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Wright, Ruth "Mitzy," N. ***Investigation of Frequency and Severity of Backing Accidents at Company XYZ***

Abstract

Driving a vehicle poses certain inherent risks and each driver must determine whether the level of risk is acceptable prior to operation of the vehicle during personal daily activities. Public road maintenance tasks are frequently performed in less than ideal situations, often exposing employees to hazards that they have little or no control over such as other drivers and inclement weather. Most equipment utilized is perform road maintenance is oversized and difficult to maneuver. The purpose of this study was to analyze the multi-causal factors associated with the high frequency of backing accidents occurring as a result of Company XYZ's road maintenance and care activities. Data collected by Company XYZ regarding vehicular backing accidents during a five year span was analyzed. The review of Company XYZ's vehicular accidents revealed that approximately 19.5% of vehicular accidents were backing related and 93% of those accidents were driver preventable. The analysis indicated the majority of backing accidents occurred with four pieces of equipment and a blind spot study was then conducted for each of these vehicles. Identification of the blind spots associated with each of the four pieces of equipment required an observer positioned in the driver's seat while the researcher placed 28" construction cones at the limit of the driver's view and then measured and documented the distance of the cones from each vehicle. Based on the results of this study, various approaches to help Company XYZ prevent further backing-related accidents include backing up slowly providing the driver maximum reaction time to changes in the surroundings, attempt to position the vehicle to allow for sight-side backing rather than blind-side backing, and to consider backing related accidents and blind spots prior to purchasing attachments for equipment.

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Chapter I: Introduction/Problem Statement

Driving on the United States highways may be for pleasure or necessity and the condition of the roads can significantly impact travelers' enjoyment and even their safe arrival at the intended destination. The amount of work required to maintain reasonably safe driving conditions on the highway system is not only costly from a monetary standpoint, but the risks involved in upkeep efforts also create human and equipment related losses. According to the United States Department of Transportation Federal Highway Administration (FHWA, 2006), the national highway interstate system was developed and modeled after the German autobahns to be used for military support operations in the event of a national emergency and to assist in the effective transportation of goods. President Eisenhower signed the Federal Aid Act in 1956 providing federal funding for the national interstate highway system (Interstate highway system, 2003). While the interstate system comprises approximately one percent of all highways in the United States, it carries roughly 50% of the heavy truck traffic and 21% of all other traffic on the road systems in this country (Interstate highway system, 2003). Citizens who use and pay taxes for maintaining the roads are presumably highly dependent on the efficiency of the organizations responsibility to maintain the road infrastructure.

Company XYZ provides services associated with the planning, design, construction and maintenance of state and federal highways in eight counties located in an upper Midwest state. The organization also manages the aid provided to county and municipality systems that qualify for state and federal dollars to support mass transit, trail and rail transportation services. The eight counties include two of the state's largest cities and represent nearly one half of the state's total population. The population growth is projected to increase 51% between 2000 and 2030 in these eight counties generating approximately 15 million trips per day for an estimate of 86 million miles per day traveled by vehicles. Given this significant increase in anticipated road use, the risk of vehicular based accidents for Company XYZ's road maintenance equipment rises proportionately.

Company XYZ road maintenance needs combined with the growing population and increased vehicular traffic on the roadways maintained by Company XYZ, creates many loss-based challenges for the organization. In the five year span from 2006 through 2010 alone, Company XYZ experienced 970 vehicular accidents including 189 backing-related accidents. In 2010, the organization experienced a total of 250 vehicular accidents, 50 of which occurred while equipment was traveling in reverse. In addition to the potential for personal injuries to occur during backing related accidents, the potential for property damage could significantly impact Company XYZ's overall efficiency. The five years of data indicates that one-fifth of all vehicle accidents are backing related hence Company XYZ needs to focus on prevention efforts. Therefore, routine occurrence of Company XYZ's backing related vehicle accidents creates substantial vehicle, property and personal injury losses and risks.

Purpose of the Study

The purpose of this study is to analyze the multi-causal factors associated with the high frequency of backing accidents occurring as a result of Company XYZ's road maintenance and care activities.

Goals of the Study

The goals of this study will be to perform the following:

1. Determine the frequency of backing related accidents.
2. Identify equipment accounting for the majority of backing related accidents.

3. Identify the blind spots associated with various types of road construction equipment used by Company XYZ.
4. Determine proportion of driver preventable backing accidents to non-preventable backing accidents.

Background and Significance

A historical perspective of accidents experienced by Company XYZ provides the foundation of the need for this research project. In the five year span between 2006 and 2010, the organization experienced at 970 vehicle-related accidents, of which 189 were backing related. Backing accidents accounted for approximately 19.5% of the vehicular related accidents during these five years. The resulting direct and indirect costs for all backing accidents would likely include asset-based areas related to personal injury, property damage, vehicle repairs, increased insurance costs, legal expenses and delays in production including road building and maintenance activities. Administrative time required to provide follow up to minimize the extent of losses and modify existing practices to include prevention measures would also be a major cost. Each backing accident at Company XYZ is reviewed by management with the employees involved in the incident. Additionally, public perception of the organization could be significantly tarnished as a result of witnessing or learning about the accident related losses that occur. The scope of work activities undertaken by Company XYZ is vast and carries numerous safety issues including accidents related to company vehicles. The opportunity to identify process deficiencies contributing to vehicle based losses is vital to the organizations future profitability.

Assumptions of the Study

Following are assumptions of this study:

1. The accuracy of accident investigation data collected by Company XYZ.
2. The accuracy of accident reports maintained by Company XYZ.
3. The perceived blind spot area is similar for all employees.
4. The accuracy and honesty of employees' accounts of accidents within the company maintained file.

Definitions

Combination vehicle. A vehicle composed of two or more separate units, a semi-truck tractor unit and an unpowered unit, semi-trailer (Truck and bus glossary, 2011).

Straight truck. A one unit vehicle capable of carrying cargo. Examples include refuse, tank and dump trucks. Straight trucks may or may not pull trailers (*Engine Mechanic*, n.d.).

Sight-Side Backing. Backing a vehicle to the left toward the driver's side of the vehicle. The recommended method for backing.

Blind-Side Backing. Backing a vehicle to the right away from the driver's side of the vehicle. A method of backing that poses higher risk levels than sight-sided backing.

Ground Assist Spotter. A person stationed on the ground level positioned with the ability to recognize and avoid backing collisions through visual hand communications to the vehicle driver (National Highway Traffic Safety Administration (NHTSA), 2006).

Blind Spot. Areas of a vehicle that are outside of the direct view of the driver (Spec'ing for safety, 2006).

Backing Crash Accident. When vehicles strike each other or stationary objects (NHTSA, 2008).

Back-Over Accident. When vehicles strike people (NHTSA, 2008).

Driver Preventable Accident. An accident which occurs as a result of the driver failing to use an acceptable level of knowledge and skills to operate a vehicle in a reasonably defensive manner.

Chapter II: Literature Review

Introduction

The purpose of this study is to analyze the multi-causal factors associated with the high frequency of backing accidents occurring as a result of Company XYZ's road maintenance and care activities. Topics which will be addressed in this chapter include backing versus non-backing vehicular accidents, frequency and severity of backing accidents, blind spots of vehicles, approaches to reducing or eliminating preventable backing accidents and company policies regarding proper backing procedures including various forms of enforcement and discipline for failure to adhere to company policies.

The National Highway Traffic Safety Administration (NHTSA, 2008) attributes backing accidents in the United States as the cause for roughly 7,000 injuries, 20% of total vehicular related accidents and approximately 292 fatalities per year. The focus on backing accident prevention by private companies and professional organizations combined with improved driver training are proving beneficial (Maisan, 2006) as the fatality rate for commercial truck accidents has fallen to the lowest rates in history. According to the National Highway Transportation Safety Administration the number of miles driven by commercial vehicles increased while fatalities decreased from 2.01 per million miles in 2003, to 1.96 fatalities per million miles in 2004 (NHTSA, 2008). From a loss prevention standpoint, the solid waste industry believes that precautionary measures must be taken to reduce backing accidents since almost half of all backing accidents in the industry are with non-moving objects including signs, poles, and vehicles (Biderman & Hooker, 2010) and backing accidents account for at least 25% of vehicular related accidents in the waste collection industry (Maisan, 2006).

