National Aeronautics and Space Administration








Don’t Mess With Excess

Texas Tech University Laboratory Explosion

Senior Management ViTS Meeting

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BACKGROUND

January 7, 2010: A laboratory explosion severely injured a Texas Tech University (TTU) graduate student. The student lost three fingers, received burns to his hands and face, and suffered an eye injury. Any institution conducting laboratory research, including NASA, can use this opportunity to compare internal policies and practices with those that existed at TTU leading up to the incident.

The ALERT Program

- The U.S. Department of Homeland Security (DHS) "Awareness and Localization of Explosive-Related Threats" (ALERT) program funds research to characterize, detect, mitigate, and respond to explosive related threats.
- TTU contracted in 2008 to do ALERT research, including synthesizing and characterizing new materials such as nickel hydrazine perchlorate (NHP), which is extremely sensitive to friction and may detonate with the slightest disturbance.

Laboratory Preparations

- TTU developed a Chemical Hygiene Plan (CHP) focused on toxic exposure hazards, not kinetic hazards, using portions of the OSHA Occupational Exposure to Chemicals in Laboratories Standard.
- TTU Principal Investigators supervised research, and verbally required students to work with no more than 100 mg of any energetic compound at once. Navy guidelines caution that 500 mg of NHP can cause injury upon detonation.
- Concerned about variability of synthesized material between tests, the students decided to synthesize one 10,000 mg batch of NHP. The students did not consult project PIs, but no requirement to do so existed.
- The fifth year graduate student/injured party (IP) had been working on ALERT for about 1 year, but had no formal training or instruction in this field.

MISHAP EVENT SEQUENCE

Detonation

- After synthesizing 10,000 mg of NHP, the injured person (IP) observed clumping in sample of NHP and transferred half of the NHP into a mortar, adding hexane. Students had observed that smaller amounts of the compound would not detonate under stress when wetted with hexane.
- The IP began to gently break up the clumps of NHP with a pestle.
- The IP removed his goggles, and walked away from the mortar.
- The IP then returned to the mortar and resumed mixing the portion of compound without goggles. The NHP sample detonated, shattering the laboratory counter, blowing projectiles into the IP and adjacent equipment.









PROXIMATE CAUSES AND UNDERLYING ISSUES

Proximate Causes

- Dry clumps of NHP reacted because of the friction created when the compound was broken up.
- Flammable hexane vapor outside the clumps contributed to the reaction at ignition.

Managing Physical Hazards

- PIs were accountable to determine synthesized chemical hazards but received no training in doing so.
- ALERT students were unaware of a 100-mg limit.
- The water/hexane wetting method was never formally evaluated.
- Students indicated that the decision to wear goggles was a personal choice.

Lessons (Not) Learned

- Two previous incidents had occurred within the same research groups 3 years prior to the January 2010 explosion; however, some students were unaware of the incidents until after the 2010 event:
  - A reaction from an experiment caused a student to flee the laboratory. Lesson disseminated: stay with the experiment to provide direction to emergency responders. The event was not recognized as a lesson in hazard evaluation and risk assessment.
  - A student used the wrong units of measure and created 30,000 mg of a known energetic material. After the student reported the synthesis, the PI immediately separated the material into less hazardous quantities. The 2010 IP witnessed the event, but the near-miss was not reported outside the research groups.
- There was no requirement or reporting system for tracking near-misses/incidents in the academic community.

UNDERLYING ISSUES

Lack of Oversight

- TTU lab inspection safety violations were considered punitive, not hazardous.
- Safety recommendations were often considered outside PI control; recommendations involving monitoring of lab activities were perceived as wasteful “babysitting.”
- PIs involved in energetic material research were unfamiliar with the Chemical Hygiene Plan (CHP).
- PIs fostered ‘tribal knowledge’ verbally in absence of documented policies or procedures.
- The Environmental Health and Safety (EHS) organization played a “consultant” role, downplaying compliance findings to non-binding recommendations. No manager was empowered in an oversight role for compliance.
- Nobody was accountable to ensure that the TTU CHP was pertinent to the work underway.
- TTU’s organizational structure blocked hazard communication to risk owners with the responsibility or means to mitigate risk.

