Purdue University

Purdue Process Safety and Assurance Center - P2SAC

The Challenge of Combustible Dust

May 8th 2019

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The first recorded dust explosion was December 14, 1785 in Turin, Italy. A dust explosion involving flour was at Mr. Giacomelli's Bakery Warehouse.

Flour dust said to be drier than normal contacted a lamp intended to help flour handlers see.

2 workers injured.

The 100 years after that explosions continued:

Year	Location	Facility	Dust
1858	Stettin, Poland	Roller Mill	Grain
1860	Milwaukee, WI	Mill	Flour
1864	Mascoutah, IL	Mill	Flour
1869	Germany	Mill	Pea Flour
1887	Hamelin, Germany	Silo	Grain

Fast forward another 100 years

OSHA promulgated its Grain Handling Facilities Standard in 1987 in response to several elevator fires in the 1970's and early 1980's

29 CFR 1910.272

February 2003

REGULATORY REVIEW OF OSHA'S GRAIN HANDLING FACILITIES STANDARD [29 CFR 1910.272] EXECUTIVE SUMMARY

Since OSHA promulgated its Grain Handling Facilities Standard in 1987, working in the grain industry is safer. Comments submitted to the Docket for this Section 610 Review from the Food and Allied Service Trades (FAST), AFL-CIO, stated "... since the promulgation of OSHA's standard in December 1987, explosions were reduced by 42%, the number of injured was reduced by 60% and the number killed was down by 70%"

As Lee Corso would say….

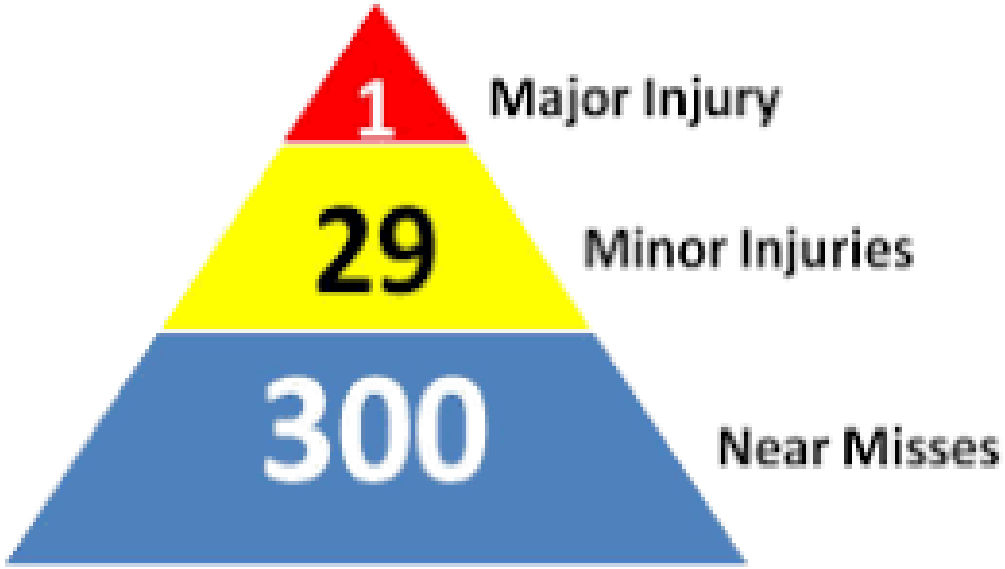
Not so fast!!

- **2006 CSB called on OSHA to develop a combustible dust standard**
- **October 2007 OSHA Combustible Dust Emphasis Program CPL-03-00-008 (Reissued 3/11/08)**
- **Imperial Sugar Feb 2008**
- **Feb 2009 Secretary of Labor Hilda Solis announced the beginning of the rulemaking process for combustible dust. There is still no rule in place ten years later.**
- **AL Solutions in 2010 was one of 9 explosions investigated by the CSB since 2003**

The U.S. Chemical Safety & Hazard Investigation Board estimates that between 1980 and 2012, there were 331 combustible dust incidents, resulting in 148 deaths and 879 injuries.

