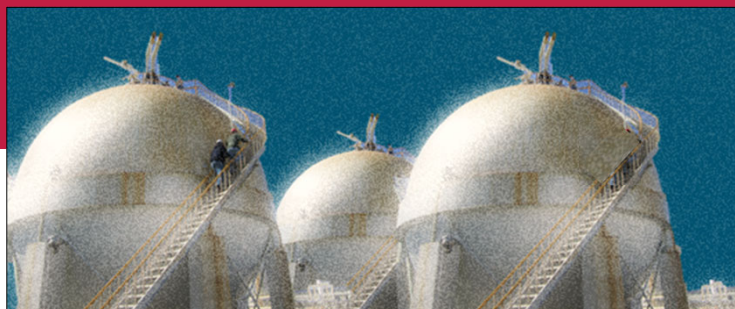


P2SAC Fall 2023 Conference
December 6, 2023



Proper Incident Investigations: *Please Don't Blame the PHA Leader*



Dr. Bruce K. Vaughen
Center for Chemical Process Safety
brucv@aiiche.org

Bruce K. Vaughen, PhD, PE, CCPSC®



More than two decades experience

Since 1989

- Research Engineer, Operations Engineer — *E. I. DuPont de Nemours*
- Process Safety Management Coordinator — *DuPont Teijin Films*
- Visiting Assistant Professor — *Rose-Hulman Institute of Technology*
- Global FMO Process Safety Leader — *Cabot Corporation*
- Principal Consultant, Process Safety — *Baker Engineering and Risk Management*

Since 2017

- Lead Process Safety Subject Matter Expert

— Center for Chemical Process Safety (CCPS)

Bruce K. Vaughen - PhD, PE, F.AIChE, F.CCPS, CCPSC®



- Co-author and Instructor of *Inherently Safer Design* Training
- Lead Process Safety Management (PSM) Auditor
- Process Hazards Analysis (PHA) Leader
- Participant in multiple reviews of corporate PSM standards
- Author of more than sixty process safety publications and conference presentations
- Author and editor of more than ten AIChE/CCPS/SACChE training modules (Safety and Chemical Engineering Education = SACChE)
- Principal or co-principle author of four CCPS Guidelines
- Co-author of introductory book on Process Safety

3

Disclaimer

All views expressed in this presentation are those of the author.
This may be a work of fiction based on real events.
Any resemblance to persons living or not is purely intentional.
Any use or misuse of this material is the responsibility of the User.

