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An Integrated Approach to Cold Store Loading Bay Design

The design of a cold store has a significant impact on its operational efficiency and operating costs. High speed door technology combined with anteroom and efficient loading bay equipment introduce potential for improvements in productivity, energy efficiency and maintenance.

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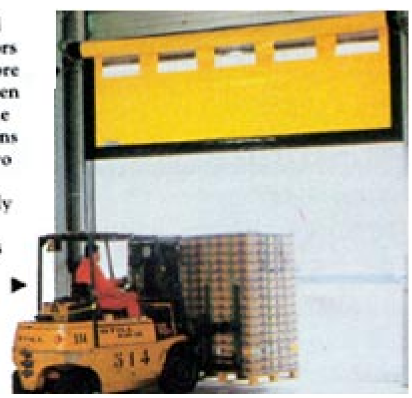
Loading bay seals or dock shelters create a barrier that helps to keep warm air and humidity from entering the cold store area.

High speed folding doors for cold store areas shorten the time the door remains open by two thirds, significantly reducing energy loss and frost build-up. ►



Many cold stores face serious problems with high energy consumption, ice buildup around doorways, frost and wet floors. These problems are symptoms of poor efficiency. They are largely caused by excessive amounts of outside warm air entering the facility at the loading bay connected with the cold store. Through careful planning of the loading bay, problems related to moisture and frost can be reduced 80-90 percent, and energy consumption can be cut in half. Productivity can be improved.

The infiltration problem at cold stores and the associated energy loss is a widely acknowledge fact. Infiltration air brings is not only heat, but also moisture in the form of humidity. This moisture leads to the frost and ice problems. A typical situation of an open freezer doorway is shown in **Figure 1**. Warm air enters and rises. Cold air, which is heavier than warm air, moves down and flows out the door, and on the floor. This ice has to be chipped out periodically. In addition, the ice on the floor presents a slipping or skidding hazard for workers and forklifts. Keeping the hot land cold air from mixing is the biggest challenge facing the plant manager.

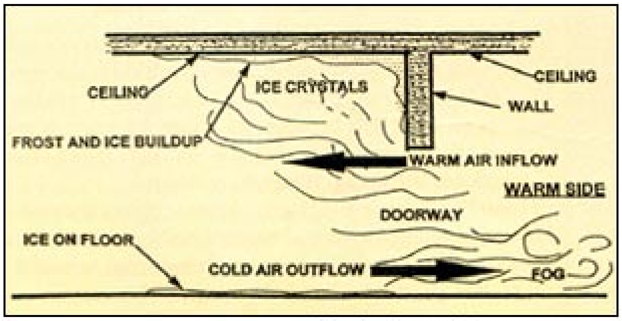


Figure 1 : An integrated loading bay solution

An integrated approach to design looks at each key areas of warm air and humidity infiltration, then applies modern solutions to create a more efficient and cost effective cold storage loading bay. This design approach involves three key areas and fours solutions.

- **Key area # 1.**

Location: Truck at the loading bay

Solution: (a) Seal the back of the truck to the building so the truck can be loaded and unloaded without interference from outside elements.

(b) Reduce the time needed to unload the truck, thereby reducing the time the facility is exposed to outside air and humidity.

- **Key area # 2.**

Location: Between the loading bay and cold storage

Solution: Providing an anteroom between the anteroom and the cold room to minimize air exchange when forklift traffic moves through.

- **Key area # 3.**

Location: The doorway into cold storage

Solution: Install a high speed door system between the anteroom and the cold room to minimize air exchange when forklift traffic moves through.

Figure 2 shows a cold store loading bay as suggested by ASHRAE (the American Society of Heating, Refrigerating and Air-Conditioning Engineers), and as they are designed and built today. The design provides efficiency and productivity.

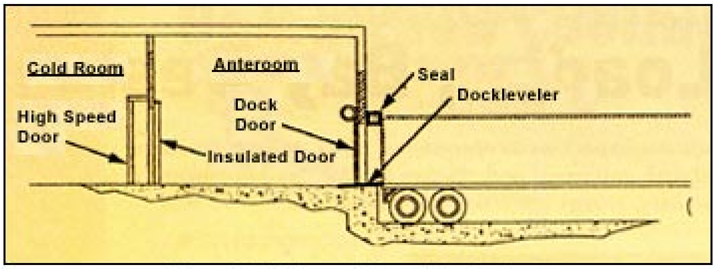


Figure 2 : Modern refrigerated loading bays

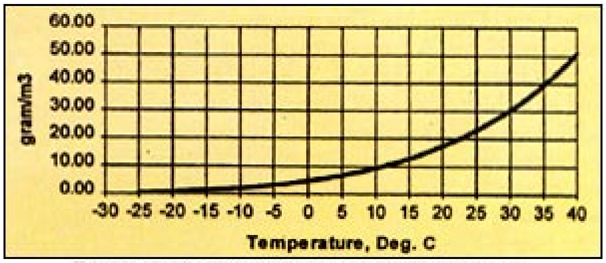


Figure 3 : Moisture in air at 100% relative humidity

Improving existing facilities

Many older warehouses have an open loading platform instead of the afternoon, and forklift traffic moves from the outside platform directly into the cold chambers. These warehouses experience high rates of air exchange into the cold rooms with extreme refrigeration losses. Changes can be made at each of the key areas to reduce total lair infiltration and improve efficiencies.