It is likely that in these cases there were previous incidents or “near misses”.

Heinrich's Pyramid



The Heinrich 300-29-1 Model

Standards and Regulation are Merely a Response to Industry Performance

Since there has been no combustible dust rule from OSHA, they refer to NFPA Standards as the recognized good practice and the way to remediate "general duty clause" citations.

General Duty Clause, Section 5(a)(1) of the Occupational Safety and Health Act of 1970, employers are required to provide their employees with a place of employment that is “free from recognized hazards that are causing or are likely to cause death or serious physical harm."

National Fire Protection Association Standards

NFPA 652 – *Standard on the Fundamentals of Combustible Dust*

NFPA 654 *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*

NFPA 61 *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities*

NFPA 664 *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*

NFPA 484 *Standard for Combustible Metals*

NFPA 68 *Standard on Explosion Protection by Deflagration Venting*

NFPA 69 *Standard on Explosion Prevention Systems*

NFPA 499 *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*

In the EU

Atmosphere Explosible (ATEX Directives)

Directive 99/92/EC – ATEX 137
“The Workplace Directive”

Directive 2014/34/EU (formerly 94/9/EC - ATEX 95)
“The Equipment Directive”

Standards require a Dust Hazard Analysis

Prescriptive approach – set of requirements that allow a gap analysis to be done against NFPA Standards or other recognized good practice.

Risk – based approach – evaluation of scenarios looking at severity of consequence and likelihood of occurrence and whether it meets an acceptable risk tolerance.

Food, Pharmaceutical, and Agricultural Processing more similar than not

Static generation

- Screening
- Vacuum systems for housekeeping.
- Equipment grounding and bonding
- Pneumatic conveying
- Free falling powder
- Moving objects – people or rolling stock

Hot surfaces

- Hot bearings
- Friction from conveyor belt slippage and alignment

Food, Pharmaceutical, and Agricultural Processing more similar than not

Sparks from metal

Hot particles

- Dryers
- Pelletizing
- Product decomposition
- Size reduction

Electrical classification

Food, Pharmaceutical, and Agricultural Processing more similar than not

Administrative policies

- Hot work
- No smoking
- Housekeeping
- Maintenance
- Training
- Procedures
- MOC

The biggest difference may be scale

Standards also require dust exposures to be managed as if they were “PSM covered” processes.

Nearly every industry has dust.

- **Agriculture**
- **Chemicals**
- **Food (e.g., candy, sugar, spice, starch, flour, feed)**
- **Grain**
- **Fertilizer**
- **Tobacco**
- **Plastics**
- **Wood**
- **Forest**
- **Paper**
- **Pulp**
- **Rubber**
- **Furniture**
- **Textiles**
- **Pesticides**
- **Pharmaceuticals**
- **Tire and rubber manufacturing**
- **Dyes**
- **Coal**
- **Metal processing (e.g., aluminum, chromium, iron, magnesium, and zinc)**

Everyone understands the hazard and has for 300 years.

So why do explosions continue to happen?

The challenge for companies is to have risk reduction that is *effective*:

- **Installed safeguards need to work. (ITPM)**
- **Installed safeguards need to be re-evaluated as the process changes. (MOC) process**

A lot of risk reduction is expected from administrative protections such as procedures, training, and housekeeping programs….the least effective protection layer.

And unlike flammable liquids, combustible dust is much harder to control since four sides of the explosion pentagon are nearly always present. Flammable and toxic chemicals typically not a problem until there is loss of primary containment.

