FORKLIFT SAFETY
A Pilot Study Evaluation of Retrofit Lights

By Thomas G. Bobick, Mathew Hause, Christina Socias-Morales, Melody Gwilliam and Tashira Decker

FORKLIFT VEHICLES ARE IMPORTANT in many U.S. industries. From 2009 to 2018, slightly less than 1.7 million powered industrial trucks, including forklifts, were shipped from manufacturers to customers in the U.S. (ITA, 2019). Forklifts are used to move supplies and products throughout facilities and onto tractor-trailer vehicles for delivery to customers nationwide. For each forklift being used, typically one or two pedestrian workers in the same area are exposed to the mobile forklifts. Thus, numerous pedestrian workers are at risk of being injured, sometimes fatally. The initial research conducted on forklifts by NIOSH (2001) indicates that forklift injuries and fatalities are mainly due to vehicle overturns, bystander (pedestrian worker) struck-by events and crushed-by-forklift events.

KEY TAKEAWAYS

- **Blue and red lights were retrofitted onto three forklifts and used for 4 months in a warehouse environment to increase the awareness of approaching vehicles.**
- **A short list of open-ended discussion questions pertaining to the retrofit lights was administered to nine employees who were operators and pedestrians.**
- **Feedback indicates that all nine employees thought the addition of the lights increased the visibility of the forklifts and improved safety by making the vehicles more conspicuous.**

Since 1980, fatal forklift injuries have increased, with about 73 fatalities annually from 1980 to 1994 (Collins et al., 1999) to an average of 86 fatalities annually from 2013 to 2017 (BLS, 2015a; 2016a; 2017a; 2018; 2019). This 18% increase may be due to improvements in traumatic occupational fatality monitoring, or to more forklifts or employees in the workplace. Regardless, it is indicative of a persistent occupational hazard. Table 1 (p. 42) presents the number of fatal injuries caused by forklifts, which includes order pickers and powered platform trucks from 2013 to 2017. Table 1 also presents forklift-related nonfatal injuries involving days away from work (DAFW). For the 5-year period, an annual average of more than 7,100 forklift injuries occurred involving DAFW. As an indication of severity, for that same 5-year period, an annual average of 2,732 (or 38%) of all forklift injuries involved workers missing 31 or more DAFW. Assuming a 5-day workweek, this is more than 6 workweeks missed for each of those 2,732 forklift-related injuries. The incidents involving workers missing 31 or more DAFW represent a total of at least 84,892 days, which equates to a total of more than 78 work-years for that category. The total may be more since there likely would be a certain number of workers who missed more than the minimum of 31 days.

Several different types of forklifts are used in indoor and outdoor settings across all U.S. industries. The focus of this pilot study is electric stand-up forklifts.

Research Study

A small pilot study was conducted by the Division of Safety Research, NIOSH, Morgantown, WV. The goal was to evaluate a commercial safety product (a retrofit safety device) that was installed on a small sample (known as a convenience sample) of three operational electric stand-up forklifts. Four of these retrofit safety products (two blue lights, two red lights) were evaluated during normal work activities to determine whether they enhanced the safety of the overall work environment. The cooperating company granted NIOSH researchers access to the workplace to collect photos of the operating vehicles and to eventually collect feedback from a sample of employees about the modifications. During the visits, the researchers observed any obvious reactions from pedestrian workers to the retrofit safety lights.

Discussions with the distributor of Hyster-Yale forklifts in the southwestern Pennsylvania area led to the identification of a customer, Bombardier Transportation, a Canada-based manufacturer of air and rail transportation equipment, that was interested in cooperating with NIOSH in the safety evaluation study. Bombardier's plant located in the Pittsburgh area (West Mifflin, PA) is focused on rail transportation. The company had recently ordered three new forklifts and was interested in cooperating with NIOSH to evaluate retrofit safety products on those forklifts. After discussing the planned testing, the company agreed to cooperate with NIOSH.

Before beginning the study, personnel of the forklift distributor conducted a training session for the four NIOSH researchers. The training included a morning session on terminology, differences among the various forklift models, functionality of the different vehicles, and specific operating techniques for the sit-down and stand-up vehicles being operated at the West Mifflin plant. The afternoon session consisted of hands-on operation by the NIOSH researchers of both the sit-down and stand-up models in use at the plant.

