Health Hazards in Road and Bridge Construction

Pam Susi, CPWR
International Bridge Conference
Pittsburgh, PA; June 8, 2010
CPWR* - the Center for Construction Research and Training

• Research and training arm of the Building & Construction Trades Department, AFL-CIO

• Conducts research aimed at improving quality of life for construction workers

• Conducts training in safety and occupational/environmental health

*Formerly the Center to Protect Workers’ Rights
CPWR – Research Program

• Since early 90s, served as NIOSH “Construction Center” to do joint research with NIOSH

• Consortium of university researchers and CPWR staff researchers

• Active involvement of building trades unions and contractor organizations
CPWR – Training Program

• NIEHS Training (approx. 4,000 workers/yr)
  – EPA Superfund Sites
  – Department of Energy Sites Nationwide
  – Urban Brownfields & Minority Worker Training

• OSHA Training Institute Education Center

• Disaster Response Training
Fatal Occupational Injuries by Industry, 2006

- Construction: 1,239
- Transport & utility: 860
- Agriculture: 655
- Manufacturing: 456
- Retail: 359
- Wholesale: 222
- Mining: 192

Occupational Disease in the U.S.

- About 50,000 – 60,000 deaths per year in the U.S. from occupational illnesses;
- Some estimates make occupational deaths the 8th leading cause of death in the U.S. ahead of motor vehicle deaths
- Costs for occupational disease and injury is estimated at $23 billion/year
Flow of Money, Management and Communication in Construction – the role of the client/owner

- Project Owner/Client (e.g. DOT)
- Project manager
- General contractor
  - Subs - electrical contractor
  - Subs – painting contractor
  - Subs - Mechanical Contractor
  - Pipefitter
Silica continues to be a problem
Silica

• NJ, OH, MI identified 576 cases of silicosis between 1993-1997
  – 45 from construction
  – 12 from heavy construction (including highway, bridge, and tunnel construction)

• New standard due out February 2011

• Special Emphasis Program in place now

• Target of Severe Violators Enforcement Program
Health effects of silica

• Silicosis
• Lung cancer
• Chronic obstructive pulmonary disease (COPD)
  – dust related, may not be specific to silica
• Autoimmune disorders
  – Rheumatoid arthritis
  – Schleraderma
• May increase susceptibility to TB
Silicosis-Related Years of Potential Life Lost (YPLL) Before Age 65 Years --- United States, 1968--2005

• the proportion of YPLL attributable to young silicosis decedents increased;
• an estimated 3,600--7,300 new silicosis cases occur annually
• Of 46 industries reported, the greatest YPLL were in construction (263; mean per decedent: 10.1 YPLL

MMWR. July 18, 2008 / 57(28);771-775
Proportionate Mortality Ratios in Construction: Silicosis

Robinson et al. 1995

Bar chart showing mortality ratios for different trades in construction:
- All trades < 65: 327
- Painters: 449
- Bricklayers: 264
- Laborers: 153

- painters (abrasive blasting)
  - 7 full-shift samples range between 0.5 – 26.2 mg/m³
  - 3 to 524 times the NIOSH Recommended Exposure Limit (REL)
- bricklayers (grinding/cutting masonry & concrete)
  - 5 full-shift samples range between 0.1 – 1.2 mg/m³
  - 2 to 24 times the NIOSH REL
- operators and laborers (road milling)
  - 22 full-shift samples ranging from 0.01 - 0.62 mg/m³
  - 0.2 to 12 times the NIOSH REL
Abrasive blasting – silica can be in paint and in abrasive used to remove paint
Asbestosis and lung cancer proportionate mortality ratios (PMRs) in construction, selected occupations, 1990-1999

<table>
<thead>
<tr>
<th>Occupation</th>
<th>PMR Asbestosis</th>
<th>PMR Lung Cancer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulation workers</td>
<td>84.08</td>
<td>1.69</td>
</tr>
<tr>
<td>Boilermakers</td>
<td>31.05</td>
<td>1.26</td>
</tr>
<tr>
<td>Plumbers, pipefitters, and steamfitters</td>
<td>8.34</td>
<td>1.17</td>
</tr>
<tr>
<td>Sheet metal workers</td>
<td>8.01</td>
<td>1.16</td>
</tr>
<tr>
<td>Plasterers</td>
<td>6.77</td>
<td>1.20</td>
</tr>
<tr>
<td>Millwrights</td>
<td>6.53</td>
<td>1.35</td>
</tr>
<tr>
<td>Electricians</td>
<td>4.04</td>
<td>1.10</td>
</tr>
<tr>
<td>Welders and cutters</td>
<td>3.59</td>
<td>1.22</td>
</tr>
<tr>
<td>Managers and administrators</td>
<td>2.23</td>
<td>1.10</td>
</tr>
<tr>
<td>Carpenters</td>
<td>1.67</td>
<td>1.19</td>
</tr>
</tbody>
</table>
Top 3 asbestos citations*

