Regularly review
- Storage area depth
- Dock width
- Door requirements
- Storage rack layout

Glimpses of a Good Installation

A pleasing appearance

Spacious plantroom

continued on page 104

continued from page 102

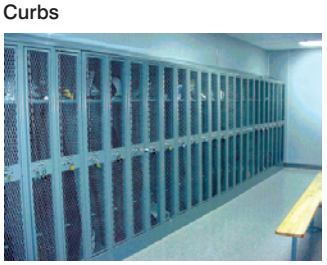
Walkways and gangways

Proper ventilation

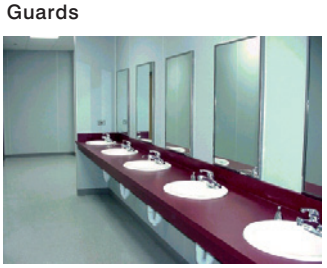
Well illuminated

Curbs

Guards



Locker rooms



Easy to clean

Conclusion

A cold storage facility may be a "big box", but it has to be built to rigid specifications.

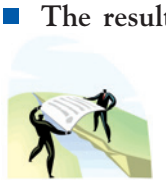
■ Building a new facility is a task that must be approached from multiple directions.

■ Close monitoring of the work during construction is crucial.

■ Make all the logistical decisions **early**; such as traffic flow, racking and staging areas.

■ Build in the temperature ranges and space necessary for your anticipated volume.

■ **The result**



- Efficient design
- Good workmanship
- Completion "on schedule"
- Successful project
- Happy owner!

❖