International Association for Cold Storage Construction


# Performance Considerations of the Thermal Envelope

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# Recommended Design Values

| Area Description | Wall Panel Thickness | Wall R-Value | Roof Insul. Thickness | Roof R-Value |
|---|---|---|---|---|
| Dry Warehouse | 3" | 24 | 3" | 18 |
| +50°F Coolers | 3" | 24 | 4" | 25 |
| +45°F Cooler/Dock | 4" | 32 | 6" | 38 |
| +32°F to +40°F Cooler | 4" | 32 | 6" | 38 |
| +28°F Cooler/Freezer | 4" | 32 | 7" | 44 |
| 0°F Freezer | 5" | 40 | 8" | 50 |
| -10°F Freezer | 5" to 6" | 40 to 48 | 8" | 50 |
| -20°F Freezer | 6" | 48 | 9" | 56 |

**Note:**
**R-Values shown are "conditioned" aged values.**

# Freezer Building Example

- We will look only at the Transmission loads for the maximum design conditions of the building (variable).
- Product loads (constant).
- Refrigeration fan motors (constant).
- Lighting heat (constant).
- Infiltration (constant).
- Material handling equipment (constant).
- Other loads (constant).

# Freezer Building - Transmission Loads Only

Components of the Transmission or Envelope Heat Loads:

- Heat flow through wall panels.
- Heat flow through the roof or ceiling – may be up to 50% of total envelope loads.
- Heat flow through the floor insulation.

# Freezer Facility Assumptions

- -20°F ice cream storage freezer.
- 24,000 sq. ft. facility  (150’ x 160’).
- Approximately 21,700 sq. ft. of wall panels.
- 35’ high.
- +34°F dock adjacent to freezer.
- Two doors between freezer and dock.
- Exterior design temperature of 90°F.
- Temperature difference is 110°F.
- Based on the maximum design load condition.

# Impact of Panel Thickness

- 4” thick urethane core insulated panel
- K-factor, Btu in/ft² hr °F
  @ 40°F mean core temperature = 0.126
- 1/K x t = R  (8 per inch of panel thickness)
- R = 32 for 4” panel
- △T / R = Q
- At 110 °F △T  and  Q = Btu/ hr. ft²
- Q = 3.44 Btu/hr. ft²

# Impact of Panel Thickness

- 5” thick urethane core insulated panel
- K-factor, Btu in/ft² hr °F
  @ 40°F mean core temperature = 0.126
- 1/K x t = R  (1/K=8 per inch thickness)
- R = 40 for 5” panel
- △T / R = Q
- At 110 °F △T  and  Q = Btu/ hr. ft²
- Q = 2.75 Btu/hr. ft²

# Impact of Panel Thickness

- 6” thick urethane core insulated panel
- K-factor, Btu in/ft² hr °F
  @ 40°F mean core temperature = 0.126
- 1/K x t = R
- R = 48 for 6” panel
- △T / R = Q
- Q = Btu/ hr. ft²
- Q = 2.30 Btu/hr. ft²

# Wall Panel Heat Flow Summary

| Panel Thickness in | Heat Flow Btu/Hr. Ft² | Wall Panel Area Sq. Ft. | Total Heat Btu/Hr. | Tons per Hour of Refrigeration |
|---|---|---|---|---|
| 4” | 3.44 | 21,700 | 74,648 | 6.22 |
| 5” | 2.75 | 21,700 | 59,675 | 4.97 |
| 6” | 2.30 | 21,700 | 49,910 | 4.16 |

