Douglas McKnight

A Practical Guide to Evaluating the Functional Utility of Warehouses

Many appraisers fail to address some forms of functional obsolescence in warehouse space. Details on interior and exterior layout, dock design, and safety and security issues play an important role in the highest and best use and functional utility of a warehouse. The author describes in clear and helpful detail the practical considerations of good warehouse design, including modes of delivery and scheduling. He cautions against the oversimplied process of considering only clear heights in the appraisal of such properties.

Most industrial properties are either warehouses or contain warehouse space, and most appraisers explicitly and routinely consider only clear heights when they consider the functional utility of warehouses. In fact, many other factors are involved in appraising warehouse space, which also plays an important role in other types of property.

One important consideration is whether the purpose of the appraisal is to estimate use value or market value. If the appraisal is to be used to allocate the purchase price in a merger or acquisition, use value is usually more appropriate; appraisals to be used for financing or tax appeals are typically based on market value. In a use value appraisal, the functional utility of the property for a particular use (i.e., warehousing a particular product) should be considered. In a market value appraisal, the appeal of the property to the general market is the standard. A use value appraisal requires the appraiser to meet with the warehouse manager to determine how well the warehouse serves his particular needs. A market value appraisal requires the appraiser to understand the kinds of warehouse features desirable to the general market. Some of the more common warehouse features are presented here.

INTERIOR LAYOUT

The interior space of a warehouse can be divided into the receiving, storage, and shipping areas. A good layout is essential to the operation of a warehouse.[1] Floors typically consist of a reinforced concrete slab on a compacted fill. If this is not practical, a structural floor is used in which reinforced concrete is supported by column footers. Dock-height

1. James A. Tompkins and Jerry D. Smith, *The Warehouse Management Handbook* (New York, New York: McGraw-Hill, 1988), 108.

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floors are generally preferred to on-grade floors, although on-grade floors can serve well for warehousing large objects in buildings equipped with overhead cranes. Ideally, the static load capacity should be sufficient to support stacks of merchandise with a safety factor of 1.95–2.00, which usually requires a floor thickness of 5–8 inches.[2] Thicker floors may represent a superadequacy.

The amount of storage space required within a warehouse depends on the storage philosophy of the occupant, aisle allowances, and the amount of honeycombing expected. There are three different warehouse storage philosophies: fixed-location, random-location, and mixed-location. In a fixed-location storage system, each stock-keeping unit is assigned to a particular location; no other stock-keeping unit may be assigned to that location. In a random-location system, any stock-keeping unit may be assigned to any available location. A mixed-location system is a combination of the two.

Honeycombing is the loss of storage space due to inefficiencies in the use of available storage area. It results when a storage space is only partially filled, either horizontally or vertically, with commodities. Although warehouse managers try to minimize honeycombing, some degree of it is necessary to avoid handling loads twice, material damage, and lost productivity.

In warehouse design, the *clear height* is the dimension from the floor to the bottom of any device hanging from the ceiling.[3] This includes the clearance under ceiling joists, overhead lighting, and legal clearances under sprinkler heads (generally 18 inches). The optimum clear height for an operation depends on the product and the storage equipment used. Generally, a clear height of 28 ½ feet is ideal. Clear heights less than 20 feet represent significant functional obsolescence, and those less than 15 feet represent severe obsolescence.

The ideal bay size for a general purpose warehouse is 33 feet × 51 feet.[4] However, because of the standard sizes of structural members, few warehouses are constructed with bays this size. The most economical bay sizes generally found are 25 feet × 50 feet or 30 feet × 30 feet.[5] It is generally desirable to align the longer bay perpendicular to the truck docks to allow a column-free cross traffic aisle behind the docks. Heavy-wall round or square tubular columns are superior to H-columns because they eliminate vermin nesting places, ensure easy maintenance, and minimize the effect of denting on column strength.

Curtain walls are typical in warehouses and superior to load-bearing walls. Load-bearing walls limit opportunities for building expansion and modification.

