NAIOP
COMMERCIAL REAL ESTATE DEVELOPMENT ASSOCIATION

Best Practices in Cold Storage Facility Development

Sponsored by: WARE MALCOMB FCL BUILDERS

Best Practices in Cold Storage Facility Development

Content by Ware Malcomb, FCL Builders and Cold Summit Development

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Cover: An exploded view of a Cold Ready speculative building. Courtesy of Ware Malcomb.

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High Velocity Throughput

Urban Logistics Prototype

Utilizing a centralized core of automation to provide receiving, storage, inventory control, and order fulfillment.

BENEFITS

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- Reduce land use for industrial distribution by a factor of 4.
- Utilize vertical height to maximize energy efficiency.
- ~25% reduction in capital to build distribution networks.
- Reduce the amount of labor versus traditional facilities.

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About the Authors

Ware Malcomb

Established in 1972, Ware Malcomb is a contemporary and expanding full-service design firm providing professional architecture, planning, interior design, civil engineering, branding and building measurement services to corporate, commercial/residential developer and public/institutional clients throughout the world. With office locations throughout the United States, Canada and Mexico, the firm specializes in the design of commercial office, corporate, industrial, science & technology, health care, retail, auto, public/institutional facilities and renovation projects. Ware Malcomb is recognized as an Inc. 5000 fastest-growing private company and a Hot Firm by Zweig Group. The firm is also ranked among the top 15 architecture/engineering firms in Engineering News-Record's Top 500 Design Firms and the top 25 interior design firms in Interior Design magazine's Top 100 Giants. For more information, visit www.waremalcomb.com/news and view Ware Malcomb's Brand Video at youtube.com/waremalcomb.

Ware Malcomb is an industry leader in cold building projects, a unique and highly specialized sector that includes cold storage, food processing and production facilities, cold laboratories, and cold medical and pharmaceutical facilities. The firm has developed an innovative speculative cold building design prototype, creating a new asset class of commercial real estate. Ware Malcomb combines this knowledge with the latest developments in technology, trucking, rail, automation and third-party logistics to innovative buildings and sites that are highly functional.

FCL Builders

Since 1976, FCL Builders has been a leader in the design and construction of cold storage, food production, warehousing and manufacturing facilities. FCL has completed over 5 million square feet of cold and food processing spaces and currently has over 1 million square feet under construction. We distinguish ourselves through a cultural commitment to service, understanding the investment of our customers and taking ownership of each project for a professional and worry-free experience. We call this the FCL Experience.

At FCL, our focus is delivering innovative and efficient cold storage and food processing facilities for some of the industry's most discerning buyers of temperature-controlled facilities, using sound engineering principles and time-tested construction strategies. Our understanding of the thermal and vapor details that are so critical to the success of cold facilities sets us apart from other builders.

The FCL Cold Storage team of CEO Carmen Dodaro, Vice President of Cold Storage Mike Llewellyn and Director of Cold Storage & Food Processing Robert Streicher together have more than 70 years of experience in the field of climate-controlled design and construction. FCL's cold building specialists on staff know the ins and outs of engineering and design for cold buildings, and bring a wealth of knowledge of cold facilities, along with their extensive construction knowledge. Our qualified and experienced team ensures every cold building will be built to the industry's best in standards and details.

Cold Summit Development

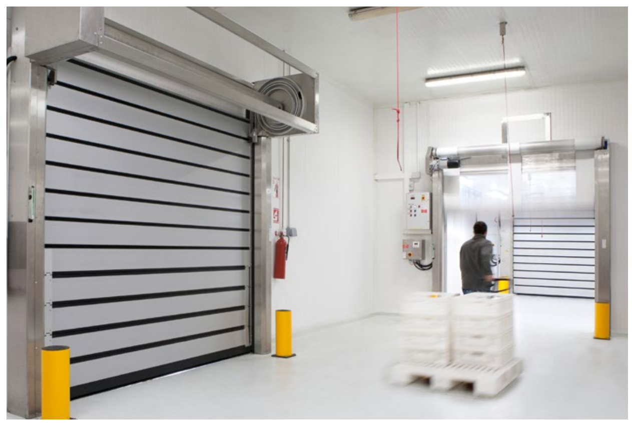
Cold Summit Development is a pure-play cold storage developer and owner of refrigerated warehouses and low-temperature distribution centers. Cold Summit's mission is to facilitate the movement of healthy products to consumers by delivering innovative, industry-leading cold storage real estate solutions with a relentless focus on product integrity.

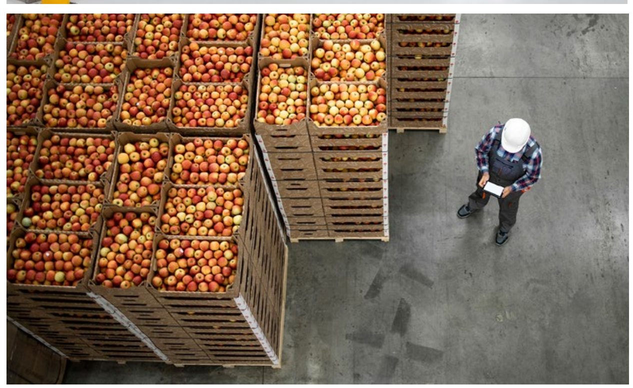
Cold Summit Development has established a team of real estate experts, delivering seamless execution throughout the complex real estate development process. From initial market and site selection based in logistics and supply chain analysis, to land entitlement and project permitting, through construction of the facility and customer-specific buildout, Cold Summit's robust and diverse skill sets provide our partners and customers certainty of execution unrivaled in the industry.

Headquartered in Sun Valley, Idaho, Cold Summit Development has offices in Oakland, California, and St. Augustine, Florida, allowing for customer and market coverage spanning the entire country. Cold Summit's core principles of Love.Listen.Communicate guide each experience with customers, the community, partners and project stakeholders.

NAIOP

NAIOP, the Commercial Real Estate Development Association, is the leading organization for developers, owners and investors of office, industrial, retail and mixed-use real estate. NAIOP comprises 20,000 members and provides strong advocacy, education and business opportunities through a powerful North American network. For more information, see naiop.org.





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Rules of Thumb for Distribution/Warehouse Facilities Design

For more information on dry warehouse design, please see NAIOP's Rules of Thumb for Distribution/Warehouse Facilities Design, available on the NAIOP website.

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Introduction

Until recently, cold storage facility development was considered a niche market, and cold warehouses comprised only about 1-2% of industrial space. However, changes in consumer behavior, such as buying meal kits and organic food, accelerated during the COVID-19 pandemic. Online grocery sales increased 54% in 2020 and totaled $95.8 billion. Sales are expected to increase by at least 17% each year through 2024.[1] As online food shopping becomes more popular, suppliers will in turn need more cold storage space.

Cold storage typically refers to the segment of the global supply chain that provides storage for products and materials that require some form of temperature control.[2] Although most facilities handle frozen and refrigerated foods, cold storage is also used for biomedical materials, pharmaceuticals, flowers and plants, artwork, chemicals, film, cosmetics and medical equipment. Facilities usually include cooler areas (33-55 degrees F) and/or freezer areas (less than 32 degrees F). Cold storage warehouses fall into two ownership categories: public or private. Private cold warehouses are leased to companies responsible for distributing the stock (e.g., grocery stores), while public refrigerated warehouses (PRWs) are usually owner/operator occupied and distribute products for companies. As cold storage is specific to end-users' needs, there is no one-size-fits-all approach to its development.

Demand for cold storage is expected to increase, especially for last-mile facilities that are close to consumers. CBRE estimates that between 2020 and 2025 over 100 million square feet of cold storage space will be built in the U.S. — an increase of roughly 47% (According to Costar, there is approximately 240 million square feet of refrigerated storage space in the U.S.).[3] As of the third quarter of 2021, the cold storage vacancy rate in the U.S. stood at 4%. However, more than 78% of cold storage facilities in the U.S. are over 20 years old.[4] The limited amount of space and the advanced age of facilities is spurring new development and, in some cases, the conversion of dry (non-refrigerated) warehouses.

It can be less complicated to build new facilities than retrofit them, but both approaches are expensive. In 2020, construction costs for a new cold storage or freezer space averaged $130 to $180 per square foot, compared to $70 to $90 per square foot for a dry warehouse.[5] This is partly due to the need for insulated metal paneling (IMP), mechanical equipment, refrigeration equipment, rooftop equipment, premium concrete slab and subfloor heating, and designs for multiple temperature zones with their own loading docks. Maintenance and energy costs are also a consideration: refrigerated warehouses consume an average of 24.9 kilowatt-hours (kWh) of electricity per square foot each year. By comparison, dry warehouses use an average of 6.1 kWh of electricity per square foot each year.[6]

Despite the high costs, capital markets are increasingly focused on cold storage. However, investors prioritize buildings with credit tenants and long-term leases that are in core industrial markets. Only a few transactions check all the boxes each year. Nevertheless, yields for cold storage have narrowed tremendously in recent years while maintaining a healthy premium over dry industrial warehouses with similar term and tenant credit profiles.[7]

Another indicator of the rising demand for cold storage is the growth of speculative development for multimarket distribution facilities. Almost unheard of five years ago, speculative designs provide a shell for the tenant to customize. In some cases, the refrigeration system is not installed until the end user is identified. Speculative cold storage can provide end users a faster speed to market than traditional build-to-suit development. Companies traditionally involved in build-to-suit development are becoming experts in speculative cold storage, such as Cold Summit Development and Ware Malcomb, which recently unveiled a "Cold Ready" prototype discussed in Chapter 3.

Due to increasing interest in cold storage, NAIOP commissioned this e-book to provide commercial real estate professionals with an overview of the topic. Cold storage development is a complex process that requires specialized knowledge and expertise. NAIOP has gathered information from industry leaders on the different types of cold storage facilities, as well as construction, design, locational, environmental and entitlement considerations. Cold Summit Development, a full-service cold storage development and advisory firm, discusses what a developer should keep in mind when embarking on a cold storage project. Ware Malcomb and FCL Builders, two firms with extensive cold storage experience, offer a closer look at the design and construction of Ware Malcomb's speculative Cold Ready prototype as well as a separate chapter on build-to-suit projects. Finally, a glossary is included in the appendix for unfamiliar terms. Readers are encouraged to contact the authors if they would like to learn more about cold storage development.

In 2019, CBRE and Ware Malcomb successfully completed the first truly speculative cold storage project in the U.S., DFW ColdSpot, in Fort Worth, Texas. The 300,000-square-foot project was designed and located specifically to target traditional PRW freezer warehouse operators, and the facility was 100% leased to a PRW operator prior to completion.
Credit: Christopher Mann

CHAPTER 1

Types of Buildings in the Cold Building Supply Chain

Manufacturing and Processing Facilities

To provide a comprehensive view of the cold building supply chain, it is important to first look at manufacturing and processing facilities for food and other goods that require the use of cold buildings. Manufacturing and processing facilities are where raw and semi-finished goods are transformed or combined into finished goods ready to make their way to the consumer.

These buildings are also some of the most complex buildings in the cold building supply chain. Like all pharmaceutical or food-grade buildings, cleanability and pest control are primary concerns in design and construction of the facilities. As with all processing and manufacturing facilities, efficient storage and handling of raw materials, process flow through the facility and finished-goods storage are critical to the success of the building. Keeping good manufacturing practices (GMP) in mind during the design process yields the best results.

Manufacturing and processing facilities are typically located in reasonable proximity to raw goods sources, while meat processing facilities are near slaughterhouses. Other food production facilities requiring large quantities of bulk goods need rail access. They also usually require a larger labor pool due to the number of employees necessary to operate these facilities. These requirements can complicate the site selection process, which is why manufacturing and processing facilities are found in almost all geographic areas.

A food manufacturing facility.
Credit: Getty Images

An example of a gateway distribution facility in Romeoville, Illinois.
Credit: Ware Malcomb

A regional cold storage distribution facility outside Chicago.
Credit: Seen Above Media, Inc.

Gateway Distribution Facilities

After leaving the processing facilities, finished goods move to the next step in the cold building supply chain: a larger-scale distribution facility or gateway distribution building. These facilities tend to be located near ports, rail hubs, or large agricultural and processing centers. Port locations receive large quantities of imported goods and seafood bound for inland locations. Rail access can be important for these facilities, and site selection becomes a critical part of the development process. These buildings range in size from 300,000 square feet up to 1 million square feet (though larger facilities are often "multi-temp" spaces incorporating freezer, cooler and ambient storage). They can accommodate large volumes of product and often have very tall clear heights. Some specialized rack-supported buildings can reach heights up to 150 feet.

Multimarket Distribution Facilities

Multimarket or regional distribution cold buildings are in industrial areas surrounding or between large urban population centers. These buildings receive goods from local manufacturing or processing facilities as well as from gateway distribution buildings. From their locations, they can service end users or last-mile distribution facilities in multiple population centers. These buildings range in size from 200,000 square feet to 500,000 square feet.

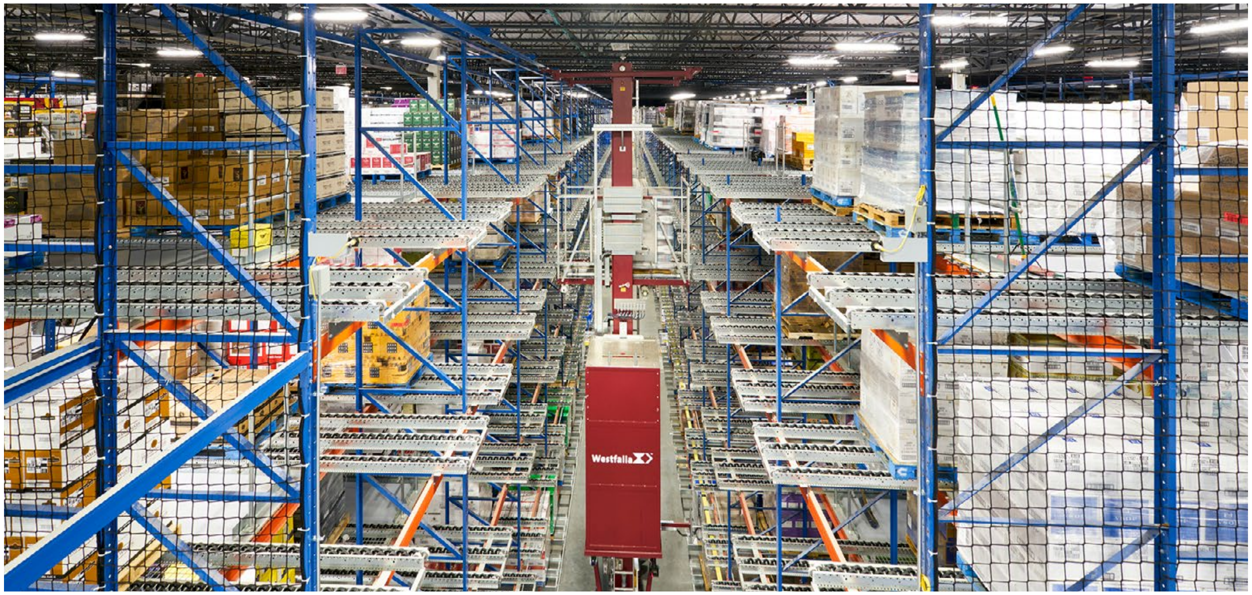
While they can be single-tenant buildings, they are also often designed and built to accommodate multiple tenants. These facilities are traditionally single-loaded and are the most straightforward structures in the cold building supply chain to design and construct. For this reason, the development community has begun constructing buildings in this category on a speculative basis, and this type of building is the focus of the design and construction chapters of this book.