The occurrence of backing-related crashes may seem to be unlikely because the speed associated with traveling in reverse is less than five miles per hour in order to park a vehicle or else exit a parking area (FHWA, 1994). The severity of forward moving accidents can be significantly higher than backward moving accidents as speeds are typically higher moving in a forward direction (Spec'ing for safety, 2006). In a joint report from the Federal Highway Administration and the Centers for Disease Control (FHWA, 1994), comprehensive costs for police-reported vehicle crashes were assigned to categories according to the severity of vehicle accidents. Estimated costs per accident were assessed based on the 1994 United States dollar value. The estimated costs were: fatal accidents - $2,600,000; critical accidents- $1,980,000; severe accidents - $490,000; serious accidents - $150,000; moderate accidents- $40,000; minor accidents- $5,000; and, property damage only - $2,000. The average costs incurred for a fatality accident was substantially higher compared to an accident causing only property damage.

Legislative Efforts to Address Backing Related Vehicular Accidents

According to NHTSA (2008), backing accidents account for an estimated 292 fatalities on an annual basis. On February 28, 2008, President George W. Bush signed into law the Cameron Gulbransen Kids Transportation Safety Act of 2007 (NHTSA, 2008). The act is named in memory of two-year old Cameron Gulbransen who killed when his father backed up the family vehicle in the driveway. Transportation Secretary Ray LaHood stated, "there is no more tragic accident than for a parent or caregiver to back out of a garage or driveway and kill or injure an undetected child playing behind the vehicle." Ray LaHood believed that the proposed rulemaking will help drivers ensure the safety of others by reducing or eliminating the blind spots directly behind vehicles (NHTSA, 2008). This legislative act includes a requirement that within 12 months of the signing by the President, the United States Secretary of Transportation was required to initiate rulemaking which expanded the driver's field of vision in passenger vehicles to reduce injuries and deaths related to backing accidents. The rulemaking requires an expanded field of view to the rear on all passenger cars, pickup trucks, minivans, buses and low-speed vehicles that have a gross vehicle rating of up to 10,000 pounds. The expanded field of view will be required when the vehicle's transmission is placed in reverse. Based on the researcher's observations, the rule has been effective at increasing the number of automobile and large vehicle manufacturers who currently install rear mounted video cameras with displays inside of the vehicle. The ruling assigned a timeline for manufacturers to have 10% of vehicles meet the requirements by September of 2012, 40% by September of 2013 and 100% of vehicles manufactured must comply with the new ruling by September of 2014 (NHTSA, 2010).

Frequency and Severity of Backing Accidents

The California Department of Transportation (Caltrans) is the state agency responsible for highway, bridge, and rail transportation planning, construction and maintenance in California. This organization has recognized the past occurrence of significant losses as a result of Caltrans driver's moving in a reverse direction and damaging vehicles and personal property. In May, 2009, a study was conducted concerning Caltrans vehicles involved in backing accidents from 1998-2007. The study was published by the Institute of Transportation Studies (ITSBerkeley) at the University of California, Berkeley (2009).

As part of the 2009 study, Caltrans collected and documented 10 years of vehicular accident information within their organization. The data included total number of vehicular accidents, number of backing related accidents, number of driver preventable accidents, equipment involved in each accident, location of the accident, and equipment-only repair costs.

Analyzing the results of the vehicle loss data indicated that average equipment-only repair costs were approximately $2,000 per Caltrans vehicle for each backing accident. Associated costs not included in the overall analysis included equipment down time, personal property damage, medical expenses, employee lost-time, and additional third party expenses such as attorney fees and litigation expenses. During the decade covered by the study, it was determined that approximately 2,926 Caltrans vehicles were involved in backing related accidents. At an average cost of $2,000 for each vehicle Caltrans incurred an approximate cost of $5.45 million dollars for equipment-only repairs. Of the 2,926 backing related accidents, 2,726 or 93% were determined to have been driver preventable (ITSBerkeley, 2009). From a loss prevention standpoint, the Caltrans study discussed methods to reduce or eliminate preventable backing accidents (ITSBerkeley, 2009). The various methods which were recommended included involved equipment (e.g., mirrors, backing video, radar/sonar); procedures (e.g., use of cones, chocks, spotters); and policies (e.g., training, and accountability).

During the decade covered by the Caltrans study, the predominant vehicles which were used by the organization for road maintenance activities including pickup trucks, cargo bodies, dump bodies, utility bodies, cone bodies, sweepers, loaders, utility vehicles, wreckers, sprayers, graders, station wagons, wheeled tractors and trash compactors (ITSBerkeley, 2009). The pickup truck body style was the prevalent vehicle type in the fleet and accounted for approximately 25% of vehicles involved in driver preventable backing related accidents while cargo body, dump body, and utility body vehicle types combined accounted for approximately 34.8%. It should be noted that the ITSBerkley (2009) study also indicated that 670 or 24.6% of the driver preventable backing accidents occurred in state owned yards or on state owned property. Other accident locations included city streets – 10.5%, freeways -13.8%, private property – 13.9%. These locations accounted for approximately 63% of the locations where driver preventable backing accidents occurred. When one considers that vehicle speed should not be significant during backing-based operations and that the overall driving zone would be reasonably controllable, it is possible that certain vehicle-oriented risk factors may be contributing toward the extent of these seemingly preventable crashes.

Blind Spots

The term blind spot is used to describe a location around a vehicle where the driver's view is impeded and thus minimizes his/her ability to back safely, potentially resulting in backing crash accidents (when vehicles strike each other or stationary objects) and back-over accidents (when vehicles strike people). In a study which analyzed the occurrence of crashes, NHTSA (2006b) segmented these two types of backing accidents into four different categories of body styles and identified police-reported backing incidents per 100,000 registered vehicles in the state of Utah. The blind spots were calculated by placing 28" orange cones behind the center of the vehicles and then backing the vehicles until the top of the cones were no longer visible to the driver looking over their shoulder. The height of the driver affects the blind spots as direct correlation links taller drivers with smaller blind spots. The NHTSA study (2006b) focused on personal vehicles and small children vehicle back-over crashes including avoidance technologies for personal vehicles. Since backing crashes often result in minor or no personal injury they frequently go unreported. Table 1 includes the backing incidents per vehicle type and blind spots for both a 5'1" tall driver and a 5'8" tall driver:

Table 1

Backing Incidents per 100,000 Registered Vehicles in Utah and Associated Blind Spots

	Back-Over Accidents	Backing Crashes	5’1” Driver	5’8” Driver
Vans	4	0.8	27’	15’
Pickup Trucks	2.5	0.79	35’	24’
Sport Utility Vehicles	2.2	0.69	24’	15’
Cars	1.7	0.29	22’	14’

The information provided in Table 1 indicates that vans and pickup trucks make up the vehicle types which are most often associated with the occurrence of back-over as well as backing-based crashes. This data appears to be in line with what could be expected due to the limited view which exists on the sides as well as rear of such vehicles.

Blind spots associated with vehicles appear to differ in relation to vehicle size, style, auxiliary attached equipment, and the presence of mirrors or other visual aids which incorporated into the vehicle. An example of how blind spot areas have been investigated in recent years can be found where Caterpillar Incorporated conducted the study *Construction Vehicle and Equipment Blind Area Diagrams* (2003) which examined the blind spot footprint for various vehicles that it produces. It is possible that this study was undertaken to help identify the extent of this issue among Caterpillar equipment and thus generate risk reduction approaches which would ultimately reduce the company’s overall extent of product liability. Figure 1 illustrates the driver’s 360 degree view of a large dump truck when he/she is using both a convex mirror and a flat mirror. As can be observed in this diagram, the driver’s flat mirror has extremely limited sight-lines in comparison with the convex mirror. It should also be noted that the vehicle’s blind spot area is not only confined to the sides and rear, but that the front area also contains a moderate blond spot area. As a result of this research, the manufacturer recommends that both types of mirrors be used in conjunction when engaging in backing maneuvers to provide maximum visibility for the vast blind spot areas when dump trucks are backing. It

Figure 1 Blind spots of Sterling 9511- 3 axle, front steer, rear dump truck.