EXTERIOR LAYOUT

A warehouse site should be designed to allow efficient ingress and egress of tractor-trailers and possibly rail cars. Warehouses are often designed without adequate consideration of the needs of truck drivers in maneuvering their vehicles. Access roads should be designed so that trucks can drive in without having to back in. Ideally, one-way service roads should have a minimum width of 12 feet, and two-way roads should be at least 26 feet wide.

The orientation of the warehouse on the site is an important consideration. In cold or moderate climates in the northern hemisphere, shipping docks facing north will incur greater heat loss than docks facing in other directions. The minimum heat loss will come from docks facing south, and docks facing east or west are preferable to those facing north.

Another important consideration is the provision for expansion. The volume of commodities moving through a warehouse, the inventory turnover, and the type of goods are likely to change over the useful life of the facility. It is quite likely that the current user or a subsequent user will require additional interior space at some point in the future. For these reasons, it is desirable to have a provision for future expansion included on the site drawings for a facility.

The truck apron and turnout track play an important role in the receiving and shipping areas (see figure 1). The apron is the area directly in front of the truck doors on which the trucks park. The turnout track is the area directly in front of the apron, which the trucks use to maneuver into and out of the

2. Ibid., 140.
3. Ibid., 144.
4. Ibid., 146.
5. Kenneth B. Ackerman, *The Practical Handbook of Warehousing* (Washington, D.C.: The Traffic Service Corporation, 1986), 154.

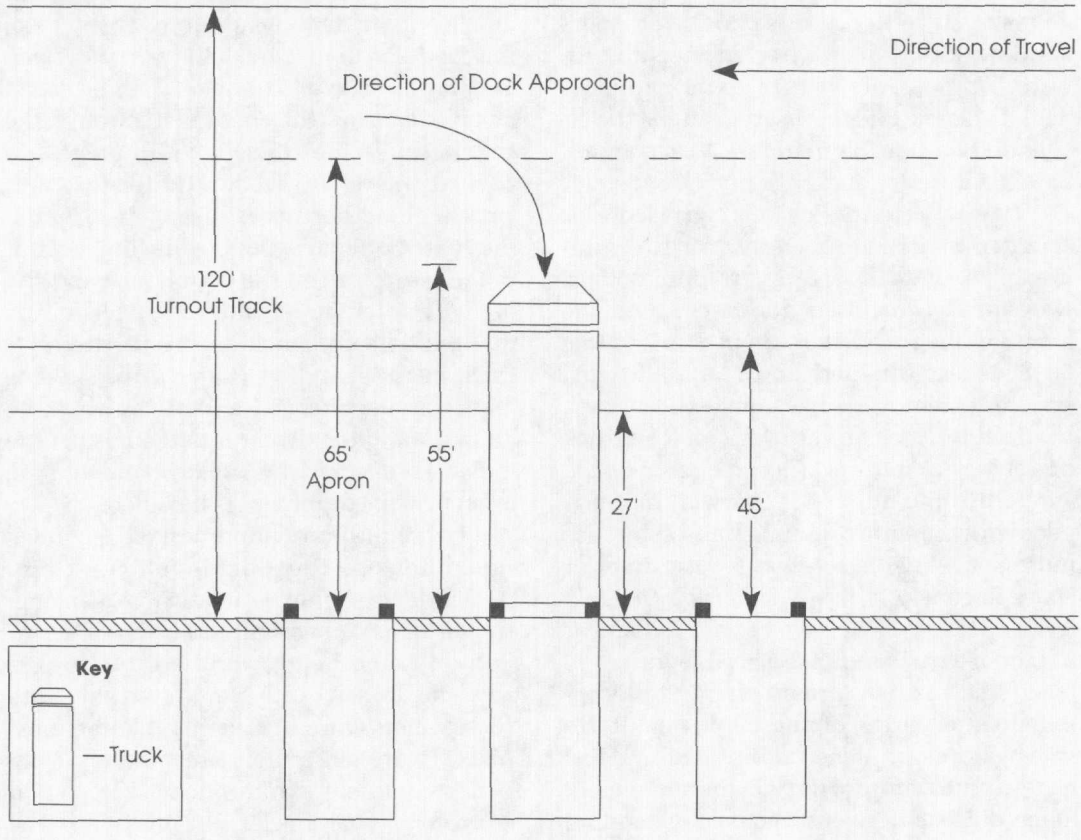
apron. In order for a facility to accommodate a typical 55-foot tractor trailer, the apron should be 65 feet, and the combination of the apron and the turnout track should be 120 feet.[6] To accommodate a 63-foot tractor-trailer combination, the longest permitted by law, an apron and turnout track should be at least 126 feet. If the apron is asphalt, it should have a concrete landing, or dolly, strip, extending 27–45 feet from the loading dock to provide support when trailers are dropped.[7] Another consideration in turnout track design is the dock approach. A truck driver backing into a dock in a clockwise direction, using a lefthand approach, is able to see the rear of the truck clearly as it turns into the dock berth. Drivers backing in using a righthand approach must rely on rearview mirrors to guide their approach to the dock. For this reason, a dock that requires a righthand approach should have a turnout track approximately 20 feet greater than that required for a lefthand approach.

