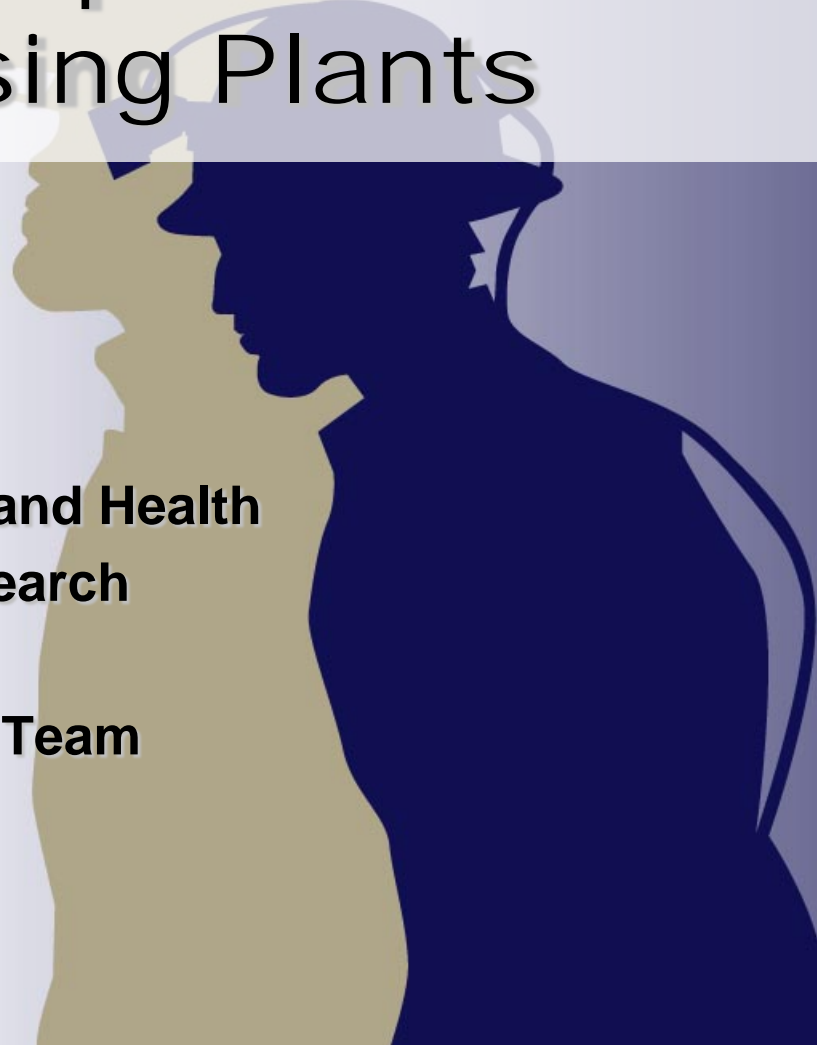


# Identifying and Solving Ergonomics Problems in Coal Preparation and Mineral Processing Plants

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**National Institute for Occupational Safety and Health  
Office of Mine Safety and Health Research  
Human Factors Branch  
Musculoskeletal Disorder Prevention Team**



# Outline

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- 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

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## Ergonomics is....

The scientific study of human interaction with the work environment

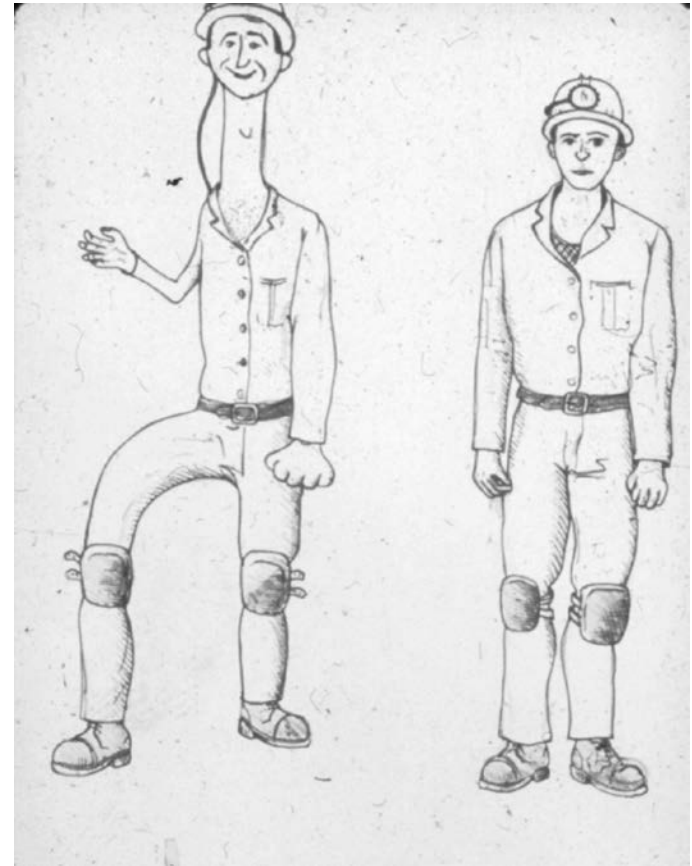
## Ergonomics considers....

