



14th Chemical Process Safety Sharing (CPSS)

How to ensure process safety Quality and Cost effectiveness in HAZOP/LOPA



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 - Initial Event/Consequence/IPLs
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 - HAZOP/LOPA Recommendation Close-out/ SRS/ SIL verification

Q & A

Introduction

To understand overall workflow



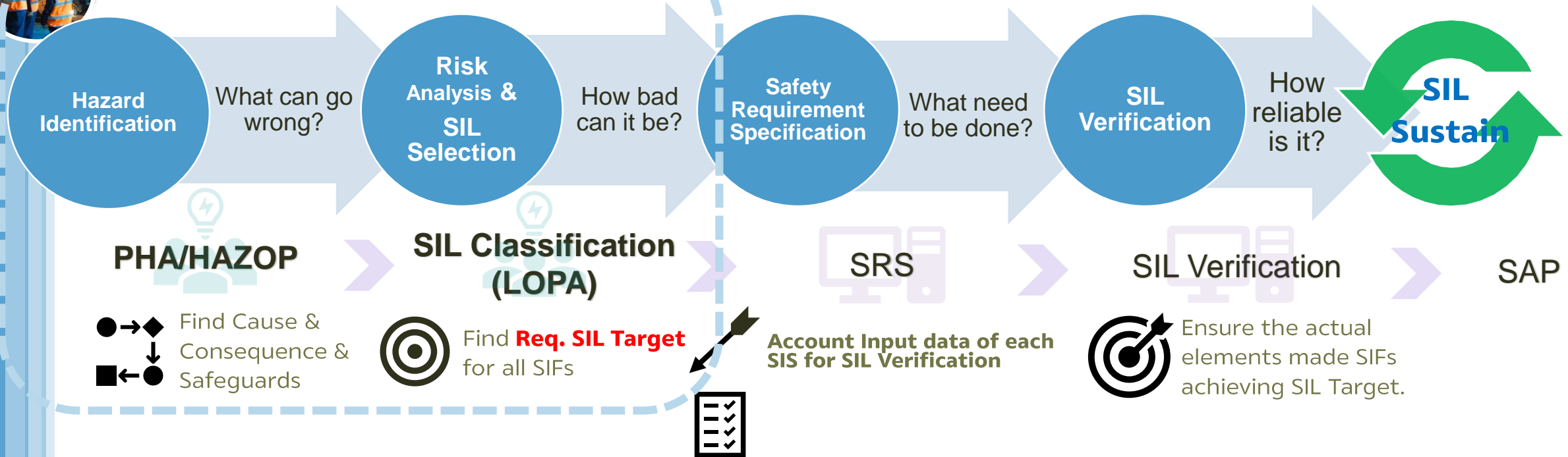
Functional Safety Life Cycles & Work Flow



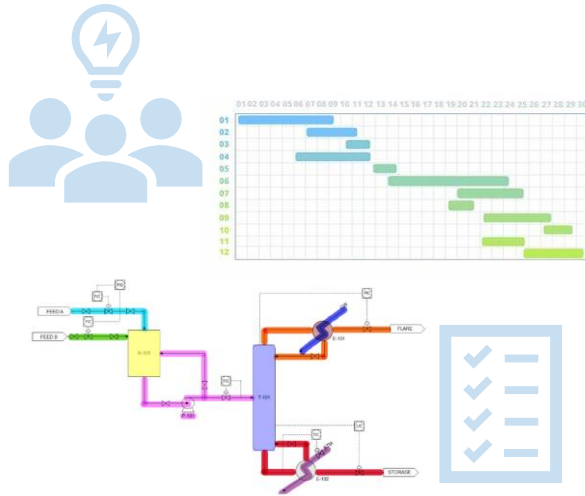
Work shop



Desktop



HAZOP/LOPA Work flow



Preparation

- **Members**
- **Schedule**
- **Qualified Input information**
Reviewed P&IDs, Control Philosophy, C&E, Datasheet, Heat & Mass Balance, MSDS

During Workshop

- **Account All initial events and All realistic consequences**
- **IPLs**
(Independent/Effectiveness/Auditability)

Post Workshop Activities

- **HAZOP/LOPA Recommendation Close-out**
- **Safety Requirement Specification (SRS)**
- **SIL Verification**

How to control Quality and cost on HAZOP/LOPA workshops

To acknowledge how to manage and control to achieve quality and minimize unintended impact from HAZOP/LOPA



1. Preparation (1/3)



1.1. Members

- **Number and Competency**
 - **Facilitator and scribe** – Request CV for review and approval
 - **Other member from all related parties (Owner, Contractor, Vendor Package)**
Process Engineer / Technical design expert of vendor package.
Operation Engineer, Instrument Engineer, Process Safety Engineer.

