

Summary

This text focused on warehousing, the storage of inventories for varying periods of time. We began with a discussion of why warehousing exists in a logistics system. A key reason for warehousing is that production and consumption may not coincide, and warehousing can help smooth out imbalances between them. We discussed the differences among warehouses, distribution centers, and cross-docking facilities.

We also examined public, private, contract, and multiclient warehousing. Public warehousing managers have a number of established duties regarding the care of goods, and customers pay only for the space that is actually used to store their products. Private warehousing is owned by the firm using such facilities, and it is best used when an organization has large and steady demand patterns. Contract warehousing involves specially tailored warehousing services that are provided to one client on a long-term basis. Multiclient

warehousing, a relatively new alternative, is a mixture of public and contract warehousing.

Various design considerations are relevant to warehousing, with trade-offs among them. For example, a decision to build up or out can affect a facility's utilization of labor, mechanization, and automation. Similarly, organizations that prefer a fixed slot location for merchandise may have to build larger facilities to have a sufficient number of storage slots.

The text concluded with an examination of some key issues in warehousing operations. The material in this section emphasized that commonsense, low-cost approaches can facilitate effective and efficient management of warehousing operations. For example, warehousing safety could be enhanced if employees refrain from jumping from one dock plate to another.

Key Terms

Accumulating (bulk-making)
Allocating (bulk-breaking)
Assorting
Contract warehousing
Cross-docking
Distribution centers
Dunnage
Fixed slot location

Fulfillment centers
Hazardous material(s)
Multiclient warehousing
Occupational Safety and Health Administration (OSHA)
Private warehousing
Public warehousing
Regrouping function

Sorting out
Throughput
Variable slot location
Velocity slotting
Warehouse automation
Warehouses
Warehousing

Questions for Discussion and Review

- 1 Why does warehousing exist in a supply chain?
- 2 Explain the four ways that warehousing facilitates the regrouping function.
- 3 Distinguish among warehouses, distribution centers, fulfillment centers, and cross-docking facilities.
- 4 Discuss the disadvantages to public warehousing.
- 5 What are the advantages and disadvantages of private warehousing?
- 6 Discuss why contract warehousing is a preferred alternative for many organizations.
- 7 How does multiclient warehousing mix attributes of public and contract warehousing?
- 8 Explain how common sense can be helpful in terms of warehousing design.
- 9 In terms of warehousing design, give examples of trade-offs involving space, labor, and mechanization.
- 10 Distinguish between fixed and variable slot locations. How might they affect warehousing design?
- 11 Discuss the trade-offs associated with order-picking versus stock-replenishing functions.
- 12 Explain the relevance of aisle width in warehouse design.
- 13 Discuss some key considerations associated with warehouse automation.
- 14 What are some potential nonstorage space needs that might impact warehousing design?
- 15 How can warehousing productivity be improved without significant investment in technology or equipment?
- 16 What is OSHA's role in warehousing safety?
- 17 Discuss how fires are a constant threat in warehousing.
- 18 What is a hazardous material? What design elements should be considered when storing hazardous materials?
- 19 Discuss how warehousing security can be enhanced by focusing on people, facilities, and processes.
- 20 How are cleanliness and sanitation relevant to warehousing operations?

One commonsense suggestion when hiring warehousing workers is not to hire people who might be predisposed to theft (e.g., individuals with substance abuse problems).

In terms of a facility's focus, experts recommend a combination of overt and covert surveillance methods. With respect to the former, electronic devices such as closed-circuit television systems can be helpful, particularly if they are monitored on a regular basis. One type of covert surveillance involves unannounced security audits that focus on shortages or overages of particular products.³⁷ You should recognize that there is virtually no limit to the sophistication or cost of devices and techniques that can be used to monitor warehousing security. Having said this, the more sophisticated security devices also tend to be more expensive, and organizations need to weigh the trade-off of whether the devices' benefits exceed their costs.

In terms of processes to improve warehousing security, the more times a shipment is handled, the greater the opportunities for loss or damage. Thus, logisticians would do well to reduce the number of times an individual shipment is handled. Table 1 highlights some possible shortcomings in warehousing security.

