Hazard Assessments

Webinar  September 29, 2016

Dennis L. Mater
dennis.l.mater@dupont.com

FR Apparel Sales Technical Leader – North America

Copyright© 2016 DuPont. “This material is only intended for this (webinar) and may not be used for any other purpose without the expressed written consent of DuPont”
Introduction

Hazard Risks and Consequences

Hazard Assessments Overview

Hazard Assessment Methodology
- Fire Assessment Overview
- Arc Flash Assessment Overview
- Multiple Hazard Considerations

Actual FR PPE Considerations

Summary
Introduction
According to The Bureau of Labor Statistics:

Nonfatal Industrial Injuries, Resulting in Lost-Time Work Cases, Due to Fire and Explosions Have Declined Over the Last 13 Years

For the years 2000 through 2013, over 32,000 workers suffered lost-time work injuries as a result of an industrial fire or explosion

Fatal Injuries Sustained as a Result of an Industrial Fire or Explosion Have Decreased Over the Last 13 Years

According to The Bureau of Labor Statistics:

For the years 2000 through 2013, close to 2,300 workers have died as a result of injuries sustained in an industrial fire or explosion.

According to The Bureau of Labor Statistics:

Despite Declining Numbers of Fatal Injures, the Trend for Fatalities is Decreasing at a Slower Rate Than Non-Fatal Injuries

Nonfatal and Fatal Occupational Injuries due to Fire and Explosion

A survey was conducted of 40 patients treated for electrical work injuries. Most patients had neurological (92.5%), psychological (90.0%), and musculoskeletal (72.5%) symptoms, which were documented on average 303.7 days after injury. 23 patients (57.5%, 14 electrical contact and 9 electrical flash) attempted to return to work on average 107.7 days after injury, but only 13 patients (32.5%, six electrical contact and seven electrical flash) successfully returned to work 59.38 days after injury.

Sources:
Hazard Risks and Consequences
Hazard Assessments

Definition of Risk:

Risk is the potential of gaining or losing something of value.
Values, or health in this context, can be gained or lost when taking risk resulting from a given action or inaction, foreseen or unforeseen.

Risk can also be defined as the intentional interaction with uncertainty
Risk is a consequence of action taken in spite of uncertainty

The Society for Risk Analysis, when tasked to formulate a definition of risk, developed 13 different interpretations across various disciplines involved in risk analysis.

RISK Newsletter, September, Society for Risk analysis, McLean, VA p. 5, 1987

Risk of occurrence vs. consequences – Low risk of occurrence does not equate to a low risk of consequences or worker injury as a result of the event.

“We don’t need PPE because the risk of a fire is low.” Yet, if a fire occurred, the probability of severe injuries may be very high.

Key consideration:
Risk of an event occurrence vs risk of injury due to a realized event.
Complacent:

…without awareness of some potential danger or defect.

dictionary.com

Risk Perception:

…subjective judgement of risk probability and consequence severity.

wikipedia.org

Personal Risk Assessment

- Human nature to assess risk based upon personal experiences
- Experiences can provide great learning opportunities
- Challenge – risk decisions based on experience alone
- Lack of experience and ability to imagine consequences
- Low Frequency/High Consequence Severity

Each time you take a risk and do not suffer a bad consequence, the belief the task was safe is reinforced or the risk of injury and negative consequence is perceived as insignificant

Success Breeds Complacency and Low Perception of Risk

REMEMBER

Performing a task previously without injury, does not suggest you are safe from harm or the risk of injury is low enough it’s not worth concern.
**Risk** $f(\text{Probability, Severity})$

**Risk level acceptance is a judgement**

- Balance:
  - Benefits
  - Expectations
  - Costs
  - Added risks due to solution itself

**ISSUE**

**Perceived Risk ≠ Actual Risk**

**Comprehensive Hazard Assessment Will Ensure Actual Hazard Risks Are Known**

**Risk is a function of two variables:**

*Probability and Severity – Greater the probability and severity, greater the risk.*
Hazard Assessments

Potential Consequences

Serious Life Altering Injuries

Burn injuries of 40% - 60% body burn*
- Average hospital stay duration
  - 54 Days (survivor)
  - 21 Days (fatality)

- Average cost of hospital stay
  → $780,000 (survivor)

- Additional Costs: lawsuits, productivity losses, OSHA fines, insurance claims

A Single Burn Injury Can Cost Millions

*A comprehensive Hazard Assessment is imperative to understand true risks and potential consequences*
Hazard Assessments Overview
What is a hazard?

