Next Generation Root Cause Investigation (RCI) and Analysis

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The Dow Chemical Company

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Biography – Kenan Stevick

- Chief Process Safety Engineer, Global Director of Process Safety, Dow Chemical Company
- 34+ years industry experience
- 21 years Manufacturing, EH&S and Engineering
  - 10 + years as Plant / Site Leader / Director
- 13 years in process safety

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- Introduction & Background
- RCI Standard and work process
- RCI effectiveness reviews and repetitive incident analysis
- Leveraging corrective actions
- Learning Experience Reports
- Conclusions

Introduction & Background

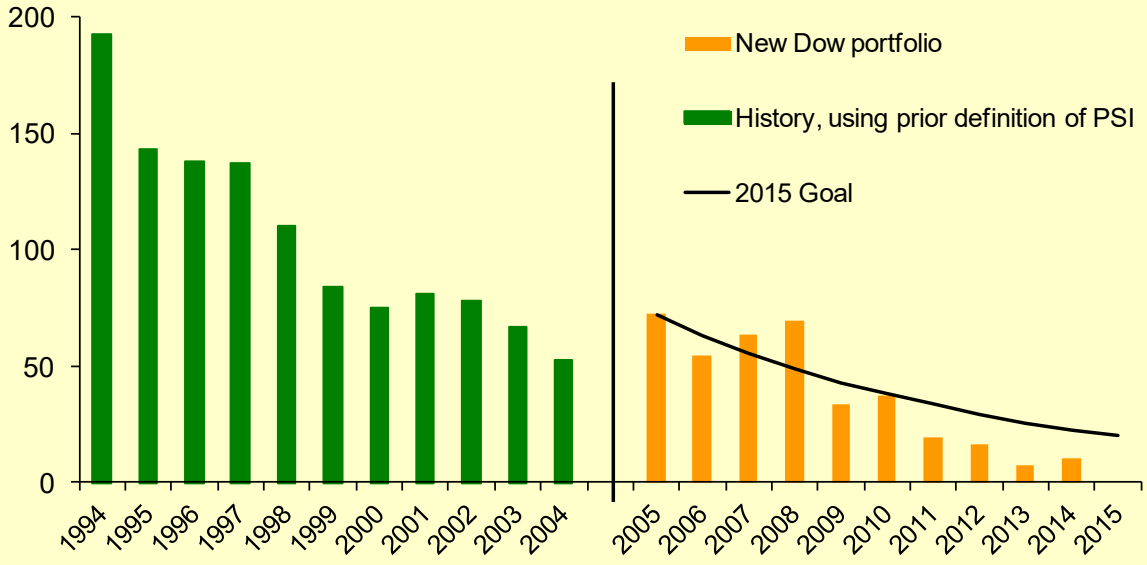
Next Generation Root Cause Investigation (RCI) and Analysis

Improvements that engage leadership and change the culture to prevent repetitive incidents

- ✓ Corporate RCI Standard and work process
- ✓ RCI effectiveness reviews and repetitive incident analysis
- ✓ Leveraging corrective actions
- ✓ Learning Experience Reports (LERs) that reinforce the proper execution of management systems