Cleanliness and Sanitation Issues

At first glance, cleanliness and sanitation might seem like issues that are more relevant to, say, restaurants and hospitals than to warehousing operations. However, warehousing cleanliness and sanitation are of paramount importance in many industries, such as the foodservice industry where clean and sanitary warehouses reduce the likelihood of foodborne illnesses. Moreover, clean and sanitary warehousing facilities can have a positive impact on employee safety, morale, and productivity while also reducing employee turnover.³⁸

Fortunately, warehouse cleanliness and sanitation are not predicated on complex theories or costly technology, but rather on common sense and diligence. For example, a leading provider of industrial cleaning equipment suggests that a company develop a schedule to clean its warehouse on a regular basis—and stick to the schedule. In addition, a company can instill a culture that focuses on warehouse cleanliness and that requires employees to clean up upon finishing a particular task. Another suggestion is to create teams of two or three people and assign each team a specific cleaning task. Rather than cleaning an entire warehouse, the teams can be assigned to one of four quadrants in order to make the task seem more manageable.³⁹

TABLE 1 Possible Shortcomings in Warehousing Security

Shortcoming	Comment
Making it too easy for dock personnel to work in collusion with truck drivers	Fewer than 5% who commit crimes are prosecuted
Relying on safeguards that simply don't work	Security cameras aren't always turned on
Approach to theft is too reactive	Don't wait until theft reaches an "unacceptable" level
Not weeding out on-the-job substance abusers or dealers	Approximately 90% of drug users either steal or deal to support their habit
Not checking your checkers on a frequent basis	They may become complacent
Not making it easy to report theft and substance abuse	Outsourcing the reporting may be more effective
Hiring high-risk employees	An ounce of prevention is worth a pound of cure

Source: Julia Kuzeljevich, "The Seven Deadly Sins in Warehouse Security," *Canadian Transportation & Logistics*, April 2006, 44.

³⁷Maria Hoffman, "Eight Ways to Prevent Cargo Theft," *Food Logistics*, July 2011, 5.

³⁸Ned Bauhof, "Keeping It Clean," *Beverage World*, July 2007, 77.

³⁹<http://www.sweeperland.com/how-to-clean-warehouse.html>

Hazardous Materials

Hazardous materials (hazmat) often receive special attention from logistics managers because of the injuries, death, and property damage they can cause. Broadly speaking, hazardous materials can negatively impact the health and/or safety of the general public. Examples of hazardous materials include explosives, flammable liquids, and flammable solids.

Government regulations often require that shipping documents indicate the hazardous nature of the materials being transported. Warehouse employees should note these warnings when receiving materials and similarly should include such warnings on outbound shipping documents when materials leave warehouses. Many countries also require organizations to create a safety data sheet (SDS) for each hazardous product to be stored in a facility. The SDS contains information about the physical and health hazards associated with a particular product as well as information about its proper storage.³²

Hazmat experts generally agree that the applicable regulations should only provide a starting point for proper storage of hazardous materials, in part because for some situations no regulations exist. These experts further suggest that hazmat storage can be managed effectively by answering four questions: *What* material is being stored? *Why* is it being stored? *Where* is it being stored? *How* is it being stored?³³

A number of design elements must also be considered with the storage of hazardous materials. Buildings that store hazmat often have specially constructed areas so that materials can be contained in the case of an accident. Likewise, these facilities may have walls and doors that can withstand several hours of intense fire. It is also important for a hazmat storage facility to have proper sprinkling systems as well as excellent ventilation.

Warehousing Security

Interest in providing building security for warehouses and other distribution facilities is a primary concern for many organizations because, according to FreightWatch International, a company that specializes in logistics security, "Freight at rest is freight at risk."³⁴ Potential threats to warehousing security include theft, pilferage, heat and humidity, vandalism, fire, and loss of electricity, among others.³⁵ These threats can present a number of negative consequences such as lost sales and revenues, additional costs to enhance security, the time and costs to file the appropriate claims, and potential danger to the public.

Some of these consequences were well illustrated in the high-profile theft of nearly \$80 million in pharmaceuticals from a Connecticut warehouse in 2010. The pharmaceutical manufacturer instituted an immediate review of its warehouse security processes and procedures and began implementing more stringent (and most costly) security practices. In addition, pharmaceuticals that are sold outside of traditional channels can create potential safety risks (e.g., lack of refrigeration could contaminate some pharmaceuticals) and the revenues from such sales are not realized by the manufacturer. And although the pharmaceuticals stolen from the Connecticut warehouse were eventually recovered, they became evidence in criminal and civil lawsuits and will be destroyed at the conclusion of all relevant legal proceedings—which means no revenues from their sale for the manufacturer.³⁶

Warehousing security focuses on two primary issues, namely, protecting products and preventing their theft, and warehousing security can be enhanced by focusing on people, facilities, and processes. In terms of people, one area of focus should be the hiring process for warehousing workers; a starting point might be determining whether an individual facility even has a formal hiring process.