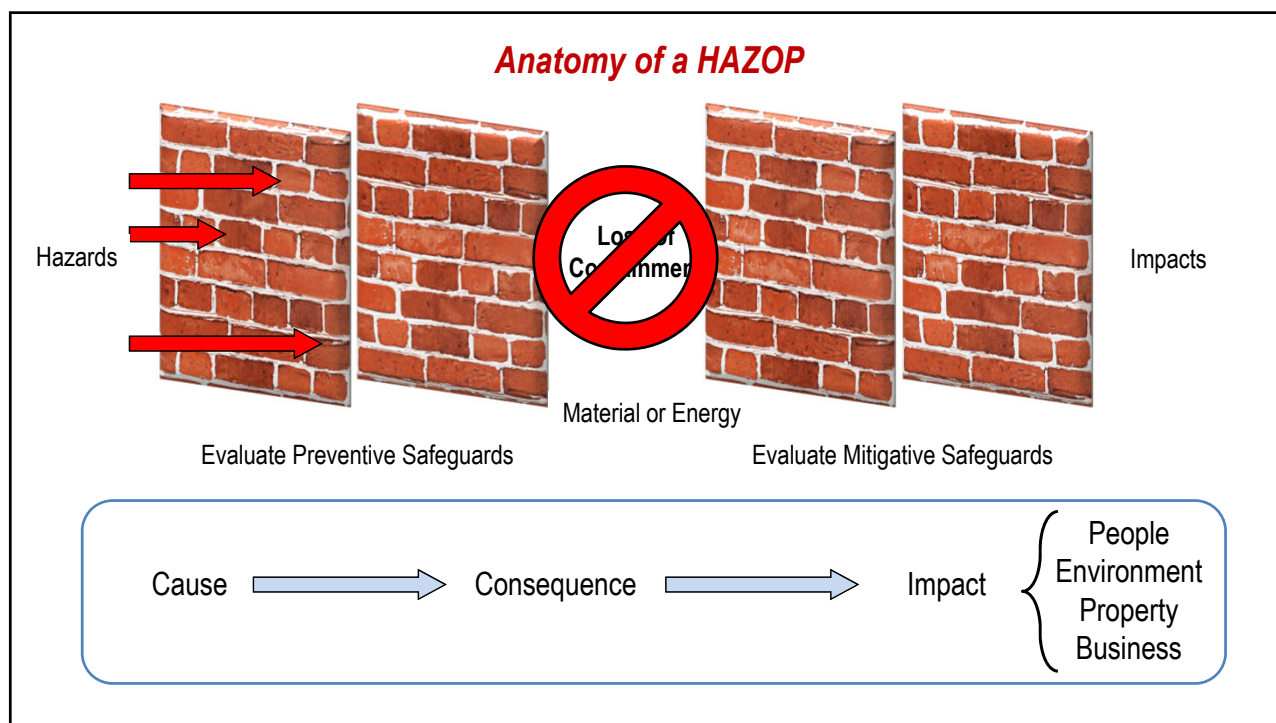
Some Alphabet Soup Ingredients

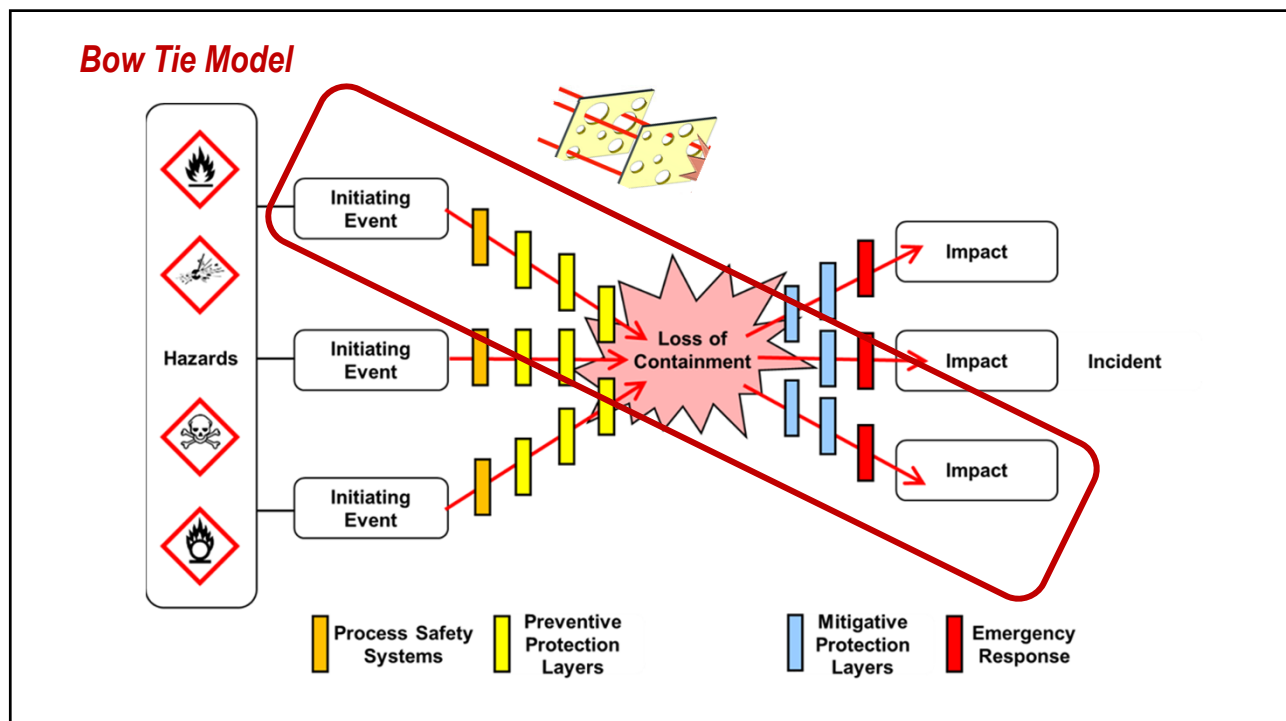
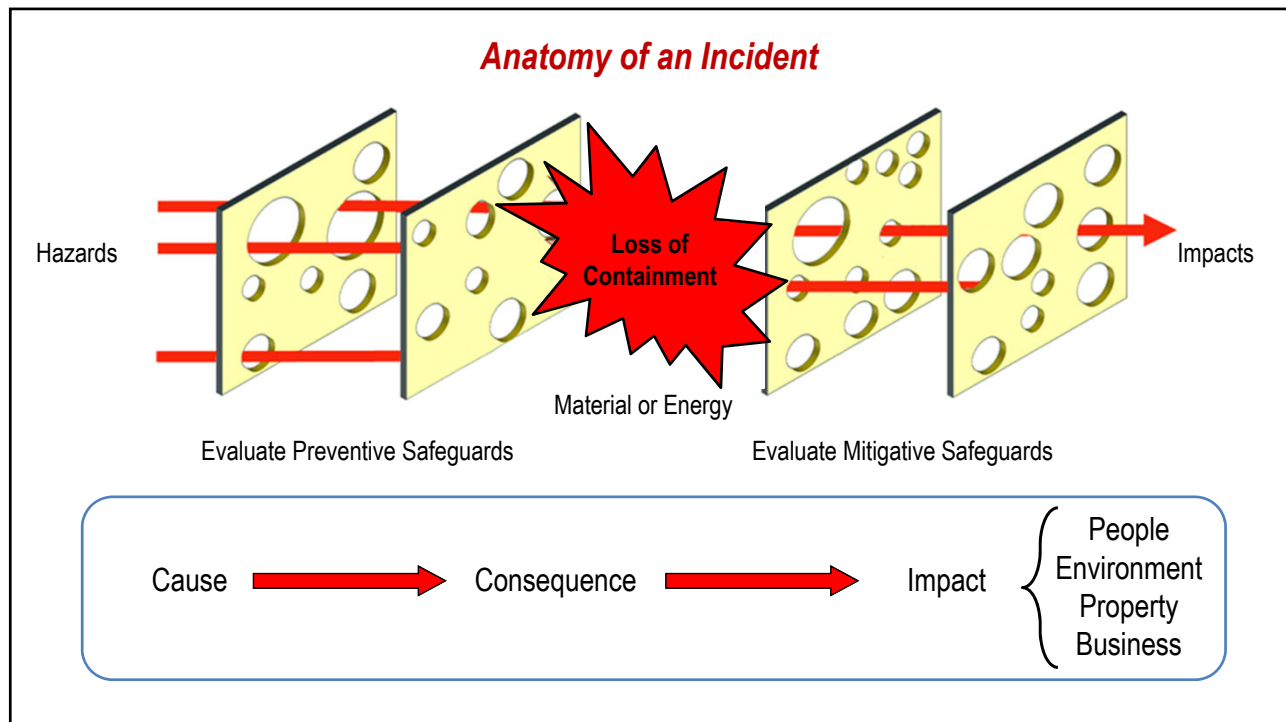


| | |
|-------|---|
| BLEVE | Boiling Liquid Elevated Vapor Explosion |
| DCS | Distributed Control System |
| ITPM | Inspection, Testing, and Preventive Maintenance |
| PHA | Process Hazards Analysis |
| TLA | Three Letter Acronym |
| RCA | Root Cause Analysis |
| HAZOP | Hazard and Operability Study |



5





Outline



- The Incident
- The Investigation
- The Investigation Team's Conclusions
- The Business Manager's Conclusion
- The Audience Participation Part
- Summary

9

The Incident



Tank storage area had three spheres containing a flammable material.

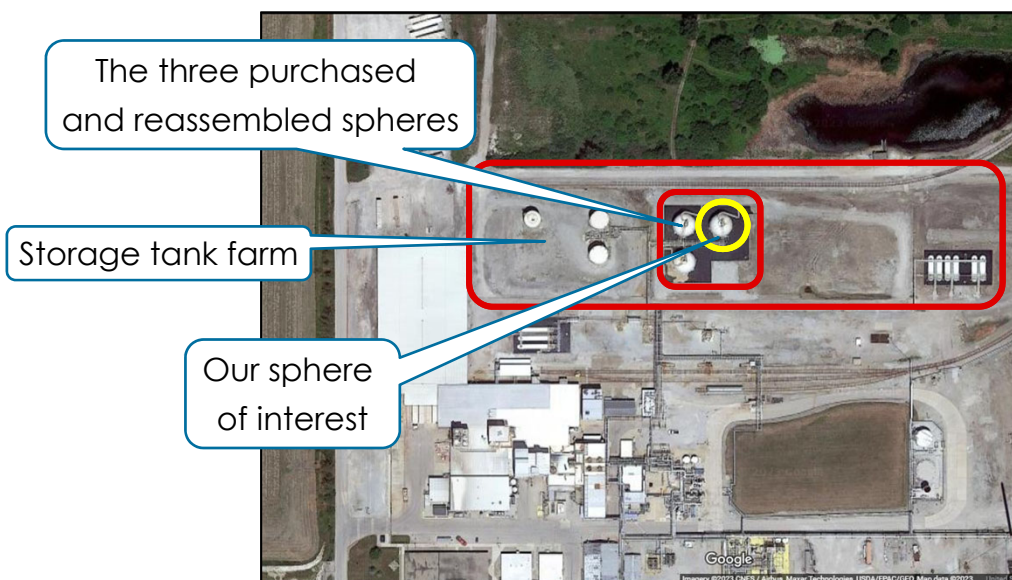
These spheres had been

- purchased used
- disassembled
- transported, and
- rebuilt at a new location.