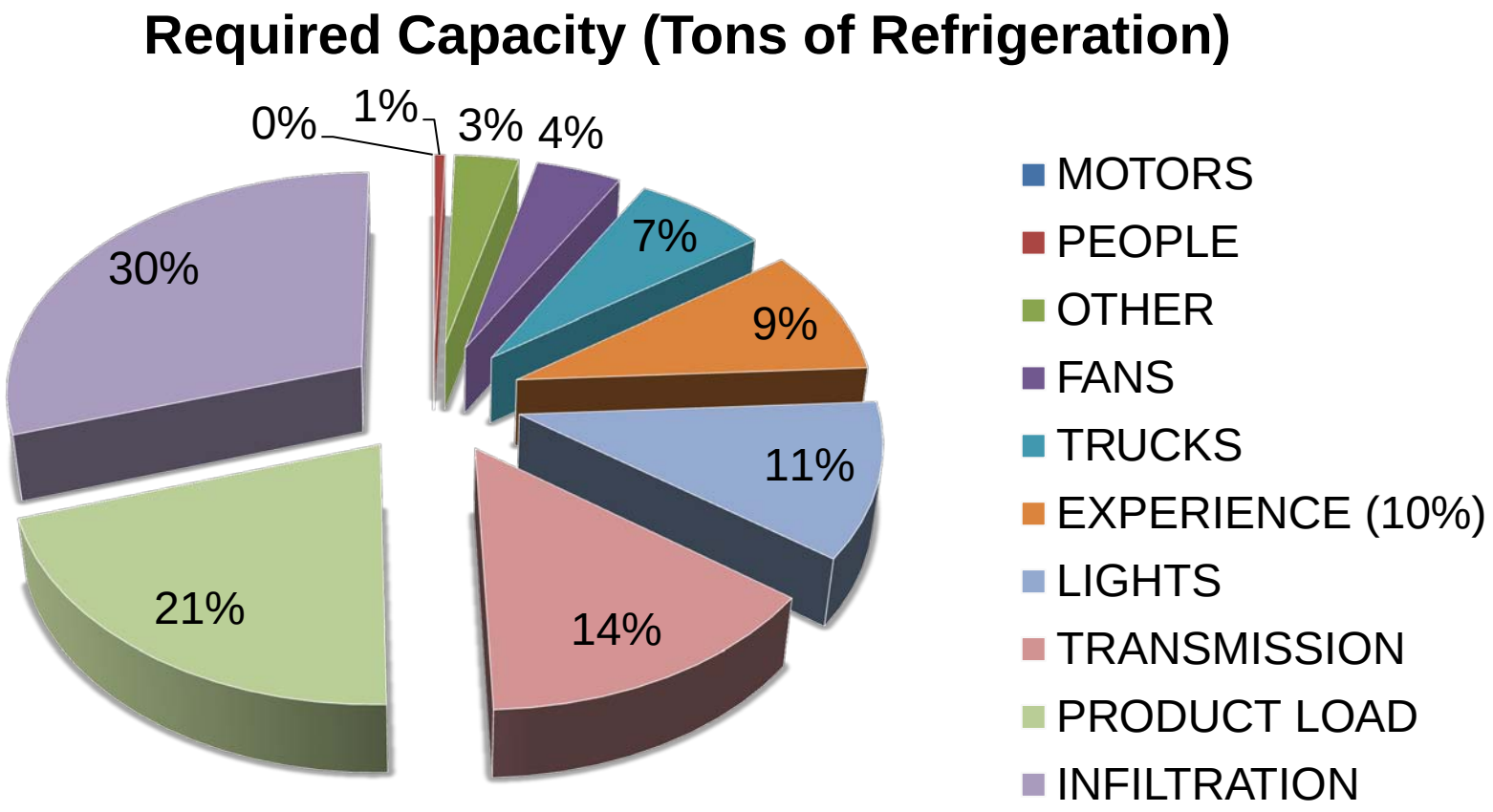
Difference between 4” panel and 6” panel is approx. 2.06 tons per hour

Note: 1 TR – 12,000 Btu/Hr.