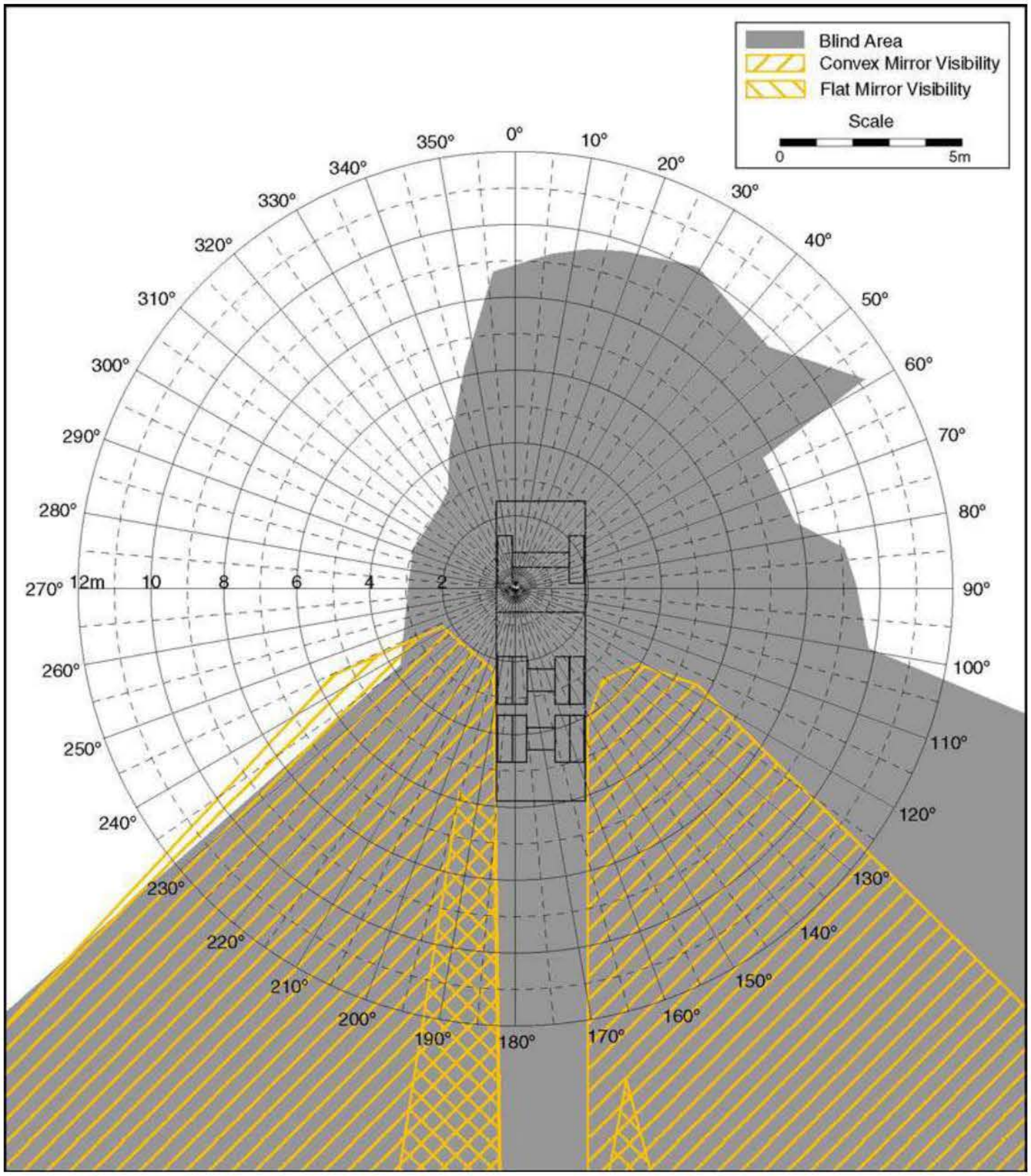

Figure 1. Construction vehicle and equipment blind area diagrams (2003). Retrieved from http://www.cdc.gov/niosh/topics/highwayworkzones/BAD/pdfs/catreport1.pdf

would seem reasonable to conclude that the blind spot mapping method presented in Figure 1 could be applied to nearly any type of on or off-road vehicle, provided that consistent measurement techniques were utilized during the blind spot analysis process.

Parking Assistance Technologies

It is reasonable to believe that the Cameron Gulbransen Kids Transportation Safety Act of 2007 (NHTSA, 2008) will help reduce the occurrence of backing-based injuries/fatalities as a result of automobile and large vehicle manufacturers meeting the requirements of the proposed standards by installing rear-mounted video cameras with displays inside of the vehicle. Information regarding parking assistance technologies and the costs associated with such equipment was addressed in the Vehicle Back-over Technology Avoidance Study published by the National Traffic Safety Administration in 2006 (NHTSA). The technologies which can be utilized to determine if/when a backing-related obstruction exists include sensor-based parking aids and visual-only systems.

Sensor-based parking aids are intended to aid drivers that are performing parking and backing maneuvers in low speed situations (less than 3 miles per hour) by providing an auditory tone or digital read-out indicating the presence and distance of obstacles that are located behind the vehicle. Typically this style of parking aid does not take into consideration moving objects but only stationary objects. Sensor-based warning technology with either ultrasonic or radar sensors to detect distance to nearby objects costs between $41.00 to $100.00 per vehicle; visual-only systems with a camera cost approximately $325.00 per vehicle, and convex mirrors average approximately $13.00 per mirror (NHTSA, 2006b).Visual-only systems include a rearview camera system that displays a video image of the area located behind the vehicle (NHTSA 2006).

Several issues were associated with the two styles of systems and their capabilities to be effective in avoiding backing related accidents (NHTSA, 2006b). Using a sensor-based system, the sensors detected an object and created a warning to the driver. The driver observed the warning sound and applied the brakes in order to stop the vehicle. Utilizing a visual system, the video displayed the image or object on a screen. The driver observed the object on the display screen and applied the brakes to stop the vehicle. Past NHTSA testing has determined that sensor based technologies are not able to detect objects 18 inches or less in height. Neither the sensor or visual detection-based technologies were able to consistently detect moving objects and pedestrians unless such objects were directly behind the vehicle, and therefore the use of such systems should be accompanied with effective and up-to-date procedures and policies (2006b).

Procedures and Policies

A backing accident can rarely be considered non-preventable (Bald, 1997). Organizations addressing internal backing accidents are more effective when they include employee participation and commitment from top management with the use of backing procedures and policies (Madel & Hansen, 2011). An effective backing policy should include avoiding backing if at all possible (Madel & Hansen, 2011). Pre-planned positioning of the vehicle in order to avoid backing is one recommended practice to consider prior to conducting work activities (Best practices for commercial autos, n.d.). Pre-planning reduces the need for backing in the event of an alternative available route. When backing cannot be avoided, the following points should be remembered:

- When possible, use a spotter and ensure that the hand signals to be used are reviewed and understood by both the driver and the spotter.

- Use available aids in the surrounding to assist during backing including mirrors, shadows and reflections.
- Get out of the vehicle and look at the surroundings prior to moving in a reverse direction, particularly after being parked. Move the vehicle immediately after reviewing the surroundings to minimize changes in the environment immediately around the vehicle.
- Rather than backing into moving traffic, back into driveways or parking spots immediately upon arrival at the destination. This tactic minimizes changes in the immediate environment around the vehicle.
- Ensure that the proper mirrors are on the vehicle and are adjusted properly to individual driver's needs.
- Ensure that back up lights and back up alarms are functioning properly prior to operating the equipment.
- Always back up slowly providing the driver maximum reaction time to changes in the surroundings.
- Roll down the windows and turn off the radio and other distractions prior to backing.
- Always attempt to position the vehicle to allow for sight-side backing rather than blind-side backing.
- Be aware of the blind spots associated with the type of vehicle you are driving.

It is interesting to note that that above guidelines specify the use of additional personnel (i.e., a spotter) who is charged with ensuring that the side and rear-area blind spot areas are free from undesirable objects. For a spotter to be effective and safe, it is important to ensure that this individual as well as the driver possess a common understanding of appropriate communications

(Best practices for commercial autos, n.d.). Hand signals are used when backing a vehicle since hearing is usually obscured by the vehicle noise. The driver must always maintain visual contact with the spotter. It is preferable that the ground assist spotter be located near the front or the driver's side of the backing vehicle in order to avoid injury. If the driver loses sight of the ground assist spotter the driver should stop all backward momentum and remain stationary until the ground assist spotter moves back into the driver's line of sight. It is also important that the driver utilize and communicate with only one ground assist spotter in order to avoid confusion and differences in multiple individual perspectives.