DOCK DESIGN

The loading dock has a very significant effect on the profitability of a warehouse. The current trend is to outsource trucking to for-hire companies. As a result, a greater variety of trucks must be serviced by the docks, requiring some flexibility in dock design.

The first considerations in dock design are location and quantity. Generally, older industrial buildings have a centralized docking system with only one dock area, reducing supervision costs and efficiently using material-handling people and equipment. In a manufacturing facility of more than 50,000 square feet, however, the continuity of materials flow is improved if the receiving dock is located at one end of the building, with the shipping dock at the other end. In the mid- to late 1980s, point-of-use docks became popular for just-in-time manufacturing. Several docks would be located around the plant perimeter, each designed to serve a particular production line

FIGURE 1 Truck Apron Design



Illustrations for figures 1–4 by Karen E. Douglas.

6. Tompkins, 158.
7. Ibid., 223.

An inadequate number of dock positions can substantially raise the cost of warehouse operations.

or operating area.[8] Because this system is designed to serve one particular manufacturing process, it is a source of obsolescence in a market value appraisal. Further, few manufacturers have been able to achieve true just-in-time operations, so point-of-use docks often represent obsolescence in a use value appraisal.

An inadequate number of dock positions can substantially raise the cost of warehouse operations. If trucks from a for-hire company are required to sit in the warehouse yard or at the dock for an extended period of time, the company is likely to charge a demurrage for the time spent waiting. If trucks drop their load in the yard, the warehouse occupant has to maintain a tractor and a driver at substantial cost to move the trailers. The number of dock positions required depends on the volume of shipments, the mode of transportation, how many carriers are used, and the time it takes to load or unload a truck. Warehouse managers rely on operations simulation software and advice from dock equipment manufacturers to calculate the number of docks they need. In addition to the number of docks currently used, it is advantageous to have knock-out panels for doors and knock-out pits for docklevelers to provide for possible future expansion. (A dockleveler is a device used to adjust the elevation of a portion of a dock to accommodate the differing heights of truck beds.)

There are four basic kinds of truck docks: enclosed, staggered, open, and flush (see figure 2). Flush docks are preferred in modern warehouses. Enclosed docks can limit the length of the trucks that can use them, must be heated and lighted, and require exhaust systems to remove fumes from truck engines. In addition, it can be very difficult for a truck driver to back into an enclosed dock in bright sunlight if the interior is not well lit. Staggered docks require a smaller apron but use more space inside the warehouse. Interior space is generally more expensive than exterior space. A 45-degree staggered dock for a standard truck requires a berth width of 56 feet versus 12 feet for a flush dock. Skimping on the width of the berth results in sprung doors, scratched equipment, and lost time due to more difficult maneuvering. Open docks have a concrete slab extending beyond the truck doors. When trucks are being loaded and unloaded, they invite theft and permit cold air to enter the warehouse, thus raising energy costs. The open dock is the least desirable type.

