Purdue Process Safety & Assurance Center
DISCLAIMER: The findings and conclusions in this presentation have not been formally reviewed by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy.
Relax, NIOSH is not OSHA

• Occupational Safety and Health Administration (OSHA) [www.osha.gov]
  • Part of the Department of Labor
  • Sets and enforces standards

• National Institute for Occupational Safety and Health (NIOSH) [www.cdc.gov/niosh]
  • Part of the Department of Health and Human Services
  • Conducts research and makes recommendations for the prevention of work-related injury and illness
Anticipating and DESIGNING OUT hazards in tools, equipment, processes, materials, structures, and the organization of work is the most effective way to prevent occupational injuries, illnesses, and fatalities.

John Howard, MD
Director, NIOSH, CDC
May, 2014
NIOSH Prevention through Design Initiative

Mission: *Design out* hazards and minimize risks associated with:

- **Tools & Equipment**
- **Processes**
- **Materials, Products, New Technologies**
- **Structures**
- **Organization of Work**
Hierarchy of Controls  ANSI/AIHA Z10

- **ELIMINATION**
  - Design it out

- **SUBSTITUTION**
  - Use something else

**ENGINEERING CONTROLS**
- Isolation and guarding

**ADMINISTRATIVE CONTROLS**
- Training and work scheduling

**PERSONAL PROTECTIVE EQUIPMENT**
- Last resort

**PtD**

1st - the PRIORITY
Moving Upstream

PtD

Move Hazard Elimination Upstream in Design Process

Business Concepts | Design | Build | Operations & Maintenance | Decommission & Recycle

Prevention through Design | Retrofit

To move worker protection from an afterthought to a forethought in process, product and facility design
A process for Fresh Thinking

Insanity: doing the same thing over and over again and expecting different results.

We cannot solve our problems with the same thinking we used when we created them.

- Albert Einstein
Agenda

- PtD & the National Initiative – *Burden, Need, Impact*
- Policy History and Current Trends
- How to *Change your Culture to Prevention*
- What do you do next?
- SO What?
The U.S. Burden is Large

• 3.7 million work-related injuries per year [1BLS 2014]
  – 4,679 deaths from injury [2BLS 2014]
• 189,400 work-related illnesses per year [1BLS 2014]
  – 47,000 deaths from illness []
• Tremendous personal/societal health impacts:
  – Untold pain and suffering for workers and families
• $250 billion per year in direct and indirect costs³

The United States:
• 3.72 million work-related injuries & illnesses/year
• About 51 thousand deaths/year – 142 per day.

The World:
• 317 million work-related injuries & illnesses/year
• Over 2.3 million deaths/year – 6300 per day. [1]

1International Labor Organization, 20 July 2016,
The NEED: Design is a Risk Factor

- Australian Study, 2000–2002
- 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

[Driscoll et al. 2008]
The NEED: Design is a Risk Factor

- **22%** of 226 injuries that occurred from 2000 to 2002 in Oregon, Washington, and California were linked partly to design [Behm 2005]

- **42%** of 224 fatalities in U.S. between 1990 and 2003 were linked to design [Behm 2005]

- In Europe, a 1991 study concluded that **60%** of fatal accidents resulted in part from decisions made before site work began [European Foundation for the Improvement of Living and Working Conditions 1991]

- **63%** of all fatalities and injuries could be attributed to design decisions or lack of planning [CHAIR safety in design tool 2001]
The NEED: Bang for the Buck

"Over the last 20 years the practice of construction has undergone profound changes. ... new technologies, such as building information modeling (BIM), have enabled projects to become more complex.

Therefore it is essential ... to have a fully integrated, extensive safety program that can respond to evolving industry needs and allow them to stay competitive. ...”

(A specific planning and design PROCESS)
Agenda

• PtD & the National Initiative – *Burden, Need, Impact*

• Policy *History* and Current *Trends*

• How to *Change your Culture to Prevention*

• What do you do *next?*

• *SO What*?
What is PtD?

The NIOSH Prevention through Design (PtD) Initiative seeks to promote the practice of eliminating or reducing worker hazards early in a project process, in the design phase.

PtD encourages efforts to anticipate and design out hazards to workers in facilities, methods, operations, processes, equipment, tools, products, technology, and the organization of work.

Education

- Strategic Goal: To encourage designers, engineers, health professionals, business, and workers to understand and use PtD.
- PDQ has been taught at many universities.
- Examples of universities that teach PDQ:
  - Harvard University
  - University of Arizona
- Taxonomy:
  - Over 70 textbooks include PDQ topics.

Research

- Strategic Goal: To measure the value of adopted PDQ solutions, address existing design-related challenges, and suggest future research.
- Lessons from Abroad:
  - A study of legally mandated PDQ in the United Kingdom and Australia indicates recommendations for the United States.
- Progress at the Top:
  - A study of Fortune 100 firms shows high rates of adoption of PDQ.

Practice

- Strategic Goal: To ensure stakeholders access, share, and apply successful PDQ practices.
- Workplace Design Solutions:
  - NIOSH has created a series of core, easy-to-use guides that integrate NIOSH research into workplace practices. More are in development, including nanotechnology.
- Green Industry:
  - Workshops have been held for the “Green” industries to promote the concept. “Green” should not be limited to environmental factors, but must include the wellbeing of workers.

Policy

- Strategic Goal: To prompt business leaders, labor, academia, government, and labor standards groups to pervasive culture that includes PDQ principles in design.
- New Standards:
  - The American National Standards Institute (ANSI), American Society of Safety Engineers (ASSE), and American Industrial Hygiene Association (AIHA) have published two key PDQ consensus standards.
  - ANSI/AIHA Z500.3 focused on the PDQ design process.

