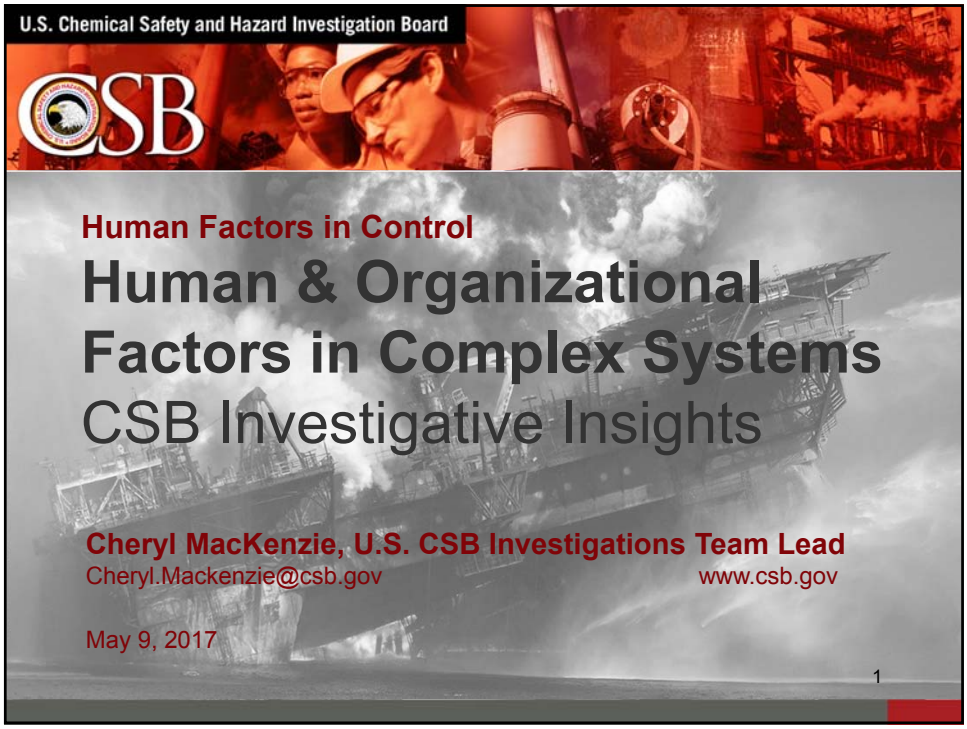
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CSB
Human Factors in Control
Human & Organizational Factors in Complex Systems
CSB Investigative Insights
Cheryl MacKenzie, U.S. CSB Investigations Team Lead
Cheryl.Mackenzie@csb.gov
www.csb.gov
May 9, 2017
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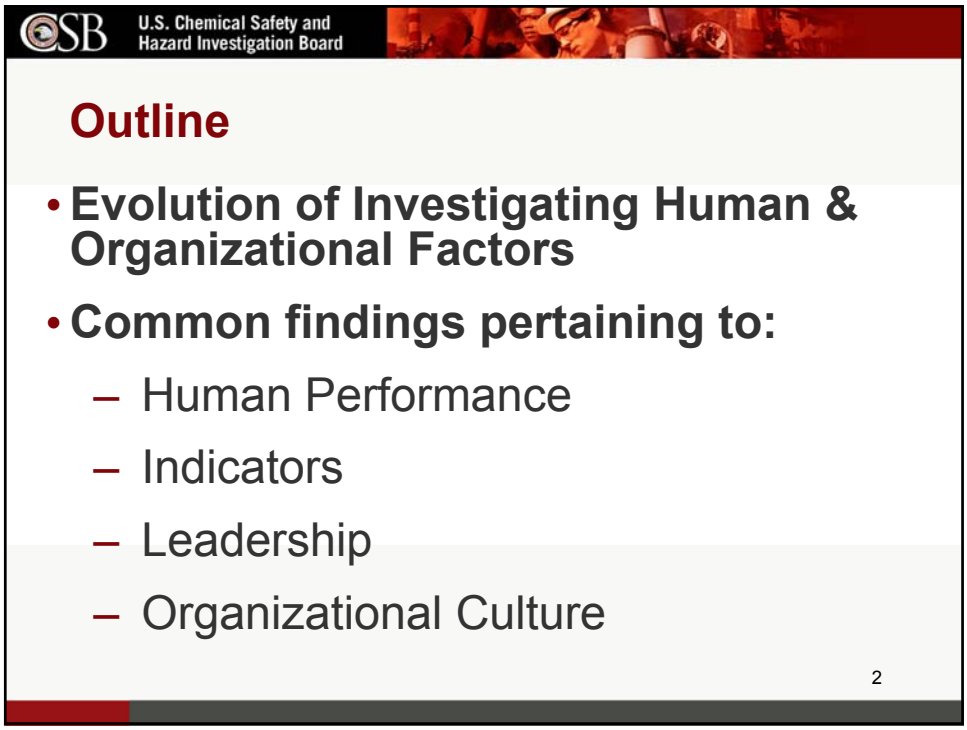
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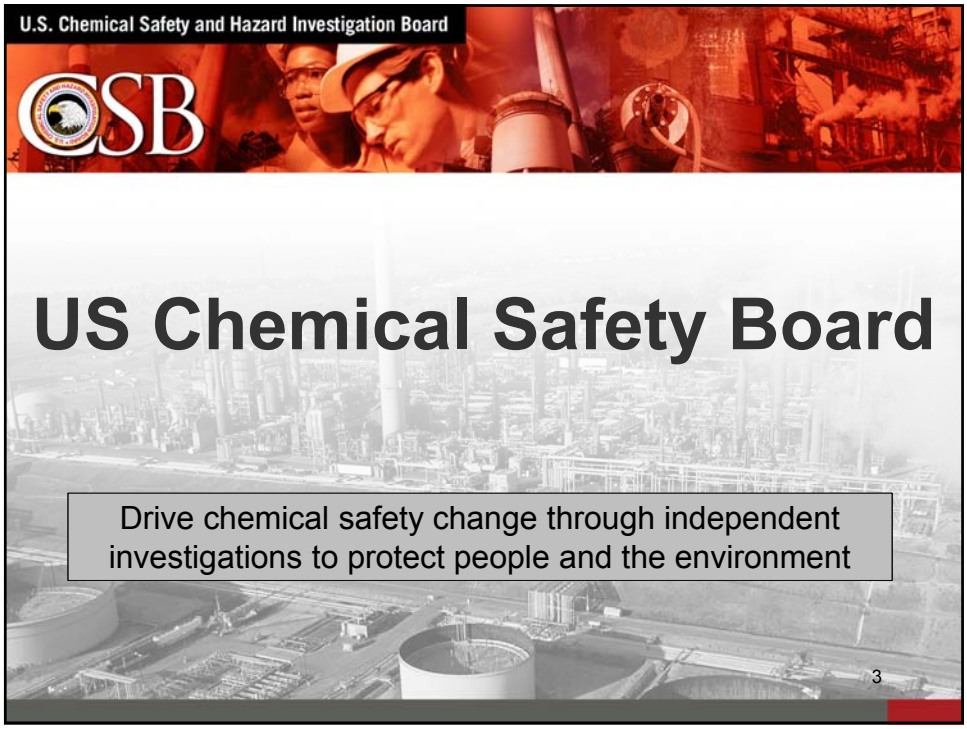
Outline
• Evolution of Investigating Human & Organizational Factors
• Common findings pertaining to:
– Human Performance
– Indicators
– Leadership
