Prevention through Design in OSH

National Electrical Contractors Association (NECA)
3rd Annual NECA Safety Professionals Conference
Chicago, Illinois
National Institute for Occupational Safety and Health (NIOSH)
Christine M. Branche, Ph.D., FACE
May 20, 2014
Overview

Background information on NIOSH
Construction Safety and Health Program
Electrical Safety
Green Construction
Prevention through Design

The findings and conclusions in this presentation have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy.
To assure safe and healthful working conditions for working men and women

Occupational Safety and Health Act of 1970 (PL 91-596) created OSHA and NIOSH
Organizational Chart of Federal Entities for Occupational Safety and Health

**Regulation and Enforcement:**
Department of Labor (DOL)
  ➔ Mine Safety and Health Administration (MSHA)
  ➔ Occupational Safety and Health Administration (OSHA)

**Research and Prevention Recommendations:**
Department of Health and Human Services (HHS)
  ➔ Centers for Disease Control and Prevention (CDC)
  ➔ National Institute for Occupational Safety and Health (NIOSH)
The sole federal government organization charged with conducting occupational safety and health research
Mission - NIOSH Construction Program

“Provide … leadership to prevent work-related illness, injury, disability, and death by … gathering information, conducting … research, and translating the knowledge gained into products, solutions, and services tailored to meet construction needs.”
Program Structure and Focus Areas

NIOSH Construction Safety and Health Program

- Intramural Research
- National Construction Center
- Extramural Investigator-initiated Grants
Ladder Safety Application for Smart Phones

Peter Simeonov, DSR and team

Developed APP to quickly and easily position extension ladder at correct angle

Graphic-oriented aid

Inclination indicator

75.5°
FATALITY ASSESSMENT AND CONTROL EVALUATION (FACE) PROGRAM

Each day, between 12 to 13 U.S. workers die as a result of a traumatic injury on the job. Investigations conducted through the FACE program allow the identification of factors that contribute to these fatal injuries. This information is used to develop comprehensive recommendations for preventing similar deaths. This web page provides access to NIOSH investigation reports and other safety resources.

Fatality Investigation Reports Indexed by Program

NIOSH FACE Reports  State FACE Reports

Search FACE Reports

Contact FACE

Nancy Romano, M.S., CSHM
FACE Project Officer
Fatality Investigations Team
Division of Safety Research
NIOSH
ndr4@cdc.gov

Contact Us:
National Institute for Occupational Safety
NIOSH
FACE includes NIOSH & STATE reports

An Electrical Worker Dies When He Falls Through a Skylight While Installing Solar Panels on the Roof of a Warehouse

California Case Report: 09CA003

Summary

AA 46-year-old electrical worker died when he fell through a skylight on a roof while installing solar panels. The victim was carrying solar panels and walking backwards because of the limited space. Walking backwards, he tripped on the raised edge of the skylight and fell approximately 40 feet to the ground below. The skylight glazing (the transparent portion of the skylight) fell in accordance with OSHA fall protection standards, there are concrete material strength to withstand worker impact. In order to prevent future incidents, employers of workers should institute a fall protection program to prevent falls through skylights.

Exhibit 3. The skylight the victim fell through.

FACE reports are very useful for training and toolbox talks
Encouraging more “Digital Story” Videos

As the use of solar energy continues to grow in California and the U.S., an increasing number of solar installation workers are exposed to fall hazards that can cause injury or death.
I worked construction for 10 years before my fall. It shattered my body and my livelihood.

Work safely. Use the right equipment.

FALLS FROM LADDERS, SCAFFOLDS AND ROOFS CAN BE PREVENTED!