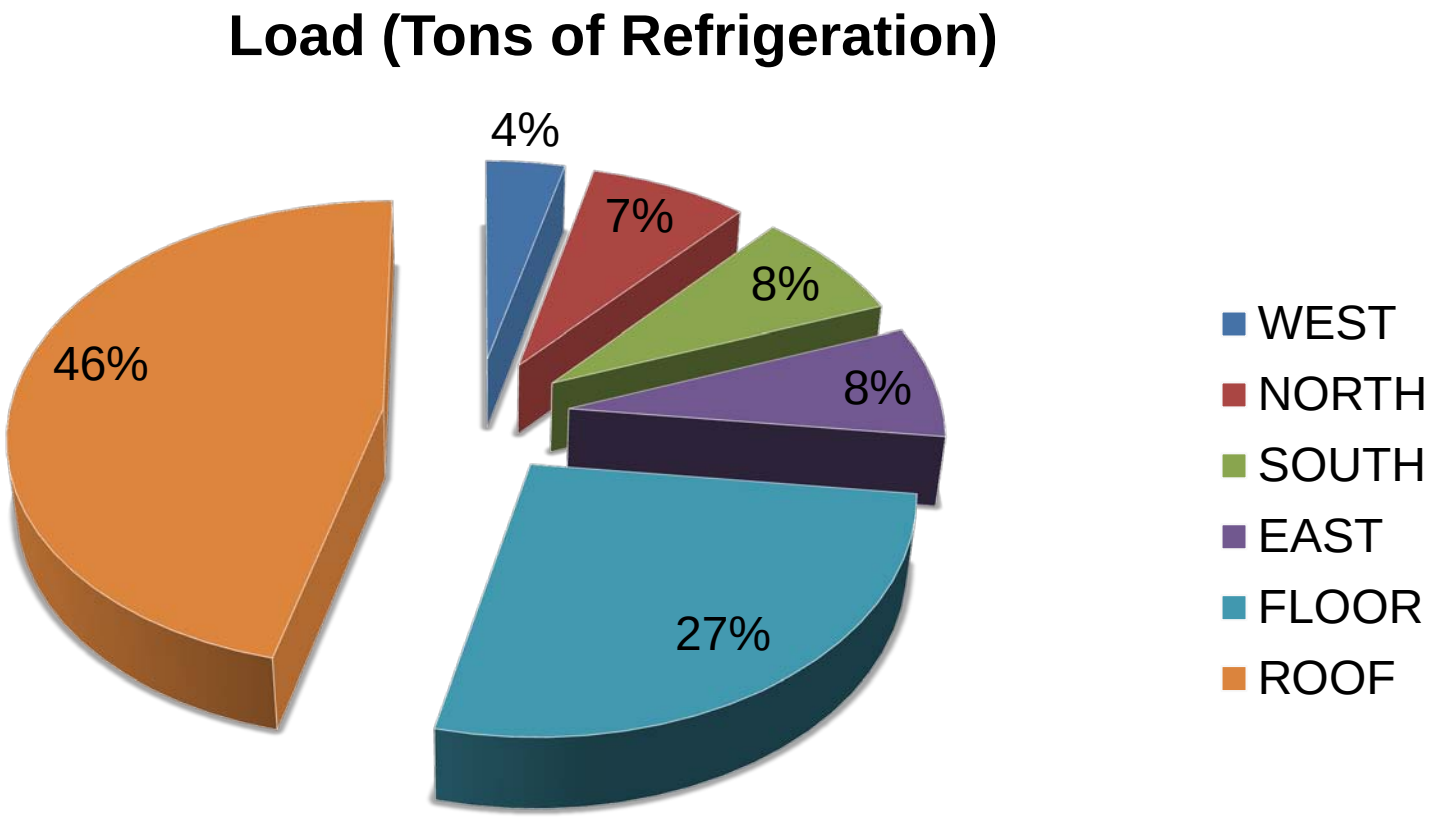
# Refrigeration Loads

| Loads | Tons per Hour |
|---|---|
| Transmission Loads | |
| Walls 6” R48 | 4.16 |
| Roof 8” R50 | 5.95 |
| Floor 6” R30 | 4.67 |
| Lights | 4.40 |
| People | 0.36 |
| MH Equipment | 6.19 |
| Product Load | 18.75 |
| Infiltration | 27.43 |
| Refrigeration Fans | 3.80 |
| **TOTAL LOAD** | **75.71** |

# Load Profile



# Transmission Load



# Load Contributions

| Contributor | Impact |
|---|---|
| Infiltration – generally the largest contributor to the load in a busy warehouse | 20-30% |
| Product – value depends on product type, storage temperature and incoming temperature | 0-30% |
| Envelope (Floor / Ceiling) – values depends on climate, storage temperature | 10-20% |
| Envelope (Walls) – value depends on climate and storage temperature | 5-10% |
| Other – made up of motors, people, trucks, fan motors, lighting | 15-20% |

# Peak Energy Cost for Walls

- Tons of Refrigeration = 75.71
- 5 Hp/Ton of Refrigeration @ -20°F
- 378.6 Horsepower
- 282 Kwh (Hp x 0.7457 = Kw)
- 282Kwh x 24 Hours/Day x 30 Days
- 203,040 Kw/month
- @ $0.10/Kw = $20,304/month

Note: This is based on 6” panel, 8” roof and 6” floor insulation.

