Safety Underground

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Deep Underground Science and Engineering Laboratory (DUSEL)

2010 NSF Large Facility Workshop

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All Facility Safety Session

1:30 TO 2:00 PM
Upper Big Branch Disaster (2010)

- Explosion pentagon (requirements for a mine explosion)

- Fuel – methane and coal dust

- Dispersion or mixing

- Ignition source

- Oxygen

- Confinement

- Imagine yourself standing inside the barrel of a cannon!
Upper Big Branch Disaster (2010)

- UBB - 29 miners fatally injured in an explosion
- Explosion hazards are preventable
- Why are they still occurring
Crandall Canyon Disaster (2007)

Low likelihood of occurrence but high consequence events
Crandall Canyon Disaster (2007)

- 9 workers fatally injured
  - Six in initial bursts
  - Three in rescue attempt
- Cause - High risk mining practice
Why are these disasters occurring?

- Reliance on prescriptive regulations for mine safety standards
- Hazard recognition is not a requirement (poorly defined in standards)
- As a result,
  - Hazards are not being adequately assessed
  - Risks are not being mitigated
- A reactive safety culture currently exist
- A proactive safety culture is needed (more on this later...)

- **Sunshine Mine fire in 1972**, 91 miners died in an Idaho hardrock silver mine
- **Belle Isle explosion in 1979**, 5 miners died in a Louisiana salt mine
Hazards in the underground environment (Multiple Fatality Events over Last 12 Years)

- Explosions
- Explosives
- Ground falls
- Mobile equipment collisions
- Fires
- Inundations
- Surface subsidence from strata collapse
- Slope or highwall failures
- Drowning
- Asphyxiation
So what’s this got to do with DUSEL? There are an increased number of major hazards in any underground environment!
What is DUSEL (Deep Underground Science and Engineering Laboratory)?

- Currently in design with NSF funds
- Sanford Laboratory (SDSTA) currently operates the footprint of the future DUSEL
- Property
  - 186 surface acres
  - 7,700 underground acres
  - 370 miles of drifts
  - 14 shafts and winzes
DUSEL’s physics mission - WIMPs (weakly-interacting massive particles)

- What is the Universe made of?
- What is Dark Matter?
- What is the origin of the elements in the cosmos?
- What can neutrinos tell us about the matter/antimatter asymmetry?
- Is ordinary matter inherently (un)stable?
- What is the spectrum of neutrinos from supernovae?
- And much more.....
DUSEL’s safety goal

To develop an enduring international underground laboratory with a best-in-world class scientific program of research, education and outreach and do so as quickly and as cost efficiently as is consistent with the highest level of safety

- EH&S functions have been developing over the last 2-years
- Rely on the Integrated Safety Management (ISM) approach
What are the construction plans for DUSEL?

- Rehabilitate a small portion of the underground to a depth of approximately 8,000-ft below the surface
- Control the hazards throughout the underground
Current activities (dewatering)
Current activities (exploration)

- Diamond core drilling
- In-situ stress measurements
- Re-entering associated drifts for inspection
Current activities (ventilation)

• Installing barriers
• Maintaining and installing high capacity fans
• Modeling
• Monitoring conditions
Current activities (preparing for early science)

- LUX surface (complete)
- LUX underground
- Majorana underground
- BGE’s (on-going)
Current activities (new developments)

- Excavating transitional space
- Rehabilitating shafts
- Adding additional ground support
Future activities underground

• **Excavate new drifts**
• **Excavate at least one large cavity (160-ft wide)**
• **Rehabilitate shafts**
Future activities (science)

- LUX, Majorana, BGE’s
- Large experiments with Cryogens
Future activities (Construction of the deep-level campus at the 7,400-ft Level)

- This is a very complex and complicated project!
- We should all be excited about the prospects for conducting “deep science and engineering research”
Let's talk about major hazards

- A **hazard** is a source of potential harm
- *Identify hazards by looking at energies*
What are the “Major” Hazards at DUSEL?