Last-Mile Facilities

Delivery of fresh and frozen food products to grocery stores and restaurants has been around for a long time, but e-commerce has significantly impacted the cold building supply chain. Newer trends such as home delivery of groceries and online ready-to-eat food orders are changing the landscape for last-mile cold buildings. Grocery chains are now looking to bypass retail stores and process online orders for home delivery directly from purpose-built micro-fulfillment facilities.

These smaller micro-fulfillment centers are located within or as close as possible to dense urban population centers. They can range from approximately 40,000 square feet to 100,000 square feet. Manual picking operations still exist for order fulfillment within these buildings, but automation is increasingly being used. These automation systems differ from the large-scale automated storage and retrieval systems (ASRS) used in warehousing operations and focus on fulfilling orders consisting of many different stock-keeping units (SKUs). There are a host of different techniques to accomplish this complex task. Many involve bringing goods in small totes to a stationary operator who then picks the goods individually for packaging.

Once orders are assembled, delivery to the end user presents the next challenge. Delivery fleets often consist of smaller box trucks or vans. They can require many vehicles to service a delivery area. Sites in dense urban areas commonly do not have space for these fleets. Some companies are willing to house fleets at adjacent sites, while others seek alternative solutions, such as building additional parking levels on-site.



An automated last-mile distribution facility in Taunton, Massachusetts.
Credit: Charlie Mayer Photography

Technology and Cold Storage

Cold storage distribution facilities often utilize some type of automation for storage and retrieval of palletized goods in the warehouse. In its simplest form, an ASRS is loaded in the receiving area of a cold dock. Pallets of goods are placed by fork truck on conveyors that run through openings in the cold dock demising wall into the warehouse. From this point, pallets are conveyed into the warehouse and placed in racks by automated cranes that run on rails in the rack aisles. The only manual handling of pallets occurs on the cold dock. ASRS is not new to the warehousing industry, but as technology and robotics continue to advance, the capabilities and efficiencies of these systems continue to improve. They excel at handling large volumes of product with a low variance in SKUs.

Still in development are the use of drones and automated vehicles for last-mile delivery of cold products. This technology is being beta-tested in select cities in the U.S. and Europe. Drones or robots can take many forms and provide opportunities in the future to help meet last-mile demand. For more information see the NAIOP Research Foundation report: The Evolution of the Warehouse: Trends in Technology, Design, Development and Delivery.

CHAPTER 2

A Developer's Perspective

Developing cold storage warehouses is complex and can be a daunting experience for some. In this chapter, Cold Summit Development, an experienced developer and owner of cold storage facilities, offers some practical considerations a firm should keep in mind when taking on a cold storage project.

Site Selection

The first step in developing a private or public refrigerated warehouse, or a distribution center with temperature-controlled space, is selecting a suitable site. There are several factors to consider, including location, lot size and shape, access to transportation and access to utilities.

In general, suitable sites are flat, rectangular, and have sufficient width to accommodate the building footprint and the necessary truck apron space. The site should also be large enough to provide on-site truck parking, employee parking and stormwater catchment areas. Power is a major component of site selection. A typical cold warehouse will require 4000 amps at 480V for every 150,000 square feet.

Credit: Jackaldu/Getty Images

Credit: Getty Images

At the macro level, site location is determined by the client's requirements for build-to-suit projects and by market conditions for speculative developments. Build-to-suit will be in a location that is central to the client's established distribution network or in a location intended to support future expansion. Speculative projects may look for markets that appear to be underserved, as indicated by low vacancy rates, aging infrastructure or recent growth in local population.

Pre-development

Zoning, Permitting and Entitlements

"Entitlement" refers to discretionary approvals, while "permitting" refers to administrative (non-discretionary) approvals. Specific site entitlement and permitting criteria are situationally dependent as requirements differ between municipalities and zoning districts. Engaging the local municipality early to identify restrictions and concerns is essential to avoid preventable costs and delays later in the project. It is often helpful to have professionally prepared, conceptual designs and any supporting technical or environmental studies to inform initial entitlement and permitting discussions. Jurisdictions review formal proposals against zoning regulations, planning codes, and other local laws or initiatives and examine a project's environmental impact. Outreach to other stakeholders within the city and community is also important, especially when public hearings are part of the entitlement process.

Early entitlement and permitting discussions can define improvements and/or adjustments required by the municipality. Some of these adjustments may be to the site design, in which case the development team adjusts the plans before submitting them for construction permits or pursues a zoning variance or entitlement to accommodate the design. In many cases, improvements are required to the surrounding infrastructure to support the site. When that happens, the goal of the entitlements and permitting discussion shifts to negotiating a proportion of improvement cost sharing and reimbursement between the developer, the municipality and any other stakeholders.

Some common entitlement and permitting discussions may involve:

Allowable Use

Refrigerated warehouse space must be developed on industrial zoned land and may require special allowable-use permits depending on the facility's intended purpose. Allowable use becomes particularly important when the facility is used for processing or packaging. Some municipalities draw a distinction between light manufacturing, which is usually acceptable in industrial zoning, and food processing, which may require special permitting.

Building Aesthetics

Some planning departments are wary of older, dilapidated buildings with metal siding, and can be hesitant to accept cold buildings utilizing an IMP exterior. It is important to understand local regulations regarding allowable building materials and aesthetic considerations.

Height Variance

Modern refrigerated facility designs are taller than industrial zoning standards in some zoning districts, so height variances are a common requirement. Conventional cold storage warehouses are currently being built up to a clear height of 75 feet, depending on application, with automated warehouses up to 150 feet.

Transportation and Logistics Access

The selected site must support commercial transportation access, usually in the form of commercial trucking. This tends to favor sites in proximity to major freeways and trucking corridors. The development of a large, refrigerated facility can have significant impacts on local traffic patterns. Site access plans that are designed to minimize impacts on surrounding traffic patterns will require fewer mitigations than those that cause significant disruptions and will be easier to entitle.

The local jurisdiction can require that adjacent roads or intersections be improved to gain site approval. The access roads that service the site may have to be improved to accommodate the increased load and volume of commercial trucks. Additionally, the site's street entry point needs to accommodate the turning radius of large tractor trailers – typically at least a 40-foot access lane – and should be positioned so that trucks waiting to enter do not back up onto the major streets in the surrounding area.

Rail is a transportation alternative that supports high shipping volumes, and it is increasingly common to see cold storage and food processing facilities with rail access. Facilities that support rail will have a loading dock area that occupies one side of the building and is specifically designed for offloading rail cars. It would be unusual for a facility to rely on rail exclusively, so rail-serviced facilities will also have the more common truck dock on another side of the building.

Credit: bucky_za/Getty Images

Credit: Artem Egorov/Getty Images

Utilities

Refrigerated space has significant utility requirements. In pre-established industrial zoned areas, utilities infrastructure will be present, but available capacity may be limited. If the site is in a planned development or is outside of industrial zoning (requires variance), utilities infrastructure may have to be added to support new construction. The timelines for required infrastructure improvements and connecting utilities to the site are typically inflexible and must be accounted for in the construction schedule.

Sizing utilities depends on the requirements of the planned cold storage facility, as well as the remaining capacities of existing facilities. Electricity and water are the traditional utility types considered, but high-speed internet access is also commonplace in modern facilities. Sewer and gas are also required, and specifics will be driven by the design of the facility and choice of equipment, as well as the integration of any industrial processing into the refrigerated space.

For example, a new project may require 6-8 MW of electricity from a local substation with additional step-down transformers for the facility's exclusive use. A dual-fed site is ideal to prevent power outages due to substation failure. The facility may also require an eight-inch water main adjacent to the site for the fire-suppression system. If the facility is producing liquid waste from a processing activity, special sewage handling will be needed. Internet speed requirements will vary depending on the complexity and quantity of the digital systems running in the facility.

Stormwater Catchment and Mitigation

Industrial-scale refrigerated space, by design, has large areas of impervious surfaces due to expansive roofs and paved areas. This creates a requirement for managing significant amounts of stormwater. These sites require stormwater mitigation that complies with local, state and federal environmental laws. Most jurisdictions will have detailed rules regarding the handling of stormwater that must be considered in site selection and design. The size and capacity of stormwater catchment features is calculated based on the area of impervious surfaces in the site plan, as well as applicable local rules and regulations.

Mitigation techniques must be designed into the site plan so that grading and site layout can channel stormwater into appropriate catchment features. The selected site should be serviced by stormwater drainage ditches and/or storm sewers that quickly remove water from the site. It is common in modern site design to include features such as stormwater ponds, grassed catchment basins or bioswales that slow down stormwater runoff and allow for water and nutrient infiltration into the ground. These features also serve to remove sediments and pollutants before the water leaves the site and can contribute to the aesthetics of the design.

Environmental

Environmental considerations for development of the site can be thought of in terms of pre-development site assessments that inform site selection, and compliance with EPA regulations and state environmental laws that affect site design.

Environmental Site Assessments (ESAs) are a necessary step of due diligence used to identify the presence of environmental contamination. The presence of environmental contamination is a significant liability and can severely reduce the value of a site. ESAs are essential because, if the developer decides to continue with development on a contaminated site, they will inherit the responsibility (and cost) of cleaning it up.

ESAs are conducted in two phases. A Phase 1 ESA identifies potential or existing environmental contamination issues from previous uses of the site. It is generally performed prior to closing on the site and consists of an examination of historical records to determine if the site has ever been used for a purpose that would generate an environmental concern. If an environmental contamination issue is discovered during Phase 1, then a Phase 2 ESA will be initiated. This consists of sampling soil, soil gases and groundwater at the site to confirm the presence of contamination, to assess the environmental impact, and estimate the cost of clean-up. Most developers justify the initial cost of conducting ESAs by the risk avoidance they provide.

Compliance with federal, state and local environmental laws is a minimum starting point for design approval. Two potential areas that might be scrutinized closely are wetlands and air quality.

Wetlands – Protected wetland features are designated by the Army Corps of Engineers. During due diligence, the presence of wetlands must be assessed. Site designs might need to be adjusted to avoid impacts on protected features. Many jurisdictions allow the developer to pay a fee for wetland mitigation banking.

These programs compensate for unavoidable impacts on wetlands at the development site by restoring or protecting wetlands at another location.

Air Quality – Refrigerated space used for storage and distribution rarely encounters air quality issues; however, refrigerated space used for processing can produce exhaust that affects air quality. A variety of technologies exist to scrub exhaust systems that can usually mitigate air quality concerns, but at a cost to the project.

The trucking use related to refrigerated space may also be of interest to air quality jurisdictions. Reefer trucks (also known as refrigerated trucks) need to idle to keep their refrigeration systems running or be plugged in to a power source. As older facilities did not always offer a plug-in option, older air quality regulations may look askance at the need for reefer trucks.

Some jurisdictions also consider industrial refrigerants, both due to potential life safety issues (e.g., with ammonia refrigerants) as well as global warming potential (GWP). They may impose regulations on types, quantities and locations for the use of these refrigerants.

Going beyond minimum requirements for efficiency and sustainability can build goodwill with local decision makers and make the property more marketable to tenants. Energy is one of the major cost drivers for refrigerated space. Technologies and practices that minimize energy requirements over the life of the building directly benefit tenants and should be built into the design.

Credit: Vonkara1/Getty Images

Business Plan and Pro Forma

A pro forma is a financial model that provides projected financial returns over time, based on known or anticipated costs, expected revenues and assumptions. The pro forma is a common tool for all property types. For cold storage development, there is more emphasis on accurately estimating construction costs (as the construction is so complex) and putting the right amount of buffer in the budget to accommodate the customization that often happens during speculative building construction. A well prepared and accurate pro forma can give investors a reasonable expectation of the return on their investment. Since change and variation in a project is unavoidable, a developer should prepare the pro forma with explicitly stated assumptions and conservative estimates of both schedules and costs.

Pursuit and Development Costs

Pursuit and development costs represented on the pro forma fit into three broad categories:

Hard costs are the tangible costs associated with building the facility such as materials, labor and facility equipment. Hard costs are sometime called "brick and mortar costs." A developer should work closely with their designers, engineers and general contractor to develop accurate estimates of hard costs as well as anticipated timelines for when each cost becomes due. The request-for-proposal (RFP) process is the accepted practice for soliciting estimated construction costs from general contractors.

Soft costs are often more administrative in nature and can include line items such as architectural and engineering fees, legal fees, additional consultant fees, indirect labor, surveys, permits and cost of inspections, and cost of construction financing. These costs will need to be estimated by the developer based on their business relationships with each of the associated line-item providers. Since soft costs can be more difficult to estimate, it is a good idea to budget conservatively for each of the soft cost line items.

Contingency costs refer to set-aside moneys reserved to cover unanticipated costs or delays not identified in the budget or scope of work for the project. Contingency funds may be allocated to hard costs or soft costs on the pro forma. In general, areas that are less certain require a larger percentage of contingency to mitigate risk.

Operating Costs and Revenue

The majority of the asset's lifecycle is in operations. The pro forma will include expected operating and maintenance costs, projected over time, annually for a duration consistent with the business plan. The revenues section of the pro forma will also be projected over time and will be unique to the assumptions of the business plan and market area. These should include expected rents and/or revenue due to the sale of the asset. A project is generally considered feasible when the pro forma indicates a positive Net Present Value with a rate of return that satisfies the project's cost of capital and meets or exceeds the equity stakeholders' required return on investment.

Assembling the Team

Selecting team members with experience and good reputations helps to mitigate risk by providing stakeholders with the confidence that the developer has the capability and trustworthiness to execute the project as agreed upon.
A development team may include, but is not limited to, the following roles:

- **Land broker** – A real estate professional or group that specializes in the acquisition of land. A land broker will be focused on the region and market of the development. This person or group may serve as a liaison between the developer and the local community.
- **Civil engineer** – Develops the site plan. Defines site preparation including grading requirements and the stormwater mitigation plan.
- **Environmental/geotechnical/due diligence third parties** – Define and inform specialized site considerations specific to their area of expertise. The complement of specialists may vary depending on the project requirements.
- **Design firm** – Designs the structure and systems of the facility. May also work with a general contractor as a design-build team or firm.
- **General contractor** – Performs the construction of the facility. Informs cost estimation. May also perform with a design firm as a design-build team or firm.
- **Leasing broker** – Provides local market intelligence and leads marketing efforts to tenants for the project. Identifies, attracts, assesses and signs tenants to the facility.
- **Land use counsel** – Legal representative that navigates the local zoning and permitting approval process. This role is very prominent with jurisdictional decision makers.
- **Transaction counsel** – Oversees the filing of necessary legal documents and permits, including those required for the acquisition and disposition of the property. Ensures correctness, compliance and timeliness of all filings.

Financing

A variety of financing models and approaches can be applied to cold storage development. The most relevant distinction between financing approaches aligns with the difference between built-to-suit and speculative development projects.

Build-to-suit projects are, by definition, designed for a specific end user. To date, this is the most common approach to developing cold storage space. Project initiation, financing and ownership of the facility may lie with the developer or the user, depending on the project execution approach. From a developer's perspective, the financing aspects of this type of project are more straightforward. The developer will be compensated via a fee structure, and the financing risk to the developer is typically low, depending on the credit profile of the end user.

