Common Cause Failure: What Are They and How to Mitigate Them?

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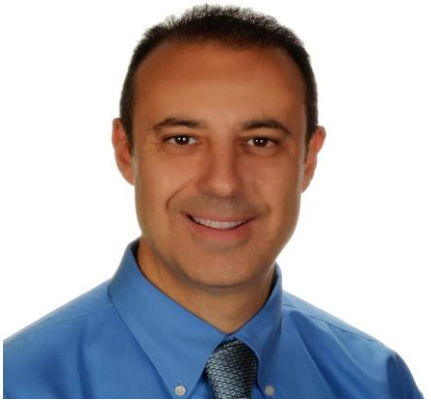

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- Ph.D., Chemical Engineering – University of Maryland @ College Park
- B.Sc. In Chemical and B.Sc. in Industrial Engineering, Bogazici University, Turkey
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About PSRG

- Established 1997 (Houston, Texas)
- Premier, global Process Safety, Risk Management & Plant Reliability consulting and training firm
- Abundant staff of more than 100 technical professionals averaging 29+ yrs experience
- Diverse industry experience with more than 1000 customers in 90 countries
- Hands-on plant operations experience
- Tailored solutions to meet Client expectations
- Highly qualified resources providing value that far exceeds the cost of our services
- Member: CCPS, IChemE

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Agenda

- What is Common Cause Failure?
- Why Common Cause Failure occurs?
  - Root Cause
  - Coupling Factors
- How can we mitigate Common Cause Failures?

What is Common Cause Failure?

Definitions and Examples

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CCPS Process Safety Glossary Definitions

- The occurrence of two or more failures that result from a single event or circumstance
- Concurrent failures of different devices, resulting from a single event, where these failures are not consequences of each other
- The failure of more than one component, item, or system due to the same cause

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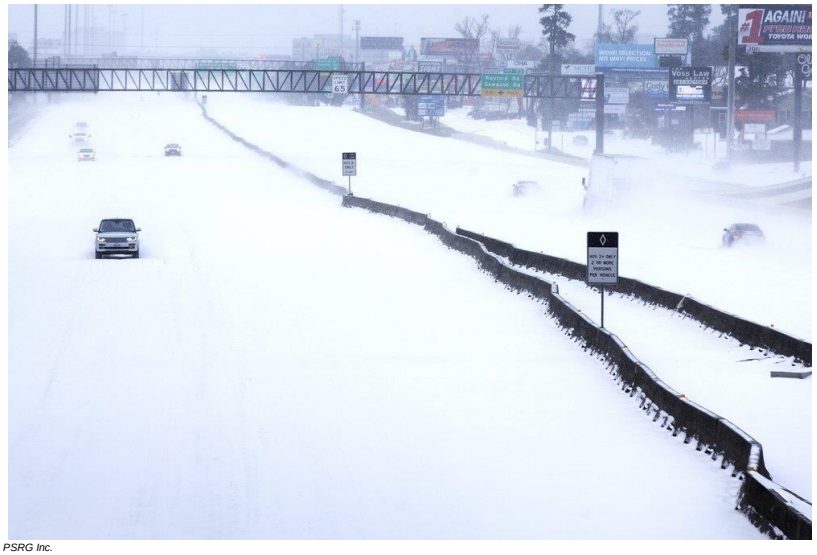
Common Cause Failure Examples #1



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Common Cause Failure Examples #2

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Common Cause Failure Examples #3

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Common Cause Failure – Definition

- The failure of a system
- Loss of effectiveness of multiple safeguards due to the same cause
- Common cause failure can be due to:
  - An immediate change such as freeze, flooding, fire
  - A slow and continuous change such as vibration, corrosion

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Why Common Cause Failure Occurs?

Failure Modes

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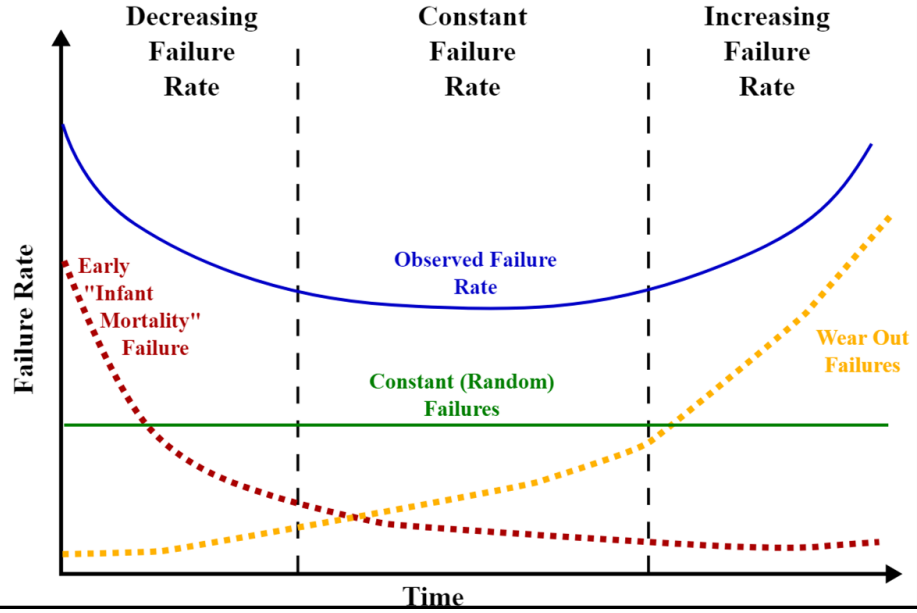
Component Failure Modes