# Energy Cost Difference for 4” vs. 6”

- Tons of Refrigeration = 2.06
- 5 Hp/Ton of Refrigeration @ -20°F
- 10.3 Horsepower
- 7.68 Kwh (Hp x 0.7457 = Kw)
- 7.68 Kwh x 24 Hours/Day x 30 Days
- 5,530 Kw/month
- @ $0.10/Kw = $553

# Energy Cost Comparison

| Electrical Rate per Kwh | Cost for Total TR | Cost for 4” vs. 6” |
|---|---|---|
| $0.07 | $14,213 | $ 387 |
| $0.10 | $20,304 | $ 553 |
| $0.13 | $26,395 | $ 719 |
| $0.15 | $30,456 | $ 830 |
| $0.20 | $40,608 | $1,106 |
| $0.25 | $50,760 | $1,383 |

Note:
Values assume continuous maximum design conditions for month.

# Return on Investment

| Electrical Rate per Kwh | Increased Capital Cost for 2” Panel | Monthly Electrical Savings for 6” vs. 4” | Years for Payback |
|---|---|---|---|
| $0.07 | $36,890 | $ 387 | 8.0 |
| $0.10 | $36,890 | $ 553 | 5.5 |
| $0.13 | $36,890 | $ 719 | 4.25 |
| $0.15 | $36,890 | $ 830 | 3.75 |
| $0.20 | $36,890 | $1,106 | 2.75 |
| $0.25 | $36,890 | $1,383 | 2.25 |

Note:
Values assume continuous maximum design conditions for month and a differential panel cost of $1.70/sq. ft.

