BES Safety Stand Down All-Hands Meeting

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BES
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BROOKHAVEN NATIONAL LABORATORY
a passion for discovery

Office of Science
U.S. DEPARTMENT OF ENERGY

Today

- All-Hands Meeting
  - Why are we doing this?
  - The Incidents
    - Chemistry, CMPMSD, CFN
  - General Observations
    - Lessons Learned
      - Chemical compatibility
      - *Lifecycle* waste hazards
    - Focus today on chemical safety
  - Human Performance
    - We all make mistakes—mitigate the consequences
  - Common Themes
  - Long-term: Develop a new chemical compatibility/waste approach
  - Waste areas and chemical compatibility

Today

- Activities in Labs
  - Each PI/Group Leader will assembly their people and discuss chemical synthesis work, chemical compatibility issues, and waste management in their labs.
  - This discussion will include a discussion of potential human errors and what steps can be done to mitigate these errors
  - Each PI/Group Leader will send their chair an email verifying the review has taken place and identifying questions

Why the stand down?

- 5 incidents in last few months
  - 2 explosions, 1 fire
  - 4 chemical safety related
- Good news: no injuries due to chemical use
  - PPE was worn, and protected people!
  - Training was generally very good and also protected people
- But, it could have been MUCH worse
  - Explosions spread glass, oil acid
  - Minutes before CFN explosion, a group of people were nearby
- Share with all the lessons learned from these near misses
- Re-invigorate our awareness of chemical hazards

Over Pressurized Vial with Chemical Release in Hood

Near Miss
Chemistry (BES Directorate)
April 7, 2010

Location: Bldg. 555 Lab 285

Description:
A Research Associate (RA) heated a sealed 15 ml vial containing 5 ml of a toxic compound (bp 42°C) in an oil bath to 150°C overnight. In the morning the vial and oil bath were broken. The internal pressure of the vial was calculated at 255 psi. The Safety and Health Services Rep determined that there was no evidence of toxic material in the air. Initial cleanup was carried out by a Waste Management Rep.

Causes:
- RA did not recognize this was a pressurized experiment.
- Vial was not designed to withstand the pressurization that took place.
- ESR process did not clearly address sealed tubes in preparative scale at high T leading to unsafe pressures.
- Communication between RA and PI was not sufficient.
- Working with Chemicals Subject Area (SA) does not address pressure hazards, at the experimental level.
- Hood was cluttered with extraneous material.

Corrective Actions:
- ESR amended to address high pressure synthesis.
- Group meeting held to address supervision.
- Chair sent email to alert CO workers to pressurization, oil bath, housekeeping and supervision issues.
- Extent of Condition walkthru carried out to reinforce housekeeping requirements.
- Chair will hold meeting to discuss chemical syntheses from literature descriptions.
- SA will be amended to address pressurization from chemicals.
- Event discussed at ESH Coordinators meeting

Technician lacerates hand in shop accident

Injury (Event ID 868)
CMPMSD
June 30, 2010

Location: Bldg. 510 Rm 1-121

Description:
The employee was disassembling a lathe setup while the lathe was not energized. The employee attempted to free up the set screw with the T-handle by rapping the handle with his hand. He slipped, and his forearm was raked across the extended chuck jaw, causing a deep, several inch long cut in his arm. The employee applied a shop towel to stem the significant bleeding, did some shop cleanup, then went to the clinic, where first aid was administered. Then the employee went to the hospital emergency room for sutures and antibiotics.

Lathe Setup in 1-121.

Preliminary Causes:

- Inattention to specific hazards of lathe disassembly: no gloves worn.
- Failure to retract sharp chuck jaws for less exposure to sharp protrusions

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Contemplated Corrective Actions:

- Establish more detailed procedure for assembling and disassembling power tools while they are not energized.
- Recommend gloves for protection of hand and arm

Insufficient Work Planning for Lead Handling

CMPMSD
Reported July 20, 2010

Location: Bldg. 480 Rm 1-152

Description:

The event took place on or about 29, 30 June and 1 July. On 20 July 2010 it was discovered that about 3000 lb.(out of 7000 total) of lead shot that had been stored in room 1-153 of Building 480 had been moved, and installed into pedestals in 1-152 . A Stop Work order was issued at that time. The posted work permit prohibited work with lead, and undocumented worker exposure to lead may have resulted.

Preliminary Causes:

- Failure to comply with conditions set in Work Permit.

Contemplated Corrective Actions:

- Workers will be tested for lead in their systems.
- Room 1-152 will be tested for lead contamination.
- Work is suspended until the Stop Work is lifted and a new work permit issued.