1.2. Schedule

- **Fit with Actual workload**

Too Tight → Will cause quality issue and additional manhours for rework.
- **Sequence of activities**

Technical reviews (P&ID review, Design review) shall be held before HAZOP session to avoid design review during HAZOP session.

1. Preparation (2/3)



1.3 Qualified Input information



- Reviewed P&IDs, Control Philosophy, C&E, Datasheet, Heat & Mass Balance, MSDS
- HAZOP is not design review session, P&ID and Design review shall be conducted before.
- Revalidation prone to find insufficient input information

Tips

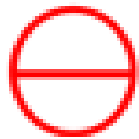
1. Kick-off meeting for HAZOP/LOPA (including HAZOP/LOPA Procedure)
 - Specify details in role and responsibilities of each participants
 - Specify requirement and action of HAZOP/SIL(LOPA) in Each Stage of work (BED/FEED/Details Engineering/Modified work)
 - Specify details of consideration (i.e. Update IEL/IPL credit data, Condition modifier Estimation, Solution when facing difficulty in consideration or meet undesirable result)
 - Any special requirements (i.e. Special activities in the plant)
2. Arrange technical review before HAZOP (P&IDs Screening /Control Philosophy reviewed /Cause&Effect reviewed)

1. Preparation (3/3)

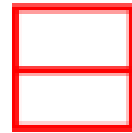


Tips

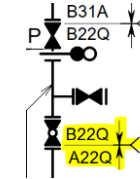
3. Mark operation/design condition (Pressure/temp./Flow) + material spec. break along with node mark up P&ID



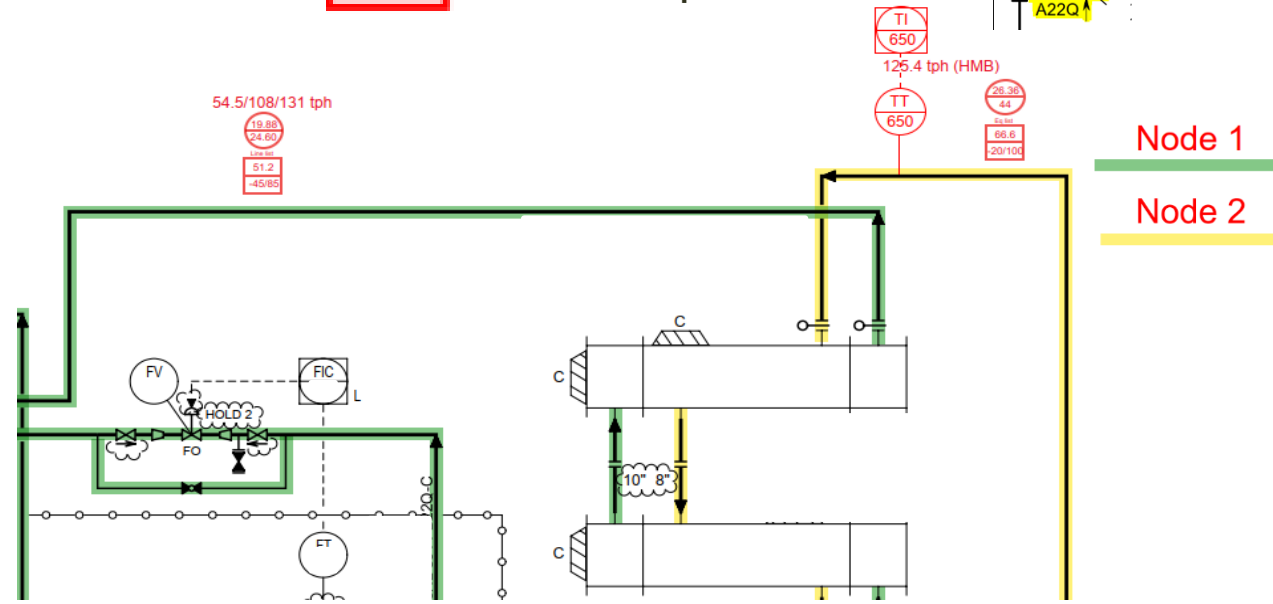
Op. Pressure
Des. Pressure



Op. Temperature
Des. Temperature



Material spec. break





2. During HAZOP/LOPA Workshop (1/3)



2.1. Record All Initial Events

- Some Initial Events are likely to be forgotten.

