

Backup Alarms

Preventing injuries caused by reversing vehicles

By Vincent A. Gallagher

SH&E PROFESSIONALS and product manufacturers long ago accepted the notion that behavioral controls such as training, instructions and warnings should be used only after exhausting feasible design methods that build safety into products, tools and the work environment. Why, then, do so many trucks, buses, vans, sport utility vehicles (SUVs), forklifts and other vehicles lack backup alarms that reduce the risk of pedestrian runovers?

Research suggests the runover hazard is a significant problem:

- National Highway Traffic Safety Administration (NHTSA) found approximately 181,500 police-reported backing crashes with 185 associated fatalities. The agency estimated a total number of 300,000 backing crashes if off-road incidents, such as those that occur in driveways, are also included (NHTSA ES-1).

- In 1985, NIOSH reported that 7,492 occupational injuries were related to forklifts running over workers' feet (Stout-Wiegand 79).

Recent cases provide further evidence:

- A mother in Missouri was run over by a reversing bus (*Bivens v. The Blue Bird Corp., Blue Bird Body Co. and Doyle L. Ray, Circuit Court of Barry County, MO, Div. I, Case No. CV199-700-C*).

- A two-year-old boy in Kentucky was crushed when a food delivery truck backed over him in his driveway. (*David and Teresa McKenzie vs. Schwan's Sales Enterprises Inc., et al, Commonwealth of Kentucky, Magoffin Circuit Court, Civil Action. The author investigated and served as an expert witness in this fatal injury case.*)

a warning signal from a backup alarm (NHTSA 2-5). Since then, safety technology to prevent backup runover injuries has improved greatly. A variety of systems are now available; these include vision systems, self-adjusting backup alarms, reverse motion alarms and sensor-operated alarms (discriminating backup alarms).

Vision systems involve cameras installed at the rear of the truck with an on-dash monitor; they are designed for use in recreational vehicles, waste haulers, emergency vehicles, buses, tank trucks and fire trucks. Self-adjusting backup alarms sense ambient noise and automatically self-adjust to 10 decibels higher to be audible in noisy environments. Reverse motion alarms begin to sound when the vehicle moves backward; they sound even if the vehicle moves backward, yet is not in reverse gear.

Sensor-operated alarms (discriminating backup alarms) sound only when a person or object is detected in the predetermined unsafe zone behind the vehicle. These devices can be designed to sound at the rear and in the cab. The frequency and intensity of the sound increases as the vehicle gets closer to collision. Some of these devices automatically apply the brakes at a predetermined distance. Others feature a digital readout that can be placed on the vehicle's dash to show the driver the distance (in feet) to travel before impact; some models use a digitized voice to convey this information.

Advocates of Backup Alarms

While some trucks, buses, forklifts and industrial vehicles are equipped with various types of backup alarms and vision systems, most in use today are not—nor are most new vehicles so equipped despite recommendations by safety authorities. Over the years, many SH&E professionals and other experts have advocated the use of backup alarms on industrial trucks. For example:

- The 1964 article, "Backup," which appeared in *Fleet Owner*, reported that Alan Cudworth, then direc-

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Attacking the Hazard with Technology

What can be done to address this hazard? In 1976, NHTSA found that 73 percent of backup accidents would have been prevented if the pedestrian could have heard

tor of research and development for Liberty Mutual Insurance Co., had patented a “discriminating” backup alarm (sounds when it senses person/object in the danger zone) using sonar (“Backup”).

- In 1968, during a national safety conference, William Murphy of the Associated General Contractors of America pointed out that an Army Corps of Engineers’ standard required reverse alarms on all self-propelled construction equipment (Murphy 78).

- In 1970, in an article entitled “Sound an Alarm When Backing Up” (published in *Road and Streets*), W.H. Weiss reported that backup alarms should be used and that they cost less than \$50 (Weiss).

- In a 1994 article, “Why Forklifts Need Signaling Devices,” which appeared in *Ergonomics in Design*, Stephen Wilcox explained why forklifts need backup alarms to prevent pedestrians from being run over (Wilcox 17).