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

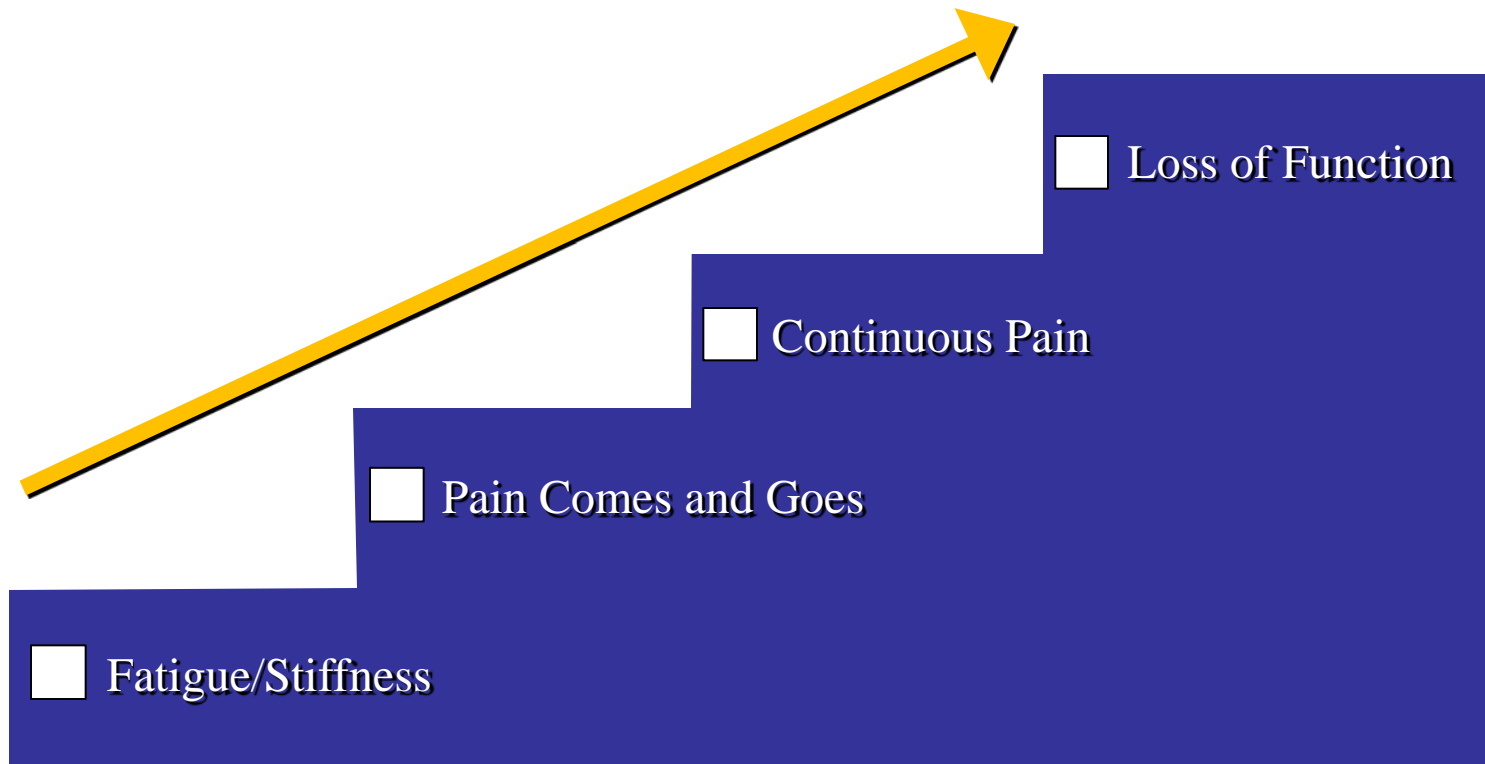


- ***Cumulative injuries***

- Develop gradually
- Musculoskeletal Disorders
  - Tendonitis
  - Low back pain



# Cumulative Injury Progression



# 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

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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

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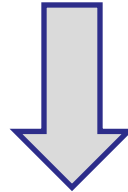
## To assess your ergonomics...

- 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

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Determine tasks of  
interest



Prioritize tasks for redesign



Perform Ergonomics Risk  
Management

# Determine Task of Interest

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## 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](http://www.cdc.gov/noish/mining)

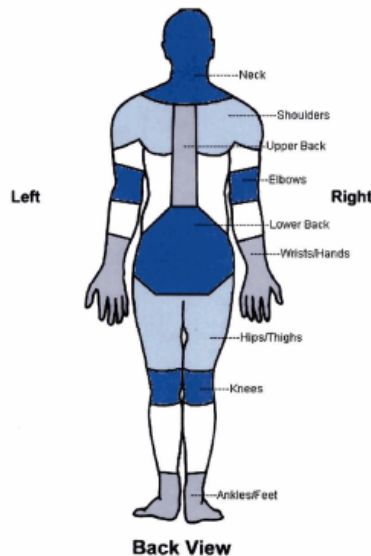
## Musculoskeletal Discomfort Survey (Based on the Nordic Questionnaire)

Employee ID: \_\_\_\_\_

Job/Position: \_\_\_\_\_ How long have you been doing this job? \_\_\_ years \_\_\_ months How many hours do you work each week? \_\_\_\_\_ Gender: M F Age: \_\_\_\_\_ Height: \_\_\_ ft. \_\_\_ in. Weight: \_\_\_\_\_

### 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.

To be answered by everyone	To be answered by those who have had trouble	
Have you at any time during the last 12 months had trouble (ache, pain, discomfort, numbness) in:	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?	Have you had trouble at any time during the last 7 days?
<b>Neck</b> <input type="checkbox"/> No <input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> Yes