After the training session, two NIOSH researchers made arrangements with Bombardier personnel to observe the operations of the three new stand-up forklifts at the plant from July 2017 through September 2018. Three visits, which were conduct-

TABLE 1

FORKLIFT-RELATED FATALITIES & DAFW, U.S. PRIVATE INDUSTRIES, 2013-2017

Forklift-related occupational fatalities by primary and secondary sources of fatality, and forklift-related occupational injuries involving days away from work (DAFW) by source of injury, all U.S. private industries, from 2013 to 2017.

	Year					
Fatality source[a]	**2013**	**2014**	**2015**	**2016**	**2017**	**Average**
Primary	70	65	71	72	54	66.4
Secondary	21	24	25	21	20	22.2
Total forklift injuries with DAFW	6,820	7,710	6,820	6,750	7,490	7,118
Struck-by (% of total)	1,670 (24.5%)	1,519 (19.6%)	1,150 (16.9%)	1,510 (22.4%)	1,570 (21%)	1,482 (20.8%)
Struck against (% of total)	430 (6.3%)	510 (6.6%)	480 (7.0%)	460 (6.8%)	450 (6.0%)	466 (6.5%)
Caught in, crushed (% of total)	900 (13.2%)	780 (10.1%)	760 (11.1%)	620 (9.2%)	490 (6.5%)	710 (10%)
DAFW injuries when days missed are "31 or more" (% of total)[b]	2,560 (37.5%)	3,280 (42.5%)	2,540 (37.2%)	2,650 (39.3%)	2,630 (35.1%)	2,732 (38.4%)

Note. Based on "Occupational Injury and Illness Classification System 2.01," by Bureau of Labor Statistics (BLS), 2012, source code 8621 (includes "forklift, order picker, and platform truck, powered"). Data from "Census of Fatal Occupational Injuries" and "Survey of Occupational Injuries and Illnesses," by BLS, n.d., www.bls.gov/iif; and "Table R69, Number and percent distribution of nonfatal occupational injuries and illnesses including days away from work, by source of injury or illness and number of days away from work, and median number of days away from work, private industry," by BLS, 2013, 2014, 2015b, 2016b, 2017b.

[a]Primary and secondary sources are mutually exclusive and should not be combined to obtain a yearly total. [b]The number of days away from work has seven categories: (a) 1, (b) 2, (c) 3-5, (d) 6-10, (e) 11-20, (f) 21-30, and (g) 31 or more days.

ed during July, August and September 2017, provided NIOSH researchers an opportunity to become familiar with the plant operation. The first retrofit modification, which occurred in October 2017, involved installing a blue light on the front of the overhead protection on all three forklifts (Photo 1). A follow-up visit was conducted in January 2018 to observe vehicle usage with the blue lights in the forward direction. The second modification completed by the forklift distributor's technician occurred in March 2018 and involved the installation of the second blue light on the rear of the canopy for all three forklifts (Photo 2). Follow-up visits occurred during May and June 2018. Finally, the third modification occurred in August 2018 and consisted of installing red lights (Photo 3) on both sides of the three forklifts to provide an indication of the turning radius (rear-end swing) as a warning to pedestrian workers. Two follow-up visits were scheduled during August and September 2018 when both blue and red lights were operational. All eight site visits were conducted by the two NIOSH researchers and each site visit lasted for 7 hours.

The three stand-up forklifts evaluated were used for a combined total of 1,259 hours over the course of the 14-month pilot study. During the eight site visits, the researchers observed order pickers and pedestrians in close proximity to the forklifts during the various stages of adding blue lights and red lights to the three stand-up forklifts for safety warning purposes.

Installing the lights incrementally allowed operators, pedestrians and researchers to become familiar with the newest addition before the next set of lights were added.

Costs

The cost of each of the lights (both blue and red) was about $200. There were four lights for each forklift for a total of $800 in components. A service contract with the local forklift distributor was prepared that included the cost of the lights and the labor to install them being paid for by the NIOSH pilot project. Because the lights were installed in three stages, there were three charges for labor with one charge for each separate installation. Labor costs for each installation was about $200 each, for a total of $600 in labor for each vehicle. The total cost (parts and labor) of installing the retrofit lights was $1,400 per forklift. The cost of parts and labor for installing the retrofit lights would be about 4% to 4.5% of the estimated cost of a new forklift similar to the vehicles used in this pilot study. Of course, if all four lights were installed at the same time, there would be only one labor charge instead of three.