– Organizational Culture
2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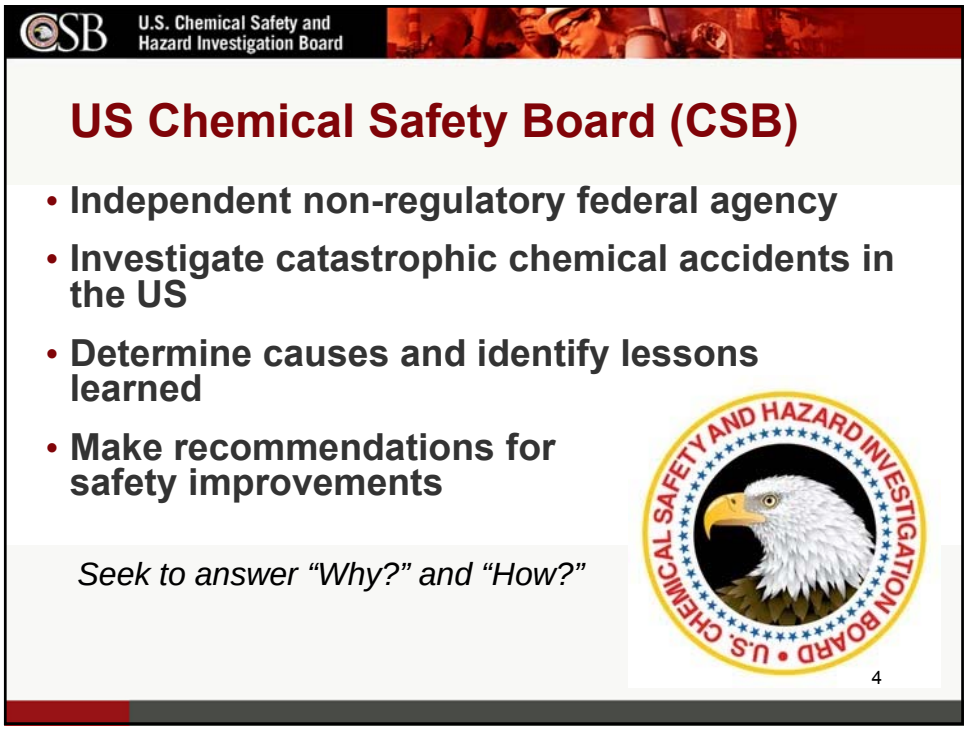
CSB
US Chemical Safety Board
Drive chemical safety change through independent investigations to protect people and the environment
3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US Chemical Safety Board (CSB)
• Independent non-regulatory federal agency
• Investigate catastrophic chemical accidents in the US
• Determine causes and identify lessons learned
• Make recommendations for safety improvements
Seek to answer "Why?" and "How?"
U.S. CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD
4

