14
Powered Industrial Trucks

Thaddeus M. Pajak and Mary Hoerster

14.1
Introduction

Much has been written about powered industrial lift truck safety, and rightly so due to the high levels of care and engineering that are required to prevent accidents. One approach to get to the core of causes of accidents and injuries to powered industrial truck operators is to understand the nature of their work, and the associated behaviors that they practice and exhibit. Like any other behavior-based approach to safety, the task is to observe and reinforce safe behaviors to lessen the likelihood of powered industrial truck injury causing accidents. The corollary certainly is that our observations should also be focused on those behaviors that contribute to lift truck accidents. Unlike other accident trends, where we can focus on the frequency of accidents, or a set of relatively minor accidents, and have a better idea of where we should apply our focus to prevent a similar severe accident, lift truck accidents have to be better controlled through safe behavior. This is to say that the stakes of mistakes of lift truck operators are higher given that a truck on truck or truck on pedestrian collision could result in a relatively more severe accident. Unsafe behaviors of lift truck operators, it could be argued, have a greater likelihood of causing a severe accident. Safety and loss prevention engineering professionals do not have the luxury of waiting for trends to develop before we act: the frequency of collision-type accidents with lift trucks is not a regular occurrence, fortunately. However, the consequences of lift truck collision-type accidents when they do occur can be severe. These two factors make a behavior-based approach one that should be considered. This is to emphasize that unsafe behaviors or a combination of unsafe behaviors have to be recognized as precursors to potentially severe accidents. For example, a lift truck operator who regularly starts to raise the lift and mast while approaching storage racks is now at a higher risk for a tip-over type of accident, and unless there is intervention to stop the unsafe behavior, it may only be a matter of time before this type of severe accident occurs. The overall safety goal of powered industrial truck accident prevention is to try to engineer out, or lessen, the likelihood of frequency of those behaviors through workplace design and equipment design and maintenance. This can be augmented

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by reinforcing safe behavior through driver training, operator–employee feedback, and task/environmental risk assessments that both reinforce safe behavior and identify risk factors that need improved controls.

The novelty of this approach is that it can be directly integrated with safety standards established for lift truck operators and the environment in which they work. As of 21 October 2010, the US Department of Labor, Bureau of Labor Statistics (BLS), Industrial Injuries and Illness, listed the following data on its web site: in the most recent 3 years for which there are data, there have been 21, 50, and 45 deaths from powered industrial truck drivers. This is according to the 2009, 2008, and 2007 accident data BLS census of fatal occupational injuries. These numbers tell us that perseverance in lift truck safety is still very much warranted. This is a significant improvement over fatality numbers from a decade earlier, when deaths due to industrial lift truck accidents were averaging around 72. According to the US Center for Disease Control (CDC) National Traumatic Occupational Fatalities Surveillance System web site there were 1021 deaths from powered industrial truck-related incidents between 1980 and 1994. Causes of fatalities by percentage for both the operators and other persons affected by lift truck accidents are as follows:

- overturns 22%
- worker on foot struck by forklift 20%
- victim crushed by forklift 16%
- fall from forklift 9%.

It is just not good enough to know and note these very general statistics. We need to drill down to some of the more detailed causes of accidents, and our efforts should be directed to those causes. Powered industrial lift truck design, use, and operation are regulated occupational exposures. ANSI/ITSDF B56.1-2009 (American National Standards/Industrial Truck Standard Foundation) has established design and operating criteria that are very specific. OSHA (Occupational Safety and Health Administration) Regulations 1910 subpart N, Subpart Materials Handling and Storage, Standard Number 1910.178, Powered Industrial Trucks adopts much of the ANSI/ITSDF criteria and codifies them into law.

Although fatal accidents have been reduced, as also have non fatal accidents, we are still seeing injuries. As of 21 October 2010, the BLS listed the following data on their web site: 2009 BLS recordable injury case rate average of 3.6 per 100 full-time employees for all industries, and 5.9 recordable case rate for warehousing and storage operations. If we extrapolate these numbers, there is the concern that given the right circumstances and combination of causal factors, these loss time and non-loss time incidents could have become fatalities. Warehousing and storage operations which use lift trucks heavily in their operations have an even greater potential for fatalities.

Safety and loss prevention engineering professionals understand that there are many thousands of events which fortunately do not make the BLS data that, *given the right circumstances and contributory causes*, could have elevated these most recent numbers. This is to say that even though unsafe behaviors are occurring that could have contributed to occupational fatalities, other mitigating factors and safety controls prevented those accidents from happening. An accident occurs when the combination of unsafe behaviors and conditions come together to be causal factors in an accident. For example, if a lift truck operator is regularly driving with an elevated lift load, and pedestrians are routinely walking in restricted lift truck-only work areas, it may only be a matter of time before a serious accident occurs. It may be the presence of oil on the floor due to poor maintenance and inspection practices that are the final accident cause factor, which, coupled with the lift truck operator's behavior and the presence of the pedestrian, finally incur a collision-type accident. The challenge that the safety and health professional faces is to identify behaviors and other causes that contribute to lift truck accidents. An inherent difficulty in controlling lift truck accidents is that there is a built-in respect for these machines that fortunately keeps the frequency of accidents at a relatively low level. ''Studies of lift truck drivers' perceptions per survey questionnaires would indicate that there is a deep understanding of the hazards of lift trucks and the nature of lift truck accidents are taken seriously'' (Majekodunmi and Farrow, 2009). Of course, when there is an accident involving a powered industrial truck, it tends on average to be potentially much higher in cost and severity than other industrial accidents because of the weight and size of industrial trucks. In the course of this chapter, analogies with over the road vehicle safety program strategies will be made because there are similarities in effective control strategies. However, the occupational work environment is a much more controllable environment which should facilitate the safety professional's effort.

14.2
Lift Truck Accident Prevention: An Integrated Approach

Opportunities remain for companies and safety and health professionals to review and reinforce powered industrial truck safety criteria. This chapter incorporates these standards, and attempts to integrate them into a framework that allows lift truck activities to be quantified in order that a safe or unsafe determination can be made. Management's responsibility in lift truck safety via a safety observation approach is discussed. Also, occupational health exposures from powered industrial truck operation are identified, and these too need to be quantified regarding health risk acceptability. Finally, and most importantly, we have to utilize what we know about accident causation, behaviors, near misses, and loss time accidents in our accident prevention focus. Owing to the potential magnitude of occupational injuries from lift truck accidents, the margin of error is much smaller when we consider the consequences.

This chapter is presented so that the safety or loss prevention engineering professional can segregate key behaviors and risk factors that contribute to powered industrial truck accidents. In addition to the actions of the industrial truck operator, this chapter also evaluates the environmental cause factors that certainly are as relevant in controlling accidents as is the lift truck itself. This is consistent with required OSHA powered industrial truck operator training requirements in two broad categories: truck-related topics and workplace-related topics.