Dock width and height are other important considerations. A dock door measuring 9 feet × 9 feet will accommodate most standard trucks. A smaller door will block access to a portion of the load, while a larger door will leave gaps, allowing heat to escape. Dock seals are desirable for preventing heat loss, sheltering lift trucks from inclement weather and enhancing security. Dock floors should be 50 inches-52 inches from ground to floor level in a standard warehouse and 54–60 inches in a refrigerated warehouse. However, additional utility can be gained if a dock is equipped to handle low trailers. These trailers are designed to carry a larger load and have floors as low as 30 inches from the ground. Portable ramps or trailer lifts can be designed to accommodate these trucks.

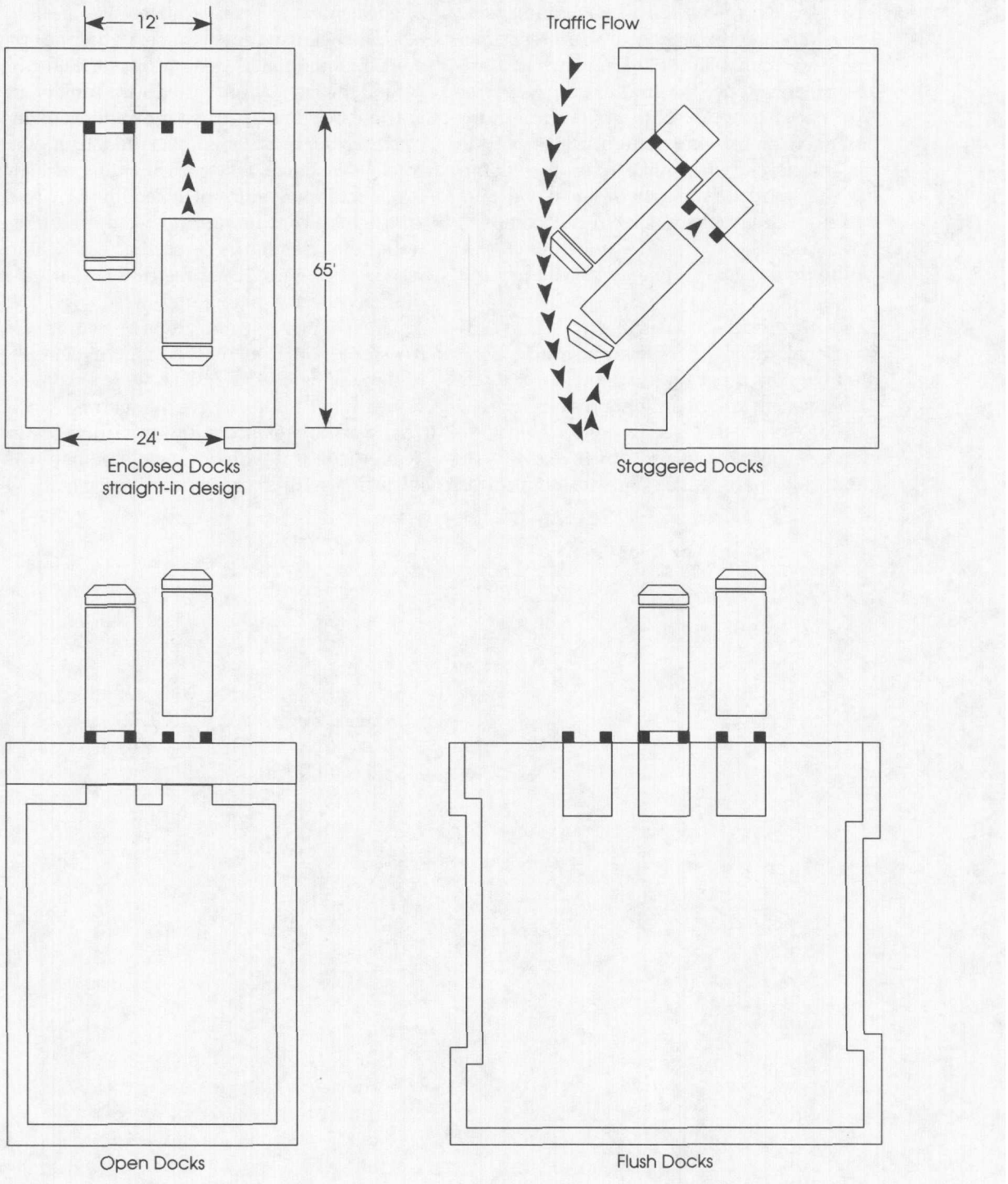
DOCK EQUIPMENT

Dock attendants cross over the dangerous gap between the truck and the dock 25,000–50,000 times per year. Four of the most common dock accidents result from trailer creep, unscheduled departure, reluctant passenger, and landing gear collapse. Trailer creep means that a lift truck has fallen through the gap because the lift truck's impact on a parked trailer inched the trailer forward. Unscheduled departure means that the delivery truck departed while the lift truck sat in the gap between the warehouse and the delivery truck. Reluctant passenger means that the delivery truck departed with a lift truck inside. Landing gear collapse means that the trailer pitched forward, throwing the lift truck and the driver into the nose of the trailer. These accidents can be avoided if the proper dock equipment is installed.

The single, most important piece of dock equipment is the dockleveler system. Docklevelers should be at least five feet long. Longer ones can accommodate a wider variety of truck heights and have a longer physical life. At one time, six-foot-wide docklevelers were sufficient to handle most loads. However, trailers are now typically loaded completely from side to side, so that seven-foot-wide levelers are installed. The corners of these levelers are tapered at the truck end to accommodate imprecise trailer spotting, allowing for a gap through which

8. Ibid., 213.

Figure 2 Four Basic Truck Docks



lift trucks can drop off the leveler. The most desirable levelers in a modern warehouse are 6½ feet wide.[9]

Other considerations are truck restraints. The Occupational Safety and Health Administration requires the use of wheel chocks to prevent trailer creep. However, drivers sometimes fail to use these, and the chocks may slide in icy or wet conditions. More complete solutions include ICC-bar restraints, automatic wheel chocking, and wheel locking barriers. ICC-bar vehicle restraints restrain the truck by hooking onto the ICC-bar hanging down from the rear of the truck. They are very