Consequences

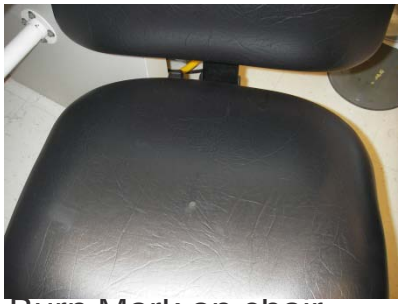
- Week or longer suspension of experiment setup/assembly

Phosphorous Sample Ignites

Fire (Reportable) SC BNL CMPMSD
(event ID 849) May 31, 2010

Weighing Station.

hood



Burn Mark on chair

Location: Bldg. 703 Lab W6

Description:

A guest researcher was weighing lump red phosphorus in the lab. The guest was moving phosphorus from the manufacturers container to a weighing pan. The (<10g) phosphorus in the container ignited when the researcher was removing material with tweezers. The researcher placed the container on a letter size paper and moved it to the hood. The researcher used tongs to move the container to a jar, then attaching a lid and extinguishing the fire

Causes:

- Root cause was transfer of energy to the red phosphorus lumps, resulting in ignition and fire.
- There was insufficient recognition that P could ignite under these low energy operation conditions, and that combustion products POx are toxic.

Corrective Actions:

- Research and recommend appropriate glove and lab coat PPE for operations with flammables.
- Determine best fire fighting strategy for phosphorus fires
- Discuss this event with department (lessons learned)
- Incorportate better storage and handling of phosphorus into ESR.

Other Considerations

- Guest was working alone with chemicals outside of regular working hours.
- Preferred emergency response is to evacuate area and call 2222 for assistance

Chemical Explosion due to incompatible materials being wasted

Near Miss
CFN (BES Directorate)
July 15, 2010

Location: Bldg. 735 Clean Room

Description:
A waste container in a satellite accumulation area (SAA) containing piranha etch (sulfuric acid and hydrogen peroxide) exploded. The top of the container shattered and some solution was sprayed out. The CFN user in that part of the lab got some liquid on the Tyvek suit , but had no directly exposure to the skin. Initial cleanup was carried out by the Fire Rescue group and subsequent cleanup of the area was done by a Waste Management Rep.

Preliminary Causes (not complete):

•A different user had recently added some waste to a container. This new waste was inadvertently added to the wrong waste bottle which contained the piranha etch. This user added an organic solution containing IPA which is known to react violently with piranha etch.

•Not properly identifying the correct waste container.

Immediate Interim Corrective Actions (not complete):

•Segregate different types of waste into acid only, base only, and organic only accumulation areas.

•Use poly coated waste bottles with vented caps for the piranha etch.

Draft: Causal Analysis (underway) and Corrective Action Plans are not complete.

Lessons learned

- Human performance: people make mistakes
  - Understand the chemical hazards better and do our best to implement plans, controls to mitigate consequences if a mistake is made
  - Procedures when something happens you did NOT expect
- Lifecycle chemical hazards
  - Hazards when using
  - Hazards when disposing of chemicals

HPI Principles

- Humans are fallible – we will make errors
- Error-likely situations are predictable
- Events don't "happen" – they are caused
- Need to anticipate that mistakes will happen and mitigate the consequences

How applicable is this to research?

To Research is Human

"To err is human; and science and technology are quintessentially human activities."

Walt Patterson, 1992 nuclear physicist

- Some human errors in research can lead to
  - tragic events, *i.e.* arc flash, laser incident
  - spectacular advances – penicillin
- Value of HPI - to protect our research from human error
  - Not just personnel injuries, but also
    - Dropped or mixed up samples
    - Equipment or data loss
    - Diverted research time
    - Reduced funding

Defining Errors

- Active Error
  - Action that results in immediate, undesired consequences
- Latent Error
  - Action that creates an undesirable condition and goes unnoticed until there are undesired consequences
  - Generally, these are hidden faults in processes, procedures, culture, system design
- Risk increases with increasing number of latent errors
- We will continue to have events if we just “fix the person”
- We need to examine the process or system – for these events and in the future – to avoid or mitigate events

Error Examples

- *Active Error*
  - Reacting methyl iodide in sealed container without ensuring container would hold the pressure
- *Latent Error*
  - No requirement to calculate pressure (should be a requirement for all sealed reactions)
  - Didn't question safety of literature procedure..No additional reviewer
  - Inadequate knowledge? Different perception of risk?
- *Active Error*
  - Pouring isopropanol into piranha etch
- *Latent Error*
  - Container identified by cap, not label?
  - Label not legible enough?
  - Insufficient knowledge? Inadequate training?
  - Inadequate segregation of organics vs oxidizers?