The focus of this chapter is primarily on the most common of the powered industrial low- and high-lift trucks as defined by ANSI/ITSDF B56.1-2009. This is the solid tire industrial lift truck that is designed to operate on the smooth surfaces of the concrete floor of warehouses and industrial plants. To set the learning expectations of this chapter, a statement from the ANSI/ITSDF B56.1-2009 Standard includes: ‘‘The use of powered and non-powered industrial trucks is subject to certain hazards that cannot be completely eliminated by *mechanical means*, but the risks can be minimized . . . Therefore, it is essential to have competent and careful operators, physically and mentally fit, and thoroughly trained . . . Serious hazards associated with industrial trucks are overloading, instability of the load, obstructions, collisions with objects or pedestrians, poor maintenance, and use of the equipment for a purpose for which it was not intended or designed.’’ All of these hazards can be observed and countered with intervention and workplace design. It can be seen consistently through the next section how workplace design affects lift truck operators’ behavior. The ANSI/ITSDF B56.1-2009 Standard is freely available online and the safety or loss prevention engineering professional is encouraged to read this document so as to understand better the risk factors that need to be addressed both from the physical industrial truck and the work environment where it is used.

14.3 Fork Truck Safety Observations

How do we know if our lift trucks are being operated in a safe manner? Since unsafe behaviors and near misses could have become accidents, we need to be aware of unsafe behaviors. The ANSI/ITSDF B56.1-2009 Standard and OSHA 1910.178 gives us some behavior criteria on which to focus. The better the safety or loss prevention engineering professional can define hazard risk factors for injuries and accidents from lift trucks, the more likely we will be able to establish comprehensive safe and unsafe behavior definitions. Risk factors, however, need to be minimized as much as possible through designing safe workplaces and establishing plant layouts that are compatible with the industrial lift trucks being used. For example, larger lift trucks cannot be brought into assembly and manufacturing areas where space is limited, and there is the risk of backing or colliding lift trucks into persons or machinery. Conversely, owing to multiple loads and efficiency purposes, larger lift trucks may be used in warehouse rack areas to bring loads to the loading dock area where those loads can be divided, and smaller lift trucks or hand trucks can be used to load trucks and trailers depending on the manner in which the trucks are being loaded.

Where do we begin with our safety observations? Here is a list of safe observations that should be included in our safety observation program. Some of these topics and the design considerations around them are elaborated in more detail below.

- Safe speeds.
- Baseline environment status maintained.
- Safe line sights maintained (clear front view or load trailing as needed).
- Horns used at intersections.

- Lift trucks being operated in permitted areas.
- Pedestrians restricted to permitted areas.
- Vehicle "attended" criteria per ANSI and OSHA being followed.
- Vehicle type and permitted use area followed.
- Three-point contact getting in and out of vehicles.
- No excessive driver body twisting or turning when getting out of lift trucks.
- Seatbelts being worn.
- Travel with tilt back.
- Travel with forks at lowest safe level.
- No raising or lowering forks while the vehicle is traveling.
- Hands, arms and head inside truck.
- Vertical load backrest commensurate with load type.
- Load engaging minimum 2/3 under load.
- Load centered on forks.
- Established direction of travel being followed.
- No entrapment and caught in between situations.
- Load stability compromised and turnover potential due to observed truck side sway.
- Load weight commensurate with lift truck capacity as per truck specification plate.
- Pedestrians using man doors only; no pedestrian traffic through bay doors.
- Lift truck operates smoothly without bounce while traveling on level surfaces.
- Lift trucks with overhead guards where falling object hazards are present.
- Dock safety:
  – Chocks in place.
  – Restraint device employed.
  – Truck engine off and brake set.
  – Dock leveler/dock plate in place and secured.
  – OALH (overall lowered height) being practiced during entry to and exit from semi-trailers.
  – Trailer roll-up doors secured.

This list is certainly not all-inclusive of all of the behaviors to be observe and monitored; however, these behaviors are those that the authors have witnessed in their professional experience. Many of these are safe practices that should be followed and are those that ANSI/ITSDF B56.1-2009 references.

14.4 Making Safety Observations

14.4.1 Safe Speeds

A starting point for making safety behaviors is to quantify what is safe speed. OSHA 1910.178 (n) (8) states: "Under all travel conditions the truck shall be operated at a speed that will permit it to be brought to a stop in a safe manner.'' The range of lift truck speed design per ANSI B56.1 is from 1 to 10 mph or 1.6 to 16 km h^{-1}. So what is a safe speed? *One safe speed limit for the entire plant is not sufficient*. There are higher hazard areas where pedestrians are present and also areas where aisles are narrower, and where electrical or other utilities or machinery are present. Different safe speeds need to be established for these areas.

The lift truck manufacturer is required per ANSI to establish stopping distance criteria based on vehicle capacities. Of course, this stopping distance has to be modified and increased by the operator if there is a ramp or any kind of incline, and if there is known moisture on the floor surface (some operations such as dairies and food processors often cannot get around the fact that there will be water on the floor). In these cases, the safe stopping distance will have to be increased. Safe stopping distance is a function of the lift truck design, speed of travel, and operator reaction and perception time. Of these variables, which one is controllable? It is the vehicle speed established by the plant management. Most industrial lift trucks do not have speedometers. Given, this, one approach to establishing safe operating speeds in areas of the plant is to make safety observations where the vehicle travels from point A to point B, a measured known distance, and the time required to traverse this distance is timed to allow the speed to be calculated. Facilities with camera systems could be monitored regularly and without the concern of coerced driver behavior when an observer is watching. A camera, if positioned properly, would possibly be able to record tens to hundreds of lift truck movements to determine if safe speeds are consistently being followed.

An alternative to driver speed monitoring is to purchase industrial lift trucks with governed, manufacturer-set speeds so that speeds are governed commensurate with your facility's needs. Most lift truck speeds are governed per design. Possibly vehicles by manufacturer or type can be restricted to certain areas of the plant. This would make safety observations readily apparent to safety observers and supervisors if the lift truck was being operated in an area for which it was not designated. By design, speed control devices will engineer out the speed risk variable that may be the key variable that contributes to some lift truck accidents.

During operator training, safe speeds can be established where the known required stopping distances are included in the training, that is, lines on the pavement can be made, and lift truck operators have to stop their trucks safely within a certain distance. This could be done both with and without loads so that lift truck operators can learn and understand the differences. Acceptable speeds can be learned based on the required stopping distance.

One other safety observation that could be made with regard to speed of travel is whether operators are manually applying pressure to the speed control device, and not ''blanking'' the control in the open position, that is, cruise control is not permitted in any occupational setting!

14.4.2
Baseline Environment Status

Much can be ascertained from a work environment from visual observation of conditions found during the safety observations. For example, if tire skid marks are observed, this would be an indication of excessive speeds. If stanchions, painted bright yellow, used to protect dock doors, equipment, or utilities, have scratches or are bent, again, this is an obvious indication of careless lift truck operation.

14.4.3
Lighting

A basic light meter can be used to substantiate a minimum of two lumens (2 lm) lighting requirements in lift truck work areas;. OSHA 1910.178 states: ''If two lumens of light are not provided, then additional lighting on the lift truck is required.'' Light meters typically measure in foot-candles (ftc); 2 lm of light = 2 ftc ft^{-2}, so these levels can be evaluated. Another way to express and measure lighting requirements is as per ANSI/ASHRAE/IESNA Standard 90.1-2007 for lighting requirements: 1.2 W ft^{-2} of space for low-bay manufacturing facilities, and 1.7 W ft^{-2} for high-bay manufacturing facilities. As light manufacturers express their light's illumination level or output in watts, the desired level using this criteria can be determined based on the floor space area that needs to be lighted. If lux (lx) is the unit of illuminance, and $1\ lx = 1\ lm\ m^{-2}$, then $9.61\ lx\ ft^{-2} \times 2 = 19.22\ lx\ ft^{-2}$ would be needed.