Until recently, speculative development of cold storage has been a less common delivery model due in part to the added financing complexity and risk to the developer. In speculative development, the project is initiated and financed before the space is completely leased (or sold). Developers are responsible for arranging financing, which will include a combination of general partner (GP) equity belonging to the developer, limited partner (LP) equity from investors and debt from institutional lenders. An acceptable loan-to-value (LTV) ratio is in the range of 55-65%. Developers are primarily compensated via the increased value of their equity stake in the project, but they may also charge development fees as appropriate. The financial risk to speculative developers is very high. Speculative developers will seek to identify and sign qualified tenants or buyers as early in the development process as possible to mitigate the financial risk of investment.

Additional Considerations

Cold storage design and construction is complex, and the firms capable of delivering a project are limited. Developers need to maintain a good reputation with designers, general contractors, subcontractors, suppliers and advisors to ensure that collaboration leads to a successful project.

Construction and material quality standards for cold storage are higher than other property types due to food and pharmaceutical safety requirements. Cold storage facilities are expected to remain functional for as long as 50 or more years. Investing in high-quality materials during construction increases the long-term value and the effective lifespan of the facility.

Cold storage buildings have complex systems that require regular monitoring and maintenance. Selecting quality equipment that minimizes disruptions due to equipment failure will also maximize the long-term value of the asset. Additionally, maintenance and servicing contracts, and/or on-site personnel responsible for the facility's systems, are necessary and should be accounted for in the cost of the project.

Given the long lifespan of cold storage facilities, it is common for them to transfer to new owners at some point in their life cycle. This change in ownership is often accompanied by a change in intended use, such as from distribution to light processing. Construction design that can accommodate multiple uses increases the flexibility of the space for future tenants. This reduces the cost of repurposing and increases the long-term value of the asset.

A rendering of Cold Summit Dallas, a 343,250-square-foot speculative multitenant facility to be completed in late 2021.

CHAPTER 3

The Cold Ready Prototype: An Approach to Speculative Facility Design and Construction

Until 2019, cold buildings were traditionally build-to-suit. The costs were quite high, as were the risks, deterring speculative development. The increasing demand for cold storage led to the construction of the first large speculative cold storage facility in the U.S., DFW ColdSpot (see page 5). Following the success of that project, Ware Malcomb further refined speculative design for cold storage and developed the Cold Ready prototype, a cold building shell design that creates additional opportunity for speculative development at a lower initial cost.

In this chapter, Ware Malcomb and FCL present their recommendations for designing and constructing a speculative Cold Ready prototype. Many of the Cold Ready considerations can also be used for general speculative development. The recommendations that follow apply to multimarket distribution and last-mile facilities described in the first chapter.

The intent of the Cold Ready design is to defer many design decisions until the end user is identified, and likewise to defer some of the costs related to those design decisions. While it has many aspects in common with speculative dry warehouse buildings, certain key features are incorporated to allow for future cold tenant improvements. All images in this chapter are courtesy of Ware Malcomb unless noted otherwise.

Site and Building Design Basics

Placement of Offices

While the construction of the offices in a Cold Ready design would be deferred to the tenant improvements, it is wise to plan for their placement. Cold storage users typically want their offices adjacent to the docks. Line of sight to both the dock and the truck court is also desirable. Most of the action of the facility is on the dock – certainly no one wants to spend more time in a freezer than strictly necessary – and it is also not ideal to have to walk through cold storage spaces when exiting the office. When designing speculatively, it is often desirable to subdivide the facility into multiple tenants, which means multiple office spaces.

The expected placement of the offices on the dock dictates the site layout (see Figure 3.1). Placing the offices toward the street frontage also means the truck yard will be toward the street frontage, which may be undesirable both from an aesthetic and a queuing standpoint. Placing both the offices and

Figure 3.1 A Cold Ready site plan.

dock toward the back of a site improves queuing and hides the truck yard, but the visual and wayfinding benefits of offices near the street are lost. Parking adjacent to the offices and primary building entrances is preferable. However, this may present challenges for office entrances inside the truck court.

Placement of Refrigeration Equipment

The next site layout issue to grapple with is placement of refrigeration equipment. The Cold Ready prototype defers installation of refrigeration equipment to the tenant improvements. This saves costs and allows the refrigeration system to be better customized to the end user. However, it is desirable to accommodate space for the possibility of ground-mounted refrigeration equipment (additional considerations for refrigeration equipment are discussed on page 27).

In selecting a place on the site for refrigeration equipment, preference is given to spaces adjacent to the building. This eliminates the need for overhead piping bridges (see Image 3.1).

Avoid placing equipment along a street frontage, as equipment may be quite tall and difficult to screen (see Image 3.2). It is preferable to keep equipment away from office spaces due to noise considerations (See Figure 3.2). Minimizing piping runs across the building roof is desirable. Ideally the refrigeration equipment would be kept close to the electrical room, to minimize conduit runs. The equipment pad may also be sized to accommodate transformers and a generator. A fire pump and tank may also be needed on the site.

Figure 3.2 Refrigeration equipment placement on rear of building and parking in front.

Image 3.1 Piping bridge.
Credit: Nostal6le

Image 3.2 Exterior equipment on a cold facility.
Credit: Troy Ament Photography

Building Loading

Another consideration for site design is the building loading. Most speculative designs incorporate a truck court at a minimum of 135 feet. Trailer parking is a highly desirable commodity and may expand the truck court to 185 feet. Most speculative buildings are designed for loading on one side of the building, though cross-dock configurations may be appropriate to certain locations.

While this is comparable to dry storage, there are a few differences. First, reefer trucks have insulated containers that raise the bed from 48 inches to 52 inches (see Figure 3.3). For speculative design, a 50-inch dock height would allow for a mixture of cold docks and dry docks as part of the tenant improvements, with the height differentials made up by dock levelers.

Second, placing dock doors 14 feet on center (rather than the commonly used 13 feet on center for dry storage) can accommodate the dock seals and lights likely to be included as part of the tenant improvements (see Image 3.3). If four doors are placed per column bay, that translates to a column bay spacing of 56 feet.

Third, many air quality regulations require power supply or "plug-ins" for reefer trucks to prevent engine idling that keeps the refrigeration running. For Cold Ready, the conduit should be run to trailer parking.

Speculative design could potentially also incorporate other loading options if they are appropriate to a particular location. For example, a facility in a location well-suited to last-mile distribution may examine options for van loading in addition to the traditional truck loading. A facility with a rail spur may incorporate an enclosed rail dock. Regardless of the type of loading, consideration should be given to allowing loading as directly as possible from building to vehicle to maintain the cold chain.

It is highly preferable for the loading areas to slope away from the building, and to avoid truck well conditions (wherein the loading area slopes toward the building) where possible. Since many cold buildings are also food buildings, it is important to avoid standing water near the building, which can attract pests.

Likewise, landscape should be selected with pest control in mind. It is typical to place a 12- to 18-inch-wide concrete or gravel pest control strip at all landscape areas adjacent to the building perimeter.

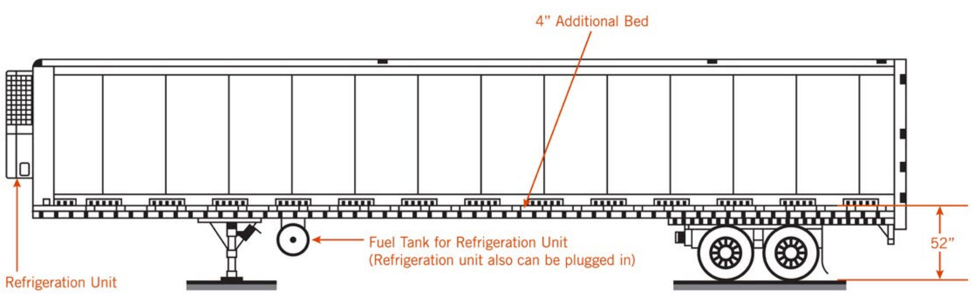


Figure 3.3 A diagram of a refrigerated "reefer" truck.

Image 3.3 A cold dock exterior.
Credit: Seen Above Media, Inc.

Cold Building Envelopes

Cold buildings have two envelopes: thermal and vapor. Continuity of these envelopes is critical. Discontinuity of the vapor envelope can allow vapor to infiltrate the building. At temperatures above freezing, that vapor will turn into condensation and form puddles, or even create indoor rain. At temperatures below freezing, the condensation becomes ice crystals, which can cause significant damage to the building. Discontinuity of the thermal envelope can create ice conditions outside of the building.

There are three major types of envelope designs for cold buildings:

- Steel-framed with IMP exterior
- Box-in-box
- Hybrid

Steel Framed

- This type of envelope utilizes exterior IMP supported by a structural steel frame. Over-deck insulation and single-ply roofing extend the envelope onto the roof. In freezer conditions, the envelope is completed with sub-slab insulation and a vapor barrier.
- It is usually constructed with a tilt-up or pre-cast dock face for durability.
- Typically less expensive than the other envelope styles, it combines the building envelope with the thermal and vapor envelopes.
- It provides good thermal and vapor continuity, as the envelopes are largely outside the building structure.
- The exterior IMPs need to be white, almond or light gray to maximize solar reflectivity. Darker colors and paint treatments may void the panel warranty. Unfortunately, some planning departments dislike the aesthetics of big white boxes.

FCL Builders: Steel Frame Construction Considerations

The construction of a cold storage building differs greatly from that of a dry warehouse. The steel-framed exterior with IMP skin traditionally costs more than a tilt wall or precast structure and needs to be sequenced differently over a longer period. Special attention must be paid to the location of the girders, columns and sag rods on the exterior of the building to coordinate locations to avoid conflicts with openings or other equipment in the building. Using R-50 over-deck insulation is ideal and is usually double the cost of R-30 insulation.

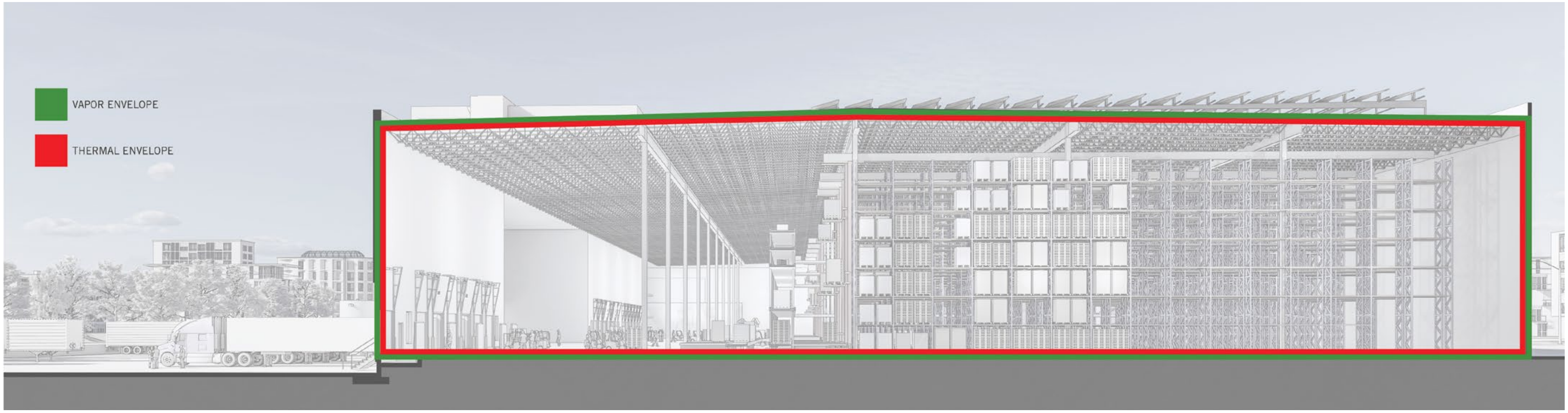


Figure 3.4 Steel framed envelope.

Box-in-box

- The building envelope is typically made of tilt-up or precast concrete, with an interior cold "box" constructed of IMP walls and ceilings. As with the steel-framed envelope, freezer envelopes are completed with sub-slab insulation and vapor barriers.
- The cold portion may be only one part of the building or may extend throughout the building.
- While box-in-box is often associated with retrofitting existing dry storage buildings for cold users, it can be used for new construction.
- The exterior concrete tilt-up or precast envelope allows for greater façade design flexibility than the steel-framed envelope.
- Most of the cold box construction can be deferred to the tenant improvements.
- The utilization of ceilings (typically included in the tenant improvements) allows for greater flexibility in the location of demising walls than over-deck insulation.
- The building structure will have some penetration through the thermal and vapor envelopes in this design; for example, where columns penetrate the ceiling.

FCL Builders: Box-in-Box Construction Considerations

The box-in-box design is a good option for existing buildings. The cost of the box-in-box is usually 20-30% more than the steel-framed option. The design needs to consider the interstitial space above the ceiling and ensure that proper ventilation or heat is installed to avoid the collection of moisture above the ceiling. The typical dry building will require some reinforcement of the roof structure to accommodate the ceiling load in a box-in-box scenario.

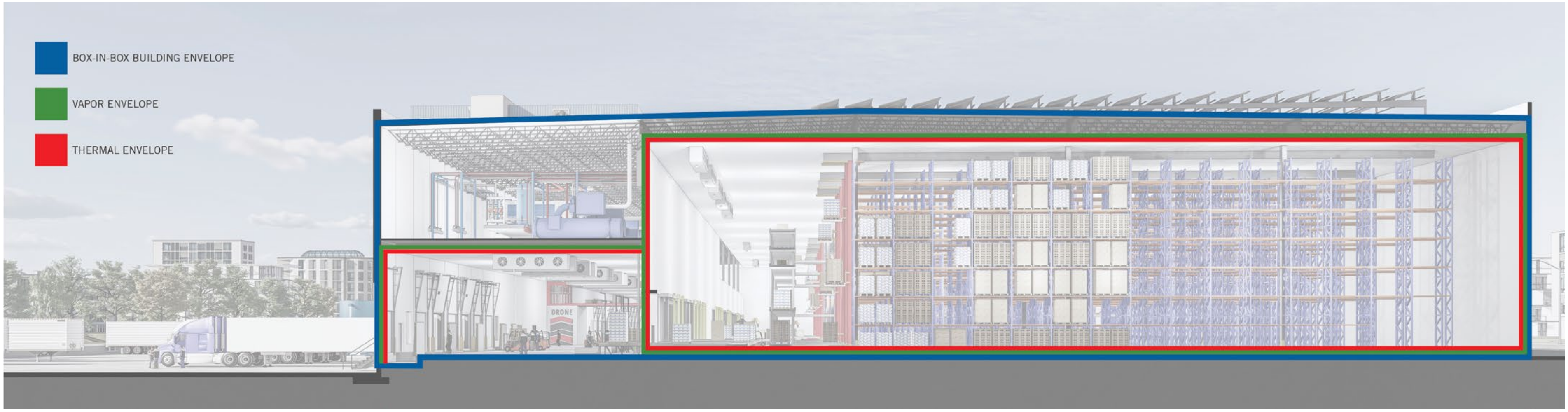


Figure 3.5 Box-in-box envelope.

Hybrid

- A hybrid solution utilizes exterior concrete walls with IMP liners but incorporates over-deck insulation in lieu of ceilings. This can reduce building costs.
- Like the box-in-box solution, the hybrid option allows a greater range of façade options than the steel-framed big white box.
- While columns no longer penetrate the ceilings, joists do penetrate the IMP walls at the ledger.

Building Heights

Maximizing clear height can be very desirable for cold storage users to maximize the number of pallet positions in the smallest footprint. Building codes limit the height of most cold buildings to 75 feet, while zoning codes may be more restrictive. The desire for ceiling-only fire protection also plays a role (See page 28 for more on fire equipment). As a result of these factors, clear heights between 40 and 50 feet are recommended for Cold Ready buildings.