Many companies with large fleets of vehicles require mandatory defensive driver training for their drivers, although it appears that education concerning the risks as well as risk reduction measures associates with the backing of motorized vehicles often not part of training (Best practices for commercial autos, n.d.). The majority of backing accidents involve striking stationary objects including trees, poles, and vehicles. Nonetheless, the accidents account for approximately 20% of all vehicle accidents. Approximately 93% of all backing accidents are driver preventable (ITSBerkeley, 2009). The number of backing related accidents will be reduced as the quantity of backing maneuvers is reduced.

According to the Workplace Accident and Injury Reduction Program (AWAIR) that was developed by the United States Department of Occupational Health and Safety in Minnesota (MNOSHA) the following items were essential for an effective safety and health program: goals and objectives; roles and responsibilities; hazard identification, analysis, and control; communication; accident investigation; enforcement of safety programs; program review; and safety committees. Other key components of the AWAIR Program, companies need to develop effective programs and procedures, train their employees according to the programs and procedures, provide the proper equipment to the employees, enforce the policies and procedures, and provide fair and consistent discipline regarding violated policies and/or procedures. The entire process is an ongoing cycle requiring management, commitment, and employee involvement (AWAIR, 2009). While this list of activities may seem overwhelming from a management execution standpoint, it should be noted that such efforts appear to be complementary of each other and thus can be applied to effectively control nearly any type of vehicle or facility-based risk that an organization may possess.

In alignment with to the prior-mentioned components of an effective management system, the area of driver training must include procedural aspects of controlling backing related accidents. The training should include proper backing and parking procedures at the start of employment along with annual refresher training. Trained supervisors conducting on-the-job audits of the employees' backing and parking habits should be a follow-up activity (Chappell, 1992). Supervisors must lead by providing consistent reinforcement of the parking and backing procedures. When a supervisor observes an improperly parked vehicle or an unsafe behavior, the supervisor must stop the activities and assist the employee to reposition the vehicle, reiterating the safety procedures. The activity should be done in a positive and constructive manner as a way to achieve employee commitment in order to avoid unsupervised and unsafe backing activities (National Highway Traffic Safety Administration, 2006b). To positively reinforce safe backing procedures, companies should incorporate training drivers with videos of potential accidents and discussing driver options in events leading up to accidents (Biderman & Hooker, 2010). The training would help drivers make informed decisions when placed in similar backing situations. It is also recommended that companies establish a written backing policy agreement and require every driver to read and sign this agreement (Hooker & Angel, 2055). The organization can base the driver's performance review and bonuses on the driver's safety policy compliance established by the company and agreed upon by the driver.

Summary

A review of the literature indicated that backing accidents accounted for approximately 20% of all vehicle accidents and that 93% of all backing accidents were preventable. These findings suggested that many employers accepted backing accidents as an inevitable operation's cost when reducing backing accidents should be considered a readily achievable goal. Employers must convey to the employees that backing does not get them ahead. There was no singular solution to avoiding backing accidents. Backing accidents can be eliminated or reduced through the multifaceted approach of utilizing the proper equipment, job planning, appropriate policies, training, enforcement and discipline. Through heightened awareness by the employer and buy-in from the employees, reducing backing accidents is an attainable goal. As backing accidents reduce in quantity and severity, only then could productivity increase while associated costs decrease.

Chapter III: Methodology

Introduction

The purpose of this study was to analyze the multi-causal factors associated with the high frequency of backing accidents occurring as a result of Company XYZ's road maintenance and care activities. The goals of this study were to perform the following:

1. Determine the frequency of backing related accidents.
2. Identify equipment accounting for the majority of backing related accidents.
3. Identify the blind spots associated with various types of road construction equipment used by Company XYZ.
4. Determine proportion of driver preventable backing accidents to non-preventable backing accidents.

The author will address the following topics in this chapter: data selection and description; instrumentation; data collection procedures; data analysis procedures; and limitations of the study.

Data Selection and Description

Company XYZ conducted internal investigations of all vehicular related accidents over a five year span covering the calendar years of 2006 through 2010 including: backing and non-backing related vehicular accidents; accident dates; equipment type; preventable/non-preventable status. In determining driver preventability for each accident, Company XYZ determined if the accident was a result of actions by their employee or as a result of actions by a member of the public.

Instrumentation

- 28" orange construction cones

- 25’ Stanley tape measure
- Convex mirrors
- Flat mirrors

Data Collection Procedures

On December 5, 2011, the author conducted an observational study of four different equipment types and the associated blind spots for each type at Company XYZ. Four to five 28” orange cones were placed on the ground around each vehicle in order to identify the blind spots of four different styles of equipment associated with the majority of backing related accidents at Company XYZ. Personal observations from the driver’s seat were made as orange cones were moved away from the vehicles to determine the blind spots. In order to identify blind spots in an equivalent manner as the study conducted by the National Highway Traffic Safety Administration (2006b) referenced in Chapter II, the cones were left in the location on the ground where the driver was able to see the top portion of the orange cones. The driver was able to use the flat and convex mirrors on the vehicles to look out the front, side, and rear windows of the vehicles; however, the two dump body trucks did not have rear facing windows.

The four pieces of equipment selected for the observational study were a 2000 International Class 33 single rear axle dump truck, a 2000 International Class 35 tandem rear axle dump truck, a 2010 Ford F-250 and a 2011 Case 821 frontend loader. The International 33 dump truck was equipped with a snow plow blade on the left side of the truck in a position that blocked much of the driver’s side window, resulting in reduced visibility for the driver. The International 35 dump truck also had a snow plow blade on the driver’s side; however, the snow plow blade on this vehicle was carried parallel and close to the truck body, causing no visibility obstruction for the driver.

In the observational study of the blind spots, the cones were placed next to the vehicle out of the driver's view and then the cones were moved away from the vehicle until the top portion of the cone could be seen by the driver. Measurements were taken of the distance the cone had traveled away from the vehicle and the results were documented in the observer's notes. A drawing was developed depicting the areas where the cones were not visible and those areas are considered the blind spots of each vehicle.

Data Analysis Procedures

The author was presented a summary report of all vehicle accidents at Company XYZ. The information in this report included a summary of vehicular accidents for the time period January 1, 2006 through December 31, 2010 and included the following categories:

- Dates of the incidents
- If the incident was reported to an outside agency or strictly handled in-house
- If an employee or a member of the public was injured
- If an injury resulted in a fatality of an employee or a member of the public
- Accident type including backing up
- If the accident was due to the actions of an employee or of a member of the public
- Type of operation at the time of the accident
- Objects involved in the accident
- Monthly totals of accidents
- Department numbers within the company that the vehicles were assigned
- Vehicles involved in accidents

Page by page the author reviewed each accident and documented the following information entering the totals for each category on an excel spreadsheet which was then used to develop figures and tables presented in Chapters IV and V of this research paper:

- Monthly accident totals
- Annual accident totals
- Five year accident totals
- Company XYZ vehicles involved in the accidents
- Total vehicular accidents
- Driver preventable accidents
- Total backing related accidents
- Total driver preventable backing related accidents

Limitations of the Study

1. The driver's height and placement of the mirrors along with the positioning in the driver's seat may affect the associated blind spots for other drivers.
2. The analysis of the accident investigation data from Company XYZ was limited to a five year span and did not include accident location data.
3. The location at which the cones were visible to the driver may not have been the same with every piece of equipment as the driver's vantage height varied due to different equipment styles.
4. It is possible that assignment of driver preventability may have been subjective as the determination is made as a result of limited information in the accident investigation process.

Summary

Company XYZ had maintained five years of data regarding backing accidents. In a review of the data collected by Company XYZ, the four vehicle types selected for the blind spot study accounted for the majority of the backing accidents. In the observational study, the orange cones presented a visual of different equipment's blind spots.