Example



Initial Event (Likely Forgotten)	Suggested Frequency (per year)
Mechanical failure	
Strainer or filter plugging (Clean fluid service)	0.01
Fix equipment failure (E.g. exchanger tube failure)	0.01
Hose failure leak and rupture	0.1
Single check valve failure on High Demand Mode	0.1
Double check valves in series failure (dissimilar type) on High Demand Mode	0.01
Safety valve opens spuriously – effect to discharge system of PSV [e.g. PSV fail open relieving to close drain drum leading to overfill & LOC]	0.01
Human failure (Commission and omission)	
Operator failure during a routine task every once per week or more often.	1
Operator failure during a routine task between once per month and once per week.	0.1
Operator failure during a non-routine less than once per month	0.01
LOTO(Lock-out tag-out)	0.01

2. During HAZOP/LOPA Workshop (2/3)



2.2. All realistic consequences

- Over-Estimation

Example 1: Loss of suction resulting in Hydrocarbon Centrifugal Pump seal leak → Potential fire and fatalities

Table 4. Equivalent Hole Sizes for a range of Release Frequencies

Equipment type	Hole size (mm)		
	LEVEL I Greater than 1.0E-2/ release source-yr	LEVEL II 1.0E-2-1.0E-3/ release source-yr	LEVEL III 1.0E-3-1.0E-4/ release source-yr
Single seal with throttle bush	2	5	10
Double seal	1	2	10

Reference : Risk-Based Approach to Centrifugal Pump Seal Selection, IChemE, Hazard 26, SYMPOSIUM SERIES NO 161, 2016

Example 2: Overpressure leading to fatalities

In IEC-61511 part 3 D.6 Example calibration based on typical criteria

Pressure	Expect Scenario
$P > \text{design } P$ but $< \text{Test pressure}$	No Loss of containment
$P > \text{design } P$ but $< 2 \text{ times of Test pressure}$	Only leakage
$P > \text{design } P$ and $> 2 \text{ times of Test pressure}$	Rupture

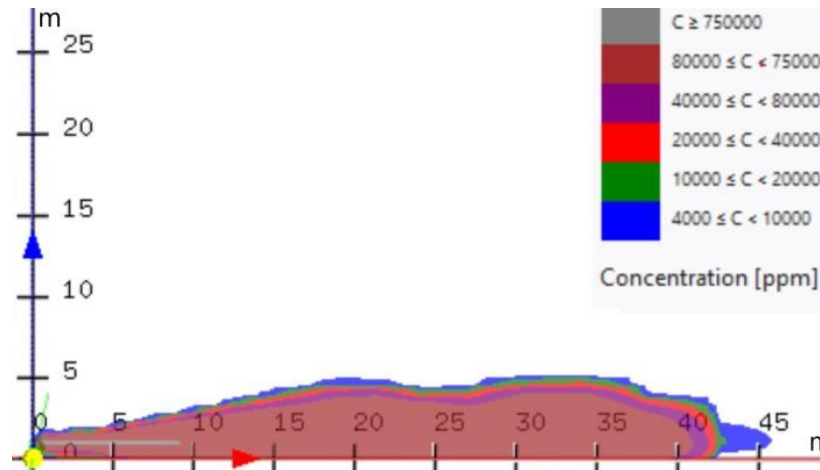
2. During HAZOP/LOPA Workshop (2/3)



2.2. All realistic consequences (Conti.)

- Under-Estimation

Example: Hydrogen leak and dissipating due to lower density than air (However, the system pressure should be considered as well buoyant force vs leak pressure)



Reference : Hydrogen doesn't always just disperse upwards. Why? Because of momentum, by Jamie Elliott - Principal Consultant, Energy Systems at DNV on 5-Sep-24



