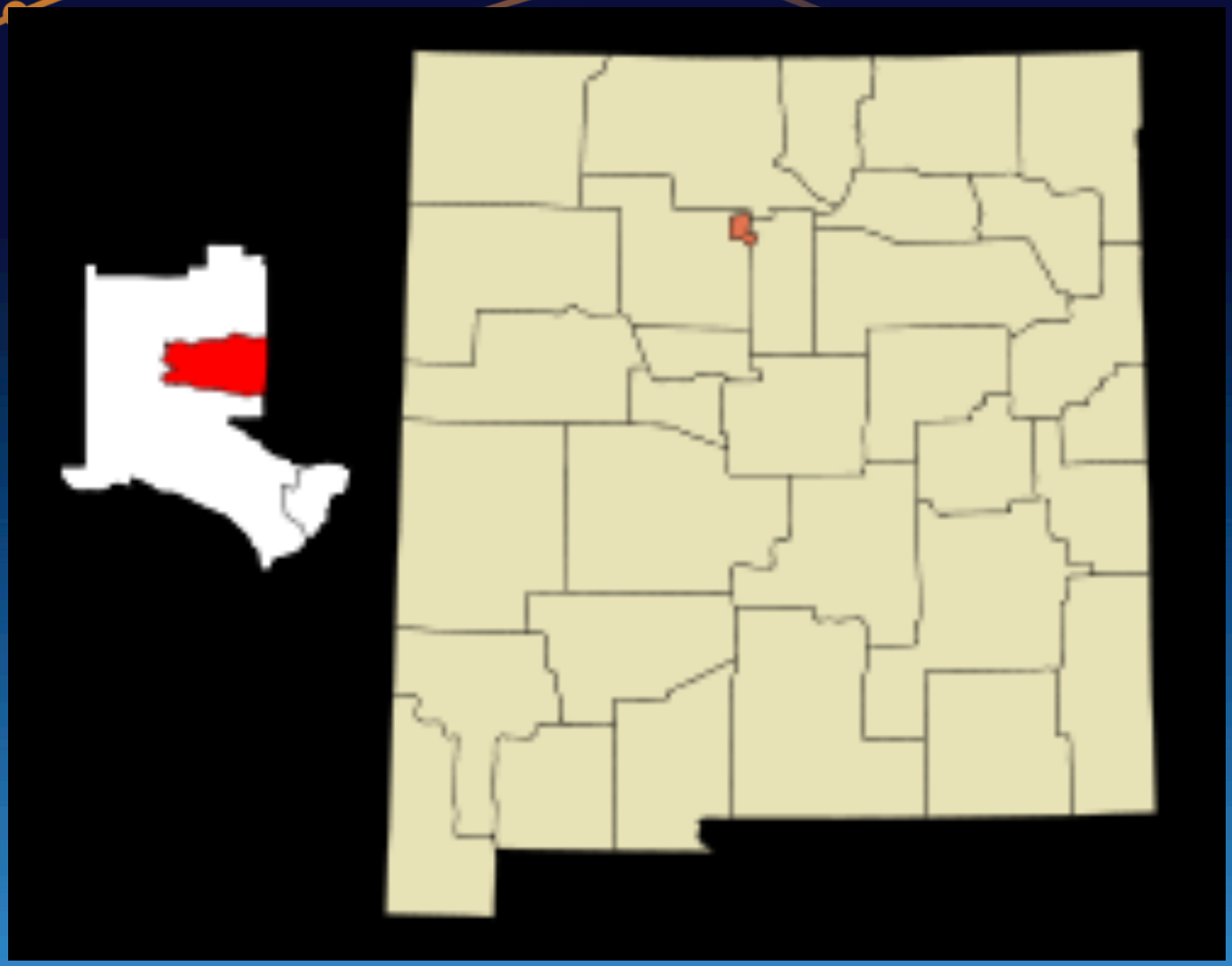
Anatomy of an Incident

Michael E. Cournoyer

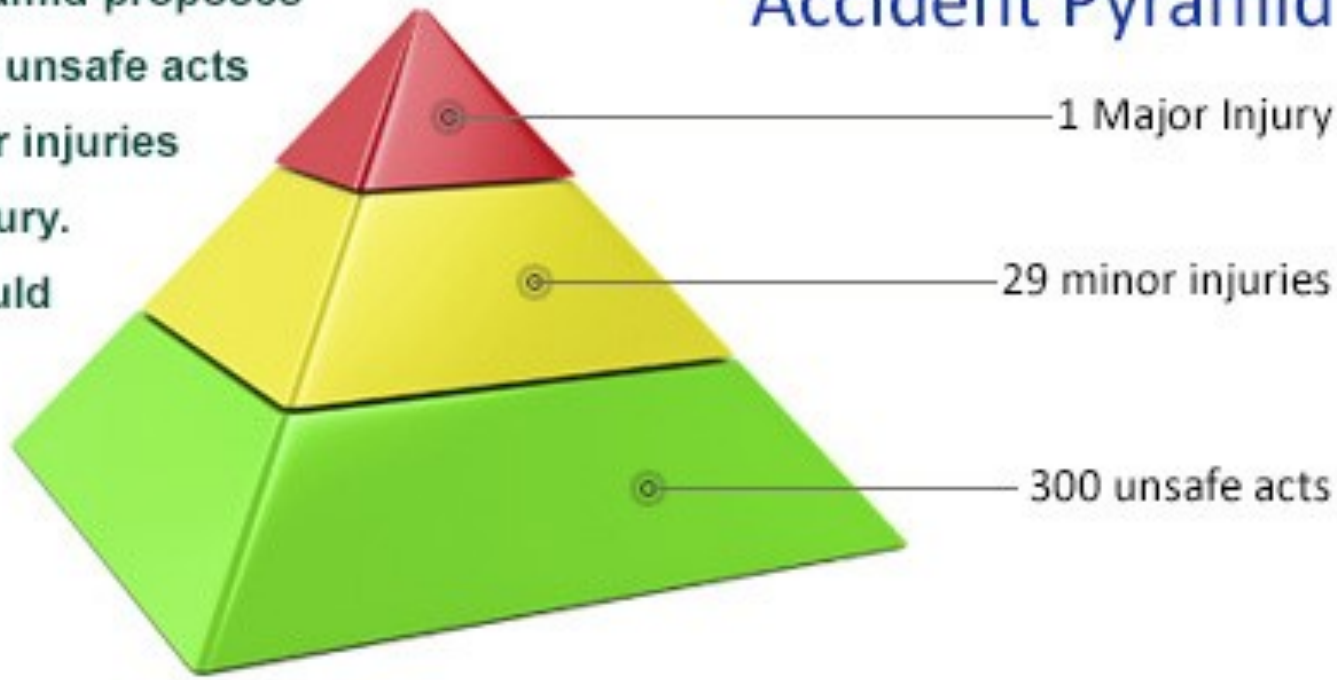
LA-UR-16-20647

March 13, 2016



Accident pyramid

The Accident Pyramid proposes that for every 300 unsafe acts there are 29 minor injuries and one major injury. A major injury could lead to a trip to the Hospital or worse, the morgue