Chapter IV: Results

Introduction

The purpose of this study was to analyze the multi-causal factors associated with the high frequency of backing accidents occurring as a result of Company XYZ's road maintenance and care activities. Data from backing related accidents at Company XYZ was collected over a five year span, covering the calendar years of 2006 through 2010. The organization experienced 970 vehicle-related accidents, of which 189 were known to be backing related. Backing accidents accounted for approximately 19.5% of the vehicular related accidents at Company XYZ in the five year span. Of the 189 backing related accidents the following four equipment types accounted for a majority of the backing accidents:

- Pickup Trucks – 91 backing accidents
- Class 33 Dump Trucks – 35 backing accidents
- Class 35 Dump Trucks – 22 backing accidents
- Loaders and skid steers - 9 backing accidents

This data was reviewed and an observational study was conducted of blind spots associated with equipment involved in backing related accidents at Company XYZ. The goals of this study included the following:

1. Determine the frequency of backing related accidents.
2. Identify equipment accounting for the majority of backing related accidents.
3. Identify the blind spots associated with various types of road construction equipment used by Company XYZ.
4. Determine proportion of driver preventable backing accidents to non-preventable backing accidents.

Frequency of Backing Accidents at Company XYZ

Vehicular accidents at Company XYZ are illustrated by month of occurrence in Figure 2. The company experienced the greatest numbers of vehicular related accidents in December. Approximately 19.5% of all vehicular accidents were backing related.

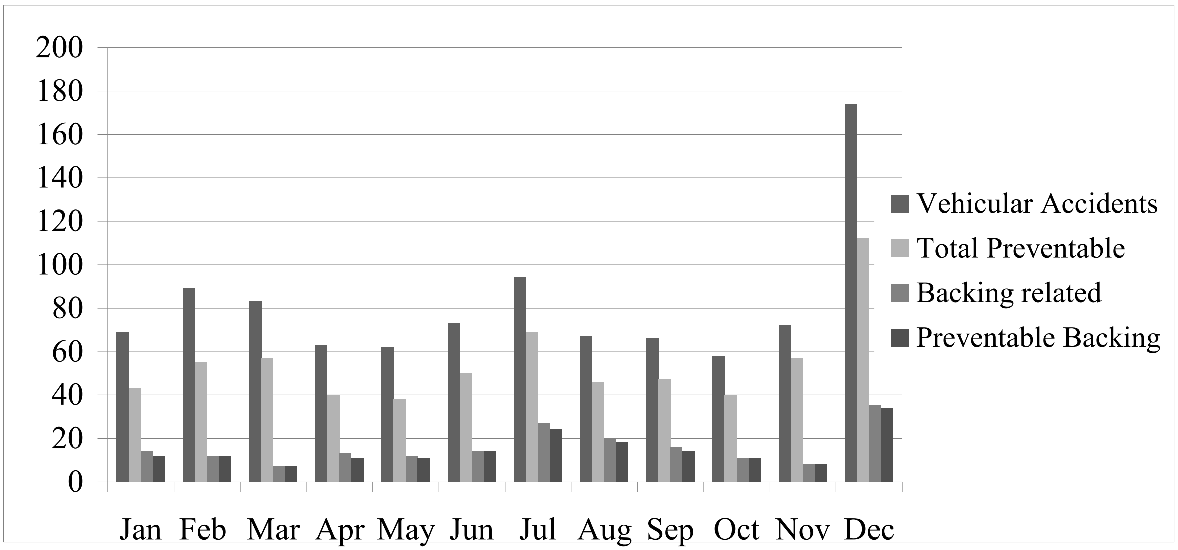

Figure 2. Accidents at Company XYZ by month

Equipment Involved in Backing Accidents at Company XYZ

Company XYZ incurred higher number of accidents with pickup trucks as there were more pickup trucks within the fleet. The following table is a representation of vehicle types that were involved in backing accidents at Company XYZ. Large dump bodied equipment also accounted for high numbers of backing related accidents. Figure 3 depicts the equipment involved in the 189 backing accidents at Company XYZ.

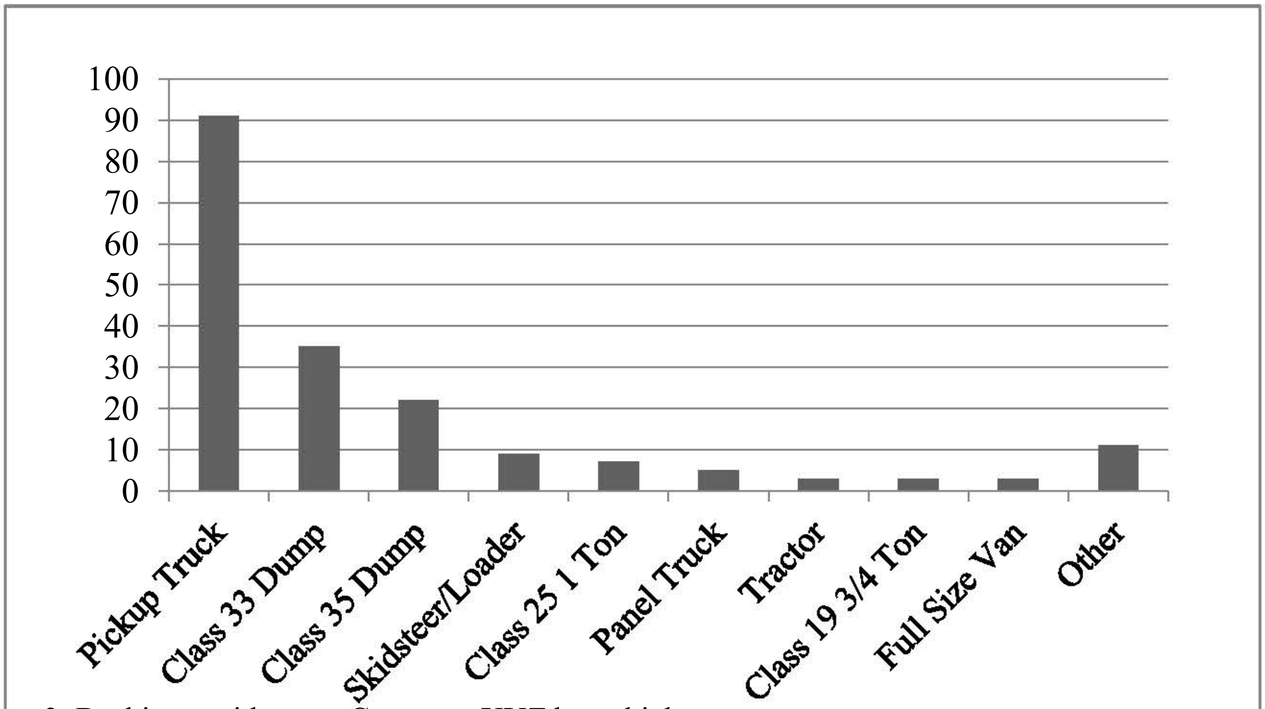

Figure 3. Backing accidents at Company XYZ by vehicle type

Blind Spots Associated with Various Types of Equipment Used by Company XYZ

The blind spots of the four pieces of equipment, in the observation portion of this study, were determined by placing orange cones around the vehicle until the cones were visible to the test driver. Once the cones were visible, the blind spot measurements were recorded by the researcher. The following figures display the blind spots of each piece of equipment. Five blind spots were identified for each of the two dump trucks; four blind spots were identified for the extended cab pickup truck and the front-end loader. Figure 4 is a not-to-scale drawing depicting the blind spots on the International Class 33 dump truck. The blind spots were much larger on the left side as the dump truck was equipped with a snow plow blade in a position that blocked much of the driver's side window resulting in reduced visibility for the driver.

The blind spot on the passenger's side of the vehicle was increased as the mirrors created blind spots resulting in an obstructed view for the driver. The blind spots on the front of the vehicle were large as a result of the obstructed view for the driver created by the hood of the truck.

