Introduction

The Occupational Safety and Health Administration (OSHA) estimates that approximately 95,000 injuries occur each year due to forklifts. The estimated number of forklifts being used in the United States is determined to be about 800,000. This means that about 12% of the people using forklifts are being injured each year. This is a staggering statistic. Other sources have found that there are about 20,000 serious forklift accidents each year. 100 people are killed each year in a forklift accident. Some sources find that lift overturns are the greatest hazard to forklift operators. Tip-over accidents are usually caused by turning a forklift at excessive speeds, traveling with a raised, unbalanced load, and striking an object. Many forklifts on the market are three-wheeled lifts. These lifts are used because they are cheaper than four-wheeled lifts. Unfortunately, the three wheeled lifts are much less stable and more prone to over-turns than four-wheeled lifts. Equally as hazardous, in this author's opinion, are the numerous pinch points created by the mast of a forklift. The mast of a forklift is designed to raise and lower tremendous amounts of weight. To perform these duties, the lifting mechanism must be powered by a high level of energy. Any accident involving the mast of a forklift is likely to be very serious. People are killed when they get crushed between the forklift mast and the operator cage, between a stationary part of the mast and a moving part of the mast, or between the lift mast and a stationary object.

One study found that nearly 45% of all injuries due to forklift accidents occur from pedestrians being struck by forklifts. Many factors contribute to pedestrian accidents, including visibility issues for forklift drivers, plant layout, driver inattention, and inadequate safety systems.

These statistics indicate that problems exist in forklift design. Any product with such high injury rates and sheer number of injured users should be examined thoroughly to determine how the hazards associated with the product can be better controlled.

The authors have been involved in numerous product litigation cases involving forklift accidents. These accidents have driven us to research forklifts and forklift safety design. This product litigation manual is an excerpt of the authors' research on forklifts. Topics covered in this manual will be design priority, types of forklifts, forklift accidents, design hazards, standards, history of lifts, and control design.

Chapter 1 – Keeping People Safe

The American Society of Mechanical Engineers' (ASME) code of ethics states as its first fundamental tenant that "Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties". The American Society of Agricultural Engineers (ASAE) includes this code of ethics within its constitution. It is clear that keeping people safe should be the first and foremost design parameter for any engineering project.

The first step in creating a safe product is identifying any potential hazards associated with the product. Once hazards associated with a design are identified the hazards must be controlled to prevent injury to the product users. Identifying hazards early in the design phase of a product is essential, since the original design can be changed if the hazards are identified before prototype production. Identifying hazards after a design has been finalized is asking for trouble – changing the design of the product will be costly at this stage.

The design process that deals with hazard control is often referred to as the Hierarchy of Safety, design priority list, and other names. The process describes basic engineering principles on hazard control. It involves different priorities for controlling a hazard. According to the Accident Prevention Manual by the National Safety Council the following priority list must be followed with any product design:

- Priority One: eliminate hazard in design
- Priority Two: use guards to neutralize hazard
- Priority Three: use warnings to prevent exposure to hazard
- Priority Four: train user in safe operation
- Priority Five: protect user from hazard with protective clothing and gear

Whenever possible, engineering and design work should use the highest priority according to this safety protocol. The first two priorities relate directly to a change in the physical design to eliminate or guard against any hazard. These are the best solutions and are the most effective. The last three priorities really deal with modifying people's behavior and are less effective than the higher priorities. The final option in the design priority is to protect the product user with protective clothing, eyeglasses, face shields, or other protective measures, depending on the actual hazard.

The design priority list, or hierarchy of safety design, is a topic often referred to in product litigation cases. The design priority list is a hazard management tool to remove hazards from designs and keep any remaining hazards from causing harm to people. When designers fail to use the most effective hazard control method, their product may be found to be unreasonably dangerous. A big issue in product litigation cases is 'alternate design'. If the plaintiffs can show technology was available to produce an alternate design that is safer, the defendant's product is likely to be judged unreasonably dangerous. Another important reason for following the hierarchy of design, in addition to protecting the health and welfare of the public – money. A company that produces the safest product possible will be much more likely to win any product litigation cases than a company that produces a product with inferior, ineffective methods of hazard control.

Priority One:

The preferred solution to hazard control is to eliminate the hazard from the design and is the top priority in safe product design. The solution of designing out the hazard works for everybody, regardless of intellectual ability or physical capabilities. There is no need for the lower priorities if the hazard is eliminated through design.