- In 1997, George Swartz wrote *Forklift Safety: A Practical Guide to Preventing Powered Industrial Truck Incidents and Injuries*, in which he called for the use of backup alarms on forklifts (Swartz 121). He reiterated that support in his 1999 book, *Warehouse Safety: A Practical Guide to Preventing Warehouse Incidents and Injuries* (Swartz 164).

- In December 1999, the New Jersey Dept. of Health and Senior Services, Div. of Epidemiology, Environmental and Occupational Health, conducted a survey of forklift-related injuries. Based on the results, the agency recommended that forklifts be equipped with backup alarms (NJDOH 3).

Other Expert Commentary

NIOSH

NIOSH is the federal agency responsible for conducting research and making recommendations for the prevention of work-related disease and injury. As a result of its research into causes of workers being run over by reversing vehicles, NIOSH has recommended backup alarms to prevent recurrence of the following situations:

- Woman struck and killed by a reversing forklift truck in a press shop (*NIOSH Alert: Preventing Injuries and Deaths of Workers Who Operate or Work Near Forklifts*; NIOSH Pub. No. 2001-109).

- A trash collector was crushed to death by a collection truck. NIOSH recommended a sensor-operated backup alarm or vision system to provide the driver with a view of the rear of the vehicle [reported in *Fatal Assessment and Control Evaluation* (FACE) 9231].

- Masonry laborer was killed when run over by a rough terrain forklift (FACE Investigation 96-NJ-058-01).

- A rear-load helper for a refuse collection company was crushed to death by the rear wheels of a garbage truck (FACE Investigation 98-TX-1101).

- Construction laborer was crushed to death by asphalt truck while paving interstate highway (FACE 95-MA-039-01).

- Sanitation worker was run over and killed at solid waste transfer station by reversing front-end loader (FACE 95-11).

- Highway department supervisor was struck by reversing dump truck (FACE 96-MO-012).

- Laborer died after being run over by rear wheels of a tractor trailer at a construction site (FACE Report 98-CA-01201).

OSHA

In an Oct. 29, 1991, letter to Senator Tom Harkin (D-IA), Gerard Scannell, then assistant secretary of labor for OSH, explained OSHA’s position:

OSHA has two requirements relating to backup alarms. Both requirements are in the construction safety and health standards and apply only to motor vehicles and materials handling equipment used in construction operations. The OSHA requirements allow employers some flexibility in determining the best method to warn of the danger of backing vehicles. Specifically, when a driver’s view to the rear is obstructed, the vehicle must either be equipped with an alarm, or an employee must signal the driver that it is safe to proceed. If an alarm is used, it must be loud enough to be distinguishable from other sounds.

[Your constituent] questioned the benefits of “noisy” backup alarms and stated the noise was a hazard on the jobsite. An analysis was made in 1971 when the standards were first promulgated. *At that time, it was determined that backup alarms saved lives* (emphasis added). We believe the benefits of backup alarms still exist. However, as [your constituent] pointed out, when the alarm sounds constantly, its usefulness as a warning device may be lost. This need not be a problem, however, as there are alarms which sound only after motion has been detected at the rear of a backing vehicle. Such alarms have been successfully used on a variety of vehicles and their use may be appropriate in the type of situation described by [your constituent]. In addition, this type of intermittent alarm would also alleviate the potential for hearing loss.

However, the current 1926 standards essentially say a backup alarm is not needed as long as a spotter is used:

- 29 CFR 1926.601(b)(4): No employer shall use any motor equipment having an obstructed view to the rear unless: (i) the vehicle has a reverse signal alarm audible above the surrounding noise level or; (ii) the vehicle is backed up only when an observer signals that it is safe to do so.

- 29 CFR 1926.602(a)(9)(ii): No employer shall permit earthmoving or compacting equipment which has an obstructed view to the rear to be used in reverse gear unless the equipment has in operation a reverse signal alarm distinguishable from the surrounding noise level or an employee signals that it is safe to do so.

National Safety Council

As early as 1948, National Safety Council (NSC) began to advocate backup alarms.