Five-step process of Integrated Safety Management

UNCLASSIFIED

Anatomy of an incident

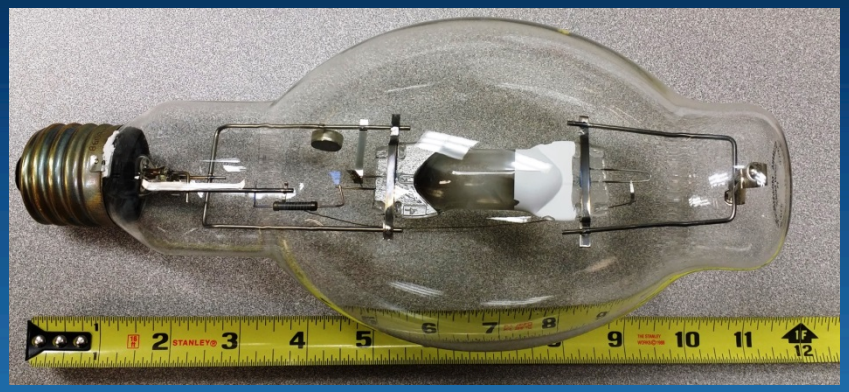
- The incident occurs
- The incident is investigated
- Causal factors are determined
- Conclusions are drawn
- Corrective actions are developed
- Lessons Learned are communicated