Priority Two:

The second best solution to the problem of potentially dangerous products is to neutralize the hazard with fixed guards, automatic-stop devices, or other protective safety devices. In Priority Two, the designer cannot eliminate the hazard by designing the hazard away. The hazard remains, but something is done to reduce this hazard that doesn't require behavior modification of the product user. For example, the danger in a power saw cannot be designed away, but the saw blade can be covered with a guard.

Guarding is less effective and desirable than removing the hazard from the design and should only be used when the hazard cannot be removed. Guarding is not as effective as a hazard-free design, but guarding is more effective at controlling hazards than the third solution to hazard control, warnings.

Priority Three:

The third alternative is to provide warnings. If the hazard cannot be designed away or guarded away, warnings are the next option. Written warnings and pictograph warnings are the two warnings commonly found on products today. Warnings should never be used instead of a guard, if there is a way to guard the hazard. Hazards that cannot be properly guarded must be warned about. Warnings must be designed using established engineering principles, or the effectiveness of the warning will be less than ideal. A poorly designed warning may not communicate the nature of the hazard to the product user, how to avoid the hazard, and the consequences of not avoiding the hazard. An improperly designed warning can cause products to be judged "unreasonably dangerous" in product litigation cases. See Safety Engineering Resources' Warnings Manual for information on warnings and warning design.

Priority Four:

Lower yet in the design priority list of hazard removal is the development and implementation of operation procedures and employee training programs. When a hazard cannot be designed away, guarded away, or warned away, behavior modification is another alternative to hazard control. Training programs, whether in the form of instruction manuals or actual classes teach product users the proper operating procedures, what the hazards of the product are, and how to avoid the hazards. Many married people have had a lifetime trying the fourth alternative without success, and without diligence; it doesn't work well in training employees, either. Modifying peoples' behavior is a complex task involving many external variables, and the effectiveness of this design priority is low compared to the higher design priorities.

Priority Five:

As a last design priority, when a hazard cannot be designed away, guarded, warned against, or trained away, protective equipment and clothing should be supplied to the product user. This is the lowest design priority because it is the least desirable method to control hazards and is not as effective as other hazard control measures. While protective measures may provide some protection, any design that must rely on protective clothing as a sole solution to hazard control is going to be a very hazardous product. Obvious problems with this design priority include ensuring the user is wearing the protective clothing or gear. Unless the protection is attached to the product, it will get lost, exposing any future product users to the full force of the hazard. Any manufacturer that relies on this priority as a means of hazard control for their product can be expected to be challenged in court by experts who produce alternate, more effective hazard control measures.

A Railroad Overpass

A good illustration of the priority concept in design would be an example of how to protect cars from trains. The best and most effective solution is to eliminate the hazard by installing highway overpasses over the railroad. With this design priority, the hazard has been removed through design with an overpass. It is virtually impossible to have a train and car wreck with an overpass.

A Guarded Railroad Crossing

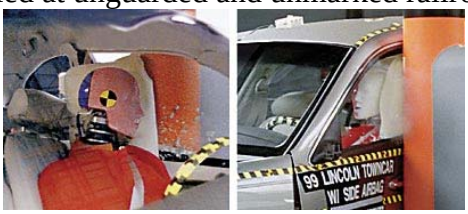
The next best thing is to provide a guard by having a railroad crossing guard that comes down with red lights flashing when a train approaches. This is the second design priority in preventing car and train accidents. This guard will prevent most accidents. Occasionally, someone will run through the gate or the gate fails. That is why this guarding solution is number two in the priority list.

A Railroad Crossing With Warning Sign

The next step downward in the design priority list is to warn by installing a typical railroad warning sign. This approach to safety is cheaper and obviously less effective than a gate or guard that blocks the highway. People will not see the warning sign or they may ignore the sign.

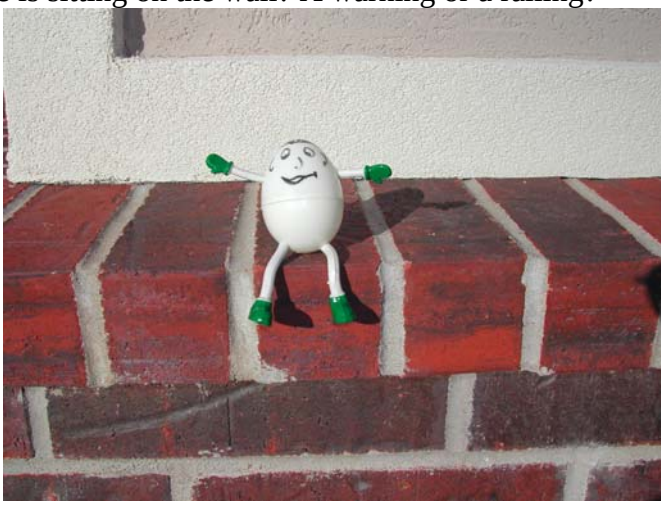
A Driver's Education Poster on Railroad Crossings

