Identifying and Solving Ergonomics Problems in Coal Preparation and Mineral Processing Plants

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Outline

I. Intro to Ergonomics
II. Assessing Your Ergonomics
III. Risk Factor Awareness
IV. Ergonomics Risk Management
V. Maintenance and Repair Injury Statistics
VI. Mitigating These Injuries
I. Intro to Ergonomics

Ergonomics is....

The scientific study of human interaction with the work environment

Ergonomics considers....

The physical and mental capabilities of workers as they interact with tools, equipment, work methods, tasks and working environment
Fit Miners to Mine Equipment?

‘Bretby Man’ by Steve Mason (courtesy Tom Leamon)

- Designed miner to fit drill-loader
- Long neck to see over booms
- Short right arm to operate control panel at shoulder level
- Short left leg for ‘deadman’ pedal (Simpson, Horberry and Joy, 2009)
Goal of Ergonomics

Reduce work-related injuries by adapting the work to fit the people performing the work

- Improve safety of work
- Improve quality of work
- Increase efficiency
- Reduce fatigue and discomfort
- Enhance the quality of life for the workers
Work-Related Injuries

• **Acute injuries**
  – Occur instantly
  – Examples: fractures, cuts, bruises

• **Cumulative injuries**
  – Develop gradually
  – Musculoskeletal Disorders
    • Tendonitis
    • Low back pain
Cumulative Injury Progression

- Fatigue/Stiffness
- Pain Comes and Goes
- Continuous Pain
- Loss of Function
Musculoskeletal Disorders (MSDs)

Affect the body’s…
- Muscles
- Joints
- Ligaments
- Tendons
- Nerves

Tend to have…
- Long durations
- Long treatment time
- Greater work disability than acute injuries
MSDs

Are a priority because…
• They can be prevented or minimized
• They can affect large numbers of people across occupations and age groups
• They impose heavy costs on employers
• They can affect a worker’s endurance, focus, quality of work, and safety

They affect your quality of life, at and away from the workplace
II. Assessing Your Ergonomics

To assess your ergonomics…

• You don’t need:
  – sophisticated instrumentation
  – a degree in Ergonomics

• You do need:
  – to be familiar with the work environment
  – to communicate with those performing the work
  – to educate your workforce
  – to be vested in injury prevention
Assessing Your Ergonomics

1. Determine tasks of interest
2. Prioritize tasks for redesign
3. Perform Ergonomics Risk Management
Determine Task of Interest

Pull injury data for all injuries
  – Identify equipment involved
  – Determine employee task at the time of injury
  – Identify contributing factors
  – Interview other employees who perform this task
  – Work with affected employee(s) on developing or implementing control strategies
Discomfort Surveys

Guidance for usage available in IC 9509 @ www.cdc.gov/noish/mining

Musculoskeletal Discomfort Survey

(based on the Nordic Questionnaire)

Job/Position: ____________________________ How long have you been doing this job? __________ years __________ months
Gender: M F Age: ______
Height: ______ ft. ______ in. Weight: ______

Employee ID: ______________________

How to answer the questionnaire:

Picture: In this picture you can see the approximate position of the parts of the body referred to in the table. Limits are not sharply defined, and certain parts overlap. You should decide for yourself in which part you have or have had your trouble (if any).

Table: Please answer by putting an "X" in the appropriate box - one "X" for each question. You may be in doubt as to how to answer, but please do your best anyway. Note that column 1 of the questionnaire is to be answered even if you have never had trouble in any part of your body; columns 2 and 3 are to be answered if you answered yes in column 1.