PLAN ahead to get the job done safely.
PROVIDE the right equipment.
TRAIN everyone to use the equipment safely.

www.osha.gov/stopfalls.gov

1 (800) 321-OSHA (6742) • TTY 1-877-889-5627
Web Addresses

Main campaign website (CPWR—The Center for Construction Research and Training) http://www.stopconstructionfalls.com

Campaign posters and fact sheets
http://www.cdc.gov/niosh/construction/stopfalls.html
http://www.osha.gov/stopfalls/

NIOSH Science blog http://blogs.cdc.gov/niosh-science-blog/
Fatality Assessment and Control Evaluation Program (FACE) reports http://www.cdc.gov/niosh/face/

To become a campaign partner: email falls@cpwr.com
https://www.osha.gov/StopFallsStandDown/index.html

- Participate in the stand-down
- Help raise awareness among workers and employers about fall hazards
- New resources
- Formal recognition, “Certificate of Participation”
Construction Safety Culture and Safety Climate

June 11-12, 2013 Workshop

Safety Culture and Safety Climate in Construction: Bridging the Gap Between Research and Practice

CONSTRUCTION

Construction workers and employers build our roads, houses, and workplaces and repair and maintain our nation’s physical infrastructure. Construction includes building new structures, renovations involving additions, alterations, or maintenance, and repair of buildings or engineering projects such as highways or utility systems. The NIOSH Construction Program provides national and world leadership to prevent work-related illness, injury, disability, and death by systematically gathering information, conducting targeted research and translating the knowledge gained into products, solutions, and services tailored to meet construction needs. In collaboration with industry and labor partners and stakeholders, including OSHA, we are dedicated to improving safety and health conditions for all construction workers.

In 2011, there were 774 fatal on-the-job injuries to workers in the construction industry — more than in any other industry sector and representing 17% of all work-related deaths in the U.S. that year. Construction is a large, dynamic, and complex industry sector, putting nearly $600 billion of construction in place in 2011. Construction workforces are organizationally complex multi-employer sites and present numerous health and safety challenges.

**Spotlights**
- Nail Gun Safety: A Guide for Construction Contractors — (Spanish) Seguridad con las pistolas de clavos
- Fall Safety: Falls Cost Campaign to Prevent Construction Falls
- New on NIOSH FACE: Search Residential and Commercial Construction Falls
- Follow us @NIOSHConstruct on Twitter

NIOSH Construction Program on Twitter
@NIOSHConstruct
Preventing Worker Deaths from Uncontrolled Release of Electrical, Mechanical, and Other Types of Hazardous Energy

**WARNING!**

Workers who install or service equipment and systems may be injured or killed by the uncontrolled release of hazardous energy.

Take the following steps to protect yourself if you install or service equipment and systems:

1. **Identify all sources of hazardous energy.**
2. **Before beginning work, do the following:**
   - De-energize all sources of hazardous energy.
   - Lockout or tagout energy sources or circuits.
   - Block fluid pipes or liquid flow in hydraulic or pneumatic systems.
   - Block machine parts against rotation.
   - Block or disconnect sources of electrical energy.
   - Disable or lockout equipment.
   - Release or block springs that are under compression or tension.
   - Vent fluids from pressure vessels, tanks, or accumulators—be aware of trapped energy, flammable, or explosive substances directly into the atmos-
   - Lockout and tagout all forms of hazardous energy—excluding electrical breaker panels, control valves, etc.

5. Verify by test and observation that all energy sources are de-energized.
6. Perform work before removing your lock and/or disconnect.
7. Make sure that you and your co-workers are aware of the hazards before re-energizing the system.
8. Participate in all training programs offered by your employer.

For more on this and other topics: http://www.cdc.gov/niosh/construction/
15 Strategic goals on top construction problems

- Steer research to problems
- Go for IMPACT
- Sector-based solutions

http://www.cdc.gov/niosh/nora/comment/agendas/construction
NORA Electrical Safety Goals

Goal 2.1 - Investigate ways to improve power line proximity warning alarms to protect operators of mobile vehicles, cranes, and nearby construction workers.

Goal 2.2 - Investigate ways to protect construction workers from electrocution hazards involving power line contact through hand-carried metallic objects and vehicle-related contacts.

Goal 2.3 - Investigate ways to protect construction workers from contact with live electrical wiring and components by studying electrical installation, maintenance, and repair tasks and recommending ways to improve work practices, techniques, and tools.
Goal 2.3.1 - Identify workers, tasks, and risk factors associated with the greatest risk for electrocution involving common electrical and non-electrical installation, maintenance, and repair tasks.

