This draft is formatted into four parts: an overview, assessment, research plan, and appendixes. The assessment is structured using the five questions that NIOSH is using for its NORA town hall meetings, and the research plan is structured similar to the White House strategy for preventing a pandemic.
Contents

Overview .......................................................................................................................... 4
Assessment ....................................................................................................................... 5

1. Who is most at risk? ..................................................................................................... 5
   Injuries ......................................................................................................................... 6
   Illnesses ....................................................................................................................... 6

2. How serious is the issue? ............................................................................................ 6
   Fatalities ....................................................................................................................... 7
   Days Off Work ............................................................................................................ 7
   Nature of Injury or Illness .......................................................................................... 8
   Body Part Affected ...................................................................................................... 9
   Source of injury and illness ...................................................................................... 9
   Event or exposure ....................................................................................................... 10

3. What research is needed? ........................................................................................... 10
   Incident Response ...................................................................................................... 10
   Surveillance .................................................................................................................. 11
   Technology Assessments .......................................................................................... 11
   Intervention Research ................................................................................................ 13
   Ergonomics of PPE ................................................................................................... 15
   Improve Existing PPE ............................................................................................... 15

4. Who are our partners? ............................................................................................... 15
   PPE Construction Industry ......................................................................................... 15
   Professional and Standard-setting Organizations ...................................................... 16
   Occupational Safety and Health Administration ...................................................... 16
   Construction Trade Organizations ............................................................................ 17
   Trade Unions ............................................................................................................. 17
   Other Governmental Agencies ................................................................................. 18

5. How can we make a difference? ................................................................................ 18
   Emergency Preparedness .......................................................................................... 18
   First Decade NORA Priorities .................................................................................. 19
   Emerging Technologies ............................................................................................. 19
   PPE Comfort .............................................................................................................. 20
   Training ....................................................................................................................... 20

Research Plan .................................................................................................................. 20

Pillar 1. Surveillance ........................................................................................................ 21
   Goal: To set priorities for further surveillance and research. .................................. 21

Pillar 2. Standardization and Certification .................................................................... 21
   Goal: To establish voluntary standards or 42 CFR certification programs for PPE. ... 22

Pillar 3. Product Development and Evaluation ............................................................. 22
   Goal: To incorporate advanced protective technologies into fully-integrated, intelligent,
   and reliable ensembles .............................................................................................. 22
   Goal: To collaborate with partners in the development of PPE to protect workers from high
   risk, frequency and/or severity hazards .................................................................... 22

Pillar 4. Education, Training, and Feedback .................................................................. 22
Goal: To improve and implement PPE training programs, guidelines, and products for optimum use and acceptance by workers

Appendix 1: Construction Subsector Descriptions
Appendix 2: Common Occupational Diseases among Construction Workers
Appendix 3: Applicable Standards and Standards Setting Organizations
National Strategy for Personal Protective Technologies  
Research for the Construction Sector  

“Providing National and World Leadership to Prevent Illnesses and Injuries”

Overview

Every day, in nearly every type of U.S. work setting, personal protective technologies are used to reduce workers' risk of job-related injury, illness, and death. These technologies include personal protective devices such as respirators, chemical-resistant clothing, hearing protectors, and safety goggles and glasses that provide a barrier between the worker and an occupational safety or health risk. In particular, respirators are a required component of many occupational safety and health programs, and may represent a worker's last line of defense against exposure to toxic fumes, vapors, or dust. More generally, personal protective equipment (PPE) is a last line defense after engineering controls.

PPE are tools that ensure the basic health protection and safety of users. PPE is any device designed to be worn by an individual when exposed to one or more safety and health hazards. PPE includes all clothing and other work accessories designed to create a barrier against or restraints from workplace hazards, and using PPE requires hazard awareness and training on the part of the user. Employees must be aware that the equipment does not eliminate the hazard; if the equipment fails, exposure will occur. To reduce the possibility of failure, equipment must be properly fitted and maintained in a clean and serviceable condition. Personal protective technologies also include devices that provide a worker with early warning of a hazard or otherwise help keep the worker safe from harm, such as sensors that detect toxic atmospheres and communication devices used for safe deployment of emergency workers.

At the request of the Congress, the National Institute for Occupational Safety and Health (NIOSH) established the National Personal Protective Technology Laboratory (NPPTL) in Pittsburgh, PA in 1999. NPPTL focuses expertise from many scientific disciplines to advance federal research on respirators and other personal protective technologies for workers. NPPTL's efforts are essential for applying state-of-the-art science to meet the increasingly complex occupational safety and health challenges of the 21st Century. NPPTL's strategic research program ensures that the development of new PPE keeps pace with employer and worker needs as work settings and worker populations change and new technologies emerge. NPPTL research also responds to the need for effective protective technologies for first responders in terrorist events and other disasters. NPPTL incorporates NIOSH's longstanding program for testing and approving respirators for use in traditional work settings.

The mission of NPPTL is to prevent work-related illness and injury by ensuring the development, certification, deployment, and use of PPE and fully integrated, intelligent ensembles. This will be accomplished through the advancement and application of personal protective technology standards.

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1 Senate Rpt. 106-293 Departments of Labor, Health and Human Services, and Education and Related Agencies Appropriation Bill, 2001 Filed Under Authority of the Order of the Senate January 6, 1999,
Construction workers build and maintain roads, houses, workplaces and physical infrastructure. This work includes many inherently hazardous tasks and conditions such as work at height, excavations, noise, dust, power tools and equipment, confined spaces, and electricity. The construction sector comprises establishments primarily engaged in the construction of buildings or engineering projects (e.g., highways and utility systems). Establishments engaged in the preparation of sites for new construction and establishments engaged in subdividing land for sale as building sites also are included in this sector. Construction work done may include new work, additions, alterations, or maintenance and repairs. Activities of these establishments generally are managed at a fixed place of business, but they usually perform construction activities at multiple project sites. Production responsibilities for establishments in this sector are usually specified in (1) contracts with the owners of construction projects (prime contracts) or (2) contracts with other construction establishments (subcontracts). Establishments primarily engaged in contracts that include responsibility for all aspects of individual construction projects are commonly known as general contractors. Establishments primarily engaged in activities to produce a specific component (e.g., masonry, painting, and electrical work) of a construction project are commonly known as specialty trade contractors.

Assessment

1. Who is most at risk?
There are substantial differences in the types of equipment, work force skills, and other inputs required by establishments in the construction sector. To highlight these differences and variations in the underlying production functions, this sector is divided into three subsectors as shown in Table 1 and described in Appendix 1. The subsector, Construction of Buildings, comprises establishments of the general contractor type and operative builders involved in the construction of buildings. The subsector, Heavy and Civil Engineering Construction, includes establishments involved in the construction of engineering projects. The subsector, Specialty Trade Contractors, comprises establishments engaged in specialty trade activities generally needed in the construction of all types of buildings.

<table>
<thead>
<tr>
<th>Code*</th>
<th>Construction Subsector</th>
<th>Employment 2005†</th>
<th>Rates, 2004‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>236</td>
<td>Construction of Buildings</td>
<td>1,727,200</td>
<td>5.5</td>
</tr>
<tr>
<td>237</td>
<td>Heavy and Civil Engineering Construction</td>
<td>974,800</td>
<td>5.8</td>
</tr>
<tr>
<td>238</td>
<td>Specialty Trade Contractors</td>
<td>4,714,000</td>
<td>6.6</td>
</tr>
<tr>
<td>23</td>
<td>Construction Sector</td>
<td>7,416,000</td>
<td>6.2</td>
</tr>
</tbody>
</table>

* North American Industry Classification System (NAICS)
† excludes self-employed and publicly employed workers
‡ [above average in bold] injury rates per 100 employees/yr; illness rates per 10,000 employees/yr

Injury and illness rates provide a measure of the success of worker protection strategies. Those portions of industry with the highest rates indicate failures in protection and opportunities for research to intervene to improve the safety and health of these workers. Using 2004 data, Table 1 shows those subsectors of the construction industry and their average injury and illness rates.