10

The Plant Layout



11

The Day of the Incident



One of the sphere's pressure gauge "pegged" at 100 psi.

Assuming a faulty gauge, the operator climbed up the sphere and replaced the gauge.

The new gauge immediately pegged at 100 psi.



12

What if?



Had the sphere failed at 100 psi, this may have occurred.

This is why Process Hazards Analyses (PHAs) are performed, to prevent such accidents

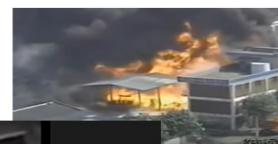


13

What if?

1998 Buchon South Korea LPG Gas station Explosion LPG

A BLEVE



Bruce Vaughan
Bruce Vaughan

14

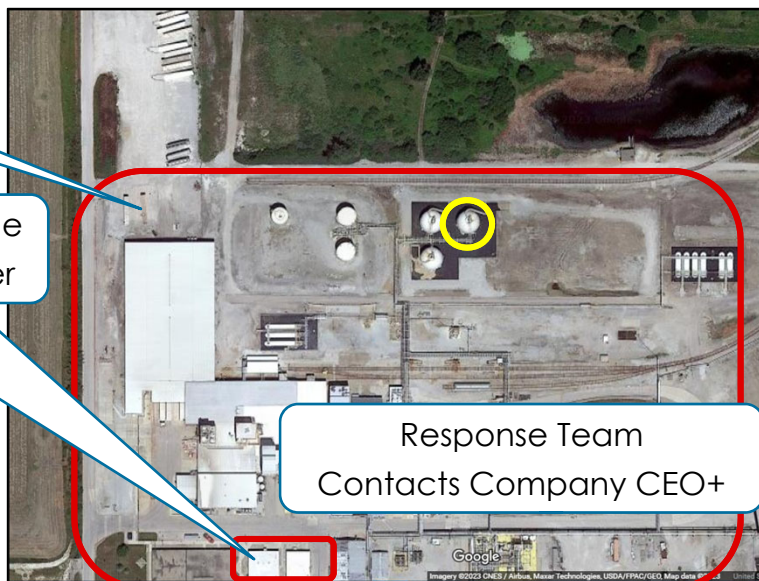
The Emergency Response



Evacuate the Plant!

Response Team Meets in the
Emergency Control Center

Response Team
Contacts Company CEO+



15

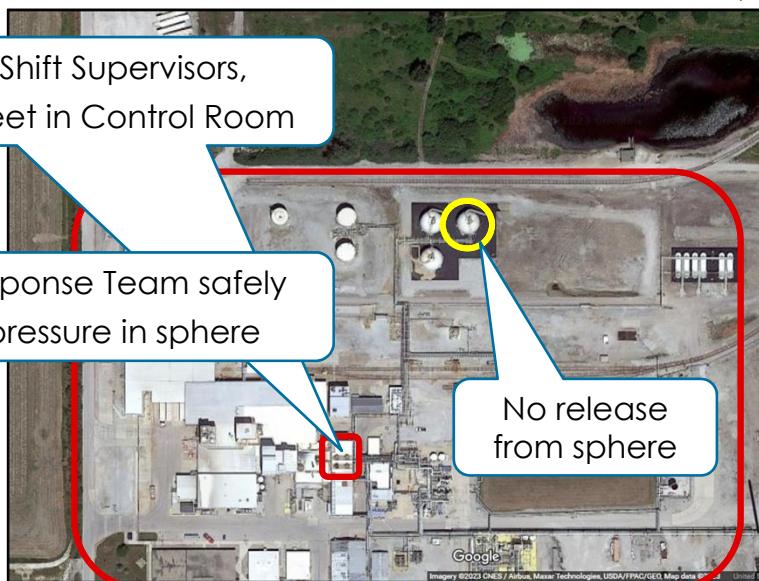
The Emergency Response



Operators, Engineers, Shift Supervisors,
and other responders meet in Control Room

Emergency Response Team safely
relieves high pressure in sphere

No release
from sphere



16

Outline



- The Incident
- The Investigation
- The Investigation Team's Conclusions
- The Business Manager's Conclusion
- The Audience Participation Part
- Summary

17

The Investigation



Some steps when investigating a major incident

- 1) Respond safely to the emergency before initiating investigation
- 2) Assemble a qualified, competent team
- 3) Gather information (including developing a timeline)
- 4) Determine root causes
- 5) Develop recommendations
- 6) Approve and implement recommendations



18

Assembling a Competent Incident Investigation Team



- Incident Investigation Leader
(trained in Root Cause Analysis (RCA))
- Process Safety Professional
- Process engineer
- Area shift supervisor and an area operator (Production)
- An area mechanic and an area electrician (Maintenance)
- Other Subject Matter Experts, as needed