Small Business

- Strategic Goal: To provide small businesses with access to PDQ resources that are appropriate for their needs.
- Outreach Efforts:
  - Not all firms are large enough to implement PDQ themselves.
  - NIOSH provides resources to key partners to facilitate adoption.
- SUCCESSs for Small Businesses:
  - Reduced volatile organic compounds exposure through painting.
  - Reduced musculoskeletal injury in grape harvesters.
  - More at NIOSH Workplace Design Solutions

Go for it!

- “Leverage” Economics:
  - Solve a clear argument problem that is well understood and appreciated. Explain how this is PDQ in action and go from there.
- Start Design Safety Reviews (DSR):
  - Gain management support. Explain how adding safety reviews to design, and using safety and exposure to the team, brings “lessons learned” and better solutions.
- Follow the “Process”:
  - Using checklists, experience, and brainstorming, the DSR team lists hazards and ranks the risks, then works to eliminate any major designing. For guidance, use the ANSI Z500.3 standard.

References:

- Architecture & Structural Steel
- Reinforced Concrete
- Mechanical Electrical

More go.gov/ptd/mpm

More go.gov/ptd/mpm

More go.gov/ptd/mpm

More go.gov/ptd/mpm
What’s next in NIOSH PtD?

• Capital Projects Processes Website (checklists, templates, model programs, etc)

• Business Case Developer Software and Manuscript

• Case Studies (with business case summaries)

• New Educational Modules (Agricultural Engineering, Manufacturing & Industrial Engineering, Capital Projects, Nanotechnology, Chemical Process Safety)
NIOSH reviews complete. Revising for Peer/Stakeholder reviews.

Chemical Process Safety
EDUCATION MODULE

Developed by Carol Clinton, PhD, PE
Jonathan Burkhardt
University of Cincinnati
Agenda

• PtD & the National Initiative – *Burden, Need, Impact*

• **Policy History** and Current **Trends**

• How to *Change your Culture to Prevention*

• What do you do **next**?

• **SO What**?
PtD is NOT new ...

1750 B.C., Code of Hammurabi, Law 229: “If a builder builds a house for someone, and does not construct it properly, and the house which he built falls in and kills its owner, then that builder shall be put to death.”

(Punitive code. PtD implied!)
Hammurabi 2.0

“My company has had a safety program for 150 years. The program was instituted as a result of a French law requiring an explosives manufacturer to live on the premises with his family.”

— Crawford Greenwalt
Former president of DuPont
PtD is NOT new ...  

1440 B.C., Bible, Moses, Deuteronomy 22:8: “When you build a new house, make a parapet around your roof so that you may not bring the guilt of bloodshed on your house if someone falls from the roof.”

(Design code. PtD specific.)
So how are we doing now that we're so advanced?
Beyond disasters - a Parallel Worker Focus

• In the early 90’s practitioners noted that
  – Design safety was **not well covered in literature**, 
  – Was **seldom found in management guides**, 
  – And was **usually not a corrective action** in incident investigations.

• Yet, **more than one third** of accident investigations listed **DESIGN as a cause**.
Moses 1.0 beats “must trust”

Avoiding the “must trust” Design Options
Design in the Prevention

2015: Best PtD ELIMINATES fall hazard (Parapet at a different facility)*
2015: PtD, but still relies on PPE or “must trust” (new hospital wing)*
1940/50: NO fall protection & later HVAC placed near edge (old hospital wing)*

* Explanatory notes added by J. Bach, NIOSH
“Green” Tech ... Skylights, Atria Windows
“Green” Tech ... think *LifeCycle* Safety

Moses 1.0?
SAFE Sustainability

Have you heard of LEED® certified “Green” buildings?
SAFE Sustainability in 2009?

**SIX LEED® Gold Certifications in 2009**

“CityCenter, the largest sustainable development in the world ... received 6 LEED Gold Awards from the US Green Building Council.”

**A Bittersweet Accomplishment ...**

**SIX Construction Deaths in 2007-2008**

The U.S. Green Building Council (USGBC) joined with NIOSH to investigate “LifeCycle Safety” in Sustainability – to include ALL occupants including those at Construction phase and later O&M.

Green, *Sustainable* - but not SAFE?

- **Sustainable?** Green designers save energy & resources and reduce pollution (and also include indoor air quality for final *occupants*).

- **Occupants?** Green designers may not think of *construction workers* or *operations and maintenance workers* as “occupants” during the entire *Life Cycle* of the endeavor.

- **Safe?** Green designers may not be skilled in worker hazard recognition or prevention.

- How "Sustainable" is *dangerous* technology?
SAFE Sustainability is gaining ground ...

- ASCE Code of Ethics ...

  “Sustainable Development ... to enhance the safety, welfare, and quality of life for all of society while maintaining ... natural resources.”

Green + LifeCycle Safety = Socially Responsible Sustainability
BIG Policy Advance in Green Building!

• In February 2015, the U.S. Green Building Council published PtD credits for the Leadership in Energy and Environmental Design (LEED) rating system.

www.usgbc.org/credits/preventionthroughdesign
www.usgbc.org/credits/preventionthroughdesign2009
Sustainability in the Workplace

Sustainable organizations strive to balance the triple bottom line of people, planet, and profit to achieve long-term success and viability. This means that organizations cannot be sustainable without protecting the safety, health, and welfare of their most vital resource: workers. Sustainability is not just about what is done, but how it gets done. It is a mindset that requires leadership; not settling for second best in any aspect of operations; setting and achieving goals beyond regulatory compliance.