International Class 33 Dump Truck

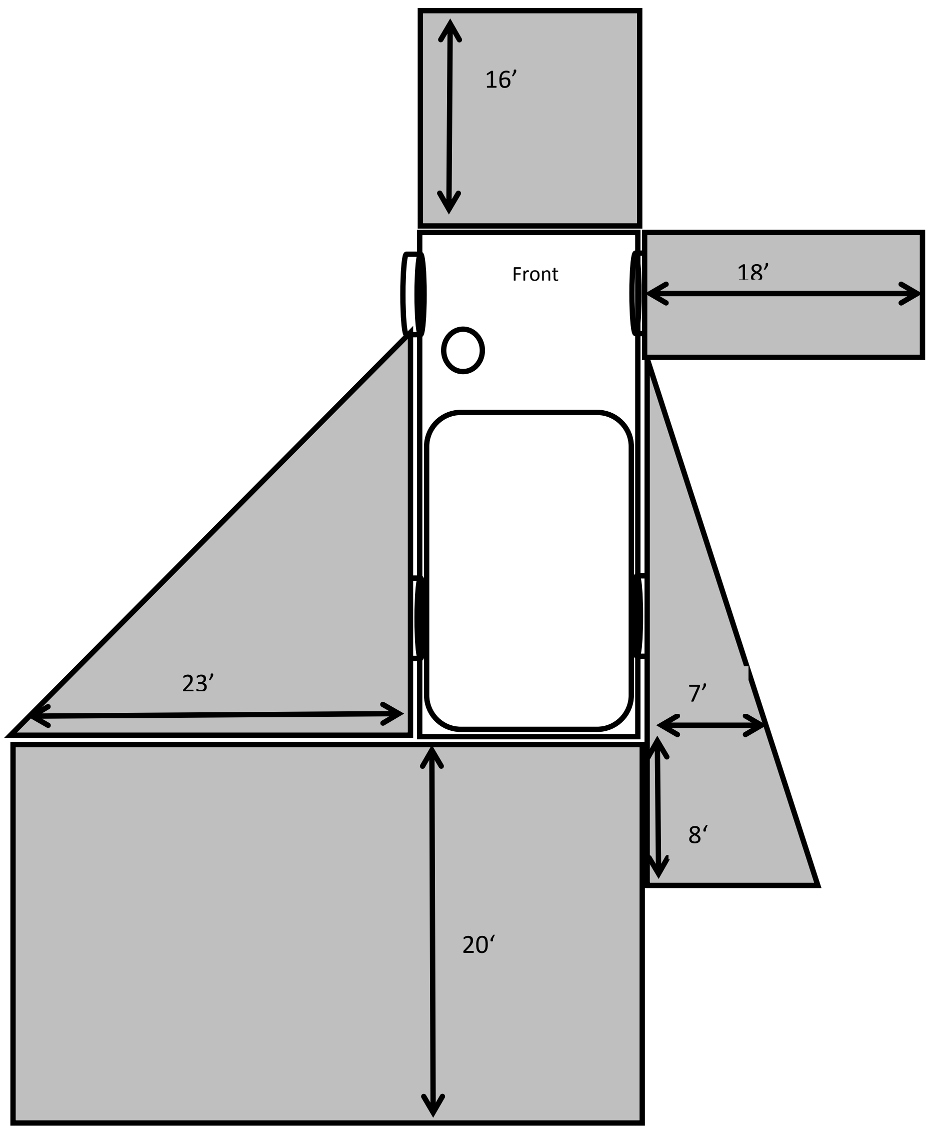

Figure 4. Drawing of blind spots on International Class 33 Dump Truck

Figure 5 is a not-to-scale drawing depicting the blind spots on the International Class 35 dump truck. The blind spots were smaller than the blind spots on the snow plow equipped International Class 33 dump truck since the snow plow blade on this vehicle was carried parallel and close to the truck body which caused no additional visual obstruction from the driver's seat. The International Class 35 dump truck has tandem rear axles and is a larger vehicle hence the blind spot on the passenger's side of the vehicle and to the rear of the vehicle were larger than the International Class 33. The reason for a smaller blind spot to the front of this vehicle is a result of the positioning of the driver's seat providing the driver a higher vantage point.

International Class 35

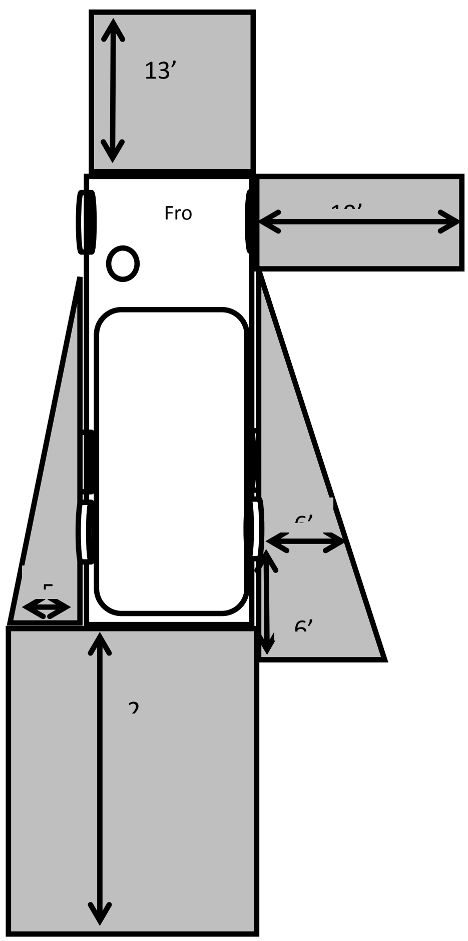

Figure 5. Drawing of blind spots on International Class 35 Dump Truck

Figure 6 a not-to-scale drawing which depicts the blind spots on the Ford F-250 Super Duty Extended Cab pickup truck. The hood and the passenger’s side mirror created blind spots to the front and passenger’s side of the vehicle. The mirrors on the left side of the truck along with the ability to look out the window resulted in basically no measurable blind spots in those areas. The tailgate and the back seat of the truck created blind spots to the rear of the vehicle.

Ford F-250 Super Duty Extended Cab

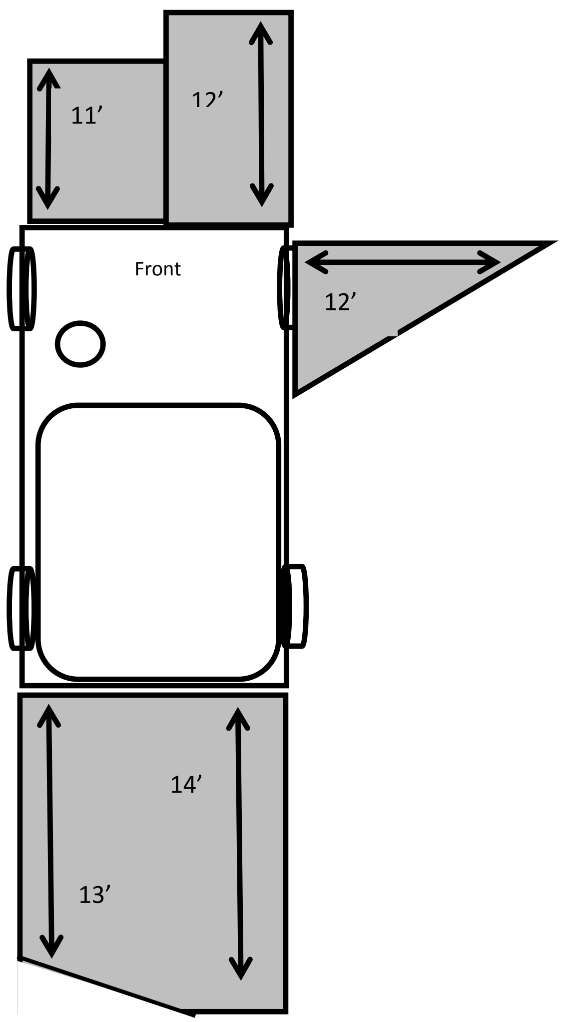

Figure 6. Drawing of blind spots on Ford F-250 Super Duty Extended Cab

Figure 7 is a not-to-scale drawing depicting the blind spots on the Case 821F Loader. The driver sits high in a mostly glass cab on the loader resulting in smaller blind spots to the front and side of the loader. The rear of the loader is a large, heavy, metal structure that is necessary to stabilize the equipment when it is carrying a heavy load in the bucket and the size of this structure affects the blind spots to the rear.

