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SIF Design Challenges: Ethylene Plant

Anurag Mishra, Principal Consultant
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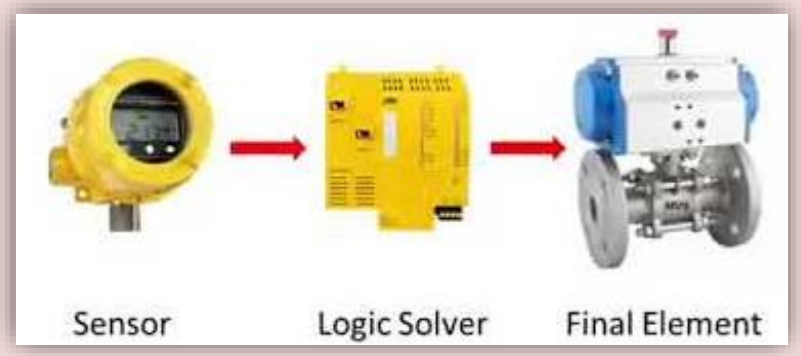
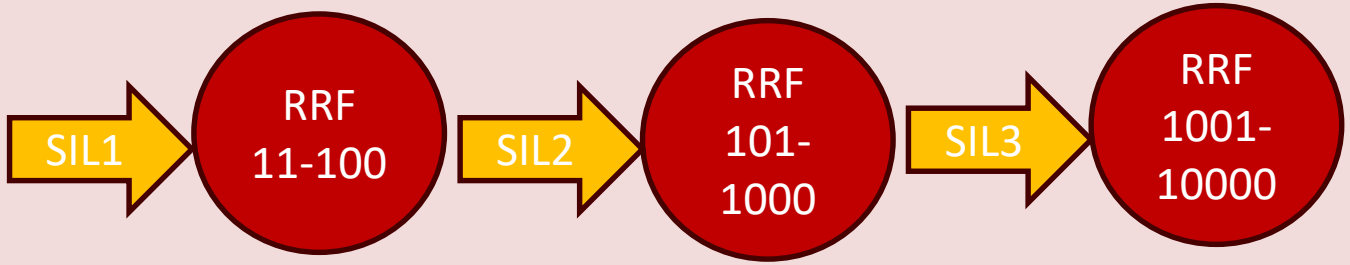
CCPS Member Company

Why SIF is required

SIF is the main preventive barrier for some of the high severity consequences scenario in Ethylene plant with potential for multiple fatalities, escalation