<table>
<thead>
<tr>
<th>To be answered by everyone</th>
<th>To be answered by those who have had trouble</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you at any time during the last 12 months had trouble (ache, pain, discomfort, numbness) in:</td>
<td>Have you at any time during the last 12 months been prevented from doing your normal work (at home or away from home) because of the trouble?</td>
</tr>
<tr>
<td>Neck</td>
<td></td>
</tr>
<tr>
<td>□ No</td>
<td>□ Yes</td>
</tr>
<tr>
<td>□ Yes</td>
<td></td>
</tr>
<tr>
<td>Shoulders</td>
<td></td>
</tr>
<tr>
<td>□ No</td>
<td>□ Yes, right shoulder</td>
</tr>
<tr>
<td>□ Yes, left shoulder</td>
<td></td>
</tr>
<tr>
<td>□ Yes, both shoulders</td>
<td></td>
</tr>
<tr>
<td>Elbows</td>
<td></td>
</tr>
<tr>
<td>□ No</td>
<td>□ Yes, right elbow</td>
</tr>
<tr>
<td>□ Yes, left elbow</td>
<td></td>
</tr>
<tr>
<td>□ Yes, both elbows</td>
<td></td>
</tr>
<tr>
<td>Wrists/Hands</td>
<td></td>
</tr>
<tr>
<td>□ No</td>
<td>□ Yes, right wrist/hand</td>
</tr>
<tr>
<td>□ Yes, left wrist/hand</td>
<td></td>
</tr>
<tr>
<td>□ Yes, both wrists/hands</td>
<td></td>
</tr>
<tr>
<td>Upper Back</td>
<td></td>
</tr>
<tr>
<td>□ No</td>
<td>□ Yes</td>
</tr>
<tr>
<td>□ Yes</td>
<td></td>
</tr>
<tr>
<td>Lower Back (small of back)</td>
<td>□ No</td>
</tr>
<tr>
<td>□ Yes</td>
<td></td>
</tr>
<tr>
<td>One or Both Hips/Thighs</td>
<td>□ No</td>
</tr>
<tr>
<td>□ Yes</td>
<td></td>
</tr>
<tr>
<td>One or Both Knees</td>
<td>□ No</td>
</tr>
<tr>
<td>□ Yes</td>
<td></td>
</tr>
<tr>
<td>One or Both Ankles/Feet</td>
<td>□ No</td>
</tr>
<tr>
<td>□ Yes</td>
<td></td>
</tr>
</tbody>
</table>
Prioritization

• Risk Ranking - several methods exists
  – NIOSH Lifting Equation
  – RULA
  – REBA

• Suggested methods
  – Review of injury data
  – Discomfort surveys
  – Talk to employees
    • What task(s) do you dislike the most?
    • Why do you dislike it?
    • What would make it better?
Implement Ergo Risk Management

To prevent an MSD, you must:

1. Recognize the risk factors
2. Determine the root cause(s) of these risk factors
3. Implement and monitor controls to reduce/eliminate risks

Available for download at www.cdc.gov/noish/mining
III. Risk Factor Awareness

AWARENESS TEST
An ergonomic risk factor is...

An action or condition found to contribute to worker discomfort or injury
MSD Risk Factors

An action or condition found to contribute to worker discomfort or injury

1. **Forceful Work** – High physical effort
2. **Poor Posture** - Poor positioning of the body
3. **Repetitive Work** - Doing the same movements many times
4. **Vibration Exposure** - Two types: hand-arm and whole body
Forceful Work

Forceful work increases the loading to the muscles and tissues

- Heavy lifting
- Carrying heavy objects
- Forceful pushing or pulling
- Forceful gripping

Effective Power Grip

Ineffective Pinch Grip
Poor Posture

Poor posture requires the body to work in a position where the muscles are less powerful

- Trunk bent over more than 20 degrees
- Twisting the trunk or head
- Elbows above shoulders
- Extended forward reaches
- Reaching behind the body
- Extreme wrist bending
- Kneeling or squatting
- Static position
Repetitive work can irritate tendons and increase pressure on nerves

- Pinching bags to seal
- Manually tightening bolts
- Using mobile equipment controls such as joysticks
- Using manual grease guns
Vibration Exposure

Vibration exposure can decrease blood flow, damage nerves and contribute to muscle fatigue and low back pain

• Whole Body
  – Sitting or standing on vibrating surfaces
  – Driving heavy vehicle

• Hand-Arm Vibration
  – Using vibrating tools

(Magid and Coermann, 1960)
• **Cold temperature** – reduces dexterity and may increase force requirements

• **Contact stress** – reduces blood flow and nerve transmission

• **Quick motions** – increases the amount of force exerted on the body
What’s the Hazard?
Designing for Aging

- Normal age-related changes affect all workers
- 53% of mining workforce is 45 or older
- As the workforce ages, the number of
  - Acute injuries decrease
  - Cumulative injuries increase
- Mining companies can design workplaces to accommodate these normal changes

Available for download at www.cdc.gov/noish/mining
What are the risk factors?
Compounding Risk Factors

- Higher Priority!
- More than one risk factor present
- Reducing any one of the risk factors will significantly reduce the probability of injury
Root Causes

Specific cause or source of a problem

- Effort or strength required
- Location or Position of parts, equipment or tools
- Design of parts, equipment or tools
- Frequency and Duration of task
- Productivity levels
- Process used or required to do the task
- Training required to perform task
- PPE worn to do task
- Environment of task
Controlling/Eliminating Risks

- **Administrative Controls**
  - Changes to procedures associated with work

- **Engineering Controls**
  - Changes to workstations, equipment, tools and environment. Used to eliminate/reduce risk factors.