Organizations of all sizes across the country and around the world have embraced this mindset as a way to showcase their values, measure impacts and outcomes, and increase their competitive advantage. However, workplace safety and health is often underemphasized, or overlooked completely. Integrating safety and health into sustainability provides an opportunity to better protect workers and achieve a truly sustainable organization.

Learn more about the connection between occupational safety and health and sustainability here.

Latest from OSHA:

Sustainability White Paper Released

Sustainability Spotlight:

Center for Safety & Health Sustainability

CSHS provides over 100,000 occupational safety and health professionals in over 70 countries with a stronger voice in shaping sustainability policies.

Officially launched in 2011, the Center for Safety & Health Sustainability, a joint effort of safety and health professional organizations in the US, Canada, and the UK, is driven by the strong belief that an organization cannot be sustainable if it does not ensure safe and healthful conditions for its workers and contractors. [ ]

Read More
Agenda

• PtD & the National Initiative – *Burden, Need, Impact*

• Policy *History* and Current *Trends*

• How to *Change your Culture to Prevention*
  
  – Culture still *NEEDS* to Change

• What do you do *next*?

• *SO* What?
Culture still **NEEDS** to Change

Safety and Health is *confused with reliability*

Safety and Health is *compartmentalized*
PtD is NOT Reliability Engineering

- **PROBLEM:** For many, Reliability Engineering replaces System Safety or PtD

- **Assumption:** If it’s reliable, it’s safe. Focusing on “failures” in accident analysis *seems* to show this.

- **Reality:** Reliable systems *can be unsafe.* Reliability and Safety are different properties.

- **Example …**
Accidents where no components fail

Batch Chemical Reactor in England

Figure 1: A chemical reactor design. (Source: Trevor Kletz, Human problems with computer control, Plant/Operations Progress, 1(4), October 1982, page 6.)
Safety & Health Compartmentalized ... 
An Example from “Deepwater Horizon”
PSM isn’t working well enough

Large, avoidable, chemical incidents continue in the U.S.

• 17 Apr 2013: Fertilizer Facility, West, TX. NH4NO3. 15 die, 160 injured

• 1 Aug 2013: Executive Order Improving Chemical Facility Safety and Security

• 2 Dec 2014: The CSB releases a video on the 30th anniversary of Bhopal (6 minutes): www.csb.gov/videos or www.youtube.com/watch?v=HZirRB32qzU

• The CSB says that the PSM regulations are in need of reform, emphasizing “Prevention through Safer Design”
Personnel Safety Burden is HIGH

- The U.S. oil and gas extraction industry (onshore + offshore) had a fatality rate seven times higher than for all U.S. workers (27.1 versus 3.8 deaths per 100,000 workers) during 2003–2010.

  - Transportation events were the leading cause of fatalities (65 [51%] with 49 being helicopter related), followed by contact with objects or equipment (21 [16%]), fires and explosions (17 [13%]), and exposure to harmful substances/environments (16 [13%]).

www.cdc.gov/mmwr/preview/mmwrhtml/mm6216a2.htm
Process and Personnel Safety?  
Process vs Personnel Safety?

Personnel Safety and Process Safety are often treated separately.

**Bhopal:** Personnel Safety and Process Safety was poor. An underlying poor Safety Culture *appears* to be a cause.

**Deepwater Horizon:** *Personnel* Safety *appeared* high (awards just prior to well blowout). Safety Culture looked good on the “surface” (by simple measures). Yet adherence to Process Safety controls and preventive maintenance was compromised, and dozens of *personnel* were killed or injured – with thousands more put at risk during the cleanup.

If Corporate Safety Culture was *REAL*, or “deep,” wouldn’t both Personnel *and* Process Safety be solid?
One “Safety Culture” or TWO?

• Is “Personnel Safety” the job of the OSH office, “Process Safety” the job of engineering, with low collaboration? (*PSM is OSHA!*)

• Is “good” personnel safety masking process safety issues – leading to a false sense of security? (vice versa?)

• Are end users/operators brought into design review for Personnel Safety/Health? (legally-required for Process Safety)

• Is the Safety Culture “surface” (tacked on, not integrated) – and everyone knows it?
CAN Process Safety BE PtD?

• It already is PtD, yet the same methods are not always applied to the full variety of worker hazards.

• Designs to avoid loss of containment episodes require specialized expertise, yet those same experts may not “see” the full range of other worker hazards.

• If OSH experts and key workers are brought in for periodic Design Safety Reviews, they can provide the expertise needed to address all worker hazards.

• The preference in either case is inherent safety. Adding “safety systems” is not needed when a hazard is gone.
Safety = Process + Personnel

IDEAS to integrate Personnel with Process Safety ...

• Top management requires (and receives reports verifying):
  – That DSR team membership include experienced, knowledgeable End-Users/Operators & Safety/Health personnel along with the normal designers.
  – The DSR to provide their lists of hazards, alternatives, and recommendations.
Culture Change ... how to DO it

See Chapter 4

See Chapter 6

www.cpwr.com/safety-culture
What’s your Safety Culture Rating?

Safety Culture and Safety Climate

The construction industry is increasingly recognizing the importance of creating a strong positive Safety Culture and Safety Climate for reducing worker injury rates as close to zero as possible. Researchers also agree that these concepts and related practices are key to reducing injuries, illnesses, and fatalities on construction work sites. To contribute to and help guide the efforts to improve construction-related safety culture and safety climate, CPWR has made these topics one of our top priorities including engaging stakeholders and developing resources and tools.