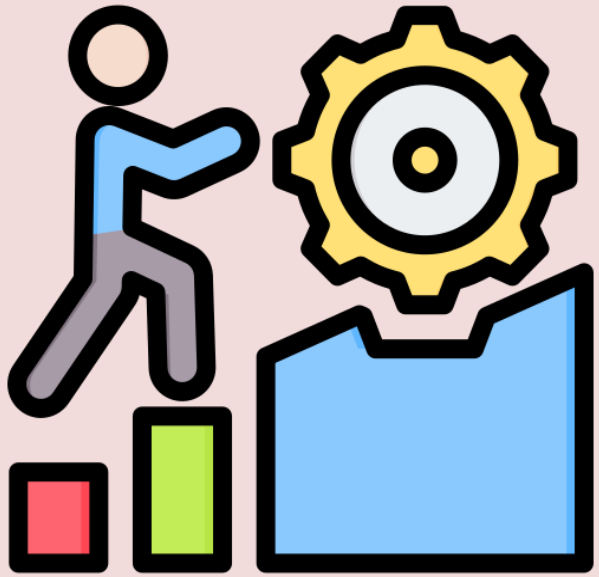




Critical SIFs and Challenges

Critical SIFs

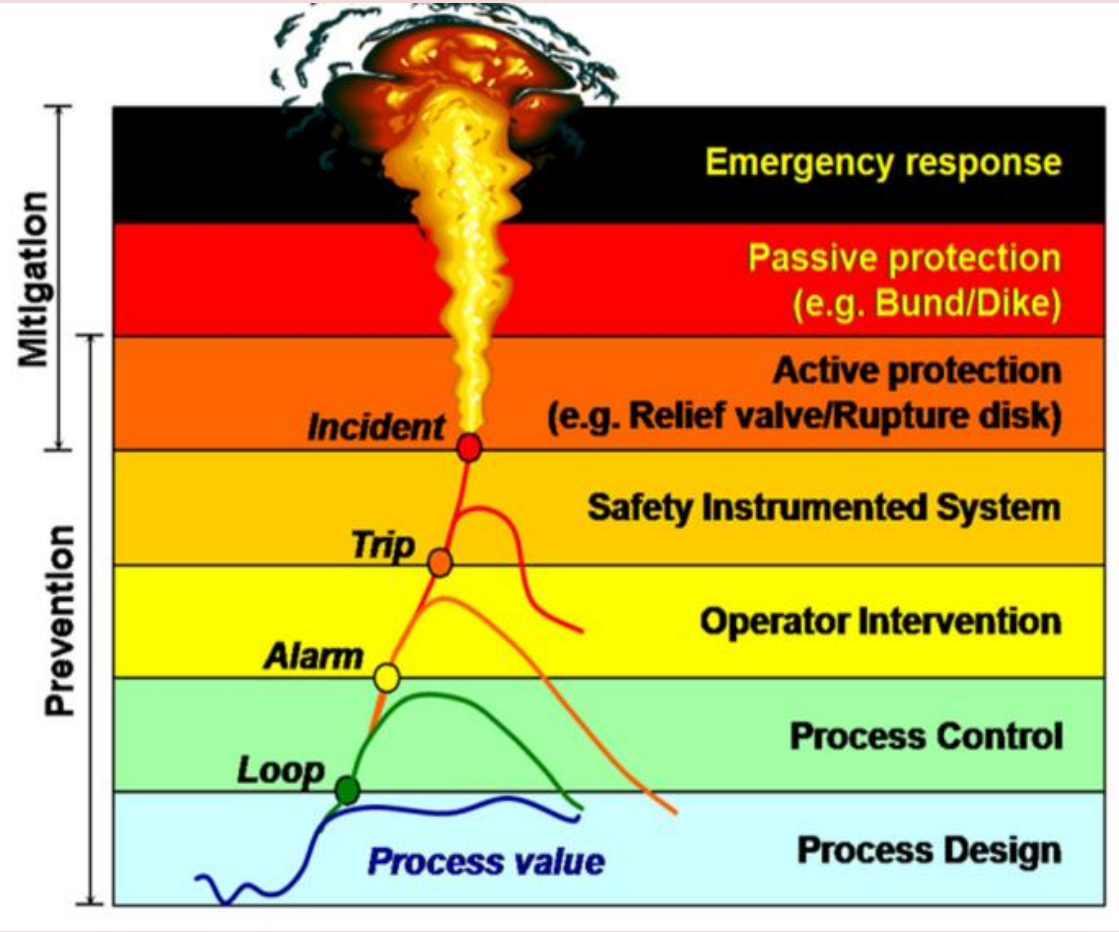
- Heater protection
- C2 Hydrogenation High reaction Exotherm protection
- Protection for Low temperature brittle fracture
- Flare overload protection