If older workers are employed, having more than required lighting is an essential aspect of facility safety and design. Older workers may have a condition known as presbyopia, ''a condition where the eye becomes focused at a fixed distance. If good lighting is provided, the depth of field of the eye is increased and the net effect is to lower the requirements for accommodation'' (Bridger, 2009). Also, if manufacturing areas, for example, are significantly brighter than storage areas, there should be a transitional lighting area to allow for ''transient adaptation'' (Fleeger and Lillquest, 2006), to allow the lift truck operator's eyes to adjust.

One final note about good lighting and making safety observations is that the physical condition of the vehicle can be better assessed. If each lift truck is identifiable by number or other marking, its baseline condition can be noted, and any dents, scratches, or other conditions that deviate from baseline would be an indication of potential unsafe driving behavior. Good lighting would better allow this assessment to be conducted. If a drivers is assigned the same lift truck from day to day, any damage to the lift truck can be traced to a specific operator. If lift trucks are being used on multiple shifts, then the OSHA Standard 1910.178 mandates that lift truck inspections be conducted every shift. This is important from a safety observation perspective because physical conditions noted on a lift truck can easily be traced to the assigned operator of the lift truck. Assigning lift trucks by driver or operator creates an ''ownership'' mentality that hopefully will facilitate care and safe operating practices.

14.4.4 Housekeeping

Another baseline environmental evaluation can be housekeeping checks. Materials stored in aisles, loose pallets, and broken pallets all not only create trip and fall hazards, but are also items that could contribute to a lift truck accident or impede the normal flow of operations. For example, materials stored in an aisle that normally is the direction of lift truck travel may necessitate travel in the opposite direction, increasing the likelihood of collisions. Although housekeeping is a static type of condition, how well it is managed definitely drives lift truck operator behavior. Safety observers should be aware of and interpret housekeeping conditions in terms of how they might affect driver behavior.

The rack storage arrangement of a product is an indication of the care that lift truck operators are taking in safely placing pallets and other loads in the racks. Overcrowding of storage racks may be an indication to add more storage or re-evaluate the compatibility of lift truck design and rack loading requirements.

Water on the floor from rain or snow that blows into the building or around trucks because the perimeter of the loading dock door has been damaged can create a hazard. This can be prevented by adding weather shrouds for each loading dock bay that prevent rain and snow from coming in around the seams of truck trailers while they are parked against the building during loading and unloading. Water on the floor also can become a problem if lift trucks are taken into the yard to retrieve materials or supplies and moisture is tracked in. Only pneumatic tire lift trucks should be taken into the yard owing to the likely uneven surfaces that will be encountered. Materials could be left at a staging area where solid-wheel lift trucks are used to retrieve the product from that point, lessening the likelihood of tracking the water.

A simple slip meter device can be used to measure the floor coefficient of friction. Although typically used for pedestrian slips and fall assessments, a baseline floor coefficient of friction can be used to determine the adequacy of cleaning practices if there is a significant decrease in the slip meter rating from one safety observation to another. The lift truck stopping distance can be affected if dirt and dust residues accumulate on the floor, affecting the lift truck tire traction. According to NIOSH document 2012-103, there is a one in one million risk of slipping on a floor when walking straight where the floor has a coefficient of friction of 0.36 or greater. The author routinely recommends a floor coefficient of friction for dry floor surfaces of at least 0.50, as this is what ASTM D 2047 recognizes as providing a non-hazardous walkway surface.

14.4.5 Overhead Hazards

Safe clearances to overhead objects such as pipes, roof supports, and gas lines are generally static and their positions do not change. Lift truck operators should be aware of them within the plant and environment and this is part of required lift truck training. Lift trucks should not be driven except with forks at their lowest point. In the event of any clearance change due to pipes or racking systems, drivers should be educated and made aware of these changes, and height clearances marked. A case in point would be rack storage systems installed that span a wall opening used by lift trucks. The reduced clearance now begins before the lift truck reaches the wall opening.

14.4.6
Other Safety Observations

Some safety observations in determining safe or unsafe conditions do have a subjective element. As much as possible, the subjectivity of the observations has to be eliminated. For example, when making the safety observations for sounding horns at intersections and other critical areas, these areas have be defined so that the observer knows whether the lift truck operator has to sound the horn in a particular area. For safety observers to make safety observations adequately they have to participate in the same training that the lift truck operator receives. This applies to both understanding the lift truck and understanding the work environment.

14.5
Loading Dock Safety

The loading dock of any industrial plant truly is the "bottom of the funnel" before the product leaves the plant for the customer or its next destination. Literally, nobody should stand in the way of the lift truck operator in getting the product into the waiting trucks. In the authors' opinion, to prevent lift truck and pedestrian collisions, there should be restrictions in the loading dock area that either limit or prohibit the number of pedestrians in this area during heavy periods of loading and unloading. Based on each business work schedule, it is feasible to restrict pedestrians from the loading dock area when known scheduled loading and unloading of trucks are being conducted. Obviously, pedestrians such as supervisors and truck drivers and others have legitimate reasons for being in this area; however, their travel can be controlled to designated walkways where there are either physical barriers or floor markings that the pedestrian has to stay behind and the lift truck operator knows are permitted pedestrian areas. Figure 14.1 illustrates a physical barrier and floor markings where an office door opens into a dock area.

Periods of very high industrial lift truck travel that are known and predictable based on loading schedules and work volumes can be designated times when no pedestrians are permitted in the loading dock areas.

If the lift truck operator is dependent on anyone to ensure their safety, it is the truck driver whose truck the lift truck operator is loading. Often the safety of the lift truck operator is completely dependent on the actions of a complete stranger. If the trucks being loaded at the loading dock are those of a common carrier or independent hauler, it may be the only time when the driver comes to this particular

Figure 14.1 Physical barrier to protect pedestrians.

dock. There are known safety protocols for loading trailers at loading docks. First and foremost is ensuring that the combination trailer and tractor power unit at the loading dock is parked securely and precisely flush against the building and the edge of the loading dock. Truck tractors should never be permitted to idle while the truck trailer is being loaded. Technology has come a considerable distance in the case of loading docks that have truck restraint systems. Restraint systems employ a hook interlock design to immobilize trailers in place to prevent the trailer from moving away while the trailer is being loaded.

Although restraint systems are a valuable safety control, currently they are not an OSHA requirement. It has been observed by the authors that businesses that are in the fulfillment and warehousing and distribution industry typically will have these, but manufacturers and other businesses whose loading docks are not used as regularly generally do not have these systems.

There is nothing wrong with redundancy. The traditional chocking system of keeping truck trailers in place can still be used even with dock restraint systems.

