A toolkit to help recognize and remediate slip, trip, and fall hazards at surface mines

Mahiyar Nasarwanji, Ph.D., C.P.E.
Alan Mayton, P.E., C.M.S.P.
Jonisha Pollard, M.S., C.P.E.
Acknowledgements

Patrick Dempsey
Lydia Kocher
Mary Ellen Nelson
William Porter
Ashley Whitson

All those I “borrowed” images from
The slip, trip, and fall (STF) prevention toolkit
What are slips?

- A loss of traction of the foot
- If the foot slides, you slipped
What are trips?

- Something that prevents the foot from coming fully through its normal swing phase

- If the foot gets stopped/snagged, you tripped
What really matters?

• Do all slips/trips lead to falls?
  Yes / No

• Is it important if I slipped or tripped but did not fall?
  Yes / No
Types of falls

Fall to the same level

• Fall to surface you are walking/working/standing on
• Fall against object at or above the surface

Fall to a lower level

• Fall to a level below which you are walking/working/standing
Our focus was on surface mining operations
Surface mining is a hazardous occupation

- **5,016** Non-fatal injuries
- **29** Fatalities
- **118,257** Lost work days
- **51,429** Days of restricted activity

Per year 2008-2017
Slips and falls are a significant contributor

- **Non-fatal injuries (surface mines)**: 24%
- **Fatalities (surface mines)**: 17%

2008-2017
Investigating fall fatalities at surface mines

Slip or Fall Fatality
2006-2015
Investigating fall fatalities at surface mines

Slip or Fall Fatality

2006-2015

- Occupations
  - Laborer
  - Equipment operator
  - Mechanic
  - Truck driver
  - Supervisor/foreman
  - Other

- Task performed
- Contributing factors
- Primary cause
Investigating fall fatalities at surface mines

- Maintenance & repair
- Operations
- Installing/dismantling
- Inspection
- Unknown/Other

Contribution factors:
- Task performed
- Primary cause
- Contributing factors

Slip or Fall Fatality
2006-2015
Primary and secondary cause of fall fatalities

- Fall from height: 49%
- Fall from stairs/ladder: 11%
- Fall into water: 18%
- Other: 22%

Unknown, Fall through opening, Failure of ground/floor/equipment, Fall through roof, Slip, Unexpected movement, Ejected from/thrown off equipment

2006-2015
5 factors contributed to 75% of the fatalities

- Fall protection: 33%
- Equipment related issues: 13%
- Operating procedure: 13%
- Barriers: 8%
- Lockout/tagout & blocking: 8%
- Other: 25%
Recommendations based on NIOSH’s Hierarchy of Hazard Controls

- **Elimination**: Design, install, or move equipment to eliminate or minimize hazards associated with working at heights. Inspect and maintain equipment regularly to prevent failure.
- **Substitution**: Move equipment or work to a lower height to minimize hazards.
- **Engineering controls**: Install guardrails and barriers to prevent access to hazardous areas, especially around unguarded floor openings.
- **Administrative controls**: Establish and use safe operating procedures when working at heights and provide adequate training.
- **PPE**: Supply and use personal protective equipment (PPE) such as a personal fall arrest system.
Falls Can Kill!

In 10 years, 55 mine workers died from falls.

Minimize working at heights
Design, install, or move equipment to reduce or eliminate fall risk.

Install barriers
Prevent access to hazardous areas and clearly identify hazards.

Use a personal fall arrest system
Use harnesses of the correct size, designed for the task, and with substantial tie-off points. Ensure you inspect, maintain, and are trained to use fall arrest systems.

Inspect and maintain equipment
Look for defects, fix damaged and improperly modified equipment, and use equipment as intended.

Pay special attention
Be especially cautious during maintenance and repair and installation, construction, or dismantling activities.

To learn more, visit www.cdc.gov/niosh/mining

Data based on an analysis of fatal accidents investigated by MSHA between 2000 and 2015 involving high and low. To read the full investigative report visit http://msd.cdc.gov/miner/miner/topics/mining/falls.html?view=full
STF hazards in the work environment

- Ladder safety
- Steps to Ladder Safety
- Simple solutions
- RRR stickers
- ErgoMine 2.0
Steps to Ladder Safety

Most standards recommend:

1. Wearing appropriate shoes
2. Cleaning the ladder
3. Inspecting the ladder
4. Facing the ladder
5. Never jumping off ladders
6. Always using three points of contact
STF hazard assessment at surface SSG mines

- We shadowed workers
- We observed their working environment

36 hours (~4 days) of observation

- Max: 73°F
- Average: 52°F
- Min: 32°F

- Dry 70%
- Rain 11%
- Snow 19%
Common STF hazards along the path of travel or on walkways

- Solid debris: 576 times
- Liquid contaminants: 469 times
- Change in level: 260 times
- Trip hazards: 159 times
- Snow/ice: 135 times
- Step up/down: 131 times

Number of times a hazard was encountered during the 36 hours of observation.
Common STF hazards along the path of travel or on walkways

- **Solid debris**: 576 times, once every 3.8 minutes
- **Liquid contaminants**: 469 times, once every 4.6 minutes
- **Change in level**: 260 times, once every 8.3 minutes
- **Trip hazards**: 159 times, once every 13.6 minutes
- **Snow/ice**: 135 times, once every 16 minutes
- **Step up/down**: 131 times, once every 16.5 minutes

Number of times a hazard was encountered during the 36 hours of observation
We also identified common hazards on stairs and ladders.

