

A Guide to Cold Storage Design

SPECIFIC TO THE COMMERCIAL ROOFING SYSTEM

NOTES:

1. REFER TO JOHNS MANVILLE WEBSITE (www.jm.com) FOR MOST UP-TO-DATE INFORMATION.
2. PLEASE SEE SINGLE PLY FLASHING SPECIFICATIONS FOR A FULL DESCRIPTION OF INSTALLATION INSTRUCTIONS. THIS DETAIL IS CONSIDERED A PART OF THIS DETAIL.
3. ANY CARPENTRY OR METAL WORK SHOULD BE DESIGNED AND CONSTRUCTED IN ACCORDANCE WITH THE APPLICABLE SPECIFICATIONS. THESE COMPONENTS SHOULD BE REVIEWED AND APPROVED BY A LICENSED DESIGN PROFESSIONAL.
4. JM TPO EDGE SEALANT IS REQUIRED ON ALL CUT OR NON-ENCAPSULATED EDGES OF REINFORCED CONCRETE. (SEE DETAIL T-MS-01)
5. JM TPO MEMBRANE PRIMER OR JM SINGLE PLY MEMBRANE PRIMER (LOW VOC) MUST BE APPLIED TO ALL SUBSTRATES. USE PEEL & STICK PRODUCTS. ROLL MEMBRANE WITH HAND ROLLER UNDER PRESSURE AT SEAM.

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Introduction

We appreciate you thinking of Johns Manville for your cold storage project. Please contact us at 1-800-922-5922 # 3 for additional information on cold storage and our details.

Johns Manville is a manufacturer of commercial roofing products and offers this general conceptual information to you as a courtesy for general educational purposes only. This complimentary assistance is not to be either used or relied upon by anyone as a substitute for professional engineering design and documentation required by any building code, contract, or applicable law. By accepting the general conceptual information, you agree it does not constitute any representations, endorsements of, or an assumption by Johns Manville of any duty or liability for either the adequacy of the design of a building, any of its components or the sufficiency of any construction.

About Johns Manville

Johns Manville is a leading manufacturer and marketer of premium-quality insulation and commercial roofing products, along with glass fibers and nonwoven products for commercial, industrial and residential applications. Our history goes back to 1858, when the H.W. Johns Manufacturing Company began operations out of a tenement building in New York City.

Today, our products are used in a wide variety of industries including building products, aerospace, automotive and transportation, filtration, commercial interiors, waterproofing and wind energy. A proud member of the Berkshire Hathaway family of companies, we serve customers in more than 80 countries around the globe. For more information please visit our website at www.jm.com (JM, n.d.).

Considerations

This document is to complement our “JM Complete TPO Application Guide,” “JM Complete PVC Application Guide,” and our “JM Complete EPDM Application Guide” found on our website: <https://www.jm.com/en/commercial-roofing/tpo-design-and-installation-considerations/>; <https://www.jm.com/en/commercial-roofing/pvc-design-and-installation-considerations/>; <https://www.jm.com/en/commercial-roofing/epdm-design-and-installation-considerations/>. Please reference these documents as well.

Please remember that Johns Manville is a manufacturer, not a design professional. We understand every cold storage project is unique, therefore, we are not certifying that these roofing assemblies and details will meet all or partial design criteria, you must consult your design professional. Johns Manville will not be held liable for flaws in construction, installation, workmanship, and design.

This document is an informational guide and not a replacement for consulting your design professional of record. Johns Manville’s NDL warranties and guarantees do not cover damage or issues that result from vapor drive or condensation in the roofing system including but not limited to consequential or incidental damages to the interior or exterior including mold growth.

The information within this document is based in our experience and knowledge of roofing systems. Again, Johns Manville is a manufacturer not a designer. This document does not claim any ownership of liability. Johns Manville will periodically make changes to its products, manufacturing, warranty requirements, and application methods. Please contact Johns Manville technical services 1-800-922-5922 # 3 for the most up to date warranty coverage, terms, conditions, and limitations. Information can also be found at www.jm.com.

Guarantee Program

In order to pursue a guarantee on a cold storage facility with Johns Manville, the following process must be followed. Please let the JM Technical Specialist know at the outset of the project and the Field Technical Representative on every subsequent visit that this is a cold storage project.