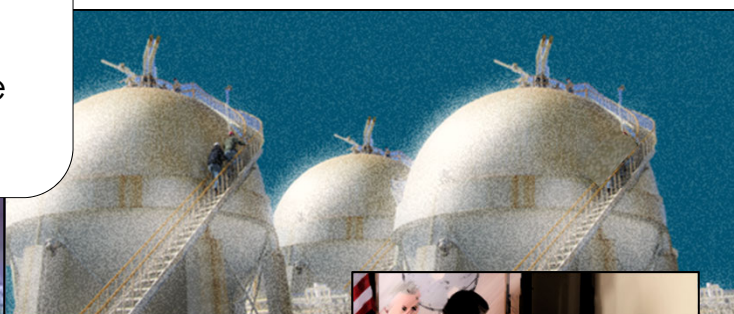
19

Gathering Information



Develop a Timeline using

- Physical evidence
- Electronic evidence
- Witness interviews



20

Data - Some physical evidence



Nitrogen pressure regulator



Pressure gauge on top of sphere



21

Data - Some more physical evidence



Pressure relief valves

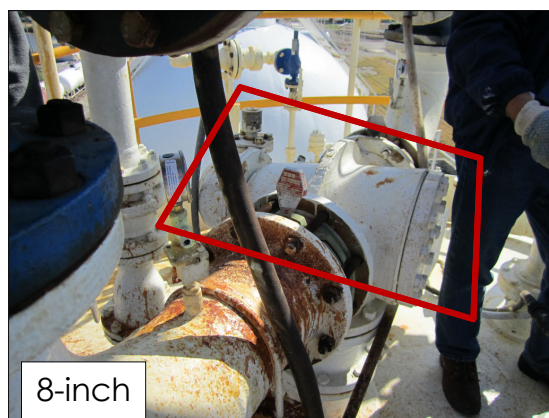


1-inch



8-inch

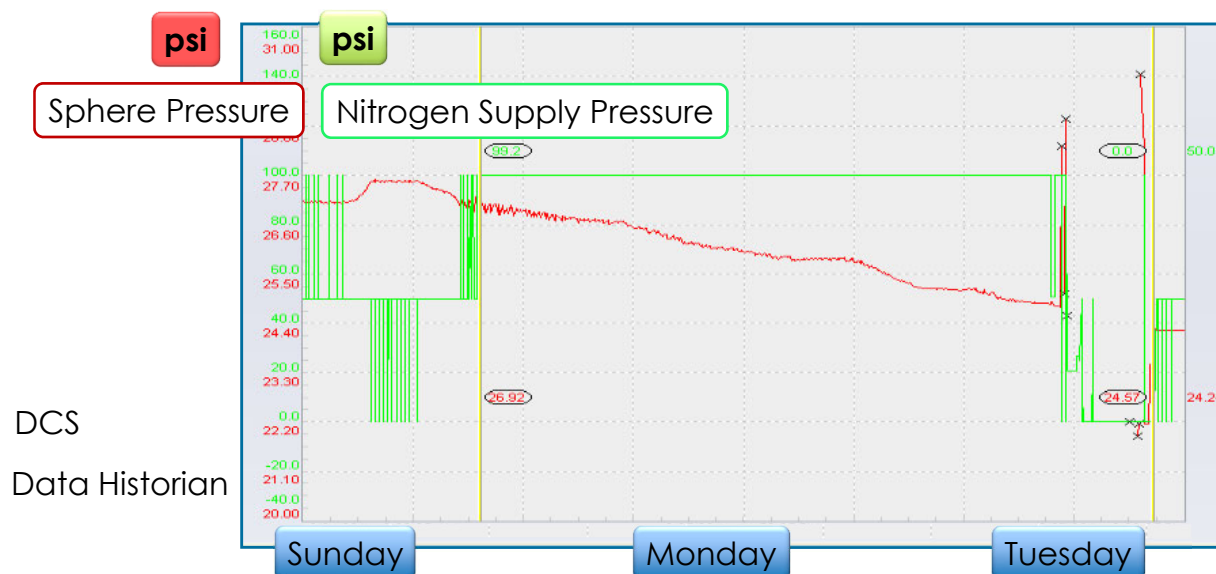
3-way valve



8-inch

22

Data - Some electronic evidence



Data - Witness interview



Operator

Noted that he had never run down the stairs as fast as he did when he saw the second gauge peg at 100 psi.

(The sphere was rated at 60 psi)



Data - Witness interview



Mechanic

Noted that the person who had serviced and maintained the spheres, including replacing the impulse tube annually, had retired a few years ago.



25

Data - Witness interview



Engineer

Noted that projects proposed for the storage area, including those for replacing the pneumatic system and for upgrading the relief valves, never made it through the approval process.



26

Data - Witness interview

Engineer

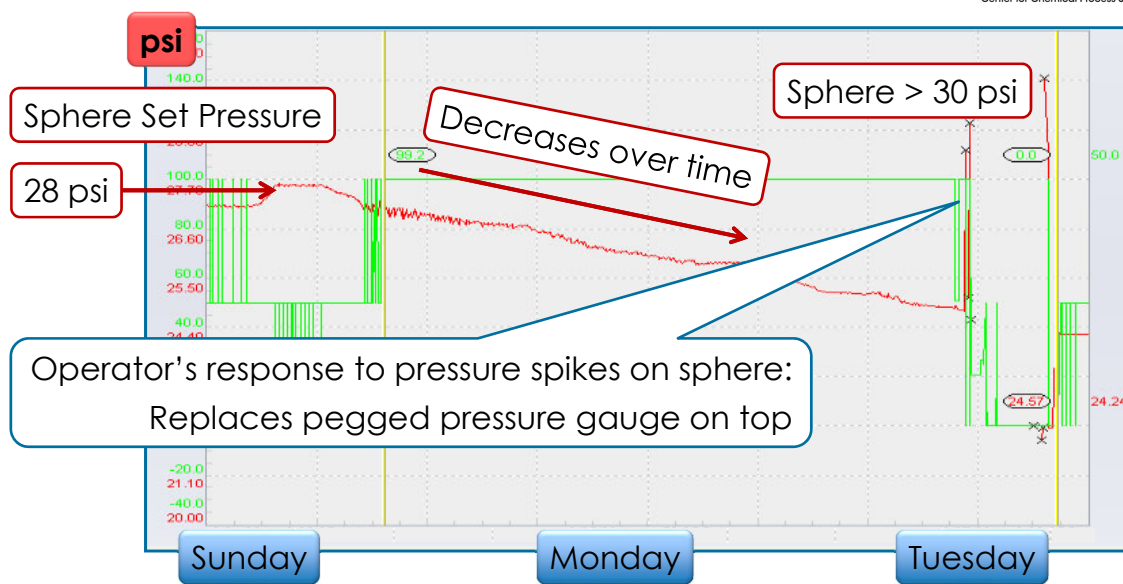
Noted that he had been too busy to review the annual relief valve “pop” results from the contractor that ran the tests on the valves taken out of service.