Stairways (n=185)
- Tread issues: 30%
- Solid debris: 25%
- Liquid contaminants: 12%

Ladders (n=28)
- Compromised transitions: 71%
- Ladder rung issues: 7%

n = number of times hazard was encountered during the 36 hours of observation

Prevent Slips
Prevent Trips
Prevent Falls

www.cdc.gov/niosh/mining

Report the hazard, repair the hazard, revisit the area.
There are “Simple Solutions”

A lot more than just STF issues: Prevention of musculoskeletal disorders and overexertion injuries.
There is an App for that... ErgoMine

http://go.usa.gov/x9Qnw
Mining equipment ingress/egress systems
Ingress and egress systems

• Ingress – getting on
  Ground → Cab

• Egress – getting off
  Cab → Ground

• Includes
  • Platforms
  • Ladders
  • Stairs
Ingress and egress from mobile equipment

Falls from all equipment
2006-2007

Ingress or egress 48%
Other 52%

Slips and falls from haul trucks
2004-2008

Ingress or egress 65%
Other 35%


Injuries during ingress and egress

- 7% of all non-fatal injuries
- 5th most common activity at time of incident
- 858 injuries per year
- 11 median days lost per injury

Based on an analysis of 20 years of MSHA non-fatal injuries data 1996-2015
We used two approaches to help corroborate evidence:

- Analysis of MSHA non-fatal injury data
  - For front-end wheel loaders
- Interviews with equipment operators
  - Any mobile equipment
Egress is more dangerous than ingress

Based on an analysis of 20 years of MSHA non-fatal injuries data for front end loaders 1996-2015
Bottom rungs with flexible rails may contribute to the issue

Based on an analysis of 20 years of MSHA non-fatal injuries data for front end loaders 1996-2015
Poor ground conditions: Step on or step in

Look out for...

- Rocks
- Hoses/pipes and other materials
- Uneven surface, ruts and holes

Based on an analysis of 20 years of MSHA non-fatal injuries data for front end loaders 1996-2015
Contaminants: slips were common

Based on an analysis of 20 years of MSHA non-fatal injuries data for front end loaders 1996-2015
Unexpected movement and equipment failure

Unexpected movement associated with blowing wind

Equipment failure – But not clear how it failed

Based on an analysis of 20 years of MSHA non-fatal injuries data for front end loaders 1996-2015
Themes from interviews and focus groups with mobile equipment operators

### Portion of I/E process leading to STF
- Egress more dangerous than ingress
  - Backward vs. forward
- Getting in and out of cab
  - Carrying items
  - Opening doors

### Features or conditions of I/E system leading to STF
- Ladder design and condition
  - Flexible rails
  - Distance from ground
  - Traction
  - Bent/damaged
- Contaminants
  - On ladders and platforms

### Superior features of I/E systems
- Ladder design and condition
  - Rigidity > flexibility
  - Stairs > ladder
  - More tread depth

### Tasks leading to STF
- Maintenance and repair
- Traction
- Lighting

### Conditions contributing to STFs
- Ground conditions
  - Weather
  - Unlevel ground
- Disrepair of unrelated parts
- Footwear
  - Metatarsal boots
  - Traction
  - Muddy boots
Summary of ingress/egress recommendations

- Provide a designated parking area that is well maintained and free of rocks, ruts, and debris
- Increase illumination on and around the ingress/egress system
- Provide deeper ladder treads with a non-slip coating (similar to linings used on truck beds). Build a boarding platform with stairs that allow operators to access the cab of the equipment without climbing a ladder.
- Provide shoe cleaning station on the equipment and on the ground
- Conduct regular inspection and maintenance
- Design doors and other movable parts to prevent unexpected movement
- Ensure consistent rung spacing (even for the bottom rung)
- Ensure that adequate handholds are provided for the length of the ladder into the cab
- Provide backpacks or shoulder straps to carry tools, equipment, lunch bags, and water bottles
- Use the “buddy system” to transport large items to the equipment

We have a more engaging way to disseminate these recommendations.
Easy to use recommendations in an interactive format
I can not predict the future, but I can tell you what we are working on
Analysis of imminent danger orders

- Slip or fall of person: 50%
- Powered haulage: 30%
- Other: 20%

- Fall protection
- Safe Access
- Unsafe Act
- Inadequate Barricades, Guarding, or Signage
- Unsafe Condition

2010-2017
Studying the biomechanics of getting on and off ladders with flexible rails
Illumination measurements on ingress/egress systems and around the perimeter of mobile equipment before dawn

<table>
<thead>
<tr>
<th>Mobile Equipment</th>
<th>Ground below 1st step</th>
<th>On 1st step</th>
<th>Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>No equipment/task lighting</td>
<td>2.9 Lux</td>
<td>0.26 Lux</td>
<td>2.6 lux</td>
</tr>
<tr>
<td>With equipment/task lighting</td>
<td>8.0 Lux</td>
<td>11.5 Lux</td>
<td>23.0 Lux</td>
</tr>
</tbody>
</table>

Recommended value for visual tasks is 100-200 Lux (10-20 fc)
More tools in the pipeline ...
The slip, trip, and fall prevention toolkit for mining
Questions?

Mahiyar F. Nasarwanji
MNasarwanji@cdc.gov
412-386-5113

STF prevention: http://go.usa.gov/xP7aN