

Considerations in Design and Construction of Freezer Buildings for Building Envelope Consultants

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Figure 1 – Frozen and refrigerated seafood processing facility.

Freezer buildings may contain many food staples, such as fish and other seafood, frozen fruit juice, and dairy and meat products.

According to the USDA,¹ the United States has 3.79 billion gross cubic feet of general refrigerated storage capacity, including both freezer and cooler space. The five states with the largest gross capacity are California with 495 million cubic feet; Florida, 274 million; Pennsylvania, 227 million; Georgia, 218 million; and Texas, 198 million.

Freezer space is defined as space that maintains temperatures at 0°F or lower. Cooler space is defined as space that maintains temperatures between 0°F and 50°F.²

Similar to an upside-down boat, a freezer building and its “exterior envelope” have to keep the water out. But it gets a bit more complicated: It must also keep out uncontrolled exterior air.

The outside air may be warmer or cooler than the inside of the freezer and usually contains more moisture. Cold air and air below freezing contain significantly less water than air above freezing. The colder it gets, the less likely the air will contain any significant amount of water. Think about the dry snow in the cold Rockies. Snowfall usu-

ally occurs between 25°F and 35°F, when a warmer and wetter air mass meets a cold air mass. Remember the deep, fluffy-powder skiing days? Or for you Eastern skiers and boarders, the “ice ages”? Once the air gets cold enough, the water or moisture vapor gets wrung out of the air mass.

The same kinds of issues must be



Figure 2 – Rack-mounted ammonia or Freon compressor units.

considered when working with a freezer or cold-storage building.

The cold air within the storage building wants to wring the water out of the air entering from the outside. The problem is that this is condensation, which becomes ice in a freezer. Defrosting a freezer warehouse is considerably harder than defrosting your own home freezer.

Freezers and cold storage are usually cooled with ammonia, as it is the cheapest and most readily available refrigerant. Other refrigerants include carbon dioxide (CO₂), chlorofluorocarbon (CFC), hydrochlorofluorocarbons (HCFCs), and similar products. The problem with ammonia is both that it is toxic and that it can be explosive in a concentration of 16-25%. During the 1930s, fluorocarbon refrigerants were developed and became common in smaller package units and the residential marketplace (Figure 2).

Walls of freezer buildings may be made of steel, tilt-up concrete, insulated metal panels, concrete masonry units (CMUs), or brick. The trick is to have a solid wall and roof deck onto which the continuous vapor/air barrier/retarder³ may be applied. The



Figure 3 – Fiberglass insulation held in place with wood frame/grid in frozen-juice plant.

vapor barrier should have a vapor permeance less than 0.01 perms.⁴ Note, however, that the laboratory perm rating of 0.01 may be 0.05 in the field.

The principle is that as warm air meets the vapor barrier, the temperature at the vapor barrier is above the condensation point or dew point. The moist air is not allowed past, just as rain would not go past; and therefore, the interior side of the vapor barrier stays dry. However, the interior face of the vapor barrier has to be protected and

insulated to maintain that warmer temperature. Various insulations can be used, depending on the designer's preference. In modern construction, these commonly include fiberglass, extruded and expanded polystyrene, and polyisocyanurate.

Historically, ground cork and sawdust have been used. Think about how thick those walls were!

The insulation can be installed with adhesive and/or stick-pinned to the inside wall vapor barrier and then protected by a

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Figure 5 – Torn vapor barrier at the perimeter allowed moist air into the building in the design shown in Figure 4.

grid of wood framing or other similar method (Figure 3). The additional framing helps hold the insulation in place and provides protection.

