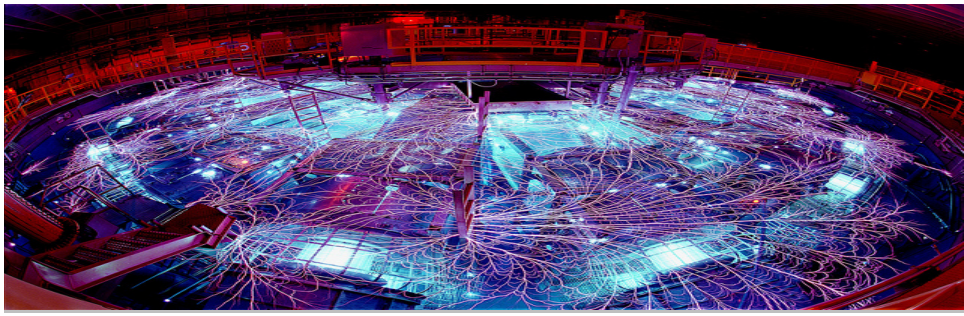
SAND2016-7703C

Layer of Protection Analysis (LOPA) Overview

Timothy Stirrup
Principal Safety Basis Engineer
Sandia National Laboratories

Exceptional service in the national interest

Sandia National Laboratories



August 6-12, 2016

2016 EFCOG Safety Analysis Working Group

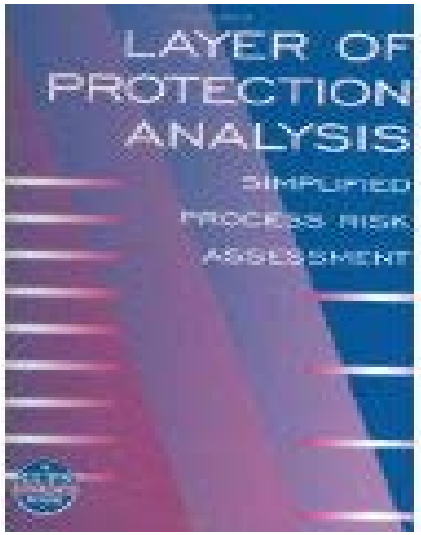
U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.
SAND No. 2011–XXXXP.

Layer of Protection Analysis Overview

- LOPA Definition
- LOPA History
- LOPA Common Elements
- LOPA Use – Motivating Factors
- LOPA Steps
- LOPA Limitations/Benefits
- LOPA Example
- LOPA References



Definition

- Simplified Form of Risk Assessment
- Order of Magnitude Categories
  - Event Frequency
  - Consequence Severity
  - Likelihood of Failure of Independent Protection Layers
- Builds On Qualitative Hazards Analysis
- Rule-Based Implementation

Purpose

- Replace Quantitative Risk Assessment
- Determine if Sufficient Layers of Controls
- Use of LOPA as Semi Quantitative Hazard Evaluation Tool for Judging Risk of Accident Scenarios
- Risk Analysis Tool that Must be Applied Correctly

History

- Origin with Company Specific Development
- Multiple Papers Published ~ 1997
- CCPS International Conference and Workshop on Risk Analysis in Process Safety (10/1997)
  - Recommendation for Book Describing and Defining LOPA
- Parallel Development of Safety Integrity Levels
- Draft IEC 61511 Part 3 ~ 1999
- CCPS Workshop ~ 2000

Common Events

- Consequence Classification Method
  - Typically Company Specific
- Numerical Risk Tolerance Criteria
  - Fatalities & Fire Frequencies
  - Required Number of IPL Credits
  - Maximum Frequency for Specified Categories
- Method of Developing Scenarios

Common Elements

Sandia National Laboratories

- Rules for Controls as IPLs
- Default Frequency Data
  - Event Frequencies
  - Credits for IPLs
- Procedure for Calculation
- Procedure for Application/Acceptance

Use

- Effectively Used Throughout Safety Life Cycle
- Preferred Use
  - Detailed Design Stages
  - Modifications to Designs
- Techniques Where Defining
  - Control Hierarchy
  - Control Requirements
- Use for Engineering/Administrative Controls

Steps

- Identify Consequence
- Select Accident Scenario
- Identify Cause-Consequence Pair
- Determine Frequency of Pair

Steps

- Identify Independent Protection Layers
- Identify Probability of Failure on Demand
- Estimate Risk
- Evaluate Risk
- Make Decisions to Reach Tolerable Risk

Benefits

- Less Time Than Quantitative Risk Analysis
- Simplified Framework for Understanding Risk
- Subsequent Improvements to HE Methods
- Rigorous Procedures
- Means of Comparing Risk

Benefits

- Defensible Process/Procedure
- As Low As Reasonably Possible Risk
- Defines Safety Integrity Levels
- Defines Hierarchy of Controls to Support Budget, Maintenance & Operations

Limitations

- Internal Risk Comparisons Valid Only When Using Same LOPA Method
- Result Values Are Not Precise
- Should Not Be Applied to All Scenarios
- Time/Resource Commitment
- Not Hazard Identification/Evaluation Tool
- External Risk Comparisons Not Typically Valid

References

- Guidelines for Hazard Evaluation Procedures, 3rd Ed; CCPS 2008
- Layer of Protection Analysis: Simplified Process Risk Assessment; CCPS 2001
- Guidelines for Initiating Events and Independent Layers of Protection Analysis, 1st Ed; CCPS 2014
- Guidelines for Enabling Conditions and Conditional Modifiers in Layer of Protection Analysis; CCPS 2015
- Layer of Protection Analysis; PII 2014