Blind Areas Around Construction Equipment

Presented by
David E. Fosbroke
NIOSH, Division of Safety Research

Traffic Management and Work Zone Safety Conference
Orlando, Florida
March 10, 2009
The findings and conclusions in this presentation have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy.
The mention of any company name or product does not constitute endorsement by the National Institute for Occupational Safety and Health.

The photographic display of any product, label, or logo does not constitute endorsement by the National Institute for Occupational Safety and Health.
Efficacy of Backup Alarms?
Evaluating Roadway Construction Work Zone Interventions

A Research Project Conducted by the National Institute for Occupational Safety and Health
Fatality Investigations

http://www.cdc.gov/niosh/face/fac eweb.html
Laborer Run Over by Dump Truck at Roadway Resurfacing Operation in Virginia

Two-lane County Road -- Four-lane State Highway
Flagger
Roller
Truck
Victim
Victim’s Work Area
Trees
Paving Machine
View from the Street
View from Inside the Cab

- Bug Shield
- Fan
- Mirror
- Air Cleaner and Door Post
- Stickers

CDC

SAFER • HEALTHIER • PEOPLE™
Characterizing the Hazard
Defining equipment blind areas
Definition of Blind Area

- A **blind area** is the area around a vehicle or piece of construction equipment that is not visible to the operators, either by direct line-of-sight or indirectly by use of internal and external mirrors.
Operator sight distances from eye level to ground

Eye level 6 ft - 3 m above ground level

18' 7"

12' 1"

3' 10"

8' 2"

8' 2"

12' 5"

Area of fully obstructed view

16' 0"

Vehicle: Bulldozer
Blind Area Mapping Methods

- International Organization for Standardization (ISO) 5006
- Manual methods
  - Light bar
  - Operator
- Computer methods
  - Design drawings
  - Laser scans
  - Photographs
Manual Light Bar Method
Manual Light Bar Example - Blind Area Diagrams - Ford 880

Ground level

Construction barrel ~3 feet

Worker partially bent over ~5 feet
Manual Light Bar Example – Euclid EH4500 Blind Area at Ground Level
Manual Light Bar Example – Hitachi EX5500 Blind Area 1500mm above Ground Level
Manual Operator Method
Manual Operator Method - Marking Blind Areas Within a Polar Grid
Manual Operator Example - Caterpillar 672CH Blind Area at 900mm above Ground Plane
Comparison of Operator and Light Bar Methods for Blind Area Mapping

Operator Method

Light Bar Method
Computer Method – Design Drawings

- Engineering CAD and 3D modeling software
- Locate machine in modeling software
- Generate eye-point light source
- Simulate light blockages
- Simulate mirror image projections
Design Drawing Example – Caterpillar CB 534D Blind Area at Ground Level
Virtual Reality Method - Machine Projected Around Subject
Digital Photographic Modeling Method
Contract Deliverable

Centers for Disease Control and Prevention

Contract 200-2002-00563

“Construction Vehicle and Equipment Blind Area Diagrams”

2003 & 2004 Final Reports
Highway Work Zone Safety

Construction Equipment Visibility

Studies show that highway and street construction workers are at a significant risk of fatal and serious nonfatal injuries while working in and around a street/highway construction job site. In addition to the risk of injury from passing motor vehicle traffic outside the work zone, there is an equally hazardous risk of injury from movement of construction vehicles and equipment within the work zone. In analyzing the data collected on fatalities and serious nonfatal injuries occurring from 1992-1998, researchers from the National Institute for Occupational Safety and Health (NIOSH) have concluded that safety efforts must also protect construction workers within work zones who are working on or around moving vehicles and equipment. [Pratt et al., 2001]

Within this web site you will find detailed diagrams to assist in visualizing the areas around various construction vehicles and equipment that are unable to be seen from the operators position. These areas are commonly referred to as Blind Areas. For each construction vehicle, three different Blind Area Diagrams are available to represent the ability of the operator to see an object at three different elevations: ground level, 1500 mm (5'), and 3000 mm (10'). The 1500 mm plane represents the average height of a channeling device, e.g., construction barrel, commonly used in road construction. The 1500 mm plane corresponds to the height of a 5th percentile female. NIOSH provides this information to safety personnel and instructors as a training aid to develop awareness about hazardous areas around construction vehicles and equipment due to limited visibility.

The test procedure for developing the Blind Area Diagrams are also given within this web site by selecting the appropriate link located on the right side of the page. This information is provided in the event safety personnel or instructors would like to develop their own Blind Area Diagrams.

Highway Work Zone Safety

Topic Index:
- Highway Work Zones
- Highway Work Zones Fatality Investigation Reports
  - In-house Reports
  - State-based Reports
- Construction Equipment Visibility

Topic Area Index:
Highway Work Zone Safety

Construction Equipment Visibility

Diagram Lookup

Below is a list of construction vehicles for which there are Blind Area Diagrams. These diagrams were created by Caterpillar Inc. under NIOSH contract number 208-2012-00563. The opinions, findings, and conclusions expressed herein are not necessarily those of the National Institute for Occupational Safety and Health, nor do they constitute endorsement by the National Institute for Occupational Safety and Health.