Insulated Metal Panel Wall Design

For the steel-framed envelope, consideration must be given to the thermal and vapor envelope wall design, while box-in-box and hybrid envelopes can defer many decisions to the tenant improvements. The preferred material for walls is IMPs.

IMPs consist of a high-density foam core sandwiched between metal siding. The foam core provides the thermal envelope, while the metal siding provides the vapor envelope. They are not the same as camlock panels, which are typically used to construct prefabricated walk-in coolers and freezers.

Each panel ranges from 24 to 42 inches wide, and standard panels are limited to 53 feet long to fit on a flatbed trailer for transport. (Some manufacturers do make extra-long panels as well.) In cold building applications, they are installed vertically.

IMPs come in different thicknesses as well. Selection of thickness is determined by R-value (insulation performance) requirements, as well as the panel span. Thickness is also impacted by the type of foam core used in the panels, as different cores have different R-values. Polyiso cores are recommended; most builders avoid EPS (Styrofoam) cores as they deteriorate over time. Minimum R-values for cold buildings are dictated by energy codes.

The metal siding of the IMP is pre-finished in white or light colors to maximize reflectivity. Polyester finishes are most commonly used for interior surfaces.

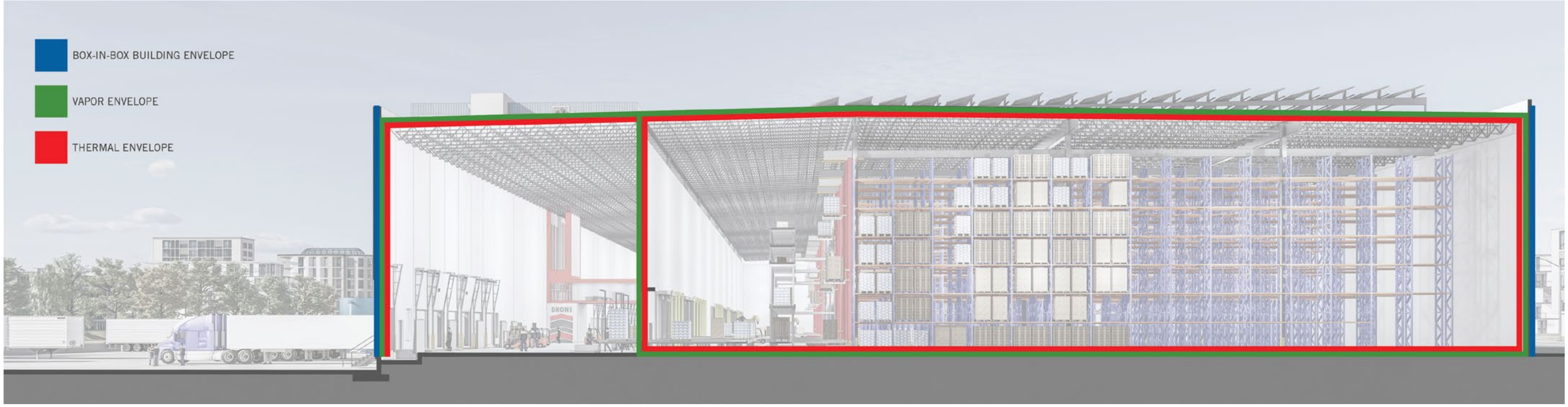


Figure 3.6 Hybrid envelope.

However, since polyesters will deteriorate in the sun, Kynar is a preferred finish for the building exterior.

Exterior IMP walls are supported by horizontal structural members called girts, which span between building columns. A structural engineer can determine the number of girts required based on wind load and panel span tables (which are published by the panel manufacturers). Additional girts may be required by insurance purposes, so it is important to consider whether to include an additional structure for potential future tenants. If the walls are taller than the IMP lengths, a girt will also be required to carry a "stack joint."

There is also a vertical joint between each IMP. To create vapor barrier continuity, it is important that the joint be sealed. Butyl sealant is a preferred sealant for cold buildings due to its ability to remain flexible at cold temperatures.

Exterior walls also include a stem wall (see Figure 3.7) from the bottom of the IMP to grade. It is preferable to keep IMPs above grade to avoid deterioration of the metal siding. Note that the bottom of the IMP may be below the finished floor level to connect with sub-slab insulation. The stem wall is most commonly made from cast-in-place concrete, though precast concrete or concrete masonry units (CMU) are also options. The IMP will be connected to the stem wall via a base channel or base angle.

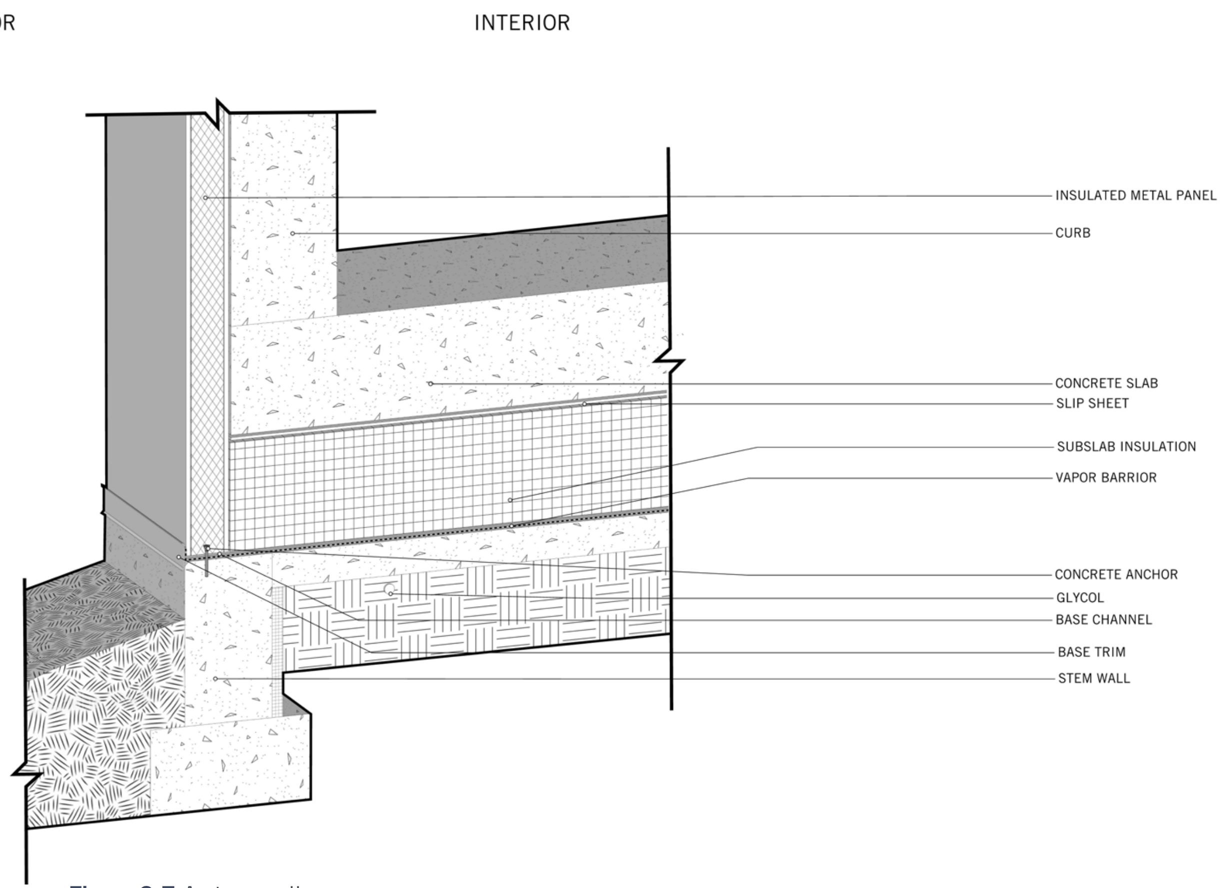


Figure 3.7 A stem wall.

FCL Builders: Insulated Metal Panel Wall Construction Considerations

The installation of the building envelope is extremely important to the performance of a cold storage building. The joints of the IMPs must be joined together properly. It is crucial to ensure that the joint is clean and fully engaged, and that the sealant has bonded to both sides of the joint to provide the thermal barrier. Installation of IMPs usually starts from one corner of the building and works toward the other corner. The installation of IMPs at changes in clear height in the building or double column lines can cause sequencing issues in the field. To minimize additional joints in the IMPs, the construction sequence needs to accommodate the installation of large panels. The contractor needs to ensure the panels are not damaged during the installation process. IMPs cannot easily be repaired if they are damaged.

Various trim pieces are used to finish the IMP walls. Trims are hem finished and may incorporate radiused corners to allow for easier cleaning.

Slab Design

To complete the envelope of a freezer in a build-to-suit facility, a multilayer slab system is designed that incorporates a sub-slab heating system, vapor barrier and insulation (see Figure 3.8). This is to prevent vapor in the ground underneath the building from freezing. A small amount of freezing can create ice crystals, which eventually push up slabs in a condition known as “frost heave” (see Figure 3.9). A large amount of freezing can make it impossible to even turn off the freezer, as the ice beneath the slab could melt and the entire building could sink.

However, the Cold Ready design takes a cue from retail construction and omits this multilayer slab system until the tenant improvements. To maximize flexibility, Ware Malcomb recommends designing all future areas that might be utilized for storage to accommodate this multi-level slab. At cold docks, while the full multilayer slab does not need to be accommodated, the slab may still be omitted knowing that condensate drain systems will need to be installed for the refrigeration system in the future. Slabs around future specialty dock equipment may be deferred as well. (See more about dock equipment on page 26.)

Planning where to accommodate the future multilayer slab system requires making assumptions about each piece of the system to determine where to place the grade.

Starting from the top, consideration needs to be given to the future finish slab thickness. Something to consider is that high clear heights and tall material handling systems are starting to drive up slab thicknesses. However, engineered flooring systems are also often utilized to reduce slab thicknesses for those same material handling systems. While dry storage may still incorporate 6-inch slabs in speculative design, consideration should be given to accommodating future slabs of 8 inches.

Future sub-slab insulation is the next layer, separated from the topping slab with a slip sheet. Thickness of the sub-slab insulation is determined by the type of insulation and R-value, which is once again dictated by energy codes. Extruded polystyrene (XPS) insulation is recommended as the basis for determining thickness.

On-level with the sub-slab insulation, columns should be set on isolation blocks. These blocks match the thickness of the sub-slab insulation and the dimensions of the column base plates. Installing column blocks throughout the building’s storage areas does add some cost, but the benefits to the future cold building envelopes are very important.

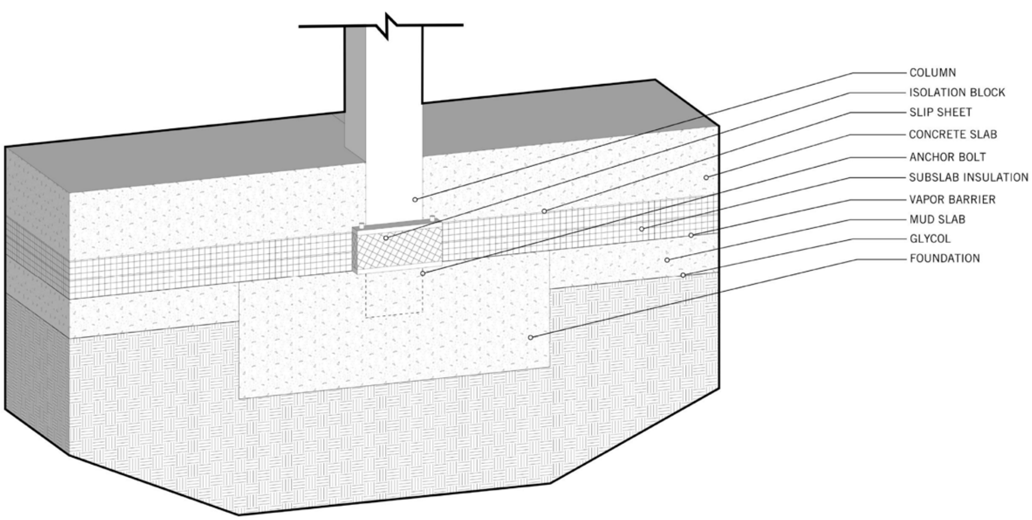


Figure 3.8 Insulated and heated slab cross section.

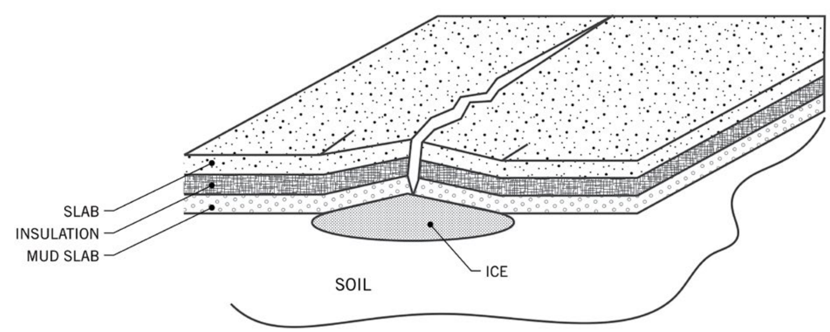


Figure 3.9 Frost heave.

Below the insulation is the future vapor barrier, and below that are the future sub-slab heating and mud slabs. Structural mud slabs are required for box-in-box and hybrid designs to support the exterior concrete walls, and thickness is determined by a structural engineer. To allow deferred installation of the sub-slab heating system, Ware Malcomb recommends placing the structural mud slabs below that system. The glycol tubing can be assumed to be three-quarters of an inch and would be set in sand for leveling of the insulation above.

Future non-structural mud slabs, on the other hand, may be desirable in areas of rocky soil to protect the vapor barrier. Future glycol heating would be set on grade or on a sand layer, with the mud slab poured directly on top. An assumption of 3 inches may be used to determine grade depth to accommodate a non-structural future mud slab.

Roof Design

Roof design for box-in-box is different from steel-framed or hybrids because box-in-box will have a future ceiling. A structural engineer should be consulted to determine how much weight the roof structure should accommodate for those future ceilings, though 3 pounds per square foot (psf) is a good rule-of-thumb.

While the roof structure would be covered by future ceilings in freezers and coolers, a tenant may wish to incorporate dry storage areas as well. Exposed wood roof structures are not preferred for food storage and safety, so a developer may consider utilizing a steel structure with metal deck to avoid needing ceilings in dry storage areas.

Steel with metal deck should be utilized on steel-framed and hybrid roofs. Open web bar joists are preferrable over heavier steel beams as they allow for better air flow for refrigeration systems. Due to the variations in refrigeration systems, it is difficult to design the roof structure to support future refrigeration equipment, so good documentation should be kept allowing for future reinforcements. (See more regarding this in the refrigeration section on page 27.)

For steel-framed and hybrid buildings, it is important to create the thermal and vapor envelope of the roof. Vapor continuity is critical in preventing vapor from moving into the building and becoming condensate, and then indoor rain or ice. Thermal continuity is important to prevent ice dams on top of the roof, which can cause significant damage over time.

The vapor envelope is provided by single-ply roofing. White thermoplastic polyolefin (TPO), fully adhered, is recommended. While mechanically attached is the most widely used roof system, the fasteners create discontinuities in the thermal and vapor envelopes. On steel-framed buildings, care should be taken to create continuity at the roof eaves between the TPO roofing and the metal siding on the IMPs (see Figure 3.10).

