U.S. Chemical Safety and Hazard Investigation Board

CSB

Texas Tech University Laboratory Explosion

CSB Webinar

October 19, 2011

Webinar Agenda

- Incident Synopsis
- Key Findings
- Texas Tech Incident Description
- Incident Analysis
- Recommendations
  - Texas Tech University (TTU)
  - American Chemical Society (ACS)
  - Occupational Safety & Health Administration (OSHA)

Incident Synopsis: Laboratory Explosion

- January 7, 2010
- Lubbock, TX
- Texas Tech University Chemistry Department
- 5th-year graduate student
- Detonation during energetic materials synthesis activities
- Loss of three fingers, one eye perforated, burns to hands and face

Key Findings At TTU

- **Systemic safety deficiencies at Texas Tech University**
  - **Physical hazards of chemicals not effectively assessed, planned for, or mitigated**
  - **Insufficient safety management accountability and oversight**
  - **Previous laboratory incidents not documented, tracked, or formally communicated**

Key Findings Beyond TTU

- A lack of comprehensive hazard evaluation guidance directly applicable to the dynamic nature of academic laboratory research
- OSHA Laboratory Standard, 29 CFR 1910.1450, often used as a model for developing laboratory safety programs, is intended to cover exposure health hazards, not the physical hazards of chemicals
- Granting agencies have an opportunity to influence laboratory research safety

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Texas Tech Laboratory Explosion

Incident Description

Research Focus of Work Involved in Incident

- **October 2008 – Northeastern University subcontracts Texas Tech**
  - **Awareness and Localization of Explosive Related Threats (ALERT)**
  - **Department of Homeland Security**
  - **Characterization, detection, mitigation, and response to explosives-related threats**

Incident Description

- December 2009, 5th and 1st year graduate students synthesize NHP (50–300 mg)

- Students observe when NHP is wet with water or hexane it will not explode on impact
- Need enough NHP for analytical tests, but concerned about reproducibility
- Decision to scale up to ~10 g made without consulting PI

Incident Description (cont)

- Clumps appear in scaled-up product
- ~5 grams transferred to mortar, pestle used to "gently" break up clumps
- Student removes goggles before breaking clumps "one more time"