<b>Shoulders</b> <input type="checkbox"/> No <input type="checkbox"/> Yes, right shoulder <input type="checkbox"/> Yes, left shoulder <input type="checkbox"/> Yes, both shoulders	<input type="checkbox"/> No <input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> Yes
<b>Elbows</b> <input type="checkbox"/> No <input type="checkbox"/> Yes, right elbow <input type="checkbox"/> Yes, left elbow <input type="checkbox"/> Yes, both elbows	<input type="checkbox"/> No <input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> Yes
<b>Wrists/Hands</b> <input type="checkbox"/> No <input type="checkbox"/> Yes, right wrist/hand <input type="checkbox"/> Yes, left wrist/hand <input type="checkbox"/> Yes, both wrists/hands	<input type="checkbox"/> No <input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> Yes
<b>Upper Back</b> <input type="checkbox"/> No <input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> Yes
<b>Lower Back (small of back)</b> <input type="checkbox"/> No <input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> Yes
<b>One or Both Hips/Thighs</b> <input type="checkbox"/> No <input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> Yes
<b>One or Both Knees</b> <input type="checkbox"/> No <input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> Yes
<b>One or Both Ankles/Feet</b> <input type="checkbox"/> No <input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> Yes	<input type="checkbox"/> No <input type="checkbox"/> Yes

# 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



IC 9497  
INFORMATION CIRCULAR/2008

**Ergonomics and Risk Factor  
Awareness Training for Miners**



IC 9509  
INFORMATION CIRCULAR/2009

**Ergonomics Processes  
Implementation Guide and  
Tools for the Mining Industry**

Available for download at [www.cdc.gov/noish/mining](http://www.cdc.gov/noish/mining)