2 http://www2a.cdc.gov/niosh-Chartbook/ch4/ch4-2.asp
Injuries
An estimated 9.6 million persons were employed in the construction industry in 2001 (note that the total employment shown in Table 1 excludes self-employed and public employees). Most of these workers were aged 25–54 (75.4%), male (90.3%), and white (90.8%). Over the years, construction has ranked among industries with the highest rates of both fatal and nonfatal occupational injuries. BLS reported that the number and rate of fatal occupational injuries in the construction sector in 2001 were the highest recorded since the inception of the Census of Fatal Occupational Injuries (CFOI). There were 1,225 fatal occupational injuries with an incidence rate of 13.3 per 100,000 employed workers. Construction has about 6% of U.S. workers, but 20% of the fatalities - the largest number of fatalities reported for any of the industry sectors. In 2001, BLS reported that the construction industry experienced 481,400 nonfatal injuries and illnesses at a rate of 7.9 per 100 full-time workers in the industry.

Illnesses
Several hazards and associated diseases among construction workers have been recognized. A list of these hazards and diseases are listed in Appendix 2. These diseases include fume fever (metal, polymer), cadmium poisoning, carbon monoxide poisoning, acute inhalation injury (NO₂, ozone, phosgene), manganese poisoning, asbestosis, silicosis, acute solvent syndrome, peripheral neuropathy, alkaline burns, photoirritant dermatitis, lead poisoning, beryllium disease, chloracne, allergic contact dermatitis, chronic obstructive pulmonary disease, dry skin or irritation, irritant contact dermatitis, occupational asthma, and hypersensitivity pneumonitis.

2. How serious is the issue?

Figure 1. Fatal occupational injury rates by trade, 2001

3 http://www2a.cdc.gov/niosh-Chartbook/ch4/ch4-2.asp
4 http://www2a.cdc.gov/niosh-Chartbook/ch4/ch4-2.asp
**Fatalities**

During the period from 1980 through 1995, at least 17,000 construction workers died from injuries suffered on the job. Construction lost more workers to traumatic injury death than any other major industrial sector during this time period. Construction has the third highest rate of death by injury: 15.2 deaths per 100,000 workers. Only mining and agriculture experience higher rates. The leading causes of death among construction workers are falls from elevations, motor vehicle crashes, electrocutions, machines, and struck by falling objects.\(^5\) Fatal occupational injury rates in the construction trades for 2001 ranged from 6.0 per 100,000 full-time workers for drywall installers to 75.6 for ironworkers—more than a 12-fold difference as shown in Figure 1.\(^6\)

**Days Off Work**

Table 2 shows the ranking of severity of injuries by days off work by subsector in the construction industry in the United States. Specialty trade contractors lead the industry with the most severe injuries with 258.7 cases per 10,000 workers with days off-of-work as a result of an injury or illness. Table 3 also shows above average rates of injury and illness for 1 day away from work for the construction of building subsector and 21 to 30 days away from work for the heavy and civil engineering construction subsector.

<table>
<thead>
<tr>
<th>Number of days away from work</th>
<th>Private industry</th>
<th>Construction</th>
<th>Construction Subsectors</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Construction of buildings</td>
<td>Heavy &amp; Civil Engineering Construction</td>
<td>Specialty Trade Contractors</td>
</tr>
<tr>
<td>1 day</td>
<td>20.3</td>
<td>32.8</td>
<td>41.1</td>
<td>18.3</td>
<td>32.9</td>
</tr>
<tr>
<td>2 days</td>
<td>16.2</td>
<td>24.7</td>
<td>22.4</td>
<td>18.4</td>
<td>26.9</td>
</tr>
<tr>
<td>3-5 days</td>
<td>26.0</td>
<td>41.6</td>
<td>32.6</td>
<td>38.8</td>
<td>45.6</td>
</tr>
<tr>
<td>6-10 days</td>
<td>17.9</td>
<td>29.8</td>
<td>26.7</td>
<td>26.7</td>
<td>31.6</td>
</tr>
<tr>
<td>11-20 days</td>
<td>16.1</td>
<td>28.8</td>
<td>20.2</td>
<td>25.5</td>
<td>32.7</td>
</tr>
<tr>
<td>21-30 days</td>
<td>9.6</td>
<td>17.0</td>
<td>15.8</td>
<td>17.2</td>
<td>17.4</td>
</tr>
<tr>
<td>&gt;30 days</td>
<td>35.3</td>
<td>69.1</td>
<td>62.1</td>
<td>68.2</td>
<td>71.8</td>
</tr>
<tr>
<td>Total</td>
<td>141.3</td>
<td>243.7</td>
<td>220.8</td>
<td>213</td>
<td>258.7</td>
</tr>
</tbody>
</table>

Bold red indicates rates above the average for the construction industry

However, the specialty trade contractor subsector had above average rates of lost-time injuries across the construction sector. Regarding the specialty trades, Figure 2 shows the average rate of nonfatal occupational injury and illness by building trade. The average rate for the trades in 2001 was 268 injuries and illnesses per 10,000 full-time workers.


Nature of Injury or Illness

Another characteristic of injury and illness rates is their nature as listed in Table 3. Workers in the subsector, construction of buildings, experienced above average injuries described as cuts, lacerations, and punctures; multiple injuries with fractures; and soreness and pain including back pain. Workers in the subsector, heavy and civil engineering construction, experienced above average injuries classified as fractures; bruises and contusions, heat and chemical burns amputations; and multiple injuries with sprains. The specialty trade contractors subsector had above average rates of injuries and illnesses related to all categories shown in Figure 3 with the exception of bruises and contusions; amputations; and multiple injuries associated with fractures.

Table 3. Injury Rate by Nature of Injury or Illness per 10,000 workers per year, 2004

<table>
<thead>
<tr>
<th>Nature of injury, illness</th>
<th>Private industry</th>
<th>Construction</th>
<th>Construction Subsectors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Construction of Buildings</td>
</tr>
<tr>
<td>Sprains, strains</td>
<td>59.0</td>
<td>91.2</td>
<td>77.9</td>
</tr>
<tr>
<td>Fractures</td>
<td>10.6</td>
<td>25.1</td>
<td>23.3</td>
</tr>
<tr>
<td>Cuts, lacerations, punctures</td>
<td>12.8</td>
<td>35.1</td>
<td><strong>36</strong></td>
</tr>
<tr>
<td>Bruises, contusions</td>
<td>12.9</td>
<td>16.6</td>
<td>14.6</td>
</tr>
<tr>
<td>Heat burns</td>
<td>2.1</td>
<td>2.7</td>
<td>0.7</td>
</tr>
<tr>
<td>Chemical burns</td>
<td>0.8</td>
<td>1.3</td>
<td>0.6</td>
</tr>
<tr>
<td>Amputations</td>
<td>0.9</td>
<td>2.4</td>
<td>1.7</td>
</tr>
<tr>
<td>Tendonitis</td>
<td>0.8</td>
<td>0.7</td>
<td>-</td>
</tr>
<tr>
<td>Multiple injuries</td>
<td>5.7</td>
<td>10.1</td>
<td>7.5</td>
</tr>
<tr>
<td>With fractures</td>
<td>1.1</td>
<td>3.0</td>
<td><strong>3.7</strong></td>
</tr>
<tr>
<td>With sprains</td>
<td>2.2</td>
<td>3.0</td>
<td>1.3</td>
</tr>
<tr>
<td>Soreness, Pain</td>
<td>11.7</td>
<td>17.1</td>
<td><strong>19</strong></td>
</tr>
</tbody>
</table>
Body Part Affected

The part of body affected by an injury or illness indicates the type of protection needed by construction workers. The specialty trade contractors subsector experienced above average rates of injuries and illnesses across all parts of the body with the single exception of body systems as shown in Table 4. The construction of buildings subsector experienced above average rates of injuries and illness on the upper extremities including the finger and hand, body systems, and the category, all other. Workers in the subsector, heavy and civil engineering construction, experienced injuries and illnesses at an above average rate to the head, the neck, lower extremities, and body systems.