A hazard is a condition or a set of circumstances presenting a potential for harm.

3 Key Questions:

What could happen? – Analysis of hazard and Potential for loss and consequences

How bad would it be if it did happen? – What are the consequences, loss, injury – Measure or degree of injury and consequences

How likely is it to happen? – Probability of the event and probability of the consequence severity


Hazard – Condition with potential to cause damage.

Probability – Likelihood of a particular hazard occurrence that will result in damage.

Severity – Estimation of seriousness in terms of harm to people and/or damage to property.
Hazard Risk Assessment vs Hazard Analysis

Hazard Risk Assessment
comprehensive and all encompassing process of identifying and assessing hazards, estimating the potential severity of worker injuries, assessing the likelihood of occurrence of injury and determining protective measures to lower the risk to acceptable levels

Hazard Analysis
A hazard analysis is a primary step in a hazard risk assessment. The result of a hazard analysis is the identification of different type of hazards.

Understand Risk and Probability of Injury, Loss or Consequences
OHSA 29 CFR 1910.132

1915.132(d)(1)
The employer shall assess the workplace to determine if hazards are present, or likely to be present, which necessitate the use of personal protective equipment (PPE). If such hazards are present, or likely to be present, the employer shall:

1915.132(d)(1)(i)
Select, and have each affected employee use, the types of PPE that will protect the affected employee from the hazards identified in the hazard assessment;

1915.132(d)(1)(ii)
Communicate selection decisions to affected employees; and,

1915.132(d)(1)(iii)
Select PPE that properly fits each affected employee...

1915.132(d)(2)
Verify that the required workplace hazard assessment has been performed through a written certification that identifies the workplace evaluated; the person certifying that the evaluation has been performed; the date(s) of the hazard assessment; and, which identifies the document as a certification of hazard assessment.
OHSA 29 CFR 1910.132

1910.132(d)(1) The employer **shall assess the workplace to determine if hazards are present, or are likely to be present, which necessitate the use of personal protective equipment (PPE).**

1910.132(d)(2) The employer **shall verify that the required workplace hazard assessment has been performed through a written certification** that identifies the workplace evaluated; the person certifying that the evaluation has been performed; the date(s) of the hazard assessment; and, which identifies the document as a certification of hazard assessment.

The Occupational Safety and Health Review Commission (OSHRC) ruled that hazard assessments undertaken... must accurately reflect the hazards encountered by employees **at each specific facility**, regardless of any operational or design similarities across multiple worksites.

Federal appeals court upheld the U.S. Department of Labor's rule interpretation requiring employers to conduct hazard assessments in the workplace...

IN THE UNITED STATES COURT OF APPEALS
FOR THE FIFTH CIRCUIT
No. 15-60462
WAL-MART DISTRIBUTION CENTER #6016,
Petitioner
v.
OCCUPATIONAL SAFETY AND HEALTH REVIEW COMMISSION

http://www.ca5.uscourts.gov/opinions/pub/15/15-60462-CV0.pdf
Considerations When Selecting a Particular Process or Method of Hazard Risk Assessment

- Stakeholders’/Workers’ Needs
- Acceptance Criteria – Stakeholders and Decision Makers
- Regulatory Requirements and Industry Precedents
- Legal Responsibilities and Issues
- Available Resources – Personnel Expertise, Time, Costs

