Mishap at an Explosives R&D Laboratory

Leadership ViTS Meeting
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Mishap with an Energetic Material at an R&D Laboratory

At 10:45 pm on February 14, 2005, a explosion and fire occurred in the R&D laboratory building M-590 at the ATK Thiokol Promontory campus.

- **Two laboratory technicians were transferring a chemical compound known as TETNB from a filter tray into 5-gallon plastic buckets.**
- **One of the technicians was killed, the other severely burned.**

Note: the explosive compound triethoxy-trinitrobenzene (TETNB) is a precursor compound in the manufacture of another explosive called triamino-trinitrobenzene (TATB). TATB is used in military weapon fuzes and warheads.

- Under normal circumstances, both TETNB and TATB are difficult to ignite with shock, friction, or electrostatic discharge, and are considered "insensitive" explosives but, nonetheless "mass detonating" or Class 1.1.

- Manufacturing of TATB has been halted in the United States due to environmental issues with previous process for manufacture.
  - **The laboratory was under contract to the Naval Surface Warfare Center to explore the capability for producing TATB using a new environmentally friendly process. The first step of a 3-step process requires the production of trinitro-phloroglucinol (TNPG) a compound that is sensitive to impact when dry.**
  - **After successfully demonstrating the new 3-step process in subscale (50-lb) batches, the incident occurred during processing the second full-scale (500-lb) batch of TETNB.**

Views inside Building M-590, Bay 105

What Happened?

- The technicians were transferring what was thought to be TETNB from a large filter tray into 5-gallon buckets
  - Standard tools include plastic spatulas and ice cream buckets
- They encountered an unusual condition: the energetic material was caked hard in the bottom and on the sides of the filter tray
  - Caked material was an unexpected result of a process considered experimental
- The technicians attempted to solve the problem on their own by removing the caked energetic material with unauthorized tools (metal scoop and plastic shovel).
- **Most probable proximate cause:**

  Impact from one of these tools resulted in ignition of a TNPG-rich crystal.

Causal Assessment

- An incomplete chemical reaction along with further process complications caused the unusual formation of hard-caked energetic material.
  - This was a new R&D process that needs additional definition to yield consistent, repeatable results.
- While sensitive material in the receiver was not specifically anticipated, the process design included considerable margin to mitigate the risk of off-nominal conditions (plastic squeegee specified).
  - A metal scoop is never the type of tool to be used in operations with explosive materials.
- The technicians were well trained, involved personally in the Hazards Analyses and table-top reviews, and experienced in handling energetic materials.
  - Plastic tools were specified in the planning documents and only plastic tools had been used in prior transfers of TETNB.
  - There was no apparent schedule pressure or management direction to remove the unusual and unanticipated caked material.
- It remains unknown why the technicians attempted to innovate and remove the caked material on their own.

Specific remediation for this R&D Environment

- Create a laboratory and test operations organization to strengthen checks and balances among engineering, operations, quality and safety functions.
- Strengthen key quality systems
  - Change control.
  - Process control.
  - Shop traveler (manufacturing procedure) discipline.
  - Nonconformance or unusual condition documentation (MRB)
  - Foreign object debris (FOD) control.
  - Review required of process owner.
- Provide technical oversight for process in development.
- Improve program oversight and assure adequate planning for process disruptions.
- Require leadership to be present whenever technicians are working on hazardous operations.
- Share lessons learned with the entire work force, reinforce the importance to absolute conformance to procedures, and require employees at all levels to inform their supervisor of anomalous, abnormal , or unusual and unexpected conditions.

