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

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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

- 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
Common Cause Failure Examples #1

Common Cause Failure Examples #2
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
Why Common Cause Failure Occurs?

Failure Modes

Component Failure Modes

- Decreasing Failure Rate
- Constant Failure Rate
- Increasing Failure Rate

- Early "Infant Mortality" Failure
- Observed Failure Rate
- Constant (Random) Failures
- Wear Out Failures

Time

Failure Rate
Failure Modes

Dependent failures

- Common cause failures (CCF)
- Cascading failures

Common mode failures (CMF)

Systematic failures and single point of failure

Independent failures

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

1. Root Cause
   - Design errors
   - Manufacturing errors
   - Implementation errors
   - Operations and Maintenance errors
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

How to Mitigate Common Cause Failures?

Mitigation Methods
How to Prevent Common Cause Failure?

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

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
Eliminating Coupling Factors

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

Modeling

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

- Beta-Factor Model (Fleming, 1975)
  - Independent and Dependent
  - Beta-factor is CCF fraction

\[ \lambda = \lambda^{(i)} + \lambda^{(c)} \]
\[ \beta = \frac{\lambda^{(c)}}{\lambda} \]
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

What is Next?

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

Thank you for your attention!

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