Hazard Assessment Resources and Tools

- OHSA 29 CFR 1910.269 – Appendix E
- IEEE Std. 1584 - Guide for Arc Flash Hazard Calculations
- NFPA 70E
- NESC – National Electrical Safety Code
- Center for Chemical Process Safety
- NFPA 551
- NFPA 2113
- ANSI Z690.3-2011 Risk Management – Principles and Guidelines
- OECD Manual for the Assessment of Chemicals
- American Chemistry Council – Principles for Hazard and Risk Assessments
- Sandia National Laboratories – Biosafety Risk Assessment Methodology
- NFPA 652
- Consultants and Industry Experts

Copyright© 2016 DuPont. “This material is only intended for this webinar and may not be used for any other purpose without the expressed written consent of DuPont”
A job hazard analysis is a technique that focuses on job tasks as a way to identify hazards before they occur.

A job hazard analysis can be conducted on any workplace job. Priority jobs to consider:
- Jobs with the highest injury/illness rates
- Jobs with potential of severe or disabling injuries or illness, even with no history of previous accidents
- Jobs in which one simple human error could lead to a severe accident or injury
- Jobs that are new to your operation or have undergone changes in processes and procedures
- Jobs complex enough to require written instructions.

Example Job Hazard Analysis Form

<table>
<thead>
<tr>
<th>Job Location:</th>
<th>Analyst:</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal Shop</td>
<td>Joe Safety</td>
<td></td>
</tr>
</tbody>
</table>

**Task Description:** Worker reaches into metal box to the right of the machine, grasps a 15-pound casting and carries it to grinding wheel. Worker grinds 20 to 30 castings per hour.

**Hazard Description:** Picking up a casting, the employee could drop it onto his foot. The casting’s weight and height could seriously injure the worker’s foot or toes.

**Hazard Controls:**
1. Remove castings from the box and place them on a table next to the grinder.
2. Wear steel-toe shoes with arch protection.
3. Change protective gloves that allow a better grip.
4. Use a device to pick up castings.
Hazard Assessments

Hazard Assessment Methodology
Hazard Assessments

Risk Assessment - Fire

Scope
- Baseline Overview
- During New Process Design
- Existing Process Changes
- Material Changes
- Periodic Reviews

Methodology
- Various – Similar Results
- Experienced Assessors
- Assumption Concerns
- Documentation

Applicability
- Obvious vs Complex Solutions
- Potential Catastrophic Consequences
- Safety Benefits
- Identify true risks

Components
- Process Information
- Fire Hazard Identification/Analysis
- Likelihood
- Risks & Risk Tolerance
- Risk Reduction
- Re-Assessment

“Guidelines for Fire Protection in Chemical, Petrochemical, and Hydrocarbon Facilities”, Center for Chemical Process Safety of the American Institute of Chemical Engineers (CCPS), 2003
Copyright© 2016 DuPont. “This material is only intended for this (webinar) and may not be used for any other purpose without the expressed written consent of DuPont”
Hazard Assessments

Risk Assessment - Fire


http://www.sfpe.org/?page=2013_Q3_1

Copyright© 2016 DuPont. “This material is only intended for this (webinar) and may not be used for any other purpose without the expressed written consent of DuPont”
Hazard Assessments

Example - Fire Hazard Analysis

Understand the fire hazard and determine mitigating strategies

Potential harm to Personnel

Inventory of all flammable and combustible materials

Material characteristics – Flammability and Combustibility

Material quantities, storage methods, locations, etc.

Loss of material containment – Rate, total amount

Scenario Development

Discharge Calculations

Fire Modeling, calculation techniques - Variables

Burn characteristics of released materials

Burn rate and heat release

Personnel – Burn Injuries, Smoke & Gasses

Equipment

Structure

"Guidelines for Fire Protection in Chemical, Petrochemical, and Hydrocarbon Facilities", Center for Chemical Process Safety of the American Institute of Chemical Engineers (CCPS), 2003

Copyright © 2016 DuPont. “This material is only intended for this (webinar) and may not be used for any other purpose without the expressed written consent of DuPont”
Hazard Assessments

