Human Factors in Control

Human & Organizational Factors in Complex Systems
CSB Investigative Insights

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Outline

• Evolution of Investigating Human & Organizational Factors

• Common findings pertaining to:
  – Human Performance
  – Indicators
  – Leadership
  – Organizational Culture
US Chemical Safety Board

Drive chemical safety change through independent investigations to protect people and the environment.

US Chemical Safety Board (CSB)

• Independent non-regulatory federal agency
• Investigate catastrophic chemical accidents in the US
• Determine causes and identify lessons learned
• Make recommendations for safety improvements

Seek to answer “Why?” and “How?”
The Evolution of Human Factors

- 1980 – “Human Factors are the study of the interactions between human and machines.” (cited in Gordon, 1998)
- 1993 – “Human factors...seeks to change the things people use and the environments in which they use these things to better match capabilities, limitations, and needs of people.” (Sanders & McCormick, 1993)
- N.D. – “Human factors refer to environmental, organisational and job factors, and human and individual characteristics, which influence behaviour at work in a way which can affect health and safety“ (UK HSE)
- 2016 – “Human Factors has been expanded to encompass...management functions, decision making, learning and communication, training, resource allocation and organisational culture.” (Cox, et al., 2016)
Evolution of Investigating Human Factors

Historic Perspective

• Technical failures and human failures similarly examined
• Human “error” as black-and-white as technical deficiencies
• Incident could have been prevented had humans followed instructions/procedure or been better trained

Evolution of Investigating Human Factors

Current Perspective

• Human variability yields both positive and negative outcomes
• Individuals make decisions and take actions that make sense to them at time
• Gaps between policy and practice give useful safety insights on indicators and org. culture
CSB Consistently Finds:

- “Error” judgement based on outcome
- Contradiction in expectations placed on the sharp end
- Organizational practices influencing human performance
- Major gaps in Work-as-Imagined versus Work-as-Done

“Error” is aJudgement Based on Outcome
BP Texas City 2005 Refinery Explosion

- 18 previous startups with deviations to process parameters
- Considered ‘successes’ instead of seen as indication that deviations were becoming normalized
Adverse outcomes are not the result of unusual actions in usual conditions, but the result of **usual** actions in **unusual** conditions.

Erik Hollnagel, “Is Justice Really Important for Safety?,” 2013

**Contradiction of Expectations**
Truths About Human Performance

We expect our novices to: We expect our experts to:

Have knowledge of prescriptive policy Know how to improvise

Comply with instruction Apply rules to situations and adapt as needed

Know basic rules, regulations, policy, and procedures Use complex adaptive problem solving or critical thinking skills to achieve results

Know and follow the plan Use intuition to know when to depart from the plan

Follow known rules, regulations, policies and procedures Add to the body of rules, regulations, policies and procedures through deliberate work improvement

Language applies to novice “control” Language applies to expert “empowerment”


Competency: the ability to do something successfully or efficiently

• Individuals can be competent and still not always achieve successful outcomes

• Error-free performance is an impossible goal
  – What are the listed barriers to the hazards identified in your hazard analyses?
  – How reliant are you on error-free performance?
Giant Industries Refinery Explosion
Gallup, NM

- April 8, 2004
- Workers removing a pump
- Valve connecting the pump to a distillation column left open
- Release and ignition of flammable material
- 4 seriously injured
Giant Industries Refinery Explosion

- Operator relied on the position of the valve wrench to determine if the valve was open
- The operator tagged and locked the valve in what he thought was a closed position
- The valve was actually open
- When maintenance began unbolting the pump, the flammable material was released, and ignited

Case of Operational Discipline?

Giant Industries Refinery Explosion

Safety System Deficiencies

- Equipment was allowed to be used in a manner for which it was not designed with no assessment of the safety implications of the change
- Additionally, the valve wrench was not permanently affixed to the valve equipment
- Due to its size, it was often removed and replaced only when needed
Giant Industries Refinery Explosion
Safety System Deficiencies

- The pump had a history of failures – 23 work orders submitted to repair the pump in the one year previous to the incident
- Yet the pump was never assessed to determine the cause of the failure

The Influence of Organizational Practices
Common Characteristics of High Hazard Operations

- Strong focus on personal safety
- Genuine shock and surprise when a serious event occurs
- Assumption that work is done in accordance with the written procedures
- Reporting on “health” of risk controls doesn’t go high enough in organisation
- And even where it does - it is often unduly optimistic

Provided by Peter Wilkinson, Noetic Group, February 2017 Deepwater Horizon Revisited Presentation