• Insufficient training
• Lack of initial exposure assessment
• Methods of compliance (controls & work practices) for class II work, 1926.1101(g)8
  – removing vinyl and asphalt flooring with ACM
  – removing roofing material with ACM
  – removing cementitious ACM siding or transit panels
  – removing ACM gaskets Removing

*As reported by OSHA federal enforcement office, 5/28/9
Chest X-ray results, selected construction trades, 3 Department of Energy nuclear weapons facilities, 1996-2006

% examined in trade who showed abnormal results

- Asbestos worker: 38.8%
- Plumber: 25.5%
- Millwright: 25.1%
- Sheet metal: 24.2%
- Boilermaker: 22.7%
- Brickmason: 22.1%
- Electrician: 19.8%
- Ironworker: 18.4%
- Teamster: 17.9%
- Carpenter: 17.2%
- Painter: 15.9%
- Laborer: 15.6%
- Op engineer: 11.7%
Distribution of cases of blood lead levels greater than or equal to 40 ug/dl by industry, MA*

*"Lead at Work", Massachusetts Division of Occupational Safety, January 2006
Blood lead levels – health effects

• Background blood levels in general population in US now at 1-2 ug/dl (vs. 10-15 ug/dl in late 70s)

• Unlike many metals (e.g. zinc, manganese) which are essential at very low concentration, lead has no value whatsoever and is toxic at low doses

• Principle health effects at low doses – cardiovascular (heart and strokes); kidney (renal), cognitive (brain), reproductive
Blood lead levels (ug/dL) and health risks

<table>
<thead>
<tr>
<th>Blood Lead Levels (ug/dL)</th>
<th>Health Risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than 5</td>
<td>None documented</td>
</tr>
<tr>
<td>5-9</td>
<td><em>Possible</em> reproductive*, <em>possible</em> hypertension (increased blood pressure) &amp; kidney dysfunction</td>
</tr>
<tr>
<td>10-19</td>
<td>All of above, possible subclinical neurocognitive effects (e.g. poorer performance on tests of memory, verbal ability and mental processing)</td>
</tr>
<tr>
<td>20-39</td>
<td>All of above, hypertension and kidney dysfunction At 30-39 reproductive effects (vs. possible effects)</td>
</tr>
<tr>
<td>40-79</td>
<td>All of above, kidney disease, neuro-cognitive deficits, sperm abnormalities, anemia, colic, possible gout</td>
</tr>
<tr>
<td>More than 80</td>
<td>All of above, more serious kidney disorders, peripheral neuropathy (wrist-drop), gout, encephalopathy (any dysfunction of the brain), anemia</td>
</tr>
</tbody>
</table>

Reproductive effects include spontaneous abortion, developmental delays, reduced birth weights
Trades at Risk

- Painters/abrasive blasting
- Ironworkers/rivet busting, torch work
- Laborers – demo work
- Carpenters – renovation of lead painted building components
- Plumbers/Pipe-fitters – lead shielding, lead pot work, hot work
Top 3 lead violations – 1926.62*

- **d(1)** initial exposure assessment

- **d(2)** interim protections for defined tasks with presumed exposure levels until exposure data shows otherwise
  - Respiratory protection, protective clothing, hand-washing, biological monitoring, training
  - Tasks presumed to require protection at 50 Xs the PEL
    - Abrasive blasting
    - Welding
    - Cutting and
    - Torch burning

- **g(1)** provision and use of protective work clothing

*As reported by OSHA federal enforcement office, 5/28/9*
Overview of Health Hazards

• Questions
• Comments???
• What are your primary oc health concerns?
• Which trades/tasks do you see with exposure risks?
Principles of Industrial Hygiene

...protection of the health and well-being of workers and the public through anticipation, recognition, evaluation and control of hazards arising in or from the workplace.