An AIChE Technology Alliance
CPS
Center for Chemical Process Safety

27

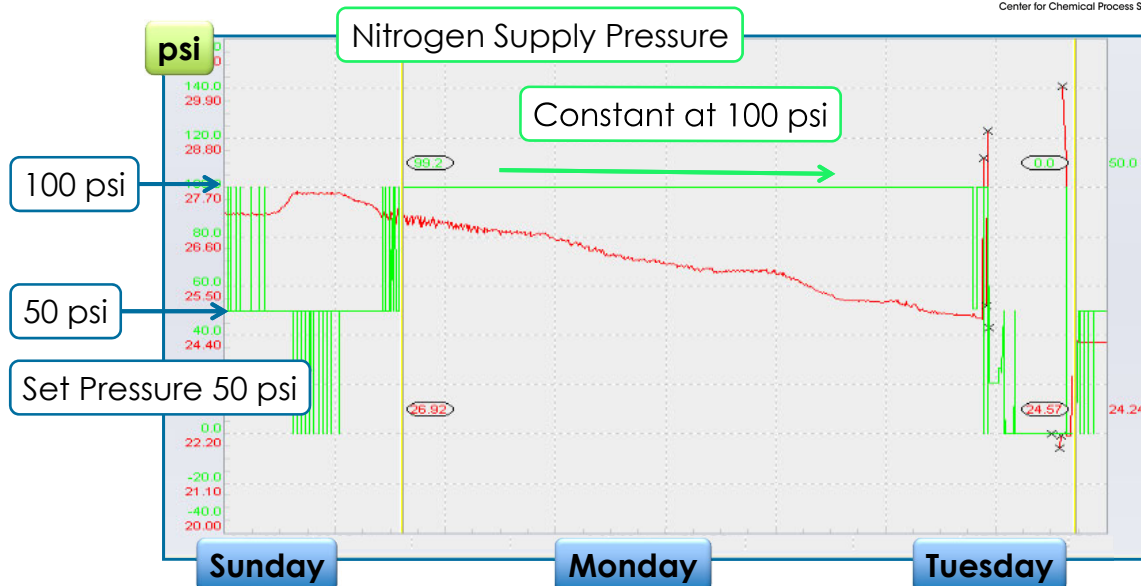
Incident Timeline – Sequence of Events



An AIChE Technology Alliance
CPS
Center for Chemical Process Safety

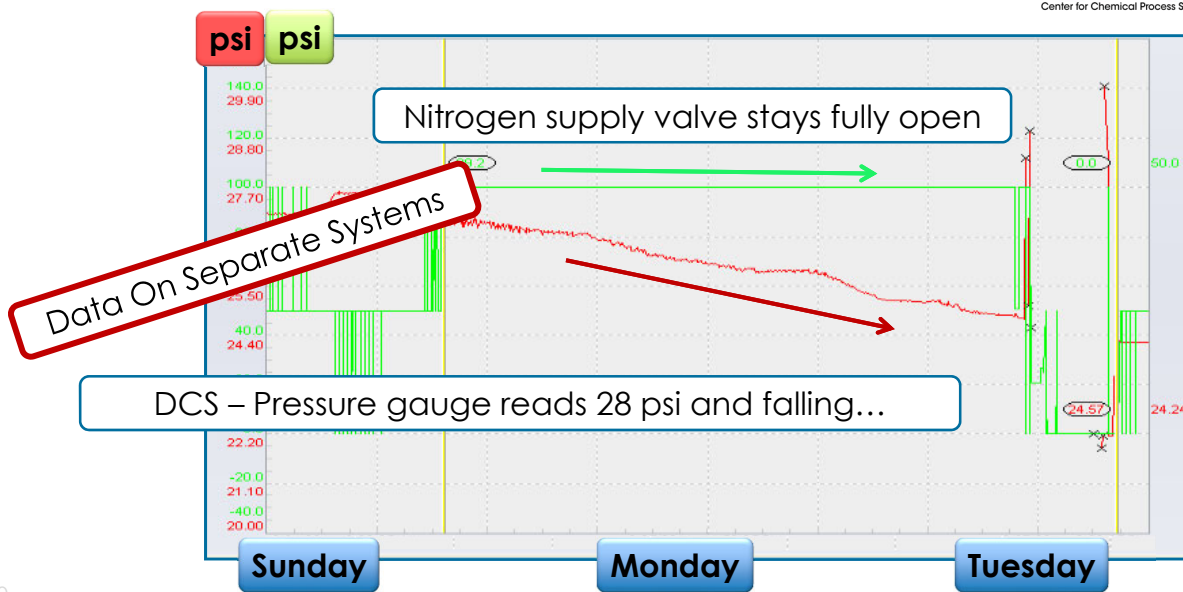
28

Incident Timeline – Sequence of Events



29

Incident Timeline – Sequence of Events



30

The Perfect Storm

31

The “Perfect Storm” – Finding #1



Find failed
Pressure gauge
impulse tube



Thus, gauge sends a *false low pressure* value to DCS,
opening Nitrogen supply and closing sphere's vent valve

The “Perfect Storm” – Finding #2



Nitrogen Supply



Find regulators in failure mode

At time of incident, **Find** 100 psi Nitrogen supply being fed to spheres

The “Perfect Storm” – Finding #3

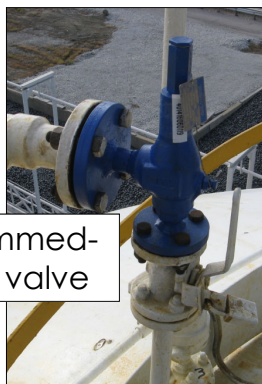


Find 3-way valve between 8" relief valves has leaked, but neither valve had lifted