- Data Sheet D-330 (1948), “Motor Trucks for Mines, Quarries and Construction,” states, “An automatic signaling device has been developed

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especially for warning workers out of the path of backing trucks."

• *Accident Prevention Manual for Industrial Operations, 4th Edition* (1959), states, "Many of the worst accidents (associated with motor trucks) are due to lack of safety devices. . . . Therefore, fundamental requirements for safe operation are that trucks be equipped with the necessary safety devices. . . . Suitable reverse alarm should be provided on all heavy mobile equipment and trucks."

• The 1968 article, "Heavy Equipment Backup Alarms," which appeared in the safety newsletter of NSC's Cement, Quarry and Mineral Aggregate Section, states, "It is our estimate that backup alarms should be as common and accepted a safety device as hardhats or safety shoes. We strongly believe that on a not-too-distant day, that will come to pass."

• Data Sheet 256 (1971) paragraph 66, "Motor Graders, Bulldozers and Scrapers," states, "All equipment should be equipped with audible reverse alarm devices which will automatically operate when the equipment is in reverse motion."

• The 1985 article, "Ultrasonic Backup Device Hears' Objects That Cannot Be Seen," which appeared in *Traffic Safety* (Vol. 85, No. 3), notes that vision systems and ultrasonic discriminating backup alarms were available to prevent pedestrian runovers.

• *Motor Fleet Safety Manual, 4th Edition* (1996) states, "Safety—No fleet purchaser will deliberately buy an unsafe piece of equipment. However, the safety department must define for the purchasing department what is considered safe. . . . safety-related items: backup alarms, vision systems to show rear view."

• *Accident Prevention Manual for Business and Industry: Engineering and Technology, 12th Edition* (2001) states with regard to materials handling equipment used in shipping and receiving areas, ". . . equip mobile equipment used in storage areas with backup warning devices." In every edition of this manual since 1969, NSC has recommended use of backup alarms for mobile equipment (forklifts) used in storage areas.

NHTSA

NHTSA does not require backup alarms on trucks and buses. However, in 1995, the agency was petitioned by Philip Sweeney of San Diego to consider requiring such devices on large motor vehicles and school buses. Via a Denial of Petition for Rulemaking (*Federal Register*, Dec. 19, 1995), NHTSA said there was no proof available of a cost-effective solution.

To support this position, NHTSA cited two studies. The first was a 1976 study conducted for NHTSA. Entitled, "An Automobile Backup Pedestrian Warning Device: Development and Evaluation," this study showed that backup alarms would not prevent injury to children younger than five years old. "[A]ny solution to the backup accident problem should be able to address the deaths and injuries to children five years of age and under," NHTSA said.

It should be noted that this same study estimated that 73 percent of runovers would have been prevented had the pedestrian heard a warning signal.

So, in essence, NHTSA concluded that while research showed backup alarms would prevent 73 percent of injuries and deaths, these devices were not a cost-effective solution because they would not be effective relative to children younger than age five. Such "logic" is difficult to understand, since no safety device is 100-percent reliable. A 73-percent reduction is significant. In the author's opinion, NHTSA must have known about the availability of discriminating backup alarms at the time it denied this petition for rulemaking; it must also have known that relatively inexpensive models were already available (e.g., one Springfield, VA, firm was selling a backup alarm for automobiles at a cost of \$19.95).

The other study cited was a technical paper, "The Consideration of Human Factors in the Design of a Backup Warning System," which was delivered by James Duchon and Linneas Laage at the Human Factors Society's 30th Annual Meeting in 1986. The abstract states, "The use of backing up automatic alarms causes the operator to lose perception of responsibility for vigilant behavior while the ground crew predictably becomes habituated to the alarm." However, a critical reading of this paper reveals that these authors did no research, scientific study, evaluation or analysis of the effects of habituation on pedestrians or the loss of perception of responsibility among operators. In fact, they conclude, "Much of this paper is based on logical inference rather than on actual research. Therefore, it is necessary to test the assumptions cited."

