LOPA Misapplied: Common Errors Can Lead To Incorrect Conclusions

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Introduction

• LOPA has been in widespread use for more than 10 years.
• Many pitfalls that can lead to misapplication
• Can end up with overly conservative results
  – Over-instrumentation
  – Higher life-cycle costs
  – More spurious trips
Introduction

• Or, even worse, you can underestimate the risk
  – Environmental release
  – Property damage and production losses
  – Fires/Explosions
  – Fatalities

• The paper contains 7 common errors with 10 real-life examples

• Due to time constraints, two are presented today
Common Error #1 – Not considering the operating culture
Error #1 (continued)

• A “war story” in the HAZOP recalled an overpressure event actually happening many years ago
  – The HAZOP team believed that an automated response was needed.

• LOPA was performed to validate the HAZOP team’s belief and to assess the level of protection needed.

• Note that the numbers contained in the following LOPA examples are for illustrative purposes only.
Error #1 LOPA

• Target event frequency
  \[ Q_{\text{tar}} = 1E-3 \text{ /yr} \]

• Initiating cause – Additive not blocked prior to shutdown. One shutdown per year and error rate of 1/10 times.
  \[ Q_{\text{init}} = 1E-1 \text{ /yr} \]

• New SIF – 1oo1 sensors/final elements shut off additive whenever heat is removed from the column.
  \[ PFD = 1E-2 \]

• Resulting event frequency
  \[ Q_{\text{res}} = 1E-3 \text{ /yr} \]
LOPA After Error #1 Corrected

- Target event frequency
- Initiating cause – Additive not blocked prior to shutdown. One shutdown per year, no credit for operator because of automation.
- New SIF – 1002 sensors/final elements shut off additive whenever heat is removed from the column.

\[
\begin{align*}
Q_{\text{tar}} &= 1 \times 10^{-3} \text{ /yr} \\
Q_{\text{init}} &= 1 \times 10^0 \text{ /yr} \\
PFD &= 1 \times 10^{-3} \\
Q_{\text{res}} &= 1 \times 10^{-3} \text{ /yr}
\end{align*}
\]
Common Error #1 – Not considering the operating culture
Error #1 Conclusions

• The LOPA must consider the effects of the operating culture.

• In this case, automation of the shut-off valves made the manual task “unnecessary”

• Not accounting for this would have resulted in an underprotected system.
Common Error #2 – Spurious Trips
Error #2

• The quench water RCV would normally be set to de-energize to trip.

• But what is the consequence of a spurious trip?
  – Usually it is production loss and business interruption
  – In this case, it was dilution of the catalyst material and potential to stall the reaction downstream – a hazardous condition.
Error #2 LOPA for Quench Tank

- Target event frequency $Q_{tar} = 1E-4 \text{ /yr}$
- Initiating cause – Contamination of tank with reactive material – estimated frequency $1/10 \text{ yr.}$ $Q_{init} = 1E-1 \text{ /yr}$
- SIF – 1oo1 sensors/final elements adds quench water on high temperature in tank. $PFD = 1E-2$
- Rupture disc designed to protect tank from overpressure. $PFD = 1E-2$
- Resulting event frequency $Q_{res} = 1E-5 \text{ /yr}$
Error #2 LOPA for Spurious Trip

- Target event frequency
  \[ Q_{\text{tar}} = 1 \times 10^{-4} \text{ /yr} \]

- Initiating cause – Stalled downstream reaction caused by spurious trip of catalyst quench water, dominated by power failure – once per yr.
  \[ Q_{\text{init}} = 1 \times 10^{0} \text{ /yr} \]

- Operators monitor temperatures in reactor, response prevents runaway.
  \[ PFD = 1 \times 10^{-1} \]

- Rupture disc designed to protect tank from overpressure.
  \[ PFD = 1 \times 10^{-2} \]

- Resulting event frequency
  \[ Q_{\text{res}} = 1 \times 10^{-3} \text{ /yr} \]
Error #2 Conclusions

• Implementing the SIF with a conventional de-energize to trip RCV, results in acceptable risk in the catalyst tank, but unacceptable risk in reactor.

• Using reliability data, we decided it was acceptable to use an energize to trip RCV in this case.
  – Resulting frequency for the catalyst tank increased to 1E-04 /yr
  – Resulting frequency for the reactor decreased to 1E-04 /yr
  – Both met the target frequency
Overall Conclusions

• As a good LOPA practitioner, it’s important to learn the pitfalls and limitations of the technique.
• Errors resulting in over or underestimation of the risk can be costly.
• The keys to identifying errors include
  1. Solid LOPA training
  2. Well-developed guidelines
  3. A strong peer review process
Questions

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