³²Maureen Brady, "Safe, Segregated and Secure: Are Your Hazardous Chemicals Properly Constrained?" *Industrial Safety & Hygiene News*, June 2012, 46.

³³Todd Nighswonger, "Are You Storing Hazardous Materials Safely?" *Occupational Hazards*, June 2000, 45–47.

³⁴FreightWatch, *US Cargo Theft: A Five-Year Review*, April 2011.

³⁵Linda Pohle, "What to Do with a Warehouse," *SIDM: Security Distribution and Management*, September 2008, 64–70.

³⁶Diane Ritchey, "The \$80 Million Theft," *Security: Solutions for Enterprise Security Leaders*, July 2012, 20–24.

lifting procedures, trying to carry too heavy a load, failing to observe proper hand clearances, and the like. Back and shoulder injuries are the most frequent among warehousing personnel; back support belts and braces are becoming more widely used, but they are only of value if workers also receive adequate training in how to safely lift various loads.

Property. Warehousing facilities generate large volumes of waste materials, such as empty cartons, steel strapping, and broken pallets, as well as wood and nails used for crating and dunnage (material that is used to block and brace products inside carrier equipment to prevent the shipment from shifting in transit and becoming damaged). The various waste materials must be properly handled because they pose threats to employee safety and may also be fire hazards.

Moreover, even with the best of practices, some goods that are received, stored, and shipped will be damaged. Special procedures must be established for handling broken or damaged items, if only from the standpoint of employee safety. A broken bottle of household ammonia, for example, results in three hazards: noxious fumes, broken glass, and a slippery floor. Aerosol cans pose hazards that are affected by the product in the cans. For example, cans of shaving cream cause little problem in fires because if they explode, the shaving cream serves to extinguish the fire; that is not the case with aerosol cans containing paints or lacquers, and such cans are often kept in special cages because in a fire they might become burning projectiles.

Indeed, fires are a constant threat in warehousing, in part because many materials used for packaging are highly flammable. In addition, although plastic pallets last longer, are cleaner, and are less likely to splinter than wooden pallets, plastic pallets tend to be a greater fire risk. High-rise facilities are more susceptible to fires because the vertical spaces between stored materials serve as flues and help fires burn. You should recognize that warehouse fires may result in substantial property damage as well as injury or death, as illustrated by the 2015 explosions at the Port of Tianjin (China). The explosions, which started with an initial explosion (and fire) at a warehouse that illegally stored thousands of tons of hazardous products, killed more than 100 people and cost insurance companies approximately \$2 billion.²⁸

A 2016 report by the National Fire Protection Association indicated that U.S. warehouses averaged approximately 1,200 fires per year between 2009 and 2013. The report indicated that the two most common causes of warehousing fires between 2009 and 2013 were those that were intentionally set and those caused by electrical distribution and lighting equipment. Moreover, the 2016 report indicated that the number of warehousing fires decreased by approximately 75% between the early 1980s and 2013.²⁹ Many warehousing fires can be prevented by common sense; flammable products, for example, should not be stored near heat sources (such as space heaters).

Motor vehicles. We mentioned earlier that forklift operations and equipment have been a particular focus of governmental safety regulations. Indeed, in the United States approximately 85 employees are killed and there are approximately 35,000 serious injuries each year while operating forklifts; approximately 40% of deaths are caused by an operator being crushed by a forklift tipping over.³⁰ An annual National Forklift Safety Day began in 2014 as an effort to provide greater awareness of safe forklift practices as well as to encourage safer operator behavior.