# III. Risk Factor Awareness

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## AWARENESS TEST



# An ergonomic risk factor is...

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



# MSD Risk Factors

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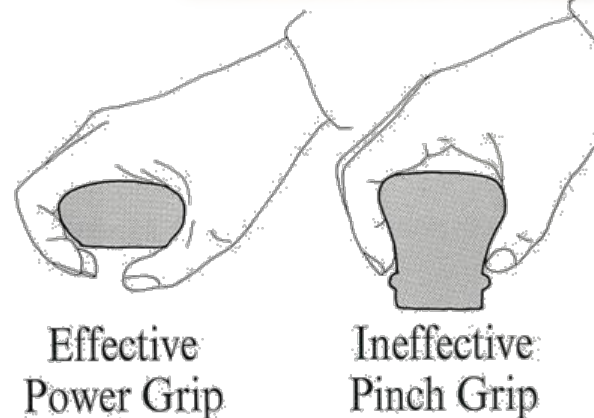
*An action or condition found to contribute to worker discomfort or injury*

- 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



# 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

Repetitive work can irritate tendons and increase pressure on nerves

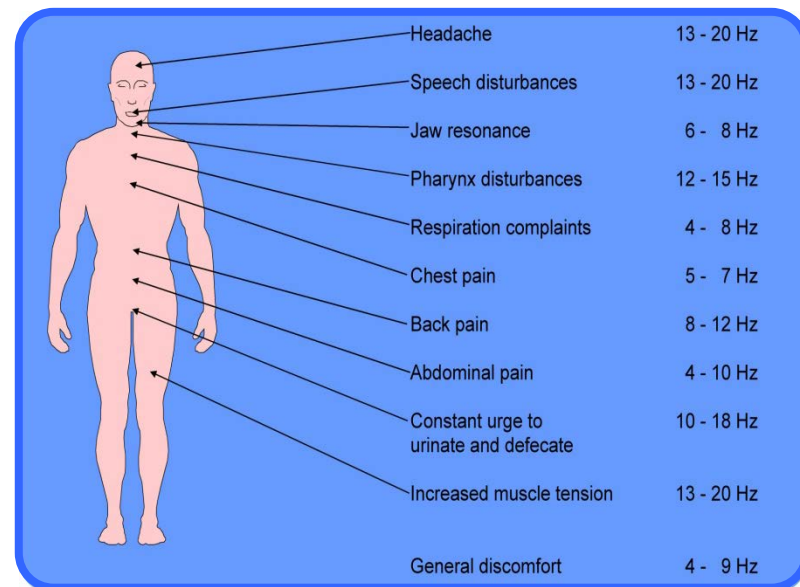
- Pinching bags to seal
- Manually tightening bolts
- Using mobile equipment controls such as joysticks
- Using manual grease guns



# 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)

# Other Risk Factors

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- **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

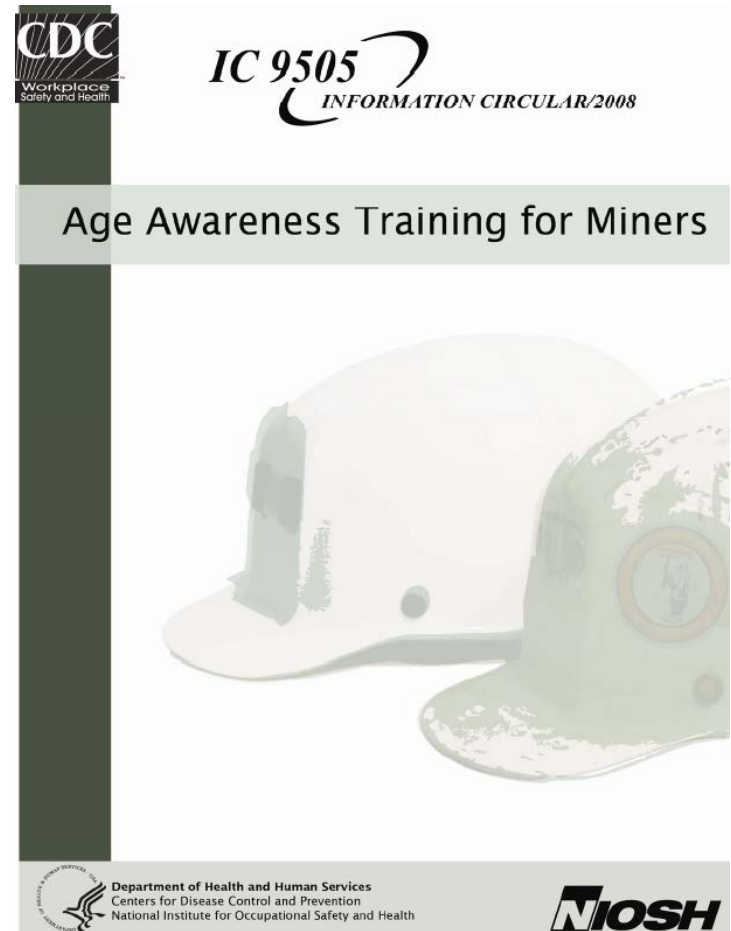
# What's the Hazard?