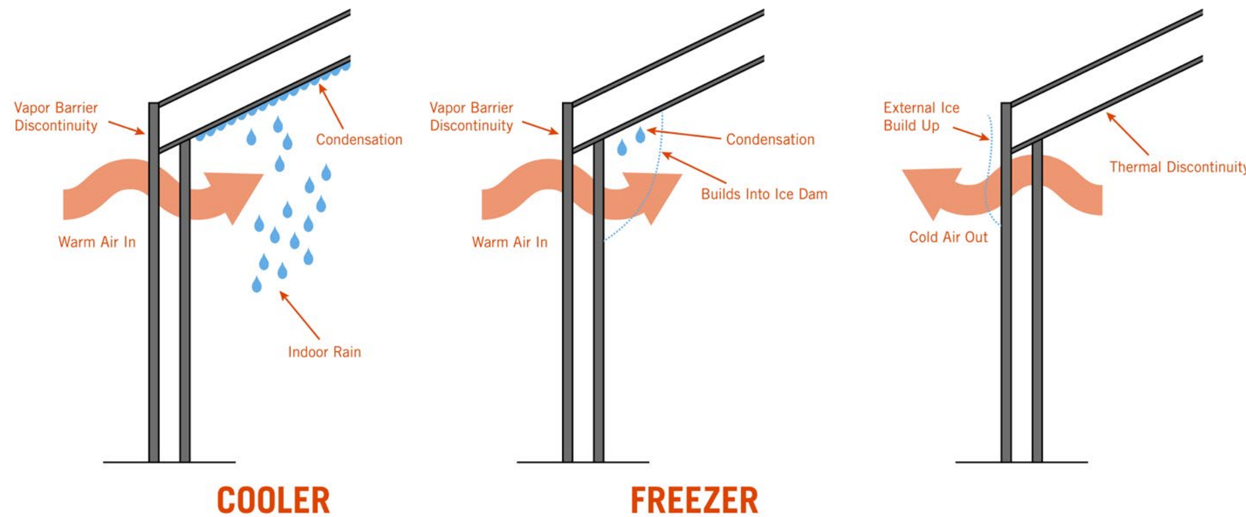


Figure 3.10 Impacts on envelope continuity.

FCL Builders: Roof Design Construction Considerations

The roof system is a main component in the vapor and thermal barriers. Sealing cold storage roof penetrations is a critical part of the roof system. Penetrations provide more opportunities for heat infiltration. It is very common to have the panel contractor make the final seal on penetrations to ensure the integrity of the envelope and the roof must be protected during welding operations on the roof. The scheduling of the roof on cold buildings can vary depending on how the rooftop equipment and/or piping is attached to the structure. Walk pads are typically installed in high-traffic areas where routine maintenance will be performed for the life of the building.

The thermal envelope is provided by over-deck insulation (see Figure 3.11). The most commonly used insulations are polyiso and XPS. Polyurethane is also an option, though it is less frequently used due to historical challenges with meeting flame spread requirements. R-value is once again determined by the energy codes. Insulation should be installed in a minimum of two staggered layers. Adhered systems are preferable to avoid the fasteners penetrating the thermal envelope, but to assist in wind resistance it is common to fasten the lower layer of insulation and adhere subsequent layers. Some insurance companies can require an upper layer of roof boards to protect the insulation, so that should be considered for prospective tenants.

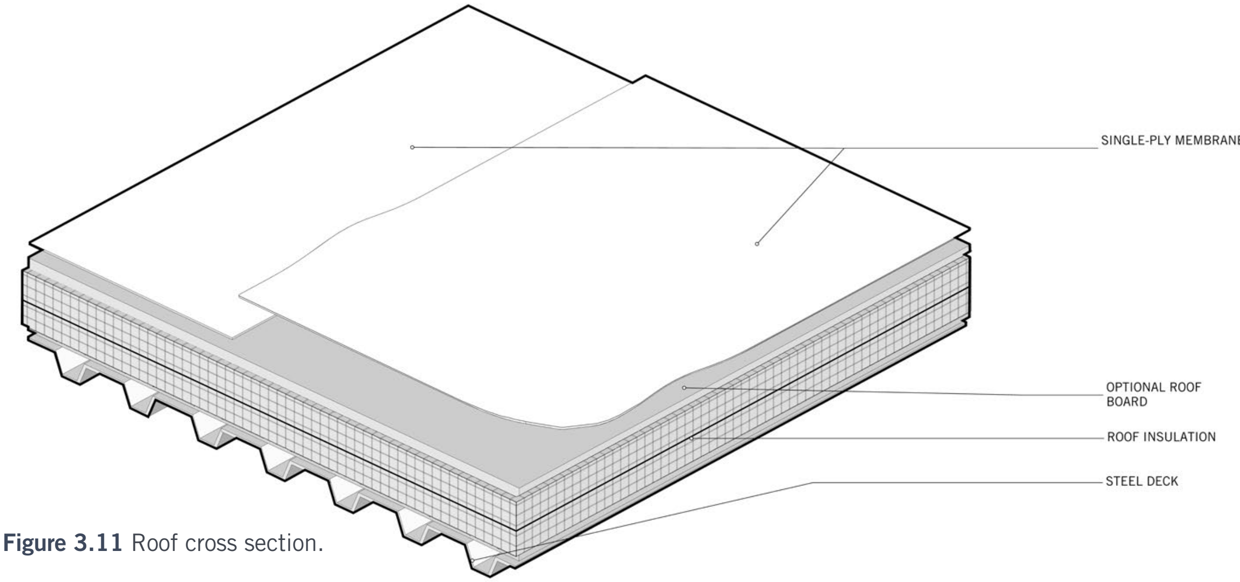


Figure 3.11 Roof cross section.

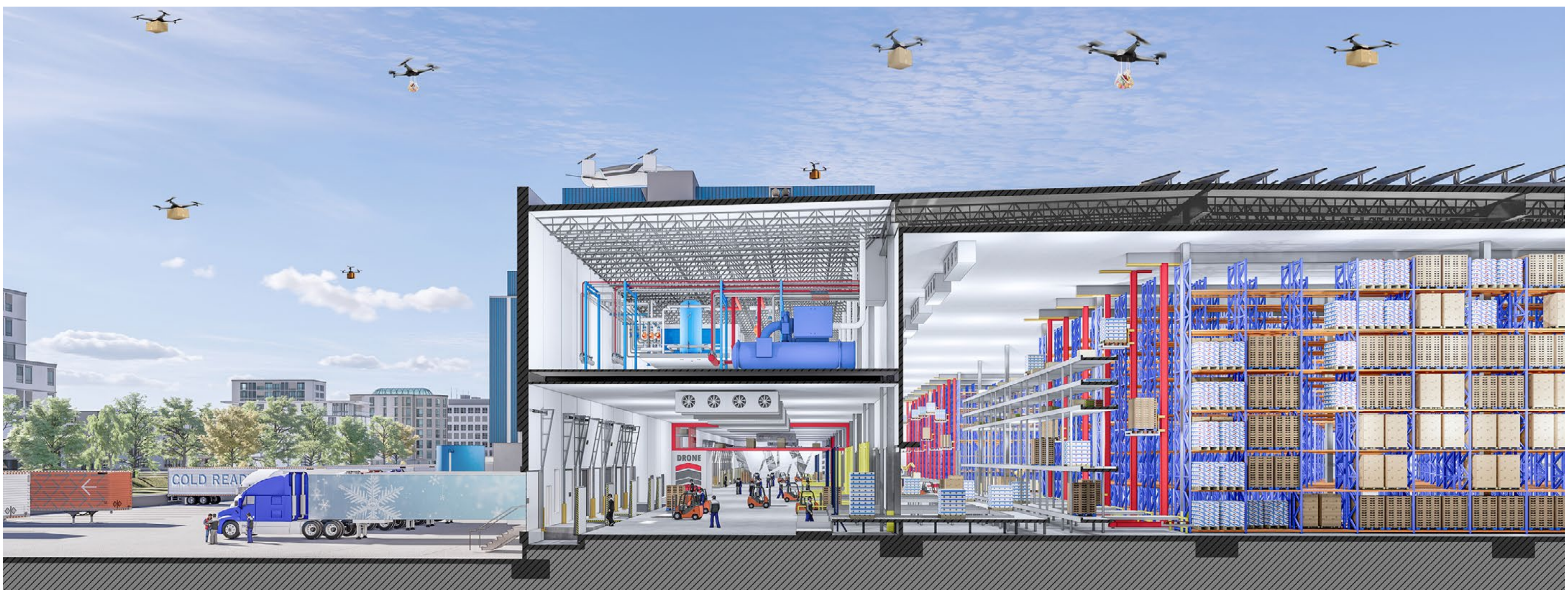


Figure 3.12 Lowered dock roof with double column line.

Roof design for steel-framed buildings incorporates a break in the roof deck between the cold dock and the storage areas (see Figure 3.12, page 24). This break allows the demising wall at the back of the cold dock to connect cleanly with the roof insulation and vapor envelopes. For Cold Ready design, only the top part of the demising wall is installed, while the rest of the demising wall may be deferred.

The break in the roof deck is achieved with a double column line. This is often taken as an opportunity to reduce clear height and reduce steel, as docks do not require the same clear heights as storage areas, though it may be desirable to allow enough clear height at the dock to accommodate a future mezzanine.

The double column line may be structurally tied together, or an expansion joint may be required. These expansion joints must be carefully designed to maintain both thermal and vapor envelope continuity.

This double column line detail may also be desirable in locations where there will be future demising walls.

Doors

While many decisions on doors can be deferred to the tenant improvements, exterior doors do need to be addressed. This is particularly challenging on box-in-box and hybrid buildings, as many doors ought to be placed on IMP liners. However, it is also desirable to defer the installation of the IMP liners to the tenant improvements. Expect to relocate some doors to liner panels as part of the tenant improvements.
It may be possible to provide knockouts for future doors in concrete walls, for example, for fire access doors, which will not be required until high-pile storage is installed. Required exit personnel doors may be filled with temporary hollow metal doors. Insulated cooler or freezer doors would replace them as part of the tenant improvements.

For steel-framed buildings, cooler and freezer personnel doors can be installed on the IMPs. These doors come in high-sill and flush-sill options (see Figure 3.13). High-sill provides a seal around all four sides of the door, but it does not allow for a level surface on both sides of the door. Thus, flush-sill doors should be utilized at accessible entrances and required exits, while high-sill doors can be used for fire access doors. Freezer personnel doors do include a heat trace, but power to the doors may be deferred to the tenant improvements.

Exterior steel stairs should be utilized anywhere where the stair is adjacent to an IMP, as moisture may be trapped between a concrete stair and the IMP, leading to corrosion.

As all types of building envelopes incorporate concrete walls at the dock, it is possible to defer dock doors to the tenant improvements. For marketability, however, it is more common to install at least some of the doors. Dock doors should be insulated, motorized and incorporate seals.

It is important to understand that cold dock equipment typically incorporates a continuous dock pit and vertical lift levelers, which means that the door extends into the dock pit 12 inches below the finished floor (see Image 3.5). However, it may not be desirable to install the dock pit, or to extend the door opening below the finished floor in case the future tenant wants to incorporate dry dock areas. A compromise is to install a door with an extra foot of length, but stop the opening at the finished floor, with a knockout below.

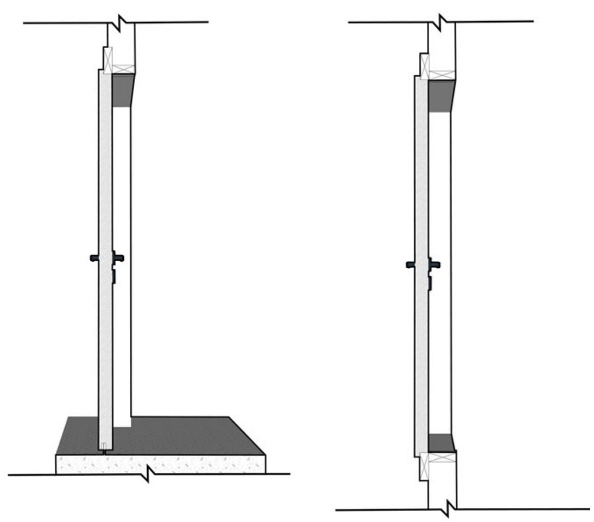


Figure 3.13 High-sill vs. flush-sill personnel door.

Image 3.5 An example of a dock pit.
Credit: Charlie Mayer Photography

Penetrations

Continuity of vapor and thermal envelopes is critical for good cold building design, but it is sometimes necessary to create penetrations for electrical conduits, plumbing pipes and other items (see Figure 3.14). Each penetration should be wrapped in insulation and sealed to minimize and mitigate infiltration.

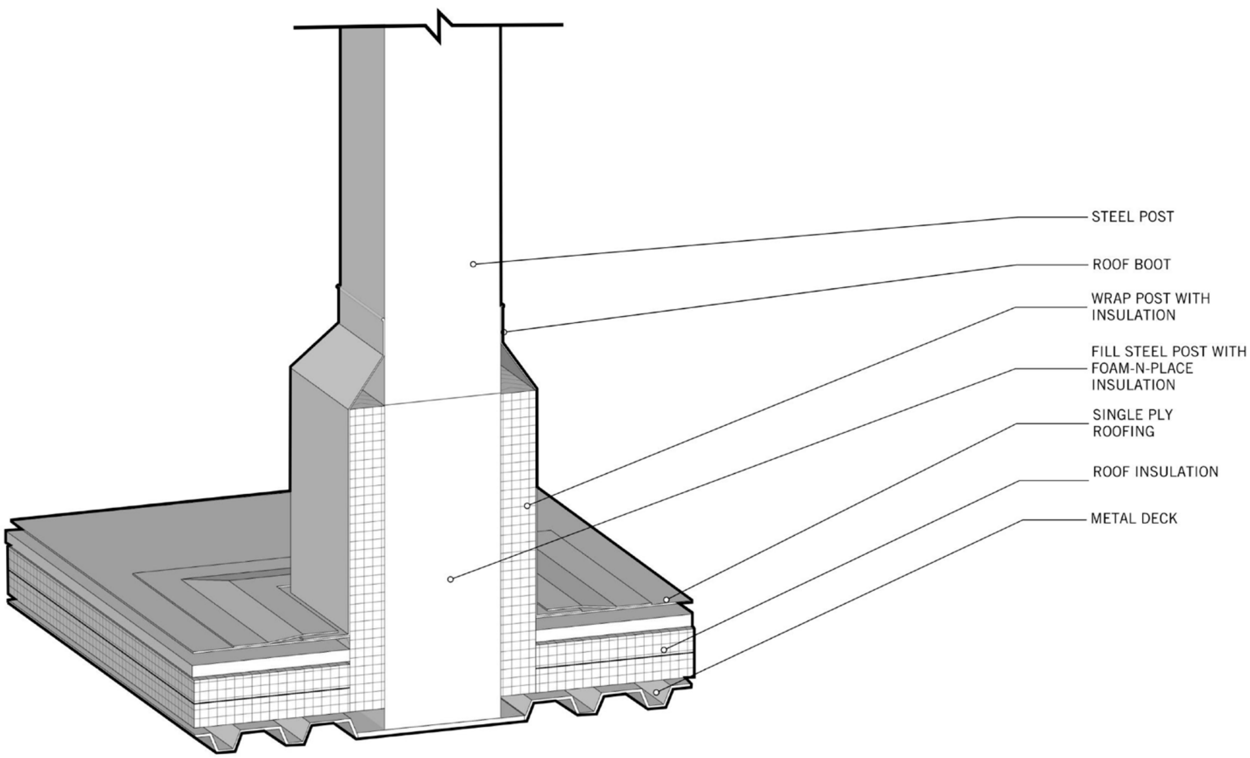


Figure 3.14 An example of wall and roof penetrations.

