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Tests of Doppler Radar Technology for Haulage Truck Backup Alarms

Objective

Reduce haulage truck accidents resulting from blind spots, with a special emphasis on reducing accidents during backing operations.

Approach

Current innovations in Doppler radar technology have led to suggestions by several institutions and manufacturers that new backup alarm systems are available that can replace or augment warning systems for backing operations on large haulage vehicles. In 1995, Spokane Research Laboratory engineers contacted research institutions, equipment manufacturers, and vendors to determine the availability of such systems. Only two manufacturer-vendors of the radar backup alarms were found. In both cases, the units had not been tested on large, off-road mine haulage trucks. A series of laboratory tests, controlled simulated tests on small vehicles, and full-scale field tests on 240-ton class, end-dump haulage trucks were conducted to evaluate the existing devices.

Field Tests

Two simple parameters were chosen as the basis for the tests: a sensing range of 30 feet and the ability of the device to "see" both small vehicles and human subjects. In the initial field test, the devices were mounted on a platform on a tower placed in the bed of a pickup truck. This test evaluated whether or not the devices would operate in real time in near-field-type conditions.

Only one sensor unit passed this test. This sensor was then tested on a 250-ton mining truck at a truck manufacturer's facility. With the assistance of an engineer and a technician from the company, two radar backup alarms were mounted on a plate centered over the tail lights, backup lights, and the backup alarm at an elevation of approximately 8 feet above the ground surface. The units were attached with two magnetic base plates to facilitate mounting on the truck. Mounting and wiring were accomplished in approximately 2 hours. Since the units needed to be wired into the 24-volt system of the truck, positive connections were made on the tail light circuit, the backup light circuit, and within the cab on the ignition circuit. The warning lights and alarms of the radar unit were also mounted within the cab of the truck on Velcro tape. Initial tests to determine if the units were wired correctly and were able to sense movement of targets were conducted while the truck was stationary. When the truck was started, a multitude of other alarms (air pressure, hydraulic pressure, backup alarm) were activated, totally confusing the driver's ability to distinguish when the radar sensing alarms were activated. To rectify this, the ground system on the truck's backup alarm was disconnected, disabling that system.

Numerous test configurations and positions of the devices were tested. The adjustable magnetic base plates made changing the positions of the devices easier, but aiming and adjusting gain were time consuming. Reasonable results were obtained when two sensors were mounted on a common base about 8 feet above the ground surface (on the light bar) and 25 degrees off horizontal to the ground, the gain was set at 35 percent of maximum, and the beams were positioned to cross to the opposite footprint. This placed the sensing beam 15 to 18 feet behind the wheels and about 10 feet on the centerline of movement. Further flattening of the beam from the horizontal tended to make the device more sensitive to other surrounding objects, with resulting false alarms. While this configuration could be considered operative, it still was problematic, since the distance over which an object was sensed was too restricted to give a truck driver much time to react to an alarm.

Since earlier tests at the Spokane facility suggested that better results were achieved at higher gains when the sensors were 11 to 12 feet above the ground, researchers decided to move the sensors higher on the truck. This new position was above the point where

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the mining truck dump body would hinge, which was at elevation of approximately 14 feet. Each sensor was focused over the rear tire toward the footprint directly behind it, instead of to the opposite side; aimed downward at 30 degrees from horizontal; and adjusted to about 50 percent gain. Tests were then run in which the haulage truck was backed through a parking lot where cars and other objects had been positioned about 20 feet on either side. In this position, the devices were able to sense a vehicle at any position behind the truck at distances ranging from 21 to 24 feet. No false alarms were generated at this setting.

At this point, personnel from the mining truck manufacturer and the Spokane Research Laboratory engineer were satisfied that the devices could operated using this configuration. However, further efforts would be required to mount the device when the dump bed was attached.

Recommendations

Although these devices show much promise for sensing objects within the blind spots of vehicle drivers, they are **not** just bolt-on-and-plug-in devices that are easy to adapt to various situations. Mounting the units to achieve optimum sensing ability without interference and false alarms is, at the very least, a tedious and time-consuming job; while a magnetic mounting bracket helps determine mounting location and aiming, the actual work of gain adjusting, aiming and pointing, evaluating the height for the sensor, and factoring out vibration and interference must be established through trial and error. How the devices perform when a truck is stationary does not indicate how well the devices work when the truck or objects behind the truck are moving. In addition, if a driver feels that performance does not meet expectations, all of the effort can be negated, almost instantaneously, by disconnecting a wire or two.

A factor that must be further evaluated is whether or not the alarms will be noticed when the standard backup alarm is in use. It is possible that the continuous beeping of the standard backup alarm will mask the active Doppler radar alarm signal. These questions will be answered only after testing in actual mining and construction situations.

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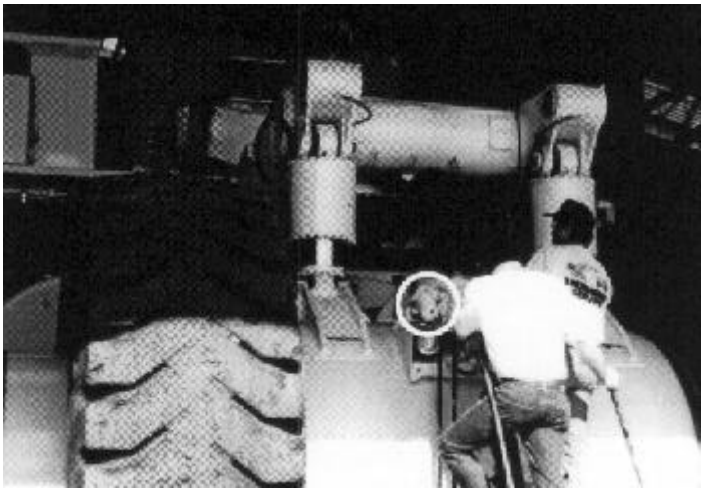
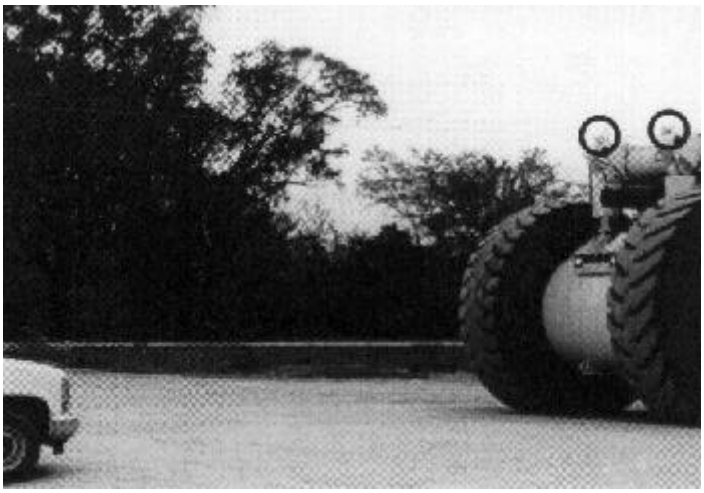
As of October 1996 the safety and health research functions of the former U.S. Bureau of Mines are now located in the National Institute for Occupational Safety and Health (NIOSH).



Mounting sensor on light bar.



Backing toward pickup truck. Note radar units mounted on top of hinge points on truck bed.