Employee Feedback

On the last day that the researchers visited the plant (Sept. 25, 2018), some basic questions were asked of nine employees (four operators, three pedestrians, two supervisors).

The questionnaire administered to the nine employees was essentially, but not exactly, the same. The questions for the supervisors were slightly different simply because they were supervisors. There were eight questions for the seven workers and seven questions for the two supervisors. The first question collected information about how many years they were operators in their careers. The second question asked whether they received regular refresher training on operating a forklift. Questions 3 through 7 dealt with various aspects related to the installation of the blue and the red lights. The last question asked whether the workers had any ideas about general safety issues in their workplace.

Of the seven workers, six were operators and one was not. On the day of the interviews, four operators were operating forklifts

while the other two operators were not assigned to a forklift but were manually filling small orders. The first question that dealt with years being an operator and the second question related to forklift retraining were skipped for the nonoperator. The remaining questions were the same for all seven workers. One supervisor was a former operator before becoming a supervisor, so the operator-related questions could be asked of that individual. One extra question for the supervisors was not asked of the workers. Thus, the questions asked of the nine employees were exactly the same for the seven workers and were very similar for the two supervisors. The questions were asked only when those individuals had some momentary downtime, and the total time to answer the questions was less than 10 minutes per person.

Operators

The total years of experience for the four operators ranged from 2 to 42 years, with an average of 14.5 years. This was career experience, not just with Bombardier. All four operators thought the lights helped to warn other workers in the area. Specifically, two operators preferred just the two blue lights, and the other two operators preferred both blue and red lights on the vehicles. Three of the four operators felt that if they had to operate a forklift not equipped with any blue or red lights, they would want their company to add them. In general, all four of the operators felt that the addition of the lights helped with safety. Conversely, two of the operators felt that, when approaching the metal racks, the front blue light caused some slight glare by reflecting off the metal vertical supports, and a little more glare when reflecting off the plastic shrink-wrap. They felt that this momentary glare was a negative aspect of the front light. A third operator felt that the location of the red lights at the front of the canopy contributed negatively because of shining in his eyes when looking at the upper shelves.

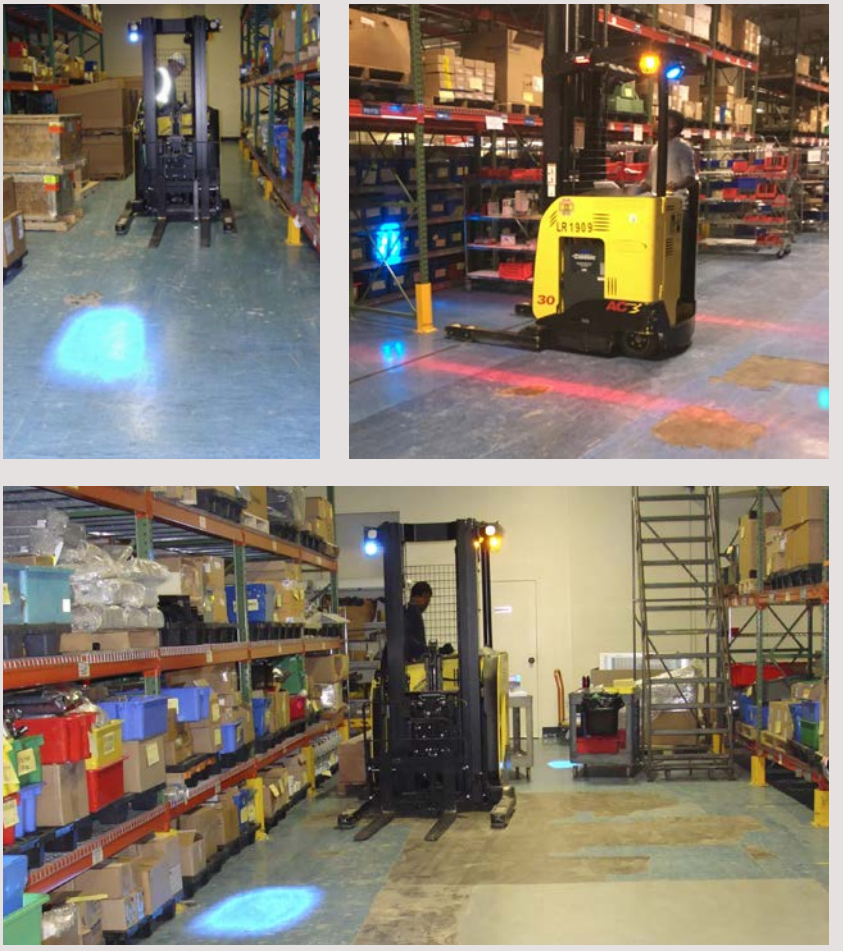
The last question was whether the workers had any ideas about how to increase safety overall. One operator suggested that additional training on forklift operation could contribute to consistency, and another operator suggested that an improvement would be to use the vehicle hydraulics to automatically move the forks left and right instead of doing it manually with the potential for a back injury.