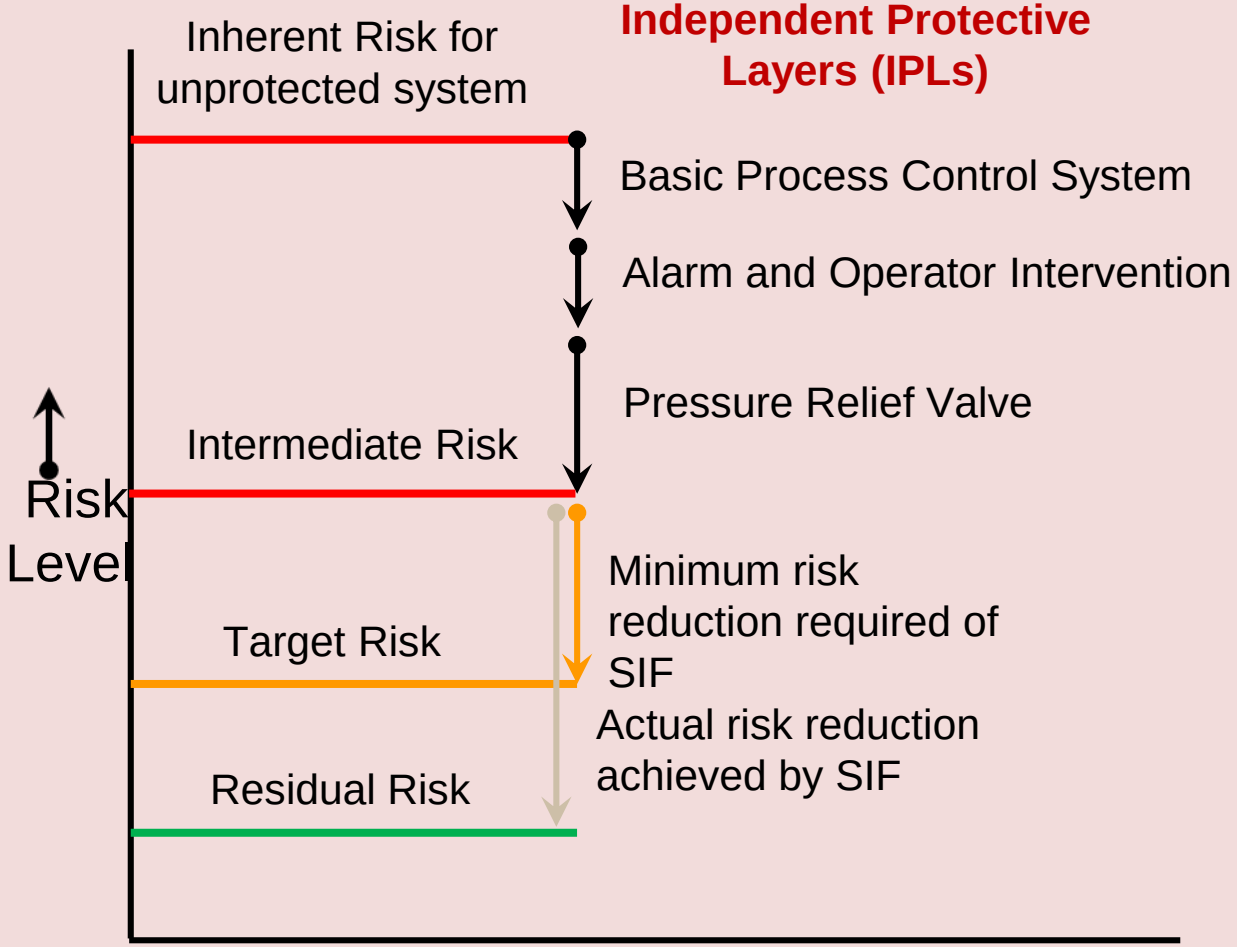


Challanges

- Primary final element identification
- Multiple SIFs for same scenario
- Extent of aggregation of initiating events
- Multiple design intent with same initiator
- Other factors: Proof test interval and failure data

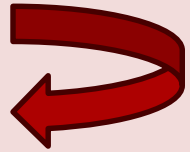
SIL Assignment : LOPA





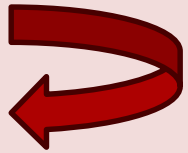
High Firebox Pressure Scenario

Cause 1: ID fan trip, Damper close



Consequence: Loss of heater draft resulting in insufficient oxygen to combust all the fuel, potential flame out resulting in unburned gas accumulating in the firebox. Ignition of this flammable mixture may result in an explosion

Cause 2 : No/low pass flow



Consequence: potential overheating of coil leading to heater coil rupture. This may result in uncontrollable fire within the firebox with High firebox pressure due to excess unignited Hydrocarbon or steam