Excerpt from “The Occupational Environment: It’s Evaluation, Control and Management (AIHA)”

Alice Hamilton (1869-1970) Physician and early founder of industrial hygiene
Construction Exposure Hazards

• Task-generated
  – Could be from in place materials
  – Could be from materials used

• Could be present at the facility or site where work is underway

• Exposure could be created by another trade/contractor working adjacent to exposed worker
Task-generated

Disturbance of in place material - Roofing tear-out, asphalt/particulate dust

Application of new roofing using MDI adhesives – new materials/same job
Site or Process Hazards

Heavy metal exposures during power plant restoration

Benzene releases at refineries
Exposure created from adjacent operation
Routes of Exposure & Special Problems in Construction

- Inhalation
- Ingestion
- Dermal
- Lack of water & soap on jobs makes potential for “take-home” hazards an issue
Recognizing Health Hazards – major categories

- Physical hazards (noise, vibration, ergonomics, thermal stress, radiation - ionizing & EMFs)
- Chemical hazards
  - Particulates (fumes & dusts)
  - Vapors (solvents)
  - Gases (methane, welding gases)
- Biological hazards (e.g. legionnaires disease, laboratory hoods & bird droppings)
Major Physical hazards

- ergonomics
- noise
- thermal stress
- radiation
- electromagnetic fields (EMFs)
Slides courtesy of Dr. Laurie Welch, CPWR and Dr. David Rempel, Univ. of California, Berkeley
Noise

• Hearing loss is a pervasive problem for all construction trades
• The average 25 year old carpenter has the hearing of a 50 year old
• Over 3500 powered hand tools in use in construction
• Generators, compressors and industrial settings create large background sound levels
“worm-driver” circular saw – 93 – 100 dBA
Customer Driven – bottom up approach to noise reduction from tools

- New York City
  - Other cities follow suit.
- Buy Quiet
  - DoD ... HAV
  - NASA
  - GSA ... HAV
- Quiet-By-Design
  - NASA
- Standards/Regulations
More Information: Ck out sound level database on web

http://www.cdc.gov/niosh-sound-vibration/

Can be used to select hearing protection and/or buy quiet decisions

CDR Chuck Hayden
chayden@cdc.gov
513-533-8152
Examples of Particulate Exposure in Construction
Common Particulate (Dusts & Fumes) Hazards

• Silica from abrasive blasting, masonry work, road work, grinding & chipping concrete
• Fumes from Welding, torch-cutting
• Grinding dust
• Metals associated with abrasive blasting
• Insulation material (asbestos and man-made mineral fiber)
• Asphalt fumes
• Diesel fumes
Metals

**Have OSHA Standards**
- Lead
- Cadmium
- Arsenic
- Chromium (hexavalent)

**No Standard—just exposure limits**
- Manganese
- Nickel
- Beryllium
Welding fumes - manganese, Cr VI (hex chrome), nickel, respirable fume
Sources of metal fume during welding/thermal cutting

- base metal (surfaces that are being welded or cut)
- coatings on base metal (such as old paint)
- electrode (rod or wire)
- flux (electrode coatings)
Confined Space Hazards in Construction

- Painters go into the interior of bridge columns to paint for to prevent corrosion
- They also may go into commercial & residential confined spaces like pools or HVAC units
Evaluating hazards – measuring exposure
Why do we measure exposure

• Evaluate degree of hazard
• Determine how well hazards are controlled
• Determine where exposures are relative to occupational exposure limits (OELs)
  – Exposure limits are typically based on concentration of contaminant (mass or volume of contaminant/volume of air)
  – e.g. hexavalent chromium permissible exposure limit set by OSHA is 5 micrograms/cubic meter (ug/m$^3$)
Diagnostic Evaluation

• Useful for identifying high exposure tasks

• Evaluating effective engineering controls

• Determining “regulated area” or exposure zones

• Verifying that engineering controls work
How do we adapt to construction from an IH/exposure assessment POV

• Involve workers in the exposure assessment process
  – They understand the work process/tools/materials
  – Communicate well with other workers
  – Integrates exposure assessment and control into the work
T-BEAM (Task-based Exposure Assessment Model )Project

• Standardized approach to which involves partnering industrial hygienists w/ journeymen workers;
• Emphasizes use and evaluation of engineering controls;
• Used since 1995 to characterize exposure to welding fumes, silica and metals.
Exposure data and descriptive data collected concurrently
Measuring air concentrations

1 pack of sugar

= 5 grams of sugar

= 5 million micrograms sugar

5 micrograms (ug) = 1/1,000,000 of a pack of sugar
A Cubic Meter ($m^3$)
5 micrograms (ug) of sugar in a cubic meter (m³) box would = 5 ug/m³