Dock Equipment

As previously discussed, it may be desirable to defer much of the dock equipment installation to the tenant improvements. But some understanding of the expectations of those tenant improvements is important in designing the Cold Ready shell.

The standard pit-style dock levelers in wide use on dry storage buildings are not desirable for cold applications:

- They are difficult to clean and can harbor bacteria in food applications.
- They often provide access for pests. While this can be mitigated by seals, it is a concern.
- Significant thermal transfer occurs through the leveler to the dock face. This can create condensation.

Instead, cold docks typically utilize vertical lift levelers. While these levelers can be placed in individual pit configurations, it is preferable to place them in a continuous pit for easier construction and cleaning. The bottom of the continuous pit may act as the structural pour strip for the exterior concrete walls.

Conduits should be placed in this bottom-of-pit/ pour-strip area to accommodate future dock controls, dock lights, dock plug-ins for reefer trucks and motorized door controls.

Dock bumper design is different for continuous pits than for standard pit levelers, so they likewise should be deferred to the tenant improvements.

Dock canopies, as well as dock seals and shelters, may be installed if desired, but they could just as easily be deferred to the tenant improvements.

Electrical conduits for the leveler and door controls must be carefully coordinated to allow for a clean and organized installation.

Refrigeration

Typically, refrigeration systems as part of the Cold Ready shell are deferred, but it is important to understand enough about the future systems to inform the design.

Refrigeration systems consist of four components (see Figure 3.15):

- Condensers are placed outside the building as they require significant air flow. Rooftops are a popular location, but that will require roof reinforcement as part of the tenant improvements. The exterior refrigeration pad, discussed in the site design section, is a good location for the condenser.
- Compressors, also known as "screws" or screw compressors, are often placed in refrigeration rooms. The Cold Ready design allows for future mezzanines above the electrical and fire pump rooms and/or above the cold dock, should refrigeration rooms be desired. Refrigeration rack systems may combine condensers and compressors in a single exterior system that could be placed on the exterior refrigeration pad.
- Evaporators, also known as "evaps," "blowers" or "coils," go inside the refrigerated room. They can be hung from the roof structure and are typically placed so they blow down a racking aisle, making it difficult to anticipate their future location. Thus, roof reinforcement for the evaps is generally deferred. They can also be placed above the roofline in penthouses. However, that requires a more complex roof design that would not be recommended for Cold Ready.
- Piping connects the previous three components. Again, future piping may require some reinforcement when it is installed.

These three components can also be combined into rooftop package units, but again it is challenging to design a spec roof around the various possibilities.

Some due diligence should be performed during site selection regarding the types of refrigerants that can be used. The primary refrigerants in common use are freon and ammonia. Freon is a greenhouse gas, and the U.S. Environmental Protection Agency (EPA) is slowly phasing it out. Ammonia, on the other hand, is considered a life safety concern. As such, it may have increased Occupational Safety and Health Administration (OSHA) standards, limitations on locations in proximity to schools and other regulations.

New technologies that reduce the amount of ammonia to safer levels are popular. Low-charge ammonia package units are a common option, though as they are typically placed on rooftops and are very heavy, so they may not be the best option for a Cold Ready building. Cascade systems replace part of the ammonia with carbon dioxide.

Regardless of the type of system, refrigeration becomes increasingly efficient as the building gets taller. Warm air rises and cool air sinks, and it is possible to take advantage of this natural cycle to cool taller buildings without significant additions to the refrigeration system (see Figure 3.16).

Sub-slab heating systems are often tied to refrigeration systems, utilizing waste heat from the system to warm the glycol. This is one reason to defer the installation of sub-slab heating.

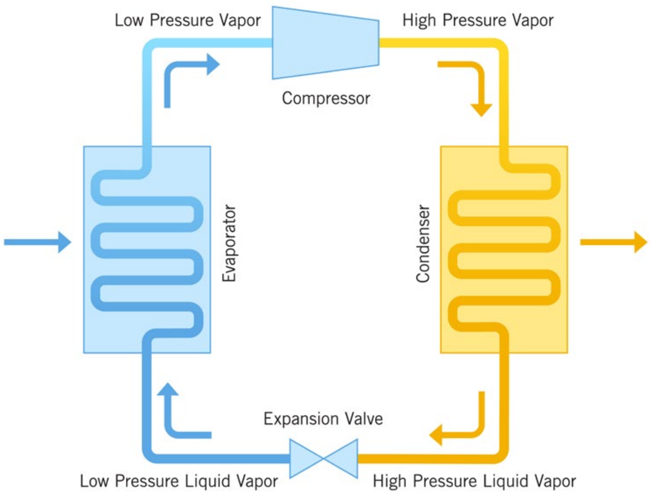


Figure 3.15 Refrigeration diagram.

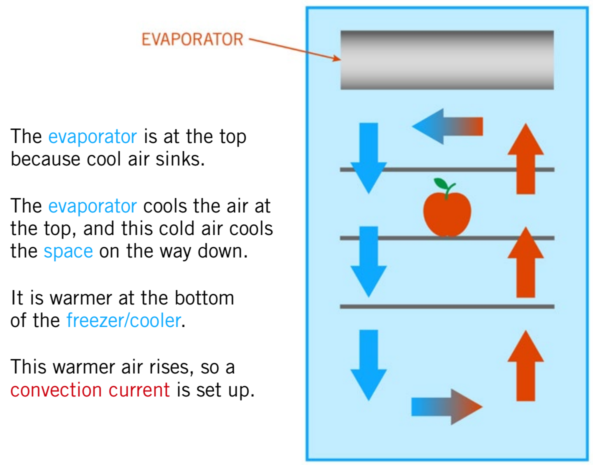


Figure 3.16 Air cycle diagram.

Fire Sprinklers

Ware Malcomb recommends early suppression, fast response (ESFR) sprinkler systems for Cold Ready buildings. New Viking K-28 sprinkler heads will allow ceiling-only protection up to 50-foot top of product with a 55-foot ceiling (or underside of deck). Quell fire sprinkler systems are also a good choice with similar storage heights possible. However, as of the writing of this e-book, not all jurisdictions will accept Quell.

Ceiling-only sprinklers are important to cold users. Accidentally hitting an in-rack sprinkler head is an especially costly mistake in freezers because once water is in the system it will quickly freeze and render the system inoperable. Until the system is removed, thawed and reinstalled, a freezer cannot be used. Automation systems often require in-racks due to density, but robots are less likely to make such costly errors. Still, most users are not yet using automation, so planning for ceiling-only protection is wise.

FCL Builders: Fire Sprinkler Construction Considerations

The fire protection system in a cold building is much more complicated to install than in a dry building. Riser rooms, housing a valve that separates the wet side of the system from the dry side, are required. Double interlock systems, which require a head triggering and a detection of a rise in temperature, are often installed to help avoid accidental discharge of water into the dry fire protection system when the freezer is at temperature. Flushing of the underground main and testing of the overhead system is required before the space is brought to temperature.

Steel-framed and hybrid buildings will require a dry sprinkler system, whereas a box-in-box design will allow for a wet sprinkler system, with dry pendant heads required to be put through the future ceilings in freezer conditions. Dry sprinkler systems will need to have riser rooms to accommodate the risers and associated compressors that pressurize the system. The riser rooms may be placed around the building perimeter or on the cold dock.

Either system will incorporate a pump room or pump house and may require a fire tank.

Electrical

Since refrigeration is the largest load and it is deferred in these projects, the Cold Ready prototype assumes a smaller initial electrical service with conduits for a future increased size. Ultimately the service size will need to be negotiated with the local utility.

As discussed in the site design section, some site space may be allocated to a future generator. The electrical design may also accommodate off-site generator services.

Electrical rooms for cold facilities are often quite large compared to dry storage, and 20-by-30-foot rooms are not unusual.

As Cold Ready is a shell design, it is desirable to defer any lighting not required by the local jurisdiction. However, keep in mind that cold buildings do not incorporate skylights, so some lighting may also be desired to show the building. Lighting should be LED and appropriate for cold temperatures. Washable food-safe light fixtures may also be desirable for food handling facilities.

Any conduit installed should be held off the IMP walls to allow for easy cleaning (see Image 3.6).

Image 3.6 Conduit held off for wall cleaning.
Credit: Tonpor Kasa

FCL Builders: Electrical Construction Considerations

Electrical conduits not properly installed can cause thermal transfer issues in cold storage buildings. The field team needs to pay close attention to where and how the conduits are installed and how to transition the conduits when they cross between two spaces at different temperatures. The electrical system feeds several motors in the refrigeration system, and many of the motors are Variable Frequency Drive (VFD) motors. Special attention needs to be given to the type of wiring and conduits that are installed to power the VFDs to make sure the electrical supply to the motor is correct. Incorrect electrical supply can damage the motors.

Racking and Material Handling

While racking and material handling design is deferred to the tenant, it is recommended to take some aspects into consideration in the shell design. The most common racking systems in use are single deep (or selective) and two-deep static rack, with aisles ranging from 9 to 12 feet.

The 56-foot bay spacing discussed on page 17 (to align to dock doors at 14 feet on center) is also well suited to these common racking systems (see Figure 3.16).

Vertically, the most common pallet height is 64 inches, though by comparing rack sections to the limitations of ceiling-only fire sprinkler protection and zoning code limitations, an ideal building height may be determined (see Figure 3.17).

Cold storage users are particularly concerned about pallet positions available, and that number may be more critical for building marketing to square footage, but by combining these concepts, it is possible to come up with estimated pallet counts.

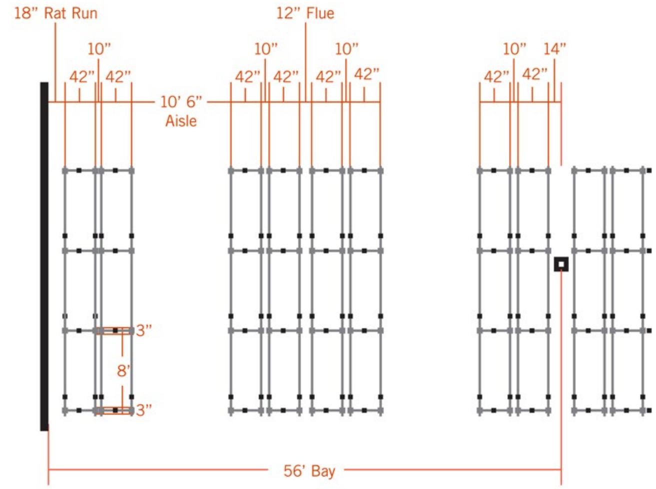


Figure 3.16 Racking diagrams for 56-foot bays.

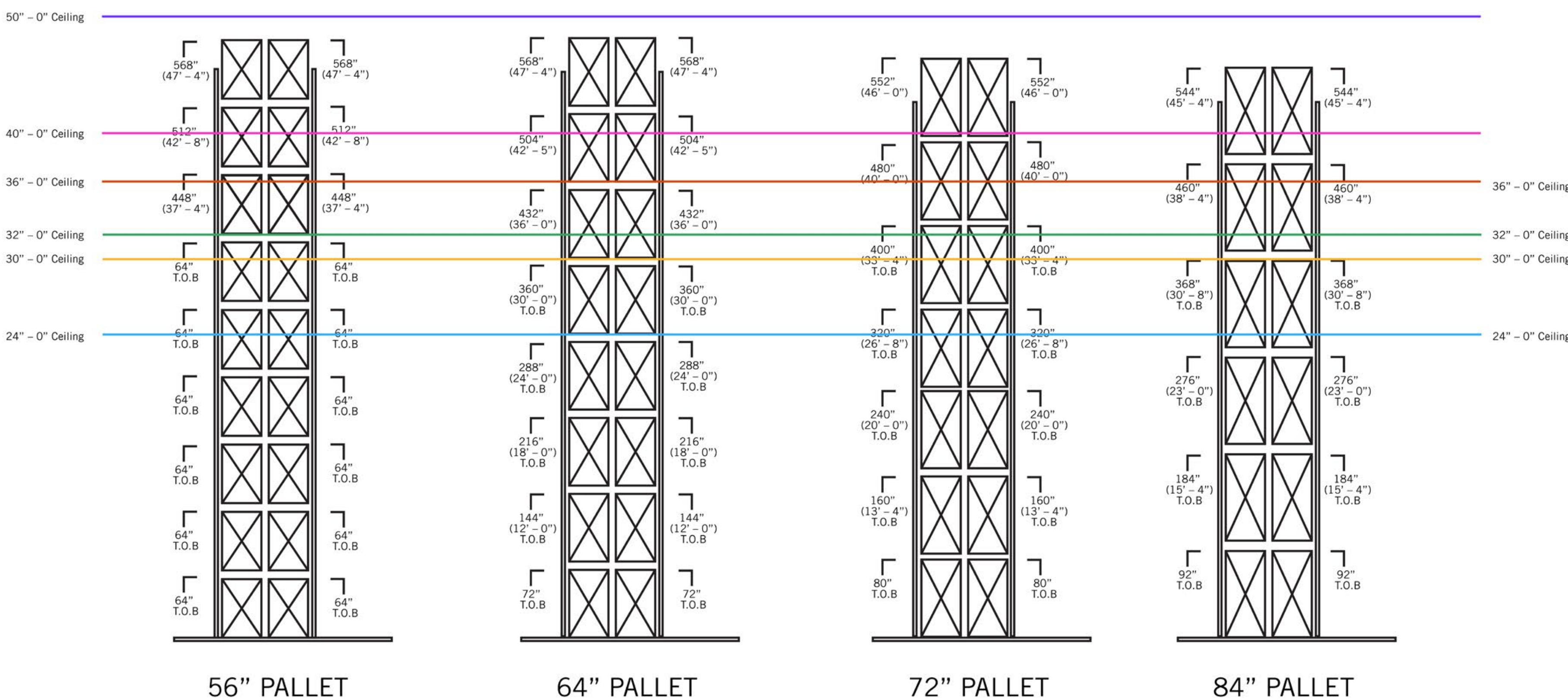


Figure 3.17 Rack sections with a 50-foot maximum top of product.

CHAPTER 4

Design and Construction Considerations for Build-to-Suit Cold Facilities

While many of the concepts of Cold Ready design can be applied to other speculative cold and build-to-suit projects, there are also options for greater customization when developing a project for a specific end user. This chapter also covers tenant improvements that can be implemented in a Cold Ready building. All images are courtesy of Ware Malcomb unless otherwise noted.

Site and Building Design Basics

Building footprints and column grids may be designed from the inside out to accommodate material handling systems. Verticality may be pushed even further if the tenant is utilizing automated material handling systems.

Truck courts may be enlarged further by users who expect long-haul trucks; sleeper cabs can extend the overall tractor-trailer length to 90 feet, with a greater maneuvering radius to match.

FCL Builders: Site and Building Construction Considerations

The selection of the refrigeration system to be used in a build-to-suit cold storage building must be one of the first decisions that is made during the design process. The refrigeration system may dictate the configuration of the building and how construction will be sequenced. This decision also needs to be made early so the equipment and materials for the system can be ordered in time to align with the construction schedule. Some equipment can have lead times as long as 52 weeks after the order is placed (see page 34 for more information on refrigeration considerations).