Goal 2.3.2 - Evaluate why electrical workers believe they need to work on energized equipment vs. de-energized equipment. Use human factors approaches to identify root causes and evaluate worker awareness of risks and precautions associated with “live” work.

Goal 2.3.3 - Identify and evaluate interventions to address risk factors associated with the groups and tasks most at risk.
National Construction Center

The Construction Chart Book
The U.S. Construction Industry and its Workers

HAZARD ALERT
SILICA

Are you in danger?

Silica can be found in many building materials, including:
- concrete
- mortar
- brick
- and some paints

If you are working with these materials, you may be exposed to silica dust.

Why it’s deadly

Exposure to silica dust can lead to serious health problems, including:
- respiratory disease
- lung cancer
- and other serious health problems.

Protect Yourself: Three Methods

1. Use Water

Wet the dust to minimize exposure.

2. Use a Vacuum

Use a vacuum to contain dust and remove it from the area.

Find out more about construction hazards.

Call 301-978-8500

Elcosh
Electronic Library of Construction
Occupational Safety & Health

ZANJAS

¿Estoy en peligro?

Si se basa en una zona que ...
- tiene arena
- tiene cemento
- tiene preparación con una tela especial

¿Cómo puedo protegerme?

Llame al 301-978-8500

Antes de entrar...

1. Busque a la persona competente

2. Trabaja solo en áreas protegidas

3. Verifique su escape

Informes más sobre los peligros en la construcción.

Llámenos al 301-978-8500

NIOSH
National Institute for Occupational Safety and Health

CDC
Centers for Disease Control and Prevention
## Rate of fatalities, selected construction occupations, 2008-2010 average, (All employment)

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Deaths per 100,000 FTEs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power-line installer</td>
<td>56.5</td>
</tr>
<tr>
<td>Ironworker</td>
<td>37.8</td>
</tr>
<tr>
<td>Roofer</td>
<td>32.9</td>
</tr>
<tr>
<td>Truck driver</td>
<td>22.8</td>
</tr>
<tr>
<td>Welder</td>
<td>21.4</td>
</tr>
<tr>
<td>Laborer</td>
<td>17.4</td>
</tr>
<tr>
<td>Foreman</td>
<td>14.6</td>
</tr>
<tr>
<td>Helper</td>
<td>14.3</td>
</tr>
<tr>
<td>Operating engineer</td>
<td>14.3</td>
</tr>
<tr>
<td>Electrician</td>
<td>10.1</td>
</tr>
<tr>
<td>Brickmason</td>
<td>8.8</td>
</tr>
<tr>
<td>Plumber</td>
<td>8.3</td>
</tr>
<tr>
<td>Painter</td>
<td>7.6</td>
</tr>
<tr>
<td>Heat A/C mech</td>
<td>6.3</td>
</tr>
<tr>
<td>Carpenter</td>
<td>6.3</td>
</tr>
<tr>
<td>Drywall</td>
<td>3.8</td>
</tr>
<tr>
<td>Construction manager</td>
<td>3.5</td>
</tr>
<tr>
<td>All construction</td>
<td>9.6</td>
</tr>
</tbody>
</table>

This research was conducted with restricted access to Bureau of Labor Statistics (BLS) data. The views expressed here do not necessarily reflect the views of the BLS.
Number and rate of electrocution deaths in construction, 1992-2010, (All employment)

This research was conducted with restricted access to Bureau of Labor Statistics (BLS) data. The views expressed here do not necessarily reflect the views of the BLS.
### Number of electrocution deaths in construction, selected construction occupations, 2008-2010 total (All employment)