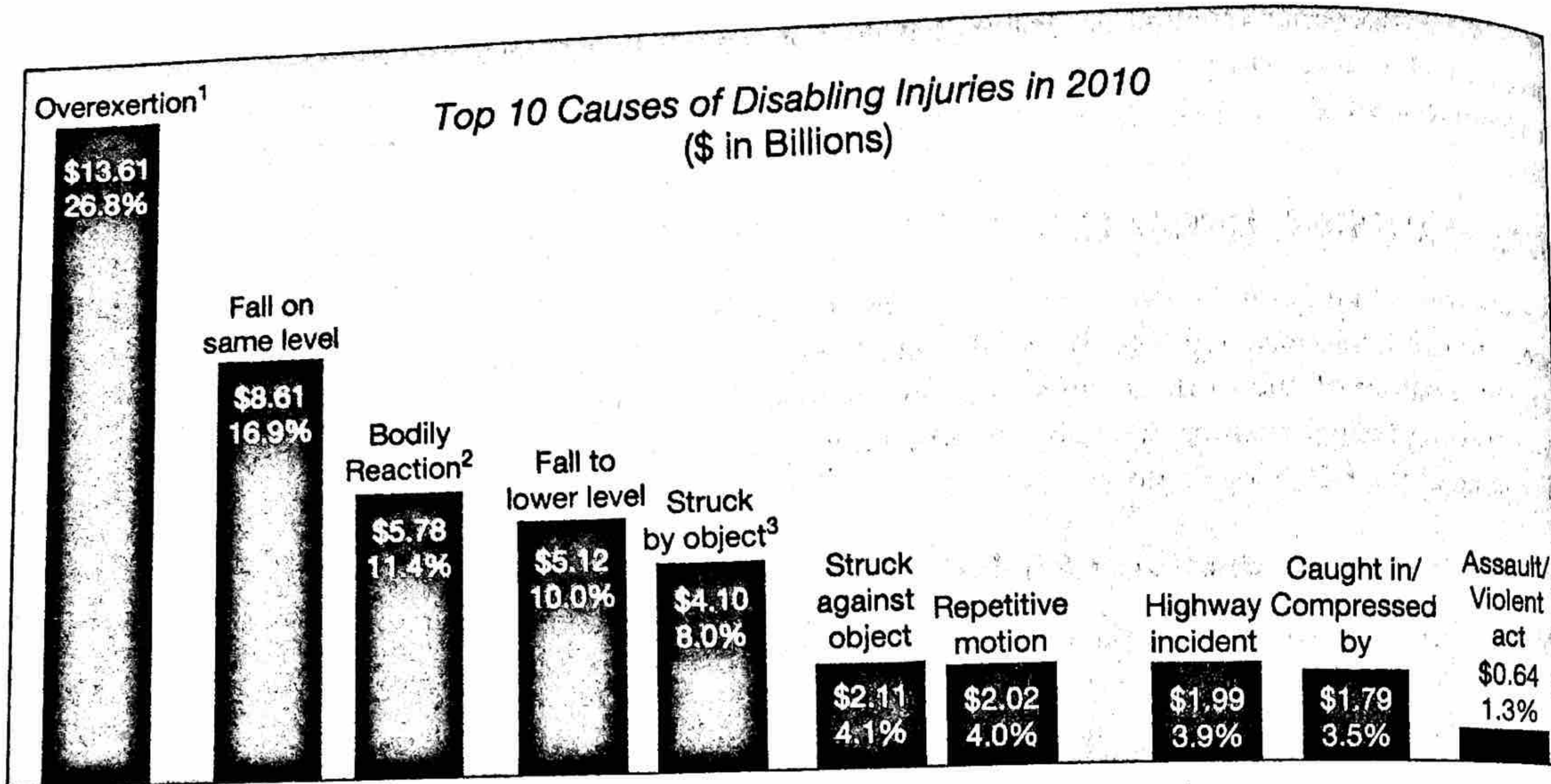
There are other vehicle-related safety considerations in warehousing; for example, tractor-trailer drivers who are backing into loading/unloading docks should utilize a lookout person to alert the driver about employees who might be walking behind the vehicle. Moreover, wheel chocks—hard-rubber wedges that are inserted under truck tires—can guard against intentional or unintentional trailer movements.³¹

²⁸Patrick Burnson, "Resilience Requires Transparency," *Logistics Management*, January 2016, 64.

²⁹Richard Campbell, *Structure Fires in Warehouse Properties* (Quincy, MA: National Fire Protection Association, January 2016).

³⁰<http://forkliftsystems.com/national-forklift-safety-day-is-june-10th/>

³¹Nowlan, "Safety Doesn't Have to Hurt Your Budget."



- ¹Overexertion – Injuries from excessive lifting, pushing, pulling, holding, carrying, throwing
- ²Bodily reaction – Injuries from bending, climbing, reaching, standing, sitting, slipping or tripping without falling
- ³Struck by object – Such as a tool falling on a worker from above
- ⁴Struck against object – Such as a worker walking into a door
- ⁵Repetitive motion – Injuries due to repeated stress or strain