OSHA Standard 1910.178 states: ''Brakes shall be set and wheel blocks shall be in place to prevent movement of trucks, trailers ... and that fixed jacks may be necessary to support semi trailers during loading or unloading if the trailer is not coupled to a tractor.'' The standard does not specifically state who is responsible for this. Management should ensure that a designated person is doing this. One person should have the responsibility for dock safety. It may not be realistic to expect the lift truck operator to perform dock safety functions, however, in the absence of a management directed and dedicated person, the lift truck operator should make sure all the essential dock safety items are in place. Consider other safeguards to make dock safety as reliable as possible. For example, place bright orange cones in front of the tractor power unit, visible to the truck driver from the driver's seat so he will know if loading is still in progress and that departure cannot be made until after the cone has been removed. This can be done the same time the chocks are removed, and only removed by a designated person(s) in charge of dock safety. It is noted that in going to and from chocks for placement and removal, if this is the lift truck operator's responsibility, can have hazards from this task. For example, it is important to provide a set of stairs with a good hand rail and non

Figure 14.2 Dock leveler between truck trailer and concrete loading dock.

slip treads with a weather covering canopy to prevent slip and fall accidents. Some docks may only have a fixed ladder for coming out of the dock area. This may not be used readily, motivating employees to jump instead of using the ladder, placing the cone in front of the tractor to alert the driver not to pull away from the dock until the cone is removed is analogous to utility companies, who will employ this cone technique behind a parked truck as it forces the driver to check behind the vehicle before moving to prevent backing accidents.

The same concept of providing motivational reminders, cones, or signs, that the dock is not safe can be used in front of the dock to alert lift truck drivers not to enter a tractor. These signs or cones can be used until the trailer is ready to be loaded. Some restraint systems employ green and red lights as indicators for safe or unsafe, and this concept is the same if a restraint system is not present.

The loading dock floor and truck trailer interface should be as smooth as possible. Dock leveler devices integral to the loading dock are mandatory devices to ensure a smooth transition. Dock levelers should regularly be inspected to make sure they are adjusted to the correct height. Whole body vibration (WBV), discussed later in this chapter, really takes a hit if every pass over the dock-trailer seam results in vibration to the truck operator. There is no OSHA standard mandating color contrasting the edge of loading docks, but doing this, and providing extra task type lighting at the loading dock will facilitate a safety culture and prevent collisions with the sides of loading docks. The following is a photo of a typical dock leveler device (Figure 14.2).

Truck trailers are dark, cavernous places, and many dock loading operations take place in the early hours of the morning. It should be standard protocol for the lift truck operator to inspect the trailer before loading, and the lift truck should be equipped with headlights to ensure that there is good visibility within the truck trailer. Referring back to our over the road vehicle analogy, daytime running lights have become standard and common place with automobiles; the question has to be asked, what is the downside or negative to adding lights to fork trucks for *all* types of loading and travel activities? Lights increase the truck's visibility in addition to providing illumination in the areas where the truck is operating. OSHA does mandate that where general lighting is less than 2 lm ft^{-2}, auxiliary directional lighting should be provided on the truck.

14.6 Whole Body Vibration

Employee injuries from collisions with fork trucks are real and apparent. Much less apparent is the phenomenon of WBV and the risks it presents. ''Vibration related disorders of mechanical stresses resulting from constriction of blood vessels are listed as a cause of musculoskeletal trauma'' (Fleeger and Lillquest, 2006). Currently the ANSI standard for Powered Industrial Trucks, ANSI/ITSDF B56.1-2009, does not specify limits on WBV. ''Long-term exposure to WBV is harmful to the spinal system, but due to limited numbers of epidemiological studies, firm dose–response relationships are undetermined'' (DiNardi, 2003).

Fork trucks do not have suspension systems. The reason is simple: stability is paramount in fork truck design. Preventing turnovers and other similar incidents due to the weights these machines move is the overriding design criterion.

The reason why the safety or loss prevention engineering professional has to be aware of WBV as a potential hazard is that various government and other agencies recognize it as an occupational hazard:

- As per NIOSH document 2006-140, human exposure to vibration remains a major risk factor associated with vascular, neural, and musculoskeletal disorders.
- Cumulative trauma is an occupational illness under OSHA definitions.
- The American Conference of Governmental Industrial Hygienists (ACGIH) has set limits on WBV to which nearly all workers may be repeatedly exposed with minimum risk of back pain and adverse health affects to the back.

Measuring and quantifying WBV is possible, but in reality it requires special equipment and expertise. WBV in conjunction with other risk factors, such as cold temperatures and sitting for long periods of time, may increase the likelihood of musculoskeletal disorders. WBV is measured and limits are established for three different directional axes including an axis measured from foot to head where, most likely, lift truck operators would experience vibration. ''The loss of the 'S' shape in sitting may be one of the reasons drivers of vehicles who are exposed to vibration in the vertical plane, or z-axis, are so prone to back trouble'' (Bridger, 2009). ''The following good work practices may also be useful for workers operating vehicles: avoid lifting or bending immediately following exposure, and use simple motions with minimum rotation or twisting when exiting a vehicle'' (ACGIH TLV, 2012 (Threshold Limit Value) and BEI (Biological Exposure Indices) TLV Booklet).

In a review of 33 industrial lift truck accidents reported as workers' compensation insurance claims between 2005 and 2011, the most frequent and costly injury type was strains and sprains, and the most costly and frequent accident cause was lifting. Other details were not available as to what the lift truck operator was doing, or what the ratio of lift truck operation to manual lifting was. However, the safety or loss

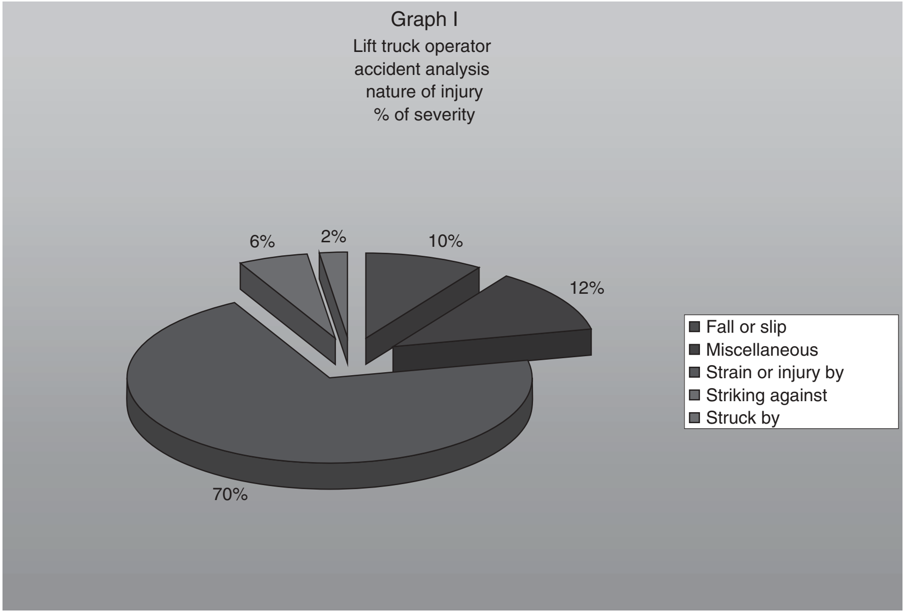

Figure 14.3 Lift truck operator cost of injuries by nature of injury.

prevention engineering professional has to be keenly aware of the effects of WBV, continual sitting, and the musculoskeletal affects that these present, especially when a subsequent lifting task is presented. Figures 14.3 and 14.4 show the nature of injuries experienced by lift truck operators, and the cause factors contributing to these lift truck operator occupational injury trends (data courtesy of Fireman's Fund Insurance Company, used with permission.)