A variety of different building footprints and site arrangements may be utilized beyond the single loaded and cross-dock configurations mentioned previously. Processing facilities may have very minimal loading areas and much larger parking requirements. Port facilities may incorporate transload areas where products are offloaded from inbound rail or trucks and immediately loaded into outbound trucks or vans.

Special Building Structures

Build-to-suit design also may incorporate structural systems that would not be considered speculatively. Rack-supported buildings, for example, can be cost-effective if they are over 80 feet tall. That is taller than the building code limitations for speculative buildings, but rack-supported buildings are often excepted from those limitations because they are classified as pieces of equipment. Still, such classifications are subject to local interpretations, so due diligence with the local jurisdiction is very important.

Pre-engineered metal buildings (PEMBs) may also be considered rather than conventional steel framing.

Insulated Metal Panel Walls

For speculative cold and build-to-suits, including the tenant improvements for Cold Ready buildings, further consideration of the design of IMP walls is required. IMPs may be installed directly to concrete walls, a condition known as liner panels. They may also be designed as free-standing partition walls.

Designing IMP interior walls is similar to designing with metal studs. Each IMP manufacturer publishes a set of span tables that can be followed to determine allowable wall heights based on thickness of the walls. Walls that exceed the published spans will require additional structural support, most commonly in the form of interior girts.

Interior walls can terminate at ceilings or connect to the roof via double column lines as previously discussed. They can also terminate at the underside of the deck. In this case, it is necessary to mitigate the thermal penetration of the roof deck and roof structure via a detail called a frost ribbon (see Image 4.1). It is important to have an experienced architect and contractor design and install the frost ribbon to prevent the development of ice. Companies such as Vapor Armour also specialize in designing and installing these critical details.

It is important to separate interior IMP walls from any interior stud walls. Thermal transfer through the studs can cause condensation that damages drywall and wall finishes.

It is also important to protect IMPs from forklifts. The forks can cause significant damage to the wall base, so protection by a concrete curb is recommended. Curbs can vary in height and depth, though 6 inches by 12 inches is recommended for speculative cold. Sloped tops and radiused bases, as well as finishing with caulk, ensure cleanability.

Build-to-suit designs may also take advantage of some of the specialty finishes for IMPs.

Slabs

While the basic composition of the multilevel freezer slab was covered in Chapter 3, a few more details need to be considered for build-to-suit projects.

Starting again from the top, the finish slab will incorporate insulation risers connecting the sub-slab insulation to the IMP walls. The vapor barrier will wrap up these risers to connect to the IMP wall via peel-and-seal or butyl.

The slip sheet protecting the sub-slab insulation from the concrete topping slab is typically 6 mil (a mil is equivalent to one-thousandth of an inch). The sub-slab insulation is typically XPS and will be rated for compressive strength. 40 psi is commonly used, though final requirements may be determined by a structural engineer. As with roof insulation, the sub-slab insulation should be installed in at least two staggered layers.

Vapor barriers incorporate two thicknesses, a 10 mil for the field and a 30 mil at locations where tearing is more likely, for example at columns and where wrapping meets the IMP walls. To create continuity, barriers are lapped and sealed with butyl or peel-and-seal.

Sub-slab insulation is required beneath freezers. It is also useful to continue the insulation through doorways in a condition called an insulation apron (see Figure 4.1). This detail prevents frost heave at doorways. Armor joints are used to tie the insulated and non-insulated slabs together.

At coolers and cold docks, this multi-layered slab system is not required. Thermal breaks through the slab are utilized to prevent thermal transfer through the slab from refrigerated to non-refrigerated areas, as that can lead to condensate puddles. Vapor barriers are generally omitted at coolers and cold

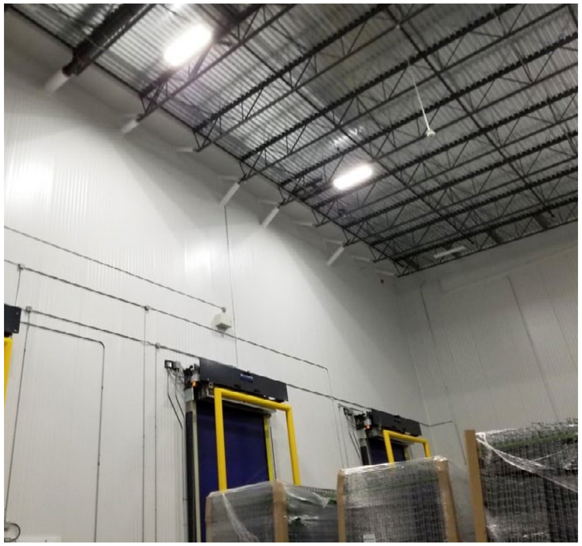


Image 4.1 A “frost ribbon” detail mitigates thermal transfer through roof structure.

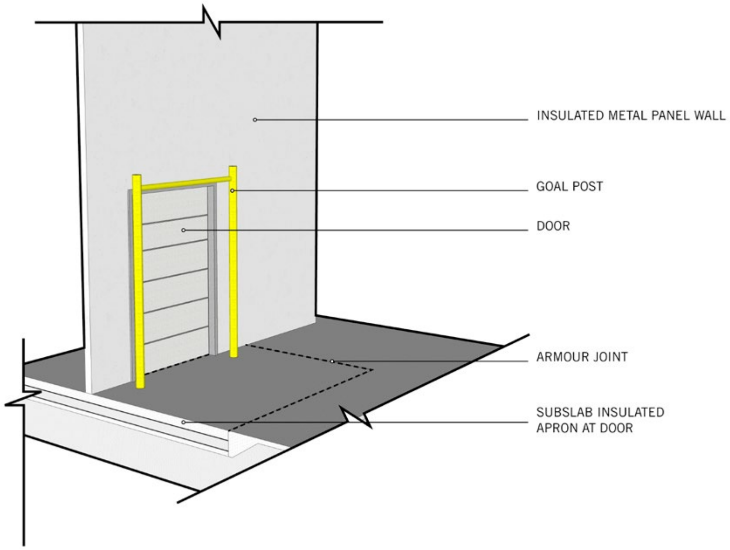


Figure 4.1 Insulation apron diagram.

docks to allow vapor trapped under the freezer an easier path to escape. However, it is important to keep vapor barriers under offices to prevent that same vapor drive from popping up floor finishes.

Slab design may also incorporate floor drains. For speculative cold, condensate drains for refrigeration systems are installed in proximity to the evaporators. For build-to-suit, drains may also be needed in warehouses where iced products are stored, or if the space is used for processing. Sloping the slabs at a quarter inch per foot allows drainage and may be required by health departments.

Slabs should be finished with products appropriate to cold temperatures. Caulking, if installed prior to temperature drawdown, should be checked and patched after the room is at temperature. Floor sealants are required for food safety. Epoxies may be desirable for processing rooms.

Ceilings

IMP ceilings consist of three parts:

- IMP ceiling panels
- Support tees that carry each end of the panel
- Rods that hang the support tees from the joists

Manufacturers provide span tables for ceilings as well. Span tables indicate the maximum span of the IMP ceiling panels based on IMP thickness, as well as the spacing of the support rods. To minimize rod spacing, it is common to run support tees along a joist. As joists are often 8 feet on center, a common arrangement is to have the support tees hanging from every other joist, with rods at 4 feet on center, and IMP ceiling panels spanning 16 feet (see Image 4.2). However, if the ceiling will be utilized as a crawl space for maintenance, maximum spans of 12 feet may be required.

In addition to determining span, IMP ceilings must also have appropriate thickness for the desired R-value as required by energy codes.

Ceilings should be detailed for thermal and vapor connections to walls. Column penetrations should be detailed to mitigate thermal transfer through the column.

For processing facilities, ceilings may be required to provide a washable surface for food safety.

Doors

There are many options for interior doors for cold buildings:

- Overhead doors:
  - » Sliding and bi-parting doors. The least expensive option for cold storage doors, sliding and bi-parting doors consist of a thick insulated panel on a wall-mounted track. These doors can be manual or motorized, but either way they are relatively slow to open, and they can easily damaged by impacts.

FCL Builders: Slab Design Construction Considerations

The construction of the slab in a cold building is always a main focus for the field team. The underfloor heating must be installed first. After the underfloor heat is installed, the mud slab is installed to protect the heating system and, in some circumstances, keep it in place. (Alternately, a sand layer may be used, or heating may be trenched in sub-grade, though mud slabs are more typical and provide better protection for the heating systems.) Depending on site conditions, the mud slab can be installed before or after the installation of the structure of the building. After the mud slab is installed, it creates a working surface for other trades that need to complete work before the floor insulation is installed. The floor insulation is laid over the mud slab, with the field team ensuring all joints in the insulation are tight and the insulation is level. The floor insulation cannot carry the weight of a concrete truck, so the floor slab may be poured using buggies or a concrete pump. This method is more labor-intensive than a traditional dry warehouse floor pour.

Image 4.2 A cold storage facility with an IMP ceiling.
Credit: Cole Group/Michael Cole

- High-speed roll-up (HSRU) doors. A popular option, these motorized insulated fabric doors are quick to open and easy to re-set if impacted.
- High-speed bi-part. Higher racking led to higher forklifts, and ultimately to higher doors. All the extra height slowed down the HSRUs, so a bi-part fabric door became a preferred option for particularly tall doors.
- Air doors/air vestibules. These allow clear openings between rooms, while an air curtain separates temperatures. These doors are quite expensive, have large footprints, and are often paired with sliding night doors.
- Strip curtains. While these plastic curtains can help maintain temperature between rooms while allowing access, they are also prone to mold, and are thus not recommended for new facilities.
- Overhead doors. These are typically installed on the warmer side of the wall to minimize the temperature requirements of their controls. They typically are protected with goalposts and/or bollards (see Image 4.3). As with all metals in cold spaces, it is important that these goal posts be corrosion-resistant, so galvanized metal is commonly utilized. They are also frequently painted safety yellow.

- Personnel doors:
  - Insulated fiberglass reinforced polymer (FRP) doors may be used between cold areas of similar temperatures.
  - Dual action, or bump doors, are useful where personnel are pushing carts or walkie jacks. These are common in food processing areas.

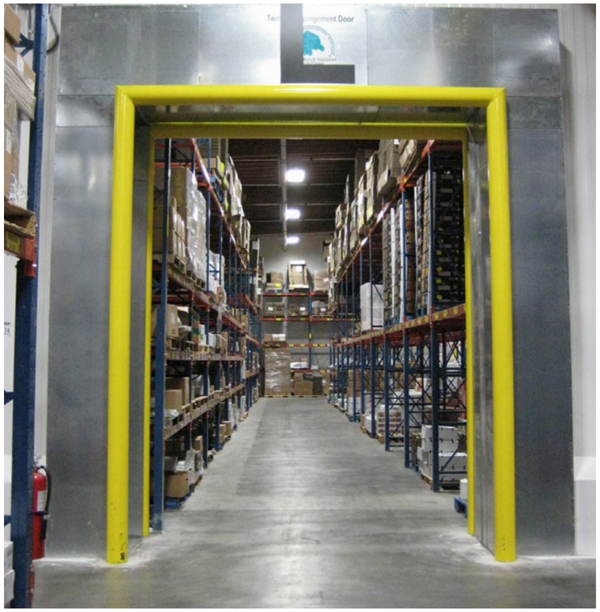


Image 4.3 Goal post example.

On the exterior side, it is possible to construct a cold dock with an IMP face. While it is not recommended for Cold Ready or speculative cold, it may be an option for a build-to-suit. Steel supports must be provided for the dock doors, and IMPs must wrap these supports to create continuity with the doors. Experienced architectural and structural engineers should be selected to closely coordinate on this type of design.

Windows in the cold spaces may also be desired for spec cold and build-to-suit designs, for example to allow a shipping office to overlook a cold dock. Windows are prone to fogging, so dual-pane, thermally broken, heated windows should be utilized at a minimum.

Dock Equipment

As previously discussed, continuous dock pits with vertical levelers are the preferred design for cold docks. The actual design of these pits requires close collaboration between architect, structural engineer and leveler manufacturer. The leveler itself is supported by a manufacturer-supplied channel embedded in the back face of the dock pit. The remainder of the pit should have edge angle or channel embeds. Stanchions are provided to support the dock controls. The pit should also have barriers to prevent forklifts and personnel from falling in. Some access should be provided into the pit to allow for cleaning, and folding steps can help with that.

Speculative cold would typically incorporate the vertical levelers, controls and dock bumpers. On the optional or build-to-suit side, various dock lights may be desired, including interior truck lights, as well as exterior stop-and-go lights. Truck restraints may also round out the dock package.

FCL Builders: Dock Equipment Construction Considerations

The recommended dock package includes vertical dock levers in a continuous pit. A continuous channel is installed at the back of the pit to help spread out the load that the vertical levers create when they are operated. Also, during the installation of the vertical levelers, the installer needs to be careful not to overheat the channel while welding. Overheating can warp the channel or damage the adjacent concrete floor. The operation of the levelers needs to be coordinated with overhead door limit switches that prevent the leveler from operating unless the door is completely open.

Refrigeration

Refrigeration for build-to-suit has many more options. Considerations for multitenant buildings include low-charge ammonia and large freon package units. A single user may utilize a central ammonia or CO² system.

Care should be taken when installing rooftop penthouses and low-charge units to allow continuity of thermal and vapor barriers from roof to penthouse/unit wall.

Installation of equipment supports and piping supports also requires care to preserve thermal and vapor continuity.

Where rooftop equipment is utilized, access to that equipment for maintenance should be considered. Ships ladders or stairways are preferable to vertical ladders. Parapets should have guardrails for fall protection, or roof tie-offs may be installed (once again with an eye to the thermal and vapor barriers). Davit cranes may also be desirable to hoist maintenance equipment and parts.

Sub-slab Heating Systems

Glycol sub-slab heating systems (utilizing waste heat from refrigeration) are recommended. Electric systems are not allowed by all jurisdictions (check local energy codes). Passive vent systems are also an option, but they can be challenging due to pest infiltration. They are also difficult to clean.

Glycol systems can come in flexible or rigid tube styles. The tubing is set in circuits and terminates at a manifold (see Image 4.4). Flexible tubes allow for smaller manifolds. It can be helpful to incorporate sensors into a glycol system to determine if a circuit has failed.

Fire Sprinklers

While ESFR and Quell systems were mentioned as part of Cold Ready design, low-oxygen systems are an option for build-to-suit cold storage. More widely adopted in Europe, these systems are still in the process of establishing regulations in the U.S., both per fire codes and through OSHA. Because they are only appropriate for rack-supported freezers over 80 feet, careful analysis is necessary prior to selecting this type of system.

FCL Builders: Refrigeration Construction Considerations

The refrigeration is the most critical element of a cold building for both design and scheduling. With an ammonia system, the installation usually starts in the engine room, where the compressor and condensers will be installed. The piping is installed from the engine room to the evaporator locations throughout the building. Inspections of all pipe welds must be performed during the installation process to ensure there are no leaks before the system is filled with refrigerant. A safety meeting is held before the system is filled to inform all those on-site about the procedures if the odor of ammonia is detected. The temperature needs to be drawn down slowly, because shrinkage could damage the joints on the insulated panels or the floor slab. After the building has been below freezing for several days, the floor joints are caulked to avoid insect/rodent infiltration, as well as to provide protection from the wheels of the forklift. Ammonia systems require a higher level of operation due to the danger involved at certain amounts and concentrations.

If low-charge ammonia, freon or carbon dioxide systems are being used, they may affect the sequencing of the construction of the building. Due to the weight of these systems, it may not be possible to crane the units into position from outside the building footprint, and sections of the roof may need to be left out to install the units.