Table 4. Injury Rates by Part of Body Affected per 10,000 workers per year, 2004

<table>
<thead>
<tr>
<th>Part of body affected:</th>
<th>Private industry</th>
<th>Construction</th>
<th>Construction of buildings</th>
<th>Heavy &amp; Civil Engineering Construction</th>
<th>Specialty Trade Contractors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>9.1</td>
<td>18.4</td>
<td>15.4</td>
<td>16.3</td>
<td>20</td>
</tr>
<tr>
<td>Eye</td>
<td>4.1</td>
<td>10.6</td>
<td>9.4</td>
<td>7.5</td>
<td>11.7</td>
</tr>
<tr>
<td>Neck</td>
<td>2.4</td>
<td>3.5</td>
<td>1.7</td>
<td>3.6</td>
<td>4.1</td>
</tr>
<tr>
<td>Trunk</td>
<td>50.2</td>
<td>79.5</td>
<td>70.0</td>
<td>68.3</td>
<td>85.4</td>
</tr>
<tr>
<td>Back</td>
<td>31.7</td>
<td>51.2</td>
<td>47.3</td>
<td>41.5</td>
<td>54.7</td>
</tr>
<tr>
<td>shoulder</td>
<td>9.2</td>
<td>13</td>
<td>9</td>
<td>12.6</td>
<td>14.6</td>
</tr>
<tr>
<td>Upper extremities</td>
<td>32.6</td>
<td>59.1</td>
<td>60.6</td>
<td>36.7</td>
<td>63.4</td>
</tr>
<tr>
<td>Finger</td>
<td>12.1</td>
<td>23.5</td>
<td>25.6</td>
<td>15.5</td>
<td>24.5</td>
</tr>
<tr>
<td>hand</td>
<td>5.6</td>
<td>11.5</td>
<td>12.0</td>
<td>4.8</td>
<td>12.7</td>
</tr>
<tr>
<td>Wrist</td>
<td>6.6</td>
<td>8.8</td>
<td>8.1</td>
<td>4.8</td>
<td>9.9</td>
</tr>
<tr>
<td>Lower extremities</td>
<td>30.2</td>
<td>59.4</td>
<td>52.7</td>
<td>67.2</td>
<td>60.1</td>
</tr>
<tr>
<td>Knee</td>
<td>11.2</td>
<td>21.4</td>
<td>21.0</td>
<td>20.4</td>
<td>21.7</td>
</tr>
<tr>
<td>foot, toe</td>
<td>6.5</td>
<td>10.9</td>
<td>9.8</td>
<td>10.8</td>
<td>11.4</td>
</tr>
<tr>
<td>Body systems</td>
<td>1.6</td>
<td>1.7</td>
<td><strong>1.8</strong></td>
<td><strong>1.9</strong></td>
<td>1.7</td>
</tr>
<tr>
<td>Multiple</td>
<td>14.2</td>
<td>19.9</td>
<td>16.3</td>
<td>17.1</td>
<td>21.9</td>
</tr>
<tr>
<td>All other</td>
<td>1</td>
<td>2.2</td>
<td><strong>2.3</strong></td>
<td>1.9</td>
<td><strong>2.3</strong></td>
</tr>
</tbody>
</table>

Source of injury and illness

The source of injuries and illnesses for workers in the construction industry are listed in Table 5. The construction of buildings subsector had above average rates of injuries and illnesses from parts and materials and from handtools, whereas the heavy and civil engineering construction subsector had above average rates from machinery and vehicles. The specialty trade contractors subsector had above average rates from chemicals and chemical products, containers, furniture and fixtures, parts and materials, worker motion or position, floor or ground surfaces, and the category, all other.

Table 5. Injury Rates* by Source of injury and illness per 10,000 workers per year, 2004

<table>
<thead>
<tr>
<th>Source of injury and illness</th>
<th>Private industry</th>
<th>Construction</th>
<th>Construction of buildings</th>
<th>Heavy &amp; Civil Engineering Construction</th>
<th>Specialty Trade Contractors</th>
</tr>
</thead>
</table>

**Bold red indicates rates above the average for the construction industry**
Event or exposure

A list of the event or exposure related to injuries and illnesses in the construction industry is shown in Table 6. Workers in the construction of buildings subsector experienced above average injury and illness rates related to being struck by and object or equipment and from repetitive motion. The heavy and civil engineering construction subsector experienced above average injury and illness rates from being caught in and object or equipment, exposure to a harmful substance, and transportation events.

Table 6. Injury Rates by Event or Exposure per 10,000 workers per year, 2004

<table>
<thead>
<tr>
<th>Event or exposure</th>
<th>Private industry</th>
<th>Construction</th>
<th>Construction of buildings</th>
<th>Heavy &amp; Civil Engineering Construction</th>
<th>Specialty Trade Contractors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact, object</td>
<td>37.6</td>
<td>82.5</td>
<td>80.8</td>
<td>76.2</td>
<td>84.4</td>
</tr>
<tr>
<td>struck by</td>
<td>19.1</td>
<td>44.5</td>
<td>46.2</td>
<td>43.5</td>
<td>44</td>
</tr>
<tr>
<td>struck against</td>
<td>9.4</td>
<td>20.2</td>
<td>16.1</td>
<td>16.2</td>
<td>22.6</td>
</tr>
<tr>
<td>caught in</td>
<td>6.2</td>
<td>8.6</td>
<td>8</td>
<td>11.2</td>
<td>8.2</td>
</tr>
<tr>
<td>Fall, lower level</td>
<td>9</td>
<td>33.3</td>
<td>32.9</td>
<td>16.4</td>
<td>37.2</td>
</tr>
<tr>
<td>Fall, same level</td>
<td>18.7</td>
<td>20.2</td>
<td>17.5</td>
<td>18.4</td>
<td>21.6</td>
</tr>
<tr>
<td>Slips, trips</td>
<td>4.2</td>
<td>7.1</td>
<td>5.3</td>
<td>5.9</td>
<td>8.1</td>
</tr>
<tr>
<td>Overexertion</td>
<td>35.5</td>
<td>48.5</td>
<td>45.7</td>
<td>34.6</td>
<td>52.4</td>
</tr>
<tr>
<td>lifting</td>
<td>19.5</td>
<td>26.8</td>
<td>25.7</td>
<td>14.7</td>
<td>29.9</td>
</tr>
<tr>
<td>Repetitive motion</td>
<td>5.5</td>
<td>5.2</td>
<td>7.1</td>
<td>3.6</td>
<td>4.8</td>
</tr>
<tr>
<td>Harmful substance</td>
<td>5.9</td>
<td>8.3</td>
<td>4.9</td>
<td>9.6</td>
<td>9.3</td>
</tr>
<tr>
<td>Transportation</td>
<td>7.1</td>
<td>9.0</td>
<td>3.6</td>
<td>20.1</td>
<td>8.6</td>
</tr>
<tr>
<td>Fires, explosions</td>
<td>0.3</td>
<td>0.8</td>
<td>-</td>
<td>1.0</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Bold red indicates rates above the average for the construction industry

3. What research is needed?

Incident Response

The Congress encouraged NIOSH to carry out research, testing and related activities aimed at protecting workers who respond to public health needs in the event of a terrorist incident. Construction workers are a primary disaster and rescue workforce for emergency response work especially in damaged buildings and structures.
**Surveillance**

More detailed investigations through surveillance methods are needed to identify and prioritize construction technologies for research. These investigations include disaggregating the high risk areas in construction by nature of injury and exposure further to gain better detail regarding the population at risk. PPE interventions can be identified by conducting case studies of investigation reports by OSHA and by NIOSH in their Health Hazard Evaluations (HHE’s) and Fatality Assessment and Control Evaluation (FACE) Programs.