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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)

6

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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

7

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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

8

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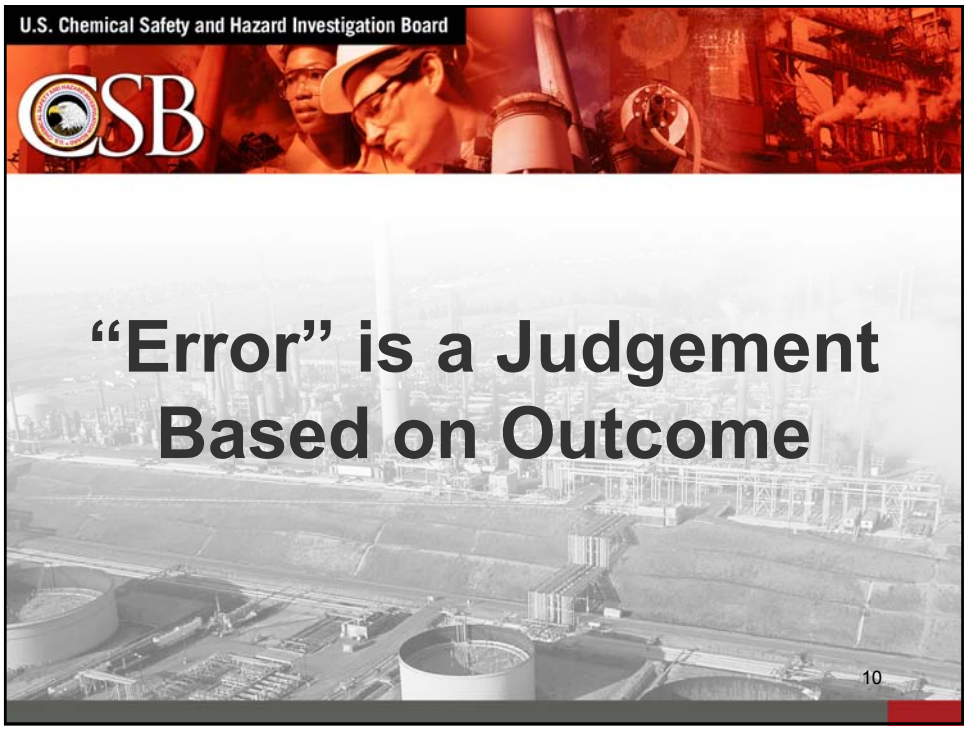
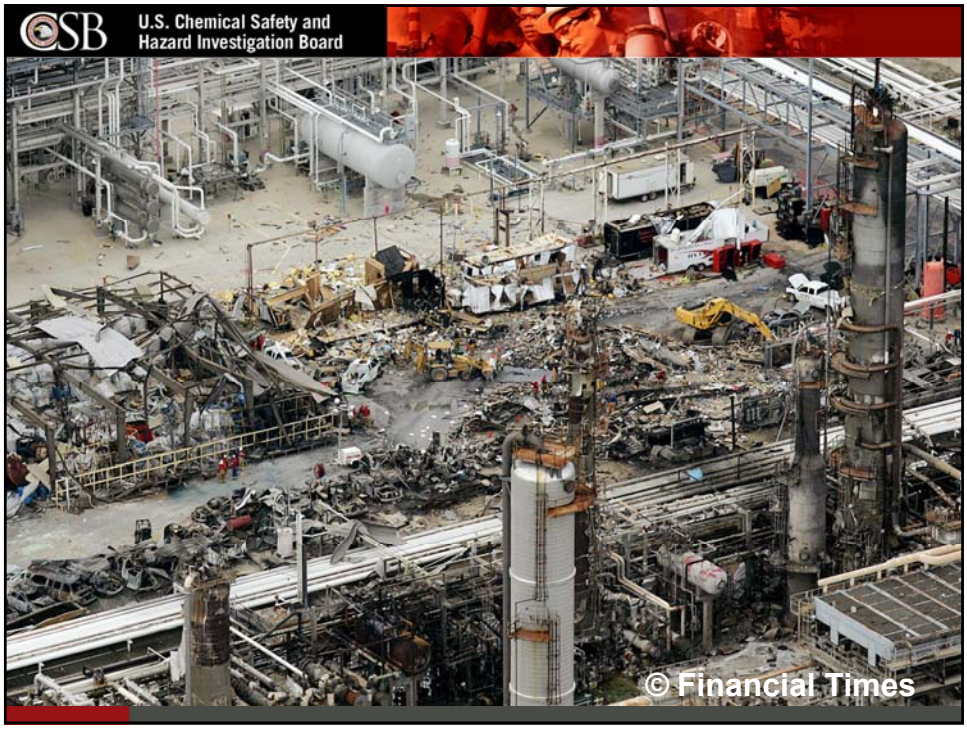
CSB Consistently Finds:

- *"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*

9





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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

12

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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

13

Contradiction of Expectations

14

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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"

Taken verbatim from Pupulidy, I., Novices, Experts & Errors: Toward a Safer Fire Ground, Wildfire, Jan-Feb 2015, v24(1), p.33 from pp.32-35.

15

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Truths About Human Performance

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?

16

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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

17

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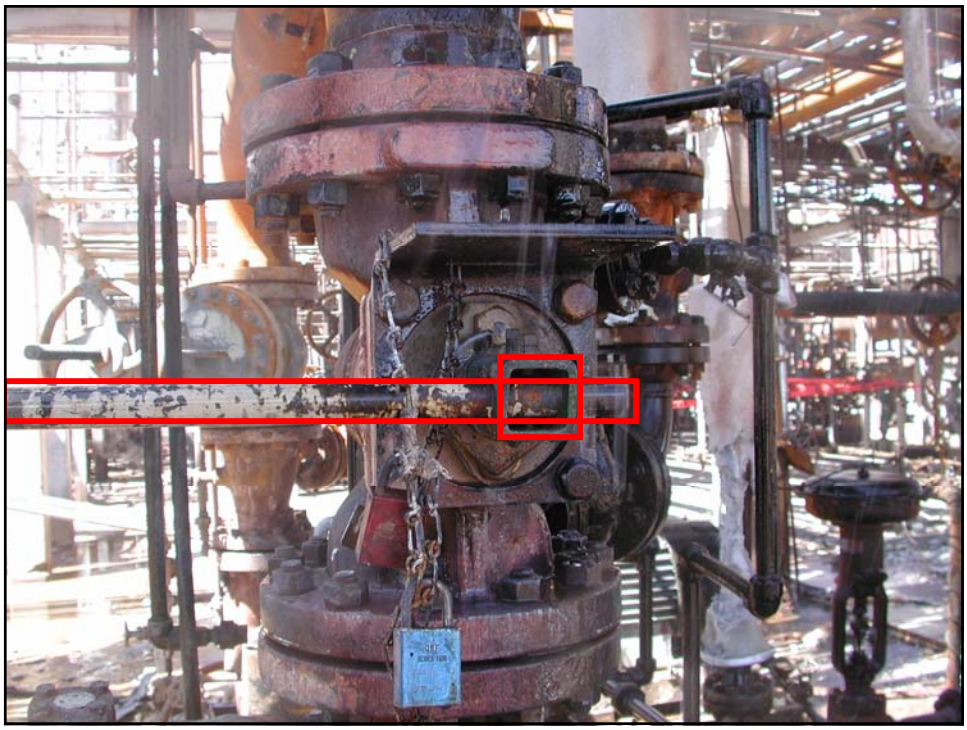

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Giant Industries Refinery Explosion

- 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?