Tips

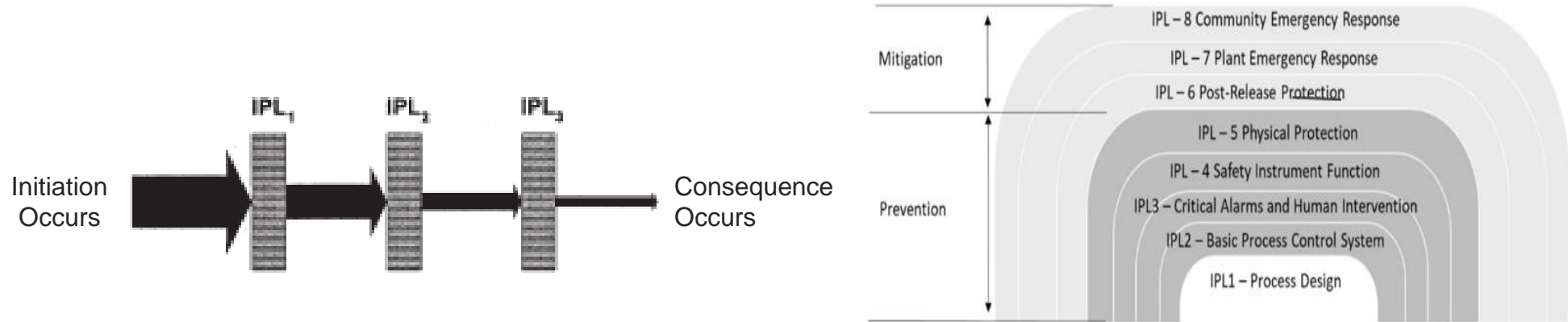
Consequence Analysis (CA) to support – CA should conduct to verify generic consequence. (i.e. Since facility siting on Pre-liminary study, PHA-Revalidation is also required to revisit CA if any change)

2. During HAZOP/LOPA Workshop (3/3)



2.3. Optimized IPLs (Independent/Effectiveness/Auditability)

- No taking duplicate IPL in the same Layer (Exception for interlock can be allowed with independent)



- Action time vs Safety time – especially Alarm, SIF response time – verify during SRS/ SIL verification

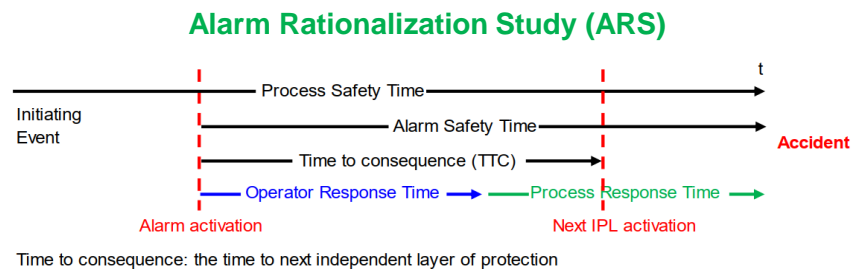


Figure 1B. Response time for ARS (Alarm Safety Time is not equal to TTC, as there is next IPL after alarm before accident)

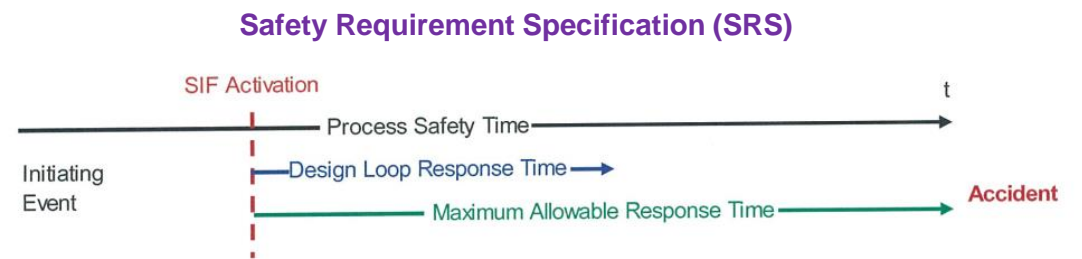


Figure 2. Response time for SRS



2. During HAZOP/LOPA Workshop (3/3)



2.3. Optimized IPLs (Independent/Effectiveness/Auditability) (Conti.)



- Select/Design IPL based on both Safety Reliability and Process Reliability Point of View
 - Know your Hazard well (Behavior of all Substances, Process Control, H&MB)
 - Know all consequences
 - Analyze in detail to all setpoint of IPLs



3. Post HAZOP/LOPA Workshop



- **Ensure dedicated IPLs are well-designed**
 - Alarm Rationalization Study (ARS) – Enough time for Operator to action
 - Safety Requirement Specification (SRS) – Safety Interlock can action in time
 - SIL Verification – Ensure Reliability Safety Interlock achieving Risk reduction target
- **Closing remaining Risk-gap or Confirm all Ambiguity Point, then close Risk-gap**
 - HAZOP/LOPA Recommendation Close-out



How all of these helping on Cost Effectiveness?



Save Manhours

(Minimize Re-work and exhausted from HAZOP)



○ Preparation

- Qualify input information
- Plan reasonable schedule by work load and quality of input information
- Select fitted Member

Save Capital cost

(Sufficient + Not Over-estimate)

○ Realistic Consequence

○ Optimized IPLs (Independent/Effectiveness/Auditability)



Thank you for your attention