# 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](http://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



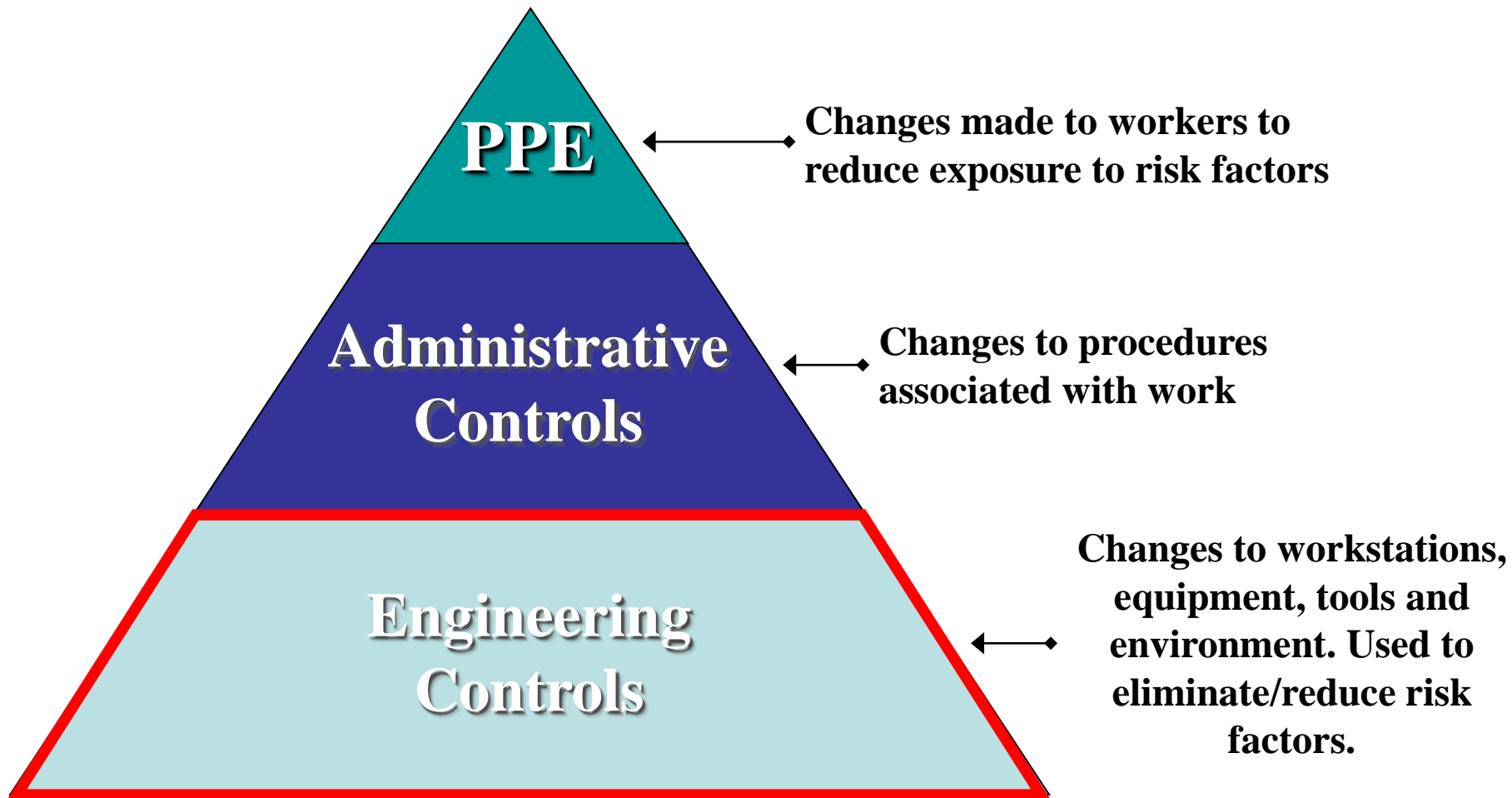
# Root Causes

## *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





# 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](http://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





# What's the Hazard?



# IV. Ergo Risk Management

Five elements to managing ergonomics risks in the workplace



# Ergo Risk Management

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## 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

RISK FACTOR REPORT CARD

Name: \_\_\_\_\_

1. Work Area/Job Title: \_\_\_\_\_

2. Describe task: \_\_\_\_\_

3. Check all risk factors that apply:

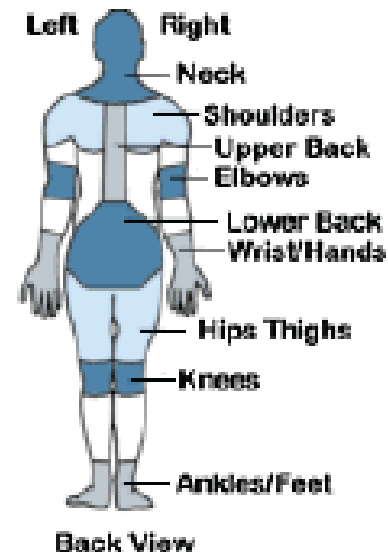
- |  |   |
|--|---|
| <input type="checkbox"/> Poor Posture    | <input type="checkbox"/> Forceful Gripping      |
| <input type="checkbox"/> Repetitive Work | <input type="checkbox"/> Heavy Lifting/Carrying |
| <input type="checkbox"/> Vibrating Tools | <input type="checkbox"/> Bouncing/Jarring       |
| <input type="checkbox"/> Static Posture  | <input type="checkbox"/> Heavy Shoveling        |
| <input type="checkbox"/> WB Vibration    | <input type="checkbox"/> Forceful Push/Pull     |

Other risk factors: \_\_\_\_\_

5. Comments/Suggestions: \_\_\_\_\_

6. Plant/Mine Name: \_\_\_\_\_

4. Place X on affected areas:



# Ergo Risk Management

## 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

# Ergo Risk Management

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## 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



ELIMINATE

MANAGE

Auto-Greaser



Powered Greaser



# Ergo Risk Management

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**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