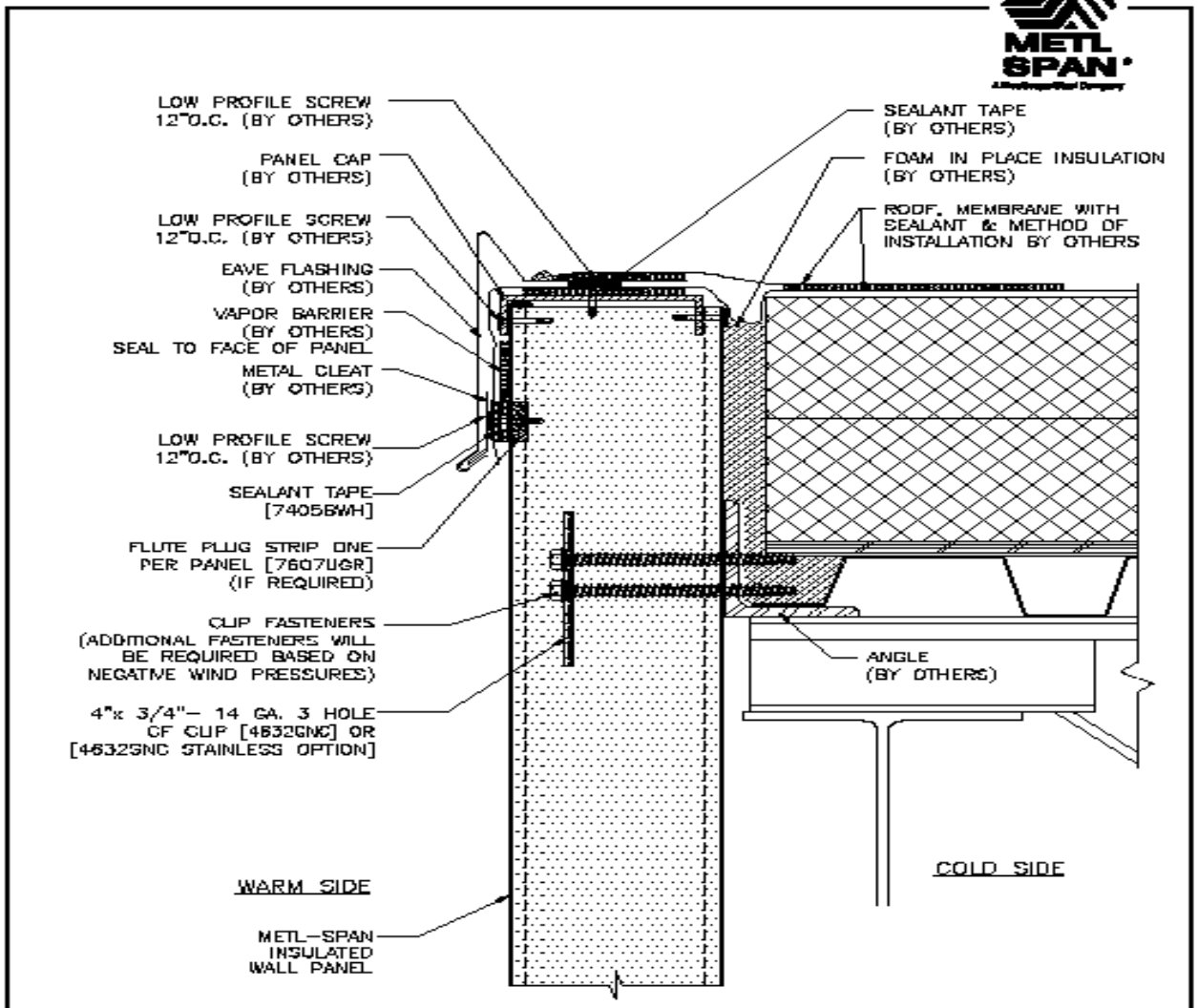
# Financial Comparison

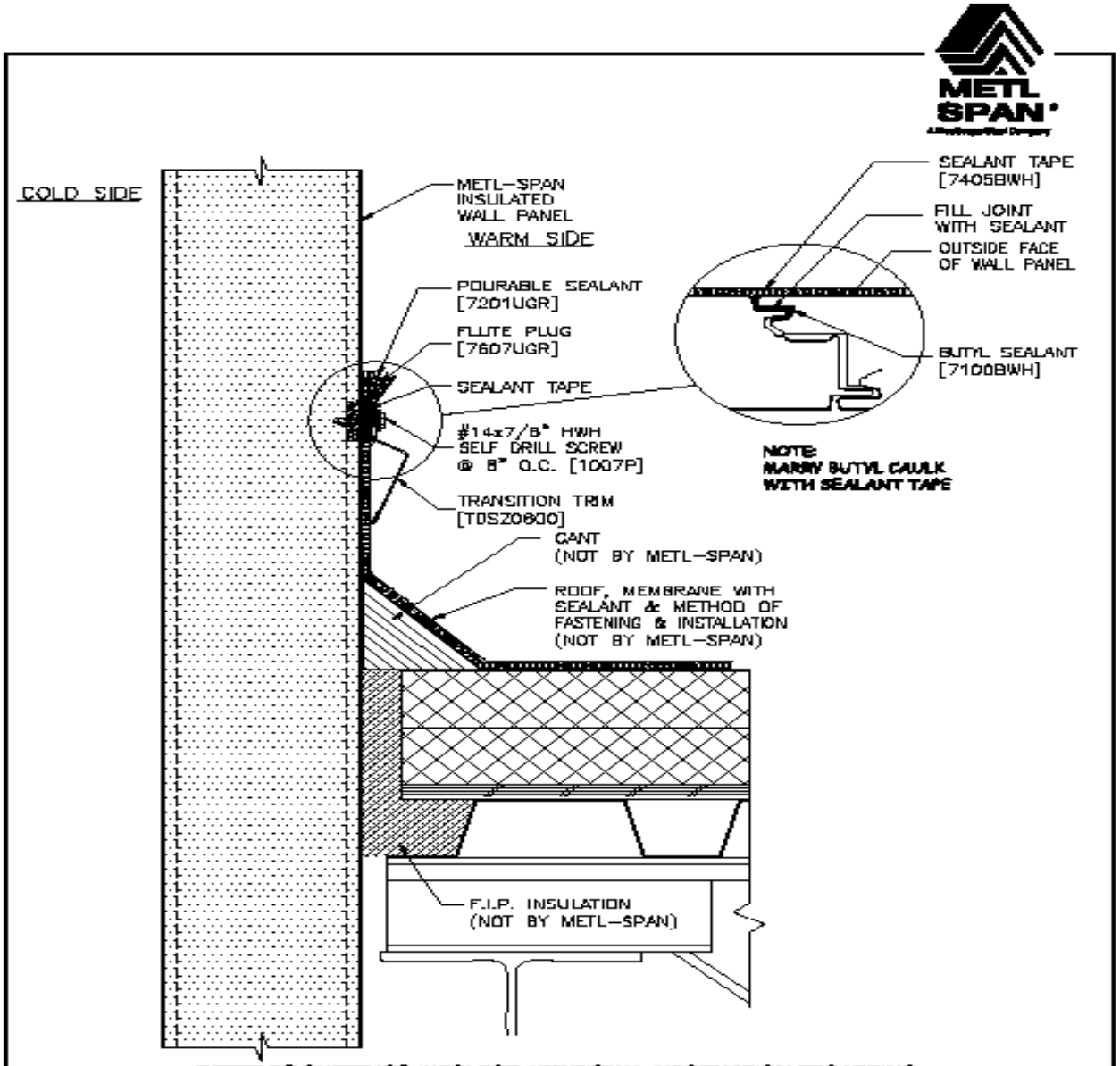
| Electrical Rate per Kwh | Increased Capital Cost for 2” Panel | Monthly Electrical Cost for 4” vs. 6” | Monthly Loan Amount for Capital |
|---|---|---|---|
| $0.07 | $36,890 | $ 387 | $282 |
| $0.10 | $36,890 | $ 553 | $282 |
| $0.13 | $36,890 | $ 719 | $282 |
| $0.15 | $36,890 | $ 830 | $282 |
| $0.20 | $36,890 | $1,106 | $282 |
| $0.25 | $36,890 | $1,383 | $282 |