SIF: Firebox Pressure High High (PAHH) :Stop Heater Firing

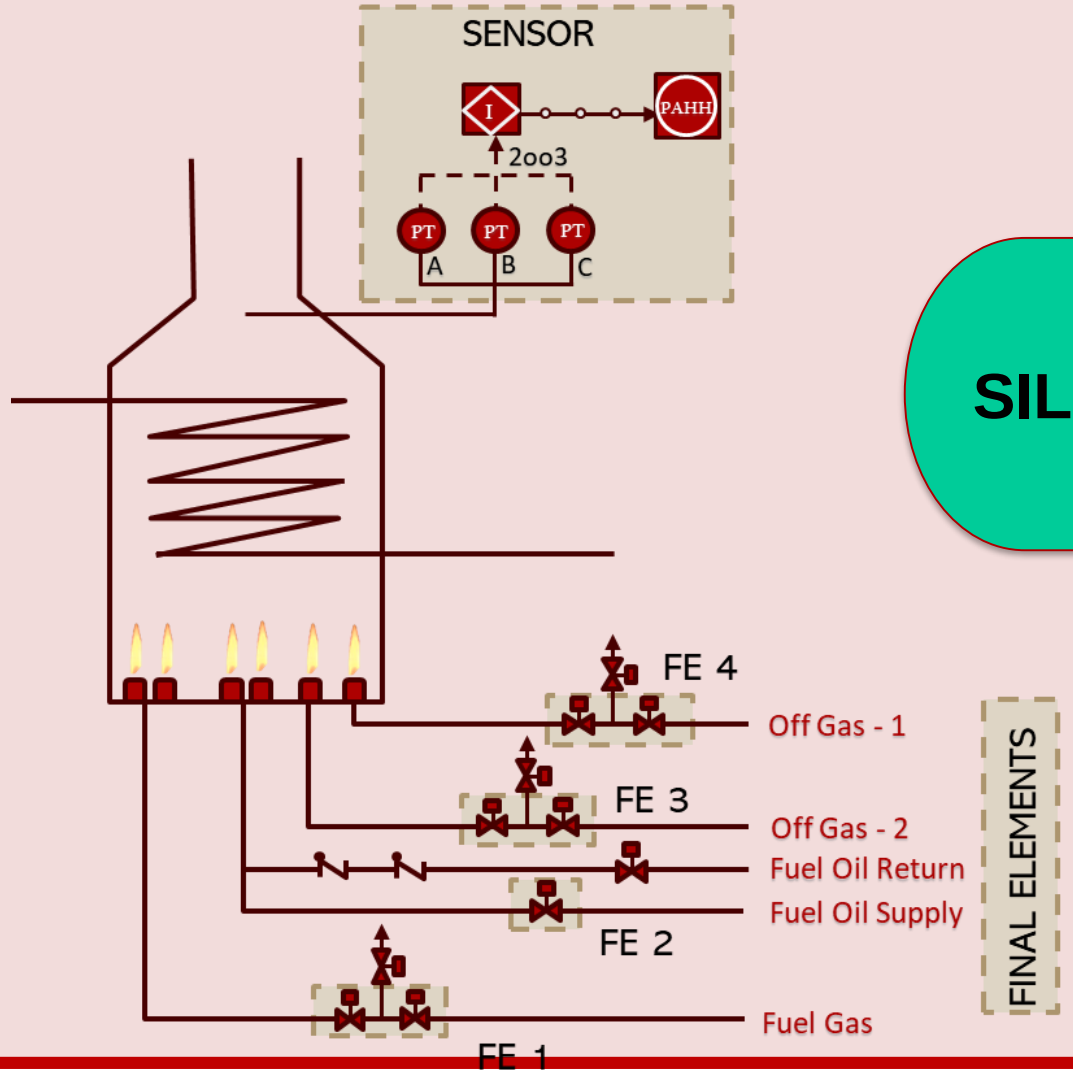
Cause-

ID Fan Trip,

Damper close

Consequence-

Increase in Firebox pressure leading to flame instability and flame out. Potential unburnt HC leading to explosion.



This may be SIL1/SIL 2 with High RRF

Cause and Effect

- Cause & Effect may have multiple actions against a function, PHA team is responsible to identify the primary actions which will directly prevent the hazardous scenario for which the function is being analyzed and bring the process to safe state.
- Other actions listed in Cause & Effect will be secondary i.e., subsequent actions to be taken to mitigate the scenarios resulting due to primary actions.

Primary Final Element Discussion

Close shutdown valves on FG, FO supply, FO return, Offgas -1 and Offgas-2 streams

5oo5

Two dissimilar check valves on FO return line will prevent accumulation of FO due to reverse flow