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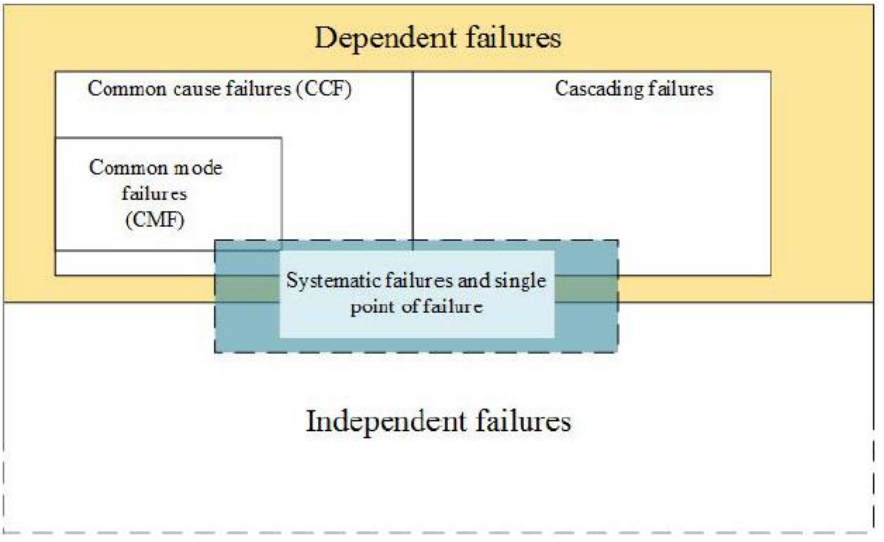
Failure Modes



Systematic Failures

- Includes Common Cause Failures
- Includes design, technical specifications, operations, maintenance, and installation
- Hard to analyze

Common Cause Failure Reasons

- Root Cause
- Coupling Factor
- Need both for Common Cause Failure to occur

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1. Root Cause

- Design errors
- Manufacturing errors
- Implementation errors
- Operations and Maintenance errors

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2. Coupling Factors

- Same design (principles)
- Same hardware
- Same function
- Same software
- Same installation team
- Same operations / maintenance team / procedures
- Same interfaces (human-machine or system-system)
- Same environment / physical location

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How to Mitigate Common Cause Failures?

Mitigation Methods

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How to Prevent Common Cause Failure?

- Remove the Root Cause
- Eliminate Coupling Factors
- Do both!

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Removing Root Cause

- Using more reliable components in the system
- Checking the system more frequently / closely
  - Staying within design limits
  - Minimizing shocks and vibrations
  - Improving diagnosis tests and their scope
- Paying attention to CCF while performing maintenance

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Eliminating Coupling Factors

- Separation / Decomposition
- Diversity / Redundancy
- Simplification / Experience
- Data Analysis / Feedback
- User Interface / Procedures
- Competency / Training / Safety Culture
- Environmental Control / Test

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Modeling

- Reliability Block Diagrams (reliability focused)
- Fault Tree Analysis (fault focused)
- Markov Chains

- Beta-Factor Model (Fleming, 1975)
  - Independent and Dependent $\lambda = \lambda^{(i)} + \lambda^{(c)}$
  - Beta-factor is CCF fraction $\beta = \frac{\lambda^{(c)}}{\lambda}$

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Risk Analysis and Common Cause Failure

- Root Cause Analysis (RCA)
- Probability of Failure on Demand (PFD) → Risk Analysis
- Independence of safeguards from each other and from the initiating event → Layer of Protection Analysis (LOPA)
- Safety Integrity Level (SIL) Verification

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What is Next?

- Include External Factors in Risk Assessment
- Assess Independence of Safeguards through LOPA
- Reliability / Availability / Maintainability Analysis (RAM)

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Summary

- Common Cause Failure is critical in Process Safety
- Consider External Events when Assessing Risk
- Address Independence of Safeguards
- Remove Root Cause and Eliminate Coupling Factors

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Thank you for your attention!

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