With regard to sprains and strains and lifting and bending, the safety professional has to be looking continually for ergonomically friendly safety opportunities. For example, lift trucks that are electric powered have to be continually recharged to restore battery electrical power (see Figure 14.5). Charging stations can be arranged where the charging station and cables are mounted above the floor level with the lift truck battery height such that the cables can be accessed and connected to the lift truck batteries without any extra bending of the upper torso.

One final and most important aspect of WBV that has to be considered is that there can be a ''thin line'' between cumulative vibration and a floor or dock irregularity height difference that if hit can cause loss of control of the lift truck vehicle. Remember that lift trucks do not have suspension systems. Dock areas especially should be inspected to make sure that the leveler is flush with the truck trailer. Other transition areas such as different warehouse sections should also be inspected and made flush to avoid excessive vibration or a potential loss of control of the truck. WBV due to conditions such as those at the docks or between building areas could be precursors to a much more serious accident if the condition causes a lift truck accident.

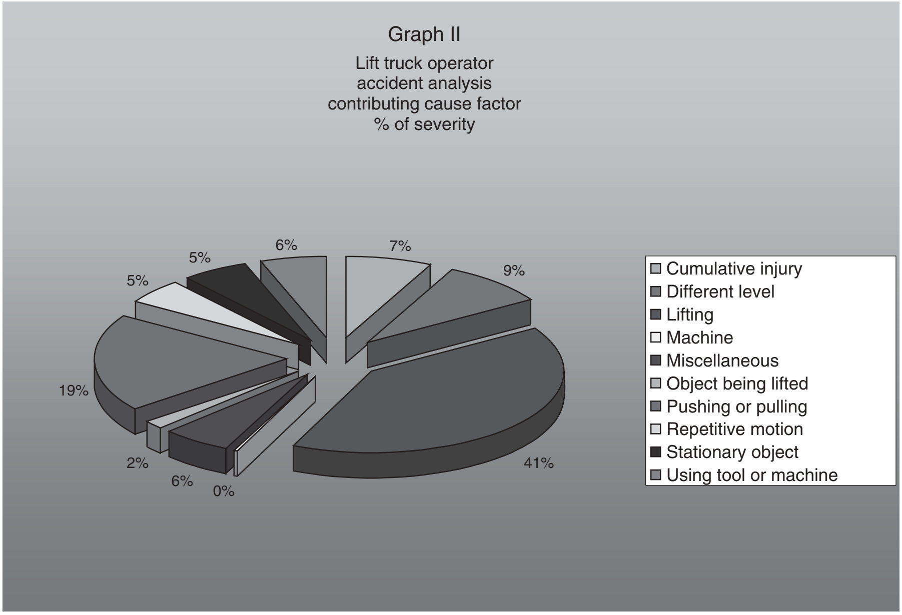

Figure 14.4 Lift truck operator injuries: contributing cause factors by percentage of cost.

Figure 14.5 Ergonomically positioned battery charging station.

14.7 Administrative Controls for Lift Truck Operator Strains and Sprain Prevention

Stretching and flexing exercise programs, diet, and wellness under the supervision of a physical therapist, nutritionist, and other qualified individuals certainly have a place in a safety and health program in preventing sprain and strain and work-related musculo-skeletal disorder (WMSD)-type injuries. Another control measure is job rotation. If operators are qualified to operate both stand-up and sit-down types of lift trucks, job rotation can be considered if skill levels can be maintained. In addition to removing the lift truck operator from the postural stress presented from sitting [lumbar disc pressure of 100 for standing versus 125–150 for sitting (Bridger, 2009)], another benefit of job rotation is that it will allow the employee to perform potentially more challenging and diverse tasks. NIOSH publication 2004-135 cites effective use of job rotation in a meat packing plant.

Technology is improving in the area of lessening WBV. Some lift truck manufacturers are now offering suspension seats to offset the complications of WBV. Recognizing this hazard and integrating safety controls such as suspension seats and stretching exercises are important, especially if lift truck operators have lift truck driving exposures for the duration of their work shift. ''One study on lower back pain in forklift workers concluded that a facility approach, improvement in seats and tires, was more effective in reducing lower back pain than a personal approach, the latter of which consisted of exercise, lumbar supports, and other means'' (Shinozaki, 2001). A tire replacement program is alluded to as part of a good preventive maintenance program following manufacturers' guidelines.

14.8 Rack and Overhead Storage and Industrial Lift Truck Operations

If a facility has product and raw material storage areas, there are the hazards of lift trucks colliding with racks and pedestrians, and the potential for objects falling on to the lift truck operator.

Most storage areas are set up in a similar fashion with products being stored in racks or solid piles. Rack storage of product tends to be more organized than loose, solid pile storage arrangements. Racks are fixed in place, and storage of raw materials and finished products tends to be more orderly than solid pile storage where there is the option of storing the product in a manner suiting the lift truck operator. Rack storage automatically creates aisles and pathways that can be maintained and kept open for safe lift truck operation. Rack storage usually means that product is being stored in the racks on top of pallets. Pallets, of course, allow for easy retrieval of the product from the racks (Figure 14.6).

Some safety considerations to include in rack storage design include the following. Maintain wide aisles for safe fork lift operation. If the facility can afford to have wider aisles, it accomplishes several things. The first is that it allows greater maneuverability space for the lift truck. It also has property sprinkler safety implications as product rack storage is less dense, requiring less sprinkler design density (e.g., 8 ft versus 4 ft aisles: In one scenario involving storage of class III commodities [according to the National Fire Protection Association (NFPA), class III commodities are products fashioned from wood, paper, natural fibers, etc., with or without cartons, boxes, or crates and with or without pallets] stored to 20 ft, the required sprinkler density for that facility would be a 12% greater water density

Figure 14.6 Typical palletized rack storage.

Figure 14.7 Rack support damaged by a lift truck.

requirement measured in gallons per minute per square foot. This is per NFPA 13 Installation of Sprinkler Systems.

Rack upright supports, especially corner and end locations, should be anchored to prevent rack and product collapse in the event of lift truck collision. An additional safeguard is to color contrast, in bright yellow or orange, the corner rack supports that are most likely to be struck. These corner locations can also be protected by concrete or metal pylons. Damage or scratches to these may indicate lack of control of lift truck vehicles (see Figure 14.7).

If the facility has the luxury of establishing directions of travel, this is a design consideration that may prevent collisions. This can be augmented with signs that state ‘‘do not enter’’ or there may be arrows on the floor showing the intended direction of travel, which will direct lift truck traffic flow (see Figure 14.8) – to promote safety

Figure 14.8 Directional travel.