1. An approved assembly letter must be obtained from a JM Technical Specialist 1-800-922-5922 #3
2. Shop drawings must be submitted and approved by a JM Technical Specialist 1-800-922-5922 #3

Please always refer to our website for the most up-to-date guarantee information: <https://www.jm.com/en/commercial-roofing/technical--guarantee--and-warranty-services/>.

It is Johns Manville’s preference to use adhered systems in cold storage design. In the instances when the single-ply membrane is being used as a vapor retarder, please use an adhered system. Please refer to: “JM Complete TPO Application Guide,” “JM Complete PVC Application Guide,” and our “JM Complete EPDM Application Guide” found on our website: <https://www.jm.com/en/commercial-roofing/tpo-design-and-installation-considerations/>; <https://www.jm.com/en/commercial-roofing/pvc-design-and-installation-considerations/>; <https://www.jm.com/en/commercial-roofing/epdm-design-and-installation-considerations/>. No additional interior vapor retarder should be specified or installed. Please refer to your designer of record on the moisture control aspect specific to your system.

Applications for a guarantee on re-roof or recover projects will require thorough in-progress inspections and the cooling unit must be shut down.

When a mechanically fastened system is necessary, please obtain an approved assembly letter from the JM Technical Specialist 1-800-922-5922 # 3 and let them know this is for a cold storage project.

About Cold Storage Buildings

The International Association for Cold Storage Construction and the International Association of Refrigerated Warehouses, “Energy Modeling Guideline for Cold Storage and Refrigerated Warehouse Facilities,” views refrigerated storage facilities as any section of that building that achieves controlled storage conditions using thermal insulation and refrigeration equipment. Such facilities can typically be classified into two groups: (1) coolers with commodities stored at temperatures usually above 32°F (0°C); and (2) freezers or low-temperature rooms operating below 32°F (0°C) (Stefan, et.al, 2013).

Basics of Moisture Control

Moisture control is of particular importance for cold storage buildings, due to extremes in internal temperature and humidity often associated with these types of buildings. What makes cold storage buildings unusual is the significant difference in water vapor pressure between the building interior and the exterior, which can result in a large vapor drive through the building envelope and its assemblies. If left unmanaged, this can result in significant build-up of condensation within the various assemblies and/or inside the building, which can lead to severe deterioration of the roof or wall structures.

Some key fundamentals regarding moisture control are:

- Water vapor drive
- Condensation control
- Air leakage versus vapor diffusion

Vapor Drive

For most occupied buildings, water vapor in the interior air tends to move outward during the colder winter months. During the warmer months, water vapor may want to move in either direction (interior to exterior, or exterior to interior), depending on the outside climate or local weather conditions. Cold storage buildings are commonly maintained at temperatures that are considerably lower than the exterior temperature. So, for cold storage buildings, exterior air is almost always warmer, and water vapor will tend to drive inward. This is especially the case in southern climates and is generally true for most geographic locations in the U.S. during most months of the year.

Condensation Control

Condensation occurs at any time water vapor in the air encounters a surface colder than the dewpoint of the surrounding air. In cold storage facilities, components of the building envelope that are colder than the dewpoint of the outside air can be found anywhere inside of or within the insulation system. The interior of wall panels, suspended ceiling supports, roof decks, and even metal fasteners that penetrate through the insulation can all become points for condensation, if exposed to outside air and humidity.

A common way to control or minimize condensation problems in the building envelope is to use a vapor retarder. When installed properly, vapor retarders help reduce water vapor diffusion into the roof, wall, and foundation systems. The most familiar use of vapor retarders are in buildings located in colder climates and buildings with high interior humidity levels, such as swimming pools, museums, and data centers. For these scenarios, the most effective location for a vapor retarder is typically directly above the roof deck and below the roof insulation layer(s), or directly behind the interior finish panel for walls. In other words, the vapor retarder is usually installed on the warm side (in winter) of the insulation. For cold storage buildings, the same principal applies. Because the vapor drive is from the exterior to the interior, however, the vapor retarder should be located on the outside of the insulation.

Most commonly, the roof membrane serves as the vapor retarder for the roof assembly (CEBA-IARW, 2018). For wall assemblies, the vapor retarder may be integrated with the insulation or may be added behind the exterior cladding (CEBA-IARW, 2018). Condensation is also minimized through an insulation system that is both well-designed and well-installed. A system with multiple layers of insulation is designed to provide continuous coverage over all cold structural elements, helps to prevent these components from being exposed to outside air and becoming a source of condensation (ASHRAE, 2018).