Hazard Analysis – Combustible Dust

**Combustible Dust:**

*solid material composed of distinct particles or pieces, regardless of size, shape, or chemical composition, which presents a fire or deflagration hazard when suspended in air or some other oxidizing medium over a range of concentrations*

---

**NFPA 652**

Chapter 4 - General Requirements

4.1* General. The owner/operator of a facility with potentially combustible dust shall be responsible for the following activities:

1. **Determining the combustibility and explosibility hazards** of materials in accordance with Chapter 5
2. **Identifying and assessing any fire, flash fire, and explosion hazards** in accordance with Chapter 7
3. **Managing the identified fire, flash fire, and explosion hazards** in accordance with 4.2.4
4. **Communicating the hazards to affected personnel** in accordance with Section 9.5

---

**Potentially Unrecognized Hazard**

*The CSB reviewed Material Safety Data Sheets (MSDS) of 140 known substances that produce combustible dusts*

- 41% of the MSDSs reviewed did not warn users about potential explosion hazards.
- Remaining 59% of MSDSs information not stated in a place or manner clearly recognized by workers, or was not specific to hazards related to combustible dusts

---

**Dust Hazard Analysis Key Considerations**

- Screening for Combustibility and Explosibility
- Quantification of Combustibility and Explosibility Characteristics
- Area Sampling
- Mixtures
- Dispersion, Concentration, Confinement

---


“Hazard Communication Guidance for Combustible Dusts” U.S. Department of Labor Occupational Safety and Health Administration, OSHA 3371-08, 2009

Copyright © 2016 DuPont. “This material is only intended for this (webinar) and may not be used for any other purpose without the expressed written consent of DuPont”
Arc Flash Risk Assessment
NFPA 70E - Annex F

Risk Assessment Procedure

Risk Assessment (General)
- Goal - Determine measures necessary to reduce likelihood of injury
- Hazard Identification and Analysis
- Responsibility

Risk Assessment
- Risk Estimation
- Possibility /Severity of Injuries
- Likelihood of avoiding hazardous event and injuries

Risk Reduction
- Protective Measures
- Controls, Awareness Devices, Procedures, Training
- PPE

Risk Evaluation
- Risk Reduction measures’ effect on risk

Risk Reduction Verification

Figure F.1(a) Risk Assessment Process.
Hazard Analysis – Renewable Energy

Electrical energy
- wind farms
- fuel cells
- Solar farms - photovoltaic

Overall fuel cell market growth 2011-2015

Hazard Assessments

Hazards:
- Flammable Fuels: Hydrogen, Fossil Fuels
- Arc Flash

In 2009, OSHA reported the investigation of 32 arc flash accidents at wind generator farms

Between 2012 and 2014, cumulative residential and non-residential photovoltaic installations have both doubled
Cumulative utility photovoltaic installations have more than quadrupled.

Ethanol Hazard Assessments

Multiple Principal Hazards in Ethanol Manufacturing

- Flammable Liquids - Fire
  - Ethanol
  - Denaturant, typically Natural Gasoline, Unleaded Gasoline
- Grain Handling – Combustible Dust
  - Corn, Other Grains
  - Dust Collection
- Process Chemicals
  - Acids/ Caustics/ Surfactants
- Other Industrial Hazards
  - Arc Flash
Multiple Hazard Considerations

Primary vs Secondary Hazards

Potential Hazards
- Fire
- ARC Flash
- Combustible Dust
- Molten Metal/Welding
- Chemical/Hazardous Substance Exposure
- Dirt/Contaminates
- Confined Spaces
- Falls, Cuts, General Safety Needs
- Static Control Needs

- Some risk from all – Mitigate the greatest risk first
- Ensure efforts to mitigate secondary risks do not compromise protection from the primary risk – (i.e. wearing non-FR outer layers in a fire risk environment)
- Ensure protection from a hazard does not create its own hazard - (i.e. heat stress)
- May need to re-evaluate risk solutions (engineering controls, work procedures etc.) to safely incorporate all concerns simultaneously
Hazard Prevention and Control