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Number of deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrician</td>
<td>69</td>
</tr>
<tr>
<td>Laborer</td>
<td>41</td>
</tr>
<tr>
<td>Foreman</td>
<td>22</td>
</tr>
<tr>
<td>Power-line installer</td>
<td>17</td>
</tr>
<tr>
<td>Roofer</td>
<td>17</td>
</tr>
<tr>
<td>Heating</td>
<td>14</td>
</tr>
<tr>
<td>Painter</td>
<td>13</td>
</tr>
<tr>
<td>Plumber</td>
<td>13</td>
</tr>
<tr>
<td>Carpenter</td>
<td>9</td>
</tr>
</tbody>
</table>

This research was conducted with restricted access to Bureau of Labor Statistics (BLS) data. The views expressed here do not necessarily reflect the views of the BLS.
Overhead power-line electrocution deaths, by construction occupation, 2008-2010 total, (All employment)

Total = 119 deaths

- Construction laborer (23%)
- Electrical worker (19%)
- Foreman/manager (13%)
- Roofer (13%)
- Painter (9%)
- Carpenter (5%)
- Other trades (18%)

This research was conducted with restricted access to Bureau of Labor Statistics (BLS) data. The views expressed here do not necessarily reflect the views of the BLS.
“Between 2008 and 2010, the main cause of electrocution deaths among electrical workers was contact with "live" (energized) electrical equipment and wiring (57.5%; chart 45d). This suggests that many electrocution deaths could have been avoided if the electrical circuits and equipment were de-energized, locked out, or tagged out before a worker began working on them.”

Fatalities from Contact with Electricity in Construction, p 45 Construction Chart Book
Green Building on the Rise

- 76% of Architects
- 66% of Contractors
- 51% of Subcontractors

... believe that green construction will be the norm for their trade or profession by 2016

Is Green Construction Better?
Not Always
Las Vegas CityCenter—The Wake Up Call

Development wins 6 coveted design certifications (Las Vegas, NV)
- More than three months before it opens, the $8.5 billion CityCenter development has received six Leadership in Energy and Environment Design (LEED) gold certifications from the U.S. Green Building Council....(Las Vegas Review Journal, September 14, 2009)

Six deaths during 2007-2008 construction phase
(Las Vegas, NV) - MGM Mirage’s CityCenter
“As green and sustainable practices become more common in the U.S, there is an opportunity to promote worker safety and health as a fundamental dimension of true sustainability. …

A sustainable product, process or technology should not only protect the environment and the consumer but also the worker. Green jobs must be safe jobs.”

NIOSH Science Blog: Going Green: Safe and Healthy Jobs, January 4, 2010
IDEA: Integrate Safety & Health into Green Construction

- **GREEN** building is on the increase
- Rating systems (e.g. LEED) are driving best practices
- How do SAFETY and SUSTAINABILITY relate?

Target: Safety and Health community
US Green Building Council (USGBC)
Architects and Designers
Owners

**LEED** = Leadership in Energy and Environmental Design
It is common to assume that green building projects are inherently safer for workers…

EXAMPLE: “Attention to environmental issues during construction leads to a safer and healthier work site”
Los Alamos National Lab Sustainable Design Guide, p64

…and common to overlook safety and health

EXAMPLE: “There currently is a blind spot in sustainable design practice when it comes to worker safety and health… Tremendous focus is placed on materials, energy and the environment, but designers typically give little, if any, consideration to the safety and health of the people who install the green features or build the projects”

LEED includes some elements related to worker health and well-being

**Building Occupants**
Major LEED focus
Largest worker group – lowest risk

**Custodial Workers**
Minor LEED focus
Smaller worker group – medium risk

**Construction, Maintenance Workers**
Minor LEED focus
Smaller worker group → highest risk potential
What about Safety and Health?
## But What is Missing?

<table>
<thead>
<tr>
<th>Type of WORKER</th>
<th>HEALTH &amp; WELL-BEING</th>
<th>SAFETY</th>
<th>ERGONOMICS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of OUTCOME</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Building Occupant</strong></td>
<td>Illness</td>
<td>Injury</td>
<td>MSD Musculoskeletal Disorder</td>
</tr>
<tr>
<td>Major focus via IEQ credits</td>
<td>Not addressed</td>
<td>Pilot Credits</td>
<td></td>
</tr>
<tr>
<td>Custodial Worker</td>
<td>Minor focus</td>
<td>Not addressed</td>
<td>Minor focus</td>
</tr>
<tr>
<td>Operations, Maintenance (O&amp;M), and Construction Worker</td>
<td>Minor focus</td>
<td>Not addressed</td>
<td>Not addressed</td>
</tr>
</tbody>
</table>
Why Construction Workers?