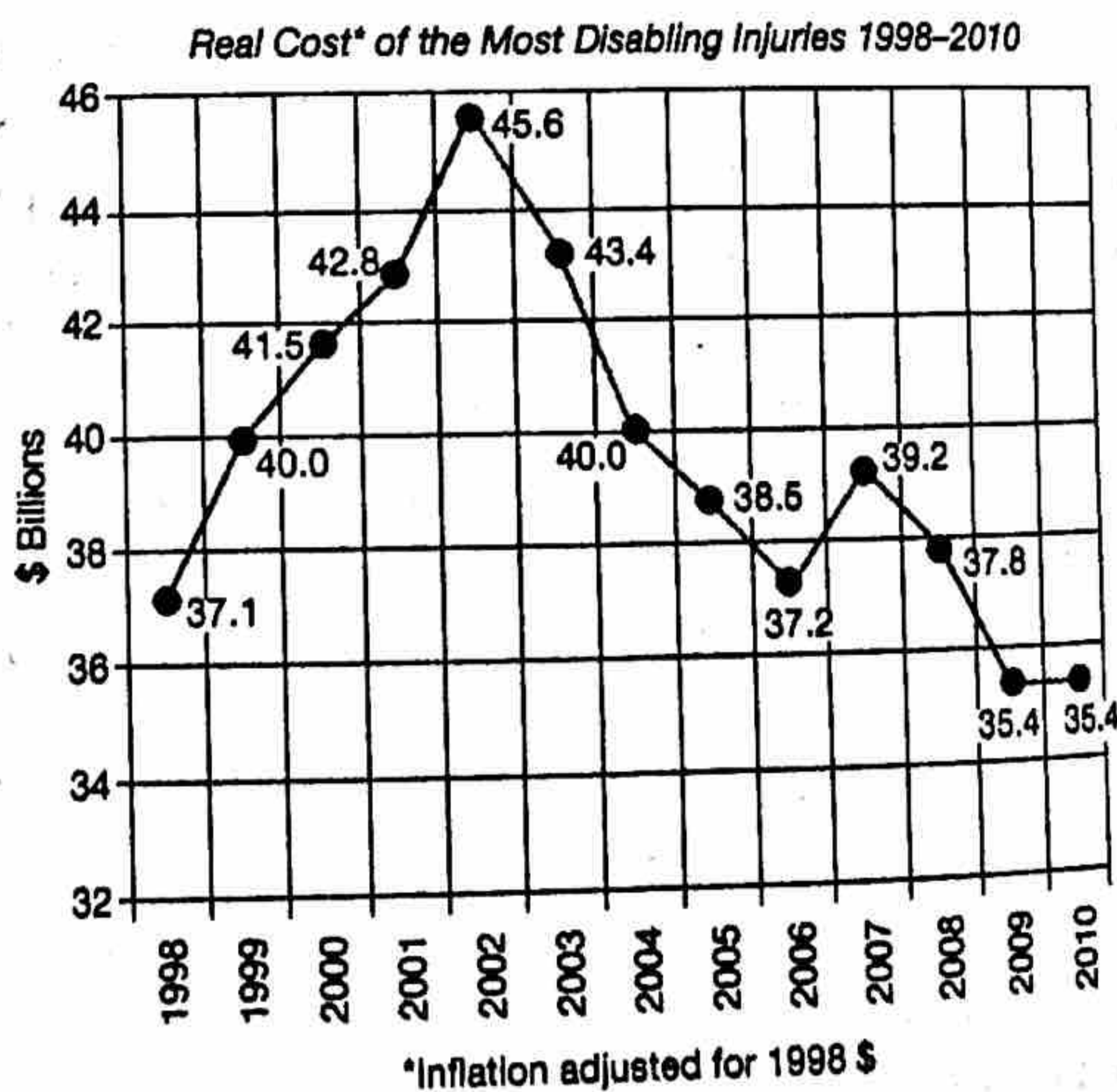
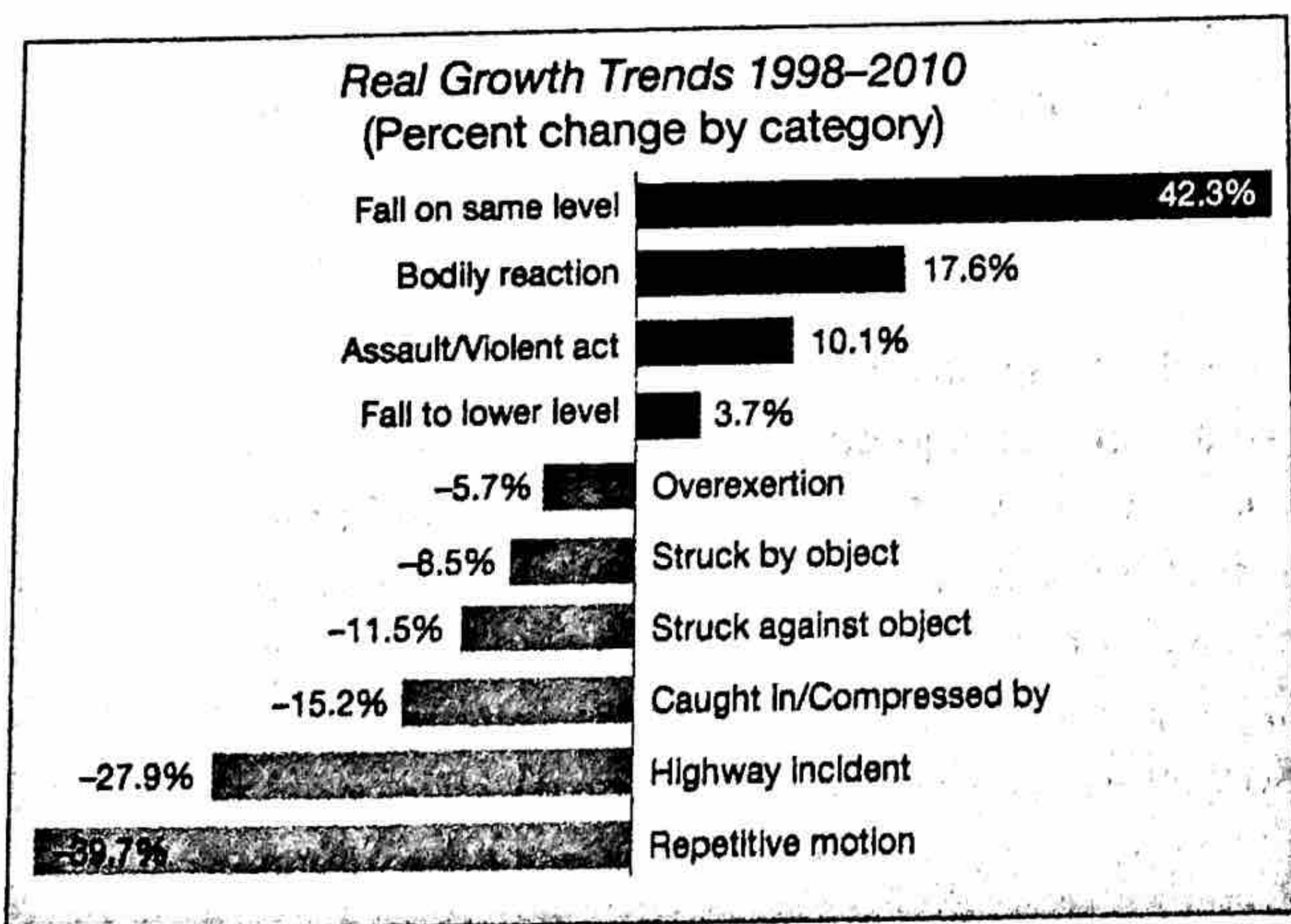