19

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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

20

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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

21

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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

23

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Process Safety

A Safety Discipline Distinct from Personal Safety

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

24

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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

25

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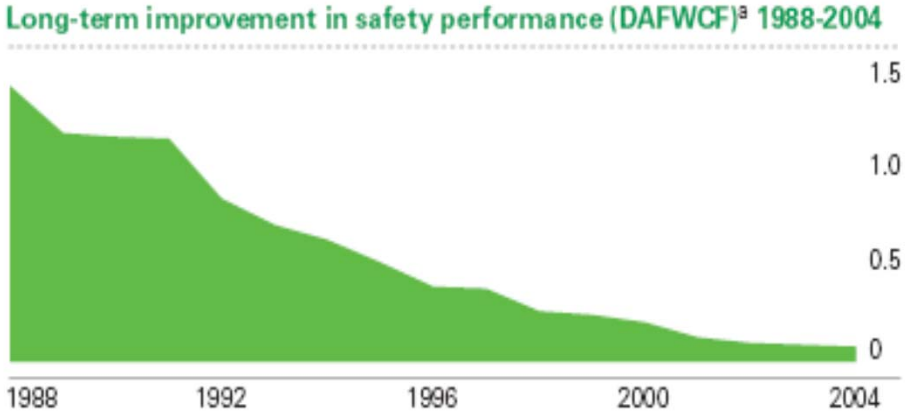
BP's "Days Away from Work" Rate



http://www.bp.com/sectiongenericarticle.do?categoryId=9010712&contentId=7021106

26

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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)

28

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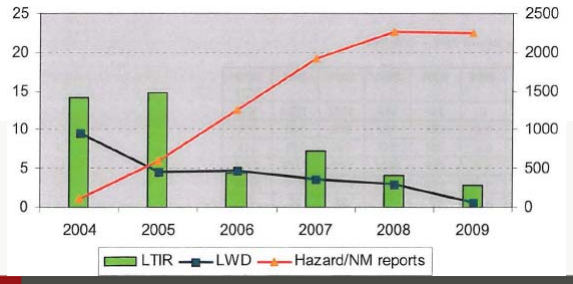
Same Policy, Different Behaviors & Expectations – Indicators of Value

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, Safely and Environment in Oil and Gas Exploration and Production held in Rio de Janeiro, Brazil, 12-14 April 2010.

29

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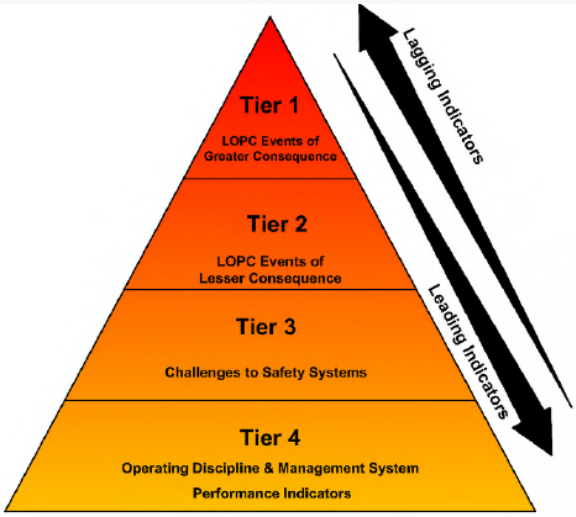
Process Safety Indicator Pyramid



API Recommended Practice, 754, 1st ed., *Process Safety Performance Indicators for the Refining and Petrochemical Industries*, April 2010, pp 8

30

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Well Control Events – Precursor Data

2008 – 2009:

- 6 riser unloading events

2009:

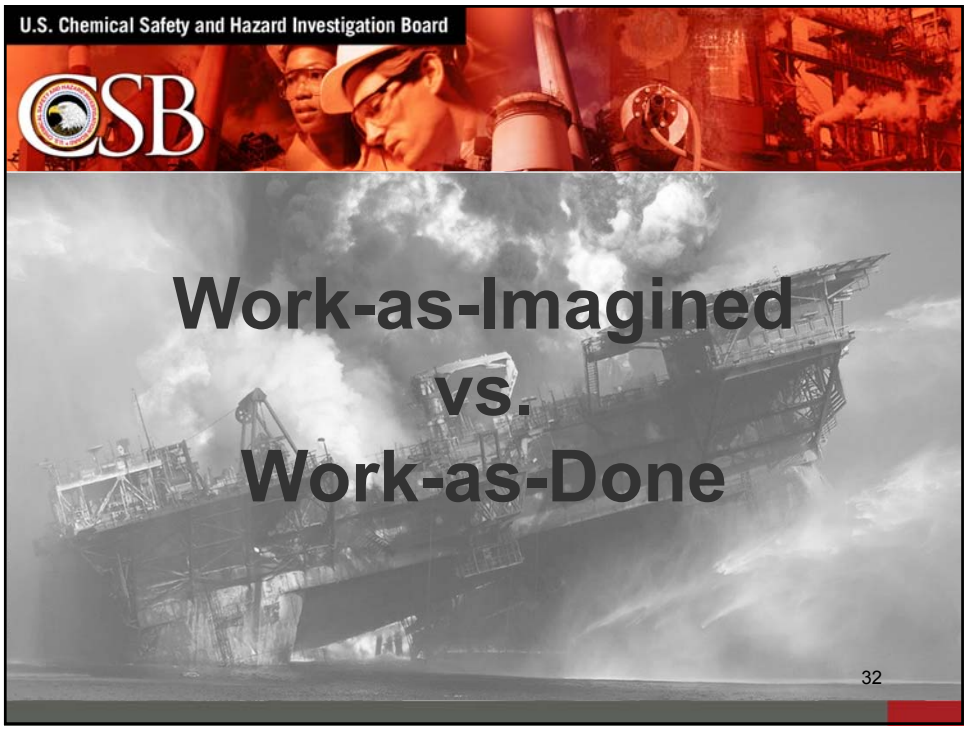
- 121 well control events
- 32 different operators
- Various geographic locations

Indicators:

- Kick volume
- Kick intensity
- Riser unloading events

Source: Transocean Well Control Events & Statistics report, 2005 - 2009

31

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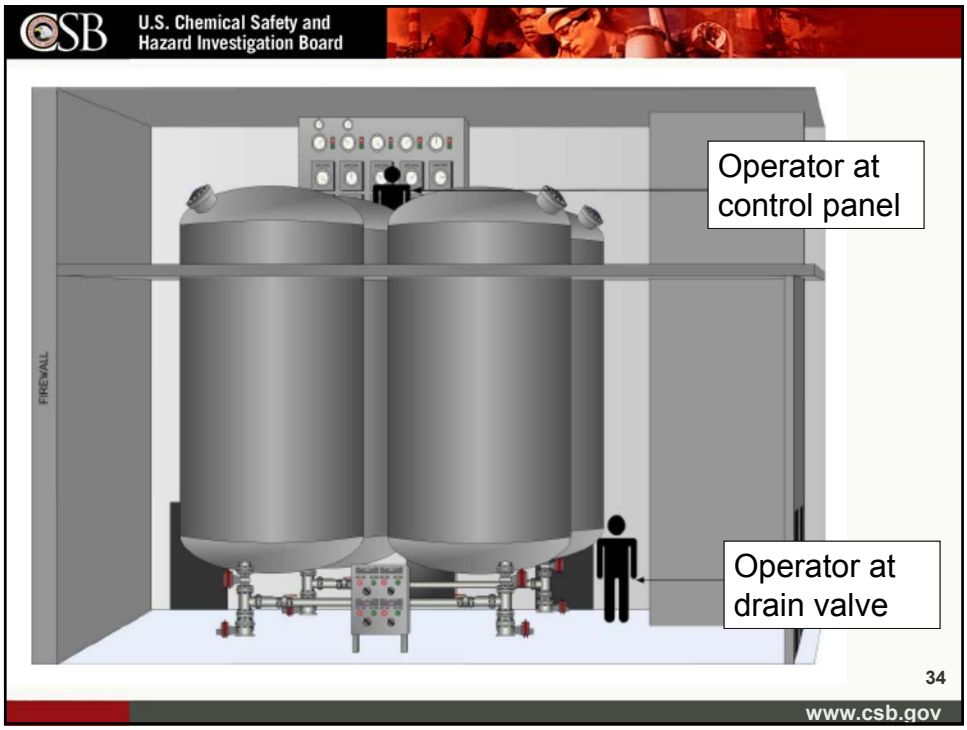
Formosa Plastics Explosion
Illiopolis, IL
• April 23, 2004
• Flammable vinyl chloride release ignited
• 5 fatalities, 2 injured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Operator at control panel
Operator at drain valve
FIREWALL
34
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Formosa 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?