- During this activity, the chemical detonates

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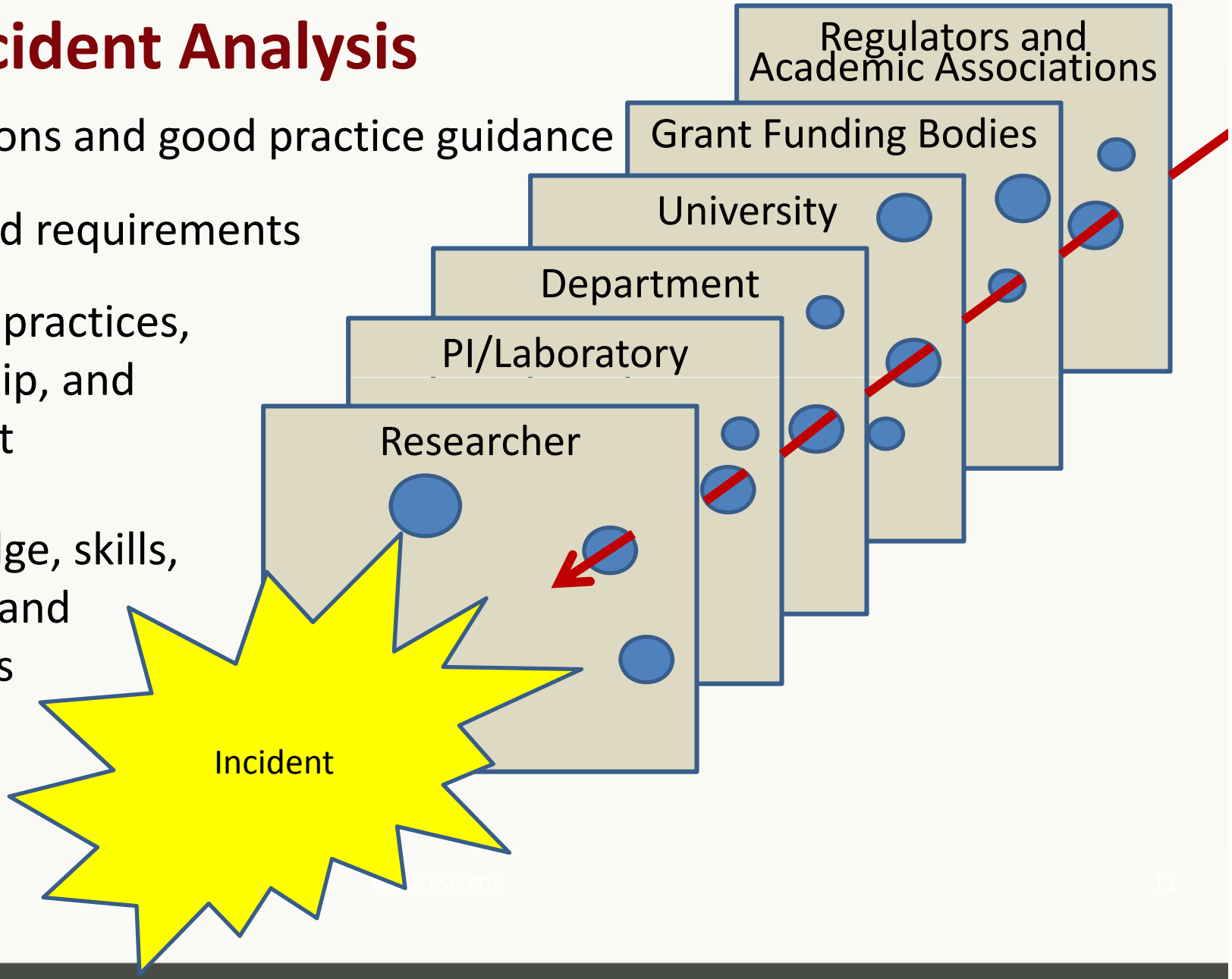
Incident Analysis

Incident Analysis

- Regulations and good practice guidance
- Rules and requirements
- Policies, practices, leadership, and oversight
- Knowledge, skills, actions, and decisions



Policies and Procedures Fail to Influence Safety

- Contract specifications:
  - No approval required for energetic materials
  - Protocol approval required for:
    - human subjects
    - recombinant DNA
    - animal care and treatment
- Texas Tech University operating policies and procedures
  - Chemical Hygiene Plan (CHP) – Policies, procedures and work practices to communicate chemical hazards
  - Handling and Storing Explosives (SOP)

OSHA Laboratory Standard Definitions

Chemical Hazards

Defined by the Laboratory Standard, CFR 1910.1450

Health Hazard

Acute or chronic health effects in exposed workers

- Carcinogens
- Reproductive toxins
- Irritants
- Other exposure type hazards
- Training

Physical Hazard

- Combustible liquid
- Compressed gas
- Explosive
- Flammable
- Organic peroxide
- Oxidizer pyrophoric
- Unstable (reactive)
- Water-reactive

- Laboratory Standard not intended to address all laboratory hazards
- OSHA: Training requirements and other safety regulations would provide employee protection

Not All Physical Hazards Equally Regulated

Chemical Hazards

Defined by the Laboratory Standard, CFR 1910.1450

Health Hazard

Acute or chronic health effects in exposed workers

Physical Hazard

- Combustible liquid
- Compressed gas
- Explosive

Other/Physical Hazards

- Ergonomic
- Ionizing radiation
- Non-ionizing radiation
- Noise
- Electrical
- Falls