- **PPE**
  - Changes made to workers to reduce exposure to risk factors.
Personal Protective Equipment

- Anti-Vibration gloves – may reduce vibration transmission but may also increase force requirement
- Knee pads – reduce pressure points
- Shoe inserts – reduce discomfort
- Cooling devices – Prevent body temperature increases
- Cold weather clothing – prevents hypothermia/frost bite
Administrative Controls

- Job enlargement
- Job rotation
- Work pace and duration
- Work-rest cycles
- Training
- Shift schedule
- Exercises and stretches
Engineering Controls

Changes to the workplace designed to reduce risk for injury → **Ergonomics** (fitting the job to the person)

“Suspending your keyboard from the ceiling forces you to sit up straight, thus reducing fatigue.”

© 1998 Randy Glasbergen. www.glasbergen.com
Engineering Controls

- Workstation/Workplace layout redesign
- Equipment design
- Tools design
- Using appropriate tool for the job
- Work environment controls
- Work methods
Simple and Inexpensive Engineering Controls

- Shoveling
- Belt Guides
- Spillage Collection

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What’s the Hazard?
IV. Ergo Risk Management

Five elements to managing ergonomics risks in the workplace

1. Identify
2. Assess
3. Control
4. Monitor & Review
5. Record Keeping
Identify risk factor exposures during manual tasks

• Identification of risk factor exposures should include consultation with employees, observation of manual tasks, and/or review of workplace records.

• Employees should be asked what they think is the most physical part of their job or what task is the hardest to do.
Risk Factor Report Card

Name: ______________________

1. Work Area/Job Title: ________________________________

2. Describe task: ____________________________________

3. Check all risk factors that apply:
   - Poor Posture
   - Repetitive Work
   - Vibrating Tools
   - Static Posture
   - WB Vibration
   - Forceful Gripping
   - Heavy Lifting/Carrying
   - Bouncing/Jarring
   - Heavy Shoveling
   - Forceful Push/Pull

   Other risk factors: ________________________________

4. Place X on affected areas:
   - Left
   - Right
   - Neck
   - Shoulders
   - Upper Back
   - Elbows
   - Lower Back
   - Wrist/Hands
   - Hips Thighs
   - Knees
   - Ankles/Feet
   - Back View

5. Comments/Suggestions: ____________________________

   __________________________
   __________________________

6. Plant/Mine Name: ________________________________
Assess MSD risks for manual tasks

- Should involve workers who perform the task
- Assist in risk control by determining root causes and severity of risk
  - Work organization and systems
  - Environment
  - Objects, equipment, tools
  - Workplace or workstation layout
Control MSD risks during manual tasks

- ELIMINATE risk when possible → Engineering Controls
- Manage residual risks
  - Administrative Controls
  - PPE
  - Other Engineering Controls
Engineering Controls

Repetitive Motion - Greasing

Auto-Greaser

Powered Greaser

ELIMINATE

MANAGE
Monitor and review all implemented control measures

- Ergo risk management is a continuous process
- It is necessary to ensure that controls function properly and do not create new hazards
- More (and/or new) workers may be affected when using administrative controls, and they should be involved in risk monitoring
Ergo Risk Management

Keep records of steps taken in risk management process

- Ensure effective risk management process is in place
- Determine effectiveness of control measures by tracking MSD incidents and severities
- Provide documentation of process to:
  - Track improvements
  - Maintain memory of why changes were made
  - Justify future changes
  - Easily share information with other sites/companies
V. MSHA Injury Statistics

- Surface facilities, plants, shops, and yards from 2002-2011
- Categorized as machine maintenance and repair or hand tools
- Determined sources and types of injuries associated with the most days lost from work

MSHA data on mining accidents available for download at: http://www.cdc.gov/niosh/mining/data/default.html
Days Lost by Type of Injury