Error Precursors

Research Demands

Time pressure (in a hurry)
Heavy workload
Multi-tasking
Repetitive, monotonous work
Lack of or unclear procedures

Individual Capabilities

Unfamiliarity with task
Lack of knowledge
Lack of proficiency / inexperience
Unsafe attitude for critical task
Illness / fatigue / emotional stability

Laboratory Environment

Distractions, interruptions - like us
Changes, departures from routine
Unexpected equipment conditions
Work-arounds
Personality conflicts

Human Nature

Stress (limits attention)
Assumptions
Complacency, overconfidence
Mindset (arrogance)
Inaccurate risk perception
Differences in risk tolerance

HPI – Risk Mitigation

- **Assumption #1**
  - We are fallible and will eventually make an error
  - Action - Examine the behaviors, systems, situations to identify and eliminate possible active and latent errors
    - Ask: *"What could go wrong?"* for the entire life-cycle of the experiment or activity

- **Assumption #2**
  - We are fallible and missed something (see Assumption #1!)
  - Action: Plan for something to go wrong
    - Ask – *"What will I do if something goes wrong?"*

Common themes

- PPE—important and worked well
- Training—also important and worked well
- Use small amounts whenever possible
- NEW FACES: Students, postdocs, new hires, users—Ensuring they are fully cognizant
- Poor communication
  - CFN had new caps—did this contribute—did we communicate the cap shift adequately?
  - Chemistry synthesis procedure—could we have discussed the procedures more thoroughly?

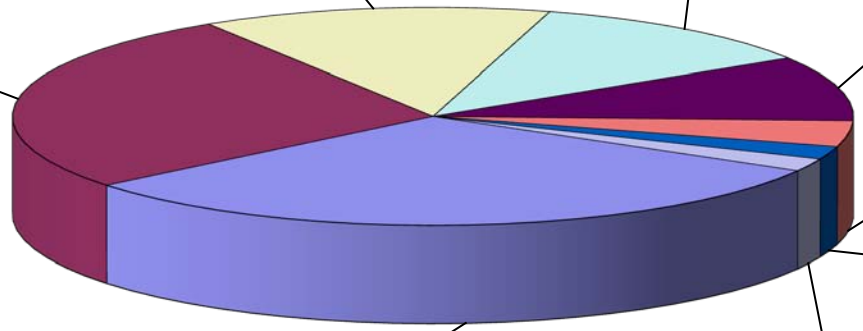
Long term: Waste/compatibility

- Excellence in Safety and Operations as well as Research
- Commissioned a group to look at chemical compatibility/waste area issues across the directorate
  - Design of accumulation areas
  - Training
  - Signage
  - Procedures
- Recommendations will come to ALD and BES Safety and Operations Council
  - Lets design things better!

All hands refreshers

- Waste area observations
- Chemical compatibility

Lab-Wide Satellite Accumulation Area Surveillance Program for May/June, 2010 (52 total findings)



Sec. containment missing 11%

Container open 13%

Wrong date 10%

Full container 27%

Not in a SAA 4%

Incompatability issue 2%

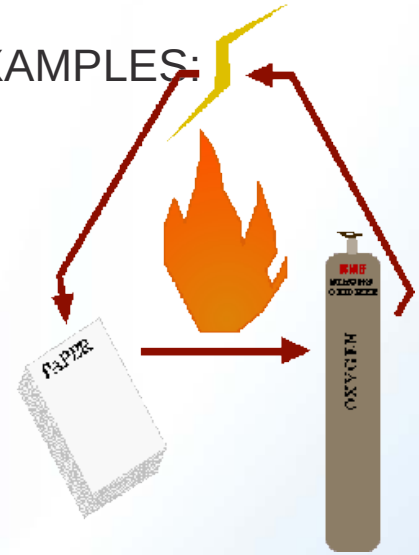
Label problem 31%

Non-waste next to waste 2%

Minor operational errors that could lead to personal injuries

Low probability for occurrence/ HIGH RISK for personal injuries

Hazardous Waste
Satellite Accumulation Area Requirements



- DO **NOT** STORE/MIX INCOMPATIBILITIES TOGETHER – EXAMPLES:
  - Oxidizers next to flammables/organics
  - Acids next to bases
  - Poisons next to acids
  - Water reactives next to aqueous solutions
  - Keep multi-hazard wastes separate (concentrated nitric acid – oxidizer and acid)
- Write specific, legible chemical names on waste labels (important for Fire Rescue/WM)
- Use undamaged, containers compatible with chemical (e.g. plastic for HF acid)
- Keep caps/lids closed
- Transfer full waste bottles to 90-Day Accumulation Area
- Do not create a new hazard due to location of SAA (blocking egress, near floor drain)
- Use waste log for multiple generators adding mixtures to same container
- DO NOT ABANDON WASTE