Dust Explosion Pentagon

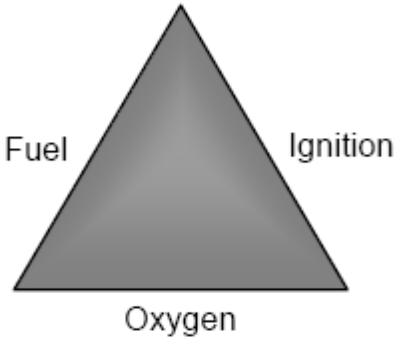


Figure 1. Classic fire triangle

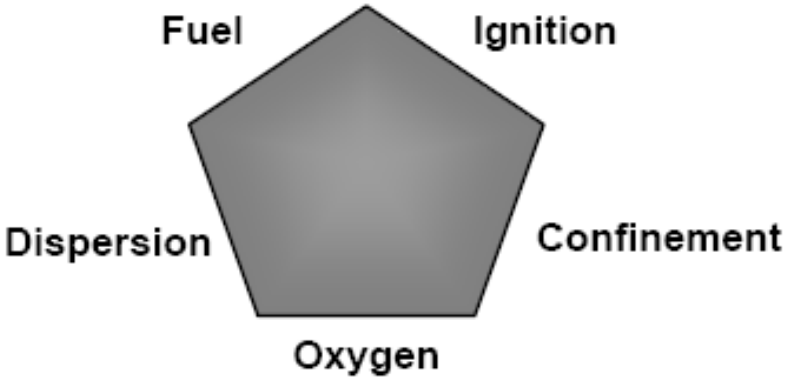
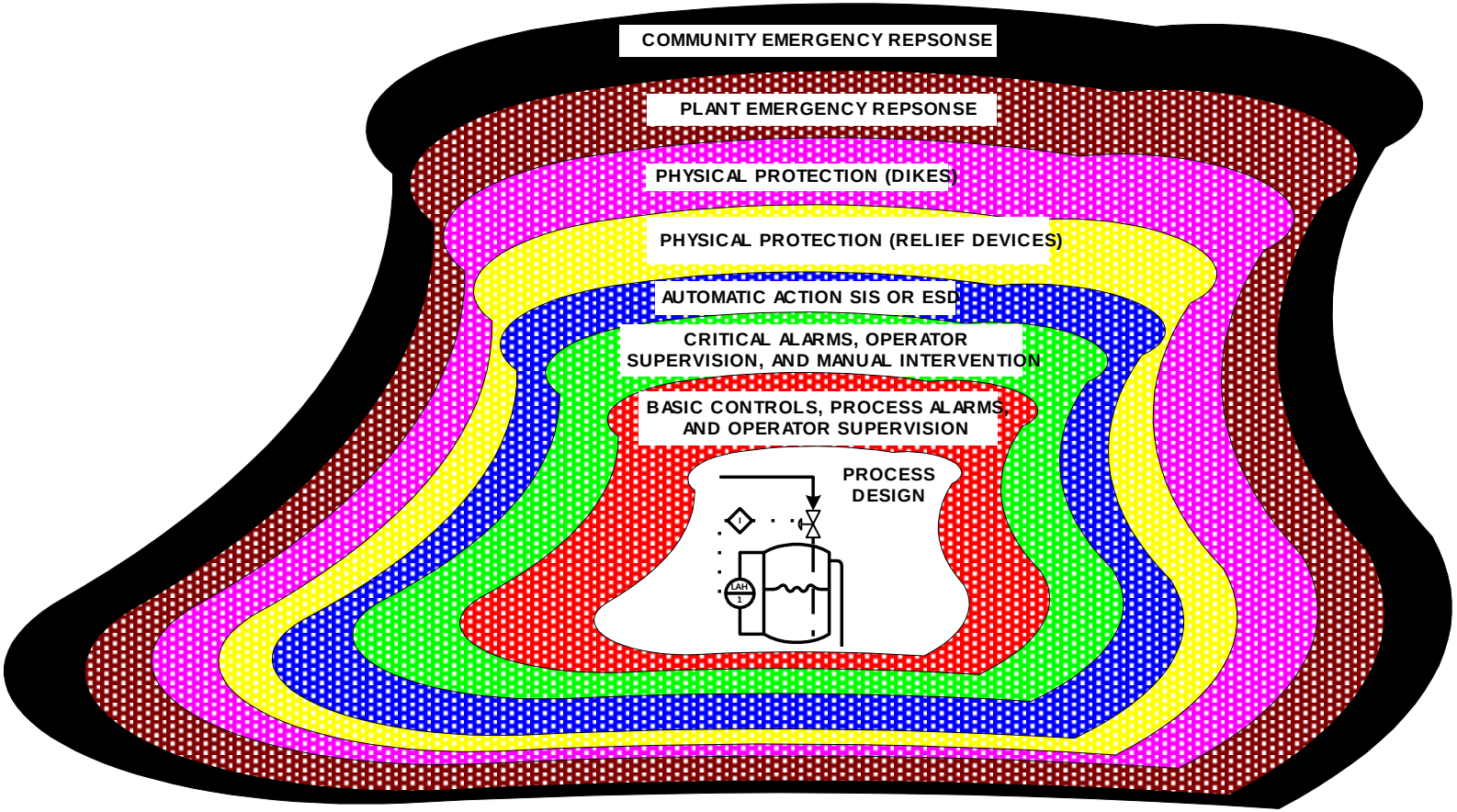
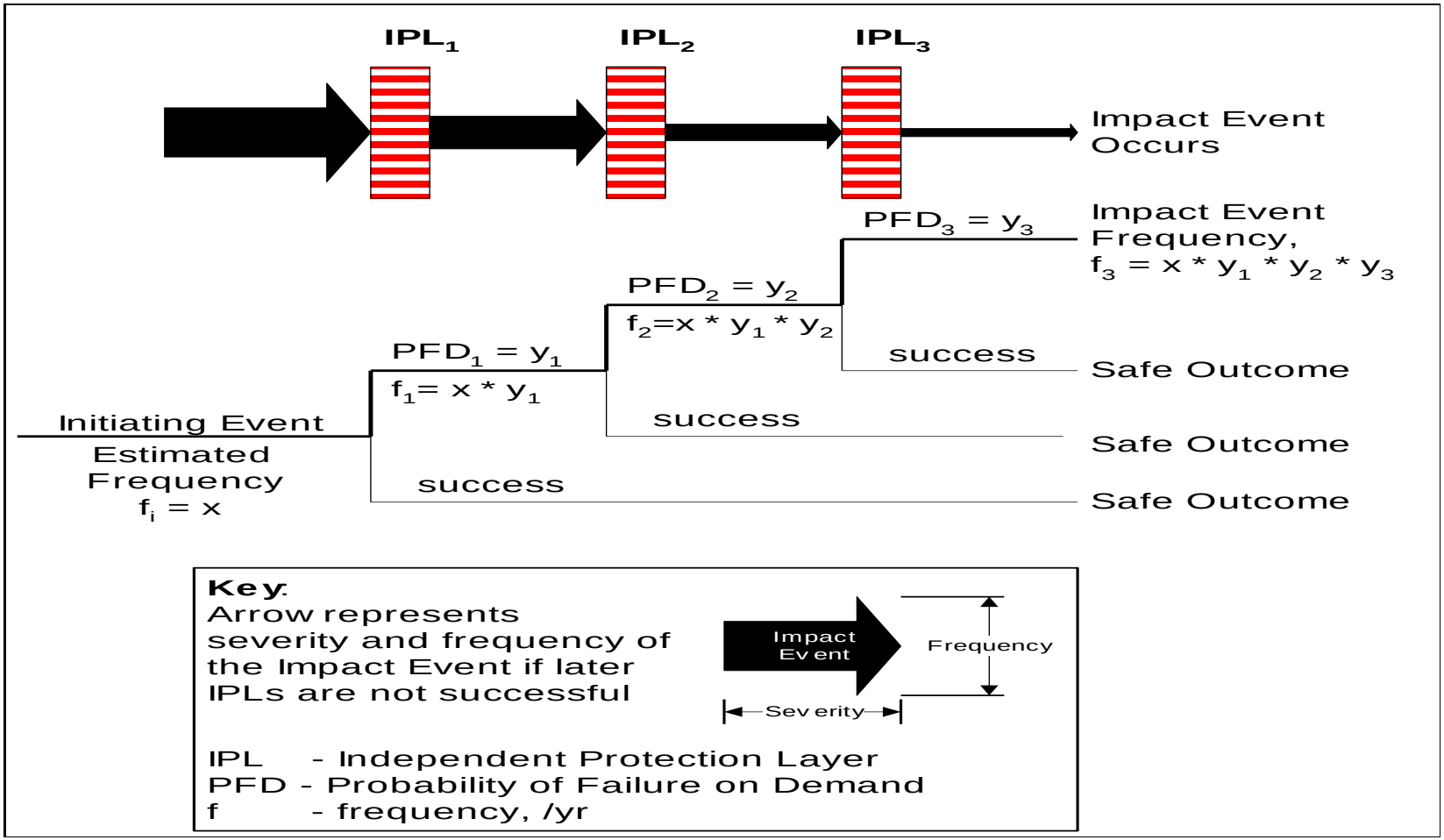