Chemical Physical Hazards Not Managed at TTU

Safety Element	Policy	Health Hazards	Physical Hazards of Chemicals
Pre- approval of procedures	CHP	✓	
Written procedures	CHP	✓	
Perform hazard determination	CHP	✓	
Standard operating procedures	CHP	✓	
Communication of hazards	CHP	✓	
Protective apparel	CHP	✓	
Training on hazards	CHP	✓	✓
Training on handling through approved facility	SOP		✓
Document material usage	SOP		✓

OSHA Coverage of Academic Institutions

- Texas Tech University voluntarily implementing a Chemical Hygiene Plan (CHP)

Universities Required to Follow OSHA Regulations		
Type	**Federal OSHA**	**State OSHA**
Private	✓	✓
Public		✓

- Of 120 incidents in CSB database ~1/2 are public universities in Federal OSHA states
- Many of them site the OSHA Laboratory Standard as guidance for creating a CHP

Lack of Safety and Research-Specific Training at TTU

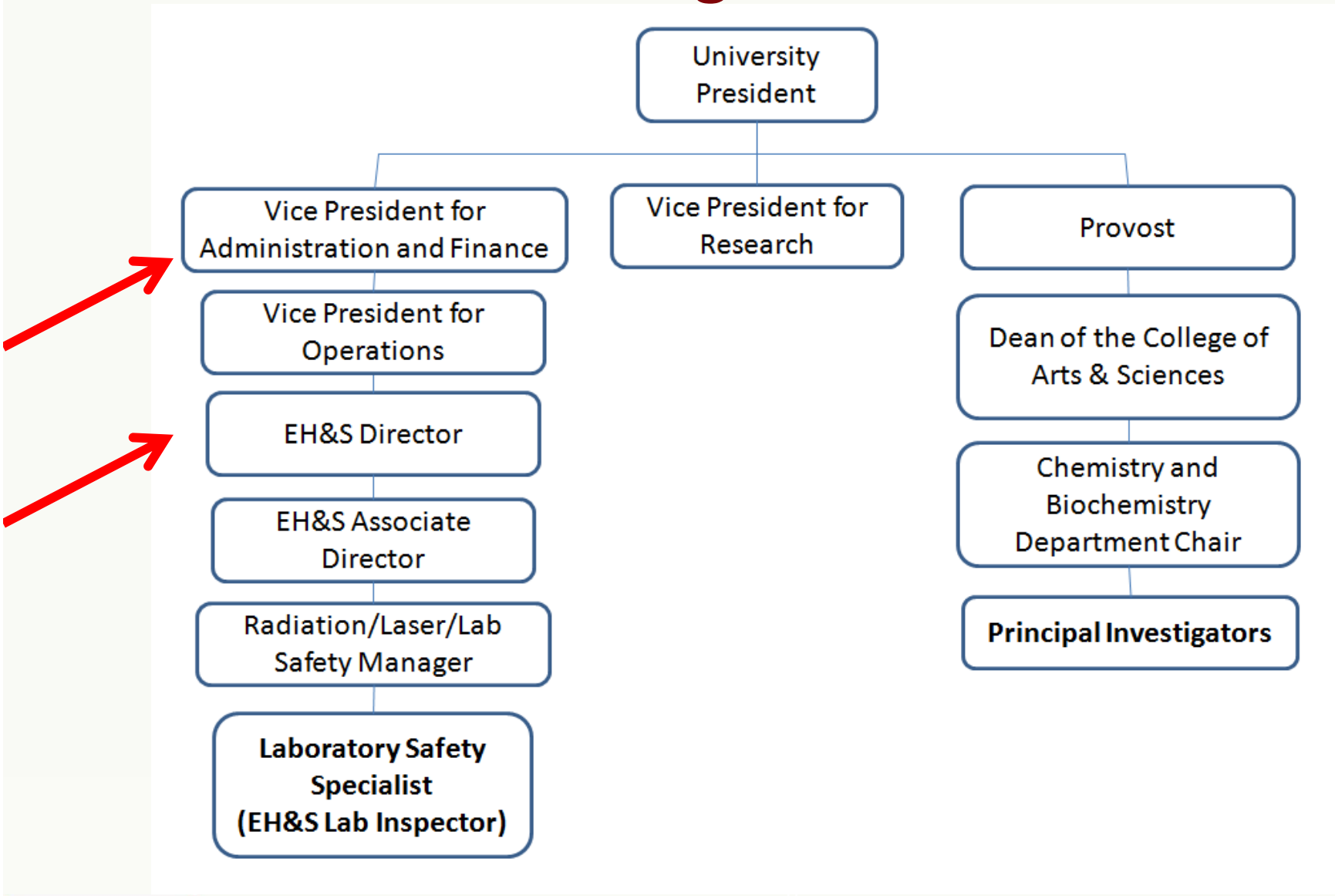
- General safety training
  - No general EH&S safety training since 2002
  - No one in charge of tracking or ensuring training occurring
  - TA's received the same general lab safety training as undergraduate students