Fatalities: 751 most of any industry
Injury rate: 203/10,000 non-fatal injuries and illnesses with days away from work

Why Maintenance Workers?

Fatalities: 226
Injury rate: 307/10,000 non-fatal injuries and illnesses with days away from work
NIOSH Construction Program and PtD

Supported the 2003 “Designing for Safety and Health in Construction” Symposium in Portland, Oregon
Mission: Design out hazards and minimize risks associated with:

- Facilities
- Work methods
- Processes
- Equipment
- Products & new technologies
Hierarchy of Controls

ELIMINATION
Design it out

SUBSTITUTION
Use something else

ENGINEERING CONTROLS
Isolation and guarding

ADMINISTRATIVE CONTROLS
Training and work scheduling

PERSONAL PROTECTIVE EQUIPMENT
Last resort

Per ANSI/AIHA Z10-2005
Personal Protective Equipment (PPE)

Last line of defense against injury

Examples:
- Hard hats
- Steel-toed boots
- Safety glasses
- Gloves
- Harnesses

OSHA [www.osha.gov/Publications/osha3151.html]
DESIGN MATTERS!
Example of the Need for PtD

Worker electrocuted when his drill rig got too close to overhead power lines.

Design engineer specified groundwater monitoring wells were to be dug directly under power lines.

Engineer could have specified wells be dug away from power lines, and/or better informed the employer of hazard posed by wells’ proximity to power lines through the plans, specifications, and bid documents.

Source: OSHA Construction Alliance Roundtable
Main finding: design contributes significantly to work-related serious injury.

37% of workplace fatalities are due to design-related issues.

In another 14% of fatalities, design-related issues may have played a role.

From Driscoll et al., 2008
Safety Payoff during Design

- Conceptual design
- Detailed design
- Procurement
- Construction
- Start-up

Ability to influence safety:
- High
- Low

Adapted from Szymberski 1997
PtD: The Basic Steps

- Identify potential hazards
- Evaluate risks
- Eliminate or reduce risks
- Communicate residual risks to downstream users
Servicing rooftop HVAC equipment

Fall exposures
“Error trap” for workers
Design issues?

No access
No power
No equipment setback from edge
No fall protection

HVAC= Heating, Ventilation, and Air Conditioning

Photo: Matt Gillen
PtD Process

- Establish PtD expectations
- Include construction and operation perspective
- Identify PtD process and tools

Design team meeting

- Owner
- Architect
- Project Manager
- Health & Safety Professional

• Trade contractor
• Health & Safety review

Design

- Quality Assurance/Quality Control
- Health & Safety review
- Value Engineering review

Internal review

- Focused Health & Safety review
- Owner review

External review

Issue for construction

- Owner review

Hecker et al. 2005
Why Prevention through Design?

Ethical reasons
Construction dangers
Design-related safety issues
Financial and non-financial benefits
Practical benefits
Ethical Reasons for PtD

National Society of Professional Engineers’ Code of Ethics and the American Society of Mechanical Engineers’ Code of Ethics clearly states:

“Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties."