9. Ibid, 230.

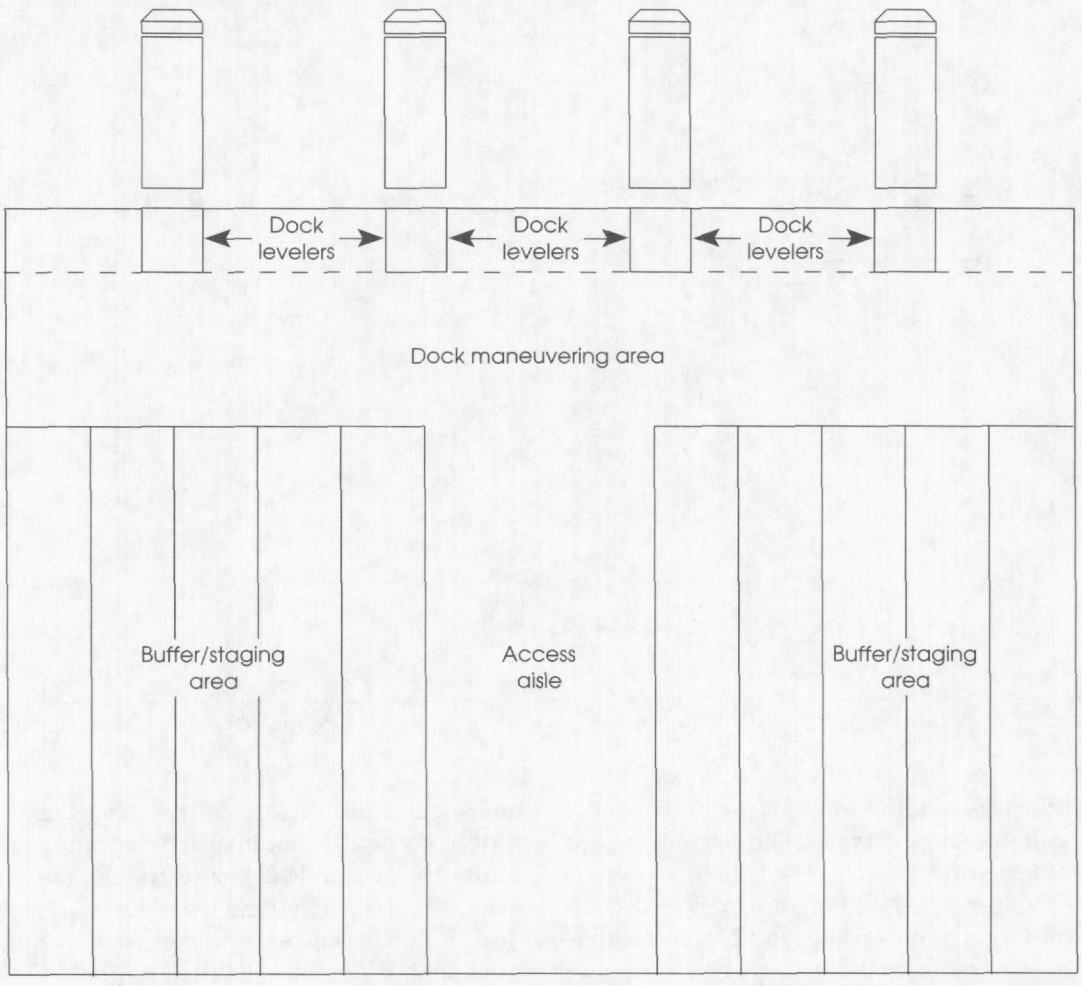
effective if they successfully hook the bar. However, because ICC-bars on some trucks are lower than the standard, these restraints need to be capable of hooking bars that are 12–30 inches above the ground to be effective. Also, because the ICC-bars on some trucks are damaged or missing, roughly one in four trucks is hard or impossible to secure with the ICC-bar. Automatic wheel-chocking and wheel-locking systems solve this problem.[10]

BUFFER AND STAGING AREAS

The setup inside the dock area also affects functional utility. Immediately inside the dock doors, space must be available for a dock maneuvering area, a buffer and staging area, and an access aisle (see figure 3). The dock maneuvering area begins at the rear line of the docklevelers and extends to the front of the buffer area. Generally, this area should be 6–8 feet wide if manual materials-handling equipment is used and 8-12 feet wide for powered material-handling equipment. Directly behind the maneuvering area is the buffer and staging area, which serves as a temporary depository for materials unloaded from the trucks. The effective use of the buffer area allows for fast and efficient unloading of trucks and helps avoid demurrage. A 40-foot-long trailer that is eight feet wide has 320 square feet of storage area, usually loaded to a height of six feet. If freight is stored 12 feet high, 160 square feet of staging area will be required. If it is stored three feet high, 640 square feet per trailer will be needed.[11]

In most high-volume warehouses, rail docks are obsolescent. They are typically needed only for warehousing large items of low value or bulk commodities. Even in these

FIGURE 3 Inside a Truck Dock



10. Tom Feare, "Selecting the Right Vehicle Restraint," *Modern Materials Handling* (January 1997): 61–62.
11. Tompkins, 233.

instances, the docks will be obsolete if the warehouse occupant uses piggyback service instead of boxcars. This situation is more likely in relatively recently developed areas than in older areas because rail tunnels and bridges in many older areas are likely to be too low to accommodate piggyback service. If a rail dock is needed, an interior rail dock is superior to an outside rail dock because it can accommodate a wide variety of rail car sizes and eliminate the difficulty of spacing external docks.