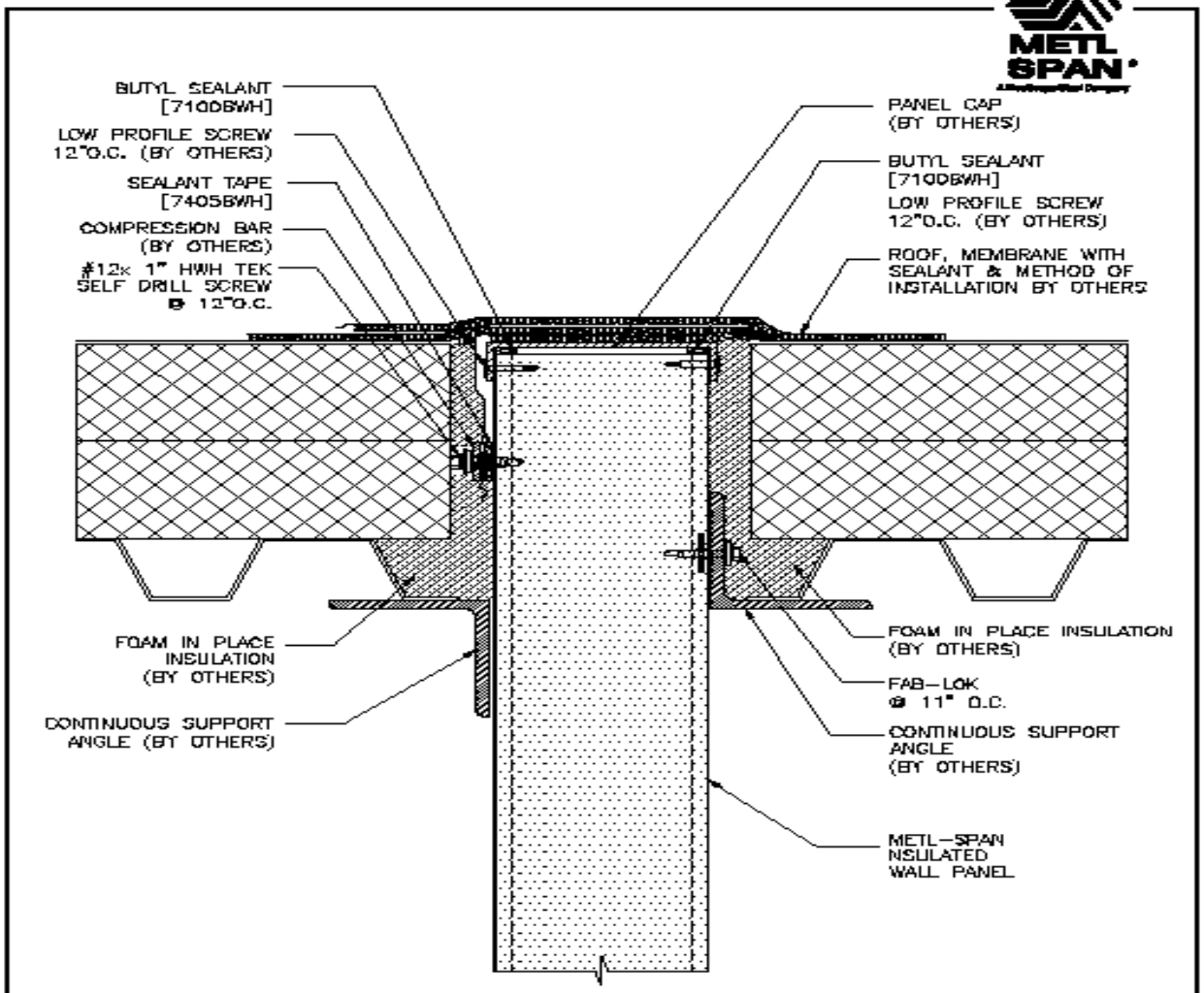
Note:
Values assume same as pervious slide and an interest rate of 4.5% over a 15 year amortization.