The incident occurs

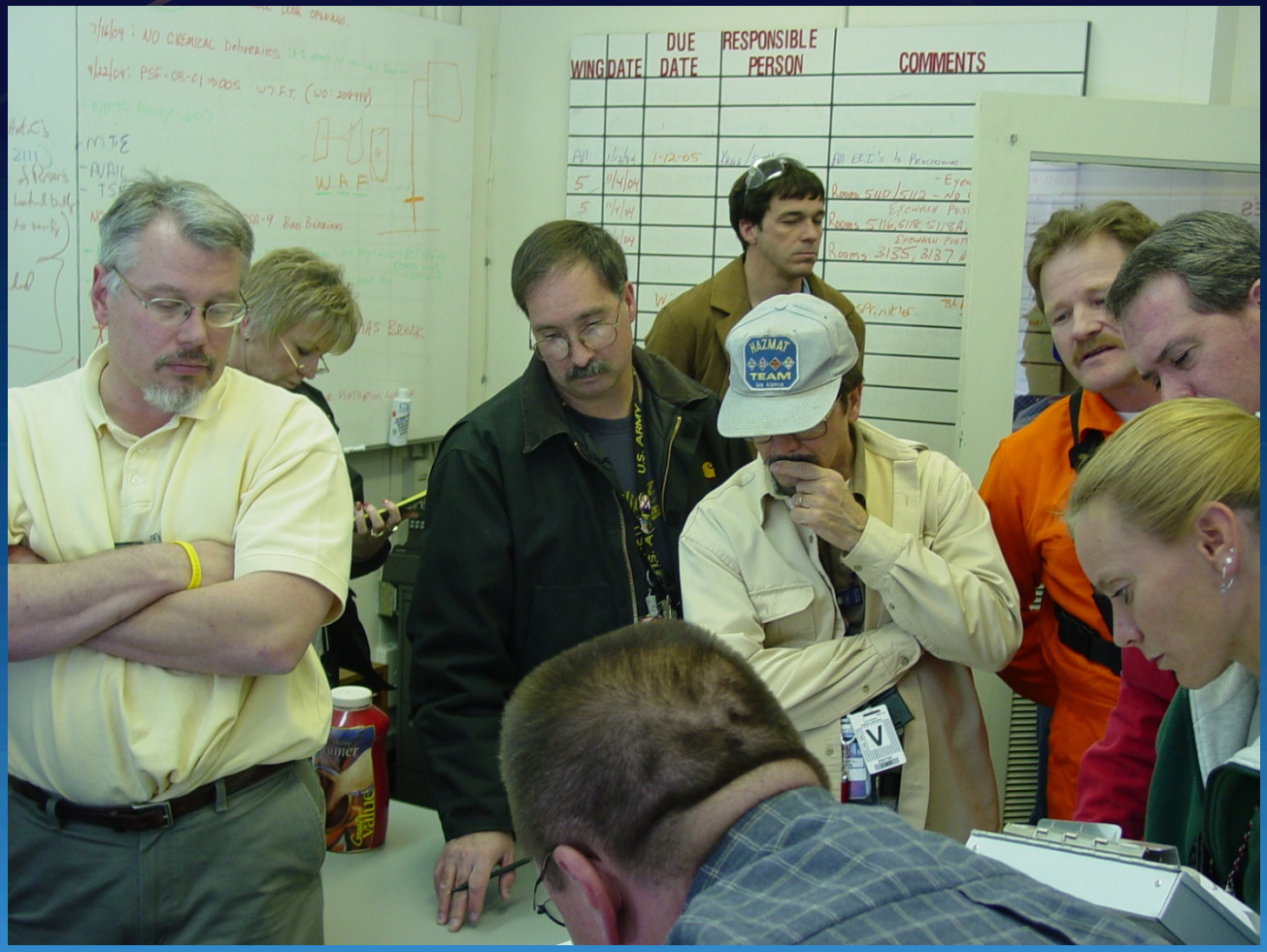
Before

The incident occurs

After



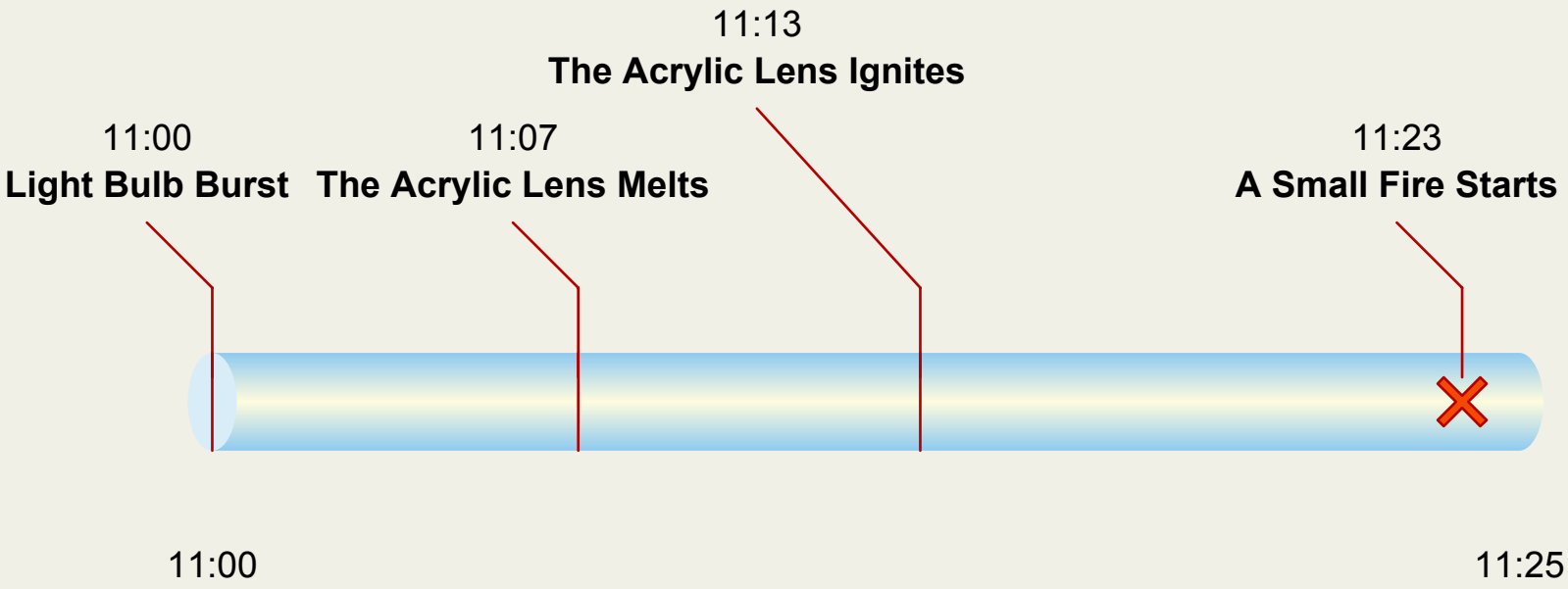
The incident is investigated



The incident is investigated

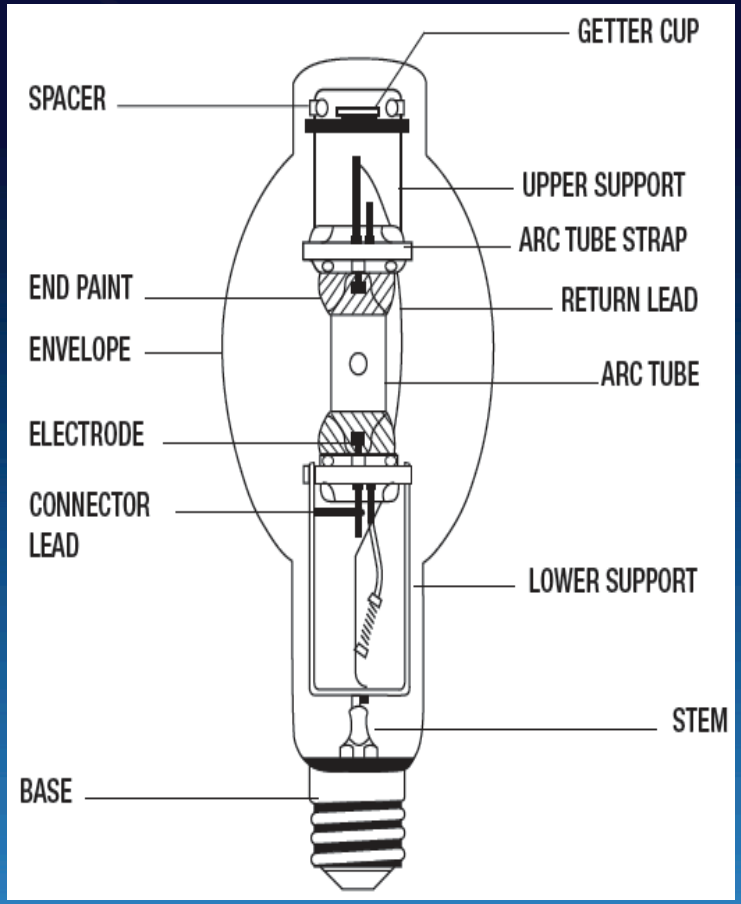
The incident is investigated

NA--LASO-LANL-CHEMLASER-2015-0001: Light Fixture Fire



The incident is investigated

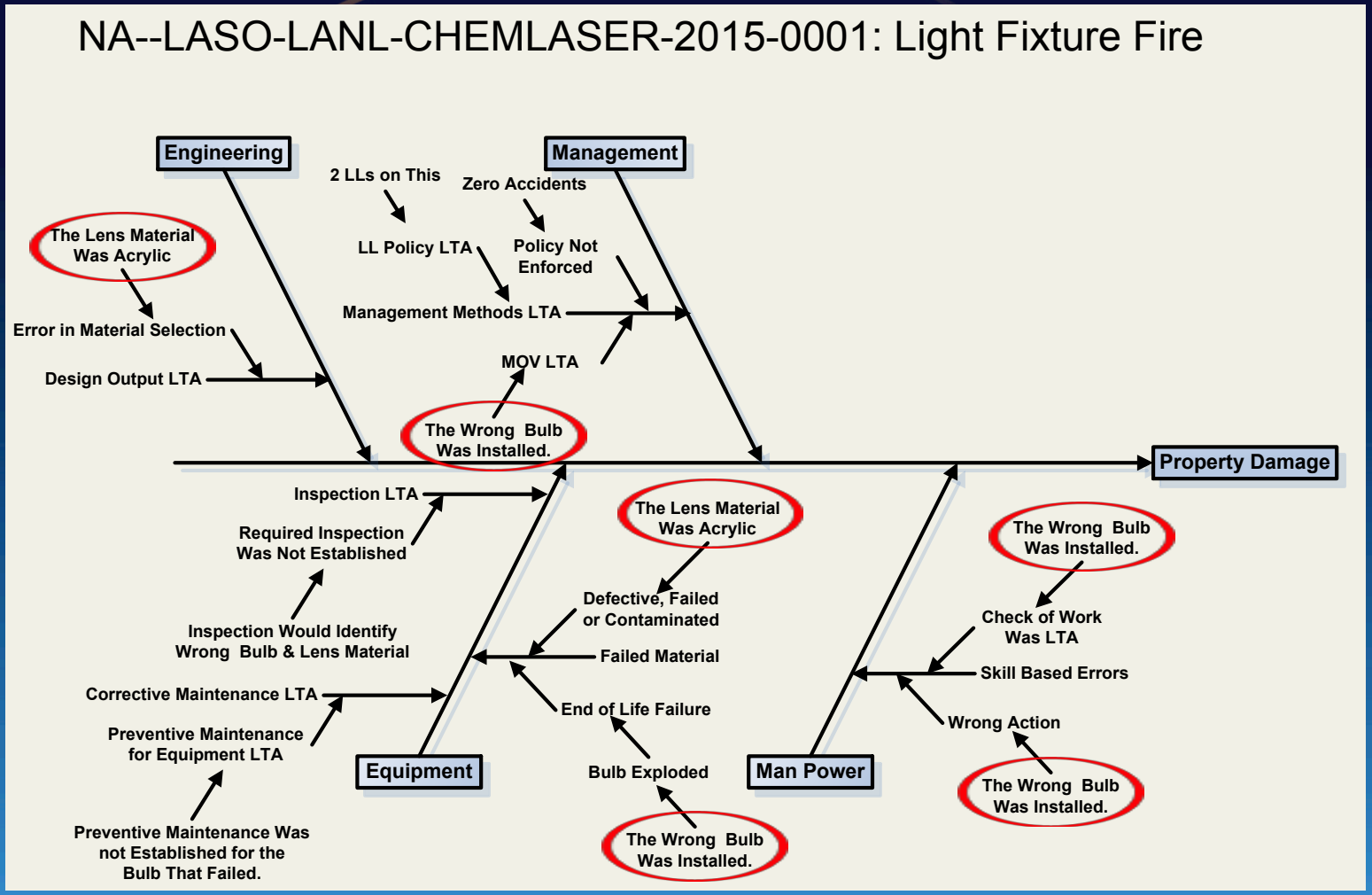
- The metal halide lamp is designed around a sealed tube with an electrode in each end
- The Arc Tube temperature range is between 1000°C and 1300°C
- This type of metal halide lamp (ANSI M59/S) is position dedicated



