Preventing Workers from Being Struck by Roadway Construction Equipment

Presenters:
Jennifer Beaupre
Mat Hause and Bob Hammer
NIOSH Publication
Building Safer Highway Work Zones: Measures to Prevent Worker Injuries from Vehicles and Equipment

Building Safer Highway Work Zones:
Measures to Prevent Worker Injuries from Vehicles and Equipment

Delivering on the Nation’s Promise:
Safety and health at work
For all people
Through research and prevention

To receive other information about occupational safety and health topics, call 1-800-CEN-NIOSH (1-800-236-6474), or visit the NIOSH Website at:
www.cdc.gov/niosh

DHHS (NIOSH) PUBLICATION No. 2001-128
Outline

- Background
- Fatality Investigations
- Blind Area Measurements
- Prevention Measures
  - Administrative Controls
  - Engineering Controls
910 worker deaths in work zones from 1992-2000

- 826 (91%) were vehicle or equipment-related (traffic vehicle, construction vehicle, or both)
Worker Fatalities in Roadway Construction

- Construction vehicles account for as many “worker on foot” deaths as traffic vehicles.
- Construction vehicle deaths are responsible for the recent increase in worker deaths.
Worker Fatalities in Roadway Construction

Deaths by Vehicle Type and Year, 1992-2000 (n=797)

Source: Census of Fatal Occupational Injuries, special research file (excludes NYC)
Worker Fatalities in Roadway Construction

Deaths by Industry, 1992-2000 (n=910)

- Highway and street construction
- Special trades contractors
- Bridge construction
- Other construction
- Public administration
- Services
- All other

Source: Census of Fatal Occupational Injuries, special research file (excludes NYC)
Workers on Foot – Construction Vehicle Only

Deaths by Construction Vehicle Type, 1992-2000 (n=258)

- Dump truck: 41%
- Semi-truck: 6%
- Grading/surfacing machine: 14.3%
- Excavating machine: 6.5%
- Other/unspec truck: 14%
- Other machine: 10.4%
- Other vehicle/other source: 7.7%

Source: Census of Fatal Occupational Injuries, special research file (excludes NYC)
Backings Fatalities in Roadway Construction

Deaths by Construction Vehicle Type, 1992-2000 (n=130)

- Dump truck: 52%
- Grader or scraper: 9%
- Semi-truck: 7%
- Pickup truck: 5%
- Other/unspec truck: 4%
- Other machine or vehicle: 4%

Source: Census of Fatal Occupational Injuries, special research file (excludes NYC)
Fatality Investigations

http://www.cdc.gov/niosh/face/faceweb.html
Example Fatality Cases

Case 1: 45-year-old boom truck driver run over by dump truck that was backing during a repositioning maneuver.

Case 2: 31-year-old worker run over by front-end loader at the site of a crushing machine.

Case 3: 35-year-old laborer run over by dump truck at roadway resurfacing operation.

Case 4: 54-year-old laborer run over by motor grader at housing development roadway under construction.
Case 1

Minnesota Face Program (MN9207)
Concrete Paving Operation Layout

Turn-around

Truck Line

Paver
Truck Queue Repositioning

New Truck

Last Truck

Turn-around

Truck Line
Case 2

Minnesota FACE Program (98MN030)
Figure 1. Incident Site (Not To Scale)
Redesigned Site Layout

Crusher

Earthen Ramp

Recommended Loader Route: Backed Down Earthen Ramp And Driven Forward Down Side Exit Ramp

Side Exit Ramp

Pedestrian Barriers
Case 3

Two-lane County Road -- Four-lane State Highway
Two-lane County Road Paving Machine Roller Truck Victim Victim’s Work Area Two-lane County Road Flagger
View from the Street
Case 4
View from Grader
Summary of Safety Hazards Identified in FACE Investigations

- Ensure that trucks are equipped with audible back-up alarm and look into installing rear sensing units
- Install strobe lights on all company-owned work trucks
- Maintain equipment
- Heavy equipment should be driven in the forward direction as much as possible
Summary of Safety Hazards Identified in FACE Investigations

- Have a comprehensive safety plan
- Conduct a pre-work safety meeting to discuss potential hazards
- Pedestrians should wear high visibility clothing and head gear

http://www.cdc.gov/niosh FACE/faceweb.html
Any Questions???

NIOSH – Morgantown, WV

JBeaupre@cdc.gov  (304) 285-6185

www.cdc.gov/niosh
Prevention Measures

Include:

- Identifying Blind Areas
- Administrative Controls
  - Backing Safety Program
  - Internal Traffic Control Plans
- Engineering Controls
  - Proximity Warning Systems
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.
Problem

- Workers must be near moving equipment
- Blind areas around equipment extensive
Vehicle Blind Spots

- Running over people
- Running over materials
- Striking other equipment and vehicles
- Rollovers
- Contact with utilities
Working in Work Zones
Non-Construction Vehicle Blind Spot Measurements

- What About Construction Equipment?
Operator sight distances from eye level to ground