This paper prompted Bureau of Mines research to determine the most reliable sensor-operated backup alarm—the discriminating backup alarm. This research found that the Doppler radar proved best because of its immunity to various weather conditions, which lead to promulgation of a standard accepting the use of discriminating backup alarms in the mining industry (30 CFR 77.410).

Other Relevant Standards

Several other standards also speak to this hazard.

• *U.S. Army Corps of Engineers, Safety and Health Requirements EM 385-1-1* (March 13, 1958). 18-12, Reverse Signal Alarms: When specified by the government official in charge, all self-propelled construction equipment, whether moving alone or in combination, shall be equipped with a reverse signal alarm which will operate automatically when the vehicle moves in reverse and which will give suitable audible sound alarm for the conditions and circumstances under which the equipment is operated.

The July 15, 1960, version of this section states, "All self-propelled construction equipment, except light service trucks, panels, pickups, station wagons, crawler-type cranes, power shovels and drag lines, whether moving alone or in combination, shall be equipped with a reverse signal alarm. The alarm shall be mounted on the rear of the equipment and shall be so protected or constructed as to withstand severe wear and tear, adverse weather and unfavorable environmental working conditions and shall be

certified by the manufacturer as fully meeting the following performance standards. . . . The use of the alarm shall be in addition to prescribed requirements for signalmen."

• *MIL-T-5302, Military Specification for Trucks, Lifts, Fork, Diesel-Engine Driven, Pneumatic-Tired, Rough Terrain Trucks 6,000-lb. Capacity (March 14, 1983).* 3.5.3, Backup Alarms: A backup alarm conforming to SAE J994, type C or D, shall be furnished. The backup alarm signal shall be audible above, and distinguishable from, the surrounding vehicle noise level.

• *Bureau of Mines, Standard 77.410 (May 22, 1971).* Mobile Equipment-Automatic Warning Devices: Mobile equipment, such as trucks, forklift trucks, front-end loaders, tractors and graders, shall be equipped with an adequate automatic warning device which shall give an audible alarm when such equipment is put in reverse.

Currently codified at 30 CFR 77.410, this standard includes the following provisions with respect to automatic warning devices in mobile equipment:

(a) Mobile equipment such as front-end loaders, forklifts, tractors, graders, and trucks, except pickup trucks with an unobstructed rear view, shall be equipped with a warning device that:

(1) gives an audible alarm when the equipment is put in reverse; or

(2) uses infrared light, ultrasonic waves, radar, or other effective devices to detect objects or persons at the rear of the equipment, and sounds an audible alarm when a person or object is detected. This type of discriminating warning device shall:

(a)(2)(i) have a sensing area of a sufficient size that would allow endangered persons adequate time to get out of the danger zone;

(a)(2)(ii) give audible and visual alarms inside the operator's compartment and a audible alarm outside of the operator's compartment when a person or object is detected in the sensing area; and

(a)(2)(iii) when the equipment is put in reverse, activate and give a one-time audible and visual alarm inside the operator's compartment and a one-time audible alarm outside the operator's compartment.

(b) Alarms shall be audible above the surrounding noise levels.

(c) Warning devices shall be maintained in functional condition.

• *U.S. Dept. of Interior, Bureau of Reclamation, Construction Safety Standard.* 19.6.8, Audible Alarms (April 1981): (b) Reverse signal alarm: No bi-directional earthmoving or compacting equipment which has an obstructed view to the rear shall be operated in reverse gear unless equipped with an automatic reverse signal alarm or a signalman is used to assist the operator.

19.9.9.(c), Audible Alarms (1997): All mobile equipment shall be equipped with a horn distinguishable from the surrounding noise level and an automatic backup alarm. The backup alarm will be functional whenever the equipment is working in close proximity to foot traffic or congested equipment areas.

ANSI/ASME B56.1

ANSI/ASME B56.1 (Low and High Lift Trucks) and B56.6 (Rough Terrain Forklift Trucks) suggest that the user must decide whether or not to equip a forklift with a backup alarm. This approach implies that some safety-related factors may preclude the use of such an alarm. This leads one to ask, "What are/could be those reasons?" In the author's opinion, the only good reason to not equip a vehicle with a backup alarm is that doing so could create a greater hazard or risk of injury. Based on the author's extensive search, however, no evidence is available which suggests that this is ever the case. None of the scientific studies or respected safety authorities referenced warns against use of backup alarms in any environment.