SAFETY AND SECURITY

According to the Bureau of Labor Statistics, the trucking and warehousing industry is the second most dangerous industry in the United States. The safety and security of warehouses is of utmost importance to protect workers and commodities. The level of security needed depends on the type of commodity stored. Theft by both employees and outsiders needs to be considered. Small and valuable commodities require higher levels of security than large low-value items. Electronic alarms and security cameras combined with videotape are two effective means of preventing theft. High fences and gates to control access to the grounds can also be effective.

Sprinkler systems are the most basic form of warehouse fire protection. If automatic sprinklers are not installed and a fire develops beyond the incipient stage, attempts to save anything in the compartment of origin is unlikely, and firefighters are instructed to direct their efforts toward preventing the fire from spreading beyond the involved compartment.[12] In addition to being installed, sprinkler systems must be designed to handle the commodities stored in the building.

The National Fire Protection Association divides commodities into four classes. Class I includes essentially noncombustible products arranged on combustible pallets, while class IV consists of the more combustible plastics.[13] Sprinkler systems must have a higher gallons-per-minute-per-square-foot rating to handle higher classes of commodities. Therefore, a warehouse designed to store rolls of paper might not be suitable for storing plastic cups. Table 1 shows the sprinkler system densities for various occupancies. The temperatures indicate the heat ratings for the sprinkler heads.

Sprinkler heads pointed toward the roof are superior to sprinkler heads pointed downward. The joints of a metal roof deck are not gas tight. If a fire reaches the bottom of a roof deck, it can heat the roof cover and cause a gas bubble between the cover and the deck. This bubble can ignite and cause the fire to spread rapidly to remote areas of the warehouse.[14] Further, steel beams elongate and fail in a fire, causing the building to collapse.[15]

COLD STORAGE AND FREEZER WAREHOUSES

Cold storage and freezer warehouses have special requirements. These facilities must be

TABLE 1 Sprinker System Densities for Storage More Than 25 Feet High

		Double-Row Racks Without Solid Shelves, Aisles Wider Than 4 Feet		Multiple-Row Racks	
		(gallons per minute per square foot)		(gallons per minute per square foot)	
Commodity Class	Encapsulated	165°F	286°F	165°F	286°F
I	No	0.25	0.35	0.25	0.35
	Yes	0.25	0.35	0.31	0.44
I, II, III	No	0.30	0.40	0.30	0.40
	Yes	0.30	0.40	0.37	0.50
I, II, III, IV	No	0.35	0.45	0.35	0.45
	Yes	0.35	0.45	0.44	0.56

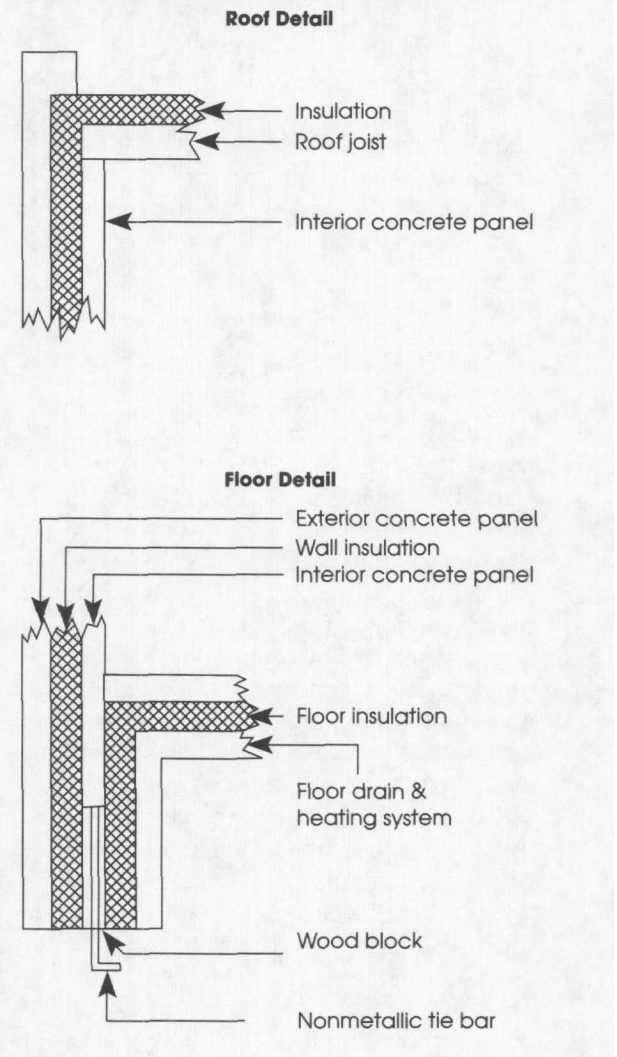
Source: Arthur E. Cope, Fire Protection Handbook (Quincy, Massachusetts: National Fire Protection Association, 1991), 8-42.

