

### What is LOPA?

Layer of Protection Analysis (LOPA) is a semi quantitative tool for analysing and assessing risk. PreDigest 3 issued in Feb 2014 provided a good start for those who are keen to use this methodology for risk assessment purposes. This issue takes this further by providing some tips when carrying out LOPA and more references.

### Useful Tips When Carrying Out LOPA

- 1) Independent Protection Layers (IPL) must meet the independence rule  
Examples not meeting this criterion include taking credit for the basic process control system as an IPL when it is the initiating event or taking credit for human intervention as an IPL when the valve an operator closes is the same as a Safety Instrumented System. For the latter, a good way to avoid this error is to specify the exact action that an operator takes, i.e. “closing control valve 1PC234” instead of a generic statement such as “operator response to DCS alarm” or “operator close valve”.
- 2) Be specific about the consequence identified when carrying out LOPA  
Just stating “fire” may not be sufficient. Harm to people, i.e. injury or fatality is a common consequence on which LOPA is used for when considering the event that causes this harm. Potential consequences for different types of scenarios (e.g. flash fire, fireball, jet fire, pool fire, vapour cloud explosion, boiling liquid expanding vapour explosion (BLEVE)) may result in different levels of harm to people. For example, a hydrocarbon gas leak within a confined structure allows for formation of a vapour cloud which could lead to a vapour cloud explosion with a larger and more serious area of harm (e.g. potential multiple fatalities) while the same leak in an open area may only result in a jet fire where harm may be more limited (e.g. serious injury or single fatality).
- 3) It is important to assign appropriate failure rate data from published sources, one of which is referenced below (Ref 2).
- 4) Complex software may not be required for LOPA  
The mathematics behind LOPA is not complicated. It is a matter of multiplication (“AND”) and/or addition (“OR”) which can be built into a spreadsheet. It is more important to get the scenario from the initiating event to the consequence correct and ensuring that the IPLs are truly valid.

	Description	Probability	Frequency (per year)
Consequence Description/Category	Overpressuring of Low Pressure Water Injection System / Major consequence (single fatality)		
Risk Tolerance Criteria (category or frequency)	Unacceptable (greater than)/Company LOPA criteria		1.00E-06
Initiating Event (typically a frequency)	Interventions per year		20
Enabling Event or Condition	Human error (per operation)	0.026	
Conditional Modifiers	Probability of downstream valve left closed or fail closed	0.030024	
	Probability of fatality given overpressure	0.5	
	Probability of a worker being in the vicinity	1	
Frequency of Unmitigated Consequences			7.8E-03
Independent Protection Layers			
PSV		1.00E-02	
Total PFD for all IPLs		1.00E-02	
Frequency of Mitigated Consequences			7.8E-05
Risk Tolerance Criteria Met? (Yes/No)		No	

### References

- 1) Singapore Chemical Industry Council, *PreDigest Issue 3 – Feb 2014*
- 2) Health and Safety Executive UK, *Failure Rate and Event Data for use within Risk Assessments*, <http://www.hse.gov.uk/landuseplanning/failure-rates.pdf>
- 3) Health and Safety Executive UK, *Expert Guidance website*, <http://www.hse.gov.uk/risk/expert.htm>
- 4) National Environment Agency, *Quantitative Risk Assessment Technical Guidance*, [http://www.nea.gov.sg/docs/default-source/anti-pollution-radiation-protection/central-building-planning/qra-technical-guidance\\_nov16.pdf](http://www.nea.gov.sg/docs/default-source/anti-pollution-radiation-protection/central-building-planning/qra-technical-guidance_nov16.pdf)
- 5) Center for Chemical Process Safety, *Layer of Protection Analysis: Simplified Process Risk Assessment*
- 6) Center for Chemical Process Safety, *Guidelines for Initiating Events and Independent Protection Layers in Layer of Protection Analysis*

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**SINGAPORE CHEMICAL INDUSTRY COUNCIL LIMITED (SCIC)**  
 8 Jurong Town Hall Road, #25-04, The JTC Summit, Singapore 609434  
 Tel : 6267 8891 Fax : 6267 8893