No Research-Specific Safety Training

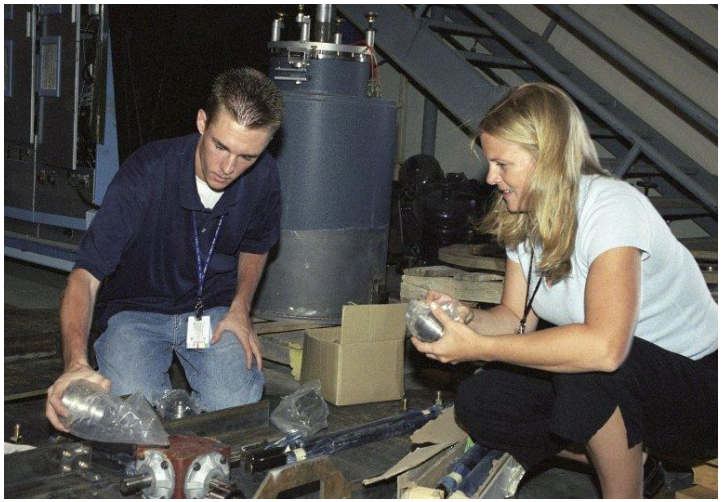
- The students synthesizing the NHP had no research-specific lab training, nor was risk knowledge assessed.

Granting Agency’s Role

- DHS lacked safety provisions specific to the energetic materials research being conducted by TTU.
- The grant funding agency has the power to end a research contract and agreement and, thus, can play a strong role in raising safety awareness and preparedness by the researcher and university.

AFTERMATH

- After the Chemical Safety Board investigation, TTU modified their organizational structure so that lab safety compliance directly affects project funding.
- PIs are now accountable for adequate training and conduct of safe operations in the laboratories and create guidelined for students performing independent laboratory procedures.
- The Office of University Programs in DHS added a Research Safety Plan to cooperative agreements with all universities funded by DHS Centers of Excellence for all sub-awards/subcontracts:
  - Identify possible research hazards associated with the types of research to be conducted;
  - Conform to generally accepted safety principles applicable to the nature of the research;
  - Ensure processes and procedures comply with the applicable protocols and standards;
  - Ensure processes and procedures prevent unauthorized activities;
  - Faculty oversees student researchers;
  - Provide education and training to develop a culture of safety;
  - Place security access controls where applicable;
  - Conduct independent, expert review of safety protocols and practices.



RELEVANCE TO NASA

Hundreds of students and faculty members participate in NASA research grants across the country. Students are often exposed to many of the same laboratory hazards as regular full-time employees.

- Comprehensive CHPs are in effect at all NASA installations where chemical laboratories are active.
- The OSHA regulations directly apply to our NASA workplaces; NASA research professionals must be familiar with effective chemical hygiene practices.
- NASA laboratories must closely couple the tenets of the hazard communication to comprehensively assure awareness of physical hazards beyond toxic exposures.
- Use of NASA CHPs and learnings from close call/ lessons learned data will protect students performing ongoing laboratory research at NASA Centers and at college campuses supporting NASA research.









RELEVANCE TO NASA

How NASA Grants Work

- NASA grants are subject to compliance "with all applicable federal, state, and local laws relating to safety".
- The NASA Technical Officers at each Center shall review and concur with unique tasks and associated requirements. They work closely with Safety and Mission Assurance, Occupational Health, Environmental, and other representatives to assure NASA Research Announcements and associated grants identify unique technical, safety, and health provisions.
- Strict requirements to assure medical protocols are included for human subject research.

For the Students in NASA's Future

- Beyond well-prepared grant provisions, it is our NASA and contractor veterans working directly with student, intern, and co-op employees and faculty members who most influence their safety and health. Here are a few points to keep in mind while working with students and faculty at NASA installations:
  - Ensure that students and visiting professors receive the same safety training your permanent employees receive.
  - Don't assume that students or visiting faculty understand unique hazards because of their education. Processes and conditions may be unique and pose hazards to those unaware of local practices.
  - Seek feedback on training effectiveness; work to improve training relevance.
  - Encourage students and visiting faculty to take non-sensitive safety and health information back to their own campus.
  - Do not lower expectations for students or visiting faculty. While it is their home institution that has ultimate responsibility for performance and behavior, they're exposed to our workplace hazards.

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