The next step downward in the National Safety Council's priority list is to provide training by having driver training classes. Behavior modification is a lofty goal that does not work very well for all people. New drivers are taught to stop, look and listen, but it is foreseeable that due to inattention, slips or gross errors, people will get killed at unguarded and unmarked railroad crossings.



When All Else Fails, Side Impact Air Bags

The nursery rhyme involving Humpty Dumpty is a child's first lesson in safety. What would keep Humpty Dumpty safe as he is sitting on the wall? A warning or a railing?



Humpty exposed to hazard

What would prevent the accident of Humpty where all the Kings' horses and all the Kings' men couldn't put Humpty Dumpty together again? If the designer of the wall would have used the design priority list, Humpty may have lived to sit on another wall. An engineer approaching the problem using the design priority would have tried to restrict access to the top of the wall. If this was not possible, a guard rail would be installed to prevent falls from the wall. This would isolate the hazard of falling by separating the hazard from the egg.

Humpty injured due to lack of hazard control

Obviously, this important concept of how to do safety design cannot be left to the whims of engineers and manufacturers. The engineering principles described in this chapter including design prioritizing must be followed to prevent injury and ensure that the life span of the product is not cut short by poor design.

With forklifts, applying the design priority list would result in forklifts that are as safe as possible. Some forklift hazards can be removed through design, while other hazards will not be removable through design. These inherent hazards, hazards caused by the function of the product such as lifting and transporting material, must instead be safeguarded. Some forklift manufacturers choose to not safeguard all possible pinch points and other hazards, instead relying on operator's manuals and training. This violates engineering design principles, and will inevitably result in accidents and injuries.

Chapter 2 – Background Information on Forklifts

This chapter gives general information regarding forklifts. Topics such as the different types of forklifts, uses for the different types, and the strengths and weaknesses of the different types will be explored. This information is useful as background for the rest of this product litigation manual, as well as providing attorneys with information to help with individual cases. An attorney who has a potential client come to him or her regarding a forklift accident will be versed in forklift theory.

Background Information

Forklifts can be classified by different methods including type of power source, operator position, and load engagement method. This chapter will be examining the general categories of industrial lift trucks, and a discussion of the strengths and weaknesses of each category will be examined.

Power Source

Industrial lift trucks can be powered by electric motors powered by large, heavy batteries, gasoline engines, diesel engines, liquefied petroleum gas powered lifts, or some combination of these power sources. Each power source has its own unique advantages and disadvantages. Electric motors powered by batteries are among the most common type of lift seen in industry. Electric motors do not produce the toxic exhaust that other power sources do, making it ideal for indoor use, particularly where there is insufficient exhaust or ventilation systems. A disadvantage of battery-powered lifts is the need for charging of the battery. The weight of lift batteries makes maintenance or replacement difficult.

Operator Position

The operator position is a topic of much debate in lift design. Operators may be placed at the rear of the lift, sitting on top of the lift, standing between the battery and the forks, or on an elevating platform. Each operator position has its advantages and disadvantages. Certain operator positions will always be more hazardous than others.

Types of Forklifts

Pallet Jack

Pallet jacks are the most basic form of forklift. Pallet jacks are intended to move heavy or light pallets for relatively short distances. Pallet jacks do not have a powered propulsion system, but are powered by the operator pushing and pulling the pallet jack. Pallet jacks do have hydraulic lift capabilities, enabling the lift to raise and support heavy loads. The hydraulic lifting mechanism is completely controlled by the operator. A simple example of a similar hydraulic lifting process is a wheeled floor jack. A wheeled floor jack has a hydraulic cylinder controlled by the arm of the jack. The idea with a pallet jack is similar, except that pallet jacks are designed with physical dimensions that allow the forks to be inserted into pallets, and the control of the pallet jack is more ergonomic than a simple floor jack. The pallet is raised by pumping the jack handle and the cylinder pressure controlled by a valve on the jack handle. The forks can be raised or lowered based on the position of this valve.