OSHA provides a rich source of recorded injuries that could be prevented with the use of PPE. Many of these investigations have been documented through the publication of *Fatal Facts*. As an example, a nitrogen back-up system that was used in a compressed air system asphyxiated a worker that was using protective respiratory gear during sandblasting operations (Accident Summary No. 67).\(^7\)

An example of an HHE is an investigation of exposures to carbon monoxide in a manhole that resulted in one fatality. The carbon monoxide migrated through soil after nearby use of explosives during the construction of a sewer line.\(^8\)

The NIOSH FACE program investigates occupational fatalities, many of which could be prevented by the use of functional PPE. A 1997 NIOSH report summarized several of these investigations that related to confined spaces.\(^9\) The report addressed atmospheric hazards including flammable and explosive gases, inert gases and asphyxiants, oxygen deficient air, and toxic gases. It also addressed physical hazards including engulfments, falls, electrocutions, and drownings.

**Technology Assessments**

There is a need to analyze technologies so that critical PPE needs with a standards perspective can be filled via research agendas for specific new technologies.

**Protective clothing**

Electrocutions ranked as the second leading cause of death among construction workers, accounting for an average of 15% of traumatic deaths in the industry. The workers most at risk of electrical injury were electricians, structural metal workers, and laborers. Focusing prevention on these populations through use of adequate protective clothing could reduce the loss of construction workers.\(^10\) Potential arc flash exposures require gloves and sleeves for protection.\(^11\)

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\(^8\) Hazard Evaluation and Technical Assistance Report, HETA-98-0020, Carbon Monoxide Intoxication and Death in a Newly Constructed Sewer Manhole.


The patterns of nail gun injuries suggest that the protective clothing worn by operators of the guns do not prevent injuries. A study of carpenters revealed that the majority of injuries from circular or "skill" saws were eye injuries from flying sawdust.

In a study, laborers cleaning structural steel with compressed air and ironworkers exposed to lead fumes from cutting had high concentrations of lead dust on clothing. The potential for "take-home" contamination was high, even though this site was thought to be relatively free of lead. In 49% of cement burn injury cases, no attempt to protect the skin had been made in a review of the problem. The majority of these injuries were located on the lower legs and knees. Full-thickness burns were reported in 66% of cases, and surgery was performed in 34% of them. These burns can be avoided by adequate skin protection.

Contact allergy to five allergens were observed significantly more often in construction workers: dichromate, epoxy resin, cobalt, thiurams and N-isopropyl-p-phenylenediamine. A strong association between cobalt and chromate allergy was found in construction workers. The use of protective gloves with minimal intrinsic contact allergy risk, e.g. due to thiurams in (synthetic) rubber or chromate in leather gloves, should be promoted.

In the paving task, polycyclic aromatic compounds content and crew were also found to be significant determinants of inhalation and dermal exposure to pyrene. Dermal exposures were consistent with the degree to which the workers have actual contact with asphalt-contaminated surfaces, thus, rakers’ exposures were approximately 6 times higher than among roller operators. The dermal exposure of paving workers to polycyclic aromatic hydrocarbons was higher during remixing than during stone mastic asphalt paving.

Respiratory Protection

Despite lowering of the permissible exposure level for lead in construction in 1993, excessive lead exposure continues to be a problem with trade groups of painters, plumbers/pipefitters, ironworkers, laborers, and electricians. The proper use of personal protective equipment such as respirators has been effective in controlling lead poisoning. A study characterized exposure for dust-producing construction tasks. More protective respirators were employed as quartz concentration increased, although respiratory protection was found to be inadequate for 42% of

Data indicate that construction workers exposed to quartz levels above occupational exposure limits are at elevated risk of silicosis and other respiratory diseases. Moreover, excess lifetime risk for lung cancer is expected when workers are exposed to quartz levels above the occupational exposure limit.

**Hearing Protection**

Construction noise regulations lack the specificity of general industry noise regulations. In addition, problems that characterize the construction industry, such as worker mobility and the large proportion of small businesses, make implementing hearing conservation measures more difficult. The prevalence of hearing protection device (HPD) use among U.S. construction workers is very poor, partly because of perceived difficulties in hearing and understanding speech communication and warning signals. In addition, masking by noise of necessary communication and warning signals is of particular concern in construction, where recent research demonstrated the association between fatalities and the failure to hear reverse alarms.

Effective hearing conservation programs in the construction industry are rare. Dependence on hearing protection devices for protection from high noise is problematic, as the protection provided by the HPD depends on both the HPD's attenuation level and the time the HPD is used.

A study of construction workers' use of hearing protection devices indicated a need for significant improvement in three trade groups—operating engineers, carpenters, and plumbers/pipe fitters—use of these devices. The results of a study showed that presumably quiet trades such as electrician are at risk of exposure to potentially harmful noise exposures, and that other workers' activities and the general environment contribute substantially to that risk.

**Intervention Research**

There is a need to develop interventions to address knowledge gaps and develop efforts for broad adoption of successful PPE interventions in targeted construction technologies. As an example, an analyses indicated of an intervention showed a significant increase the use of hearing protective devices.

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The number of Hispanics in the construction work force continues to grow and their fatal and nonfatal occupational injuries are higher than those in any other ethnic group in the United States. Involving hard-to-reach workers is a difficult process because of language and cultural differences within ethnic groups. Focusing on safety and health for this group may reduce injuries and promote safe workplaces. In addition, self-employed workers present a challenge for interventions. In one study, self-employed carpenters comprised 17% of injured persons but 36% of those with unpaid bills.

A PPE program must be comprehensive to be effective. It requires commitment and active participation at the planning, development, and implementation stages from all levels: senior management, supervisors, and workers. A good PPE program consists of several essential elements: workplace survey, selection of appropriate controls, selection of appropriate PPE, fitting, training, management support, and PPE storage, maintenance and care as well as auditing of the program. Research is needed to remove barriers to an effective program and develop methods to simplify the program.

Sprains and strains receive scant attention from the PPE industry because of their association with overexertion. Nonetheless, PPE may have an important role to serve in reducing the severity of these injuries with creative applications of personal protective strategies to reduce overexertion—e.g., the contentious area of extra-skeletal bracing; see the accompanied drawings for Sitting/Kneeling Support. This support device makes hip support available where the work requires kneeling, which reduces tension in the thigh muscles, by widening the angle of the knees, reduces compression on the knees, ankles and lumbar region (middle to lower back), and improves blood circulation. Anthropometric information such as body size or body segment measurements of some occupational groups differs significantly. Glove design can provide for more grip with less force upon the musculoskeletal system. Products that enter the market need to be evaluated for their efficacy and effectiveness, e.g., back or limb supports.

Personal detection system innovations may offer solutions to amputations when other controls fail, such as saws equipped with a safety system that detects when someone accidentally contacts the spinning saw blade, and then stops the blade in milliseconds.