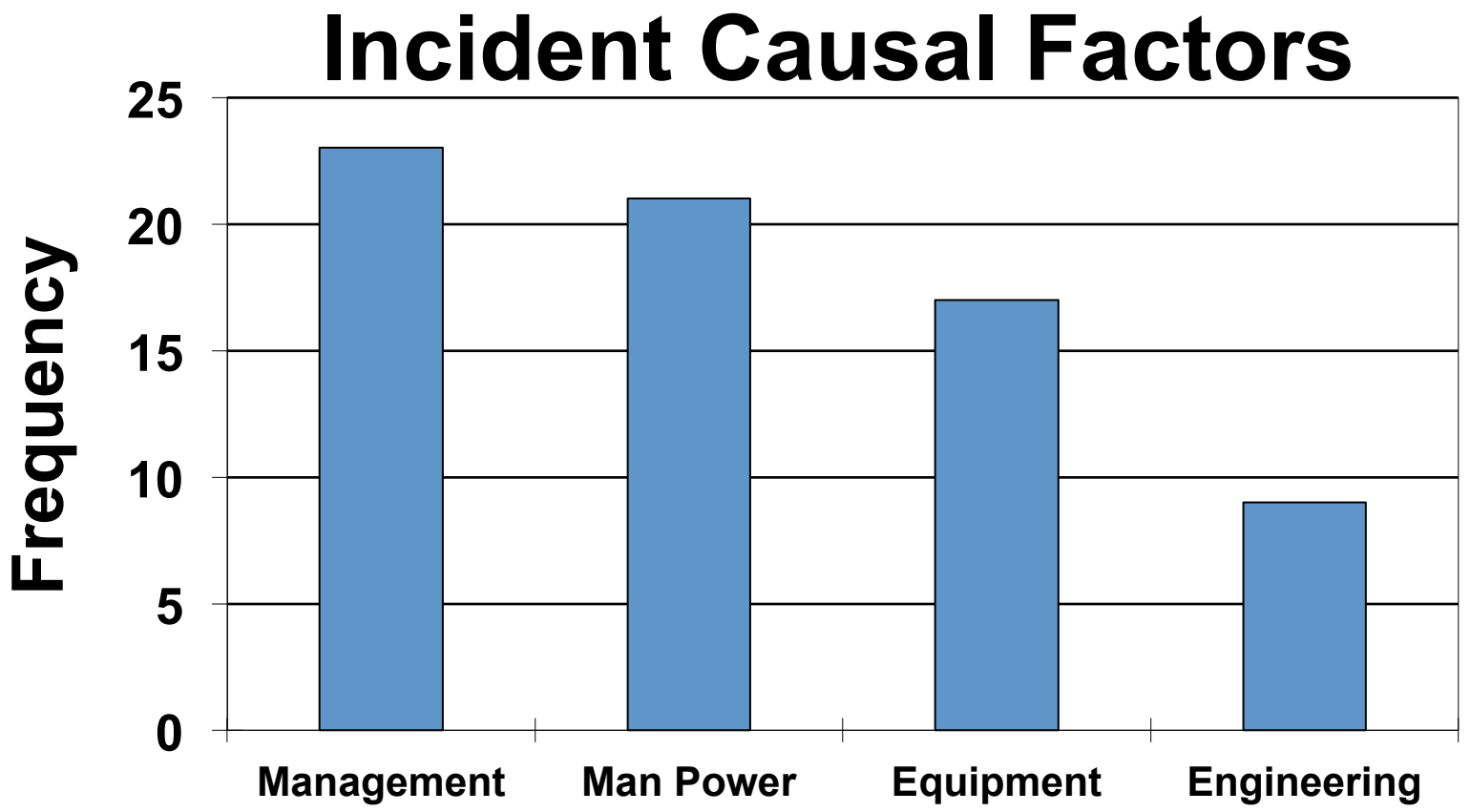
The incident is investigated

- Lamp position is horizontal
- The fixture had an acrylic lens
- The acrylic material has a flash point > 250°C and an Auto-Ignition temperature > 400°C.

Causal factors are determined



Causal factors are determined



Conclusions are drawn

- A wrong metal-halide lamp bulb caused a small fire.
- The acrylic lens material exacerbated the incident.
- The engineer should have required lenses that are compatible with metal-halide lamp.
- The worker should have known that he or she was installing the wrong bulb.

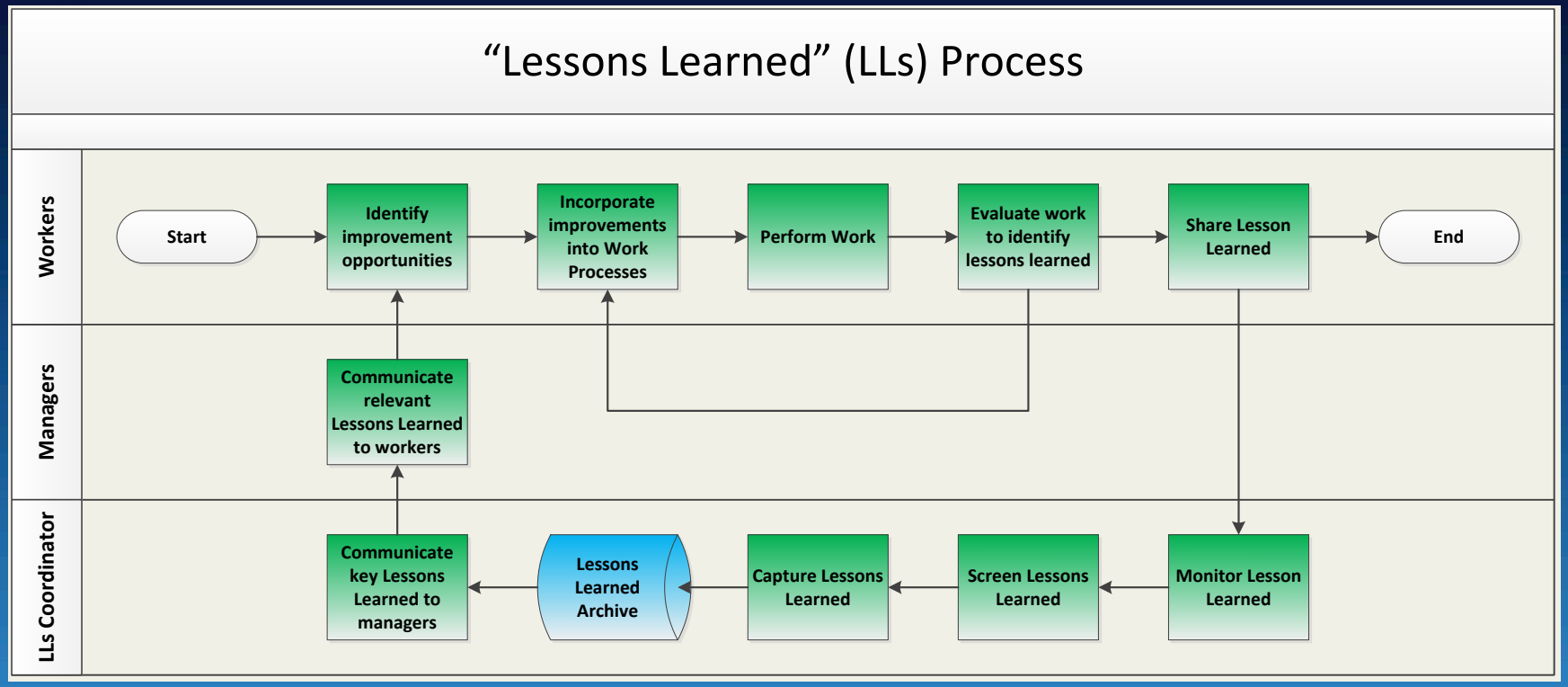
Conclusions are drawn

- The worker's supervisors should have checked the workers task and discovered that the wrong bulb was installed.
- The worker's manager should have monitored the workers task.
- Implementing Lesson's Learned from two previous incidences could have prevented the small fire.