The June 2013 Safety Culture and Climate in Construction: Bridging the Gap between Research and Practice Workshop, resulted in a report and recommendations, and led to the development of materials, resources, and research that stakeholders can use to strengthen the industry’s safety culture and climate.

- NEW Worksheets and a Rating Tool to Help You Strengthen Jobsite Safety Climate. This new publication is an update of the first workbook, which was called "Strengthening Jobsite Safety Climate by Using and Improving Leading Indicators" (2014). The new version reflects input from construction industry stakeholders, including members of the NORA Construction Sector Council, and contains the new Safety Climate Assessment Tool (S-CAT). The S-CAT was developed by researchers at CPWR and Washington State University.

www.cpwr.com/safety-culture
Agenda

• PtD & the National Initiative – *Burden, Need, Impact*

• Policy *History* and Current *Trends*

• How to *Change your Culture to Prevention*
  – Give Examples of PtD *Benefits*
  – Introduce Collaborative Design
  – Use a PtD *PROCESS*
  – Leverage Ergonomics!
  – Do Accident Investigation Differently
  – Address Liability Concerns
  – Include Prevention in Additional Contract Provisions
  – Include Prevention in Purchasing Specs
  – Make a Business Case

• What do you do *next?*

• *SO What ?*
Real Examples and Savings ...

Working Safer by Design

Presented By:
TJ Lyons CSP CRIS
Construction Safety Manager
Gilbane Federal
Good: Protect the Receiver ...

PtD During Construction

Conventional pedestrian protection (rooftop mechanical upgrades – NYC)
Better: Stop it at the Source!

PtD During Construction Must Answer “What’s in this for me?”

Rooftop barrier instead – 1/3 the cost (six figures)✔

Photo by Jeff Hutchens

Courtesy of TJ Lyons, Gilbane Federal
Design moves costs up front ...

THE GLOBAL GROWTH OF PREVENTION THROUGH DESIGN

Bradley Giles, P.E., CSP, STS
Vice President – ESH&S, URS Corporation
Difficult work in tight spaces ...

Conventional tray support system (all supports are hand assembled in the field.)
Re-design: Modular, Pre-fab ...
Planning: Prefab unit installed

Cable tray bundle being lifted into Absorber building Unit 1 by electricians and ironworks (timing correct – no overhead steel)
Move **LOWER** costs up **FRONT**!

<table>
<thead>
<tr>
<th>Cost category</th>
<th>Preassembly</th>
<th>Stick build</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Craft hours</td>
<td>1,300</td>
<td>7,910</td>
<td>6,610</td>
</tr>
<tr>
<td>Craft related costs</td>
<td>$79,812</td>
<td>$477,391</td>
<td>$397,579</td>
</tr>
<tr>
<td>Material and assembly costs</td>
<td>$142,408</td>
<td>$132,389</td>
<td>($10,019)</td>
</tr>
<tr>
<td>Engineering hours</td>
<td>743 (required to develop design of modules)</td>
<td>0 (original design based on typical details from previous project)</td>
<td>(743)</td>
</tr>
<tr>
<td>Engineering costs</td>
<td>$92,291</td>
<td>0</td>
<td>($92,291)</td>
</tr>
<tr>
<td><strong>Total costs</strong></td>
<td><strong>$314,511</strong></td>
<td><strong>$609,780</strong></td>
<td><strong>$295,269</strong></td>
</tr>
</tbody>
</table>

The above represents a 48% total savings and a 83% installation savings. Opportunities for future savings will be by the elimination of the added engineering costs by standardizing this method of supporting cable tray in long runs of vertically stacked tray and stacked tray in concentrated areas. The constructability approach is being applied to 75% of project applications, duct work, cable trays, piping, handrail, stairwells, etc. The project has worked since August 2008 1.8 million safe work hours without a days away case.
Prefabrcication, Modularity

Modular Service Risers

Dr. Mike Toole,
www.DesignForConstructionSafety.org
Inherently Safer Chemical Process Design

- **Intensify/Minimize**
  - Reduce inventories of hazardous materials

- **Substitute/Eliminate**
  - Use less hazardous materials

- **Attenuate/Moderate**
  - Reduce severity of conditions by using a better catalyst

- **Limit Effects**
  - Transport in less hazardous form, via safer methods, via safer routes

- **Simplify**
  - Simplify material handling

[Hendershot 2011]
Intensify/minimize the Reaction

- Minimize feedstocks
- Minimize reactor size
- Dilute catalyst
- Use automatic feed controls
- Minimize pipe runs
- Minimize pipe diameter
- Process options
- Equipment options
- Chemical phase
- Minimize fugitive emissions
Substitute/eliminate

- Substitute/eliminate
  - Optimize catalyst selection (for maximum conversion)
  - Optimize suspension agent (to ensure dispersion)
  - Consider fluid with higher heat capacity than water (to minimize volume needed for bath); or fluidized bed reactor
  - Use external jacket rather than internal coils for heat transfer (to prevent contamination by heat transfer fluid)
  - Use high grade metals, or line reactor and storage tanks to prevent contamination from corrosion
Attenuation/moderation

- Operate at temperature and pressure as close to ambient as possible
- Construct reactor to handle maximum potential emergency pressure
- Have redundant sensors (e.g., temperature and pressure) tied to automatic feed shutoff
- Build within enclosure to contain leaks, explosions; double-walled tanks
Attenuation/moderation (cont.)