Figure 2. Dust explosion pentagon

Traditional Barriers to Event Escalation



Mitigated Event Frequency



Escalation of Dust Scenarios Is Rather Short

Hot Bearing from ineffective maintenance

- **Initiating Event**
- **High temp alarm with operator response**
- **High temp interlock initiating shutdown**
- **Explosion suppression and isolation**

Piece of metal breaks free inside equipment

- **PM of equipment**
- **Light sensing device with suppression**

And risk reduction needs not only to be effective, but cost effective.

Risk reduction is resource intensive.

Spurious trips of these systems can be very expensive. Unlike the re-seating of a relief valve, the resetting of explosion deflagration devices can cost $10's of thousands per instance.

And risk reduction needs not only to be effective, but cost effective.

If there was a car that cost $500,000 that would never experience a wreck in your lifetime would you buy it? What if it was $300,000?

Would it matter what outcome you are protecting yourself from?

What if have never had a wreck?

What if I couldn't guarantee a once in a lifetime frequency?

Dust Hazard Analysis

Everyone has probably seen the dust explosion pentagon. Analogous to the fire triangle, there are five requirements to have a dust explosion. A dust hazard analysis, or DHA, is a detailed examination of how one or more sides of the pentagon can be removed or controlled if it can't be eliminated. Another part of the analysis in the US is whether the installation has required protections spelled out in NFPA standards.

IGNITION SOURCES – This is typically the only side of the pentagon that has multiple lines of attack.

- Hot work policies to prevent open flames and sparks.
- Grounding and bonding for low MIE (minimum ignition energy) dust
- Electrical classification
- Hazard monitoring systems for hot bearings, friction, misalignment, slippage
- Tramp metal removal
- Light or IR sensing technology to identify hot particles or sparks

DISPERSION – Material being conveyed will be suspended, but it also has to be in a concentration above the minimal explosible concentration (MEC). This side of the pentagon is assumed to be present unless additional testing shows concentrations are below this threshold.

OXYGEN -Unless the process is inerted with nitrogen or other inert gas, oxygen will always be present. Oxygen levels low enough to be below the minimum oxygen content (MOC) are in the 6% to 10% range and present other occupational safety hazards.

CONFINEMENT – Enclosed equipment such as baghouses, dryers and conveyors will always have confinement.

If this leg is removed, there remains the potential for flash fire.

FUEL – If the dust has been characterized as combustible there is no way to remove this side of the pentagon. Good housekeeping programs, however, reduce the likelihood of secondary explosions which are often the most catastrophic.

It is my view that the challenge with combustible dust is that companies are likely to be operating at a mitigated risk level higher than would be expected for flammable and toxic chemicals based on what is viewed as reasonably practicable.

Thank you for the opportunity to be with you today!