A 1986 letter of interpretation regarding this standard indicated that various factors must be considered before deciding whether to equip forklift trucks with backup alarms (ANSI/ASME). These include lighting, ambient noise levels, traffic routes for material and personnel, floor conditions, and proximity of machinery, equipment and workstations. The letter pointed out that indiscriminate use of backup alarms *might* (emphasis added) encourage the driver to ignore his/her responsibility of looking in the direction of travel and being alert to impending danger. It also indicated that automatic continuous alarms can become so commonplace that they will soon be ignored by persons in the area and highlighted the need for management and trained operators to follow the requirements of B56.1.

Let's consider these points, beginning with noise. The actual number of workers at risk of hearing loss is quite small. NSC's injury data show that less than two workers in 10,000 in private industry suffer hearing loss (NSC 72). Furthermore, with an OSHA-required hearing conservation program in place, no hearing loss should occur as a result of backup alarms on forklifts. If, through the medical surveillance required within the hearing conservation program, an employ-

Do Forklift Operators See Their Entire Path of Travel While Reversing?

NIOSH supported a human factors study that considered the problem of pedestrian runover injuries caused by forklifts traveling in reverse (NIOSH 58-61). The study found the following factors increased the likelihood that a forklift operator would back up without having a full view of the path of travel:

- One tends to get a stiff neck from turning around.

- Even when one does turn around, s/he cannot turn 180 degrees from the normal driver position.

- One must turn from one side to the other and, thus, may miss important visual information from the blindspots.

- One might attend to obstructions or other problematic conditions on one side of the truck or load.

- While reversing and turning the forklift, an operator must look forward to ensure the load does not swing and strike a person or object.

- A worker may make several maneuvers of backing and going forward, and may only check for pedestrians before the first such maneuver.

- When going around a corner, an operator may go too fast or fail to stop and check for traffic.

- Operator may be instructed to hurry.

- Operator may be on incentive pay system.

- Operator may fail to establish and maintain communication with workers in the environment.

- Workers fail to heed warnings of forklift operators.

- Narrow aisles, crowded aisles, blind intersections and doors, and ambient noise camouflaging the truck's noise interact with lack of effective communication among workers who share the same general space and/or tasks.

When advocating backup alarms, SH&E professionals can point to the fact that the cost to install these alarms on a fleet of trucks is significantly less than paying damages involved in just one third-party lawsuit.

er notices that workers are beginning to lose the ability to hear in speech frequencies, that employer must implement administrative controls. This should further ensure that no workers suffer hearing loss, even with some added noise from backup alarms.

With respect to habituation, no scientific research says that habituation is a phenomenon which causes a greater hazard or increased risk relative to the use of backup alarms. In the author's experience, habituation can actually cause backup alarms to be effective, not ineffective.

Workers typically pay little attention to sounds that are too far away to cause harm, just as drivers pay little attention to an ambulance siren that is several blocks away. Yet, people pay greater attention to a sound as it gets louder as the vehicle approaches. Sound corresponds to the laws of physics. The law of the inverse square dictates that as a sound source approaches, its intensity increases logarithmically. The intensity of the sound received by a worker at five ft. is four times the intensity s/he would receive when the forklift truck was at 10 ft., not two times. The intensity at five ft. is 16 times higher than the intensity of the same signal when it was 20 ft. away. So, as the truck approaches, the intensity of the sound received by the worker appears louder and louder and, therefore, becomes more alarming and likely to prevent injury.

Worker confusion is another cited concern. In the author's opinion, if a worker is confused about the proximity of a forklift due to multiple sounds in a particular work environment, then s/he simply does not recognize the danger and is in the same position as s/he would be if the forklift had no backup alarm. No inherent danger or increased risk occurs due to multiple alarms.