- Laboratory-specific training
  - PI to ensure training for materials is adequate
  - No formal training for working with energetic compounds
  - Graduate students independently completed literature reviews prior to beginning work

Insufficient Safety Accountability and Oversight at TTU

- University safety policies not enforced
- Findings and recommended safety changes resulting from EHS inspections not consistently enforced
- Organizational structure inhibited safety improvements

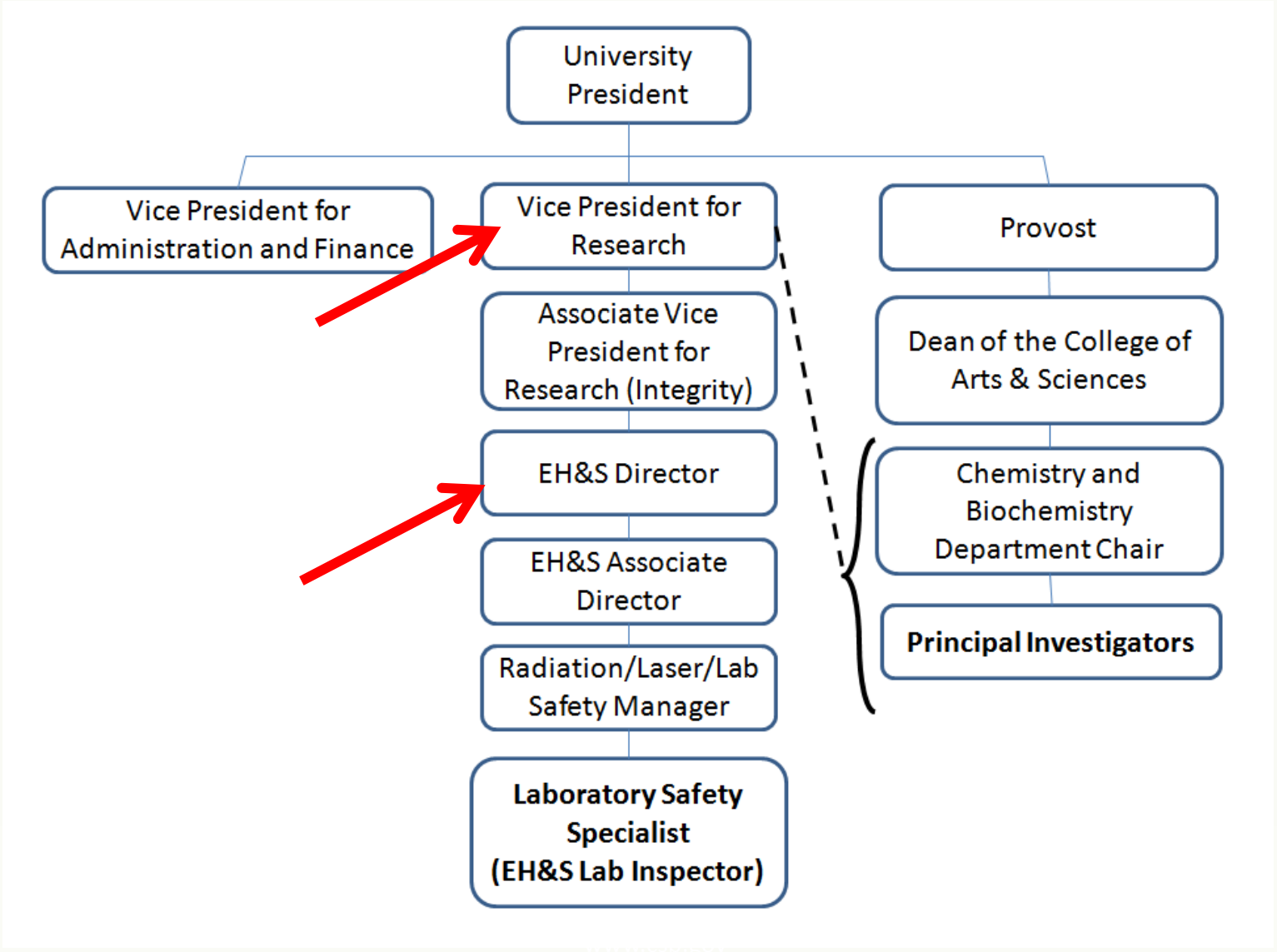
Pre-Incident Organizational Chart



Insufficient Safety Accountability and Oversight at TTU

- University safety policies not enforced
- Findings and recommended safety changes resulting from EHS inspections not consistently enforced
- Organizational structure inhibited safety improvements
- Individual PIs determined the extent of safety policies and practices within their labs

Post-Incident Organizational Chart



Lack of Formal Communication at TTU

- Safety critical information provided verbally
  - 100 mg synthetic limit
  - Assumed senior students would convey information down
  - Students believed they should only work with “very small amounts” of material
- Group meetings
  - Focused on experimental results
- Lab notebooks
  - Varied greatly—some documented only new discoveries, some daily work activities
  - Not consistently reviewed by PIs

Incident/Near Misses Not Reviewed for Safety Improvement at TTU

- Incident 1: Production of excess nitrogen
  - Reaction that began to make loud banging noises
  - Student was frightened and left the scene
  - Building cleared and local fire department responded

- Analyze the safety management system
  - Was training sufficient?
  - Was an adequate hazard evaluation completed?