Simply click on the vehicle model to view the corresponding Blind Area Diagrams.

- **2 Axle, Front Steer, Rear Dump Trucks**
  - Sterling Acterra 7500
  - GMC 3500HD
  - GMC 4500HD
  - GMC 7000

- **3 Axle, Front Steer, Rear Dump Trucks**
  - Ford 880
  - Ford LT9511
  - Sterling 9511
  - Sterling LT7501

- **Articulated, 3 Axle, Rear Dump Trucks**
The point was representative of the 95th percentile worldwide operator as defined in ISO 3411 "Earth-Moving Machinery - Human Physical Dimensions of Operators and Minimum Operator Space Envelope" (BIP) as defined in ISO 5353:2001 for earth-moving machinery and tractors and machinery for agriculture and forestry - Seat Index Point (SIP). Light source horizontal spacings as defined in ISO 5353 for the various sectors of vision around the machine. Shown in Figure 3 were used for mapping the shadows which represent the visibility blind areas. These horizontal spacings represent the ability of an operator to move his head laterally to see around visibility blockages.

Blind areas were determined for these planes of vision: the ground plane, a plane at 900 mm above ground to correspond to the height of channeling devices, and a plane at 1500 mm above ground to correspond to the height of a 50th percentile standing female. The 1500 mm above ground plane also corresponds to a height that is slightly less than the stature of the 95th percentile operator as defined in ISO 3411. Polar plots of the recorded data were generated with 5-degree increments and 1-meter intervals up to the 12-meter or 24-meter test circle perimeter, depending on machine size.

The indirect visibility, through the use of mirrors, was measured using a single light source in accordance with ISO/CD 14601-1:2001: Earth-Moving Machinery - Surveillance and Rearview Mirrors, Field of Vision - Part 1 - Test Method.
NIOSH Safety and Health Topic:

Highway Work Zone Safety

Construction Equipment Visibility

NIOSH Manual Method

In 2001, NIOSH began evaluating promising strategies to prevent workers from being struck by construction vehicles and equipment operating in roadway work zones. The evaluation methods required the use of equipment blind area diagrams, which were developed using two approaches. First, NIOSH contracted with Caterpillar, Inc. to use standard test methods (physical measurements and computer simulations) for creating blind area diagrams. Second, NIOSH staff developed a manual method for creating blind area diagrams in a relatively short period of time. Although none of the blind area diagrams shown in this website were created using the NIOSH manual method, it is explained here as a low-tech alternative. The NIOSH manual procedure is more subjective than the ISO methods used by Caterpillar, Inc.; however, the NIOSH procedure does not require specialized apparatus or software (e.g., measuring seat index point, mounting light flaments, computer design drawings) and it does not require a particular location (i.e., large, enclosed warehouse where light shadows can be projected on a grid). The NIOSH manual method can be used by construction companies, labor unions, and training organizations to better understand the blind areas around their own equipment.

For the NIOSH manual method, blind areas are defined as those areas where the equipment operator, who is seated in the equipment cab, cannot see an object by direct line of sight or in mirrors. Three different objects are of interest: 1) the ground itself, 2) a road construction barrel, and 3) a worker. This procedure results in three blind area plots that define the visibility around these three objects of interest, represented respectively by the following heights: the ground, 900 mm above the ground, and 1500 mm above the ground.

Test Site Preparation

A flat area at least 24 m on each side, such as a gravel or asphalt parking lot, is required for the layout of the test grid. The area should be cleared of any large rocks. Using a surveyor's transit, mark a grid on the test site using stakes, spray paint, paint chalk markers, or any other method.

Highway Work Zone Safety

Topic Index:

Highway Work Zones
Highway Work Zones Fatality Investigation Reports

Topic Area Index:

Home
Diagram Lookup
Test Procedure
Physical Measurements
Recommendations for Evaluating & Implementing Proximity Warning Systems on Surface Mining Equipment

Evaluation of Systems to Monitor Blind Areas Behind Trucks Used in Road Construction and Maintenance: Phase 1

Department of Health and Human Services
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

NIOSH

CDC

SAFER • HEALTHIER • PEOPLE™
Detection Zones

- Rear camera
- Generator

Diagram showing:
- Water truck
- Generator
- Danger zone
- Warning zone
Blind Area Diagram Usage

Worker Free Zone Activity Part 1

F800 Dump Truck

Loader, Clark 75C
Blind Areas at Height of 1500 mm
David E. Fosbroke
NIOSH
Division of Safety Research
Morgantown, WV
(304) 285-6010
dFosbroke@cdc.gov