Air Leakage

In addition to, and separate from water vapor drive, air can be forced to leak into or out of a cold storage facility. Any time a small (or large) hole or defect is present in the building envelope, air can leak through if there is a pressure difference to force it. The holes can be literally anything: seams in roof decking or wall panels, unsealed joints, penetrations for utilities, door seals or fastener penetrations are a few examples. Forces that push air through gaps could come from the wind, mechanical equipment, or simply the temperature difference between a cold storage facility and the outdoors.

Air Barriers vs. Vapor Barriers

Moisture transported into a cold storage facility by air leakage is a far larger issue than moisture brought in by vapor diffusion, because of the comparative amount of moisture transported during each process (ASHRAE, 2017).

The process of water vapor diffusion is a relatively slow process, where individual molecules of water vapor percolate through solid materials. How quickly this process happens depends on a material's water vapor permeance. Materials considered effective vapor retarders for the roof of cold storage facilities should have a permeance less than 0.1 US perms (CEBA-IARW, 2018).

Moisture transport by air leakage, on the other hand, can be a very rapid process. In this case, the water vapor is carried by the air, and travels just as quickly as a volume of air can leak through a hole or crack. Multiple examples can be found in building science literature that point to air leakage being able to move moisture approximately 100 times faster than diffusion (Reynolds, 2019).

Often, vapor retarder systems also act as air barriers. This can be especially true in roofing systems, where the roof membrane may provide both functions. In this case, it is critical that vapor retarder and air barrier systems be continuous when used in cold storage buildings. Laps, penetrations, and the roof-to-wall interfaces should all be sealed to prevent air leakage. Any discontinuity will lead to condensation problems (ASHRAE, 2018).

Design Considerations/Project Conditions

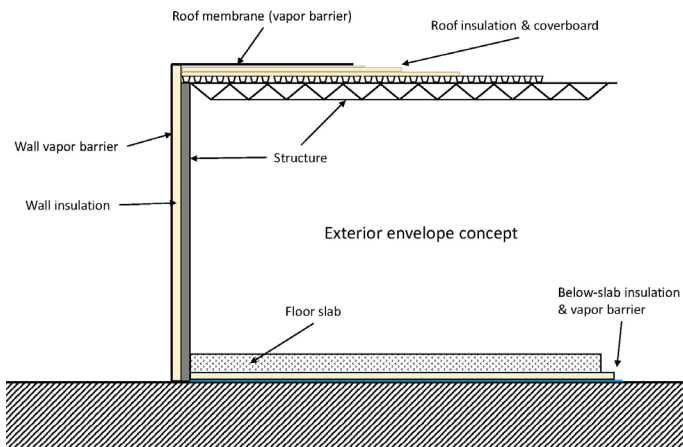
Basic Concepts of Cold Storage Envelope Design

Due to the unique demands and loads placed on a cold storage building, they should be designed to have an uninterrupted, continuous building envelope that will:

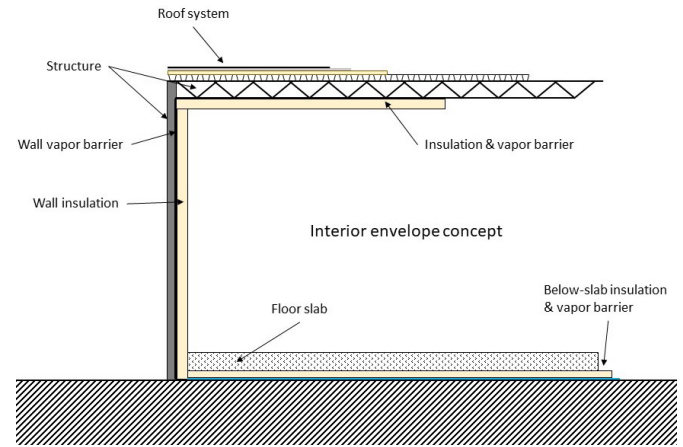
- Provide sufficient insulation to minimize heat gains/losses and maintain interior temperatures
- Control the movement of air and water vapor
- Allow for the effects of thermal expansion and contraction

There are several ways to achieve these objectives. The ASHRAE Handbook: Refrigeration, Chapter 23, describes three commonly used methods for cold storage construction. Conceptual drawings of the three methods are provided below in Figures 1 through 3.