Figure 3 Workplace Safety Issues Source: Reprinted with permission of Liberty Research Institute for Safety, August 30, 2012.

Warehousing safety can be influenced by governmental regulations. In the United States, safety standards have been set for warehousing equipment and operations, and OSHA inspectors make frequent visits to industrial workplaces to ensure regulatory compliance. Forklift operations and equipment have received particular attention from OSHA in part because of the number of deaths and injuries associated with them. For example, only trained and certified warehousing employees are permitted to operate a forklift and forklift operators must be recertified every three years.

Warehouse safety considerations fall into three primary categories—employee, property, and motor vehicles²⁶—and we will discuss each of these in the paragraphs that follow. With respect to *employee safety*, consider one warehousing professional's advice: "It costs more to recruit, train, and replace a worker than to provide a safe environment."²⁷ Workers can be injured due to improper

²⁶Joe Nowlan, "Safety Doesn't Have to Hurt Your Budget," *Industrial Distribution*, January 2008, 25–27.

²⁷Don High In, "Getting a Lift from Safety," by Ed Engel, *Warehousing Management*, January–February 2001, 5.

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²⁸Patrick Burnson, "Resili

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³⁰<http://forkliftsystems.com>

³¹Nowlan, "Safety Does

When designing warehousing facilities, it is also important to keep in mind external space-related needs, which unfortunately are sometimes overlooked. These include areas for vehicles waiting to be loaded and unloaded, space for vehicle maneuvering (e.g., turning, backing up), and employee parking.

WAREHOUSING OPERATIONS

Learning
Objective **4**

Because operating a warehousing facility has many facets, efficient and effective warehousing management can be an exacting task. Workforce motivation can be difficult because of the somewhat repetitive nature of the work. It can also be strenuous and physically demanding, and on occasion warehousing facilities can be dangerous places. Some of the more significant operational issues are discussed in the following sections.