Pedestrian Workers

Three pedestrian workers were interviewed. One of them had never been an operator. The other two still are operators, even though they were not operating that day. Their career experience as forklift operators was 18 and 7 years. Again, this experience includes time beyond their tenure with Bombardier. For the questions related to their reaction to the blue and red lights, all three felt that the addition of the lights helped to warn workers in the area. Two pedestrians preferred it when both the blue and red lights were on the vehicles. The third pedestrian preferred just the blue lights. All three generally felt that the addition of the lights helped with safety. When asked if the lights had a positive or negative effect on performing their jobs, two commented that they felt the lights had a positive effect, and the third employee, who was an operator, also felt that the lights caused glare. Concerning the last question on additional ideas for safety, two pedestrians commented that the operators needed to drive the forklifts more slowly. The third pedestrian mentioned that padding is needed on unguarded corners of the storage racks. It was interesting to note that when the operators were on foot, they commented that the forklift should be operated at a slower speed.

Supervisors

Two supervisors were interviewed. Their supervisory experience ranged between 7 and 12 years. One had previously been an operator for 15 years; the other had not been an operator. Both supervisors preferred the vehicles with both the blue and red lights installed. One supervisor felt that, as a pedestrian, adding the blue lights improved safety and by adding the red lights, the forklifts were even more visible. When asked about receiving any feedback from the workers regarding the lights,



(Counterclockwise from top left) Photo 1: Single forward-facing blue light installed. Photo 2: Forward- and rear-facing blue lights installed. Photo 3: Red lights installed on each side, with the front blue light visible on the storage rack and the rear blue light visible on the floor (right edge of photo).

one supervisor mentioned the problem of glare already identified by the workers. However, one supervisor mentioned that in the beginning of the study the lights made the vehicles more noticeable, but later they became "part of the norm," which was surprising since the research team had not heard that from any of the other workers interviewed. Unfortunately, the researchers could not follow up on that observation because it was at the end of the shift on the last day of the visits.

Regarding the question on additional ideas for overall safety, one supervisor commented that the vehicles should be operated at a slower speed and that the operator should not have the option to change the speed. The other supervisor provided comments regarding the additional safety efforts that Bombardier has implemented, including having a 10-minute daily morning meeting that includes talking about safety first, and that everyone attending the meeting has to contribute. Managers are required to perform a monthly walk-through, and the company uses a dangerous concerns/near-miss form to encourage input from workers about how to improve safety. These forms are used together by management and the reporting employees to ensure that concerns are addressed and changes are incorporated to make the workplace safer.

Discussion

The blue lights were well-received by the employees who answered the questions, and they felt that the lights provided extra warning to pedestrian workers and other vehicle operators. The blue light is specifically positioned to project about 12 to 15 ft in front of (or behind) the forklift while moving either in the forward or rearward directions. This provides a critically important warning to pedestrian workers who may be approaching an intersection and who are located around the corner, out of operator's line of sight. The workers on foot have stated that the movement of the blue light on the floor before the forklift arrives in the intersection provides a valuable warning for them. A revolving yellow light, which is located on top of the overhead protective structure, is activated when the forklift is turned on and remains revolving until the forklift is powered off. The yellow light is on top of the vehicle and does not project downward onto the floor. Thus, the yellow light does not provide any type of warning to workers who are on foot and around a corner from a moving forklift.

Regarding the issue of glare, the research team suggested to the forklift manufacturer's technical sales representative the idea of automatically dimming the front blue light when the forklift is paused to remove or place a load on the racks. The representative explained that it might work but would require modifying the wiring by the manufacturer and would be an aftermarket alteration, which would be an additional expense. Such an alteration should be requested when a new machine is being ordered to make the wiring alteration less expensive.

The location of the red lights was also a problem, but that has already been remedied by the forklift distributor by moving the location of the red lights toward the rear of the canopy, thus eliminating the glare.