- Build a “dump tank” area with a diluent or short-stopping agent to receive reactor contents in event of emergency
- Provide for manual addition of diluent or short-stopping agent directly into reactor in emergencies
- Provide insulation to prevent external heat from causing runaway reaction
- Optimize design of pressure relief system
Limit effects

- Have aggressive leak detection and repair program
- Redundant controls to prevent runaway reactions/over-pressurization
- Provide controls to prevent reverse flow during overpressure situations:
  - For example, back into the feed storage tanks,
  - Through check valves,
  - Positive displacement pumps, or
  - By elevating feed tanks above reactor with pressure relief device on feed line
- Reduce drying and packaging equipment
- Carefully check packaging lines for pinch points and other hazards
- Ensure control-room displays are intuitive
- Fail-safe controls
- Minimize pipe bends, seams, joints, valves (balance with minimizing mass within pipe segments)
- Train workers frequently to make safe behavior automatic
He discusses...

- New era of chemical engineering
- Responsibility of chemists for health and safety from design to product
- Need for toxicology education in university coursework
- Prioritizing sustainability in chemical engineering (both in process and end application)
- Reduction of chemical waste by improving process
- Enthalpic vs Entropic approaches

Link: vimeo.com/20060171
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  – Give Examples of PtD Benefits
  – Introduce Collaborative Design
  – Use a PtD PROCESS
  – Leverage Ergonomics!
  – Do Accident Investigation Differently
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  – Make a Business Case

• What do you do next?

• SO What?
• Regulatory standard applicable to work with highly hazardous chemicals 29 CFR 1910.119
• Major sections include:
  • Process safety information
  • Process hazard analysis and pre-startup safety reviews
  • Operating procedures
  • Employee involvement and training
  • Contractor oversight
  • Mechanical Integrity
• Management of change
• Incident investigation
• Emergency planning and response
Several advantages of collaborative, multi-disciplinary teams ...
Collaborative Design Advantage ...

Will ensure you have the legal and technical know-how
Collaborative Design Advantage ...

Will ensure you have end user and operator experience, preferences, and lessons-learned.
Collaborative Design Advantage ...

Will ensure you reach consensus on important issues
Collaborative Design Advantage ...

Will do a better job managing change
Collaborative Design Advantage ...

Will help ensure follow-through
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• What do you do next?

• SO What?
Process Safety Mgt & PtD Process

- Regulatory standard applicable to work with highly hazardous chemicals 29 CFR 1910.119
- Major sections include:
  - Process safety information
  - Process hazard analysis and pre-startup safety reviews
  - Operating procedures
  - Employee involvement and training
  - Contractor oversight
  - Mechanical Integrity
  - Management of change
  - Incident investigation
  - Emergency planning and response
Walking through a Simple Example ...

PtD

Moving Hazard Elimination Upstream in Design Process

Business Concepts

Design

Build

Operations & Maintenance

Decommission & Recycle

Prevention through Design

Retrofit

To move worker protection from an afterthought to a forethought in process, product and facility design
Walking through a Simple Example ...

Purchase the ANSI/ASSE z590.3 PtD Standard!

If you already have a Process/Systems Safety Design Safety review system, make sure it includes worker hazard protection as an equal priority.

If you need a System, follow the z590.3

It is “Systems Safety Light”

It is GENERAL, SHORT (but with helpful appendices), and is a safety review PROCESS for any type of business.
The International System Safety Society
Professionals Dedicated to the Safety of Systems, Products and Services

About the Society
Journal of System Safety
Chapters
Conferences
Products and Resources
Joining the Society
Member Upgrades
Corporate Membership
Professional Development
Contact
Employment Opportunities
System Safety Links
Tech Fellows

Vision Statement
To make the world a safer place through safer systems.

Mission Statement
Advance the system safety discipline by creating an international, interdependent network of system safety professionals dedicated to the continuous improvement of the art, sciences and technology needed to provide the best total system safety solutions. Be the recognized international leader in the system safety discipline.

Welcome
The International System Safety Society is a non-profit organization supporting safety professionals worldwide. With a wide range of individual and corporate members, the Society is affiliated with major corporations, educational institutions, and government agencies.

About the Journal
Journal of System Safety is the official publication of the System Safety Society and is the leading source of cutting-edge information about the latest developments in the system safety field.

Notice of the Reduction in the Number of Journal of System Safety Society Issues
The finances of the society were hurt by the government sequestration. In the past, conference income amounted to over half of our total income and the loss of this income for last year combined with the anticipated reduction in conference income for future years has caused the executive council of the society to aggressively cut costs. One of the many areas we have had to cut back is in the number of publications per year of the Journal of System Safety (JSS). This decision was not reached lightly.

MIL-STD-882E
Click here for a copy

www.system-safety.org
The Systems Safety Process (MIL STD 882E)

Element 1. Document the Systems Safety Approach
Element 2. Identify and Document Hazards
Element 3. Assess and Document Risk
Element 4. Identify and Document Risk Mitigation Measures
Element 5. Reduce Risk
Element 6. Verify, Validate and Document Risk Reduction
Element 7. Accept Risk and Document
Element 8. Manage Life-Cycle Risk
Making Design Safety Reviews work

Buy the ANSI/ASSE z590.3 PtD standard, it is loaded with helpful guidance in a very short space, then expands on that with many helpful appendices. For example, though summarized and annotated for this slide, the z590.3 provides guidance on running Design Safety Review meetings:

Typical design safety review, DSR, meeting:

1. The project leader distributes drawings and checklists (you need to prep those earlier).
2. The team chooses a facilitator, often a disinterested designer not assigned to or intimately familiar with the project.
3. The project leader describes the project and answers questions.
4. The project leader, or assistant, updates documentation, e.g. design punch list, hazard tracking tables (method not fixed in stone – use what works for your company and team. Documentation examples to follow come from the Army and the MIL STD 882, e.g. hazard lists in a table).
5. Facilitator leads a methodical review using a generic checklist, with team members asking detailed questions to ensure thorough consideration of hazards and their control. Checklist items and sections that are not applicable are so noted. (brainstorming happens here)
6. Additional discipline checklists are reviewed as appropriate.
7. Keep and have everyone sign the marked up copy of the checklists.
The PtD Process in a Business LifeCycle

• The following Process diagram illustrates key points

• It is not a real business’s example, but a mixture of various diagrams and terms - for concepts

• The reference to 30, 60 and 90% design points comes from construction and is NOT an official PtD “rule”

• Do the design reviews at the best points for your business and your process ...
## Checklist + Multidiscipline Brainstorming

Use checklists of common design issues.

(e.g. Advanced Safety Management, Fred Manuele)

Design team members with similar system experience provide inputs from LESSONS LEARNED.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.0 Structural Framing</strong></td>
<td></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><strong>2.0 Accessibility</strong></td>
<td></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 + Multidiscipline Brainstorming**

*Prevention through Design*

**Design for Construction Safety**

A very thorough Bibliography compiled by Dr. Nicholas Tymvios (updated June 12, 2016)

**Design Tools**

- **SiDeRuE** (Safety in Design Risk Evaluator) assists building designers with assessing the construction safety risk associated with their designs.
- **Safe Design Guidelines** distributed by the San Francisco Public Utilities Commission.
- **1600+ PtD list** compiled by Alan Speegle (The Southern Company). Note: This spreadsheet is most helpful for process (i.e., industrial) construction. The attached file was posted 12/14/11. Please discard the previous version posted.

Researchers and practitioners have created **The Sustainable Construction Safety and Health (SCS)S rating system** to evaluate construction worker safety and health on construction projects.

OSHA’s hazard identification training tool may prove helpful for education design engineers and other non-safety professionals about common construction site hazards.

**Workplace Design Solutions developed by NIOSH**

- Preventing Falls from Heights through the Design of Embedded Safety Features
- Preventing Falls through the Design of Roof Parapets

**Construction Workplace Design Solutions**

developed by the OSHA Alliance Program’s Construction Roundtable

- Falls From Roof Edge
Risk Assessment Code (RAC) Matrix …

![Image of Risk Assessment Matrix]

Example from MIL STD 882

<table>
<thead>
<tr>
<th>PROBABILITY</th>
<th>SEVERITY</th>
<th>Catastrophic (1)</th>
<th>Critical (2)</th>
<th>Marginal (3)</th>
<th>Negligible (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequent (A)</td>
<td>High</td>
<td>High</td>
<td>Serious</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>Probable (B)</td>
<td>High</td>
<td>High</td>
<td>Serious</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>Occasional (C)</td>
<td>High</td>
<td>Serious</td>
<td>Medium</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Remote (D)</td>
<td>Serious</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Improbable (E)</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Eliminated (F)</td>
<td></td>
<td></td>
<td>Eliminated</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Documenting Design Safety Reviews

• Do what works best for your company and your team

• The examples of hazard lists on the following slides are from the MIL STD 882 and the Army Corps of Engineers, e.g. Preliminary Hazard List (PHL), Preliminary Hazard Analysis (PHA), and Hazard Tracking List (HTL)

• You’ll need to create your own punch lists or tables if only to avoid conflicting acronyms! (e.g. PHA means something different in Chemical Process Safety)
# PHL - Preliminary Hazard List

<table>
<thead>
<tr>
<th>Hazard ID</th>
<th>Hazardous Element</th>
<th>Causal Factor</th>
<th>Effect</th>
<th>RAC</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Roof Falls from roof while cleaning or maintaining skylights</td>
<td>Roof pitch or weather conditions cause workers to lose footing</td>
<td>Death from falls</td>
<td>1</td>
<td>Mitigation may also reduce maintenance manpower requirements</td>
</tr>
<tr>
<td>1.2</td>
<td>Interior ceiling and electrical Falls from man lift or storage shelves while changing light bulbs</td>
<td>Inability to access light bulbs over storage racks with man lift</td>
<td>Death from falls</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