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33 http://www.sawstop.com/how-it-works-overview.htm
Ergonomics of PPE

Regarding ergonomic aspects of PPE design and use, research has addressed problems related to a comparison of body strain and work time limitation for users wearing gas-tight and drill suits with a focus on an optimum combination of protection and comfort.\textsuperscript{34,35} Based on the findings from a NIOSH study, face length and face width are recommended measurements that should be used for defining the panel for half-facepiece respirators.\textsuperscript{36} Results from another study indicated that postural stability is altered with PPE use and with fatigued postural muscles.\textsuperscript{37} Researchers and designers who use anthropometric databases to evaluate human-machine interfaces and PPE must use caution in selecting databases that are adequate for their occupational applications.\textsuperscript{38}

Improve Existing PPE

Hazard reduction with the use of PPE to protect construction workers needs continuous attention, not only to improve the protective technologies but also to improve the proper use and care for these technologies. Known hazards and PPE include the following (Also see Appendixes 2 and 3):

- Lung and respiratory protection (inhalation) – dust, chemicals, fumes, aerosols
- Whole body protection – air supplied suit (corrosive environment), encapsulating suit
- Skin and dermal protection – protective clothing and garments around toxic and irritating chemicals, heat, hot metal, flame-retardant clothing, cold
- Hand protection – gloves, barrier creams, hand leathers, and arm protectors
- Foot protection – safety shoes and boots with non-slip soles and heels
- Head and hair protection – hard hats, hair nets, cold
- Eye and vision protection – protective eyewear, welding helmets
- Hearing protection – acoustic earmuffs and plugs
- Electrical protection – insulated gloves, sleeves, clothing, tools
- Body loads or impacts – shoulder pads, padded aprons, shin guards, knee pads, gloves
- Fall protection – lifelines, body support

4. Who are our partners?

PPE Construction Industry

A significant partner in PPE research is the PPE construction and marketing industry. As an example, NIOSH held a meeting for all respirator manufacturers on December 12, 2005, at the NIOSH site in Pittsburgh, Pennsylvania. The meeting addressed replacement rates, and alternatives to the silica dust tests for powered, air-purifying respirators (PAPRs), labeling for filtering face piece respirators, and other topics and included a Standard Application Procedures

Professional and Standard-setting Organizations

Professional organizations also provide viable partners in PPE research. These include the National Safety Council, American Conference of Governmental Industrial Hygienists, American Industrial Hygiene Association, and American Society of Safety Engineers. Standard-setting organizations include the American National Standards Institute, American Society of Testing Materials, European Committee for Standardization, International Organization for Standardization, National Fire Protection Association, and Standards Council of Canada. Several PPE standards that apply to construction industry workers are listed in Appendix 3.

Occupational Safety and Health Administration

The Occupational Safety and Health Administration (OSHA) has an active program for assistance and compliance related to construction safety and health. Elements of that program are described below.

Safety and Health Regulations for Construction

OSHA has promulgated occupational safety and health standards unique to the construction industry. These standards as related to PPE are listed in Appendix 3.

Directorate of Construction

The Directorate of Construction develops workplace safety standards and regulations to ensure safe working conditions for the nation's construction workers; and coordinates with and provides assistance to other regulatory agencies on the implementation and enforcement of major construction laws and standards.

Advisory Committee on Construction Safety and Health

The OSHA Advisory Committee on Construction Safety and Health is a continuing advisory body established by statute that provides advice and assistance in construction standards and policy matters to the Assistant Secretary.

Construction Alliances

OSHA and its allies work together to reach out to, educate, and lead the nation's employers and their employees in improving and advancing workplace safety and health. National alliances that have or currently been established include the following:

- Air Conditioning Contractors of America
- American Concrete Pipe Association
- American Society of Civil Engineers Construction Institute
- American Society of Safety Engineers
- Board of Certified Safety Professionals
- Construction Management Association of America
- Crane, Hoist and Monorail Alliance
- Drug Free Workplace Alliance
- Gilbane Building Company
Hispanic Contractors of America, Inc.
Independent Electrical Contractors, Inc.
International Association of Foundation Drilling
International Safety Equipment Association
Mason Contractors Association of America
Modular Building Institute
National Association of Home Builders
National Demolition Association
National Electrical Contractors Association
National Hearing Conservation Association
National Telecommunications Safety Panel
Risk and Insurance Management Society
The Roadway Work Zone Safety and Health Coalition
Sealant Waterproofing and Restoration Institute
Washington Group International

**Strategic Partnership Program**

The OSHA Strategic Partnership Program embraces collaborative agreements. In which its partners agree to work cooperatively to address critical safety and health issues. National partners include Electrical Transmission and Distribution Construction Contractors and Trade Associations and AMEC Americas as well as the International Brotherhood of Electrical Workers and Building and Construction Trades. OSHA has established several other regional partnerships.

**Construction Trade Organizations**

The construction industry and its many trade organizations provide opportunities for partnerships. These organizations include the Advanced Construction Leadership Forum, which is a body of leaders from business, research, education and governmental organizations. The Forum provides policy advice and research guidance to the National Council for Advanced Construction on strategies for the success of U.S.-based construction in a new industrial era. Some employer organizations include the following:

- Associated General Contractors of America
- National Erectors Association
- Associated Builders and Contractors (an open shop organization)
- Association of Minority Contractors
- Women Construction Owners and Executives
- National Electrical Contractors Association
- Heavy Constructors Association

**Trade Unions**

Construction unions are potential partners in occupational safety and health especially through their apprenticeship programs. These unions are listed below.

- Building and Construction Trades Department, AFL-CIO
Center to Protect Workers’ Rights
- International Union of Bricklayers and Allied Craftworkers
- International Brotherhood of Boilermakers, Iron Ship Builders, Blacksmiths, Forgers and Helpers
- International Brotherhood of Electrical Workers
- International Association of Heat and Frost Insulators and Asbestos Workers
- International Association of Bridge, Structural, Ornamental and Reinforcing Iron Workers
- Sheet Metal Workers International Association
- Operative Plasterers' and Cement Masons' International Association of the United States and Canada
- International Union of Elevator Constructors
- International Union of Painters and Allied Trades
- International Brotherhood of Teamsters
- International Federation of Professional and Technical Engineers
- International Union of Operating Engineers
- Laborers' International Union of North America
- United Union of Roofers, Waterproofers and Allied Workers
- United Association of Journeymen and Apprentices of the Plumbing and Pipefitting Industry of the United States and Canada
- United Brotherhood of Carpenters and Joiners of America
- Utility Workers Union of America

Other Governmental Agencies
The Department of Commerce\(^{39}\) is an important partner as it leads the United States effort for a more competitive construction sector. The National Science Foundation is another potential partner as it funds collaborative university-business programs. Important research regarding PPE is also performed by the Defense Advanced Research Projects Agency of the Department of Defense and the Department of Homeland Security. In addition, the U.S. Department of Housing and Development is responsible for enforcing safety of manufactured housing.

5. How can we make a difference?

Emergency Preparedness
The attacks of September 11, 2001 have demonstrated the need for improved PPE. Improvements are needed in PPE ensembles, guidelines, and effective delivery systems of equipment. There is also a need for quick access to expert information regarding complex emergencies.\(^{40}\) Communications are an important adjunct to the PPE ensemble as well.


**First Decade NORA Priorities**

An original NORA priority addressed PPE. That priority addressed chemical protective clothing, noise, respirators, and eye safety. NIOSH’s Protective Clothing Program is aimed at protecting the skin from various health hazards that may be encountered in the workplace or during a terrorist attack. The program has evolved over the years to incorporate a broad range of studies of how chemicals seep through barrier materials, leak through small holes, or change the barrier material to reduce its protection.

Noise-induced hearing loss is 100 percent preventable but once acquired, hearing loss is permanent and irreversible. Non-linear hearing protectors (NLHPs) have been developed to provide improved communication and ability to hear warning signals while protecting workers from hazardous noise. However, the existing American and international standards for testing linear hearing protectors cannot address the performance and effectiveness of nonlinear (level dependent and active noise cancellation) devices. NIOSH is developing standardized laboratory test methods for acoustic and psycho-acoustic assessment of NLHPs, which addresses the shortcomings of current ANSI and ISO standards.

Respirators protect the user in two basic ways. The first is by the removal of contaminants from the air. Respirators of this type include particulate respirators, which filter out airborne particles; and "gas masks" which filter out chemicals and gases. Other respirators protect by supplying clean respirable air from another source. Respirators that fall into this category include airline respirators, which use compressed air from a remote source; and self-contained breathing apparatus, which include their own air supply.