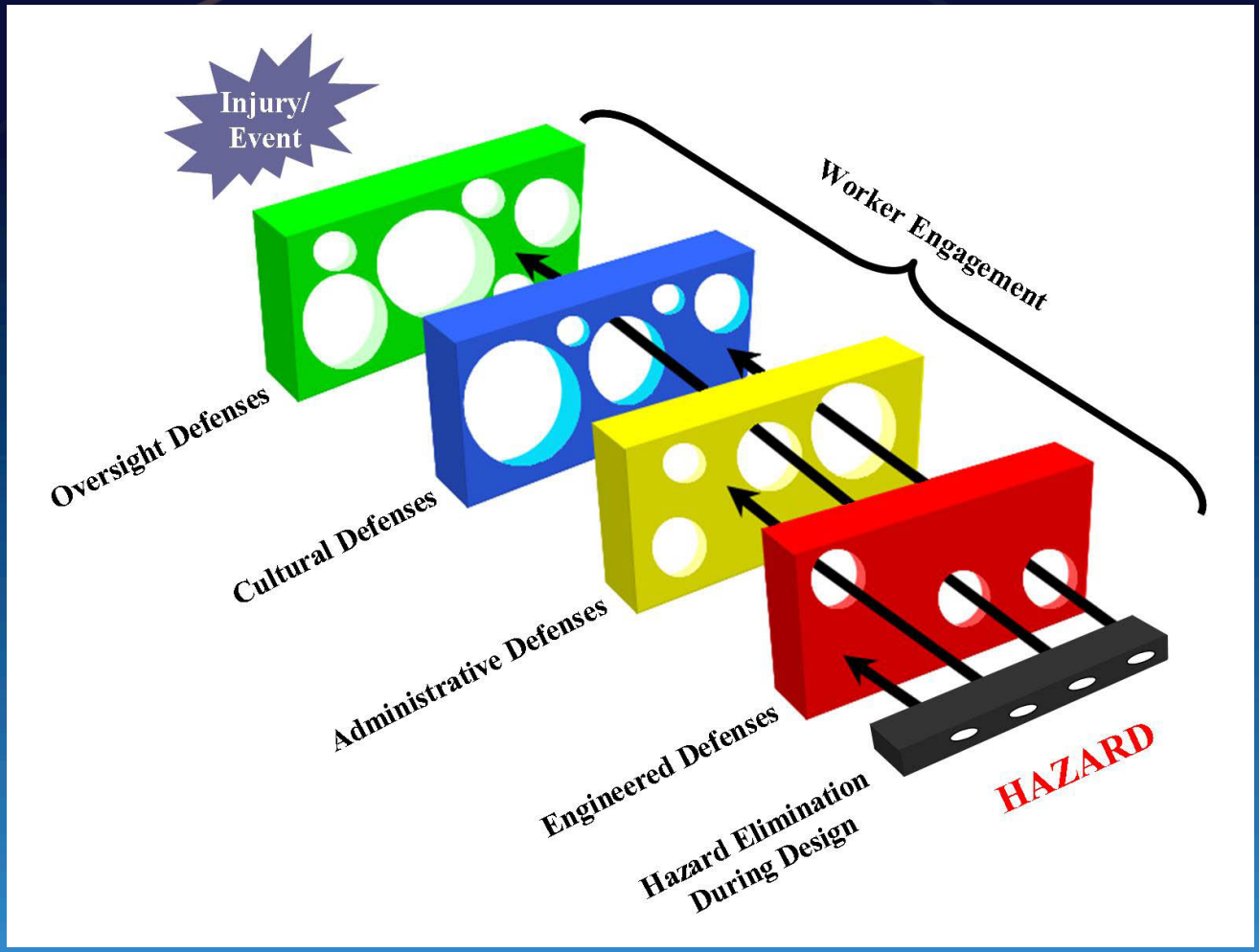
Corrective actions are developed

- Position metal-halide lamp all in one direction
- Store only one type of metal-halide lamp bulbs Replace acrylic lens with lenses that are compatible with metal-halide lamp
- Iterate the importance of management monitoring programs

Lessons Learned integration with work performance



Defense in Depth



Slip simulator training

Year	ADPSM Employees	Total Trained*	With S/T/F Injuries
2011	481	0	8
2012	484	229	8
2013	491	385	5

*None of the Trained Employees Had an Injury

P-Value for a Chi Square Test

$$\chi^2 = \sum_i \sum_j \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

	Injury (Slip, Trip, Fall)	
Trained	**Yes**	**No**
Yes	0	614
No	21	800

X^2 = 15.9385

The P value is 6.5E-05

This result is significant at p < 0.05

The association between rows (groups) and columns (outcomes) is considered to be extremely statistically significant

Lessons Learned integration with work performance

Lessons Learned integration with work performance

- Metal halide light failures - Small fires start when burning diffuser falls to ground, 2012-SR-SRNS-0004, 2012
- Metal halide bulb fails, shatters outer glass envelope, hot glass shard chars wood crate, 2015-FSO-FNAL-022, 2015

Lessons Learned integration with work performance

- Assign a Metal-Halide Lamp Subject Matter Expert (SME)
- Have the Metal-Halide Lamp SME make an inventory of metal-halide lamps
- Have managers perform an inspection of metal-halide lamps in their areas of responsibility

Lessons Learned integration with work performance

- Have the Metal-Halide Lamp SME revise the Metal-Halide Lamp procedure such that corrective actions have been incorporated
- Have the Metal-Halide Lamp SME supervisor review Metal-Halide Lamp procedure