- Hand Lacerations: 6%
- Hand Fractures: 8%
- Back Strains: 14%
- Shoulder Strains: 13%
- All Other Sprain/Strain: 15%
- All Other Fractures: 16%
- All Other Laceration: 4%
- All Contusions: 6%
- Other: 18%
Over-exertion Injuries

• Back Strains
  – Using axes/hammers – MDL 14
  – Using wrenches – MDL 12.5
  – Handling metal covers and guards – MDL 12
  – Handling metal, NEC – MDL 11
  – Using crow/pry bars – MDL 10

• Shoulder Strains
  – Handling metal, NEC – MDL 74
  – Using crow/pry bars – MDL 64.5
  – Using axes/hammers – MDL 52
  – Handling metal covers and guards – MDL 48
  – Using wrenches – MDL 45
Struck by or Caught in Injuries

• Foot fractures
  – Struck by metal covers and guards – MDL 28
  – Struck by metal, NEC – MDL 17

• Head and facial fractures and lacerations
  – Struck by crow/pry bars – MDL 10

• Hand fractures and lacerations
  – Struck by axe/hammer – MDL 10
  – Caught in metal, NEC – MDL 17
  – Struck by metal, NEC – MDL 9
  – Struck by metal covers and guards – MDL 12
VI. Mitigating These Injuries

- Consider the worker
- Consider the environment
- Remember our hierarchy of controls
Hand and Finger Injuries

- Usually ignored
- Have many factors
  - Worker characteristics
  - Workplace conditions
  - Transient work practices
  - Worker capabilities

Can’t we just prevent them with gloves?
Gloves

• The good
  ✓ Are designed to protect the hand from injury
  ✓ Come in many types for differing levels and forms of protection
  ✓ Work well when they fit properly

• The bad
  ✗ Reduce dexterity
  ✗ Reduce flexibility
  ✗ Reduce tactile sensitivity
  ✗ May reduce grip strength
Hand and Finger Injuries

How should we approach hand injuries?

Think beyond just the hand...
Hand may be injured due to...

- Handling heavy objects
  - Reduce weight of materials
  - Use lift-assist devices

- Unexpected motion
  - Protect from hazardous energy
  - Properly block equipment

- Getting caught in pinch points
  - Add hand holds to equipment
  - Add handles to guards

- Using knives or other cutting devices
  - Use safety cutters, with protected or retracting blades
## Sources of Injury

<table>
<thead>
<tr>
<th>Source</th>
<th>Frequency</th>
<th>Days Lost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal NEC (pipe, nails, wires, etc.)</td>
<td>4681</td>
<td>72,289</td>
</tr>
<tr>
<td>Ground</td>
<td>1085</td>
<td>58,051</td>
</tr>
<tr>
<td>Metal covers and guards</td>
<td>2093</td>
<td>51,997</td>
</tr>
<tr>
<td>Axe, hammer, sledge</td>
<td>1417</td>
<td>30,216</td>
</tr>
<tr>
<td>Wrench</td>
<td>1037</td>
<td>26,021</td>
</tr>
<tr>
<td>Crowbar, pry bar</td>
<td>1149</td>
<td>25,561</td>
</tr>
</tbody>
</table>
Equipment Guarding

- Required by MSHA to protect employees from moving parts

- Also contributed to:
  - over 200 injuries per year
    - Crushed, fractured, and lacerated hands
      - Caught in, struck by
    - Back strains
      - Overexertion
    - Shoulder strains
      - Overexertion
  - Nearly 52,000 days lost
Workers will remove and replace guards as needed to gain access to equipment.

Factors contributing to injuries include:
- Weight
- Size
- Coupling
- Pinch points

Redesign ideas
- Add handles to guards
- Make guarding modular to reduce weight
- Use lighter weight materials
- Consider hinges to eliminate handling
Improve Coupling When Possible

Add handles, eliminate a pinch point, prevent a hand injury

Add handles, promote neutral posture, prevent a shoulder injury
A knowledgeable workforce can help reduce injuries!

Available for download at www.cdc.gov/niosh/mining

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The findings and conclusions in this presentation are those of the authors and do not necessarily represent the views of NIOSH. Mention of company names or products does not constitute endorsement by the Centers for Disease Control and Prevention.
Ergonomics is about working safely so you can enjoy life!