Close shutdown valves on FG, FO supply, Offgas -1 and Offgas-2 streams

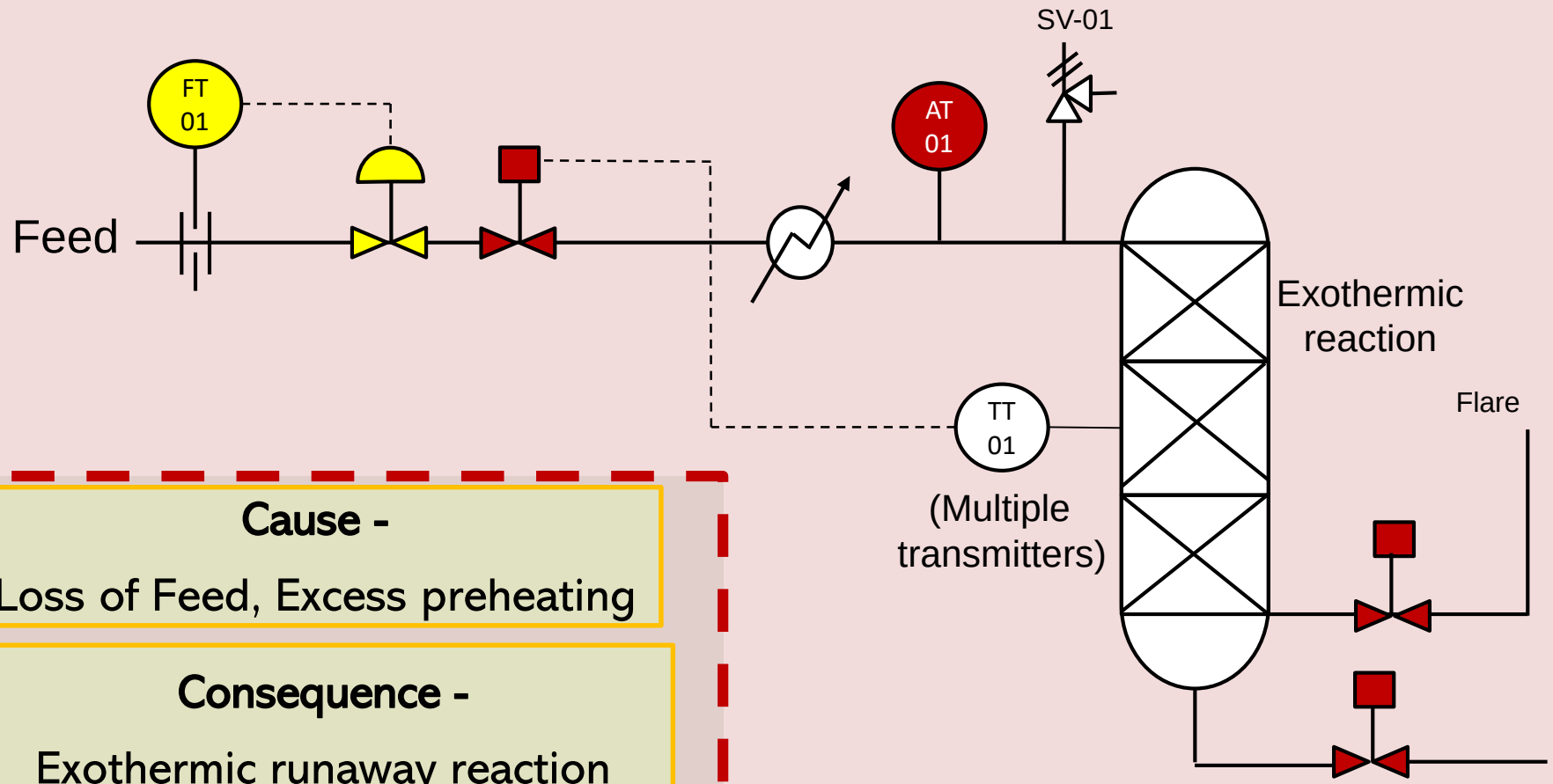
4oo4

Offgas-1 is intermittent with less flowrate compared to main fuel sources. If, at minimum air flowrates explosive atmosphere can be considered less likely

Close shutdown valves on FG, FO supply and Offgas-2

3oo3

C2 Hydrogenation Reaction TAHH



Cause -

Loss of Feed, Excess preheating

Consequence -

Exothermic runaway reaction leading to loss of containment

Final Element Success Criteria

4oo4?

a) Close XV to isolate feed

b) Close XV to Isolate Reactor Outlet

b) Open Blowdown

c) Nitrogen purge

Multiple SIFs for a Scenario

- Both Low Low pass flow and High High firebox pressure trip of heater may be safeguards for same scenario
- low pass flow trip is the preventive safeguard for tube rupture
- High firebox pressure is the result of tube rupture
- High firebox pressure will be preventive safeguard for flame out scenario due to loss of draft

- For trip of Hydrogenation reactor both low feed flow and high reactor temperature may be listed as safeguards

- PHA team should elaborate the scenario and indicate clearly which SIF is primary protection for the Hazard scenario