Case 821F Loader

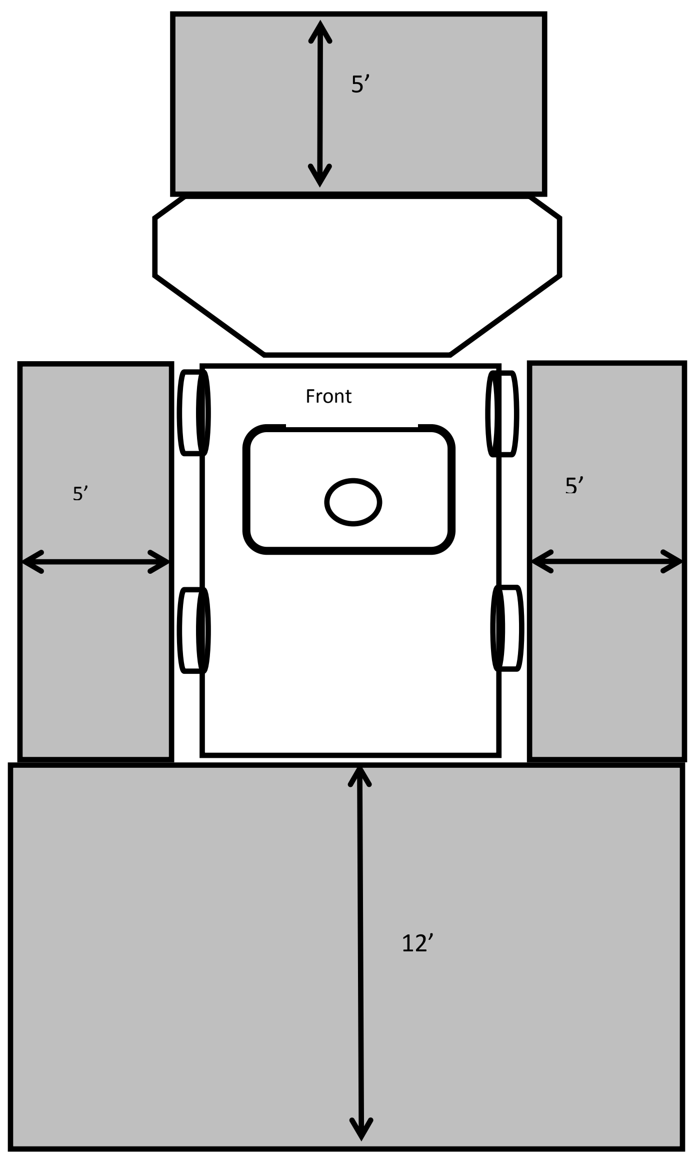

Figure 7. Drawing of blind spots on Case 821F Loader

The results of the above blind spot study of equipment which is utilized at Company XYZ appear to be similar to the Caterpillar blind spot study (2003) from the standpoint that the height of the vehicle significantly contributes to the location as well as size of the vehicle blind spots.

Driver Preventable Accidents at Company XYZ

Company XYZ experienced approximately 970 vehicular accidents in the five year span covering calendar years 2006 through 2010 of which 189 involved backing. The tables below categorize the number of vehicular accidents and their relationship to backing and non-backing accidents during the five year span covered in the data analysis.

Table 2 depicts monthly and five year total backing accidents at Company XYZ and demonstrates that December consistently accounted for the highest numbers of backing accidents. In averaging the five year total of 970 accidents within the organization, vehicular accidents occur approximately every 3.75 days and backing accidents occur approximately every 19.3 days. It was determined by Company XYZ, that of the 189 backing accidents, 176 were considered driver preventable occurrences.

Table 2

Accidents at Company XYZ from 2006-2010 by Month

2006-2010	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2006-20102
Vehicular Accidents	69	89	83	63	62	73	94	67	66	58	72	174	970
Total Preventable	43	55	57	40	38	50	69	46	47	40	57	112	654
Backing related	14	12	7	13	12	14	27	20	16	11	8	35	189
Preventable Backing	12	12	7	11	11	14	24	18	14	11	8	34	176

Table 3 identifies the total number of vehicular accidents which occurred at Company XYZ in the five year time span and assigns what the organization believes to be the extent of driver preventability to both backing and non-backing accidents. Approximately 189 of the total 970 vehicular accidents at Company XYZ were backing related and the organization determined that 176 backing accidents were preventable.

Table 3

Accidents at Company XYZ from 2006-2010

Total Accidents	970
Total Non-Backing Accidents	781
Total Backing Accidents	189
Total Preventable Accidents	654
Total Preventable Non-Backing Accidents	478
Total Preventable Backing Accidents	176

The columns in Figure 8 identify total vehicular accidents and backing accidents. Driver preventable backing accidents represent approximately 176 of the 189 backing accidents.

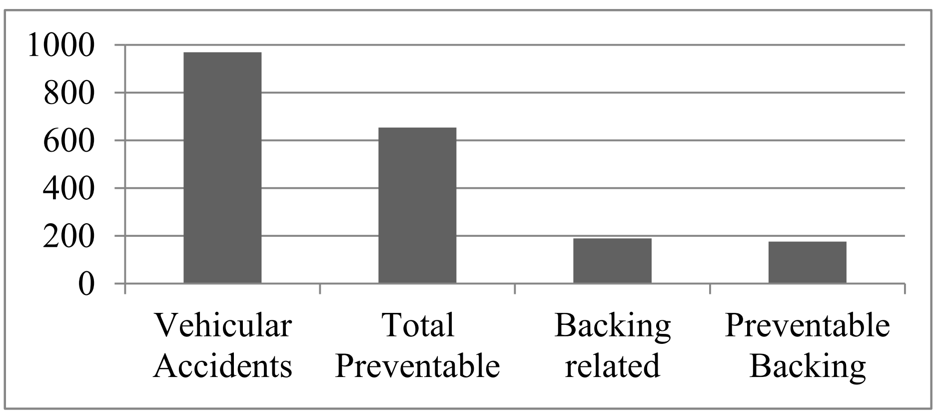

Figure 8. Backing versus non-backing accidents at Company XYZ

Figure 9 is a representation of the percentages that apply to the type of accidents occurring at Company XYZ within the five year time span. Using the organization's determination regarding driver preventability 93% of all backing related accidents were driver preventable.

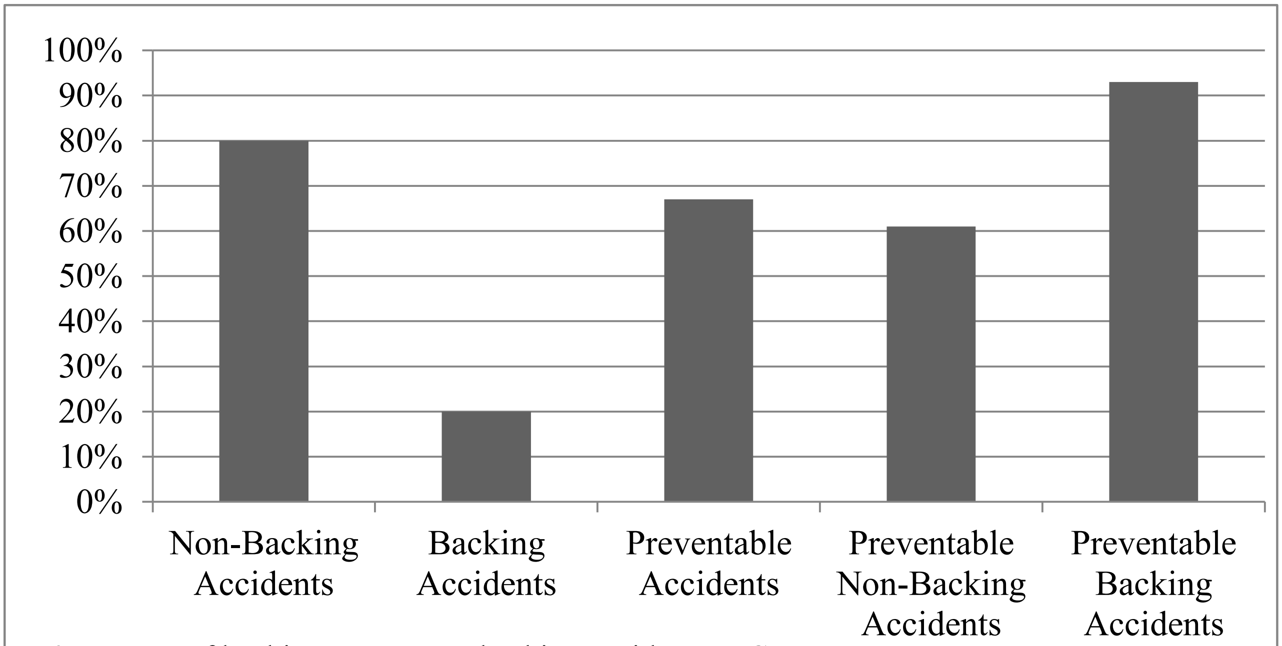

Figure 9. Percent of backing versus non-backing accidents at Company XYZ

Company XYZ experienced 189 backing related accidents in the five year span review in this study. As depicted in Figure 10, 176 of the backing related accidents were driver preventable.