  - Was the worse-case scenario planned for?
  - How will research activities be communicated to emergency responders if the responsibly party is not able to provide them?

Incident/Near Misses Not Reviewed for Safety Improvement at TTU (cont.)

- Incident 2: Inadvertent scale up
  - Unintentionally used wrong units of measure and created an excess of a known energetic material
  - Error was made known when reported at a group meeting

- Analyze the safety management system
  - Did student feel comfortable acknowledging the error?
  - How long did it take for the scale up to be reported?
  - Could a written procedure have reduced the chances of the scale-up?
  - Why did the 30 grams of energetic material not detonate? Was it luck or did some other safety system work?

Near Misses Not Reviewed for Safety Improvement at TTU (cont.)

- No formal tracking and recording system for incidents and near misses
- Not all graduate students aware of the previous scale-up incident
- No assessment of incidents, at the laboratory, department, or university level, was made at TTU to identify appropriate safety changes
- Safety metric to measure status or improvement
  - Reporting needs to be encouraged
  - Need to train workers to identify near misses

Hazard Determination Not Completed at TTU

- No hazard evaluation of scale up or effectiveness of hexane to mitigate explosive nature of compound
- CHP indicates PI will complete hazard determination
  - Does not define what it should include
  - Does not indicate who will be responsible for determining it has been completed
  - Students should be involved with hazard evaluation
- Lack of hazard evaluation guidance for academic environment
- Hazards can vary widely among different labs and within a lab itself