Aggregation of Initiating Events

SIF for Brittle failure Protection TALL

Low Low temperature to close XV to protect CS piping downstream of cold box

Eg: on residue off gases from cold box

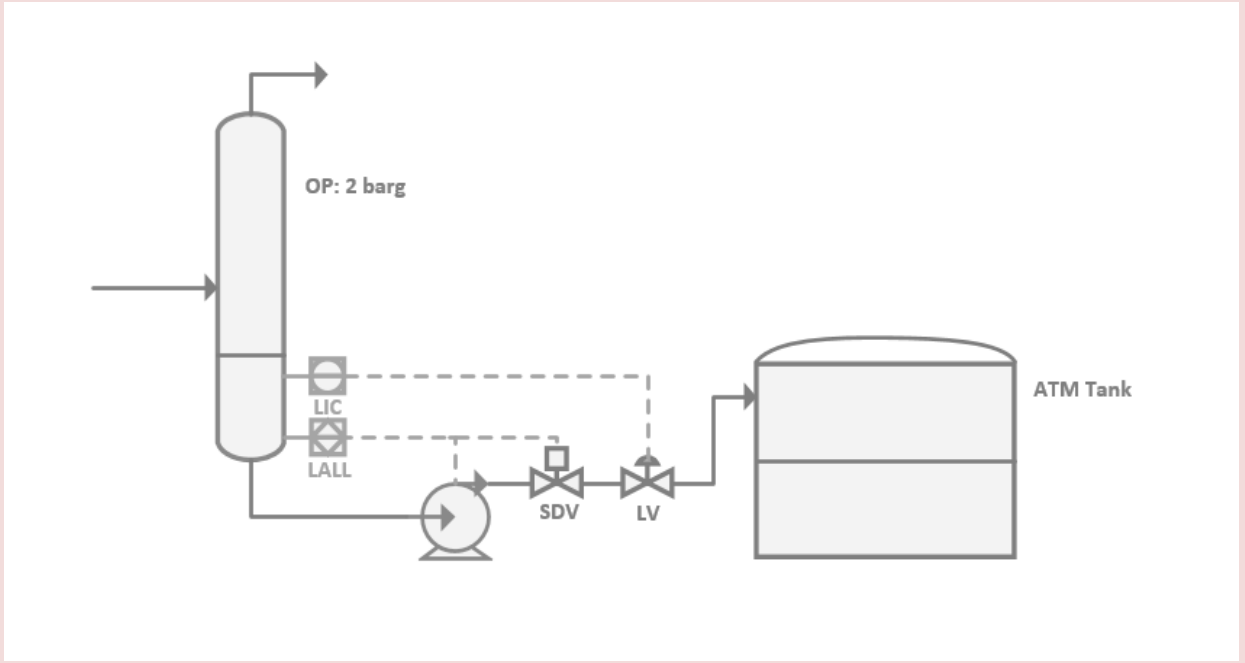
- Loss of C3R: Multiple Causes
  (0.1*5+0.01*5= 0.55)
- Loss of charge Gas flow (transient) Multiple causes
  (0.1*5+0.01*5=0.55)
- If no other IPL, Demand is high (0.55+0.55 >1)

In such cases:

- Apply High Demand SIF LOPA approach?
- Consider limiting the Initiating event likelihood to 1 and determine the gap?