Area of fully obstructed view

The No-Zone

Vehicle: L-132
5 ton Dump Truck
Methods

- Manual methods
- Computer method
- International Organization for Standardization (ISO) 5006
Target Stand
Blind Area Diagrams - Ford 880

- Ground
- Construction Barrel ~3ft
- Worker partially bent over ~5ft
Marking Blind Areas Within a Polar Grid
Blind Area Determination
Blind Area

Not Visible to Operator

Visible in mirrors only
Comparison of Manual Methods

Field Crew

Light Bar
Hazard Area Analysis

- Vehicle operating speeds
- Vehicle direction of movement
- Worker reaction time
Hazard Area Around Ford 800 Dump Truck

- Greatest Risk
- Orange
- Yellow
- Green
- Grey
- No Risk
- Dump Truck
Hazard Area Around Ford 800 Dump Truck
Future Work

- Complete blind area diagrams for 14-16 more pieces of construction equipment.

- Package and distribute comprehensive blind area diagram document.
Conclusions

- With these techniques, worker exposure assessments across the different types & makes of construction equipment are possible.

- Understanding where current visibility limitations are around heavy equipment, and what levels of risk exist, will aid in the development of new protective technologies, worker training, and safer operational procedures.
Questions?
Prevention Measures (con’t)

- Administrative Controls
  - Backing Safety Program
  - Internal Traffic Control Plans

- Engineering Controls
  - Proximity Warning Systems
Key Elements of a Vehicle Backing Safety Program

- Equipment designed to minimize blind areas
- Equipment inspections/preventative maintenance
- Layout work areas to avoid backing
- Use of spotters
- Training for operators and workers on foot
- Use of high visibility vests
- Use of other backing safety devices (engineering controls)
Backing Safety Program

Prevention Measures

- Equipment designed to minimize blind areas
Backing Safety Program
Prevention Measures

Operator Training:
- Avoid having to backup
- Do walk around
- Be aware of blind areas
- Use a spotter
Backing Safety Program
Prevention Measures

Worker Training:

- Be aware of equipment blind areas
- Stay out of all blind areas and swing radius
- Make positive eye contact with operators
Operator Human Factors

- Expectancy
- Perception time
- Reaction time
- Ability
Worker Visibility:

- Require workers to wear high-visibility clothing.
- Apparel that covers moving parts of the body is best.
- Consider apparel with different designs front and back.
Internal Traffic Control Plans
Why Develop an Internal Traffic Control Plan?

- Coordinate vehicle/equipment movement inside the work zone
- Limit exposure of workers on foot to construction traffic
- Reduce hazards for equipment operators
Traffic Control Plans
Proposed Definition of Internal Traffic Control Plans (ITCP)

“STRATEGIES TO CONTROL THE FLOW OF CONSTRUCTION WORKERS, VEHICLES AND EQUIPMENT INSIDE THE WORKZONE”
ITCP Principles of Safe Construction Traffic Control

- Reducing the need to back up equipment
- Limiting access points to work zones
- Establishing pedestrian-free areas where possible
- Establishing work zone layouts commensurate with type of equipment
- Providing signs within the work zone to give guidance to pedestrians, equipment and trucks
- Designing buffer spaces to protect pedestrians from errant vehicles or work zone equipment
ITCP Components

- Notes Page
  - Safety Points
  - Personnel
  - Equipment
- Legend
  - Method Specific
- Work Area Diagrams
  - Dimensions
  - Movement Flow
  - Workzone Limits
  - Signage
Internal Traffic Control Plan

Safety Points:

- No workers in traffic zone
- Spotter uses hands free radio to talk to trucks
- No workers on foot between a backing truck and the paver
- No rollers within 50 feet of the back of the paver
- Inspectors remain away from paving train and notify spotter before obtaining samples
Internal Traffic Control Plans

Symbols’ Legend

- LIGHT(S)
- CHANNELING DEVICE(S)
- BARRIER
- DIRECTION OF TEMPORARY TRAFFIC OR DETOUR
- DIRECTION OF TRAFFIC
- TRUCK MOVEMENT
- SIGN (SHOWN FACING RIGHT)
- PORTABLE LAVATORY

- On foot personnel classes -

- PEDESTRIAN WORKER
- SPOTTER
- INSPECTOR
- PEDESTRIAN-FREE ZONE

- FOREMAN
- FLAGGER
- SURVEYOR
- OTHER CLASS
Internal Traffic Control Plans
Symbols’ Legend

- Vehicle Types -

ROLLER  PAVING MACHINE
GRADER  FRONT LOADER
BACKHOE  DUMP TRUCK (EMPTY)
DOZER  DUMP TRUCK (FULL)
OIL TRUCK  WATER TRUCK
CRANE  FORKLIFT
SWEEPER  BOTTOM DUMP
PICKUP TRUCK  MILLING MACHINE
Internal Traffic Control Plans