One additional issue that was mentioned by one supervisor was that the retrofit lights may lose their effectiveness over time as they become the norm. None of the seven workers mentioned anything about the lights losing their effectiveness. The lights are still currently being used at the facility. Personal experience related to field work over many years has shown that if add-on modifications are perceived by the workers as being ineffective, then it is likely that those modifications will be removed and tossed away. Since the lights are still in operation, they probably have not lost their effectiveness and have not faded into the background.

Forklift operators are evaluated every 3 years, as required by OSHA regulation 29 CFR 1910.178(l)(4)(iii). Both supervisors commented that every 3 years is adequate for most workers, although if an incident occurs, additional training will be required. This is specified in OSHA regulation 29 CFR 1910.178(l)(4)(ii)(B). In addition, evaluation training can be scheduled even before the 3-year time period if needed, such as if an operator has been observed to operate the vehicle in an unsafe manner, according to 29 CFR 1910.178(l)(4)(ii)(A). The NIOSH research team suggested that refresher training should be conducted every 12 to 18 months, especially if an employee is an infrequent operator. Complacency can lead to taking shortcuts, which may contribute to hazardous actions.

Speed of vehicle operation was mentioned as an area of concern by the pedestrians and a supervisor. Three speeds are indicated on the vehicles (1, 2 and 3). Corresponding speeds (feet per minute or miles per hour) were not designated on the vehicles. The research team suggests that vehicles should be operated at the slowest speed. Also, the proper technique is to tilt the forks upward before moving, which is company policy, to stabilize the load against the back rest when transporting a load. Despite these minor observations, the operation of the West Mifflin plant was well run with workers who were conscientious and safety conscious.

Along with the retrofit lights that were evaluated in this study, other devices that could be used to assist with avoiding collisions between forklifts and workers include proximity warning systems. Proximity warning systems are two-part devices that consist of a transmitter and a receiver. The transmitter is mounted on the forklift and the receiver is worn by all workers. Various transmitting sources are used to interact with the receivers worn by both operators and pedestrians. These can include the use of radio frequency, magnetic, ultrasonic, laser and lidar, to name a few (Kinney, 2001; Ruff, 2007). Some energy sources can be detected around corners, whereas other technologies only work as line-of-sight detection. The proximity warning systems are more expensive than the retrofit safety lights and are more complicated to use. In addition, the sensitivity of the system is a critical component since it is easy to detect the receivers worn by workers who are on the other side of walls in break rooms or restrooms. This leads to false positive warnings. The use of proximity warning devices was discussed with the cooperating company, but the company chose not to make the extra financial investment in a proximity warning system. Thus, such a system was not part of this pilot study.

Conclusion

All nine of the employees questioned thought that the addition of the lights increased the visibility of the forklifts and improved safety in the work area by making the vehicles more conspicuous. Six employees questioned preferred the combination of blue and red lights. The other three employees preferred only the blue lights. Since the use of the lights was well received by the operators and pedestrians, Bombardier should continue using the blue and red lights at the current location. If company management agrees, blue and red lights could be used for safety purposes in other plant locations in the U.S., or even worldwide.

Future studies are needed to expand on this pilot study and confirm the efficacy of the blue and red lights in reducing injuries or forklift damage due to collisions. This could include

comparing retrofit blue and red lights on forklifts between larger groups of employees and managers at different work sites, over longer observation periods and collecting more in-depth measures regarding their effectiveness (e.g., changes in annual number of injuries per 1,000 workers, dollar cost in damage to forklifts, annual number of workers' compensation claims).

Severe injuries from forklifts are rare, so these studies may need to span many years and include retrospective data analyses to make statistically significant comparisons. Future studies should include other manufacturing businesses or even other industries to support the evidence that the retrofit blue and red lights are a mechanism to improve forklift visibility and workplace safety. Future studies should involve different study methodologies, including observational and experimental designs. For the success of these future studies, stakeholders should be involved at all levels of the private sector, government research and regulatory agencies, and employee representation from trade organizations and unions.

Not enough information is available about the use of retrofit lights on existing forklifts. Because of this lack of information, it would be beneficial to other safety professionals if the unsafe situations, which might be avoided in the future because of using the lights, were documented and published in a safety-related journal to help educate others in the safety community. OSH professionals in other warehousing operations can use the results from this pilot study to develop safe working conditions for their operations. **PSJ**

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