Example Industrial Hazard Evaluation Tool

○ Not Recommended

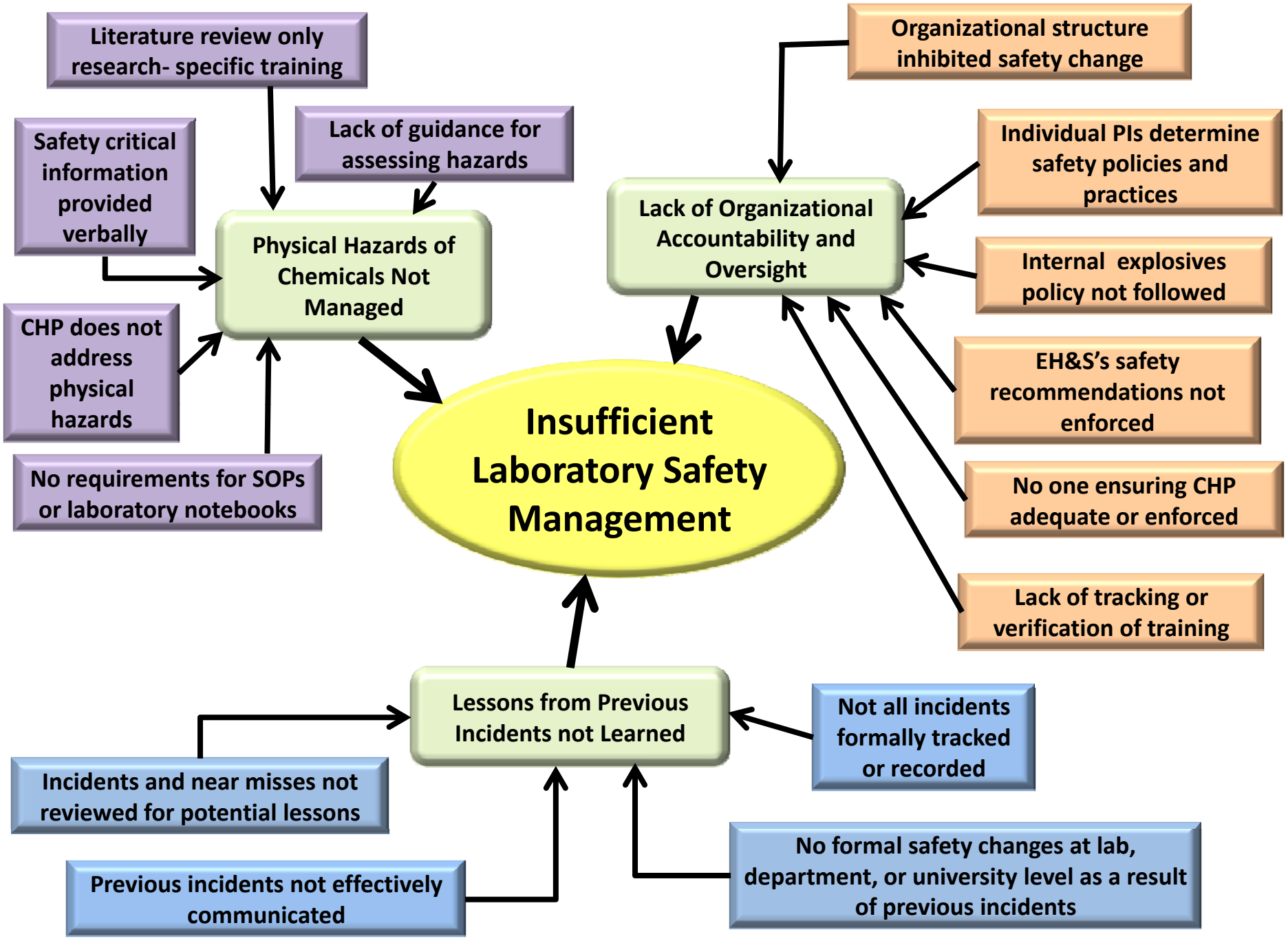
● Recommended

	Safety Review	Checklist	Relative Ranking	Preliminary Hazard Analysis	What-If	What-If /Checklist	HAZOP
R&D	○	○	●	●	●	○	○
Pilot Plant Operation	○	●	○	●	●	●	●
Construction/Start-up	●	●	○	○	●	●	○
Routine Operation	●	●	○	○	●	●	●
Modification	●	●	●	●	●	●	●
Incident Investigation	○	○	○	○	●	○	●
Decommissioning	●	●	○	○	●	●	○

Abbreviated from: CCPS. *Guidelines for Hazard Evaluation Procedure;* 3rd ed.; Center for Chemical Process Safety/AIChE, 2008.