35

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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

36

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Organizational Culture

37

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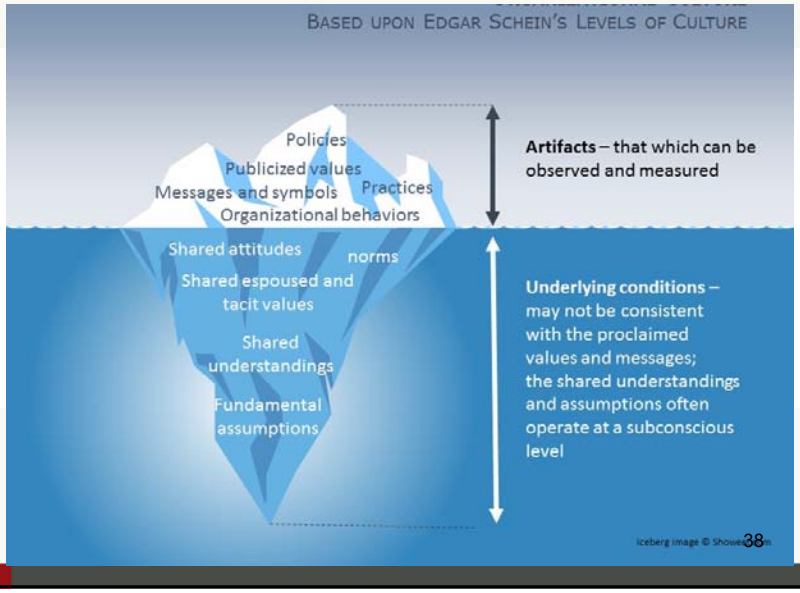
Organizational Culture



38

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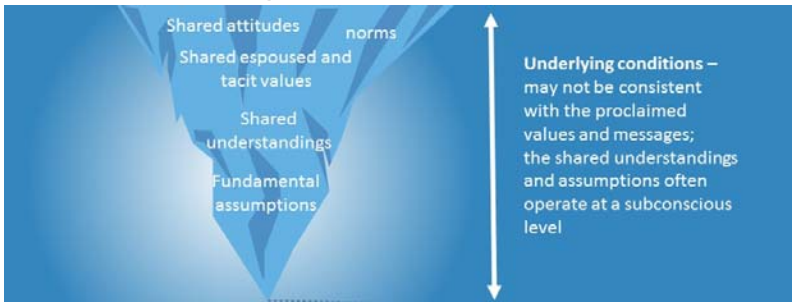
Organizational Culture

- 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

39

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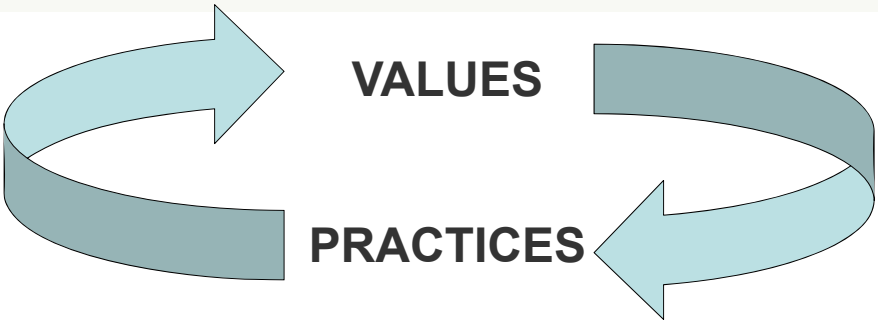
Organizational Culture



40

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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

41

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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

42

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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.

43