Using HAZOP/LOPA to Create an Effective Mechanical Integrity Program

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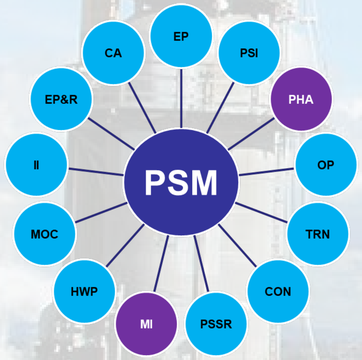
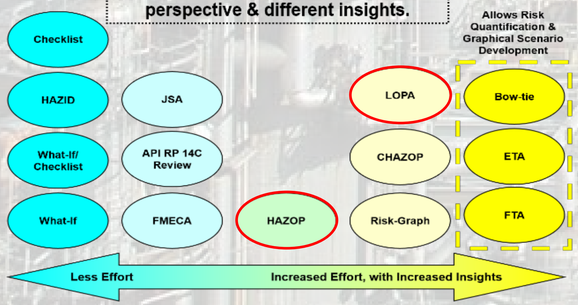
Current PSM Program Elements



- Employee Participation
- Process Safety Information
- Process Hazard Analysis
- Operating Procedures
- Training
- Contractors
- Pre-Startup Safety Review
- Mechanical Integrity
- Hot Work Permit
- Management of Change
- Incident Investigation
- Emergency Planning & Response
- Compliance Audits (CA-IIPP)

Potential Process Hazard Analysis (PHA) Methodologies

Each of these tools provides a different perspective & different insights.



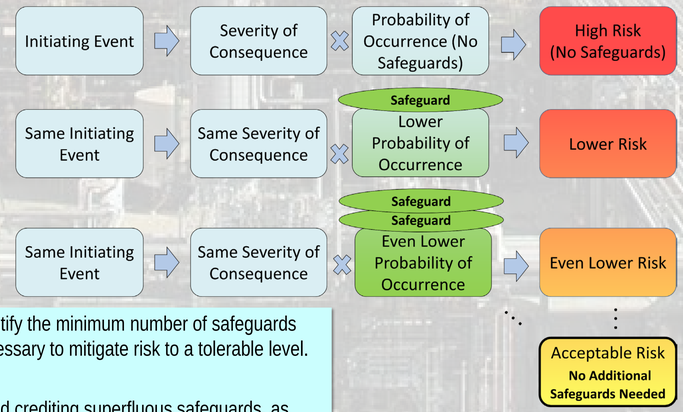
Basis of a Mechanical Integrity (MI) Program

Key Attributes

1. Accommodate both safety and operational issues
2. Identify when a safety feature is needed
3. Be able to scale up/down
4. Provide optional quantification
5. Scenario-based, Risk-driven

HAZOP/LOPA: A Tool for Scenario-Based Risk Identification

Identification of Safety-Critical Equipment

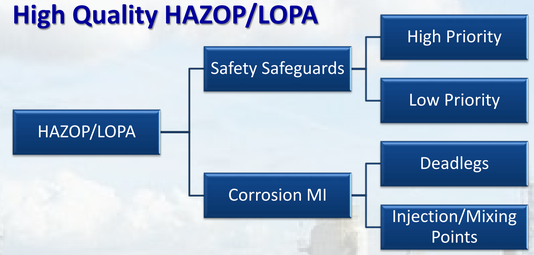


Identify the minimum number of safeguards necessary to mitigate risk to a tolerable level.

Avoid crediting superfluous safeguards, as their inclusion into the MI Program can deter focus from more critical equipment.

Implementation of an Optimized Mechanical Integrity Program

Favorable Elements of a High Quality HAZOP/LOPA



- Documentation that consistently, accurately, and comprehensively applies equipment tag numbers that match with other Process Safety Information (PSI).
- Clear documentation of safeguard functions and Independent Protection Layers (IPLs).
- Worksheets that are filterable by safeguard type allow for increased usability (e.g. printable lists of PSVs and critical check valves).
- Identification of deadlegs and mixing/injection points to verify inclusion in the MI Program.

Categorization and Prioritization of Equipment to Lower Recurring MI Costs

- Repair prioritization
- Inspection/testing methods based on failure modes identified in HAZOP/LOPA
- Testing intervals
- Maintenance outage periods
- Streamlined MI Program
  - Identification of low priority equipment

Equipment and Key Failure Modes	
Safety Instrumented Function (SIF)	- Well-defined testing, inspection, and preventative maintenance requirements
Safety – High Priority	- Equipment failure modes that can initiate a high consequence HAZOP/LOPA scenario - IPL Safeguards that could mitigate a high consequence HAZOP/LOPA event
Safety – Low Priority	- Other equipment failure modes that could result in a safety consequence - Non-IPL Safeguards credited by the HAZOP/LOPA
Operational	- Equipment failure modes that do not result in a safety consequence

Independent Protection Layer (IPL) Verification

IPL Requirements:

1. Independence
2. Functionality
3. Integrity
4. Reliability
5. Auditability
6. Access Security
7. Management of Change

Calculated values in Table 1 assume equipment is tested and inspected regularly.

Table 1. Standard Initiating Event and Failure Frequencies

Example Values Used for LOPA	
Initiating Cause Likelihoods	
Initiating Cause	**Events / Year**
BPCS instrument loop failure	1×10^{-1}
Regulator failure	1×10^{-1}
Pumps and other rotating equipment failure	1×10^{-1}
Safety valve opens spuriously	1×10^{-2}
Pump seal failure	1×10^{-1}
Independent Protection Layer (IPL) Probability of Failure on Demand (PFD)	
IPL	**PFD**
Basic process control system, if not associated with the initiating event being considered	1×10^{-1}
Safety valve fails to open on demand	1×10^{-2}
Rupture disc fails to open on demand	1×10^{-2}
SIL-1 IPL	$> 1 \times 10^{-2}$ & $\leq 1 \times 10^{-1}$
SIL-2 IPL	$> 1 \times 10^{-3}$ & $\leq 1 \times 10^{-2}$
SIL-3 IPL	$> 1 \times 10^{-4}$ & $\leq 1 \times 10^{-3}$