Chemical Compatibility

	DOT Class	Flammable, Liquid	Flammable, Solid	Spontaneously Combustible Liquids	Acids, inorganic (Corrosive)	Acids, oxidizing (Corrosive)	Acids, organic	Alkalis (bases) (Corrosive)	Oxidizers	Organic Peroxides	Poisons, inorganic	Poisons, organic	Water- reactives	Organic solvents
Flammable, Liquid	3	C	C	C	C	C	C	C	N	C	C	N	C	C
Flammable, Solid	4.1	C	C	C	N	N	C	N	C	C	C	N	C	C
Spontaneously Combustible Liquids	4.2	C	C	C	N	N	C	N	C	C	C	N	C	C
Acids, inorganic (Corrosive)	8	C	N	N	C	C	N	N	C	C	N	N	N	N
Acids, oxidizing (Corrosive)	8	C	N	N	C	C	N	N	C	N	N	N	N	N
Acids, organic		C	C	C	N	N	C	N	N	N	N	N	N	C
Alkalis (bases) (Corrosive)	8	C	N	N	N	N	N	C	C	N	C	N	N	N
Oxidizers	5.1	N	N	N	C	C	N	C	C	C	C	N	N	N
Organic Peroxides	5.2	C	C	C	N	N	C	N	C	C	N	N	C	C
Poisons, inorganic	6.1	N	N	N	N	N	N	C	C	N	C	N	N	N
Poisons, organic	6.1	C	C	C	N	N	N	N	N	N	N	C	C	C
Water- reactive (Dangerous when wet)	4.3	C	C	C	N	N	N	N	N	C	N	C	C	C
Organic solvents		C	C	C	N	N	C	N	N	N	N	C	C	C