Introduction & Background

Process Safety Incidents



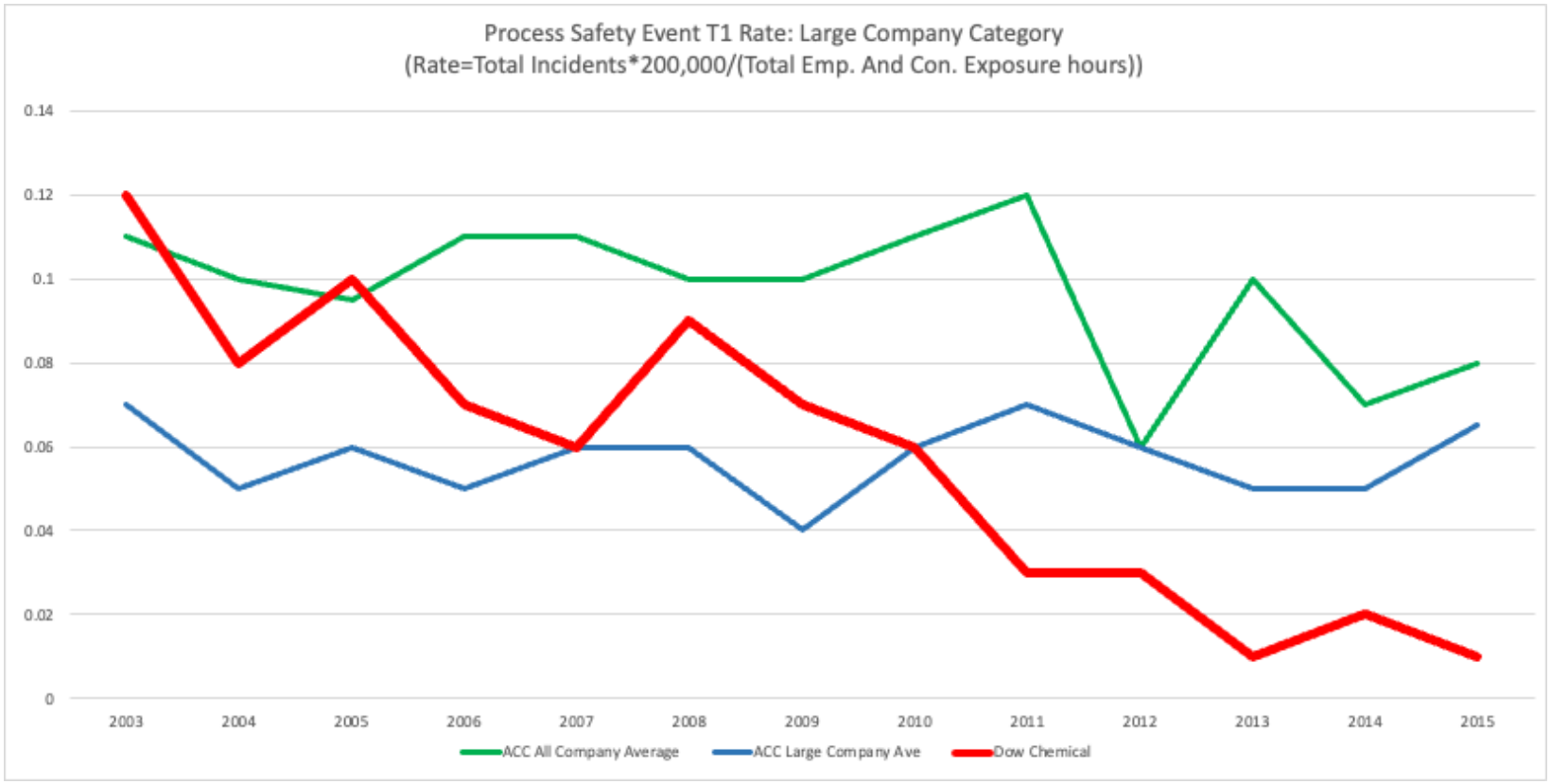
Generational goals to reduce PS and LOPC Incidents

- 1996 → 2005: 90% Reduction
- 2005 → 2015: 75% Reduction
- 2015 → 2025: Eliminate

2005 → 2008 Plateaued performance

- Repetition
- Same Failure Modes / Management Systems
- Action Plan

Tier 1 Process Safety Incident Rate



RCI: Identification of Management System Opportunities

- Legacy RCI Standard
  - ✓ Required finding corrective and preventive actions for unplanned and potential unplanned events
- Legacy RCI Work Process:
  - ✓ Find effective solution, not having the solution was the root cause
  - ✓ Did not formally recognize required protection layers and their failure

RCI: Identification of Management System Opportu

- New investigation process
  - ✓ Identify the cause for every required protection layer and management system failure, including both:
    - ➢ Dow standard required protection layers and
    - ➢ Risk assessment validated protection layers
  - ✓ Involve the function responsible for the local implementation of each management system failure
  - ✓ Establish corrective actions for each protection layer and management system failure
  - ✓ Include the appropriate level of functional ownership for management system corrective actions
- ✓ **By definition: For every PSI, every preventative MS Failed**

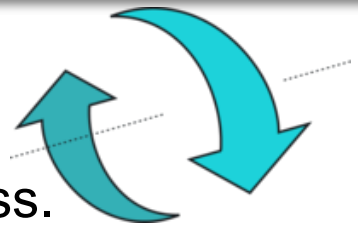
RCI: Identification of Management System Opportunities

- Management system opportunities
  - ✓ A mana…ent system may cov…ection layers
  - ✓ If the m…
  - ✓ Even if…tem is not fixed th…

A management system may need to be corrected at a single facility, in other cases a management system needs to be corrected across a site, a business or for the entire company

- Involving …tion of the manager…
  - ✓ Identification of the correct management system failure
  - ✓ Proper ownership of the corrective action
  - ✓ The appropriate level of correction for a management system and drives the improvement

Repetitive Incident Analysis:



- RCI team reviews past incidents in a facility, site or business.
- Key questions:
  - ✓ Was this a repetitive incident within the plant by equipment type and protection layer failure type?
  - ✓ Was this a repetitive incident within the plant by protection layer failure type or management system failure on a different equipment type?
  - ✓ Was this incident type a historical, significant event that is reviewed as part of the plant process hazard assessment or a scenario in LOPA? Or is this new to the plant?
  - ✓ The same questions are assessed for a site and business.
- This process is greatly aided by a searchable database of incidents.