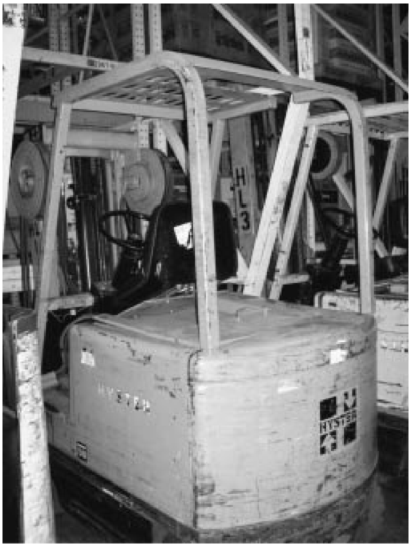

Figure 14.9 Overhead guard protection.

through design, and to motivate employees to behave safely, signs such as directional signs, speed limits, and caution signs reinforce safe behavior. Drivers can be trained to understand which aisles to travel down and which path to take on the return trip. These practices do take time and consideration, but with the right planning and workplace design, they could be valuable design factors that prevent collisions.

If product and materials are removed from pallets manually and partial pallet loads are placed back in racks, a good safeguard is to secure via shrink wrap or other means loose items that could fall between the vehicle driver's enclosure roll-over protection (see Figure 14.9). Also, if aisles are wide enough, lift trucks traveling in the same direction should not be able to pass unless all lift trucks have appropriate overhead guard protection.

Lift truck load capacities are predicated on the maximum lift height of the lift truck. The manufacturer's load design plate specifically states the weight and load height limitations. Most likely heavier loads are being stored on lower levels, possibly on the lowest level of the racking system. Racking systems should be designed commensurate with lift truck load capacities at full extension. This would apply if a racking system for product storage is being installed new where lift trucks are already in place. It may be necessary to evaluate lift truck capabilities to ensure safe lifts from the highest anticipated rack heights and lift loads. The proper lift truck, with manufacturer design load and lift height limitations, has to be commensurate with the workplace storage designs. This can be a targeted safety observation if there are concerns about the load weight and lift height by comparing these with the lift truck design plate.

If pedestrians have to be in rack and other storage areas for purposes such as inventory or inspection of product, their presence should be communicated to lift truck operators. Signs, or cones placed in aisles where inventory is being done, for example, would prevent lift truck operators from using that aisle until the inventory work is completed. This may seem excessive in terms of administration and effort; however, the consequences of allowing lift trucks to operate while pedestrians are present in the same work area have to be considered.

14.9 Carbon Monoxide and Dilution Ventilation

These two items are interrelated. Elevated levels of carbon monoxide (CO) are indicative of a plant environment that is not properly ventilated. CO is generated due to incomplete combustion. Carbon fuel-burning industrial lift trucks that may need engine work, such as propane fuel lift trucks, can contribute to elevated CO levels. The ACGIH has established a TLV 8 h time-weighted average (TWA) of 25 ppm. Other sources of CO can be improperly ventilated natural gas heaters and even loading dock trucks whose exhaust is brought back into the plant via fresh air make-up points. ''Carbon monoxide is an odorless, tasteless, invisible gas that has a high affinity for oxygen-carrying blood hemoglobin, and can cause death by asphyxial hypoxia if present in levels that are excessive'' (Williams and Burson, 1985).

The effects of CO should be part of the hazard communication program and symptoms at low levels of CO include headaches, dizziness, fatigue, shortness of breath, and nausea. Employees who smoke are already predisposed to the effects of CO due to having elevated levels of carboxyhemoglobin (COHB). Smokers can have 4–10 times the COHB levels of non-smokers. ''In the general non-smoking population when CO exposure levels do not exceed 25 ppm, COHB levels are in the range of 0.3–0.7%, while for smokers it is 2.0–3.0%'' (DiNardi, 2003). This health effect is relevant given that excessive exposure to CO could adversely affect the lift truck operator's ability to control the truck.

Fortunately, most industrial environments are such that there are high ceilings, open dock doors, and large open spaces due to storage where fork trucks are used, allowing for dilution of CO. CO is ubiquitous and mixes freely with the air. Where there may be a concern about CO from lift truck operations due to smaller spaces and heavy lift truck traffic, or during the winter months when there is less make-up air from open dock doors, the plant ventilation system should be set up to ensure proper plant environment air exchanges to allow for dilution ventilation. Alternatively, the more simplistic and desired approach would be to replace the propane fuel-type truck with an electric truck.

If exposure to CO is a real potential, and electric lift trucks cannot be utilized, industrial ventilation guidelines for air exchanges and fresh make-up air in cubic feet per minute per building occupant should be followed.

14.10
MVR Program and Physical Requirements

Industrial lift truck operators should be managed like any other vehicle operator. Industrial lift trucks are vehicles for moving materials. There is a higher injury severity potential for an individual who is operating a 6000 lb loaded vehicle than an employee who is putting boxes of blue cheese-stuffed olives on to pallets. In other words, the consequences of a mistake are much greater with the industrial lift truck operator. Any fleet safety program for over the road trucks will have a motor vehicle record (MVR) program as an integral part of their overall safety program. The significance and correlation are that management should be aware of industrial lift truck drivers who have had their driver license revoked or suspended due to excessive accidents or serious moving violations such as driving under the influence of alcohol or drugs (DUI) or reckless driving. There is a good chance that most businesses that have fork lift operations also have a fleet of vehicles for which they have an established MVR program. It is recommended to include the lift truck drivers in this program. Many insurance companies have established MVR criteria that could be adopted and implemented.

The following is an excerpt from advice given by a safety and health consultant to the manager of a large commercial vehicle fleet business who was questioning the need and reasons for having an established MVR program. Management of the company viewed the MVR program as a hindrance and excessive regulation to operating their vehicle fleet:

> Per your request about MVR programs, I want to respond to let you know what my position is:
> MVR programs following strict MVR guidelines for vehicle moving violations and accidents are a requirement that will help you maintain a safe vehicle fleet. Our belief is that an MVR program is an essential tool for managing your vehicle operators. It benefits your company to maintain and adhere to the program because it lessens the likelihood of accidents by having qualified drivers on the road. There is a correlation between drivers with poor MVRs and higher incidence of accidents. This is the primary reason that the MVR program is a strict requirement. The benefits of an

MVR program are having fewer accidents and a more profitable delivery fleet by having fewer accidents.

Research has proven that accurate MVRs can help predict future crash involvement. As reported in the California Department of Motor Vehicles Research Division 1994 Report *An Inventory of California Driver Accident Risk Factors*, "Accident risk increases as a function of the number of accidents and citations on a driver's prior record." The data for the study were developed by analyzing the MVRs of over 200 000 California drivers over a 12 year period.

The same applies to industrial lift truck operators. It would be negligent entrustment to allow an operator to drive an industrial lift truck without first doing an extensive check of that individual's driving record. Although third-party liability exposures are not necessarily present, there is this potential for third-party liability to visitors to the plant such as common carrier drivers or to temporary employees who are co-workers with lift truck operators but technically are third-party persons who have been hired through an employment agency.