Risk Reduction Measures

1. Culture
   - Attitudes, Beliefs, Understanding

2. Engineering
   - Technical solutions to make equipment safer

3. Work Practices
   - Proper Tools
   - Proper Procedures

4. PPE
   - Clothing
   - Eye Protection
   - Foot Protection
   - Head Protection
   - Hand Protection
   - Hearing Protection
   - Respiratory Protection

PPE - Last Line of Defense

- Leadership & Expectations
- Accountability & Consequences
- Right Metrics
- Right Organization & Structure

- Thermal Hazards &
- Flame Resistant Apparel
Actual PPE Considerations
Hazard Assessments

Fire Hazard PPE

Nomex® IIIA Coverall vs. Typical Non-FR Cotton Work Wear

Thermal Manikin before and during an ASTM F1930 exposure

Total 6 cal/cm² - 2 cal/cm²s heat flux @ 3 seconds

NFPA 2112 minimum requirement
Hazard Assessments

Fire Hazard PPE

**Predicted Burn Injury**

NOMEX® IIIA, 6 oz/yd²

- 3 seconds @ 2.0 cal/cm²s
- Total Exposure: 6.0 cal/cm²
- Predicted Burn Injury: 10.7%

100% Non-FR Cotton Shirt and NON-FR Cotton Jeans

- 3 seconds @ 2.0 cal/cm²s
- Total Exposure: 6.0 cal/cm²
- Predicted Burn Injury: 86.9%
Hazard Assessments

Fire Hazard PPE

**Predicted Burn Injury Survivability**

NOMEX® IIIA, 6 oz/yd²

- 3 seconds @ 2.0 cal/cm²s
- Total Exposure: 6.0 cal/cm²
- **Predicted Burn Injury: 10.7%**

100% Non-FR Cotton Shirt and NON-FR Cotton Jeans

- 3 seconds @ 2.0 cal/cm²s
- Total Exposure: 6.0 cal/cm²
- **Predicted Burn Injury: 86.9%**
Aren’t all “Flash” fires 3 second duration and 2 cal/cm$^2$s or less?

- Identified in NFPA 2112 for Thermal Manikin Testing

DOE China Lake Experiments with LNG Vapor Cloud Fires
- 28 m$^3$ spills occurring in ~1.6 min
- Measured peak heat flux values of over 7.2 cal/cm$^2$s
- Duration (~< 5 sec).

DOE China Lake Experiments with LPG Vapor Cloud Fires
- 5.8 m$^3$ (1,530 gal) release.
- Measured an average heat flux value of 3.3 cal/cm$^2$s
- Duration (~ 16 sec)

- 25 gallons JP-4 fuel spread over a 30 ft. x 20 ft. pit then ignited
- Average fuel burn time – 30 seconds
- Measured peak heat flux values of over 6.5 cal/cm$^2$s
- Average measured heat flux on instrumented manikin – 2.9 cal/cm$^2$s

$\text{Duration} \times \text{Heat Flux} = \text{Total Energy}$
Nomex® IIIA Coverall vs. FR Treated 88/12 Cotton/Nylon

Thermal Manikin before and during an ASTM F1930 exposure

Total 8 cal/cm² - 2.0 cal/cm²s heat flux @ 4 seconds
- 2.66 cal/cm²s heat flux @ 3 seconds
- 4.0 cal/cm²s heat flux @ 2 seconds
### Hazard Assessments

## Fire Hazard PPE

**Predicted Burn Injury**

**NOMEX® IIIA, 6 oz/yd²**

- 4 seconds @ 2.0 cal/cm²s
- Total Exposure: 8.0 cal/cm²
- **Predicted Burn Injury: 34.4%**

**88/12 FR Treated Cotton / Nylon, 7.7 oz/yd²**

- 4 seconds @ 2.0 cal/cm²s
- Total Exposure: 8.0 cal/cm²
- **Predicted Burn Injury: 69.7%**
Fire Hazard PPE