RCI Effectiveness Review:

- Manufacturing and Process Safety Leadership Reviews
  - ✓ All protection layers and management system failures were identified and corrected.
  - ✓ Appropriate leveraging of management system opportunities
    - ➢ Are appropriate actions being taken across a facility, site or business, consistent with the level of management system failure
    - ➢ Are corporate corrective actions warranted
    - ➢ Should the incident should be communicated for learning value
- Leveraging to Tier 2 Process Safety Events and High Potential Process Safety Near Misses

Leveraging Corrective Actions

What Happened: Case Study – Corporate Wide Actions

Ethylene piping failure due to Corrosion Under Insulation (CUI) – Picture 1
Note that CUI is particularly aggressive where operating temperatures cause frequent or continuous condensation and re-evaporation of atmospheric moisture.

Management System Failure

Corporate Mechanical Integrity (MI) Standard and Work Process was not specific on performing CUI inspections

Corporate Corrective Actions

- Update MI Standard and Work Process to clearly articulate CUI Requirements
- Train Maintenance and Production Leadership
- Technology Centers define and prioritize susceptible areas for CUI
- Facilities to carry out CUI Inspections within a defined time frame and report back findings

Results

Additional finding of severe CUI, prevention of repeat incidents – Picture 2

Picture 1

Picture 2

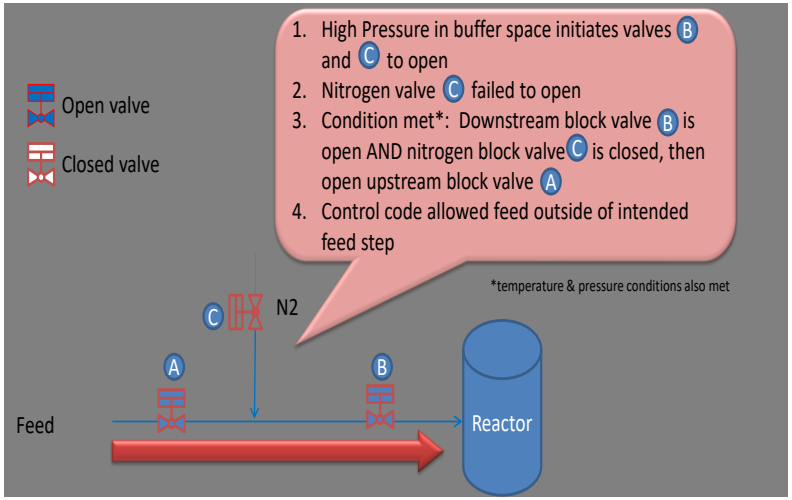
Leveraging Corrective Actions

What Happened: Case Study – Business Actions

The investigation of a product quality issue uncovered that additional raw material had been added inadvertently (and automatically) five hours after the termination of the feed step. Further investigation uncovered issues with the code for the reactors' double-block-and-buffers that led to the event. This case was classified as a HP PSNM due to the high learning value and the potential to have a PSI under slightly different circumstances.

Management System Failure

Inadequate checkout of the process control code conditions for allowing raw material feed upstream valve opening outside of raw material feed step.



