Slip, Trip & Fall Hazard Identification, Investigation, and Remediation at Surface Mining Facilities

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Participating Mines and Miners
Take home: Slip, trip, and fall (STF) prevention tools

http://go.usa.gov/xP7aN
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
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
Mine Safety and Health Administration Data

• Burden and research need
• Guide research to most significant problems
Surface mining is a hazardous occupation

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

Per year 2008-2017
STF are a significant contributor

Non-fatal injuries (surface mines)

- 24% Others

Fatalities (surface mines)

- 17% Others

2008-2017
Investigating fall fatalities at surface mines

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

2006-2015
Primary and secondary cause of fall fatalities

- Fall from height: 49%
- Fall from stairs/ladder: 22%
- Fall into water: 11%
- Other: 18%
- Unknown: 18%
- Fall through opening: 11%
- Failure of ground/floor/equipment: 11%
- Fall through roof: 11%
- Slip: 11%
- Unexpected movement: 11%
- Ejected from/thrown off equipment: 11%

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

- Fall protection: 33%
- Equipment related issues: 13%
- Operating procedure: 13%
- Barriers: 13%
- Lockout/tagout & blocking: 8%
- Other: 8%

2006-2015
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
STF hazards in the work environment

- STF taxonomy
- STF hazard list
- Ladder safety
  - Steps to Ladder Safety
  - Simple solutions
  - RRR stickers
- STF hazard assessment
- STF checklist & recommendations
- ErgoMine 2.0
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, 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
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
There are “Simple Solutions”

ERGONOMICS IMPROVEMENTS
AT SURFACE MINES

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
Maintenance and Repair Audit Modules

**Administrative**
1. Tools and safety devices
2. Communication
3. Lock Out/Tag Out
4. Working at heights

**Facility**
5. Slips, Trips and Falls
6. Environmental Factors
7. Machine guarding

**Pre-Maintenance**
8. Equipment Access
9. Maintenance Preparation
10. Housekeeping

**All Maintenance Tasks**
11. Blocking
12. Posture Assessment
13. Gross Posture Assessment
14. Hand Tool Use

**Specific Maintenance Tasks**
15. Screen Maintenance
16. Greasing
17. Conveyor Maintenance
Audit Question Examples

5.18: Do any permanent ladders share landings with stairways (see picture below)?

Figure 2 (Tap to Enlarge): Stairway and permanent ladder that share a landing.

5.4: Do all walkways have toe boards (see figure below)?

Figure 1 (Tap to Enlarge): Example of walkway with toe board.

5.2: In addition to overhead lighting, are light sources mounted near ground level to improve illumination of walking areas?

○ Yes
○ No
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%


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

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
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
Easy to use recommendations in an **interactive format**
Recommendations for boot replacement based on tread wear to prevent STF
How do boots wear and does wear influence STF risk?

- Outsole wear results in changes to treads that may impact slip resistance (e.g. ability to evacuate liquids).
- Most footwear research in the STF area has focused on non-mining occupations.
- Our aim was to measure wear longitudinally to develop recommendations for replacement based on tread wear (contract is testing boots at end of study).
- Volunteer miners were provided new boots and their wear was tracked.
Boot was cut into parts to allow for better alignment

Virtual calipers added to 3D scans to measure wear
Examples of Wear

<table>
<thead>
<tr>
<th></th>
<th>Heel</th>
<th>Arch-Ball</th>
<th>Ball</th>
<th>Toe</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Months</td>
<td>-26%</td>
<td>-13%</td>
<td>-26%</td>
<td>-27%</td>
</tr>
<tr>
<td>6 Months</td>
<td>-44%</td>
<td>-21%</td>
<td>-36%</td>
<td>-40%</td>
</tr>
</tbody>
</table>
Activity log tracked hours and locations worked and STF events

STF Events By Job Title

- Maintenance: 46%
- Plant Operator: 29%
- Manager: 13%
- Dispatcher: 10%
- Mobile Equipment: 2%

58 Total STF events
Data from 17 participants from Mine 2

Average number of working days (8 h) a pair of boots was used until they were returned

- Maintenance/Utility: 218.0 days
- Plant Operator: 254.9 days
- Manager: 318.6 days
- Mobile equipment operator: 349.2 days

Half were returned in under 134 days

Data from 22 participants from Mine 1

Disclaimer: The findings and conclusions in this report/presentation have not been formally disseminated by the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention and should not be construed to represent any agency determination or policy.
Electrical protection may be compromised at the end of life of the boots due to holes, fissures, and leaks.

Electrical conductivity testing based on ASTM F2412/13

1 of the 3 boots initially sent for testing failed.
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>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>haul trucks</td>
<td>19</td>
</tr>
<tr>
<td>wheel loaders</td>
<td>12</td>
</tr>
<tr>
<td>dozers</td>
<td>3</td>
</tr>
<tr>
<td>excavators</td>
<td>3</td>
</tr>
<tr>
<td>motor grader</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lighting Condition</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 ...
Slip, Trip, and Fall Prevention for Mining Website

http://go.usa.gov/xP7aN
Manual materials handling safety currently being addressed by three specific aims

1. Provide mining-specific information to minimize materials handling risks at mine sites.

2. Develop workplace guidance and performance specifications for hand protection to prevent severe hand and finger injuries associated with materials handling.

3. Determine the efficacy of using exoskeletons to reduce the physical demands of manual materials handling tasks at mine sites.
Questions?

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