Some employers also warn that it is easy to disarm backup alarms—something employees who find the alarms annoying may be tempted to do. These devices are supposed to be alarming and, therefore, annoying. A management system which cannot ensure that safety devices are not bypassed is likely to have many more significant problems than the fact that backup alarms are being defeated.

Backup Alarms: Not a Panacea, but Part of the Answer

Over-the-road trucks, construction vehicles, SUVs and vans have physical obstructions to reverse travel. Backup alarms are a primary way to reduce the risk of reverse runovers. Certainly, driver diligence is important. The same holds true for forklift operators. However, driver safety training and supervision should not be the only risk-reduction response. It is highly foreseeable that forklift operators will not always turn far enough to see both sides of the aisle while reversing (see sidebar on pg. 31).

Backup alarms are not a panacea. Even when the truck or forklift is designed to be safe, the hazard of a moving truck will always remain. However, by designing these vehicles and the work environment to be as safe as possible, and by providing operator training and appropriate supervision, the risk of

workers being run over by trucks can be significantly reduced.

SH&E professionals—especially those who work for companies that have fleets—can become advocates of backup alarms. Although vision systems and sensor-operated alarms are beginning to see more widespread use, industrial decision-makers must be encouraged to use these safety devices on all trucks, vans, SUVs and similar vehicles.

SH&E professionals need not wait for government to legislate safety. When championing these safety devices, SH&E professionals can point to the fact that the cost to install these alarms on a fleet of trucks is significantly less than paying damages involved in just one third-party lawsuit. In many cases, the truck owner and manufacturer are also sued when a truck runs over a pedestrian (other than the employer's own worker). Why wait for that lawsuit, catastrophic injury or death to encourage the use of backup alarms on all trucks and forklifts? Hopefully, the profession will eventually be able to look back on this era as society now looks back on automobiles without seatbelts and airbags, construction workers without hardhats and homes without smoke detectors. ■

References

- ANSI/ASME. B56.1C-1987, Safety Standard for Low and High Lift Trucks. Interpretation: 1-6, No. 3, Sept. 3, 1986.
- "Backup." *Fleet Owner*. Feb. 1964.
- Duchon, J. and L. Laage. "The Consideration of Human Factors in the Design of a Backup Warning System." *Proceedings of the Human Factors Society 30th Annual Meeting*. Santa Monica, CA: HFS, 1986.
- Murphy, W.B. "Protective Devices on Heavy Equipment." Presentation at National Safety Conference, Washington, DC, Feb. 1-2, 1968.
- National Highway Traffic Safety Administration (NHTSA). "An Audible Automobile Backup Pedestrian Warning Device: Development and Evaluation." Contract DOT-HS-5-01185. Washington, DC: NHTSA, July 1976.
- NHTSA. "Backing Crashes: Problem Size Assessment and Statistical Description." Washington, DC: NHTSA, Jan. 1994.
- NIOSH. "Human Factors Analysis of Material Handling Equipment." Contract No. 210-76-0115. Morgantown, WV: NIOSH, Div. of Safety Research, Jan. 1978.
- National Safety Council (NSC). *Injury Facts*. 1999 ed. Itasca, IL: NSC, 1999.
- New Jersey Dept. of Health and Senior Services (NJDOH). "Death on the Job: Forklift Fatalities in 1998." Trenton, NJ: NJDOH, Div. of Epidemiology, Environmental and Occupational Health, Dec. 1999.
- Swartz, G. *Forklift Safety: A Practical Guide to Preventing Powered Industrial Truck Incidents and Injuries*. Rockville, MD: Government Institutes Inc., 1997.
- Swartz, G. *Warehouse Safety: A Practical Guide to Preventing Warehouse Incidents and Injuries*. Rockville, MD: Government Institutes Inc., 1999.
- Stout-Wiegand, N. "Characteristics of Work-Related Injuries Involving Forklift Trucks." *Journal of Safety Research*. 18(1987): 179-190.
- Weiss, W.H. "Sound an Alarm When Backing Up." *Road and Streets*. May 1970.
- Wilcox, S. "Why Forklifts Need Signaling Devices." *Ergonomics in Design*. Oct. 1994.

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