OSHA PEL for hex chrome = 5 ug/m³
Occupational Exposure Limits (OELs)

• OSHA PELs (permissible exposure limits) enforced by law
• NIOSH Recommended Exposure Limits (RELs)
• ACGIH TLVs – American Conference of Governmental Industrial Hygienists Threshold Limit Values (recommended)
## T-BEAM Welding Fume Results

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of Workers</th>
<th>No. of samples</th>
<th>Mean (mg/m$^3$)</th>
<th>Std. Dev.</th>
<th>Range (mg/m$^3$)</th>
<th>Range Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>28</td>
<td>103</td>
<td>5.78</td>
<td>7.04</td>
<td>&lt;1.02-37.3</td>
<td>37</td>
</tr>
<tr>
<td>1996</td>
<td>35</td>
<td>92</td>
<td>4.12</td>
<td>3.71</td>
<td>0.10 – 18.0</td>
<td>180</td>
</tr>
<tr>
<td>2004</td>
<td>16</td>
<td>19</td>
<td>7.91</td>
<td>3.79</td>
<td>2.37 – 15.3</td>
<td>6.5</td>
</tr>
</tbody>
</table>

No adequate OEL for welding fume; previous TLV and PEL was 5 mg/m$^3$

ACGIH TLV for respirable particulate is 3 mg/m$^3$
## T-BEAM Manganese Exposure Results (1995 – 1996)

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample Size</th>
<th>Mean (mg/m³)</th>
<th>Range (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>61</td>
<td>0.20 or equal to the TLV</td>
<td>0.0005 – 1.3105</td>
</tr>
<tr>
<td>1996</td>
<td>75</td>
<td>0.07 or about 1/3 the TLV</td>
<td>0.0010 – 0.4700</td>
</tr>
</tbody>
</table>
“Hierarchy of Controls”

• Engineering controls
  – Substitution
  – Ventilation
• Administrative controls
• Personal protective equipment
Engineering Controls in Construction

- Industrial hygiene involves protecting workers through control of the environment;

- OSHA standards require use of engineering controls as primary means of control;

- however, engineering controls in construction are still rare
Engineering controls

- More effective
- Reduces variability in exposure
- More comfortable for the worker
- Requires training in correct use
- Requires up-front planning when designing and bidding job
Respirator, welding hood, and fall protection left no room for air monitoring equipment
Respirators impede communication and may be removed by worker.
Local Exhaust Ventilation (LEV)
Correct placement of LEV hood
Incorrect placement of LEV hood
Preventing exposures to asphalt fumes with LEV on all new highway-class asphalt pavers

- National Scope (manufactures/labor/govt.)
- Controls designed by manufacturers for their equipment
- Incentivized by pending regulation
- More info – Contact Scott Earnest, NIOSH, GEarnest@CDC.GOV
Overview of Industrial Hygiene in Construction

- Questions
- Comments?
- How often do you do or see personal air monitoring?
- How often do you see use of engineering controls? What are some examples?
A Case Study: Engineering Controls for Abrasive Blasting - Substitution

• NIOSH recommended ban on use of abrasive containing more than 1% silica (1974)
• NIOSH study shows alternative abrasives may also pose metal hazards, w/ specular hematite least hazardous (1990s)
• With the NJ DOT, CPWR employs T-BEAM approach to identify lowest risk substitute for silica sand (2001)
Working with the NJ DOT we evaluated the following abrasives:

- 2002 - Specular hematite
- 2003 - Coal slag
- 2004 – Steel grit
- Contractor was the same throughout the study; pedestrian bridges being repainted were similar throughout study
Other health hazards of abrasives - metals

- Manganese – neurological effects (parkinsonism)
- Chromium VI & Nickel – lung cancer and occupational asthma and skin sensitizer
- Beryllium – berylliosis & lung cancer
- Arsenic – lung cancer
Comparison of Abrasives

• Silica levels at or below 0.1% for alternative abrasives
• Airborne silica exposure still elevated because of silica in the paint
• Arsenic & beryllium levels are increased with coal slag use
• Cadmium, chromium, nickel, and manganese higher in steel grit exposures
General Conclusions/Findings

- All abrasives resulted in lower silica exposure than we’d expect to see with use of silica sand
- Other hazardous agents were of concern (e.g. beryllium, manganese, etc)
- Paint poses an important source of hazardous exposure, including silica
Ben Franklin says “Go Flyers!!!!”