The "Perfect Storm" – Finding #4



1" Relief Valve



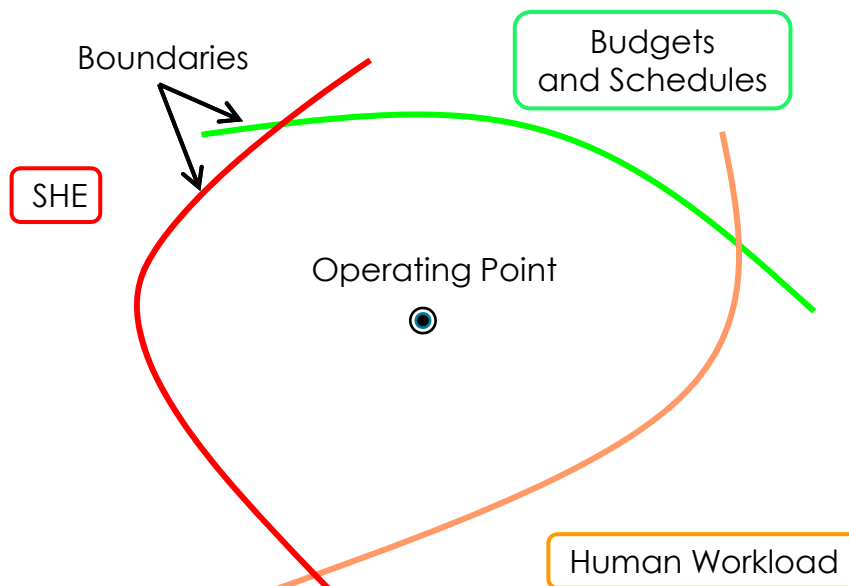
Valve set to activate at 33 psi

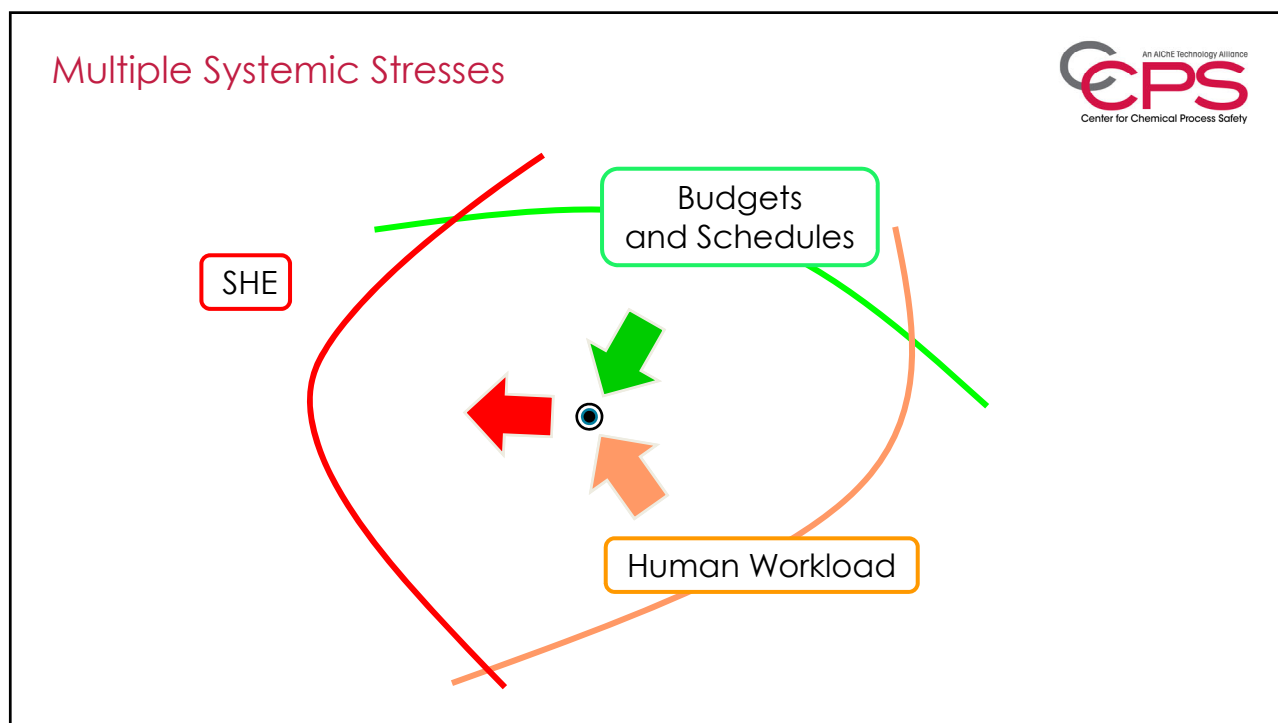
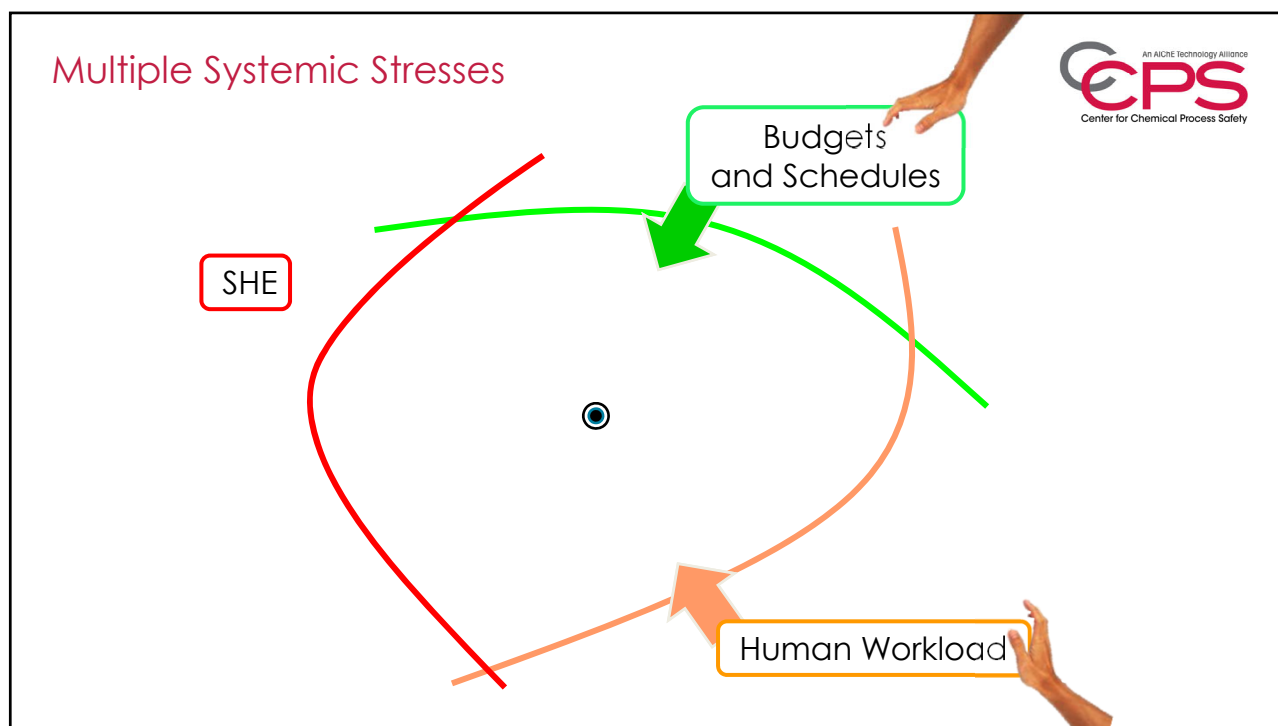
Two 8" Relief Valves