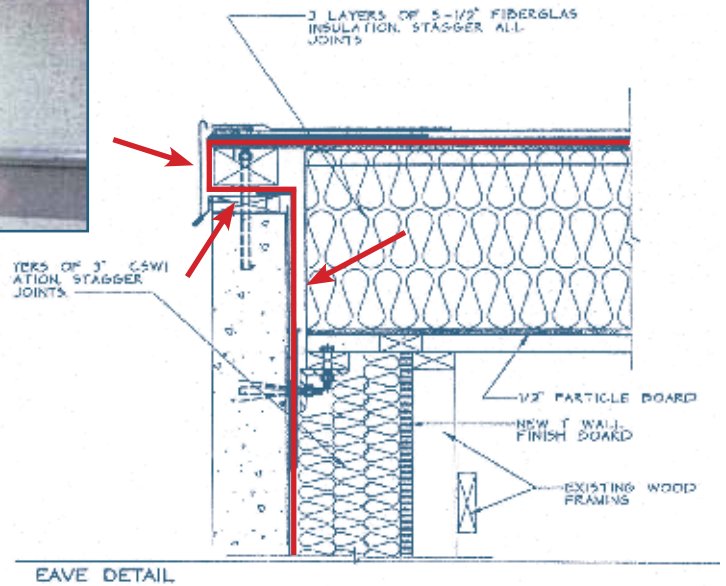
Obviously, the laps or seams in the vapor barrier need to be sealed and the insulation joints offset to avoid a thermal short-circuit. The attachment methods for any framing need to be isolated and minimized to avoid thermal bridging.

In this author's experience, problems with freezers most commonly occur at roof-to-wall transitions and at penetrations. The roof-to-wall transition usually forces the

vapor barrier from the inside surface of the wall to the outside top edge of the wall. This transition forces the vapor barrier to deal with the anchor points for the roof structure in an attempt to keep the vapor retarder continuous (Figure 4).

While Figure 4 with the embedded metal

Figure 4 – Edge detail of frozen juice freezer shown in Figure 5.



is not a great roof edge detail, it is pretty simple. One can see that the vapor barrier (the red line pointed to by arrows) is relatively continuous.

Sometimes during the construction process, the vapor barrier becomes damaged as it wraps over the top of the wall (Figure 5).

In this case, the warm, moist air entered the top of the wall and showed up as ice balls on the wall below, after saturating and freezing in the fiberglass insulation (Figures 6 and 7).

Often, the cooling and refrigeration equipment is outside of the building or the freezer unit (Figure 8). Where the piping for the refrigerant goes through, the wall needs to be sealed in a manner that does not let air penetrate, yet allows for movement of the piping. The piping



Figure 6 – Icicles extending down below the roof-to-wall joint due to air leakage from the exterior.

Figure 7 – Infrared photo taken in area similar to Figure 6.



may move due to thermal expansion and contraction or vibration, so flashing boots, just like roofing, are required.

Sometimes the designer relies a bit too heavily on the materials manufacturer who wants to sell a product that may not be appropriate for the application. The design in Figure 9 shows a lack of knowledge on the part of the designer (or at best, the drafter). Note that the roof system is a mechanically fastened single ply. In this case, the manufacturer convinced the owner that the thermal bridge of the roofing and insulation screws would not present a problem.

Another source of air penetration through the wall can be joints at wall



Figure 8 – Insulated refrigeration line penetrating exterior wall of freezer building.