Just as important as MVR programs in managing lift truck operators is the need to ensure that employees are physically able to operate the lift truck. One approach is to include lift truck operators in a once every 2 years program to receive Department of Transportation-type physical examinations. This would include tests of hearing, sight, blood pressure, and other critical health parameters that could contribute to an accident if not taken care of by medical intervention. For example, individuals who have myopia can see close-up objects, but "experience difficulties with tasks such as driving where the target objects are more than 5–10 m away" (Bridger, 2009). Lift truck operators too could be part of a drug testing program.

14.11 Case Studies

The following case study incidents are presented for the purpose of demonstrating what kind of safety observations can be made to identify potential accident causes.

14.11.1 Case Study 1

14.11.1.1 The Events

In a large printing operation, an employee using a clamp forklift truck was transporting two waste-paper bales from the scrap paper area. One paper bale (~0.5 ton) was placed on top of another 1 ton bale; however, the top bale was not strapped to the bottom bale. As the forklift driver made a turn, he had to brake suddenly for a nearby pedestrian. The sudden stop and turn caused the top bale to fall off and strike the pedestrian. A review of the accident showed that the forklift operator was trained and certified, but the employee was in an area where pedestrians were prohibited according to plant safety rules.

14.11.1.2 Preventive Measures

- Establish a policy that only loads in the clamp device can be handled.
- Physical barriers need to be installed if pedestrians have to use this portion of the building; alternatively, pedestrian traffic needs to be rerouted to a different area of the building if physical barriers cannot be installed.
- Although the lift truck driver was trained, a safety observation program to reinforce safe behavior, such as traveling in reverse when views are obstructed, needs to be implemented.

14.11.2 Case Study 2

14.11.2.1 The Events

At a dairy production plant, a tractor-trailer rig backed into a loading dock to offload its supply of packaging materials. During the operation, a warehouse manager told the truck driver to move his rig to another bay. The driver jumped into his cab and started to pull away, not knowing that a forklift operator was still in the trailer. Just as the truck moved forward, the forklift operator backed up and fell out of the open trailer.

14.11.2.2 Preventive Measures

- Establish a policy that truck drivers cannot be in cabs during loading and unloading once trailers are properly positioned in place.
- Lift truck operators need verbal or visual confirmation that truck and trailer are secured in place, the truck driver is out of the tractor, wheels are chocked, and it is safe to load. This should be the responsibility of a dock manager or other person.
- Restraint systems to lock the trailer in place could have prevented this tragedy. If a restraint system is not available, only a designated person, other than the truck driver, is authorized to remove the chocks.
- This case exemplifies the importance of the lift truck operator or one specific designated person being in charge of chocking and controlling the departure of trucks. That person in charge could have done the necessary chocking, restraint system (Interstate Commerce Commission (ICC) bar interlock), and verbal and physical communication to the lift truck operator that it is now safe to unload the truck. Physical communication may be as simple as removing a cone or other warning device from the bay door to demonstrate that it is safe to enter the trailer.

14.11.3 Case Study 3

14.11.3.1 The Events

A heavy load of lumber badly hurt a lift truck operator while she attempted to dislodge an obstruction from the underside of a pallet. An investigation determined that the operator apparently climbed between the mast and underside of the pallet to remove an obstruction (there were no witnesses to the incident). Either she slipped, or the load shifted, catching her under the pallet that was stacked with lumber. The operator had been doing the job for 15 years, with over 10 years behind the wheel of a forklift. Her training was current and she had an excellent safety record. The employer, a kitchen cabinet manufacturer, had never experienced a serious accident such as this in 40 years of business.

14.11.3.2 **Preventive Measures**

- Establish defined safety procedures (assistance, other equipment, etc.) if a load cannot be safely removed or placed in a rack.
- Behavior and environmental factor-type inspections focusing on changes in environmental status could have identified obstacles to safe load removal such as objects not properly stored in racks. This would have pre-empted the lift truck operator taking action on her own.

14.12
Using Acceptable Safety Tolerances in Defining Preventive Maintenance

As a starting point, an effective preventive maintenance program will follow manufacturers' guidelines. Mechanical failures can contribute to lift truck accidents. The variables listed below should be assessed during inspections and during scheduled preventive maintenance. Where practical, lift truck safety parameters should be quantified during mechanics' inspections of lift trucks. Lift trucks that are being used on multiple shifts should receive pre-shift inspections. This is per OSHA 1910.178.

Some important lift truck mechanical parameters that possibly can be quantified or deemed safe either via trained staff or manufacturers' representatives include:

- Tire wear.
- Steering tolerances acceptable.
- Manufacturer-approved replacement parts and components.
- Mast control lift response.
- Inspections of hydraulics.
- Maximum mast height does not exceed the lift truck specification plate.
- Tilt tolerances acceptable.
- Stopping distances met at prescribed speeds as per the lift truck design.

Comprehensive inspections and preventive maintenance by mechanics have to be augmented by daily or pre-shift inspections. These inspections will identify and report any damage or issues; however, operators have to report all lift truck incidents even if damage appears minor. Where lift trucks are deemed unsafe, an authorized person should lock out the vehicle to prevent it from being used. Hour counters should be used according to the manufacturer's recommendations for wear items to preclude equipment breakdowns. One of the indirect negative consequences of equipment breakdown and out-of-service issues is that it may precipitate the use of other equipment for a purpose for which it was not intended to be used.

14.13 Industrial Lift Truck Accident Costs

Historical loss and accident data (employee injury potential) related to lift truck accidents should be the primary reason for adopting lift truck engineering and design practices that will lessen the likelihood of lift truck accidents. This justification for adopting safety preventive measures can be strengthened by understanding the financial costs associated with lift truck accidents.

There are tangible costs associated with having lift truck accidents and they are explored in this section. Typically when discussing loss costs associated with industrial lift truck accidents, costs are separated into direct and indirect costs. Indirect costs are downtime due to accidents, replacement personnel, and equipment due to accidents, delayed deliveries, and so on. Indirect costs can often equal or exceed the direct cost of funding for accidents. Direct costs include the physical damage to equipment and product, and the medical and indemnity costs associated with the lift truck operator's injuries. To fund these indemnity and medical costs, it is typically done through some type of workers' compensation insurance mechanism. The following is a brief synopsis of funding for industrial lift truck accidents, and the safety professional needs to understand the financial impact that lift truck accidents have on a business. As much as it would appear that lift truck safety control and prevention measures, such as an integrated behavior and workplace design approach, would stand on their own merits, the reality is that the cost of lift truck accidents has to be demonstrated to justify the time and expense of implementing some of the lift truck safety controls proposed.

Funding for workers' compensation is a statutory requirement. Most small- to medium-sized businesses purchase workers' compensation insurance via a guaranteed cost program. This is an insurance program where the business pays a set premium, and no matter what the costs incurred from accidents are, there are no immediate economic ramifications. There is no limit on the amount of payout that a guaranteed workers' compensation insurance program will pay. The eventual ramifications of frequent and costly lift truck accidents are significant and they are explained below.