Personal protective eyewear, such as goggles, face shields, safety glasses, or full face respirators must also be used when an eye hazard exists. The eye protection chosen for specific work situations depends upon the nature and extent of the hazard, the circumstances of exposure, other protective equipment used, and personal vision needs. Eye protection should be fit to an individual or adjustable to provide appropriate coverage. It should be comfortable and allow for sufficient peripheral vision. Selection of protective eyewear appropriate for a given task should be made based on a hazard assessment of each activity, including regulatory requirements when applicable.

**Emerging Technologies**

An array of emerging technologies can improve the safety of PPE. They can ease the fit testing of HPDs. Communication devices between donned respirators can be improved with technologies. Technology can also improve the estimation of exposures required for planning respiratory protection. Emerging technologies for glove material designed for different potential dermal exposures have increased the choices available for protection.

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**PPE Comfort**

Acceptance of PPE can be improved by optimizing their design with protection, comfort, and productivity as criteria. Proper protection of the hands can be comfortable.\(^{45}\) The lack of dexterity in gloves has been a barrier to their use and acceptance.\(^{46}\) Fit guidelines for apparel can lead to improved comfort and acceptance of clothing.\(^{47}\)

**Training**

Training to respond to emergencies requires planning and evaluation. PPE is critical is part of this response. Common emergencies include fires, medical emergencies, HazMat releases, special rescues (e.g., confined space), workplace violence, bomb threats, external emergencies, weather and power failure.\(^{48}\) Safety signs have been found to be ineffective in encouraging the donning of PPE.\(^{49}\) Failures or deficiencies in hearing conservation programs can often be traced to inadequacies in the training and education of noise-exposed employees and those who conduct elements of the program. A study of a revised structure for health promotion model indicated it may be useful in increasing the use of hearing protectors among construction workers.\(^{50}\) Results of a research study regarding relatively low level of English communication skills among young Latino workers, pointed to the need for increased worker safety training programs.\(^{51}\) Seasonal tasks related to construction work also need to be considered in training programs.\(^{52}\)

**Research Plan**

In addition to the above assessment, an important aspect of this Research Plan is to provide a framework for future U.S. Government planning efforts that is consistent with The National Security Strategy and the National Strategy for Homeland Security. It recognizes that preparing for and responding to emergencies cannot be viewed as a purely federal responsibility, and that the nation must have a system of plans at all levels of government and in all sectors outside of government that can be integrated to address the threat of emergencies whether small or catastrophic. It is guided by the following principles:

- Engineering control or inherently safer systems should be used to negate the need for PPE. PPE should only be used as a "last line of defense" when engineering control systems or hazard elimination are not feasible.
- Employers should have credible preparedness plans to respond to PPE needs within their workplaces. Individual workers should be prepared for the use of PPE and be trained in the use of PPE for their particular working conditions.


• The private sector should play an integral role in PPE research and development and should be a part of the national deployment of PPE technologies.
• Partnerships will be leveraged to address the threat of uncontrolled hazards, especially the threat of terrorist attacks.
• Three criteria are important in assessing the need for PPE research:
  ► Frequency of the occupational safety and health problem.
  ► Severity of the occupational safety and health problem.
  ► The preventability of the problem with PPE.

The Research Plan addresses the full spectrum of construction workplaces from small contractors to large construction operations plants in America. While the circumstances of these environments are very different, our strategic principles remain relevant. Four pillars of the Research Plan are described below:

Pillar 1. Surveillance
Occupational health surveillance can be viewed as the tracking of occupational injuries, illnesses, hazards, and exposures. Occupational surveillance data are used to guide efforts to improve worker safety and health, and to monitor trends and progress over time. This effort will analyze and interpret existing data, undertakes data collection efforts to fill gaps in surveillance data, provides support to state agencies to conduct occupational surveillance and associated prevention efforts, and works with Federal, State, and private sector partners to improve occupational health surveillance.

Goal: To set priorities for further surveillance and research.
Priorities under this goal include:

■ Investigate high risk subsectors and populations for injuries and illnesses that can be prevented with PPE.

■ This surveillance effort involves the review and monitoring of HHEs, FACE, and OSHA inspection reports regarding construction to identify severe injuries and illnesses that PPE could prevent and PPE failures to protect workers.

■ The emergence of new technologies need to be evaluated for both potential hazards as well as use in PPE.

Pillar 2. Standardization and Certification
NIOSH is developing appropriate standards and test procedures for PPE used to protect workers in hazardous environments. This development work includes the validation of performance-based PPE specifications including shelf life. Concepts, standards (when fully developed), and other documents will be posted when they become available. This development work involves international collaboration in PPE standards as well as with partners from government and industry.
Goal: To establish voluntary standards or 42 CFR certification programs for PPE.

One priority under this goal includes:

■ NIOSH issues recommendations for respirator use. Industrial type approvals are in accordance to the NIOSH federal respiratory regulations 42 CFR Part 84.

Pillar 3. Product Development and Evaluation

PPE such as respirators and protective clothing can be used to isolate workers from the hazard. PPE must not only be effective, but also practical for use in the workplace. PPE must be designed and made available to properly fit and protect the growing numbers of female, minority, and disabled workers. Microsensing devices assess workers’ exposure to environmental contaminants, notify workers before chemicals break through protective clothing, and identify failures in containment systems for hazardous materials. New materials in clothing would improve the protection of workers from burns, explosions, and hazardous chemicals. In addition to field surveys of chemical protective clothing (CPC) performance, studies need to examine ways to detect when chemicals have gotten inside CPC, and how to effectively remove chemicals from protective clothing after it has been contaminated. PPE research includes literature searches and data gathering, laboratory and field studies, and materials, shelf-life and design evaluations.

Goal: To incorporate advanced protective technologies into fully-integrated, intelligent, and reliable ensembles.

Goal: To collaborate with partners in the development of PPE to protect workers from high risk, frequency and/or severity hazards.

Priorities under this goal include:

■ Continuation of ongoing research, e.g., hearing protectors, respirators, protective clothing, eye protection.

■ Investigation and evaluation of PPE emerging into the marketplace, e.g., barrier creams, extra-skeletal braces, personal detection monitors, armor, high friction footwear and gloves, personal restraints.

■ Investigation of test methods for PPE effectiveness for different anthropomorphic characteristics.

■ Evaluation of optimal PPE systems that not only protect the worker but remove barriers to effective use, e.g., discomfort or cumbersomeness, communication needs, non-productive downtime.

Pillar 4. Education, Training, and Feedback

The purpose of training and training-related research is to understand and act on the multiple factors influencing occupational education and training effectiveness. NIOSH evaluates the
impact of training programs and their components by investigating theoretical models gleaned from health promotion, psychology, learning and educational perspectives, the role of attitudes, beliefs, behavioral intentions, and other characteristics of the individual that affect learning and transfer of learning into action, barriers affecting adoption of health and safety behaviors promoted by training, and environmental influences on occupational safety and health training.

**Goal:** To improve and implement PPE training programs, guidelines, and products for optimum use and acceptance by workers.
Appendix 1: Construction Subsector Descriptions

236 Construction of Buildings

This subsector comprises establishments primarily responsible for the construction of buildings. The work performed may include new work, additions, alterations, or maintenance and repairs. The on-site assembly of precut, panelized, and prefabricated buildings and construction of temporary buildings are included in this subsector. Part or all of the production work for which the establishments in this sector have responsibility may be subcontracted to other construction establishments usually specialty trade contractors.

237 Heavy and Civil Engineering Construction

This subsector comprises establishments whose primary activity is the construction of entire engineering projects (e.g., highways and dams), and specialty trade contractors, whose primary activity is the production of a specific component for such projects. Specialty trade contractors in Heavy and Civil Engineering Construction generally are performing activities that are specific to heavy and civil engineering construction projects and are not normally performed on buildings. The work performed may include new work, additions, alterations, or maintenance and repairs. Specialty trade activities are classified in this subsector if the skills and equipment present are specific to heavy or civil engineering construction projects. For example, specialized equipment is needed to paint lines on highways. This equipment is not normally used in building applications so the activity is classified in this subsector. Traffic signal installation, while specific to highways, uses much of the same skills and equipment that are needed for electrical work in building projects and is therefore classified in Subsector 238, Specialty Trade Contractors. Construction projects involving water resources (e.g., dredging and land drainage) and projects involving open space improvement (e.g., parks and trails) are included in this subsector. Establishments whose primary activity is the subdivision of land into individual building lots usually perform various additional site-improvement activities (e.g., road building and utility line installation) and are included in this subsector.