- Strata (collapse)
- Gases (explosions)
- Water (inundation & drowning)
- Gravity (falls-from or falling objects)
- Spontaneous combustion (combustible materials)
- Struck-by (mobile equipment)
- Poisonous gases (hydrogen sulfide)
- Electricity (electrocution)
- Fire (Diesel, electrical equipment, etc)
- Cryogens (rapid expansion > asphyxiation)
Assess hazards (Look for big energies)

- Chemical – coal, sulfide minerals, gases, fuels, lubricants, degreasers, solvents, paints, etc.
- Electrical – high voltage, batteries, etc.
- Gravitational (objects) – falling rock, tools, machinery, structures, etc.
- Gravitational (people) – falling from or into equipment, structures, ladders, shafts, etc.
- Machine (fixed) – powered by electrical, hydraulic, pneumatic, combustion, etc.
- Machine (mobile) – haulage trucks, LHDs, locos, tools, etc.
Looking backward at Homestake Mine for answers
(from Steve Mitchell’s book)

• 270 fatalities from 1876 to 2003 (mine + timber)
• Prior to 1918 ~ 7 to 8 per year
• After 1918 ~ 1 or 2 per year

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• 41-pct falls of ground
• 20-pct falls of person
• 14-pct explosives
• 8-pct powered haulage
• 5-pct falling object (other than rock)
• 4-pct struck by (cage, skip, cable, etc)
• 8-pct other (electrocution, asphyxiation, drowning, etc.)
Mining methods (many accidents related to unique work practices)

- **Square-set stopes**
- **Cut-and-fill stopes**
Mine safety (a 125-year history of innovation)

- 1911 – mine rescue team
- 1916 – full-time safety engineer
- 1923 – safety bonus system (300 shift accident free-$10)
- 1931 – mine rescue team equipped with McCaa self-contained breathing apparatus
- 1953 – USBM training, stench warning system, Central Safety Committee and Workmen’s Safety Committee
- 1954 – safety glasses mandatory
Major hazards were not being adequately addressed

- Some past work processes represent a significant risk for the project (17 fatalities at Homestake Mine between 1977 and 1994)
  - Hoist conveyance issues
  - Shaft rehabilitation issues
  - Drilling, blasting, mucking and installation of support issues

![Graph showing NFDL Incidence Rate and Operator Hours over time from 1995 to 2005 for Homestake and Nation.](image-url)
Risk and potential unwanted events

- A **risk** is the chance of something happening that will have a negative impact on objectives
  - A situation or condition releases a hazard
  - This unwanted energy release causes an incident, or worse, an accident
- Look for **potential unwanted events**

Risk = Probability of occurrence × Consequence of outcome
Need to focus on major hazards

Common perception – by reducing near misses and minor injuries and fatalities will also be reduced

Statistics demonstrate – a reduction in near misses and minor injuries is not always associated with a reduction in the occurrence of fatal injuries

Implication – major hazards need to be addressed directly
Major hazard risk assessment is a fundamental requirement for DUSEL?

- **Understand Potential Loss** – what consequence types?
- **Examine Potential Energies** – what sources of harm?
- **Review Existing Controls and Investigate New Ideas for Control** (additional ways to reduce risk?)

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**Flowchart:**

1. Understand the hazards
2. Identify the risks
3. Analyse & Evaluate risks
4. Consider the controls
Remember -- Not all controls are equal

<table>
<thead>
<tr>
<th>Control Category</th>
<th>Major Control Issue</th>
<th>Risk Reduction Effectiveness</th>
<th>Potential for Human Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eliminate Hazard</td>
<td>Organizational</td>
<td>Complete</td>
<td>Doesn’t exist</td>
</tr>
<tr>
<td>Minimize Hazard</td>
<td>Engineering</td>
<td>High</td>
<td>Human error plays a minor role</td>
</tr>
<tr>
<td>Physical Barriers</td>
<td>Assessing</td>
<td>Medium</td>
<td>Human error is possible</td>
</tr>
<tr>
<td>Warning Devices</td>
<td>Work process</td>
<td>Low</td>
<td>Human error can play an important role</td>
</tr>
<tr>
<td>Procedures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personnel Skills and Training</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In reality most organizations use controls with reduced effectiveness (from NIOSH field data)
Questions to answer

- Was the threat or hazards identified and understood?
- What were the controls that were supposed to prevent the incident?
- Why didn’t they work as intended?

Only if threats and hazards are understood can controls be properly determined and their effectiveness evaluated.
Utilize incident investigations

- Identify root cause
- Determine why controls didn’t work
- Determine actionable outcomes that correct organizational issues

Investigation path
“Focus on the Right Things”

• Set clear direction to solve specific high risk problems
• Focuses on priority concerns and conditions undergoing change
• Gets involvement and commitment from a wide cross-section of the operation’s work force
• Decrease potential losses associated with risky work processes
• Build teams to mitigate major hazards
• Audits and review to provide assurances to management that the controls are being applied to some operational standard
• Go beyond simply complying with existing standards and regulations
• Develop a **proactive safety culture**
• Integrate safety programs into all aspects of the organization
• Develop a self-regulating philosophy where work processes utilize **leading practices**