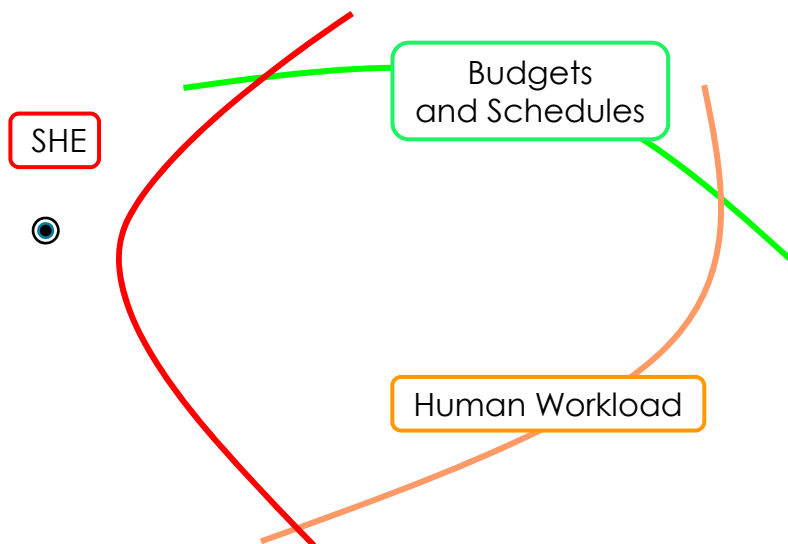
Valves set to activate at 34.5 psi

Multiple Systemic Stresses

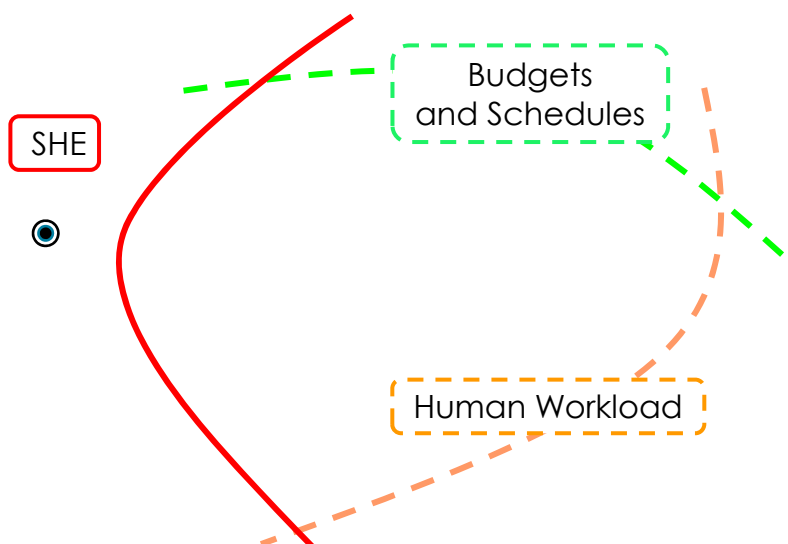




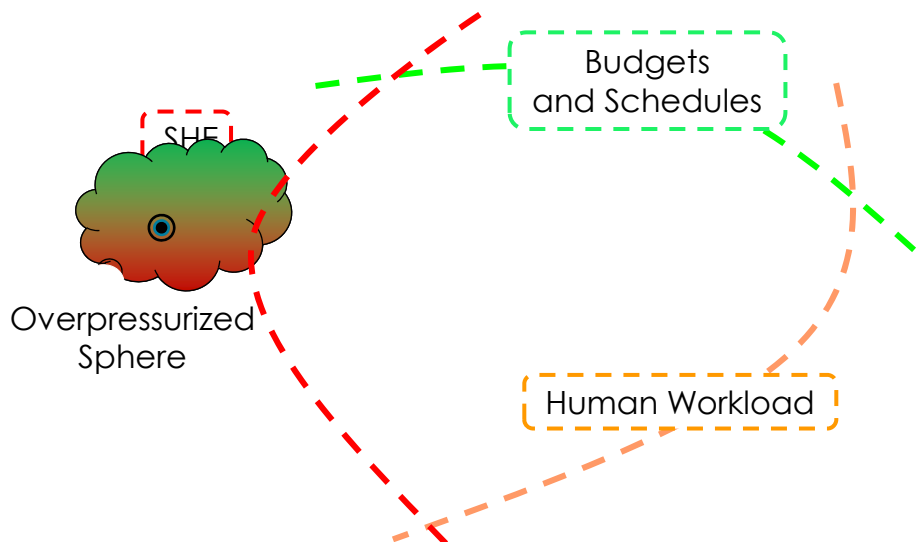
Multiple Systemic Stresses



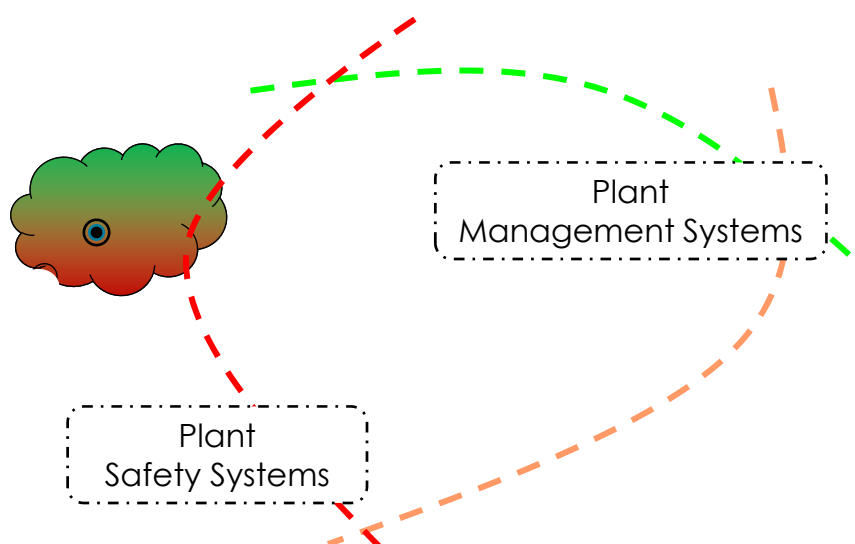
Multiple Systemic Stresses



Multiple Systemic Stresses



Root Cause Analysis



Using A Decision-based Time Line

Several Years

| Who | Years | | | | | | |
|----------------|--------------|--------------|--------------|--------------|--------------|------|------|
| | 1985 to 1989 | 1990 to 1995 | 1995 to 1999 | 2000 to 2004 | 2005 to 2009 | 2010 | 2011 |
| Engineering | | | | | | | |
| Purchasing | | | | | | | |
| Operations | | | | | | | |
| Maintenance | | | | | | | |
| SHE RM PHAs | | | | | | | |