Lessons Learned integration with work performance

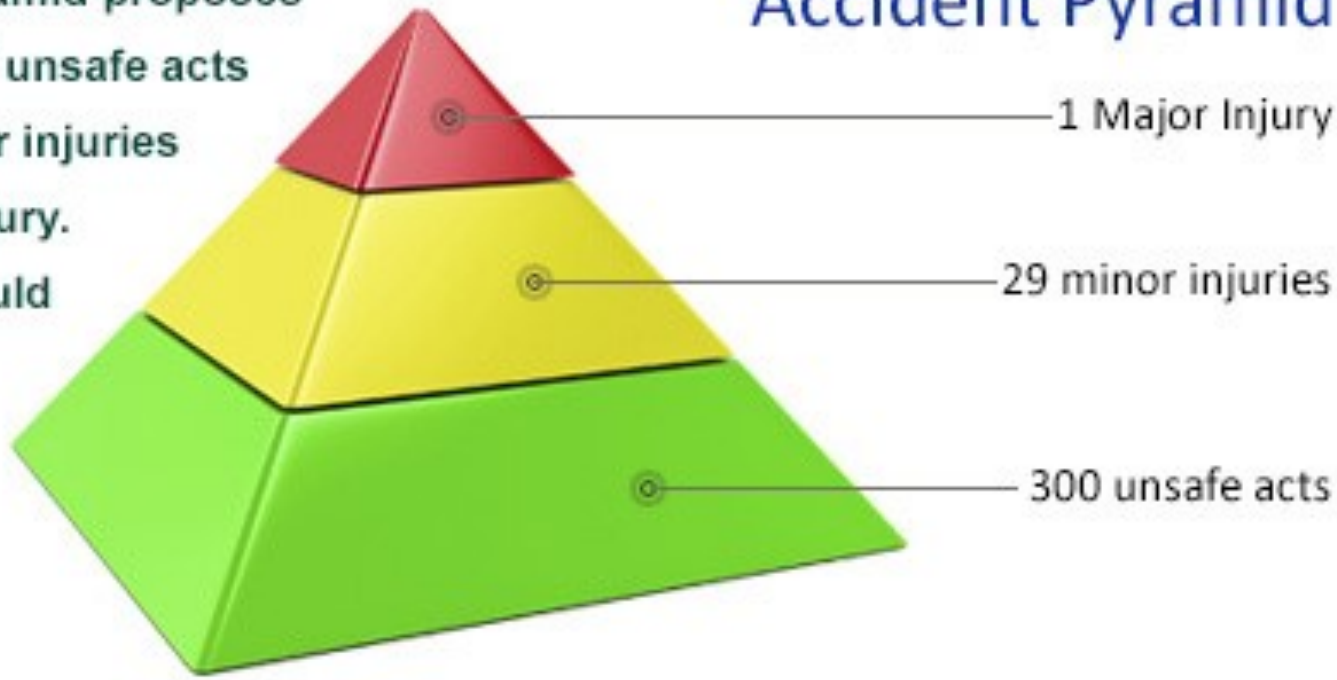
- Replace all metal-halide lamps with light-emitting diode (LED) lamps.
- LED lamps have a lifespan and electrical efficiency that is comparable to metal-halide lamps.
- LED lamps contain no mercury.

Lessons Learned integration with work performance

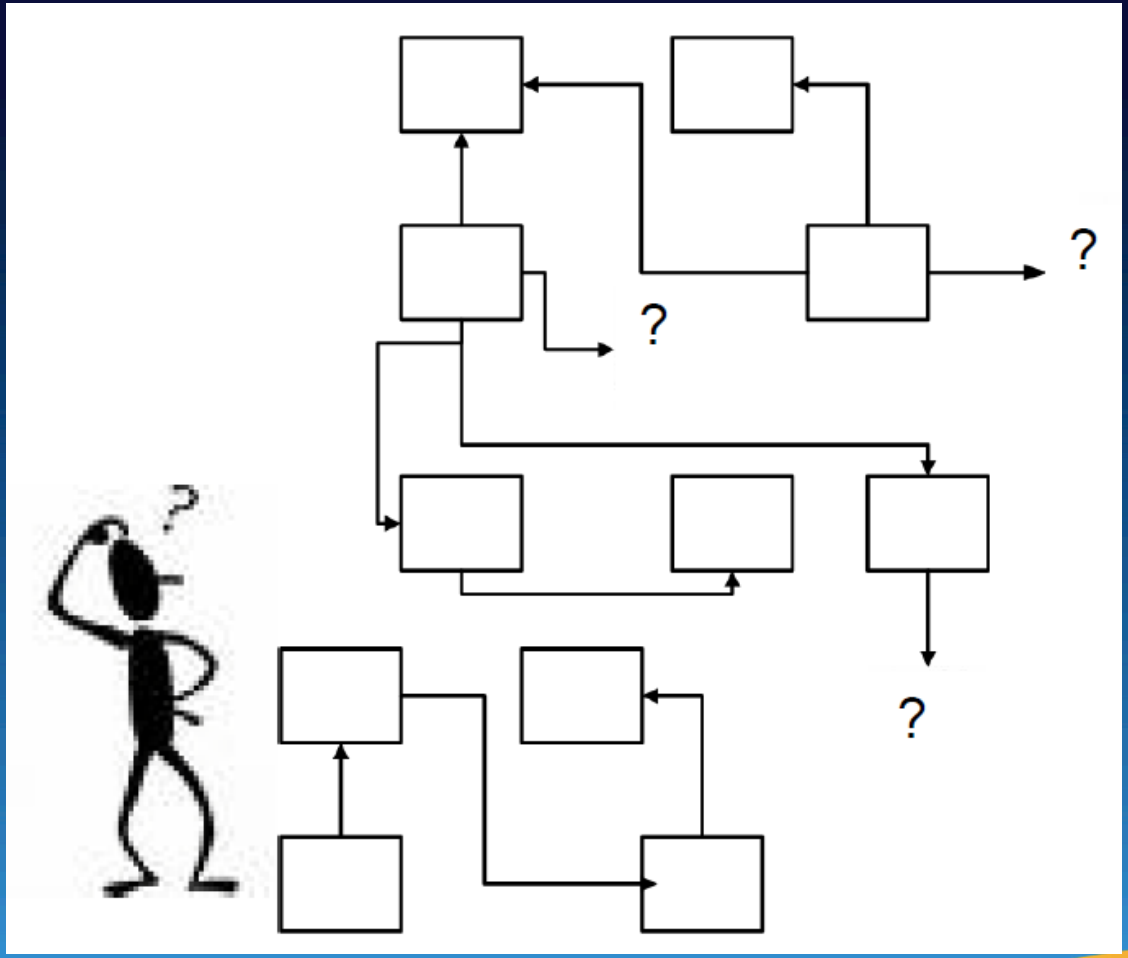
- No ballast bypass or rewiring is required.
- LED lamps operate at < 93 °C, are thermally regulated and may be positioned at any angle. In addition the operating life is 2 and half times longer than metal-halide lamps: 50,000 hr life vs 20,000 hr.