Safety Influence of the Grant Funding Agency

- DHS is one of 19 federal agencies that collectively provide over $25.3 billion for academic research
- Post incident implementation - Research Safety Plan
  - Identify research hazards
  - Research protocols/practices conform to accepted safety principles
  - Processes and procedures comply with the applicable protocols and standards
  - Processes and procedures prevent unauthorized activities
  - Faculty oversees student researchers
  - Develop safety culture through education and training
  - Independent review of the safety protocols and practices


Literature review only research- specific training
Safety critical information provided verbally
Lack of guidance for assessing hazards
Physical Hazards of Chemicals Not Managed
CHP does not address physical hazards
No requirements for SOPs or laboratory notebooks
Organizational structure inhibited safety change
Individual PIs determine safety policies and practices
Lack of Organizational Accountability and Oversight
Internal explosives policy not followed
EH&S's safety recommendations not enforced
No one ensuring CHP adequate or enforced
Lack of tracking or verification of training
Insufficient Laboratory Safety Management
Lessons from Previous Incidents not Learned
Not all incidents formally tracked or recorded
Incidents and near misses not reviewed for potential lessons
No formal safety changes at lab, department, or university level as a result of previous incidents
Previous incidents not effectively communicated

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Recommendations

Recommendation to OSHA

2010-5-I-TX-R1

Broadly and explicitly communicate to the target audience of research laboratories the findings and recommendations of the CSB Texas Tech report focusing on the message that while the intent of 29 CFR 1910.1450 (Occupational Exposure to Hazardous Chemicals in Laboratories Standard) is to comprehensively address health hazards of chemicals, organizations also need to effectively implement programs and procedures to control physical hazards of chemicals (as defined in 1910.1450(b)).

At a minimum:

a. **Develop a Safety and Health Information Bulletin (SHIB) pertaining to the need to control physical hazards of chemicals; and**

b. **Disseminate the SHIB (and any related products) on the OSHA Safety and Health Topics website pertaining to Laboratories (http://www.osha.gov/SLTC/laboratories/index.html)**

Recommendation to American Chemical Society

2010-5-I-TX-R2

Develop good practice guidance that identifies and describes methodologies to assess and control hazards that can be used successfully in a research laboratory.

Recommendations to Texas Tech University

2010-5-I-TX-R3

Revise and expand the university chemical hygiene plan (CHP) to ensure that physical safety hazards are addressed and controlled, and develop a verification program that ensures that the safety provisions of the CHP are communicated, followed, and enforced at all levels within the university.

Recommendations to Texas Tech University

2010-5-I-TX-R4

Develop and implement an incident and near-miss reporting system that can be used as an educational resource for researchers, a basis for continuous safety system improvement, and a metric for the university to assess its safety progress. Ensure that the reporting system has a single point of authority with the responsibility of ensuring that remedial actions are implemented in a timely manner.

Statement from Texas Tech University

TTU Web URL for accident and response: www.CSBresponse.ttu.edu

Press contact: Chris Cook, Director of Communications

Email contact: chris.cook@ttu.edu

Call in conference call to Texas Tech University: 2:00 CDT, Wednesday, October 19th, 2011, call in number is (877) 226-9790, access code is 7151060


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CSB
Texas Tech University
Laboratory Explosion
The CSB's Laboratory Safety Video
Available Tomorrow
October 20, 2011
www.csb.gov