# Panel Attachment Considerations

- Set the wall girt attachment elevations based on the span capability of the panel.
- Set the fastener pattern based on the wind load transfer at the girt line.
- Keep the panel’s metal skins set at 26 gauge unless a change is required for other reasons.
- Watch corner conditions closely.


METL SPAN
LOW PROFILE SCREW 12"O.C. (BY OTHERS)
PANEL CAP (BY OTHERS)
LOW PROFILE SCREW 12"O.C. (BY OTHERS)
EAVE FLASHING (BY OTHERS)
VAPOR BARRIER (BY OTHERS) SEAL TO FACE OF PANEL
METAL CLEAT (BY OTHERS)
LOW PROFILE SCREW 12"O.C. (BY OTHERS)
SEALANT TAPE [74056WH]
FLUTE PLUG STRIP ONE PER PANEL [7607UGR] (IF REQUIRED)
CLIP FASTENERS (ADDITIONAL FASTENERS WILL BE REQUIRED BASED ON NEGATIVE WIND PRESSURES)
4"x 3/4"– 14 GA. 3 HOLE CF CLIP [4632GNC] OR [4632SNC STAINLESS OPTION]
WARM SIDE
METL–SPAN INSULATED WALL PANEL
SEALANT TAPE (BY OTHERS)
FOAM IN PLACE INSULATION (BY OTHERS)
ROOF. MEMBRANE WITH SEALANT & METHOD OF INSTALLATION BY OTHERS
ANGLE (BY OTHERS)
COLD SIDE
REFER TO SHEET 'CS-INFO' FOR ADDITIONAL INFORMATION REGARDING THE APPLICATION OF SEALANTS, FASTENERS AND CLOSURE MATERIALS.
EAVE DETAIL
APPLICATION:
FREEZER OR COOLER
CS-EE-01
DATE: OCTOBER 1, 2008


METL-SPAN
COLD SIDE
METL-SPAN INSULATED WALL PANEL
WARM SIDE
POURABLE SEALANT [7201UGR]
FLUTE PLUG [7607UGR]
SEALANT TAPE
#14x7/8" HWH SELF DRILL SCREW @ 8" O.C. [1007P]
TRANSITION TRIM [TDSZ0600]
GANT (NOT BY METL-SPAN)
ROOF, MEMBRANE WITH SEALANT & METHOD OF FASTENING & INSTALLATION (NOT BY METL-SPAN)
F.I.P. INSULATION (NOT BY METL-SPAN)
SEALANT TAPE [7405BWH]
FILL JOINT WITH SEALANT
OUTSIDE FACE OF WALL PANEL
BUTYL SEALANT [7100BWH]
NOTE:
MARRY BUTYL CAULK WITH SEALANT TAPE
REFER TO SHEET 'CS-INFO' FOR ADDITIONAL INFORMATION REGARDING THE APPLICATION OF SEALANTS, FASTENERS AND CLOSURE MATERIALS.
LOW ROOF/HIGH WALL INTERSECT DETAIL
APPLICATION:
FREEZER OR COOLER
CS-WR-03
DATE: OCTOBER 1, 2008