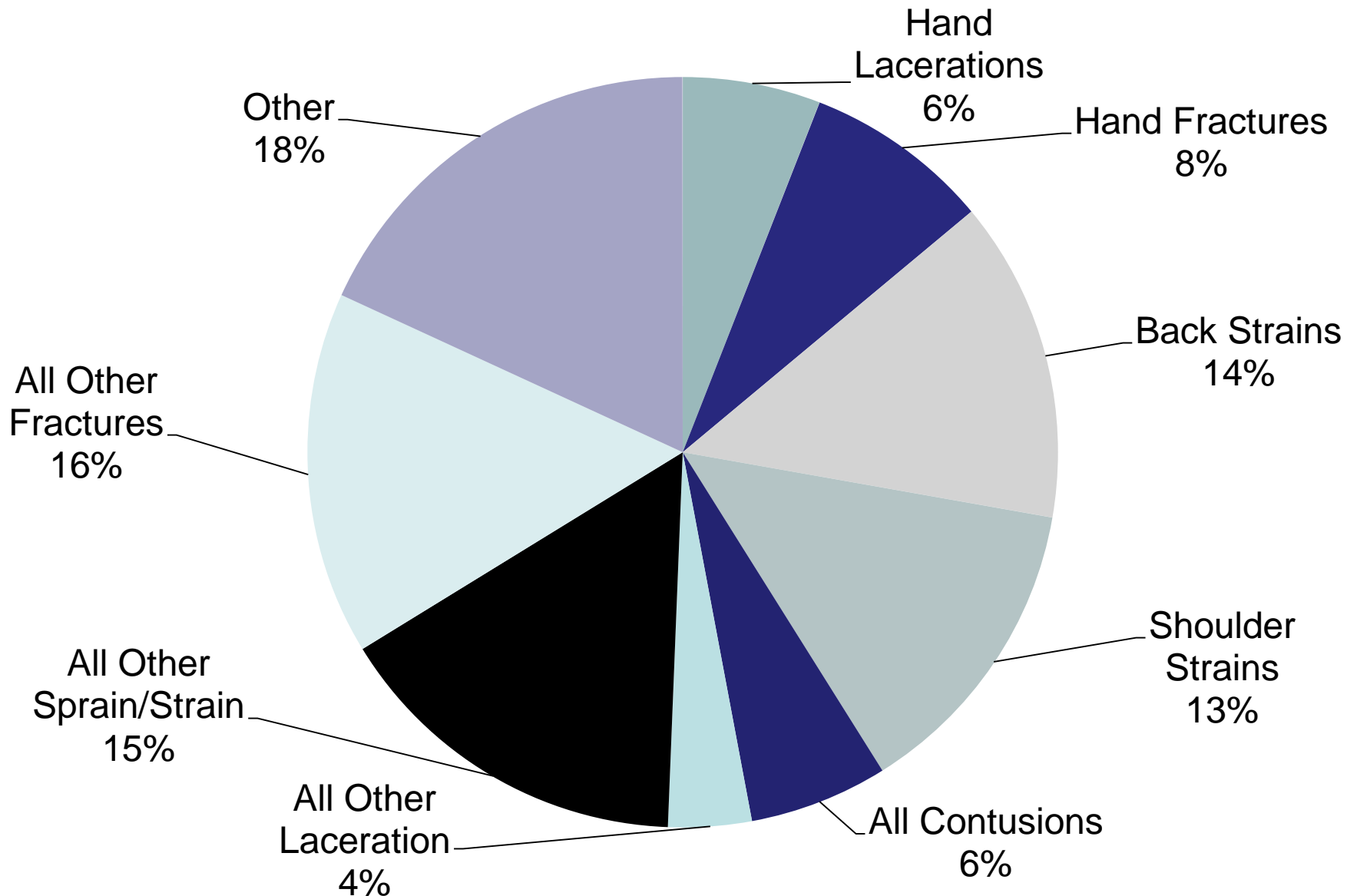
- Ensure effective risk management process is in place
- Determine effectiveness of control measures by tracking MSD incidents and severities
- Provide documentation of process to:
  - Track improvements
  - Maintain memory of why changes were made
  - Justify future changes
  - Easily share information 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