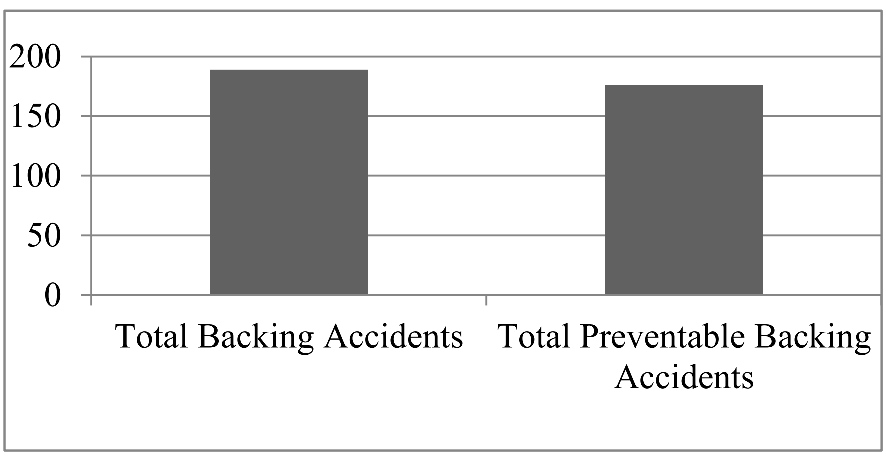

Figure 10. Preventability of backing accidents at Company XYZ

Summary

Company XYZ has predetermined criteria to classify driver preventable accidents and did not provide the researcher with the standards for this decision making process. However, according to the organization, approximately 19.5% of all accidents at Company XYZ were backing related and roughly 93% of backing accidents were driver preventable. The majority of backing related accidents involved pickup truck bodied equipment followed by larger dump style bodied equipment. According to personal communication with a company representative, pickup trucks were involved in accidents at numerous locations as they were utilized for many different situations at Company XYZ and dump bodied equipment and driver preventable backing accidents most frequently occurred on company owned property. Blind spots increased on larger pieces of equipment at Company XYZ and were equivalent to the blind spots identified in the literature review of this study.

Several significant findings can be established as a result of the data analysis and observational study done by this researcher at Company XYZ. The data results from Company XYZ compared to the selected data results from this study's literature review indicate several parallel conclusions identified below.

The analysis of the data from Company XYZ and the literature review have overlapping results. In comparing the author's literature review with the informational outcome of the data analysis of Company XYZ the following comparisons were made:

- Literature review results:
    - Approximately 20% of vehicular accidents are backing related.
    - Approximately 93% of all backing related accidents are preventable.
    - Pickup trucks account for the majority of backing accidents.

    - Large bodied equipment has larger blind spots resulting in a greater number of backing accidents.
    - Accidents occurring in the yard or on company owned property account for the majority of backing accidents.
    - The speed at which backing accidents occur was relatively slow resulting in minimal repair costs compared to forward motion accidents.
- Company XYZ results:
    - Approximately 19.5% of vehicular accidents are backing related.
    - Approximately 93% of all backing related accidents are preventable.
    - Pickup trucks account for the majority of backing accidents.
    - Large bodied equipment has larger blind spots resulting in high numbers of backing accidents.
    - Accidents occurring in the yard or on company owned property account for the majority of accidents.
    - Speeds are slow with backing accidents resulting in minimal damage.

Chapter V: Conclusions and Recommendations

The purpose of this study is to analyze the multi-causal factors associated with the high frequency of backing accidents occurring as a result of Company XYZ's road maintenance and care activities. In a review of data collected by Company XYZ, the four vehicle types selected for the blind spot study accounted for the majority of the backing accidents. The goals of this study included the following:

1. Determine the frequency of backing related accidents.
2. Identify equipment accounting for the majority of backing related accidents.
3. Identify the blind spots associated with various types of road construction equipment used by Company XYZ.
4. Determine proportion of driver preventable backing accidents to non-preventable backing accidents.

Data from backing related accidents at Company XYZ was collected over a five year span covering the calendar years of 2006 through 2010. The data was analyzed and an observational study was also conducted to determine blind spots associated with the four equipment types most frequently involved in backing related accidents at Company XYZ. The data results from Company XYZ compared to the selected data results from this study's literature review indicated several parallel conclusions.

Conclusions

- Backing accidents account for approximately 20% of all vehicular related accidents.
- Approximately 93% of the backing related accidents were driver preventable.

- Blind spots on equipment vary depending on the body style, driver's position and equipment on the vehicle.
- Backing accidents often have a minimal per occurrence cost; however, Company XYZ experienced 189 backing accidents in a five year time span. Backing related accidents carry an average cost of $2,000 for equipment-only repairs totaling an estimated $378,000 loss over the span of five years.

Recommendations

Based on the above conclusions, following are proactive recommendations which Company XYZ should consider in order to reduce the occurrence of backing-related accidents in the operations side of its organization:

- Avoid backing whenever possible by preplanning work activities and altering the route if appropriate.
- If backing is required, use a ground assist spotter and ensure that the hand signals are reviewed and understood by both the driver and the spotter before beginning.
- Use available aids in the surroundings to assist in the backing including mirrors, shadows and reflections.
- Rather than backing into moving traffic, it is advisable to back into driveways or parking spots immediately upon your arrival at the destination. This tactic minimizes changes in the immediate environment around the vehicle.
- Get out of the vehicle and look at your surroundings prior to moving in a reverse direction, particularly after being parked.
- Ensure that the proper mirrors are on your vehicle and that they are adjusted to individual driver's needs.

- Ensure that back up lights and back up alarms are functioning properly prior to operating the equipment.
- Always back up slowly providing the driver maximum reaction time to changes in the surroundings.
- Roll down the windows and turn off the radio and other distractions prior to backing.
- Always attempt to position the vehicle to allow for sight-side backing rather than blind-side backing.
- Be aware of the blind spots associated with the type of vehicle you are driving.
- Address backing within policies, procedures, training, discipline and enforcement.
- Consider backing related accidents and blind spots prior to purchasing attachments for equipment.
- Place orange cones behind parked vehicles that expect to back out in order to prevent others from parking in the location directly behind the vehicle.
- Garage parking design should minimize backing of large equipment.
- Place stationary mirrors inside of garages to improve the driver's overall view.
- Avoid designing parking spots that require blind side backing.
- Apply the use of sensor based systems and visual based systems to a select group of vehicles and assign those vehicles to employees that have a positive outlook and adapt well to change. Use predetermined timeframes to analyze backing related accidents that occur with vehicles that have the new systems and compare the backing related accidents with the vehicles that do not have the new systems.

Conduct a survey of the drivers and incorporate their feedback for future equipment selection.

Reactive recommendations to analyze and determine trends after backing accidents:

- Conduct a post-accident investigation to determine if backing was necessary or if the driver could alter the route in the future to avoid backing.
- Conduct a post-accident survey of the driver regarding what methods of control were used at the time of the accident and what methods of control the driver believes would have prevented the backing accident.
- Identify locations where backing accidents occur and analyze the trends in order to implement methods of control to reduce future accidents.
- Review vehicle attachments and placement (e.g., plows) on the equipment in the post-accident investigation to determine if the attachments affected the driver's ability to back safely. Utilize this information to purchase and affix attachments to the equipment to reduce backing accidents.
- Conduct a post-accident interview with the driver to determine if the accident was driver preventable and apply the disciplinary policy consistently.
- On a quarterly basis select specific driver preventable backing accidents and conduct presentations of the accident details to all drivers. The items presented could include photographs, scope of work being conducted, equipment used, costs incurred, methods of control used and not used, blind spots, location of the backing accident and that the accident was driver preventable in order to heighten awareness and encourage buy-in to reduce backing accidents. Allow the driver's

the opportunity to discuss the backing accidents including suggestions on how the accident could have been prevented.

Areas of Further Research

Additional research should be explored in the following areas:

- Data collection and analysis of a company that utilizes sensor based systems and visual aid systems and the effectiveness of the systems to reduce the frequency and severity of backing related accidents
- Data analysis should include driver information such as length of time driving professionally; height of the driver; method of control used to prevent backing accidents; and driver recommendations regarding effective control methods in backing accident prevention.
- Data analysis of vehicle attachments resulting in limited visibility and increased blind spots.
- Data collection of associated costs incurred from backing related accidents.

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