12. Arthur E. Cope, *Fire Protection Handbook* (Quincy, Massachusetts: National Fire Protection Association, 1991), 8–29.
13. National Fire Protection Association, *General Storage* (Quincy, Massachusetts: National Fire Protection Association, 1998), 231.
14. Francis Brannigan, *Building Construction for the Fire Service*, 2nd ed. (Quincy, Massachusetts: National Fire Protection Association, 1989), 247.
15. Ibid., 221.

specially designed to be fully insulated, have a monolithic vapor barrier, and have a means of channeling heat beneath the structure's foundation. This is accomplished by incorporating double-layer construction. A subfloor and a finish floor, as well as an inner wall and an outer wall, are separated by insulation and a vapor barrier. This insulation envelope must not be breached at any point. In addition, a floor drain and heating system must be installed within the subfloor. Because of the unique floor construction required, it is not feasible to convert a regular warehouse into a refrigerated warehouse. The details of the roof and the floor construction of a cold storage facility are illustrated (see figure 4).

Most cold storage facilities are constructed with metal walls. Tilt-up concrete walls, however, can improve insulation. This is particularly true if the panels are large, minimizing the number of points from which heat could escape.[16]

FIGURE 4 Roof and Floor of a Cold Storage Facility



QUANTIFYING FUNCTIONAL OBSOLESCENCE

Curable functional obsolescence for warehouses can usually be calculated using the cost to cure methods outlined in *The Appraisal of Real Estate*.[17] For example, an obsolescent interior rail dock can be cured. It can be filled with sand and covered by a concrete slab that is equipped with hooks and removable in case the dock is needed again someday. Despite the measures, there is often no active rental market for large warehouses or large manufacturing facilities with warehouse space. For this reason, it is often impractical to estimate incurable obsolescence by capitalizing a rent loss, as *The Appraisal of Real Estate* suggests. The best method of estimating incurable functional obsolescence under these circumstances is to capitalize the additional expense that the warehouse is forced to incur as a result of the functional problem. For example, a warehouse with bearing walls and an inadequate number of dock doors would incur demurrage charges that it would not incur if it had adequate doors. Capitalizing these charges could provide an estimate of incurable functional obsolescence from this source. Lost revenue resulting from longer delivery times may be another source of functional obsolescence.

The functional utility of warehouse space encompasses much more than just clear heights. The layout of the building and surrounding yard area, as well as the dock design, play important parts as well. All these factors must be considered when an appraiser estimates the value of an industrial property as a whole and of the warehouse space in particular.

16. Craig Shutt, "Zeroing in on Freezer Facilities," *Building Design and Construction* (January 1997): 44-46.

17. Appraisal Institute, The Appraisal of Real Estate, 11th ed. (Chicago, Illinois: Appraisal Institute, 1996), 387.