NSPE [www.nspe.org/Ethics/CodeofEthics/index.html]
ASME [www.sections.asme.org/Colorado/ethics.html ]
Accidents in Construction Linked to Design

22% of 226 injuries linked partly to design, 2000-2002 study in Oregon, Washington, California

42% of 224 fatalities in U.S. during 1990-2003 linked to design

60% of fatal accidents resulted in part from decisions made before site work began, 1991 study in Europe

63% of all fatalities and injuries could be attributed to design decisions or lack of planning
## Integrating Occupational Safety and Health with the Design Process

<table>
<thead>
<tr>
<th>Stage</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptual design</td>
<td>Establish occupational safety and health goals, identify occupational hazards</td>
</tr>
<tr>
<td>Preliminary design</td>
<td>Eliminate hazards, if possible; substitute less hazardous agents/processes; establish risk minimization targets for remaining hazards; assess risk; and develop risk control alternatives. Write project specifications.</td>
</tr>
<tr>
<td>Detailed design</td>
<td>Select controls; conduct process hazard reviews</td>
</tr>
<tr>
<td>Procurement</td>
<td>Develop equipment specifications and include in procurements; develop “checks and tests” for factory acceptance testing and commissioning</td>
</tr>
<tr>
<td>Construction</td>
<td>Ensure construction site safety and contractor safety</td>
</tr>
<tr>
<td>Commissioning</td>
<td>Conduct “checks and tests,” including factory acceptance; pre–start up safety reviews; development of standard operating procedures (SOPs); risk/exposure assessment; and management of residual risks</td>
</tr>
<tr>
<td>Start up and occupancy</td>
<td>Educate; manage changes; modify SOPs</td>
</tr>
</tbody>
</table>
PtD Process Tasks

Perform a hazard analysis
Incorporate safety into the design documents
Make a CAD (BIM) model for member labeling and erection sequencing

Photo courtesy of Thinkstock

Adapted from Toole 2005; Hinze and Wiegand 1992
Designer Tools

Checklists for construction safety [Main and Ward 1992]


Construction safety tools from the UK or Australia
  – Construction Hazard Assessment Implication Review, known as CHAIR [NOHSC 2001]
# Example Checklist

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td><strong>Structural Framing</strong></td>
</tr>
<tr>
<td>1.1</td>
<td>Space slab and mat foundation top reinforcing steel at no more than 6 inches on center each way to provide a safe walking surface.</td>
</tr>
<tr>
<td>1.2</td>
<td>Design floor perimeter beams and beams above floor openings to support lanyards.</td>
</tr>
<tr>
<td>1.3</td>
<td>Design steel columns with holes at 21 and 42 inches above the floor level to support guardrail cables.</td>
</tr>
<tr>
<td>2.0</td>
<td><strong>Accessibility</strong></td>
</tr>
<tr>
<td>2.1</td>
<td>Provide adequate access to all valves and controls.</td>
</tr>
<tr>
<td>2.2</td>
<td>Orient equipment and controls so that they do not obstruct walkways and work areas.</td>
</tr>
<tr>
<td>2.3</td>
<td>Locate shutoff valves and switches in sight of the equipment which they control.</td>
</tr>
<tr>
<td>2.4</td>
<td>Provide adequate head room for access to equipment, electrical panels, and storage areas.</td>
</tr>
<tr>
<td>2.5</td>
<td>Design welded connections such that the weld locations can be safely accessed.</td>
</tr>
</tbody>
</table>

Checklist courtesy of John Gambatese
Construction and Maintenance workers play key roles in the built environment “Life Cycle”

“Life Cycle Safety”

Green building is oriented towards “Life Cycle” thinking
Closer look: Construction Life Cycle

1. RAW MATERIALS
2. MANUFACTURING
3. WASTE
4. TRANSPORTATION
5. USE
6. MAINTENANCE
7. DISPOSAL
8. LANDFILL

Construction workers

Construction workers

Construction workers

Construction & Maintenance workers
Life Cycle Safety: What do we Mean?