Using A Decision-based Time Line

Several Years

| Who | Years | | | | | | |
|-------------|------------------------------|--------------|--------------|-------------------|--------------------|---------------|------|
| | 1985 to 1989 | 1990 to 1995 | 1995 to 1999 | 2000 to 2004 | 2005 to 2009 | 2010 | 2011 |
| Engineering | Spheres Installed 1988 | | | Pilot Design ? | Sphere Upgrades | | |
| Purchasing | | | | | | | |
| Operations | | | | | | | |
| Maintenance | | | PMs | Annual PMs | Annual PMs | Annual PMs | |
| SHE PHAs | | 1990 | 1997 | 2002 | 2006 | | 2011 |

HAZOP

Sphere Incident


Using A Decision-based Time Line

Several Months

| Who | When - 2011 | | | | | | | | |
|-------------|-------------|-----|-----|-----|-----|-----|-----|-----|-----|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| Engineering | | | | | | | | | |
| Purchasing | | | | | | | | | |
| Operations | | | | | | | | | |
| Maintenance | | | | | | | | | |
| SHE | | | | | | | | | |

Using A Decision-based Time Line

Several Months

| Who | When - 2011 | | | | | | | | |
|-------------|---|-----|-----|-----------------------------------|--|---|--------------------------------------|---------------------------------|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| Engineering | | | | | | | | | |
| Purchasing | | | | No Response from Tyco | | | Still no 1" | |  |
| Operations | | | | | | Notified Sphere PM Due in July for both 1" and 8" | Delay PM (Crane needed for 8") | | |
| Maintenance | Tyco 1" Valve supply issues | | | Tell Purchasing <u>Need</u> 1" | | | Annual PM Due | PM Overdue | |
| SHE | A/B Unit PHA Revalidation Team Meetings and Completion | | | Verifying safeguard PMs | Begin Raw Materials and Hydrogen PHA Revalidation Team Meetings | | | Hydrogen part of PHA Delayed | |

Outline



- The Incident
- The Investigation
- The Investigation Team's Conclusions
- The Business Manager's Conclusion
- The Audience Participation Part
- Summary

47

Team's Conclusions



Root Cause:

Sphere at high pressure due to all three relief valves not activating



48

Team's Conclusions



Contributing Cause:

- Failure of the Nitrogen supply pressure regulator



Management Systems include:

Operating Procedures (Walkthroughs)

Also

Asset Integrity and Reliability (ITPM)

49

Team's Conclusions



Contributing Cause:

- Failure in the safeguard design for redundancy and functionality



Management Systems include:

Process Technology (Design)

Also

Asset Integrity and Reliability (ITPM)

50

Team's Conclusions



Contributing Causes:

- *Failure to adequately confirm safeguard functionality*
- *Failure of the Inspection, Testing, and Planned Maintenance (ITPMs) programs*



Management Systems include:

Asset Integrity and Reliability system

51

Outline



- The Incident
- The Investigation
- The Investigation Team's Conclusions
- The Business Manager's Conclusion
- The Audience Participation Part
- Summary

52

The Business Manager's Investigation Conclusion



Root Cause:

The PHA Team did not predict *this scenario*

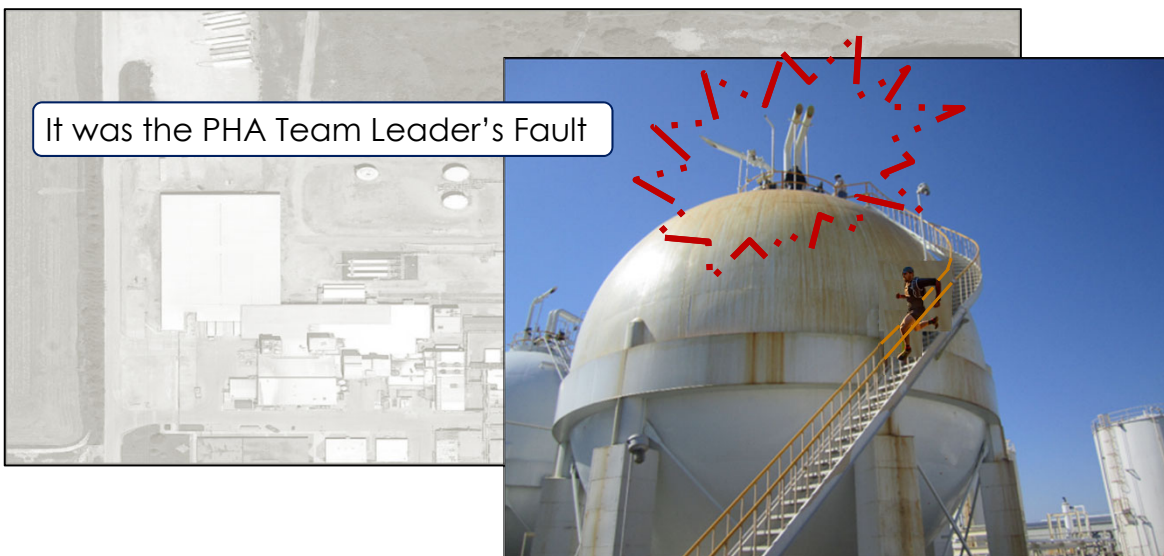


53

The Business Manager's Conclusion



It was the PHA Team Leader's Fault



54

Outline



- The Incident
- The Investigation
- The Investigation Team's Conclusions
- The Business Manager's Conclusion
- The Audience Participation Part
- Summary

55

Audience Participation – Question #1



Was the Investigation Team qualified?



Show of Hands:

Yes

No

The business manager?



Yes

No

Why?

56

Audience Participation – Question #2



Assume the PHA Team used the HAZOP Methodology
Would a HAZOP have identified this scenario?

Show of Hands:

Yes

No

Why?



57

Audience Participation – Question #3



Was it the PHA Team Leader's Fault?

Show of Hands:

Yes

No

Why?



58

Audience Participation – Question #4



Would a Business Manager have funded a PHA Team that could have identified this scenario?

Show of Hands:

Yes

No

Why?



59

Outline



- The Incident
- The Investigation
- The Investigation Team's Conclusions
- The Business Manager's Conclusion
- The Audience Participation Part
- Summary

60

Summary



What are some take-aways from this presentation?

- 1) The HAZOP Methodology is a structured approach to identify *potential* scenarios (cause-consequence pairs). It does not predict every situation, and it does not account for other ineffective process safety systems.
- 2) An effective investigation's Root Cause Analysis does not stop at the human(s) involved.
- 3) The Incident Investigation must identify the systemic issues.

61



Thank you for your time and attention

Questions?

62