Predicting the future

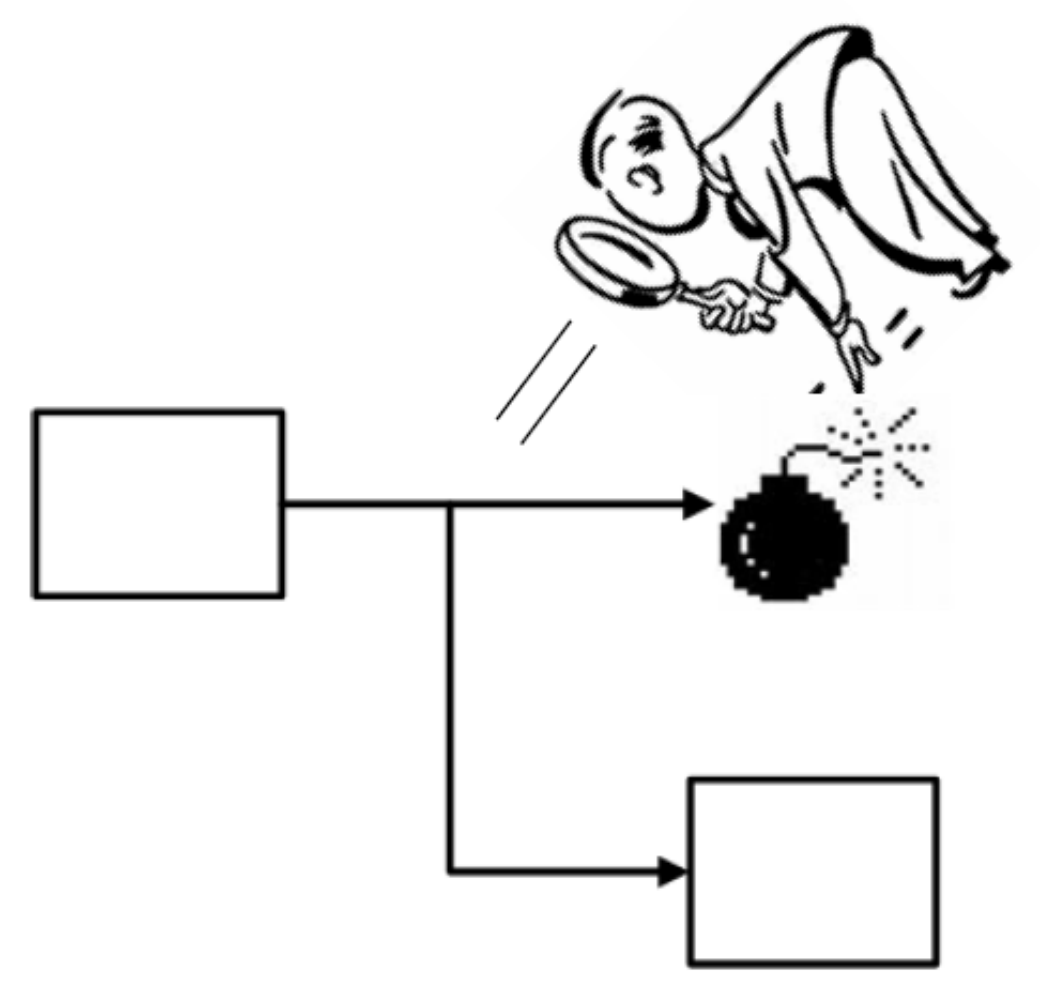
The Accident Pyramid proposes that for every 300 unsafe acts there are 29 minor injuries and one major injury. A major injury could lead to a trip to the Hospital or worse, the morgue



How the people involved saw it before the accident



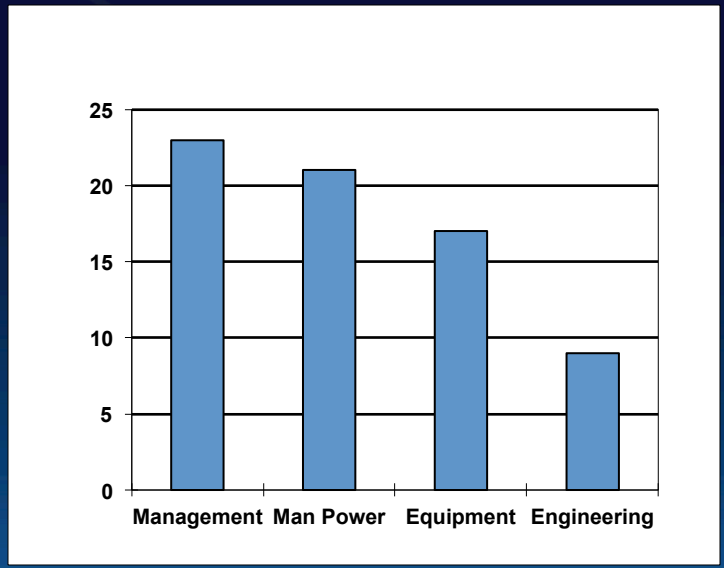
How the investigator sees it after the accident



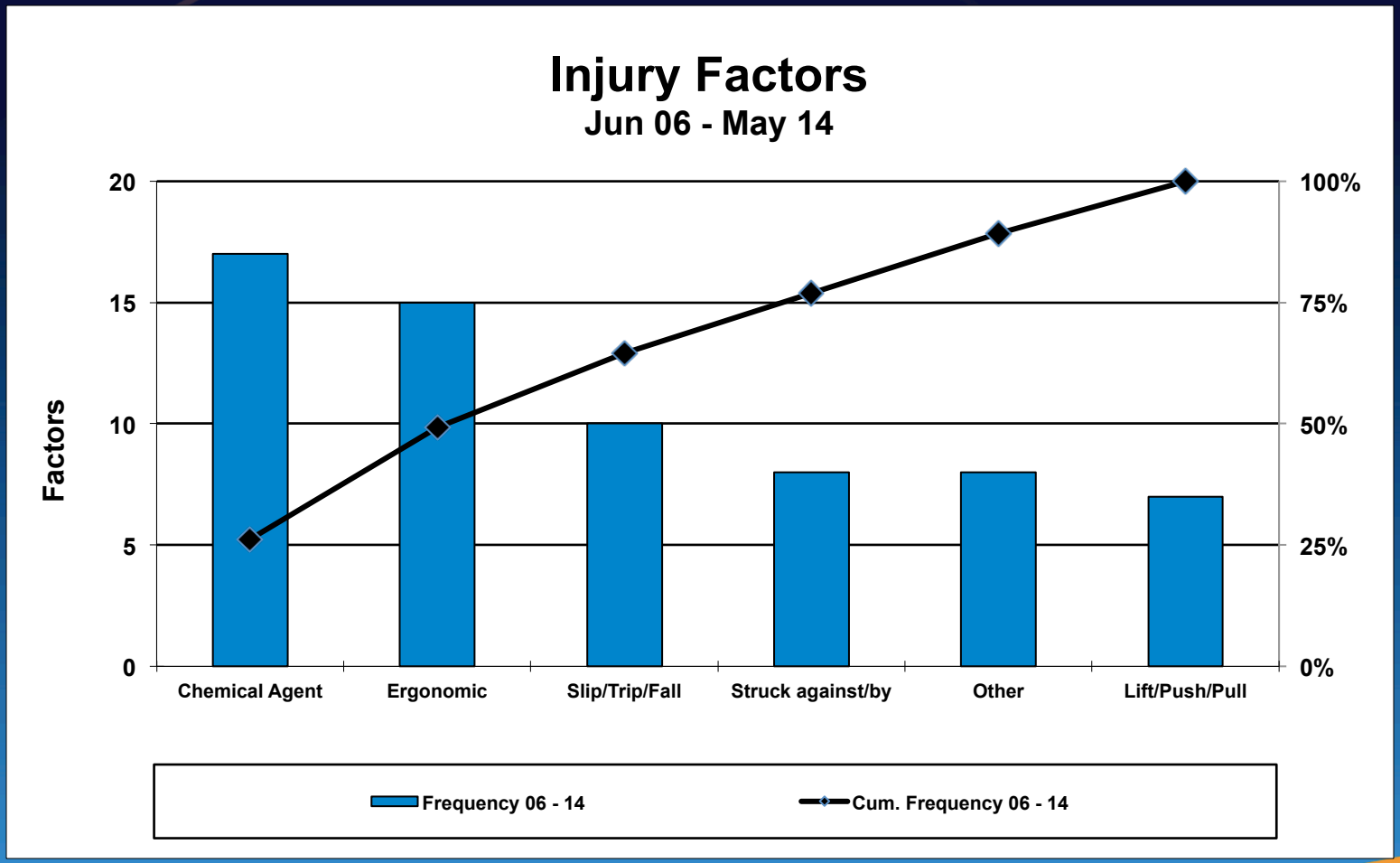
Fire the person who reported It

Latent organizational conditions

- Managers going around telling there workers to be safe is difficult to track.
- Tracking preventive maintenance, safety meeting attendance, and chemical container inventory is easy to track.