Larger businesses that are paying over hundreds of thousands of dollars in workers' compensation premium because of their larger payrolls are eligible for some form of self-funded insurance program. One such program, for example, is known as a ''large deductible program.'' In such a program, a business assumes the cost of lift truck accidents up to a set limit, for example, up to $500 000. Above this amount, an insurance mechanism through commercial insurance is provided to cover the extra costs. Typically, the large deductible program, like the guaranteed cost program, is purchased through a commercial insurance carrier. With the large deductible program, the industrial lift truck accident costs are apparent and obvious. All money paid to cover medical and indemnity costs associated with an accident is dollars that cannot be used for other business purposes. It behooves companies with self-funded insurance programs to control their costs and accidents because they are paying for their own accident costs up to a predetermined limit! These companies have a financial stake in their own performance.

The majority of businesses are insured through a guaranteed cost type of workers' compensation insurance program. The consequences and costs of having lift truck accidents with this type of program are less apparent, but they are real. The amount that any business pays for their workers' compensation insurance is based on a class rate, and that class rate applies to all like businesses, for example, all warehouse and distribution companies or all fulfillment companies, two business types that use lift trucks heavily. The workers' compensation premium is based on the total payroll and a class workers' compensation rate (rate is expressed as a dollar amount per $100 of payroll). This is where the economic impact comes in: accident costs due to lift truck accidents, although they do not have a theoretical limit, do have an impact on how much premium a company pays. The premium paid by a company is modified by their accident experience, and therefore is known as their experience modifier. Experience modifiers can be credit or debit modifiers. Modifiers can range anywhere from less than a 0.75 credit modifier to greater than a 1.50 debit modifier. What this means is that two identical companies, each paying the same base rate insurance premium, will be paying significantly different total premiums.

14.13.1 Example

Company Z and Company X both pay workers' compensation premiums of $100 000. Company Z has a debit modifier of 0.6, and company X has a credit modifier of 1.6. The net affect of these company's modifiers is that Company Z pays $60 000 in workers' compensation premium and is rewarded for its consistent safety experience. Company X pays $160 000 in premium as it is expected that this much premium will be needed to pay for *future* accident costs based on their past accident cost performance! It is apparent which business will have more money to invest in new lift trucks and other safety controls.

14.14 Conclusions and Establishing Safe Behavior Observation Management Programs

One unsafe behavior can cause an accident (Figure 14.10). As can be seen in the preceding paragraphs, we can affect behavior through equipment and plant engineering design. The effect that the environment design has on lift truck operator behavior cannot be overstated. In effect, we are motivating via workplace design

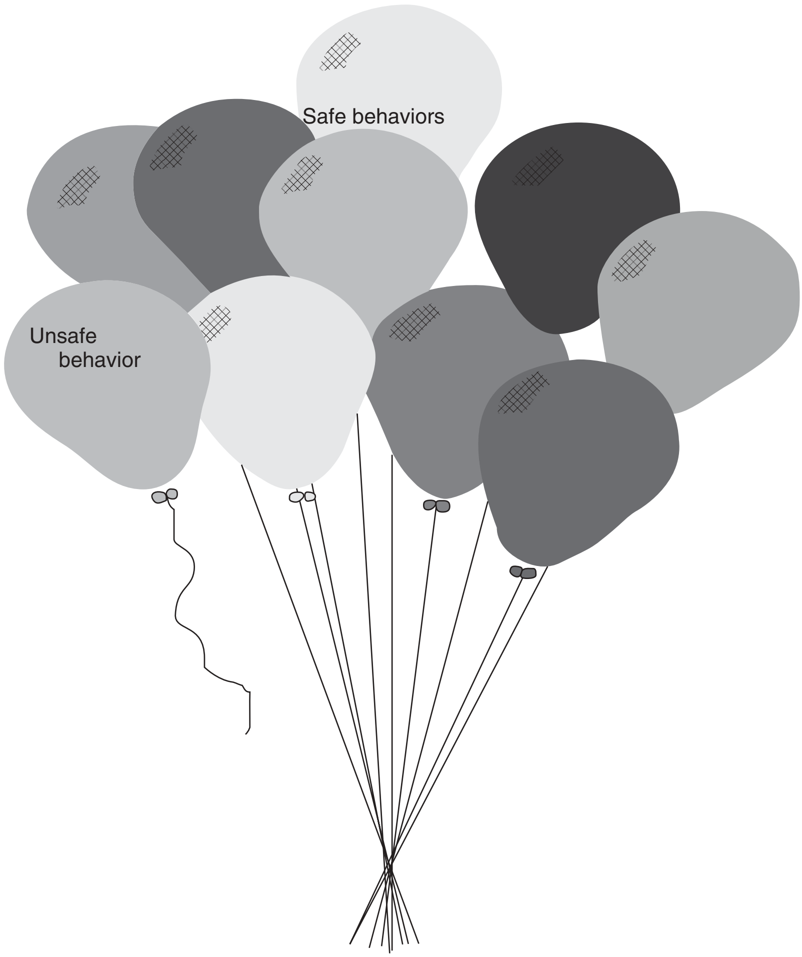

Figure 14.10 One unsafe behavior can cause an accident.

and conditions. As we cannot affect behavior through workplace and environment design to influence lift truck operator behavior, we then have to intervene and reinforce safe behavior. OSHA 1910.178 I, 4, ii, A, B, and C Refresher Training and Evaluation define the requirements of when refresher training and evaluations are mandatory for lift truck operators. Training is a form of motivational intervention where basic safe operating principles can be reinforced.

Training does not have to be a lengthy sit-down classroom session. Safety training can be very effective through short, concise training sessions. One approach is to have review meetings after safety observations have been made. Safety observers who are making the safety observations are individuals who have also been trained initially in lift truck safety, and are making observations focusing on the areas defined in this chapter. Safety observers should set a goal of a set number

Table 14.1 Safety observation worksheet.

Safety observation	Number of observations	Number safe	Number unsafe
Lift truck type			
Travel with forks at lowest safe level			
Hands, arms and head inside truck			
Established direction of travel being followed			
Additional observations . . .			
Totals			

of observations of the key behaviors that could cause an accident. All safety observations can be collected and tabulated and reviewed by the safety professional. Results and analysis can be shared with the lift truck drivers. Care has to be taken to ensure that observation findings are not accusatory or personal. The goal is to increase the percentage of overall behaviors that are safe.

Incentives in the form of monetary awards, bonuses, catalog gifts, and so on, do have a place in motivating lift truck operator behavior. Lift trucks have hour counters. One approach is to evaluate safe behaviors based on lift truck hour operating time. Traditional incident rate approaches based on man-hours worked can be used; however, translating man-hours into lift truck-hours may make it more tangible to the lift truck operators. Ideas solicited from lift truck operators to make their peers operate more safely may be more readily accepted and implemented.

A safety observation worksheet approach as shown in Table 14.1 can be used by safety observers to record and document safety observations that are made.

The safety or loss prevention engineering professional should quantify the level of lift truck safety performance that they will accept, and preferably that level of tolerance is no unsafe behaviors. The closer safety observations get to 100%, the more confidently we can predict safety results. Given the nature of lift truck accident trends, low frequency but high severity, this approach attempts to quantify the effectiveness of our safety training, our workplace design, preventive maintenance, and all other safety criteria. This approach provides the safety professional with continual feedback confirmation as to how effective their safety efforts have been.

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