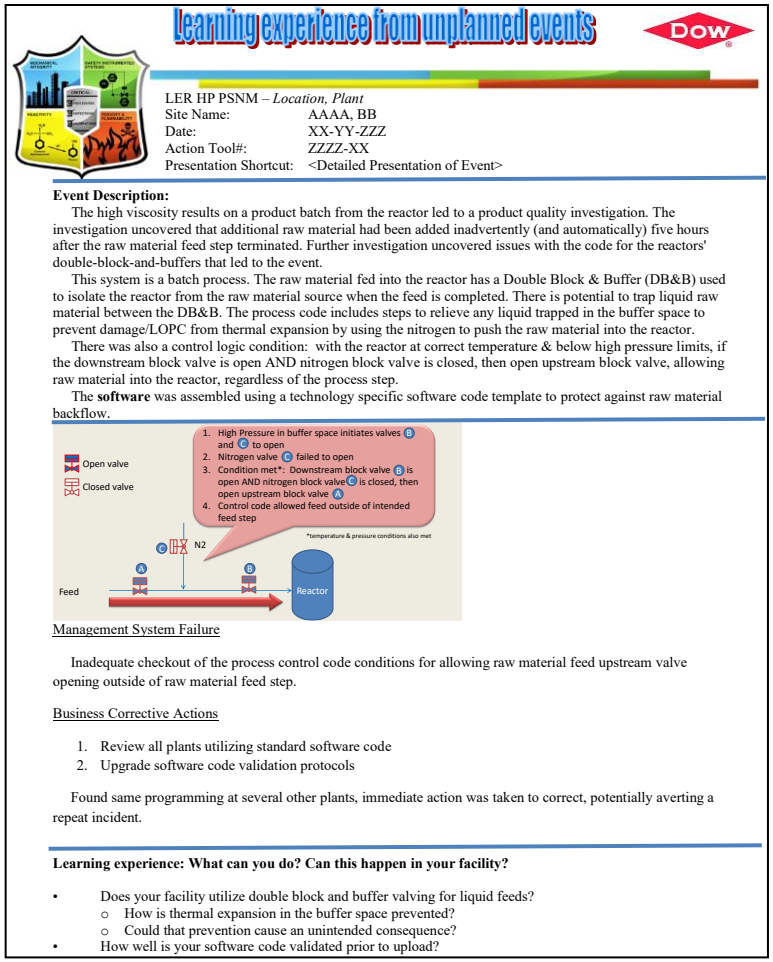
Business Corrective Actions

Review all plants utilizing standard software Code. Upgrade software code validation protocols

Results

Found same programming at several other plants, immediate action was taken, potentially averting a repeat incident. A LER was generated for review across the company.

Learning Experience Reports: Reinforcing Strong Management Systems



learning experience from unplanned events

LER HP PSNM – *Location, Plant*
Site Name: AAAA, BB
Date: XX-YY-ZZZ
Action Tool#: ZZZZ-XX
Presentation Shortcut: <Detailed Presentation of Event>

Event Description:

The high viscosity results on a product batch from the reactor led to a product quality investigation. The investigation uncovered that additional raw material had been added inadvertently (and automatically) five hours after the raw material feed step terminated. Further investigation uncovered issues with the code for the reactors' double-block-and-buffers that led to the event.

This system is a batch process. The raw material fed into the reactor has a Double Block & Buffer (DB&B) used to isolate the reactor from the raw material source when the feed is completed. There is potential to trap liquid raw material between the DB&B. The process code includes steps to relieve any liquid trapped in the buffer space to prevent damage/LOPC from thermal expansion by using the nitrogen to push the raw material into the reactor.

There was also a control logic condition: with the reactor at correct temperature & below high pressure limits, if the downstream block valve is open AND nitrogen block valve is closed, then open upstream block valve, allowing raw material into the reactor, regardless of the process step.

The **software** was assembled using a technology specific software code template to protect against raw material backflow.

Management System Failure

Inadequate checkout of the process control code conditions for allowing raw material feed upstream valve opening outside of raw material feed step.

Business Corrective Actions

1. Review all plants utilizing standard software code
2. Upgrade software code validation protocols

Found same programming at several other plants, immediate action was taken to correct, potentially averting a repeat incident.

Learning experience: What can you do? Can this happen in your facility?

- Does your facility utilize double block and buffer valving for liquid feeds?
  - How is thermal expansion in the buffer space prevented?
  - Could that prevention cause an unintended consequence?
- How well is your software code validated prior to upload?

"Learning Event Reports" (LERs), are published on all process safety incidents & HP-PSNM, leveraging to Tier 2 PSE.

One-page summaries that are broadly communicated across the company to reinforce the importance of:

- the proper definition, design, and implementation of protection layers
- operating within the constraints and maintaining all protection layers

The goal is to prevent repetitive failures by providing learning in a simplified manner that reinforces the appropriate behaviors in all functions of the company.

Leaders review the learnings and determine if they are applicable to any of their facilities, sites, or businesses.

Learning Experience Reports: Key Elements

learning experience from unplanned events

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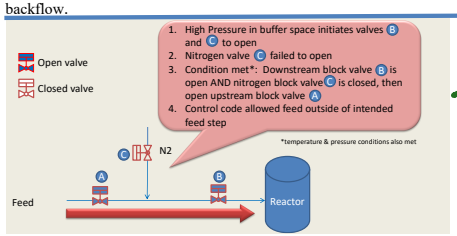

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Event Description

Picture, drawing or schematic

Root Cause Details

Corrective actions

Key learnings to leverage

Conclusion

Effective RCIs:

- correcting all protection layer failures and their associated management systems
- appropriately leveraging the corrective actions and learnings
- engaging leadership

are foundational to building a strong culture.