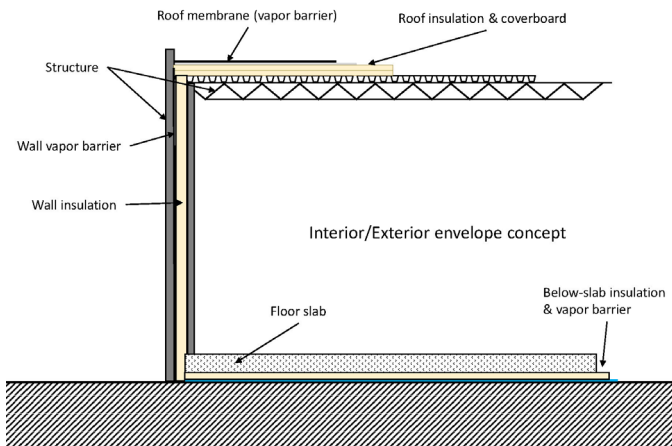
Exterior Envelope System Method (ASHRAE 2018)



Interior Envelope System Method (ASHRAE, 2018)



Interior/Exterior Method (ASHRAE, 2018)



The Exterior Envelope System approach uses a vapor retarder system located on the exterior side of the building's structural system. The vapor retarder system "encapsulates" the building by being located on the outside of the exterior walls' insulation layer, under the floor and over the roof's insulation layer (ASHRAE, 2018). The Interior Envelope System approach uses a vapor retarder system located on the interior side of the structural system. In this case, the vapor retarder system is located under the roof deck, inside the exterior walls and possibly above the floor. Insulation systems would then be located to the interior of the vapor retarders (ASHRAE, 2018).

The Interior/Exterior approach combines an exterior vapor retarder and insulation system on top of the roof structure with a vapor retarder and insulation system on the interior of the walls (ASHRAE, 2018).

Design Considerations

Insulation

Insulation plays a critical role in the building envelope performance of a cold storage building. In order to minimize the potential for condensation and optimize energy efficiency, appropriate amounts of insulation should be used. Insulation type and R-value selection are affected by numerous factors, such as cost, desired energy efficiency, suitable material properties, interior design temperatures, and climatic conditions. The table below offers suggestions for minimum envelope R-values for insulation in cold storage buildings (ASHRAE, 2018). These R-values are based on the 2018 ASHRAE Handbook – Refrigeration, Chapter 23, and are consistent with other cold storage industry resources (CEBA-IARW, 2018). Local jurisdictions may also require specific minimum insulation R-values for cold storage facilities. For example, refrigerated warehouses in California require a minimum R-40 in roofs and R-36 in walls for freezers and R-28 for roofs and walls for coolers (CEC, 2018). However, it is the designer’s responsibility to determine the appropriate amount of insulation for each building envelope assembly.

The type of insulation used should be suitable and compatible for use in a cold storage building. A commonly used insulation type is closed-cell foam insulation. JM ENRGY 3[®] polyiso insulation is a common option for roof systems, JM ENRGY 3 CGF is a non-organic facer option. JM AP[™] Foil-Faced and CI Max[®] polyiso sheathing and Corbond III[®] closed-cell spray polyurethane foam are good options for wall systems. Additionally, all roof and wall penetrations, such as mechanical curbs or roof hatches, and penetrations for utilities should be appropriately insulated and sealed.

Recommended Minimum Insulation R-values

Table 1.1

Type of Facility	Temperature Range, °F	Thermal Resistance R, °F-ft ² -h/Btu		
		Floors	Walls/Suspended Ceilings	Roofs
Coolers	40 to 50	Perimeter only	25	30
Chill coolers	25 to 35	20	25	35
Holding freezer	-10 to -20	27	35	45
Blast freezer	-40 to -50	30	45	50

(ASHRAE, 2018)

Roof Membrane

The primary purpose of the roof membrane is to prevent water entry into the roof assembly. In cold storage facilities, an additional key function is to often act as the vapor retarder (CEBA-IARW, 2018). However, the roof membrane may also contribute to energy efficiency of the roof assembly if a cool roof is specified (Pacific Gas & Electric Company, 2007). The report by PG&E further predicted that a cool roof (solar reflectance 0.70) could deliver energy savings versus a dark roof (solar reflectance 0.20) for cold storage facilities in California of \$0.30-\$0.50 per ft², with an assumed cost premium of \$0.20 per ft² (Pacific Gas & Electric Company, 2007). JM roof membranes that would be considered “cool roofs” would include JM TPO, JM PVC, and DynaLastic[®] CR G, among many others.