At the loading bay key areas, the truck outsides the building should back up to a flexible seal or dock shelter that is fitted around the loading bay door. This creates an effective barrier, protecting the building's interior not only from heat and humidity, but also form dust and insects during loading. The seal or dock shelter is mounted on the exterior building wall, and designed to be flexible and adaptable to today's wide variety of trucks.

Also at the loading bay, a dock leveler is used to bridge the gap between the truck and the building. By providing a ramp, forklifts can drive into and out of the trucks with full pallet loads, moving goods quickly between the trucks with full pallet loads, moving goods quickly between the truck and the freezer while remaining inside the building. The dock leveler helps energy efficiency by reducing loading and unloading time, thus reducing the time the warehouse is open to warm outside air leaking in. The loading bay door should be kept closed when there is no truck at the loading bay.

An anteroom is then used to separate the cold room from the loading bay.

Providing this intermediate area brings the temperature down in two steps, and provides an air lock.

In addition, a door system, using both a high speed door and an insulated door. Effectively separates the anteroom from the cold room. The insulated door remains open during warehouse operating hours, allowing the high speed door to control the air exchange.

Controlling air exchange

High speed doors are constructed of light weight, flexible materials for durability. They have minimal insulation properties, but since air exchange is the dominant mode of refrigeration loss, the door's speed becomes more important in controlling refrigeration loss than its insulating properties.

The air exchange occurring through a doorway depends on the temperature difference and the size of the door, and is proportional to how long the door is open. A truck of the size equivalent to a 40 foot container normally holds about 20 pallet loads. For every truck being loaded, a forklift will travel through the doorway to the cold room 40 times - twice for every pallet load because of the empty return trip. A traditional slow-moving insulated door will be open for about 30 seconds to allow the forklift through. This adds to 600 seconds to load one truck. A modern high speed door will be open for about 10 seconds per passage, or 200 seconds per truck. A high speed door thus reduces the air exchange to one third.

Humidity, which turns into frost and ice, increases defrosting requirements and exacerbates the air exchange problem. **Figure 3** shows how much moisture is held in air at 100 percent relative humidity. The amount of moisture increases exponentially with the temperature. Nearly all of the moisture contained in the air that flows into a freezer will condense and freeze to ice because air can hold very little moisture at temperatures below freezing. At - 10°C, air can hold only about 2g/m^3.

The problem with air exchange is summarized in **Figure 4**. The results shown in the table are based on an outside temperature of 30°C, a relative humidity of 80 percent, and a freezer temperature of -10°C. It assumes a 2.4m x 3.0m door into the freezer, and pallet loads per truck being loaded or unloaded. Without an anteroom, the temperature difference across the cold room door becomes 40°C, which is the difference between the outside temperature and the cold room temperature. When the anteroom is included, it is assumed to be kept at the mid pint, i.e. 10°C, which makes the temperature difference across the cold room door 20°C.

The table is based on a theoretical calculation involving only air exchange caused by the temperature difference. If effects caused by wind and other pressure differences are included, then the improvements become even more dramatic.

Two keys results stand out from the table:

- The anteroom in combination with a speed door to the freezer reduces the air infiltration to the freezer from 2,900 to 700 cubic meters per truck load of cargo moved, a 76 percent reduction. With a 40°C, which is the difference between the outside temperature and the cold room temperature. When the anteroom is included, it is assumed to be kept at the mid point, i.e. 10°C, which makes the temperature difference across the cold room door 20°C.
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Two key results stand out from the table:

• The anteroom in combination with a speeds door to the freezer reduces the air infiltration to the freezer from 2,900 to 700 cubic meters per truck load of cargo moved, a 76 percent reduction. With a 40°C temperature difference between the outdoors and the freezer, this will translate to 32kWh of refrigeration saving for each truck load of cargo moved. If the facility loads 5 trucks a day, this turns into about 40,000kWh a year. This represents a drastic saving in energy cost.

• The anteroom in combination with a high speeds door to the freezer reduces the humidity infiltration from 70.6 kg per truck load of cargo to 5.6 kg, a 92 percent reduction. This leads to much less defrosting and much less work required to chip ice around the doorway, so maintenance costs will be lower. It also leads to better management of the freezer environment.

Design decision

Ideally, anterooms and high speed doors should be included in the original design of the cold room, but they can also be retrofitted, as can dock levelers and seals. In a situation where the cold store is served by an open loading bay platform, the platform can be enclosed with insulation panel to provide an anteroom. If a cold store has an anteroom but no high speed door, the high speed door can simply be added.

Figure 4 can help evaluate the improvements that can be expected. For instance, if a high speed door is added to a cold store without an anteroom, air infilteration will decrease from 70.6 to 23.5. The numbers in the table can be used to gauge improvement in typical situations.

Figure 4: Illustrating the problem with air exchange

Operating Details	Temperature Difference	
	No Anteroom 40°C	Anteroom 20°C
Air Exchange when door is open, m3 per sec	4.9	3.5
Door open time, seconds per truck load, low Speed door	600	600
Door open time, seconds per truck load, high Speed door	200	200
Total air exchange, m3 per truck load, low speed Door	2,940	2,100
Total air exchange, m 3 per truck load, low speed Door	980	700
Temperature outside cold room door, °C	30°C	10°C
Humidity outside cold room door, gram per m3	24	8
Total humidity infiltration, kg per truck load, low Speed door	70.6	16.8
Total humidity infiltration, kg per truck load, high	23.5	5.5