# 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

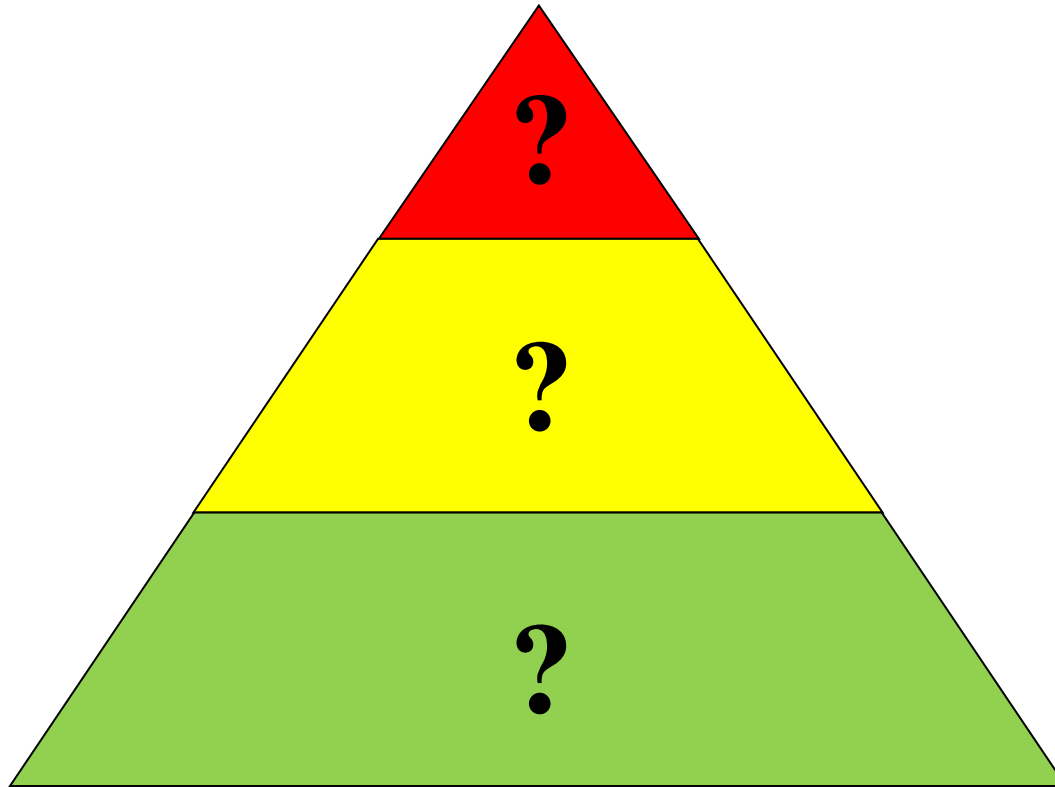


# Struck by or Caught in Injuries

- 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

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**How should we approach hand injuries?**



**Think  
beyond just  
the hand...**

# Hand may be injured due to...

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- 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

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

# 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



# Equipment Guarding

- 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**

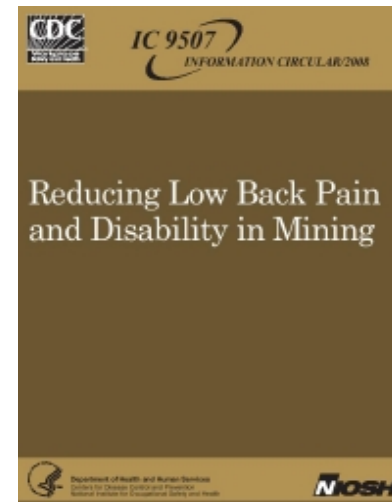
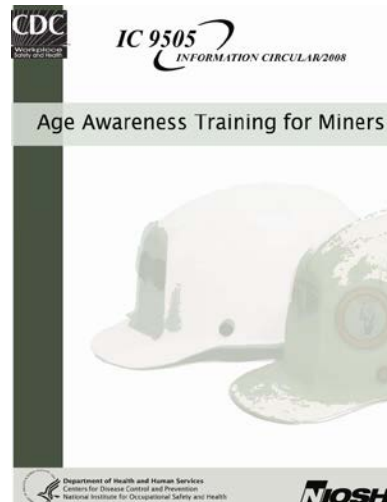
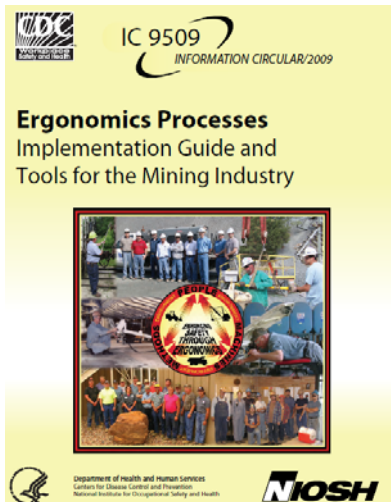
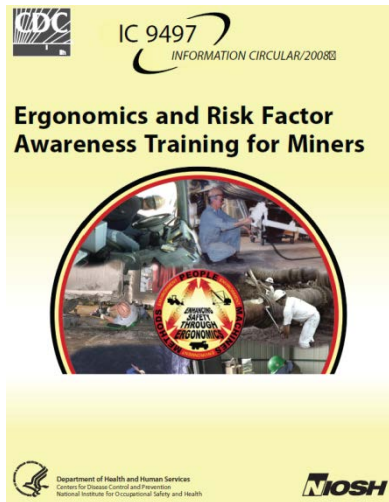


**Add handles, promote neutral posture, prevent a shoulder injury**



# A knowledgeable workforce can help reduce injuries!

Available for download at [www.cdc.gov/niosh/mining](http://www.cdc.gov/niosh/mining)



Available for download at [www.cdc.gov/niosh](http://www.cdc.gov/niosh)



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Ergonomics is about  
working safely so  
you can enjoy life!