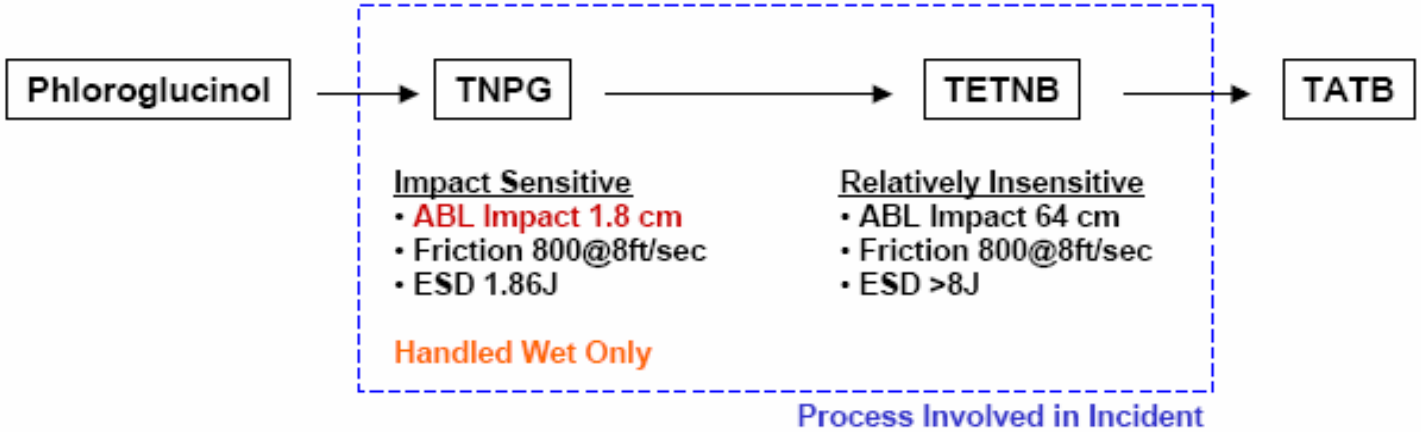
Apply Lessons of the Past

- Learn from experience by not repeating mistakes
  - Mishaps are not Acts of any Supreme Being – Mishaps are caused and are preventable.
- Stress application and adherence to safety standards.
  - Know the material properties and associated processes.
    - Make decisions based on data.
  - Observe change control and process control protocols.
    - Make changes to process only after a review.
    - Make changes based only on understanding of hazards.
  - Achieving safety in processes requires process discipline.
    - Use mishap prevention techniques (hazard analysis, process failure modes and effects (FMEA), etc.) to anticipate and prevent process failures and unwanted outcomes.
  - Follow established procedures.
    - Make sure the procedures are well-developed, well-written, and fully understood.
    - Make sure the written procedures and the actual shop floor practices match – allow no process “creep.”

Back-Up Information

Process Overview

- ATK developing a three-step process for manufacture of TATB
  1. Nitration of phloroglucinol to make **TNPG**
  2. Alkylation of TNPG to make **TETNB**
  3. Ammonolysis of TETNB to make **TATB**.

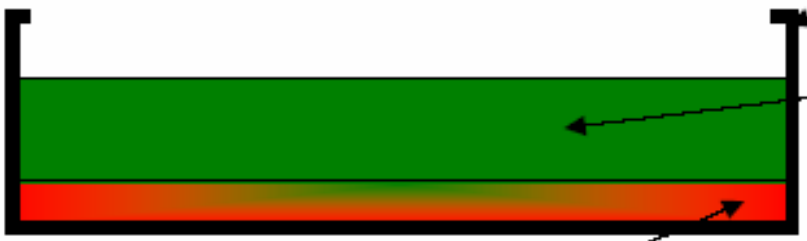


Incident occurred as TETNB was being removed from a filter receiver and being placed in 5-gallon buckets for transfer and storage

Ignition Scenario Summary

1. TETNB material in filter receiver was under-reacted and under-washed.
   - 11% DETNP (partially reacted TNPG), 4% TNPG (impact sensitive)
   - Second batch in 500 Gallon Reactor; First attempt at 65% Loading

2. Being more water soluble, DETNP and TNPG were concentrated in the bottom of the receiver forming an unusual hard, dry cake
   - Localized concentrations of up to 24% TNPG



Impact Safety Factors

	Metal Scoop	Plastic Shovel	Plastic Squeegee
TETNB	2	5	100
TNPG	-30	-10	2
DETNP	1	3	60

3. Lab technicians improvised on their own, and used unauthorized tools (metal scoop, plastic shovel) to remove caked material.

4. Impact, most likely from an unauthorized tool, caused local ignition of TNPG and mass ignition of the DETNP

Filter Receiver

Filter Receiver (cleaned)

New Filter Bag

Perforated Filter Bed

Exterior M590