238 Specialty Trade Contractors

This subsector comprises establishments whose primary activity is performing specific activities (e.g., pouring concrete, site preparation, plumbing, painting, and electrical work) involved in building construction or other activities that are similar for all types of construction but that are not responsible for the entire project. The work performed may include new work, additions, alterations, maintenance, and repairs. The production work performed by establishments in this subsector is usually subcontracted from establishments of the general contractor type or operative builders but, especially in remodeling and repair construction; work also may be done directly for the owner of the property. Specialty trade contractors usually perform most of their work at the construction site, although they may have shops where they perform prefabrication and other work. Establishments primarily engaged in preparing sites for new construction are also included in this subsector. There are substantial differences in types of equipment, work force skills, and other inputs required by specialty trade contractors. Establishments in this...
subsector are classified based on the underlying production function for the specialty trade in
which they specialize. Throughout the Specialty Trade Contractors subsector, establishments
commonly provide both the parts and labor required to complete work. For example, electrical
contractors supply the current-carrying and noncurrent-carrying wiring devices that are required
to install a circuit. Plumbing, Heating and Air-Conditioning contractors also supply the parts
required to complete a contract.
## Appendix 2: Common Occupational Diseases among Construction Workers

<table>
<thead>
<tr>
<th>Job Title</th>
<th>Hazardous Job Task (Associated Disease)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulator</td>
<td>Installed insulation before 1975 (COPD, asbestosis) Remove insulation installed before 1975 (COPD, asbestosis) Work with glue solvents (acute solvent syndrome) Use n-hexane as glue solvent (peripheral neuropathy after prolonged high exposure) Use epoxy or isocyanate sealants, adhesives or foams (COPD, ACD, OA) Spraying Portland cement products such as fireproofing, gunite, or shotcrete (COPD, ACD, mild ICD, ICD, alkaline burns)</td>
</tr>
<tr>
<td>Roofer</td>
<td>Installed insulation before 1975 (COPD, asbestosis) Remove insulation installed before 1975 (COPD, asbestosis) Apply asphalt to cables, pipes or roofs (photodermatitis) Clean up equipment with solvents (acute solvent syndrome) Install or remove lead roofing (lead poisoning) Machine or sand allergenic wood (ACD, OA) Use epoxy or isocyanate sealants, adhesives or foams (ACD, OA)</td>
</tr>
<tr>
<td>Brick, block and stone mason</td>
<td>Installed insulation before 1975 (COPD, asbestosis) Remove insulation installed before 1975 (COPD, asbestosis) Mix &amp; lay cement or concrete (COPD, ACD) Grind or cut tiles, stones, bricks or terrazzo (silicosis) Sandblast (silicosis) Wear rubber gloves (ACD) Mixing and spreading grout (COPD, ACD, mild ICD, ICD, alkaline burns) Using mortar to set brick, cinder block, and other masonry (COPD, ACD, mild ICD, ICD, alkaline burns) Pouring, leveling, smoothing, and finishing concrete (ACD, mild ICD, ICD, alkaline burns) Grinding of finished concrete, which releases cement dust (ACD, mild ICD, ICD, alkaline burns) Tending concrete pour and hosing out ready mixed con, mixer, and chute (ACD, mild ICD, ICD, alkaline burns)</td>
</tr>
<tr>
<td>Concrete or terrazzo worker</td>
<td>Mix and lay cement or concrete (COPD, ACD) Grind or cut tiles, stones, bricks or terrazzo (silicosis) Wear rubber gloves (ACD) Use epoxy or isocyanate sealants, adhesives or foams (COPD, ACD, OA) Preparing cement underlayer for terrazzo (COPD, ACD, mild ICD, ICD, alkaline burns) Grinding of finished concrete, which releases cement dust (COPD, ACD, mild ICD, ICD, alkaline burns)</td>
</tr>
<tr>
<td>Carpenter</td>
<td>Installed insulation before 1975 (COPD, asbestosis) Remove insulation installed before 1975 (COPD, asbestosis) Work with glue solvents (acute solvent syndrome) Use n-hexane as glue solvent (peripheral neuropathy) Use epoxy, acrylate, isocyanate, or formaldehyde-resin adhesives (ACD, OA) Machine or sand allergenic wood (COPD, ACD, OA) Remove old paint (lead poisoning) Paint, oil-based (acute solvent syndrome) Paint, water-based (ACD)</td>
</tr>
</tbody>
</table>

53. [http://www.haz-map.com/jobtasks.htm](http://www.haz-map.com/jobtasks.htm)
55. [http://www.cdc.gov/elcosh/docs/d0400/d000458/d000458.html](http://www.cdc.gov/elcosh/docs/d0400/d000458/d000458.html)
**Construction, industrial or maintenance painter**
- Paint, 2 part epoxy or urethane (ACD, OA)
- Clean up equipment with solvents (acute solvent syndrome)
- Machine or sand creosote treated wood (photodermatitis)
- Dismantling formwork contaminated by Portland cement (COPD, ACD, mild ICD, ICD, alkaline burns)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Associated Diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandblast</td>
<td>COPD, COPD, silicosis</td>
</tr>
<tr>
<td>Surface preparation of cadmium alloy</td>
<td>cadmium poisoning</td>
</tr>
<tr>
<td>Surface preparation of beryllium alloy</td>
<td>beryllium disease</td>
</tr>
<tr>
<td>Remove old paint</td>
<td>lead poisoning</td>
</tr>
<tr>
<td>Paint, oil-based</td>
<td>COPD, acute solvent syndrome</td>
</tr>
<tr>
<td>Painted with oil-based paints with heavy exposure to solvents for more than 10 to 20 years</td>
<td>chronic toxic encephalopathy</td>
</tr>
<tr>
<td>Paint, water-based</td>
<td>ACD</td>
</tr>
<tr>
<td>Paint, 2-part epoxy or urethane</td>
<td>COPD, ACD, OA</td>
</tr>
<tr>
<td>Spray paint, chromium, nickel &amp; cobalt pigments</td>
<td>ACD, OA</td>
</tr>
<tr>
<td>Spray paint, lead-based</td>
<td>lead poisoning</td>
</tr>
<tr>
<td>Clean up equipment with solvents</td>
<td>acute solvent syndrome</td>
</tr>
</tbody>
</table>

**Electrician/repairer of transformers, electrical, or electronic equipment**
- Remove insulation installed before 1975 (asbestosis)
- Degrease metal (acute solvent syndrome)
- Solder or braze (ACD, OA)
- Braze using cadmium-based solder (cadmium poisoning)
- Remove or replace PCB contaminated fluid in transformers (chloracne)
- Splice electrical cable using lead (lead poisoning)
- Use epoxy or isocyanate sealants, adhesives or foams (COPD, ACD, OA)

**Plumber, pipe fitter, or steamfitter**
- Installed insulation before 1975 (COPD, asbestosis)
- Remove insulation installed before 1975 (COPD, asbestosis)
- Degrease metal (acute solvent syndrome)
- Work with glue solvents (acute solvent syndrome)
- Apply asphalt to cables, pipes or roofs (photoirritant dermatitis)
- Wear rubber gloves (ACD)
- Solder or braze (ACD, OA)
- Braze using cadmium-based solder (cadmium poisoning)
- Repair or remove water lines or cast iron soil pipes (lead poisoning)
- Clean up equipment with solvents (acute solvent syndrome)
- Weld (see associated diseases for welder)