**Predicted Burn Injury Survivability**

**NOMEX® IIIA, 6 oz/yd²**
- 4 seconds @ 2.0 cal/cm²s
- Total Exposure: 8.0 cal/cm²
- **Predicted Burn Injury: 34.4%**

**88/12 FR Treated Cotton / Nylon, 7 oz/yd²**
- 4 seconds @ 2.0 cal/cm²s
- Total Exposure: 8.0 cal/cm²
- **Predicted Burn Injury: 69.7%**

Copyright© 2016 DuPont. “This material is only intended for this (webinar) and may not be used for any other purpose without the expressed written consent of DuPont”
Non-FR Fabrics Can Ignite and Burn and Melt When Exposed to An Electric Arc

Non-FR Cotton

Before Electric Arc Flash

During Electric Arc Flash

After Electric Arc Flash

The Untreated Cotton Garment Did Ignite and Continued to Burn.
Arc Flash Hazard PPE

Arc Rated Garments Will Resist Ignition and Offer Increased Protection

Arc Rated PPE

Before Electric Arc Flash

During Electric Arc Flash

After Electric Arc Flash

Arc Rated Garment Did Not Ignite nor Break-Open
PPE Considerations

Hazard Protection Considerations

Thermo-Man® ASTM F-1930 Comparison

Arc Flash

PPE Category 1

- Nomex® IIIA 6 oz
  - ASTM F-1930 2.0 Cal/cm² - 3s: 10.70%

PPE Category 2

- 88/12 FRT Cotton Nylon 7 oz
  - ASTM F-1930 2.0 Cal/cm² - 4s: 69.70%
PPE Considerations

**Multiple Hazard Protection**

DuPont Nomex® MHP 7.0oz

- Actual Weight 7.0 oz/sqyd
- Multiple Hazard Protection
- NFPA 2112
- ATPV 8.4 – Category 2
- EN ISO 11611 Class 1 - Small Molten Metal Splatter
- Inherent Nomex® and Kevlar® Based Engineered Blend
- Flame resistant properties not affected by laundering
- Tested to 200 industrial launderings

When Considering PPE Choices, The Fabric Determines Many of the Desirable Garment Characteristics
Summary
Conclusions and Summary

- True Hazard Risks and Consequences Must be Understood
- Perceived Risk can be Much Different Than the Actual Risk
- Hazard Risk Assessments are Required for Each Worksite
- Important to Match Hazard Assessment Methodology to Workplace
- Efforts Should be Expended to Eliminate Hazard Risks
- PPE Fabric and Garments Should Match Assessed Hazards

Comprehensive Hazard Risk Assessment is Imperative for Worker Protection
Thank You
Hazard Assessments

Disclaimer

- “This information corresponds to our current knowledge on the subject and may be subject to revision as new knowledge becomes available. It is your responsibility to investigate other sources of information on this issue that more appropriately addresses your product and its intended use. DuPont Thermo-Man® thermal protection system is based on ASTM Standard F 1930-99 which applies to flame resistant clothing. These conditions may not by typical of the conditions encountered in actual situations. The results of these tests are only predictions of body burn injury under these specific laboratory conditions. These results do not duplicate or represent garment or fabric performance under actual flash fire conditions. The user is solely responsible for any interpretations of the test data provided by DuPont, and included in this material, and for all conclusions and implications made concerning the relationship between mannequin test data and real life burn injury protection. SINCE CONDITIONS OF USE ARE OUTSIDE OUR CONTROL, DUPONT MAKES NO WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE AND ASSUME NO LIABILITY IN CONNECTION WITH ANY USE OF THIS INFORMATION. This data is not intended for use the user or others in advertising, promotion, publication or any other commercial use and is not a license to operate under, or intended to suggest infringement of, any existing trademarks or patents.”

- “Copyright © 2016 DuPont. All rights reserved. The DuPont Oval Logo, DuPont™, ™, Nomex® and Thermo-Man® are registered trademarks or trademarks of E. I. du Pont de Nemours and Company or its affiliates.”