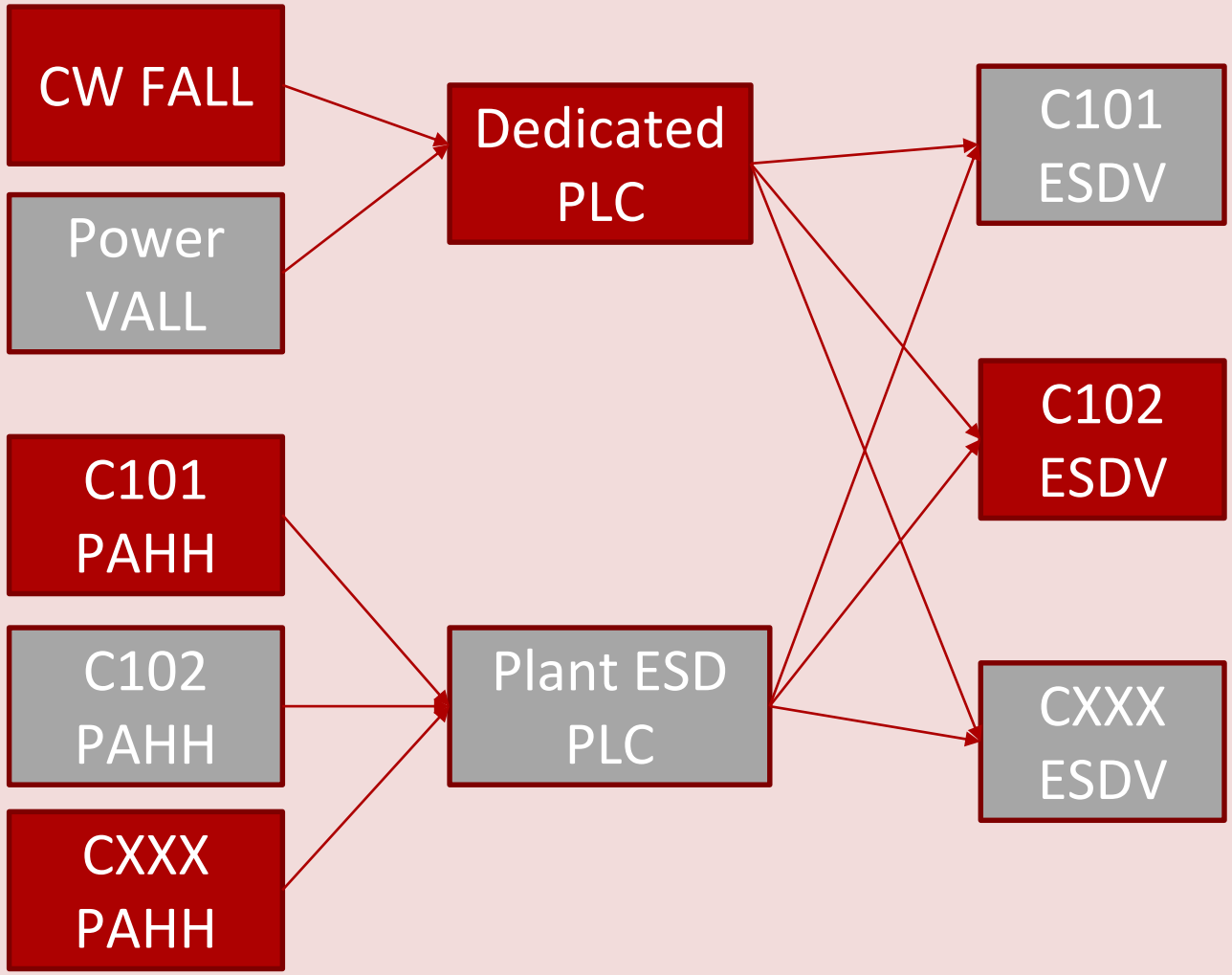
Multiple Design Intent

- What is the purpose of this SIF?
- What are the hazards it mitigates?
- How does it achieve the purpose?



SIF	Purpose	Sensor(s) / Initiator (s)	Final Element(s)	Assigned SIL
A	To prevent damage to pumps	Level Transmitters on column bottom	Stop pumps	1
B	To prevent gas blowby lead to overpressurization and tank roof fire of storage tank	Level Transmitters on column bottom	Close SDV in pump discharge	2

Flare Overload Protection



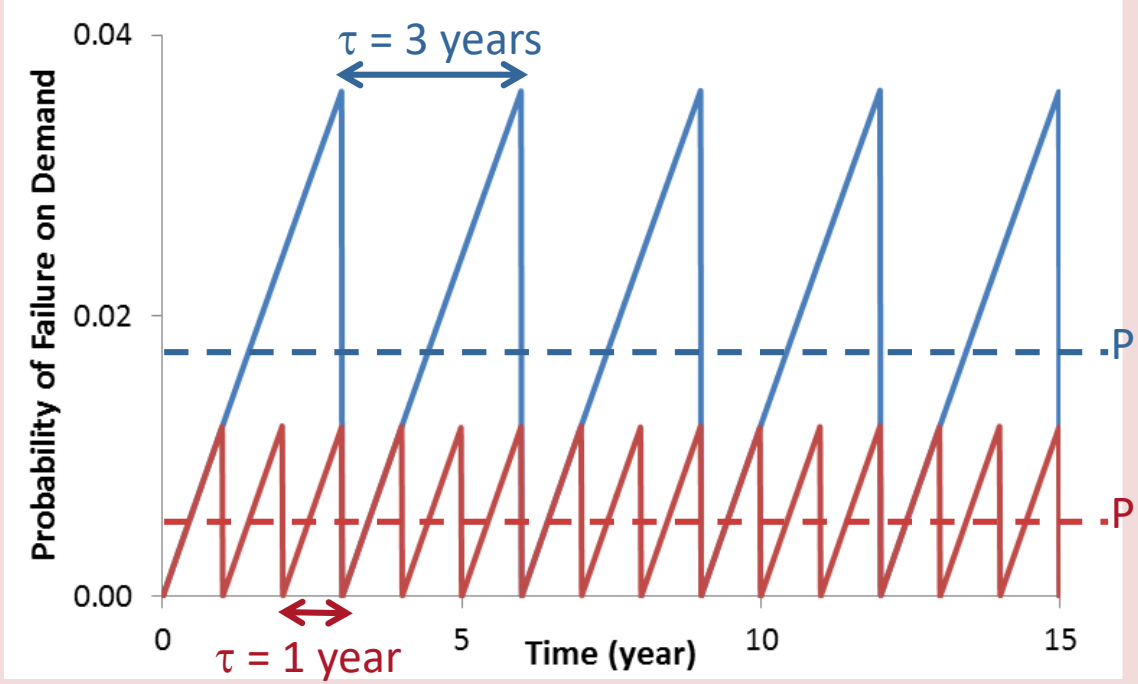
- Most of the Overpressure protection SIFs are also part of flare Load Mitigation
- Unmitigated load from one or combination of SIF Failure can result in overload on Flare
- Do we need same level of reliability from all these final elements?
- Flare load mitigation study to identify the minimum combination of SIF required for Flare load mitigation

Operational Factors influencing SIF Design

Assumptions made in SIF Design	What happens during Operation
Demand Rate on the SIF	Actual Demand Rate
Generic / Vendor Failure Rate Database	Field Failure Rate Data
Architecture of Initiators and Final Elements	Degraded Mode of Operation
Specified Proof Test Interval and Coverage	Actual Proof Test Interval and Coverage
Specified Mission Time	Actual SIF Operational Life
Assumed PFD for IPLs	Actual Performance of IPLs