... to comprehensively address building-related OSH risks for all affected worker groups across all life cycle stages.
Life Cycle Safety =

Life Cycle Assessment
Thinking

Job Hazard Analysis
Thinking

Prevention through Design
Thinking

Comprehensively looking at risks affecting all building stages
Life Cycle Assessment: Basic Steps

1: Goal definition and scoping
Define product or activity and identify boundaries

2: Inventory analysis
Identify and quantify energy and material inputs and environmental releases

3: Impact assessment
Assess human and ecological effects

4: Interpretation
Evaluate and select preferred product or activity

From: EPA LCA101 "Life Cycle Assessment: Principles and Practice"
## Life Cycle Safety Review

<table>
<thead>
<tr>
<th>STAGE</th>
<th>GROUP</th>
<th>KEY TASKS</th>
<th>HAZARDS/RISKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation</td>
<td>Construction -Electricians</td>
<td>-Moving panels and supplies to roof</td>
<td>-Cranes/rigging</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Installing panels and wiring</td>
<td>-Falls from ladder</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-Falls from roof</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-Material handling</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-Electric shock</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Maintenance -In house or</td>
<td>-Replace/repair broken panels</td>
<td>-Falls from roof</td>
</tr>
<tr>
<td></td>
<td>electricians</td>
<td>-Clean panels</td>
<td>-Electric shock</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Inspection</td>
<td></td>
</tr>
<tr>
<td>Recycle and replace</td>
<td>Construction -Electricians</td>
<td>-Removal of panels after 25 year life span</td>
<td>-Cranes/rigging</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Moving new panels to roof</td>
<td>-Falls from ladder</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Installing new panels and wiring</td>
<td>-Falls from roof</td>
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<tr>
<td></td>
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</tr>
</tbody>
</table>
PtD: A Good Strategy for the Electrical Industry

- Innovative industry
- Technology-oriented
- History of design-related changes
- Has industry mechanisms for developing standards, e.g., NEC
1910.304 and 1926.404
“Wiring design and protection”

Includes specific clearance distances needed for power conductors
Design of Equipment

“Much can be done to improve operational safety by the careful design and selection of electrical equipment…Circuits and equipment should be installed so that all sections of the system can be isolated as necessary…

Switch disconnectors should be suitably located and arranged so that circuits and equipment can be isolated without disconnecting other circuits that are required to continue in service…

Control panels should be designed with insulated conductors and shrouded terminals so that commissioning tests, fault-finding, calibration, etc can be carried out with a minimum of risk.”

Electricity at Work: Safe working practices, UK Health and Safety Executive, p 6
http://www.hse.gov.uk/pubns/books/hsg85.htm
Design of Installations

The Basics:
- Adequate space
- Access
- Lighting
Design of Installations

How can the installation:

- Provide flexibility for future modifications?
- Provide a lower category of arc flash exposures?
- Provide isolation flexibility to reduce the need to work live?
Clients Likely to be Interested in PtD

Industrial clients where shut downs are expensive

Hospitals

Lab facilities

Security and emergency response operations

Emerging areas:
- Smart Grid
- Microgeneration
Realities and Barriers

Safety and health professionals are not designers

Architects and engineers do not always have safety in mind

There are costs

There are concerns about liabilities

A collaborative effort is needed to accomplish PtD → a “safety design review”
Business Value of PtD

Anticipate worker exposures—be proactive

Align health and safety goals with business goals

Modify designs to reduce and eliminate workplace hazards in

- Facilities
- Equipment
- Tools
- Processes
- Products
- Work flows

Improve business profitability!
Life Cycle Safety Review example: Photovoltaic (PV) Panels

Photo: NIOSH Draft PtD Solar Panel Case Study
Photovoltaic (PV) Panels

HAZARD: New electrical hazard in that the energy source cannot be switched off unlike other electrical installations.

EXPOSURE: Known fall hazards from ladders and roofs because installation and maintenance commonly involve work at height.
<table>
<thead>
<tr>
<th>STAGE</th>
<th>GROUP</th>
<th>KEY TASKS</th>
<th>HAZARDS/RISKS</th>
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<tbody>
<tr>
<td>Installation</td>
<td>Construction, Electricians</td>
<td>- Moving panels and supplies to roof</td>
<td>- Cranes/rigging</td>
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<td>- Installing panels and wiring</td>
<td>- Falls from ladder</td>
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<td>- Falls from roof</td>
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<td>- Material handling</td>
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<td>- Electric shock</td>
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<tr>
<td>Maintenance</td>
<td>Maintenance, In house</td>
<td>- Replace/repair broken panels</td>
<td>- Falls from roof</td>
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<td></td>
<td>or electricians</td>
<td>- Clean panels</td>
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<td>- Inspection</td>
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<tr>
<td>Recycle and replace</td>
<td>Construction, Electricians</td>
<td>- Removal of panels after 25 year life span</td>
<td>- Cranes/rigging</td>
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<td>- Moving new panels to roof</td>
<td>- Falls from ladder</td>
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**O&M considerations for Onsite Renewable Energy Credit**