**Sheet metal worker**
- Installed insulation before 1975 (COPD, asbestosis)
- Remove insulation installed before 1975 (COPD, asbestosis)
- Machine metal (ACD, OA, HP)
- Machine lead (lead poisoning)
- Degrease metal (acute solvent syndrome)
- Solder or braze (ACD, OA)
- Braze using cadmium-based solder (cadmium poisoning)
- Forge metal (carbon monoxide poisoning)
- Weld (COPD, see associated diseases for welder)

**Welder, cutter, or burner**
- Installed insulation before 1975 (COPD, asbestosis)
- Remove insulation installed before 1975 (asbestosis)
- Degrease metal (acute solvent syndrome)
- Prepare surface of cadmium alloy (cadmium poisoning)
- Prepare surface of beryllium alloy (beryllium disease)
- Remove old paint (lead poisoning)
- Solder or braze (ACD, OA)
- Braze using cadmium-based solder (cadmium poisoning)
- Gas or arc weld, cut or burn, metal fume fever
- Arc weld stainless steel (OA) carbon monoxide poisoning, acute inhalation injury, siderosis,
<table>
<thead>
<tr>
<th>Heating and air conditioning installer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installed insulation before 1975 (COPD, asbestosis)</td>
</tr>
<tr>
<td>Remove insulation installed before 1975 (COPD, asbestosis)</td>
</tr>
<tr>
<td>Braze using cadmium-based solder (cadmium poisoning)</td>
</tr>
<tr>
<td>Degrease metal (acute solvent syndrome)</td>
</tr>
<tr>
<td>Solder or braze (ACD, OA)</td>
</tr>
<tr>
<td>Weld (see associated diseases for welder)</td>
</tr>
<tr>
<td>Use epoxy or isocyanate sealants, adhesives or foams (COPD, ACD, OA)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dry wall taper, plasterer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before 1975, mixed, sprayed or sanded drywall compound, fireproofing plaster or acoustical cement (COPD, asbestosis) mixing and applying plaster, stucco, and EIFS (COPD, ACD, mild ICD, ICD, alkaline burns)</td>
</tr>
</tbody>
</table>

ACD = allergic contact dermatitis; COPD = chronic obstructive pulmonary disease; mild ICD = dry skin or irritation; ICD = irritant contact dermatitis; OA = occupational asthma; HP = hypersensitivity pneumonitis.
Appendix 3: Applicable Standards and Standards Setting Organizations

**U.S. Department of Human Services**

NIOSH

42 CFR PART 84, Approval of respiratory protective devices

**U.S. Department of Labor (DOL)**

Occupational Safety and Health Administration

29 CFR 1910 – Safety and Health Regulations for General Industry

1910.138 Hand Protective Standard

29 CFR 1926 – Safety and Health Regulations for Construction

1926 Subpart C - General Safety and Health Provisions

1926.28 - Personal protective equipment.

1926.62 App D - Qualitative and Quantitative Fit Test Protocols (lead)

1926.65 App A - Personal Protective Equipment Test Methods (hazardous waste, emergency response)

1926 Subpart E -- Personal Protective and Life Saving Equipment

1926.95 - Criteria for personal protective equipment.

1926.96 - Occupational foot protection.

1926.100 - Head protection.

1926.101 - Hearing protection.

1926.102 - Eye and face protection.

1926.103 - Respiratory protection.

1926.104 - Safety belts, lifelines, and lanyards.

1926.105 - Safety nets.

1926.106 - Working over or near water.

1926.107 - Definitions applicable to this subpart.

1926 Subpart L App B -- Criteria for Determining the Feasibility of Providing Safe Access and Fall Protection for Scaffold Erectors and Dismantlers

1926 Subpart M App C - Personal Fall Arrest Systems - Non-Mandatory Guidelines for Complying with

1926.502(d)

1926.500 – Scope, application, and definitions applicable to this subpart

1926.501 – Duty to have fall protection

1926.502 – Fall protection system criteria and practices

1926.503 – Training Requirements

1926.760 - Fall protection.


1926.959 - Lineman's body belts, safety straps, and lanyards.

1926.800(g)(2) – Self-rescuers

1926.1127 App C - Qualitative and Quantitative Fit Testing Procedures (cadmium)

1926.1101 (h), (i) Asbestos – Respiratory protection, Protective clothing

**U.S. Environmental Protection Agency**

40 CFR 211 hearing protector label requirements

**U.S. Army Corps of Engineers**

EM 385-1-1, Safety - Safety and Health Requirements

Section 5 - Personal Protective and Safety Equipment

**American National Standards Institute**

ANSI Z88.7-2001, Color Coding of Air-Purifying Respirator Canisters, Cartridges, and Filters

ANSI Z88.10-2001, Respirator Fit Testing Methods

ANSI Z 88.2-1969, Standard Practice for Respirator Protection
ANSI Z41.1-1991, Protective Footwear
ANSI S12.6-1997, Methods for Measuring the Real-Ear Attenuation of Hearing Protectors
ANSI Z87.1-2003, Standard for Occupational and Educational Eye and Face Protection Devices
ANSI Z49.1:2005, Safety in Welding and Cutting
ANSI Z359.1-1992, Safety Requirements for Personal Fall Arrest Systems, Sub-Systems and Components
ANSI Z98.1, Safety Requirements for Industrial Head Protection
ANSI Z98.2, Safety Requirements for Industrial Protective Helmets for Electrical Workers
ANSI Z136.1, Laser Safety Standards
ANSI J6.6-1971, Rubber Insulating Gloves
ANSI/ASSE Z359.1, Safety Requirements for Personal Fall Arrest Systems
ANSI/ISEA 105-2005, Hand Protection Selection Criteria
American Society for Testing Materials
ASTM F23 Protective Clothing
ASTM F955 Standard Test Method for Evaluating Heat Transfer through Materials for Protective Clothing upon Contact with Molten Substances
ASTM F739-99a, Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases under Conditions of Continuous Contact
ASTM F1383-96, Standard Test Method for Resistance of Protective Clothing Materials to Permeation by Liquids or Gases under Conditions of Intermittent Contact
International Organization for Standardization
ISO 13.340.01 Protective equipment in general
ISO 13.340.10 Protective clothing, Including flameproof clothing
ISO 13.340.20 Head protective equipment, Including helmets, eye-protectors, hearing protectors, ear muffs, teeth protectors and hoods.
ISO 13.340.30 Respiratory protective devices
ISO 13.340.40 Hand and arm protection, Including protective gloves, sleeves and mits
ISO 13.340.50 Leg and foot protection, Including safety boots and shoes
ISO 13.340.60 Protection against falling and slipping, Including safety ropes, harnesses and fall arrestors
ISO 13.340.99 Other protective equipment
ISO 3873:1977 Industrial safety helmets
ISO 4007:1977 Personal eye-protectors, Vocabulary
ISO 4849:1981 Personal eye-protectors, Specifications
ISO 4850:1979 Personal eye-protectors, Synoptic tables of requirements for oculars and eye-protectors
ISO 4869-1:1990 Acoustics, Hearing protectors, Part 1: Subjective method for the measurement of sound attenuation
ISO 4869-2:1994 Acoustics, Hearing protectors, Part 2: Estimation of effective A-weighted sound pressure levels when hearing protectors are worn
ISO 6161:1981 Personal eye-protectors, Filters and eye-protectors against laser radiation
ISO 8194:1987 Radiation protection, clothing for protection against radioactive contamination, design, selection, testing and use

*American Conference of Governmental Industrial Hygienists*
Guidelines for Selection of Chemical Protective Clothing, 1987
A Guide for Control of Laser Hazards, 1990

*National Fire Protection Association*
NFPA 70E Standard for electrical safety requirements for employee workplace
NFPA 2112 Standard on flame-resistant garments for protection of industrial personnel against flash fire