METL SPAN
BUTYL SEALANT [710DBWH]
LOW PROFILE SCREW 12"O.C. (BY OTHERS)
SEALANT TAPE [740SBWH]
COMPRESSION BAR (BY OTHERS)
#12x 1" HWH TEK SELF DRILL SCREW @ 12"O.C.
PANEL CAP (BY OTHERS)
BUTYL SEALANT [710DBWH]
LOW PROFILE SCREW 12"O.C. (BY OTHERS)
ROOF, MEMBRANE WITH SEALANT & METHOD OF INSTALLATION BY OTHERS
FOAM IN PLACE INSULATION (BY OTHERS)
CONTINUOUS SUPPORT ANGLE (BY OTHERS)
FOAM IN PLACE INSULATION (BY OTHERS)
FAB-LOK @ 11" O.C.
CONTINUOUS SUPPORT ANGLE (BY OTHERS)
METL-SPAN INSULATED WALL PANEL
REFER TO SHEET 'CS-INFO' FOR ADDITIONAL INFORMATION REGARDING THE APPLICATION OF SEALANTS, FASTENERS AND CLOSURE MATERIALS.
WALL / ROOF DETAIL
APPLICATION: FREEZER / COOLER COOLER / AMBIENT
CS-WR-01
DATE: OCTOBER 1, 2008

# Considerations for Cavity Space Ventilation Above Ceiling Panels

- Dead air space promotes condensation.
- Still air begins to “participate” with the insulation and a dew point can develop.
- Moving air serves to keep air space temperature elevated for the same moisture levels in air.
- Recommend at least six volumetric air changes per hour in the cavity space.
- Relative humidity is relative – it’s the actual moisture in the air that matters.

# Considerations for Temperature Pull-down

- Keep refrigeration set above freezing until moisture formation and condensation has stopped occurring.
- Keep refrigeration on for at least a week before going below freezing.
- Step the room down about 10° at a time and hold for two days at each step.
- Make provisions for pressure equalization.

# California Title 24

- “Title 24” is California’s Building Energy Efficiency Standards became effective for Refrigerated Warehouses on January 1, 2010.
- Section 126 addresses the energy efficiency of refrigerated spaces within buildings. A refrigerated warehouse with total cold storage and frozen storage area of **3,000 square feet or larger** are subject to the Code.
- EXCEPTION 1: A refrigerated space less than 3,000 square feet must meet the Appliance Efficiency Regulations.
- EXCEPTION 2: Areas designed **solely for the purpose of quick chilling or freezing of products** with design cooling capacities of greater than 240 Btu/hr-ft2 (2 tons per 100 ft2).

# Envelope Insulation Values

| MINIMUM TITLE 24 VS ASHRAE RECOMMENDATIONS | | | |
|---|---|---|---|
| **SPACE** | **SURFACE** | **MIN R-VALUE TITLE 24 (°F·hr·ft²/Btu)** | **ASHRAE* (°F·hr·ft²/Btu)** |
| Frozen Storage | Roof/Ceiling | R-36 | R-35 to R-50 |
| (below 32°F) | Wall | R-36 | R-35 to R-40 |
| | Floor | R-36 | R-27 to R-32 |
| Cold Storage | Roof/Ceiling | R-28 | R-24 to R-40 |
| (32°-55°F) | Wall | R-28 | R-24 to R-32 |

** ASHRAE Recommended R-Values (2010)*

*Other restrictions are placed on mechanical equipment, lighting, and sub-floor heating (frost heave protection).*

# Owners Considerations for Performance Evaluation

- Thermal Performance – Based on ASTM C-1363 Thermal Testing. System test based on actual application including full panels, clips and sealants.
- Structural Performance – Based on ASTM E-72 Structural Testing.

# FM4880

- Combustible components such as foam when used in non-combustible construction has to meet the requirements of IBC chapter 26. To waive the thermal barrier requirement (i.e. gypsum) the product must meet testing standards of FM4880, UL1040 or NFPA286.

# FM4880

- Up to 2005 the FM4880 approval for exterior walls did not have structural testing requirements. FM4880 was a testing classification for fire protection only.

# FM4881

- FM4881 Standard was introduced in 2005 and sets structural performance requirements for all exterior wall systems including, but not limited to metal, concrete, composite and glass. This standard is required on all projects that are FM Global insured.

# FM4881

- Requires the use of Data Sheet FM 1-28 for calculating wind ratings.
- The design pressures are calculated based on FM Global Property Loss Prevention Data Sheet 1-28.
- A safety factor of 2 is applied to the design pressure to determine wind ratings which are published in increments of 5 PSF.

# FM4881

- Products that receive approval recognition have been evaluated to provide assurance that they will perform their intended functions and maintain the integrity of the building envelope for that stated design conditions.