---

*PtD: Prevention through Design*
## PHA – PRELIMINARY HAZARD ANALYSIS

<table>
<thead>
<tr>
<th>Hazard Source</th>
<th>System</th>
<th>Causal Factors</th>
<th>Effects</th>
<th>RAC</th>
<th>Comments</th>
<th>Recommended Actions</th>
<th>Control RAC</th>
<th>Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Falls from roof while cleaning or maintaining skylights</td>
<td>Roof</td>
<td>Roof pitch or weather conditions cause workers to lose footing</td>
<td>Death from falls</td>
<td>IC</td>
<td>High</td>
<td>Fixed exterior ladder. Tie-off points for work performed on roof.</td>
<td>ID</td>
<td>High</td>
</tr>
<tr>
<td>Falls from man lift or storage shelves while changing light bulbs</td>
<td>Interior ceiling and electrical</td>
<td>Inability to access light bulbs over storage racks with man lift</td>
<td>Death from falls</td>
<td>ID</td>
<td>High</td>
<td>Mitigation may also reduce maintenance manpower requirements</td>
<td>IE</td>
<td>Medium</td>
</tr>
<tr>
<td>Risk</td>
<td>Hazard</td>
<td>Cause</td>
<td>Design Process element affected</td>
<td>Impact on Project Objectives</td>
<td>Risk Manager</td>
<td>Agreed Response to Risk</td>
<td>Expected Resulting Risk</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>--------</td>
<td>-------</td>
<td>---------------------------------</td>
<td>-----------------------------</td>
<td>--------------</td>
<td>-------------------------</td>
<td>------------------------</td>
<td></td>
</tr>
<tr>
<td>HIGH</td>
<td>Falls from roof while cleaning or maintaining skylights</td>
<td>Roof pitch or weather conditions</td>
<td>(whatever makes sense for your design methods)</td>
<td>Cost, Schedule Slippage</td>
<td>Designer, Const. Mgr, Constructor</td>
<td>Fixed exterior ladder. Tie-off points for work performed on roof.</td>
<td>LOW</td>
<td></td>
</tr>
<tr>
<td>HIGH</td>
<td>Harm from chemicals</td>
<td>Exposure to chemicals</td>
<td>Investigative, Construction</td>
<td>Cost, Schedule Slippage</td>
<td>Designer, Const. Mgr, Constructor</td>
<td>Add HTRW CEGS to Design Specifications</td>
<td>LOW</td>
<td></td>
</tr>
</tbody>
</table>
“To me that is probably one of the most significant learnings of the whole accident - the degree to which the inadequacies of that experience feedback loop ... Significantly contributed to making us and the plant vulnerable to this accident.”

— Herman Dieckamp
President of the utility at Three Mile Island
Design Expertise + Feedback Loop = PtD

**Concept**
- Team? Method? Budget for DSR’s

**30% Design**
- Design Safety Review (DSR)

**60% Design**
- Design Safety Review

**90% Design**
- Design Safety Review

**Build or Prefab**
- Purchasing Specs, Added Contract Provisions, Construct

**Commission**
- Install, Debug, Safety Verification

**Use, Production**
- Beneficial Occupancy, Startup, Use, Maintenance

**Decommission**
- Disposal/Demo Hazard Control

**PHL**

**PHA**

**Hazard Analysis**

**Hazard Tracking List (HTL)**

**Risk Acceptance**

**Lessons Learned**
- (Operators, Incidents, Retrofits)

**Owner’s Manual**
- (residual risk SOH program)

**Implementation**
- Change Orders

**Feedback Loop**

**Design Expertise + Feedback Loop = PtD**
Simplify the Complex ... recap

- **Prepare**: Management support & accountability (e.g. copies of tracking lists). Decide & Recruit team. Gather checklists.

- **First Meeting**: Bring worker protection to the table, literally. Multi-discipline: Designers, key end users, Health & Safety pros. Common hazards checklist(s). Brainstorm. (PHL, Preliminary Hazard List)

- **Next meeting**: Rank them. Update w/new inputs. (PHA, Preliminary Hazard Assessment)

- **Future meetings**: Keep checking off eliminated or reduced hazards. Update w/new inputs. (Hazard Tracking List, HTL)

- **Turnover**: Give the customer written guidance for remaining hazards of use and maintenance (Owner’s Manual).
Agenda

• PtD & the National Initiative – *Burden, Need, Impact*

• Policy *History* and Current *Trends*

• How to *Change your Culture to Prevention*
  – Give Examples of PtD Benefits
  – Introduce Collaborative Design
  – Use a PtD PROCESS
  – Leverage Ergonomics!
  – Do Accident Investigation Differently
  – Address Liability Concerns
  – Include Prevention in Additional Contract Provisions
  – Include Prevention in Purchasing Specs
  – Make a Business Case

• What do you do next?

• SO What?
A clear and present danger...

- 66 to 78% of lost-time cases ERGO-related
- 40% of workers-comp costs from over-exertion, bodily reaction, repetitive motion ... ERGO
- Up to 50% of total claims are ERGO
- Up to 60% of total costs are ERGO

Ergonomics in Process Safety?

If it is too difficult or complicated or nasty to inspect some components ...

• How well do you really know the condition of your system?
• You’ve lost a “leading indicator”
• Mechanical integrity is not assured
• A loss of containment episode is more likely
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  – Do Accident **Investigation** Differently

• What do you do **next**?

• **SO What?**
PSM & “Accident Investigation”

• Regulatory standard applicable to work with highly hazardous chemicals 29 CFR 1910.119

• Major sections include:
  • Process safety information
  • Process hazard analysis and pre-startup safety reviews
  • Operating procedures
  • Employee involvement and training
  • Contractor oversight
  • Mechanical Integrity
  • Management of change
    • Incident investigation
    • Emergency planning and response
You can only “Design Out” what you KNOW

• A *Blame Culture*? “88% human error” (H.W. Heinrich)
  – We “investigate,” find human error, and *STOP*
  – We short-circuit analysis and miss *system* problems, i.e. contributing factors, root cause(s)
  – “Corrective Action?” ... re-brief, re-train, re-mind

• Better: A *FACT-finding culture* (not Fault-finding)
  – *START* at human error, don’t stop there
  – Find *system* conditions that *provoke* human error
  – DESIGN OUT *error-provocative conditions* – *PtD!*
Identify, then design out, system conditions that PROVOKE error

Fumbling for his recline button, Ted unwittingly instigates a disaster.
Error Provocative in the real world
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• What do you do next?

• *SO What ?*
AIChe Code of Ethics

Hold paramount the safety, health and welfare of the public and protect the environment in performance of their professional duties.
ABET (A-K)

Criterion 3. Program Outcomes and Assessment

Engineering programs must demonstrate that their graduates have:
(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs
(d) an ability to function on multi-disciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
Schools are Learning PtD

2011 Educating the Engineer of 2020 Workshop: Overview

Prevention through Design: Designing a Safer Tomorrow through Engineering Today

Tuesday, September 20, 2011 Stewart Center, Room 310U, Purdue University

Overview of the workshop | View the workshop agenda | Register for the competition

Please RSVP for the workshop and/or lunch to events@purdue.edu. Please indicate if you will attend the Workshop and lunch or Workshop only.