Paving Model Plan – Traffic Adjacent
Steps in Preparation of ITCPs

- Review TCP (for Work Zones) and Other Contract Documents
- Determine Site Specific ITCP Needs
- Draw Work Space
- Add Pedestrian and Equipment Paths
- Locate Staging Areas
- Prepare Notes and Plan
Revised Internal Traffic Control Plan
Site 2
Internal Traffic Control Plans for
Asphalt Paving Operations
On Freeway Segments
Task 7.1
Contract No. 200-2002-00596
Submitted to the
CENTERS FOR DISEASE CONTROL
and PREVENTION
CONTRACTS MANAGEMENT BRANCH
Submitted by
C.L. Williams Consulting, Inc.
4720 W. Maverick Lane, Suite #103
Lakeside, Arizona 85929
May 16, 2003

Internal Traffic Control Plan
Draft Development Guide
Internal Traffic Control Plans for
Asphalt Paving Operations
On Freeway Segments
Task 8.1
Contract No. 200-2002-00596
Submitted to the
CENTERS FOR DISEASE CONTROL
and PREVENTION
CONTRACTS MANAGEMENT BRANCH
Submitted by
C.L. Williams Consulting, Inc.
4720 W. Maverick Lane, Suite #103
Lakeside, Arizona 85929
June 19, 2003
Engineering Controls
Blind Spot Intervention Types

- Backup alarms
- Spotters
- Visual Devices
- Sensors/Parking Aids
- Other/Hybrid devices
Evaluating Systems

Which work best for construction sites?

- Preliminary test in parking lot.
  - Feasible to mount system on trucks?
  - Minimal false alarms?
  - Reliable detection of a person?

- Long term test.
  - System evaluation forms
  - Driver interviews
  - First hand observations during ride-along
  - Winter and summer tests
Systems Selected for Long Term Tests with WSDOT
Camera Systems

Clarion heated camera

Intec camera
Ultrasonic System

Hindsight 20/20

Sensors
Camera and Radar
Sanding Truck

- Two systems selected for winter tests on a sanding truck:
  - Preco’s Preview radar
  - Clarion heated camera with shield

- 2 month test (Dec. – Jan.) in harsh conditions
Camera and Radar
Sanding Truck
Camera and Radar
Sanding Truck

Results:

- Camera and radar effective in dry conditions

- Problems in snow, rain:
  - Snow, ice, mud build-up after 5 miles
  - Camera lens shield froze then broke
  - Radar false alarms from snow and mud on antenna

- Improvements needed!
Camera and Radar
Dump Truck

- Camera and radar worked best when mounted high
- Could not mount either system on the tailgate or hitch area
- Designed bridge for mounting systems
Camera and Radar
Dump Truck

Camera field of view

Radar detection of a standing person

Crouching person not detected here
Results:

- Ride-along showed very few false alarms from radar, but camera more useful
- Clearance problem with bridge under asphalt loading bins and wheeled loaders
- Bridge won’t work - camera and radar must be mounted on dump box
Hindsight Sonar
Dump Truck

Ultrasonic-based system
Hindsight Sonar
Dump Truck

Results:

- Drivers said system is reliable in most conditions
- Concerned about detection range of 8 ft
- Some false alarms in heavy dust
- Constant false alarms when trailer is being pulled (optional trailer system needed)
- Tests continue on smaller vehicles
Intec Camera System
Dump Truck

- Small camera that can mount on side of dump box
- Size of 2 inch cube
Intec Camera System
Dump Truck

Results:
- Small size allowed for good mounting location
- Most drivers found it useful
- Reliable operation during 5 month test
- Would have problems in winter
Guardian Alert Radar System
Dump and Bridge Insp. Trucks
Guardian Alert Radar System
Dump and Bridge Insp. Trucks

Results:

- Small and easy to mount
- Does not detect people very well
- Good detection of other objects
Conclusions

Sensor systems (radar, sonar, infrared):
- False alarms are possible
- Nuisance alarms can be numerous in crowded work areas

Camera systems:
- Provide view of blind area
- Do not alarm so potential collision may go unnoticed
- May not work in winter conditions
- Good solution for crowded work zones during warmer months

A combination of sensors and a camera may be best solution for warmer months
- Alarm prompts driver to check video
- Video allows driver to check source of alarm
Previous test results prompted Preco to modify their radar system:

- Smaller package
- Ignores some mud/snow on sensor face
- Tests on 3 dump trucks this spring
System Improvements

- Intec developing new cameras for winter-time use:
  - Small, heated enclosure
  - Innovative methods to keep lens clean
  - Winter tests to be scheduled
New Ideas

The TagView System

How it Works

TagView™ has three main components:

- Small, low cost tags secured to each worker or embedded in an Electronic Guardrail™ in the area to be monitored
- Rugged reader units located on vehicles operating in the area
- LCD displays located in the vehicle cabs

The reader emits an interrogation signal which is detected by any tags within range (typically 50 to 100 feet). The tags respond with predetermined timing signals, which the reader interprets. The reader determines the distance to the closest tag, and a cab-mounted display unit alerts the vehicle operator with visual and/or audible warnings. The cab display can be programmed with warnings and alerts which change appropriately with tag distance.
NIOSH Publication

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

NIOSH –
Morgantown, WV

bhammer@cdc.gov - (304) 285-6379