**HAZOP Example 1**

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| Node: Crude Fired Furnace H-1001 |
| **Deviation** | **Cause** | **Consequence** | **Safeguard** | **Recommendation** |
| No/Less flow of crude | 1. No level in storage tank | 1. Damage pump due to dry run |  | 1. Install LSLL on crude storage tank to trip crude pumps. |
| 2. Damage to heater coils due to over-temperature | 1. FSLL that will shut-off furnace burners |
| 2. Pump failure or trip | 1. Damage to heater coils due to over-temperature | 1. FSLL that will shut-off furnace burners2. Standby pump |  |
| 3. Control valve (FV-2311) close more due to any failure in its control loop |  |  |  |
| 4. Plugging of line |  |  |  |

**HAZOP Example 2**

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| Node: Hexane Surge Tank |
| **Deviation** | **Cause** | **Consequence** | **Safeguard** | **Recommendation** |
| High Level | 1. Pump failure or trip | 1. Overfilling of tank and overflow from vent that may lead to fire and fatality2. No flow to next process | 1. Control loop will close LV-902. LAH-903. LSHH-10 will close SDV4. Dike*5. Vibration switch on pump* |  |
| 2. LV-90 open more due to any failure in its control loop | 1. Overfilling of tank and overflow from vent that may lead to fire and fatality | 1. LAH-90 (dependent)2. LSHH-10 will close SDV3. Dike |  |

Worst Probable scenario

S1 = pump failure + Overfilling…fatality

~~S2 = pump failure + no flow to next process~~

S3 = LV-90 open + overfilling…fatality

**LOPA Calculations for Scenario: S1**

Step 1: Consequence and severity

Consequence: Overfilling of tank and overflow from vent that may lead to fire and fatality

Severity:

based on approach 1: Category 4 >>>> fc = 10-5 /year

based on approach 2: single fatality >>>> fc = 10-5 /year

based on approach 3: (conditional modifiers/enabling conditions)

single fatality >>>> fc = 10-5 /year

condition 1: ignition probability P1 = 5%

condition 2: exposure probability P2 = 50%

condition 3: fatal injury due to exposure (based on probit) P3 = 50%

Step 2: Scenario = 1 cause + 1 consequence

**S1 = pump failure + Overfilling…fatality**

**condition 1: ignition probability P1 = 5%**

**condition 2: exposure probability P2 = 50%**

**condition 3: fatal injury due to exposure (based on probit) P3 = 50%**

Step 3: initial event frequency

Pump failure >>>> fi = 1/year

Step 4: IPL (independent protection layer)

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| --- | --- | --- | --- | --- | --- | --- |
| Safeguard | Independent | Specific | Effective | Auditable | IPL | PFD |
| LIC-90 | √ | √ | √ | √ | **√** | **0.1** |
| LAH-90 + Operator | × | √ | × | × | **×** | **-** |
| Dike | √ | √ | √ | √ | **√** | **0.01** |

RRF >= 10 , PFD <=0.1

Step 5: Calculate scenario frequency

fc = fi x PFD1 x PFD2 x …. x P1 x P2 x …

10-5 = 1 x 0.1 x *x* x 0.01 x 0.05 x 0.5 x 0.5

PFD(SIF) = 0.8

Step 6: Making decision

PFD=0.04 >>>> SIL(SIF) = SIL1

**LOPA Calculations for Scenario: S3**

**Step 1: Consequence and severity**

Consequence: Overfilling of tank and overflow from vent that may lead to fire and fatality

Severity:

based on approach 2: single fatality >>>> fc = 10-5 /year

**Step 2: Scenario = 1 cause + 1 consequence**

S3 = LV-90 open + overfilling…fatality

**Step 3: initial event frequency**

Control loop failure >>>> fi = 0.1/year

**Step 4: IPL (independent protection layer)**

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| --- | --- | --- | --- | --- | --- | --- |
| Safeguard | Independent | Specific | Effective | Auditable | IPL | PFD |
| LAH-90 + Operator | × | √ | × | × | **×** | **-** |
| Dike | √ | √ | √ | √ | **√** | **0.01** |

**Step 5: Calculate scenario frequency**

fc = fi x PFD1 x PFD2

10-5 = 0.1 x 0.01 x *x*

PFD(SIF) = 0.01

**Step 6: Making decision**

PFD=0.01 >>>> SIL(SIF) = SIL1

If 0.1=<PFD<1 SILa : no special safety requirement

If 1=<PFD non-SIL : no safety requirement