Co-sponsors

Purdue College of Engineering

The National Institute for Occupational Safety and Health (NIOSH)

Advance Purdue

Regenstrief Center

Program Chairs

Michael Harris, Professor Chemical Engineering, Associate Dean, College of Engineering, & Co-Chair, Engineer of 2020 Committee

Peter Meckl, Professor of Mechanical Engineering, & Co-Chair, Engineer of 2020 Committee

James McGlothlin, Associate Professor of Health Sciences, Director: Graduate Program in Occupational & Environmental Health Sciences

Craig Miller, Professor of Computer Graphics Technology, College of Technology

Yet, where PtD is not required by law, legal counsel has sometimes recommended avoidance of PtD due to designer liability concern...
Designer liability progress

Safer Design often becomes a legal “duty and standard of care.” Now, rather than recommend against implementing PtD, legal counsel is now telling the best ways to do it ...
Attorneys now advise **HOW to DO PtD**

An excellent example of a change in approach is found in the specific guidance in the “Clark Hill Construction Law Update” of November 2\textsuperscript{nd}, 2015:

www.clarkhill.com/alerts/prevention-through-design-overview
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• What do you do **next**?
• **SO What**?
What do you do NEXT?

• **Leverage Ergonomics!** (you may actually want to start here – after good success, explain PtD then start recruiting for a broader PtD design process.)

• **Give Examples of PtD Benefits** (use these slides and links)

• **Teach solutions to common problems** (NIOSH ed. Modules, Checklists provided for PDC participants to download)

• **Learn from Social Marketing** (Involve & learn from end users – choose them wisely)

• **Introduce Collaborative Design** (add key operators/end users and Safety/Health)

• **Use a PtD PROCESS** (Management behind it and asking to see hazard tracking sheets, tailor a checklist for a specific project, hold periodic Design Safety Reviews with the above key individuals added to the usual designers, managers)

...
What do you do **NEXT**?

• **Do “Accident Investigation” Differently** (read and share provided articles, gain management commitment to find facts for continuous improvement - not blame, go from fault-finding to fact-finding for systemic causes, call it “Incident analysis”)

• **Learn from your Safety Culture Rating** ([www.cpwr.com/safety-culture](http://www.cpwr.com/safety-culture))

• **Address Liability Concerns** (IF it is an issue in your business – see the slides and legal guidance article provided)

• **Include Prevention in Additional Contract Provisions** (“cement” it into corporate memory)

• **Include Prevention in Purchasing Specs** (ditto)

• **Make a Business Case** (Go with simplest first as in examples here. Use calc tools when needed)
Agenda

• PtD & the National Initiative – Burden, Need, Impact
• Policy History and Current Trends
• How to Change your Culture to Prevention
• What do you do next?
• SO What?
So WHAT?
An Example of YOUR impact …

• Though we never forget the people hurt or killed, we seldom know the ones we saved …
• But we DO save some, many in fact
• Just compare statistics between companies, or even countries – some are WAY better than others
• Statistics aren’t numbers, they are people
• They’re doing something different and saving people’s lives, limbs, and lungs
• Here’s an example I ran across in Europe …
Construction kills more people ...

38a. Number of fatalities, by major industry, 2010
(All employment)

- **Construction**: 802 deaths
- **Transportation**: 689 deaths
- **Agriculture**: 624 deaths
- **Wholesale & Retail**: 503 deaths
- **Manufacturing**: 333 deaths
- **Mining**: 172 deaths
- **Information**: 45 deaths
- **Utilities**: 42 deaths
- **Finance**: 24 deaths

- The Construction Chart Book, 5th Ed, 2013 (pg. 38)


Saving *FIVE* times the lives ...

<table>
<thead>
<tr>
<th>Construction Fatalities per 100,000 Full-time equivalents (FTE)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>United States</strong>: 9.4</td>
</tr>
</tbody>
</table>

- **1**The Construction Chart Book, 5th Ed, 2013 (pg. xv)
- **2**Health and safety in construction sector in Great Britain, 2014/2015 (pg. 12)
- See Construction Site Safety, Wikipedia.org, for other countries
Saving **FIVE** times the lives ...

- The United Kingdom has a construction fatality rate **1/5th** that of the USA.

- That MEANS: For every 5 people who die in our average construction, 4 of them would still be whole and healthy with their families ... had they done the same work in the U.K.

- Someone **IS** saving lives. How?
The “U.K. Toolbox”

- **Great Worker Training** and *use of Safety Inspections* are some of the tools that save 5 times as many lives in the U.K. *Add Leadership* that makes training and inspections happen. *Add PtD* – as it is foundational LAW in the U.K. since 1994.

- “But we can’t apply U.K. law here” TRUE, so *focus* on every point where your *specs* touch on *Training, Inspection, Management accountability,* and include PtD additional provisions.

- *This is LEVERAGE to save many lives.*
Mr. Bach was so impressed by what he saw at the Edinburgh castle, Scotland, that he interviewed “Bill” the construction manager.

Bill confirmed that the U.K. differences Mr. Bach knew of were in fact true.

(Mr. Bach does not know Bill’s last name, so he is now Bill “Edinburgh”)
So WHAT?
The Ultimate Reason
Savings Lives, Saving Families
Questions?