Proof Test Interval

Effect of Proof Test Interval on Reliability of SIF



0.02

0.01

Shorter Proof Test Interval → Lower Probability of Failure on Demand (PFD)

Key Take Away

- PHA team should also discuss and indicate the basic SIF design requirement like primary final element and SIF design Intent
- Realistic assumptions need to be made at design stage of SIF with feedback from Operation
- Early acknowledgement of complex SIFs allows evaluating various options for SIF design or reviewing the SIL target by implementing additional IPLs (Independent Protection Layers) or for redesign of the process system.
- Due to lack of detailed information, assumptions made at design stage need to validated during operational phase
- Operational phase must strictly follow the minimum testing and maintenance regime, mission time etc. used in SIL Verification unless SIF reliability has been reassessed with revised parameters

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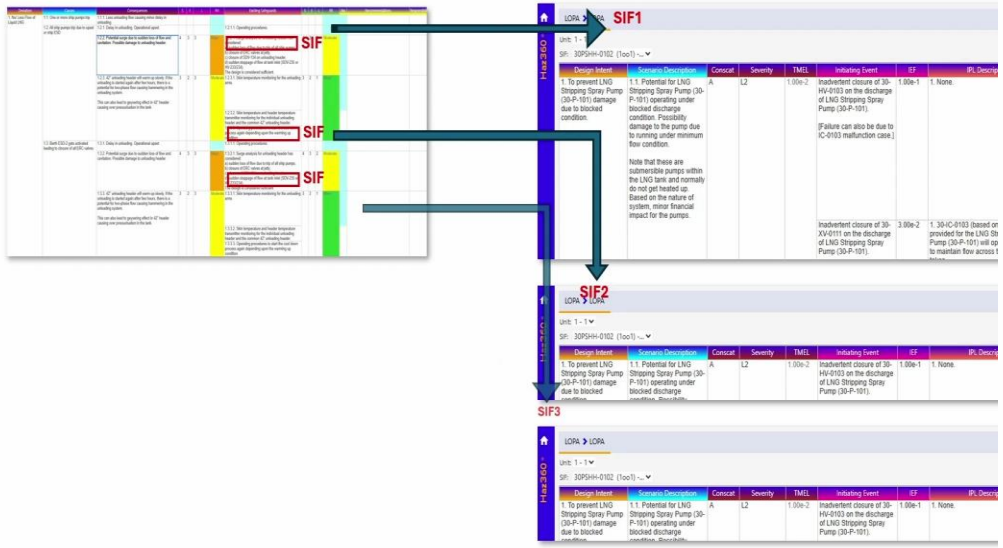

SIL Classification ➡ SIL Verification

HAZOP

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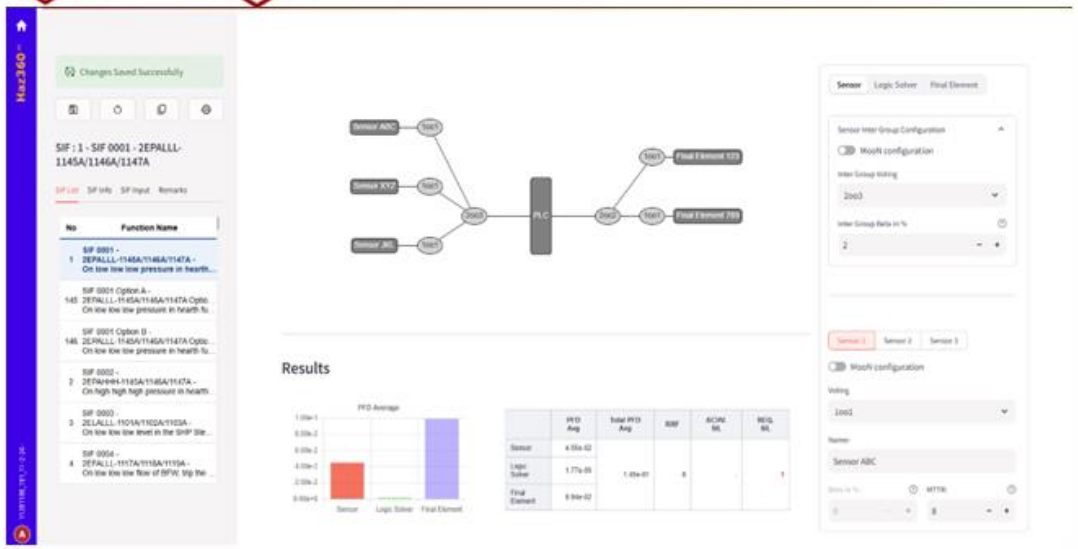
SIL Ver



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Contact Details:

Anurag Mishra
anurag.mishra@irescglobal.com

Q&A

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