Image 4.4 Glycol manifolds.

Electrical, HVAC and Plumbing

While some of the requirements have been touched on in the previous chapter, there are some additional notes on MEP (mechanical, electrical and plumbing) design for build-to-suit.

It is recommended to provide a separate battery-charging room. While battery charging can be achieved on the cold dock, it does typically require ventilation. It is not desirable to ventilate a refrigerated space; it is better to do that in a separate room where possible.

Humidity control systems may also be desired by certain users. While refrigeration systems tend to dehumidify, they may need to be balanced with additional systems to maintain a specific humidity range.

Racking and Material Handling

In addition to ASRS, there is an ever-growing number of options for racking and material-handling systems. A few additional popular options include:

- Very narrow aisle (VNA) racking systems increase pallet positions with special material-handling equipment that can utilize narrow guided aisles.
- Push-back racking is a first-in first-out arrangement where pallets are pushed back onto a rack that is three, four or more pallets deep.
- Mobile rack systems increase pallet count by reducing aisles, with racks moving on a track system to open up an aisle.

Regardless of the racking system used, it is important to keep racks off the walls to allow for pest control.

It is not uncommon for spacing of structural columns to be dictated by racking systems. If this is desirable, it is important for the racking designer to be involved at the beginning of the design process.

FCL Builders: Racking and Material-Handling Equipment (MHE) Construction Considerations

Racking and MHE is usually one of the last tasks on the construction schedule. The racking and MHE installers need to take every precaution to not damage the floor slab during rack installation. If the floor slab is heavily reinforced, the rebar pattern may need to be coordinated with the bolt pattern for the racking to avoid conflicts or spalling of the concrete slab during rack installation.

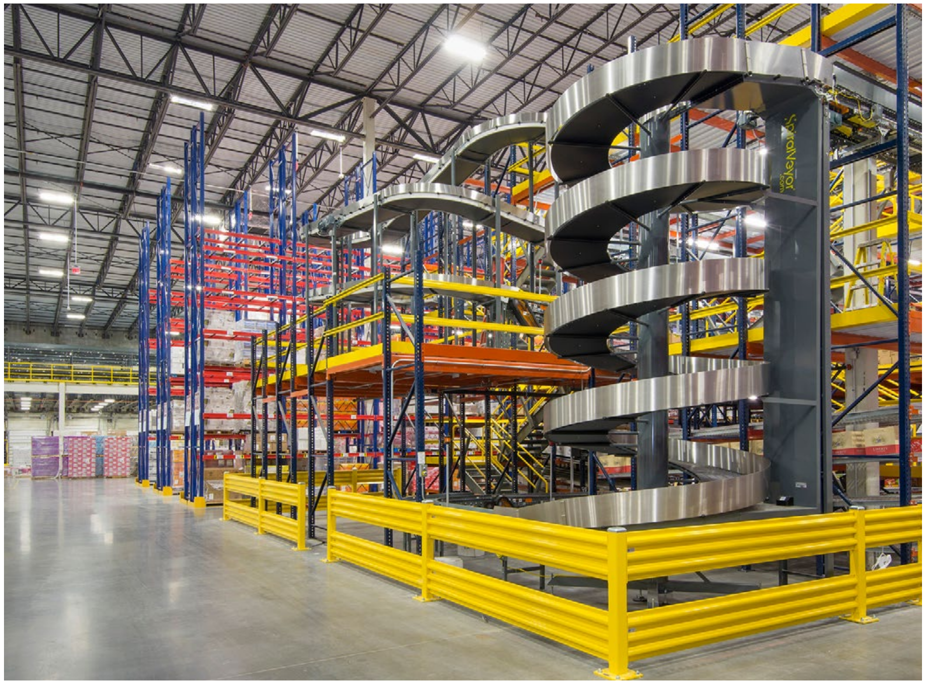


Image 4.5 An example of cold warehouse distribution racking.
Credit: Joel Howe

A Final Word: Food Safety

When designing a facility that will be handling food, knowing safety standards and requirements is essential. Food safety is an especially complex matter and is regulated by federal, state and local agencies (see Table 4.1). Utilizing architects, engineers and contractors with experience in food-safe design can help navigate these requirements.

Most food safety codes are centered around the basic concept of maintaining facility cleanliness. Design choices should be made with an eye to making things easy to clean, with smooth surfaces, radiused corners, and no difficult nooks and crannies. Effort should be made to prevent entry of pests, and to designate areas where pest control companies can set traps. Some areas may need to be regularly washed down, so the building should be designed with materials and fixtures that can stand up to hot water and wash chemicals.

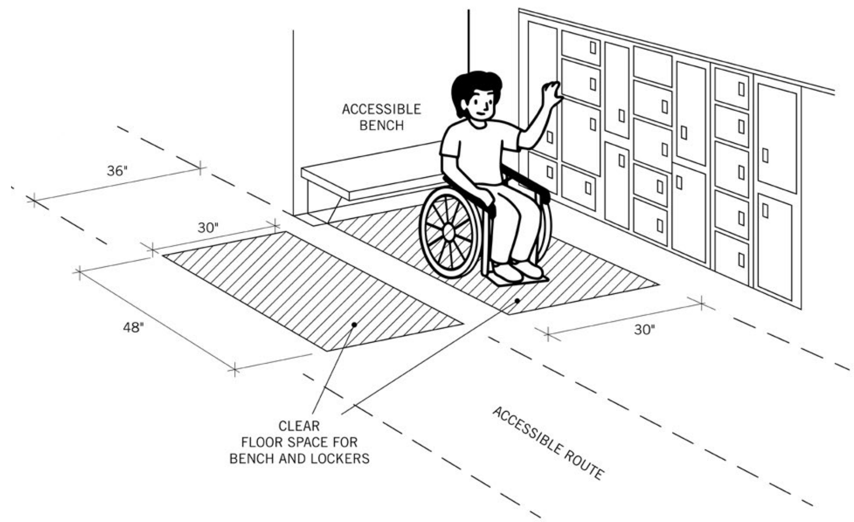
An essential consideration is the cold chain — maintaining food at safe temperatures as it moves from space to space. Refrigeration systems should ideally be incorporated into every space food moves through, including circulation corridors. Alternatively, refrigerated rooms may be arranged to allow a clear path for food to move between rooms.

FOOD SAFETY REGULATORY AGENCIES	
Federal Regulations	U.S. Department of Agriculture (USDA)
	Food and Drug Administration (FDA)
	The Centers for Disease Control (CDC)
State & Local Regulations	Each State's Food Code
	Each State's Health Department
	County, District or Regional Health Departments
Private Sector Regulations	Accreditors
	Third Party Certification a.k.a. Auditors
	Standards
	Industry Groups

Table 4.1 Food Safety Regulatory Agencies

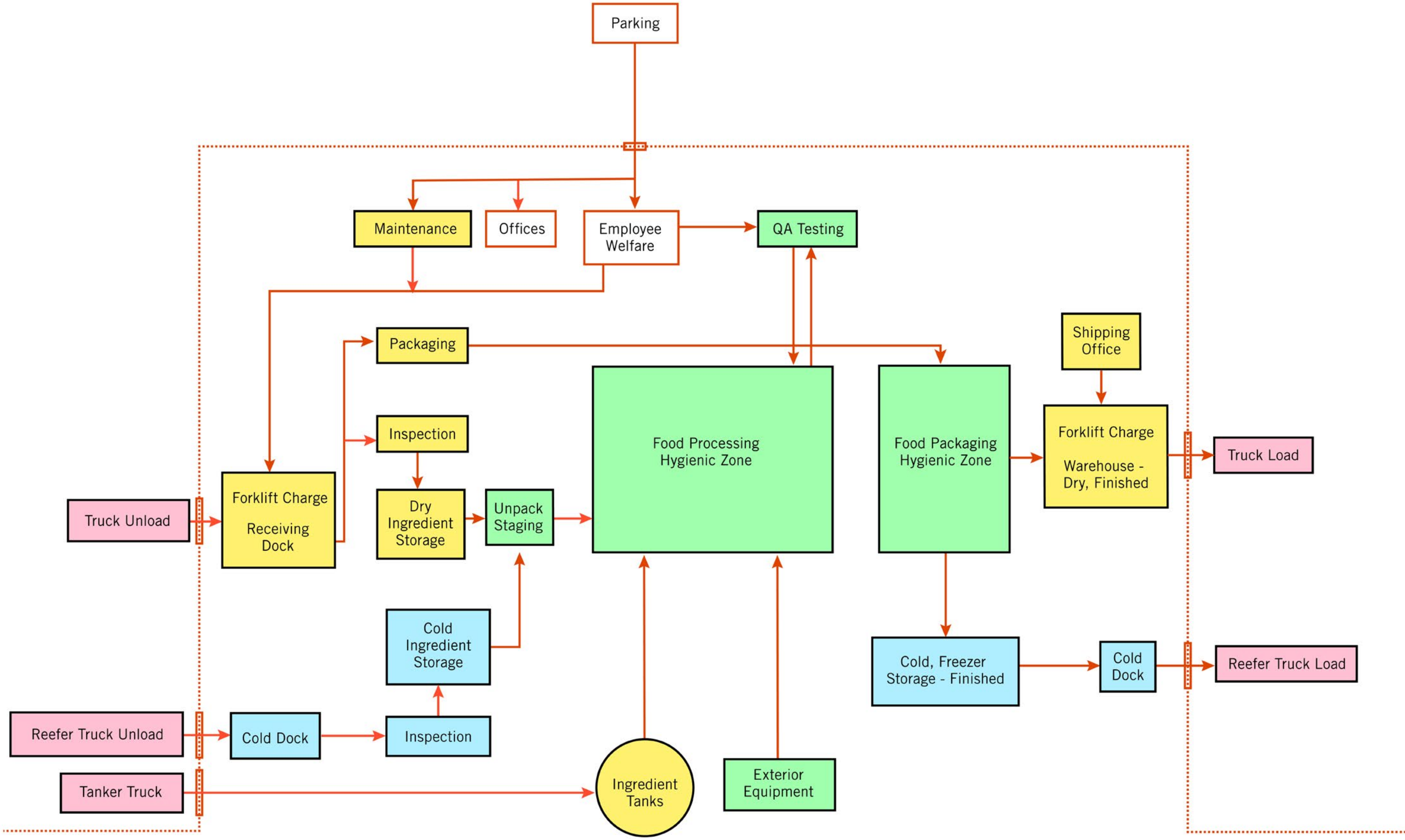
Another key concept is HACCP – Hazard Analysis and Critical Control Points. A HACCP plan examines how both product and personnel move through a facility and identifies risks to food safety. A building designed with an understanding of HACCP principles can improve food safety by incorporating hand-washing sinks in important locations, by preventing motion of employees between rooms that might lead to cross-contamination, and more.

Food facilities may incorporate specialty support spaces. For example, U.S. Department of Agriculture (USDA) facilities may have USDA offices and labs. Additionally, quality-assurance labs can allow for product testing. ADA-compliant locker rooms (see Figure 4.2) allow personnel to put on appropriate clothing and personal protective equipment, as well as storing personal items that may carry contaminants.



ACCESSIBLE LOCKERS

Figure 4.2 A diagram of an ADA-compliant locker room.



Food facility flow diagram.

Retrofits and Additions for Cold Facilities

Traditionally, large-scale manufacturing and processing facilities are built to suit because they have so many custom requirements that a retrofit of an existing building is often cost-prohibitive and does not result in an efficient operation.

Retrofits of existing cold buildings to accommodate a new user do occur; they vary in scope and in cost per the project requirements. A primary consideration when conducting a retrofit is the condition of and capacity of the existing utility infrastructure. If the existing capacity of utilities is not sufficient for the proposed new use, the project will likely not be feasible within the subject building.

Building additions and expansions are also quite commonplace with cold buildings. Many cold buildings are designed with expansion in mind, assuming land is available. In these cases, expansion is more easily executed from a planning perspective. The critical piece of an expansion project is typically keeping the existing building in operation during construction. Cold buildings are often food- or pharmaceutical-grade buildings and have cleanliness and security requirements that need to be maintained for continuous operation. Working with experienced architecture and contracting teams to determine project phasing and construction containment measures is key.

Conclusion

The advent of speculative cold storage and Cold Ready creates many new options for cold buildings. While there will always be some users looking for the specialty options available with build-to-suit, speculative options can fulfill many end user's needs.

Still, with any cold building, working with a qualified design team, as well as experienced contractors, can help avoid many potential pitfalls, from ice to indoor rain.

As cold storage facility development is a highly specialized and complex property type, this e-book provides guidance on only some of the many aspects of its development. The rise of online sales for temperature-sensitive items such as food and pharmaceuticals as well as the need for last-mile delivery options will attract new players to the cold storage game and has poised the industry for unprecedented growth. Increased automation and technological advances in new and existing warehouses will continue to drive innovation, efficiencies and best practices. Cold storage is an essential part of the global supply chain and presents increasing opportunities for those ready to take on its challenges.

APPENDIX

Glossary

Automated Storage and Retrieval System (ASRS): A computer-controlled system for automatically placing and retrieving loads from defined storage locations. It provides dense inventory storage to maximize floor space.

Cold Building: A general term for buildings incorporating refrigeration systems – includes cold storage and cold processing/manufacturing buildings.

Cold Chain: The Global Cold Chain Alliance defines cold chain as "managing the temperature of perishable products in order to maintain quality and safety from the point of origin through the distribution chain to the final consumer."

Cold Ready: Ware Malcomb's prototype design for a speculative cold building shell.

Compressors: A component of a refrigeration system that is typically found in a refrigeration room. Also known as "screws" or screw compressors.

Condenser: A component of a refrigeration system that is placed on the building exterior.

Demising Wall: A specially constructed wall or partition that separates two different uses or occupancies. In cold buildings, a demising wall may separate rooms of differing temperatures.

Dry Storage: Non-refrigerated warehouse space. May be ambient or conditioned.

Evaporators: Also known as "evaps," "blowers" or "coils," evaporators are a component of the refrigeration system installed inside of a refrigerated room. They can be hung from the roof structure or placed above the roofline in penthouses.

Global Warming Potential (GWP): A measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide.

Good Manufacturing Practices (GMP): The practices required to conform to the guidelines recommended by agencies that control the authorization and licensing of the manufacture and sale of food and beverages, cosmetics, pharmaceutical products, dietary supplements and medical devices.

Insulated Metal Panel (IMP): A panel consisting of an insulated core sandwiched between metal siding. IMPs are a common building material for cold construction.

Micro-fulfillment: The strategy of placing small-scale warehouse facilities in densely populated urban locations closer to the consumer for faster delivery times.

Penthouse Refrigeration: Refrigeration evaporators may be placed above the roofline in "penthouse" structures, which makes them easier to access for maintenance. These structures are open to the room below.

Public Refrigerated Warehouse: Cold storage warehouses available for hire on a third-party basis.

Reefer Truck: A truck with a refrigerated trailer.

Ships Ladder: A ships ladder is a steep stairway with a slope between 50 and 70 degrees from the horizontal.

SKU: Stock Keeping Unit, a unique code assigned to a product by a retail store for inventory tracking.

Specialized Rack-Supported Buildings: A facility in which a complete independent storage rack system provides structural support for a building's roof and walls.

Variable Frequency Drive Motors: VFD motors control compressors, evaporator and condenser fans, and pumps. Variable frequency drives make it possible to quickly provide the necessary cooling or heating to maintain a uniform temperature, humidity, air-circulation or fresh air requirements in cold storage while keeping energy consumption to a minimum.

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