“Provide building operators with the manufacturer’s recommendations for operating and maintenance procedures. **Operators may need guidance on how to maximize efficiency, including information about cleaning method and frequency for solar panels**” LEED Reference Guide
Apply the Hierarchy of Controls

Upstream: design options to reduce fall hazard:

Designer to provide for fall protection via:
- Parapet
- or Permanent guard rail
- or anchors and horizontal lifeline for fall restraint or fall arrest system

Another strategy: design to build sections on ground

Photo: NIOSH Draft PtD Case Study
Downstream Planning: Contractor to set up using a scissor lift to aid in the PV panel installation process.
A 46-year-old electrical worker died when he fell through a skylight on a roof while installing solar panels. The victim was carrying solar panels and walking backwards because of the limited space around the skylight. As the victim was walking backwards, he tripped on the raised edge of the skylight frame and fell onto the skylight."

16,272 solar panels were being installed on a roof with 357 existing skylights. 18 inch clearance between skylight and PV panels.

Need for safeguards and safety planning.

http://www.cdc.gov/niosh-face/stateface/CA/09CA003.html
Research

- Benchmarked the PtD role of the designer in the United Kingdom
- Established the management system components and the business value of PtD among subset of Mercer companies
- Supports the development of a rating system to quantify risks associated with specific design features
- Create a design roadmap to link PtD activities to each stage of design
- Evaluate specific PtD Best Practices for their impact on the bottom line
PtD in engineering textbooks
PtD in engineering and H&S curricula
   - 2 dozen university partners
   - ABET
   - NCEES
Develop and disseminate engineering education modules
Develop and disseminate educational programs to health and safety professionals
   - ASSE, AIHA
Collaboration with ABET

Ensures entry-level preparedness of incoming engineers
Opportunity to collaborate on consensus standards
Accreditation stimulates innovation in education
Published Textbooks

- Water Supply and Wastewater Removal
- Occupational Ergonomics: Theory and Applications
- Prevention Through Design: Transdisciplinary Process
- Engineering Mechanics and Design Applications
Websites

NIOSH Prevention through Design websites
http://www.cdc.gov/niosh/programs/PtDesign/

www.cdc.gov/niosh/topics/PtD/

PtD wiki
http://www.orcehs.org/wiki/display/orcehs/PtD+Case+Studies

E-mail: preventionthroughdesign@cdc.gov
Mechanical – Electrical Systems

Developed by James McGlothlin, MPH, Ph.D., CPE
Associate Professor, School of Health Science
John R. Weaver, Facility Manager,
Birck Nanotechnology Center
Anna Menze, Research Assistant
Purdue University
MECHANICAL–ELECTRICAL SYSTEMS

Electrical Hazards
MECHANICAL–ELECTRICAL SYSTEMS

Uninterrupted Power System

Nanotechnology Laboratory
Summary

Prevention through Design

• Is the preferred approach
• Provides potential solutions for tackling a major cause of fatalities
• Provides opportunities for working with owners and clients to improve safety and productivity
“In many respects, PtD is a transformative concept for the 21st century. It views investments in worker safety and health as an integral part of business efficiency and quality, rather than as a cost. It is also a practical concept that has already been used successfully in several model applications.”

John Howard, MD
Director, NIOSH, CDC
November 22, 2010
Christine Branche
Principal Associate Director
Director, Office of Construction Safety and Health
Construction Program Manager
202-245-0625|cbranche@cdc.gov

With thanks to
Matt Gillen (retired)
Former Deputy Director, Office of Construction Safety and Health
Former NIOSH Construction Program Coordinator

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