Warehousing Productivity Analysis

Productivity is a measure of output divided by input, and although a number of different productivity metrics can be used to assess warehousing productivity, not all are relevant to all kinds of facilities. Representative measures of warehousing productivity include cases shipped per person, product lines shipped per person, pallets shipped per person, average warehouse capacity used, and forklift capacity used, among others. These and other productivity metrics can be utilized to provide comparisons within an organization over time.

In addition, external data may be available that can be used for benchmarking purposes depending on the relevant metrics being analyzed. Suppose, for example, that the cases picked and shipped per hour at a particular warehouse increased from 72 to 84 over a two-year period. Although this represents a 16.7 percent $([84 - 72]/72)$ productivity improvement over the two years, the 84 cases per hour might be viewed much differently when compared to warehousing industry data that shows a median of 100 cases picked and shipped per hour and a best practice metric of more than 250 cases picked and shipped per hour.²²

It is important to recognize that increases in warehousing productivity do not always require significant investment in technology or mechanized or automated equipment. For example, one suggestion for improving warehousing productivity involves a review of existing procedures and practices to identify the tasks that are creating the largest inefficiencies and then developing methods to reduce or eliminate the inefficiencies without adding to or upgrading present technology or equipment. Organizations can also examine their facility layouts; long horizontal runs and frequent backtracking could be symptoms of layout problems. Something as basic as adding cross aisles could reduce the length of horizontal runs as well as the length of backtracking. Another low cost suggestion for improving warehousing productivity is to play music, if conditions permit; research suggests that worker productivity increases when music is playing.²³

Safety Considerations

Warehousing facilities can be dangerous places to work. In the United States, for example, forklifts account for *one of every six* workplace deaths.²⁴ Figure 3 provides a listing of workplace safety issues, and many of these safety issues, such as falls and bodily reaction, are associated with warehousing facilities. You should recognize that many suggestions for dealing with warehousing safety are commonsense—and low cost—in nature. Consider, for example, several of the Occupational Safety and Health Administration's (OSHA) suggestions to improve warehouse safety: "prohibit 'dock jumping' (jumping from dock plate to dock plate) by employees;" "prohibit stunt driving (of forklifts) and horseplay;" "keep floors clean and free of slip and trip hazards."²⁵

²²Karl B. Manrodt and Kate L. Vitasek, "DC Measures 2012," *WERC Watch*, Spring 2012.

²³John Tufts, "9 Tips for Improving Warehouse Productivity," *Multichannel Merchant Executive Insight*, March 6, 2012, 1.

²⁴Eric Scharski, "Want a Safer Warehouse? Start with Forklift Users," *Food Logistics*, January/February 2015, 36–41.

²⁵www.osha.gov/Publications/3220_Warehouse.pdf

conventional aisles.¹⁸ However, it is easier to operate mechanical equipment in wider aisles and wider aisles reduce the chances of accidents and product damage.

Narrower aisles require specialized storage and handling equipment, such as narrow aisle (very narrow aisle) lift trucks, which are capable of simultaneously moving both vertically and horizontally. This specialized equipment is noticeably more expensive than traditional lift trucks, and it is not unusual for specialized lift trucks to cost twice as much as traditional lift trucks. However, specialized lift trucks can be twice as productive as traditional lift trucks.¹⁹

Degree of Warehouse Automation

The degree of automation is another important consideration in warehousing design. For our purposes **warehouse automation** will refer to utilizing mechanical or electronic devices to substitute for human labor. Examples of warehouse automation include narrow aisle forklifts, automated guided vehicles, automated storage and retrieval systems, radio frequency identification, and robotic picking, among others. Although warehouse automation offers the potential to reduce labor costs and to improve warehouse productivity, it is important for managers to ensure that the automation results in noticeable improvement in warehousing effectiveness and efficiency. To this end, an organization should first assess whether it is ready for automation, because automation can be complex, expensive, and disruptive to day-to-day operations. If an organization is ready for automation, then it's important to evaluate how the automation will support the organization's logistics system.²⁰

Other Space Needs

Although many would assume that the primary role of warehousing involves the storage of product, it is not uncommon for a warehousing facility to operate with only *20 percent* of the space being occupied by product.²¹ Because every warehousing facility sets aside areas for nonstorage activities, it's important to know about them. These nonstorage activities include, but are not limited to, the following:

1. An area where transport drivers and operators can wait while their equipment is loaded or unloaded
2. Staging, or temporary storage, areas for both incoming and outgoing merchandise
3. Employee washrooms, lunchrooms, and the like
4. Pallet storage and repair facilities (Facilities that receive unpalletized materials but ship on pallets may require a pallet-assembly operation.)
5. Office space, including an area for the necessary computer systems
6. An area designed to store damaged merchandise that is awaiting inspection by claim representatives
7. An area to salvage or repair damaged merchandise
8. An area for repacking, labeling, price marking, and so on
9. An area for accumulating and baling waste and scrap
10. An area for equipment storage and maintenance (For example, battery-powered lift trucks need to be recharged on a regular basis.)
11. Specialized storage for hazardous items, high-value items, warehousing supplies, or items needing other specialized handling (such as a freezer or refrigerated space)
12. A returned or recycled goods processing area

¹⁸Mary Aichlmayr, "Narrow-Aisle: Form Follows Lift-Truck Function," *Material Handling Management*, June 2009, 18–20.

¹⁹Josh Bond, "Avoiding a Tight Spot in Narrow Aisles," *Modern Materials Handling*, September 2015, 12.

²⁰Bridget McCrea, "7 Steps to Take before You Install an Automated Warehouse System," *Modern Materials Handling*, September 2015, 8–11.

²¹<http://www.ioptimizerealty.com/2012/12/21/measuring-utilization-warehouse/>

that slots the most frequently picked items in the most accessible location; velocity slotting generally reduces an order picker's travel distance.¹⁵

A well-thought-out slotting plan can reduce labor costs, increase pick and replenishment efficiencies, and increase order accuracy.¹⁶ To this end, organizations need to understand the attributes of fixed and variable slot locations for merchandise. With a **fixed slot location**, each SKU has one or more permanent slots assigned to it (think of a parking garage that assigns particular parking spaces to certain individuals). This can provide stability in order picking in the sense that the company should always know where a specific SKU is located. However, this may result in low space utilization, particularly with seasonal products.

Alternatively, a **variable slot location** involves empty storage slots being assigned to incoming products based on space availability. One example of variable slot location is the closest available storage position, with "closest" defined as the shortest travel time to an entrance or exit point. Although variable slot location generally results in more efficient space utilization, from an order picking perspective it requires a near-perfect information system because there must be flawless knowledge of each product's location.

Build Out (Horizontal) versus Build Up (Vertical)

A general rule of thumb is that it's cheaper to build up than build out; building out requires more land, which can be quite expensive, particularly in certain geographic locations. As an illustration, during 2015 a 1.5-acre land parcel in London, England was priced at £25,000,000!¹⁷ Alternatively, although building costs decline on a cubic-foot basis as one builds higher, warehousing equipment costs tend to increase.

Order-Picking versus Stock-Replenishing Functions

Organizations must decide whether workers who pick outgoing orders and those who are restocking storage facilities should work at the same time or in the same area. Although the latter scenario may result in fewer managerial personnel being needed, it may also lead to congestion within the facility due to the number of workers. One suggestion to reduce congestion is for order pickers and stock replenishers to use different aisles for their respective activities—again, this requires a very good information system to identify where a given employee is at any time.

Two-Dock versus Single-Dock Layout

A two-dock layout generally has receiving docks on one side of a facility and shipping docks on the other side, with goods moving between them. In a one-dock system, each and every dock can be used for both shipping and receiving, typically receiving product at one time of the day and shipping it at another time. Viewed from overhead, the goods move in a U-shaped rather than a straight configuration. This alternative reduces the space needed for storage docks, but it requires carriers to pick up and deliver at specific times. In addition, this alternative may also result in an occasional mix-up in that received product is sometimes reloaded into the vehicle that delivered it.

Conventional, Narrow, or Very Narrow Aisles

Aisle width might seem like an arcane issue until you realize that as aisle space increases, the storage capacity of a facility decreases. For example, narrow aisles (defined as between 9.5 feet and 12 feet wide) can store 20% to 25% more product than conventional aisles (more than 12 feet wide), while very narrow aisles (defined as less than 8 feet) can store 40% to 50% more product than

¹⁵Bryan Jensen, "Racing Past Velocity: Slotting Your Facility to Optimize Order Picking," *HVACR Distribution Business*, December 2012, 26–28.

¹⁶Paul Hansen and Kelvin Gibson, "Effective Warehouse Slotting," *The National Provisioner*, May 2008, 90–94.

¹⁷<http://www.rightmove.co.uk/property-for-sale/London/land.html>