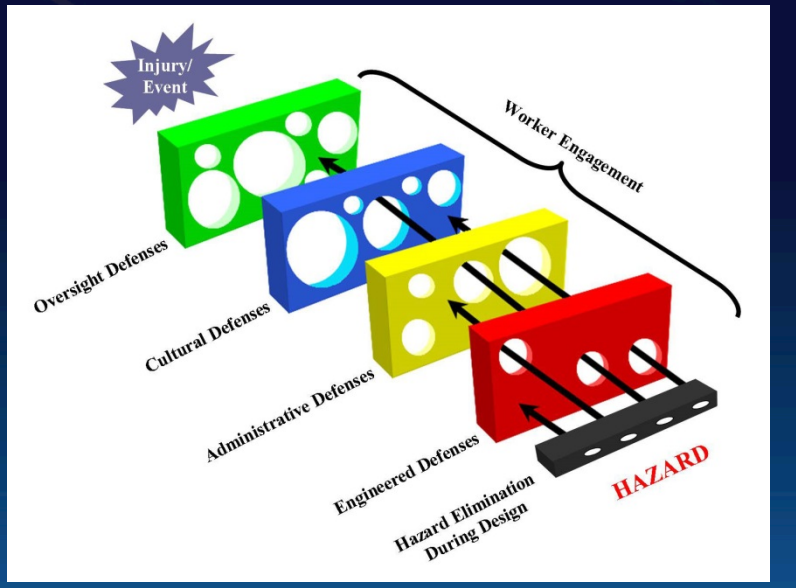


What do you work on first?

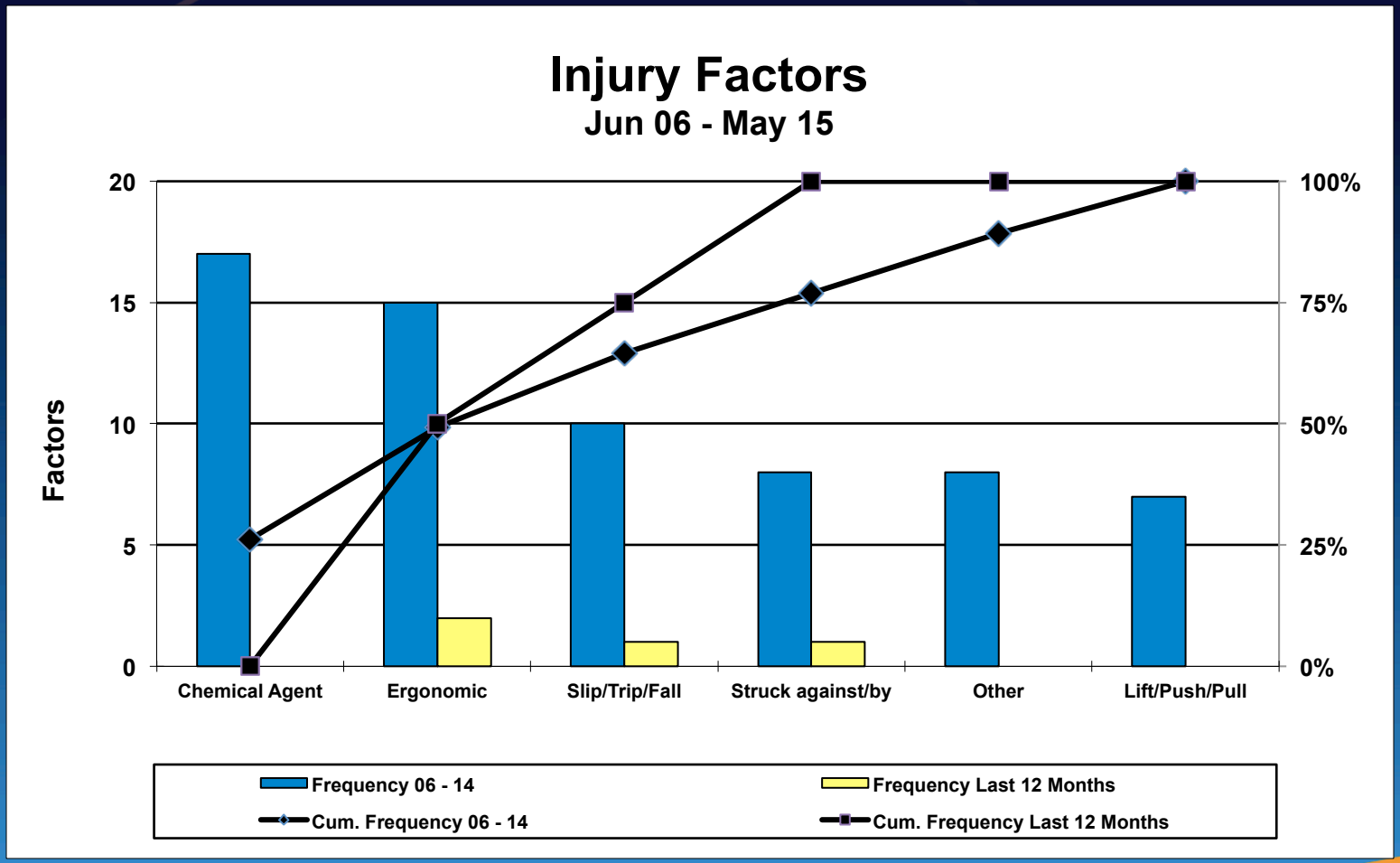


Safety improvements are hard to prove

- Redundant defenses improve safety margins, but also increase complexity.
- Flawed defenses and safety hazards become more difficult to detect.
- Redundant defenses make safety improvements more difficult to identify as well.



Improvement can't be measured



Summary

- A wrong type of metal-halide lamp bulb exploded causing a small fire.
- Latent organizational conditions created error-likely situations and weaken defenses.
- Corrective action included standardizing the type of metal-halide lamp bulbs, replacing acrylic lens with lenses that are compatible with metal-halide lamp, and adding the inspection of metal-halide lamp to management monitoring programs.
- A significant improvement to the task consists of replacement of metal-halide lamps with LED lamps.
- This improvement was shared through a Lessons Learned Program.

Conclusions

- Latent organizational conditions that create error-likely situations and weaken defenses have been identified and controlled.
- Incorporating corrective actions selected from the DOE CAT provide corrective based on decades of incidences.
- Effective improvements have been implemented that reduce or eliminate the risk of another metal-halide lamp fire incidents.
- This increases technical knowledge and augments operational safety.

Acknowledgements

- The author would like to acknowledge the U.S. Department of Energy and LANL's Plutonium Science & Manufacturing directorate for support of this work.
- The author would like to acknowledge James D. Jurney (MET-2) for information on the Light Fixture Fire incident.