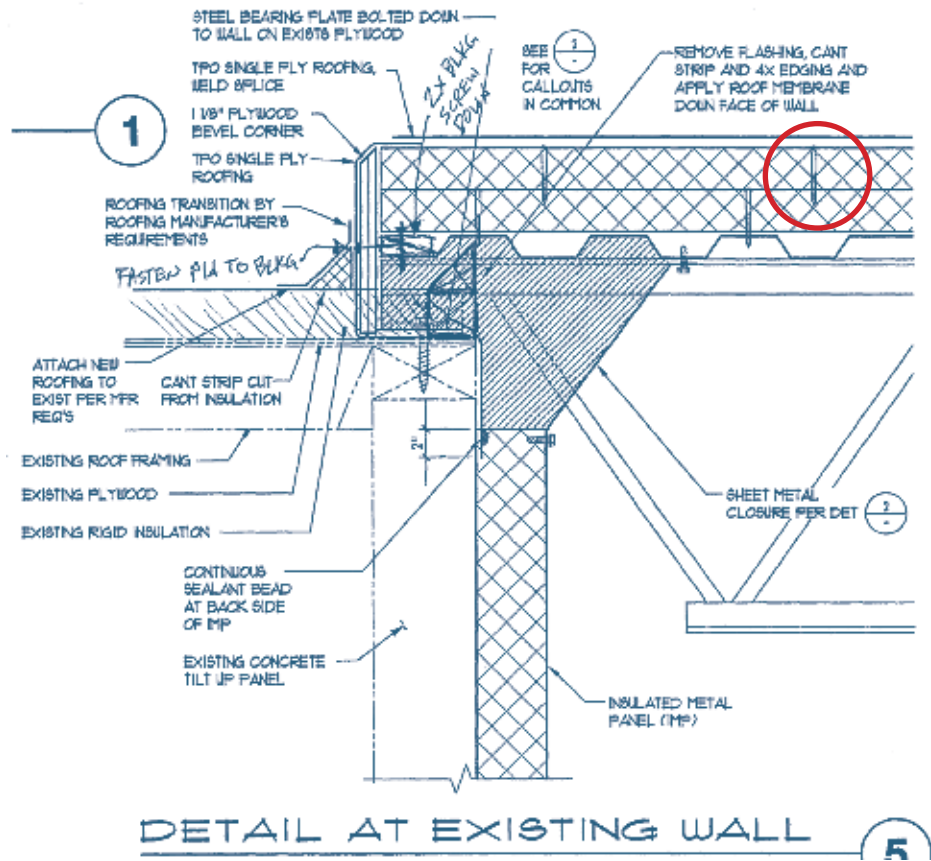


Figure 9 – This detail shows mechanical fasteners (“air” fasteners) creating thermal bridging if the membrane is mechanically attached to the metal deck below, as approved by the roofing materials manufacturer.



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Figure 10 – This sealant joint needs to be replaced as part of reestablishing the air and vapor barrier on the exterior wall of the freezer building.

panels. While in theory, air vapor transmission should be blocked on the inside of the wall by the vapor barrier, open joints in a tilt-up wall panel or masonry wall may allow degradation of the vapor barrier and, subsequently, vapor (and water) entry (Figure 10).

Obviously, the roof membrane on the outside of the building serves as an excellent vapor barrier. However, some materials are more vapor-permeable than others and should be reviewed prior to use. The roofing system should be compatible and integral with the materials used for the vapor barrier from the interior (in other words, for example, asphalt-based self-adhered flashings should not overlap a PVC single-ply roof membrane).

In summary, while the design can be complicated, the concept is simple. The

vapor barrier is just like a “roof” over insulation, except that it is applied to both the roof and the walls. We have not discussed how the slab or floor is insulated and the vapor barrier installed, but the concept is the same.

The consequences of not considering the effects of moisture vapor and a vapor barrier can be expensive. 

REFERENCES

1. USDA, “Capacity of Refrigerated Warehouses,” 2009 Summary, page 1.
2. USDA, “Capacity of Refrigerated Warehouses,” 2009 Summary, page 11.
3. When this paper was initially peer-reviewed in 2005, the reviewer was concerned with the use of the

term “barrier” instead of “retarder” as we use it on insulated roof assemblies. In this author’s opinion, the term barrier is more appropriate. The intent is the same, but a “barrier” should do just that—not allow air or vapor through. The barrier better be a very good, almost-perfect retarder! So much for semantics.

4. Fortifiber, “Suggested Application Specifications.”

Editor’s Note: This article is an updated version of the paper titled “Design Considerations for Cold Interior Environments,” published in the *Proceedings of the 2005 RCI 20th International Convention and Trade Show*.



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Ray Wetherholt founded Wetherholt and Associates in 1984 to assist owners in resolving water intrusion-related issues. Previously, he worked for a commercial construction inspection and testing company. Projects have ranged from

green roofs on homes, to large manufacturing buildings for an aircraft manufacturer, to the Experience Music Project. He has spoken at RCI events and taught numerous RCI and related industry courses, including the SWRIstitute’s “Liquid-Applied Sealants” course. In his spare time, he helps his wife with a small farm and ski patrols at Stevens Pass Resort.

MCA to Conduct Research

The Metal Construction Association (MCA) is pursuing several research projects over the course of the next few years. They are:

- Evaluate the ability of cool wall panels and other wall materials to reduce building energy usage. Funded through a grant from the Lawrence Berkeley National Laboratory (LBNL) in Berkeley, California.
- Evaluate the air permeability of metal roof panels to measure the level of wind-uplift resistance. To be conducted at the University of Florida at Gainesville.
- Study the effects of spray polyurethane foam insulation on metal panels. Address concerns about oil canning and potential damage to paint films as a result of spray foam curing. In conjunction with the Spray Polyurethane Foam Alliance and the Metal Building Manufacturers Association.

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