Vapor Retarder Perm Ratings

Vapor retarders are typically membranes with relatively low permeance values, but not all vapor retarders are equal. Vapor retarders used in construction are typically characterized into three classes (ICC, 2018), as shown in table 1.2. Most roof membranes are Class I vapor retarders. Perm ratings for single-ply membranes range from 0.03 to 0.06 perms. An example of Class II vapor retarders are asphalt felts, which have perm ratings ranging from 0.3 to 0.8 perms. Examples of Class III vapor retarders are latex or acrylic paint. JM recommends that Class I vapor retarders be used for cold storage buildings.

It is important to note that these are material ratings; the full system needs to be designed and installed correctly for proper functionality. Each building component on the interior of the prime vapor retarder should be more permeable than the last, to allow any moisture that might get through to continue diffusing to the interior (ASHRAE, 2018). Additional low-perm materials towards the interior of an assembly may become a site of condensation or ice.

Table 1.2

Vapor Retarder Class	Permeance (U.S. perm, grain/ft ² -hr-in. Hg)	Example Materials
I	≤0.1 perm	JM TPO, JM EPDM, JM PVC, JM Vapor Barrier SA, JM Vapor Barrier SAR
II	>0.1 perm, ≤1.0 perm	½” ProtectoR [®] HD
III	>1 perm, ≤10 perms	2” ENRGY 3 [®]

Thermal Shorts/Thermal Bridging

It is important for design professionals and contractors to be aware of the potential for thermal bridging in the envelope of cold storage buildings. To avoid and reduce the effects of thermal bridging, air leakage, and expansion/contraction, roof installation should be installed in at least two layers with board seams offset. To reduce the effects of thermal bridging, JM strongly recommends that the roof membrane and upper layers of insulation are adhered. Mechanical fasteners for the roof membrane or the upper layer of insulation or coverboard should be avoided as the fasteners may become sources of thermal bridging and condensation or frost. When the substrate is a steel roof deck, it is recommended that the first layer of insulation (i.e., the layer in direct contact with the roof deck) may be mechanically attached. Remaining layers should be installed with adhesives. Induction welded plates also come with options that include a thermal break in the system. Polymer tubes break the link between the metal fastener and the induction plate and have proven effective at reducing thermal bridging in thermoplastic systems (OMG, 2018). Example: https://omgroofing.com/sites/default/files/documents/FA1021UK_TreadSafe_EPDM_DS_A4.pdf

For wall systems, insulated metal panels and combinations of continuous insulation (closed-cell foam boards or closed-cell spray polyurethane foams), tend to reduce thermal bridging (CEBA-IARW, 2018). Insulation materials should be installed so as to cover structural components.

Expansion and Contraction

All elements of the roof assembly for a cold storage facility should accommodate building movement, which could otherwise lead to damage to the roof or vapor retarder system. Penetrations in roofs and walls, such as pipes, ducts or conduits, could move due to thermal expansion/contraction or vibration from operations. It is important to select flashings that can accommodate both movement and a broad temperature range, such as pre-manufactured flashing boots. Examples of some JM pipe boot options may be found at: <https://www.jm.com/en/search-results/?q=boots>

Execution/Application

It is JM's preference to use adhered systems in Cold Storage design. In the instances when the single-ply membrane is being used as a vapor retarder, it is highly recommended that an adhered system be used. Please refer to: "JM Complete TPO Application Guide," "JM Complete PVC Application Guide," and our "JM Complete EPDM Application Guide" found on our website: <https://www.jm.com/en/commercial-roofing/tpo-design-and-installation-considerations/>; <https://www.jm.com/en/commercial-roofing/pvc-design-and-installation-considerations/>; <https://www.jm.com/en/commercial-roofing/epdm-design-and-installation-considerations/>. Please refer to your designer of record on the moisture control aspect specific to your system.

Re-roof or recover projects will require thorough inspection and the cooling unit must be shut down.

When a mechanically fastened system is necessary please obtain an approved assembly letter from the JM technical group 1-800-922-5922 # 3 and let them know this is for a cold storage project.

Citations

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