Process Safety
A Safety Discipline Distinct from Personal Safety

<table>
<thead>
<tr>
<th>Process Safety</th>
<th>Personal Safety</th>
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<tbody>
<tr>
<td><strong>Scope</strong></td>
<td></td>
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<tr>
<td>Complex technical and organizational systems</td>
<td>Individual injuries and fatalities</td>
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<tr>
<td><strong>Prevention</strong></td>
<td></td>
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<tr>
<td>Management systems: design, mechanical integrity, hazard evaluation, MOC</td>
<td>Procedures, training, PPE</td>
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<tr>
<td><strong>Risk</strong></td>
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<tr>
<td>Incidents with catastrophic potential</td>
<td>Slips, trip, falls, dropped objects, etc.</td>
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<td><strong>Primary actors</strong></td>
<td></td>
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<tr>
<td>Senior executives, engineers, managers, operations personnel</td>
<td>Front line workers, supervisors</td>
</tr>
<tr>
<td><strong>Safety Indicators: Leading and Lagging Examples</strong></td>
<td></td>
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<tr>
<td>HC releases, inspection frequency, PSM action item closure, well kick response, # of kicks</td>
<td>Recordable injury rate, days away from work, timely refresher training, # of behavioral observations</td>
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CSB Investigations Experience

Major process safety incidents occur even at facilities with low LTI rates

Valero McKee Refinery propane fire
Sunray, Texas - 2007

Bayer CropScience pesticide waste tank explosion
Institute, West Virginia - 2008

BP’s “Days Away from Work” Rate

http://www.bp.com/sectiongenericarticle.do?categoryId=9010712&contentId=7021106
Safety Observation Program
What Indicators Do They Provide?

Policy: Employees shall observe and report unsafe situations/activities

• Transocean crews required to submit daily START card
• Crewmembers believed the focus on the quantity not quality of observation.
• “people [tried] not to rat people out so to speak, you know like you wanted to be helpful, […] whereas some of the higher-ups in the office, they kind of wanted to weed out problems …”
• “I’ve seen guys get fired for someone [writing] a bad START card about them”

(pg 143-144, Vol 3 CSB Macondo Report)
Policy: Employees shall observe and report unsafe situations/activities

- While # of reports went up, # of incidents went down
- Initial resistance to program but attitudes changed when worn tools and equipment were repaired/replaced

Source: B. R. Read; A. Zartl-Klik; C. Veit; R. Samhaber; H. Zepic; Safety Leadership that Engages the Workforce to Create Sustainable HSE Performance; The SPE International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production held in Rio de Janeiro, Brazil, 12-14 April 2010.

Process Safety Indicator Pyramid

Well Control Events – Precursor Data

2008 – 2009:
• 6 riser unloading events

2009:
• 121 well control events
• 32 different operators
• Various geographic locations

Indicators:
• Kick volume
• Kick intensity
• Riser unloading events

Formosa Plastics Explosion
Illiopolis, IL

- April 23, 2004
- Flammable vinyl chloride release ignited
- 5 fatalities, 2 injured

Operator at control panel

Operator at drain valve
Formosa Plastics Explosion

- Operator in the process of cleaning a reactor accidentally drained a full reactor
- Operator bypassed an interlock to open the reactor bottom valve
- Reactor’s highly flammable contents released
- Operations staff attempted to stop release
- Vinyl chloride ignited

Incompetent operations staff not following interlock policy?

Formosa Plastics Explosion
Safety System Deficiencies

- **Policy vs. Practice:** bypass of interlock essentially accepted practice

- **Incident Investigations:** Lessons from previous incidents not shared and learned

- **Treated Symptom, Not Problem:** Never made an engineering design change to safeguard unintentional opening of an in-use reactor
Organizational Culture

Based upon Edgar Schein's Levels of Culture

- Policies
- Publicized values
- Messages and symbols
- Practices
- Organizational behaviors

Artifacts – that which can be observed and measured

Underlying conditions – may not be consistent with the proclaimed values and messages; the shared understandings and assumptions often operate at a subconscious level.
Organizational Culture

• The underlying conditions help us to understand why we see the artifacts we do

• SMS deficiencies and WAI vs. WAD gaps reveal both indicators & opportunities for safety improvements
How Does Leadership Play a Role?

- Senior leaders should be able to articulate the difference between process safety (or MAH) and personal safety
- Metrics for both types of hazards are reported to the top
- Bad news travels up the organization
- Senior leaders are incentivised to improve control over process safety

Emerging Lessons

- Need more “error” tolerant systems, with acknowledgement/acceptance of cognitive biases
- Process safety risks must be driven by data, not personal experience
- Safety opportunity resides within the gaps between policies and practice – the focus is not on the fact that the gap exists, but why the gap exists
Disclaimer

This presentation for the Human Factors in Control Forum by Cheryl MacKenzie, Investigator for the U.S. Chemical Safety and Hazard Investigation Board, on May 8, 2017, is for general informational purposes only. The presentation is the view of Ms. MacKenzie. References, conclusions or other statements about CSB investigations may not represent a formal, adopted product or position of the entire Board. For information on completed investigations, please refer to the final written products on the CSB website at: www.csb.gov.

Questions?

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