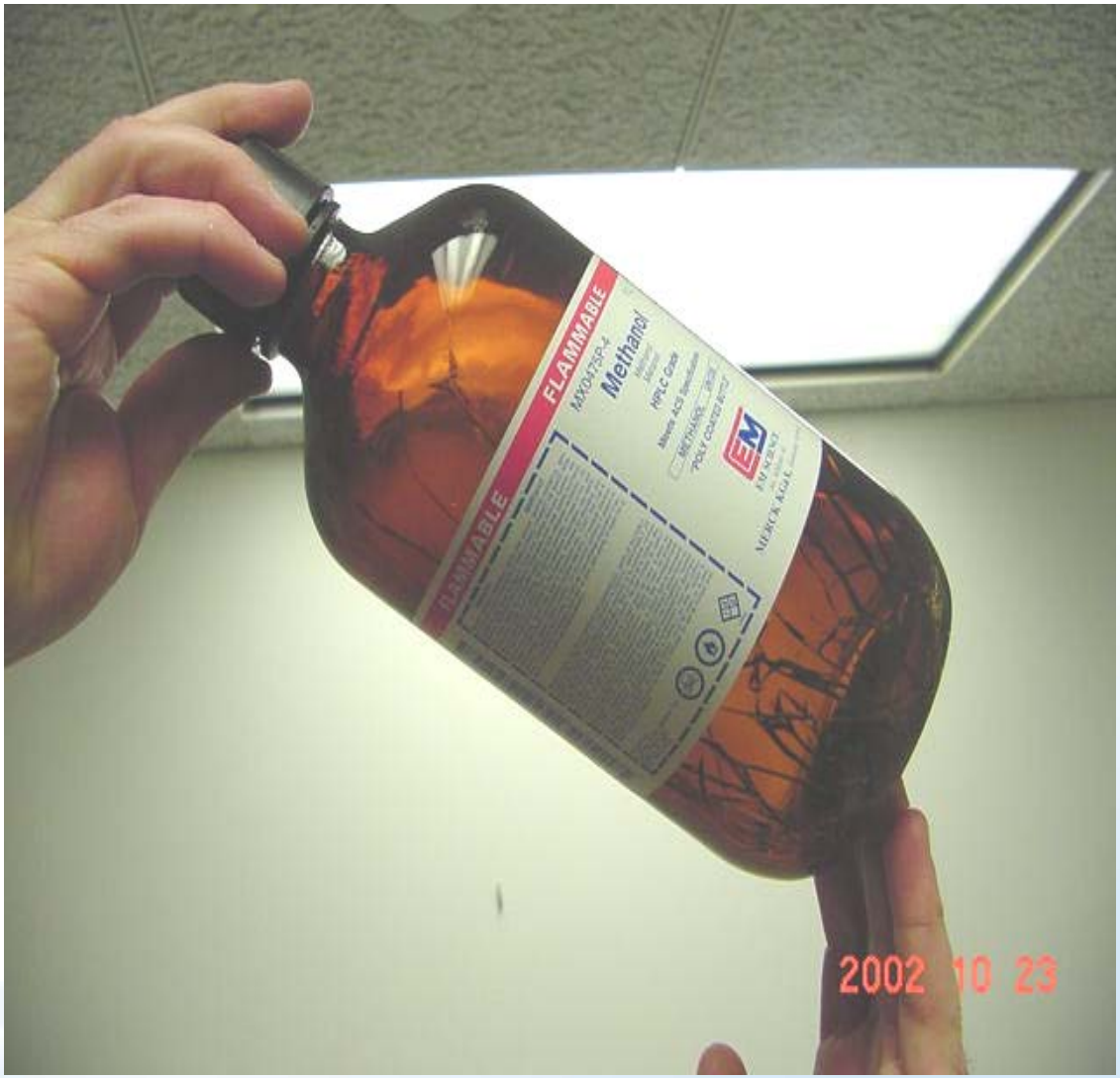
Chemical compatibility

1	Inorganic Acids	1																						
2	Organic acids	X	2																					
3	Caustics	X	X	3																				
4	Amines & Alkanolamines	X	X		4																			
5	Halogenated Compounds	X		X	X	5																		
6	Alcohols, Glycols & Glycol Ethers	X					6																	
7	Aldehydes	X	X	X	X		X	7																
8	Ketone	X		X	X			X	8															
9	Saturated Hydrocarbons									9														
10	Aromatic Hydrocarbons	X									10													
11	Olefins	X				X						11												
12	Petrolum Oils												12											
13	Esters	X		X	X									13										
14	Monomers & Polymerizable Esters	X	X	X	X	X	X								14									
15	Phenols			X	X			X							X	15								
16	Alkylene Oxides	X	X	X	X		X	X							X	X	16							
17	Cyanohydrins	X	X	X	X	X		X									X	17						
18	Nitriles	X	X	X	X												X		18					
19	Ammonia	X	X					X	X					X	X	X	X	X		19				
20	Halogens			X			X	X	X	X	X	X	X	X	X	X				X	20			
21	Ethers	X													X						X	21		
22	Phosphorus, Elemental	X	X	X																	X		22	
23	Sulfur, Molten									X	X	X	X				X						X	23
24	Acid Anhydrides	X		X	X		X	X							X		X	X	X	X				24

X Represents Unsafe Combinations

Represents Safe Combinations

Plastic Coated Methanol Bottle
After laboratory explosion/fire
Bottle has multiple cracks but liquid contained



Incident communication reminder

If an emergency/unexpected event occurs, what steps need to be taken?

1. **Get to a safe location**
2. **Call x2222 or 911 (from a cell phone 631-344-2222)**
3. **Attend to any injured person if you are able to assist**
4. **Call the ES&H Coor., LEC, Bldg. Manager and inform them of the situation**
5. **Contact the supervisor of the lab**
6. **Notify the Dept. Chair and ALD**

TODAY

- **Pause/reflect: on chemical safety**
- **Group Leaders/PI's** need to go back to their labs and discuss and review with their staff :ESRs, SOPs, Operator Aids to consider chemical safety Include the following points in your discussions:
  - Chemical Compatibility Issues:
    - Storage – include the amount, age, need
    - Use – are all the steps clearly stated, precautionary warnings
    - PPE – appropriateness – new rules for chemical labs
    - Waste handling –are chemicals being treated properly?
    - Consider the controls for handling waste including:
    - PPE, hoods, segregation.
  - Consider HPI ideas– what mistakes can be made/how do we mitigate?
  - Oversight of newly assigned staff, hires, guests, and students
  - Training both CBT and OJT
  - Response to unexpected events, consequences of mistakes
- **Meet with ECRs – regarding waste issues**
- **Group Leaders/PI's**
  - Must send an e-mail to their Department Chair verifying they have had the discussion with their staff and communicate any finding you wish to share with others.