Effective PHA Applications & Tips for Evolving Guidelines

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Evolution of SMS Guidelines & Regulations to Performance (Goal) – Based Standards

1987 – CCPS
1990 – API RP 750
1992 – PSM
1996 – RMP
2013 – CSB Interim Rpt.
2013 – E.O. 13650
2013 – OSHA PSM RFI
2014 – CSB Reg. Rpt.

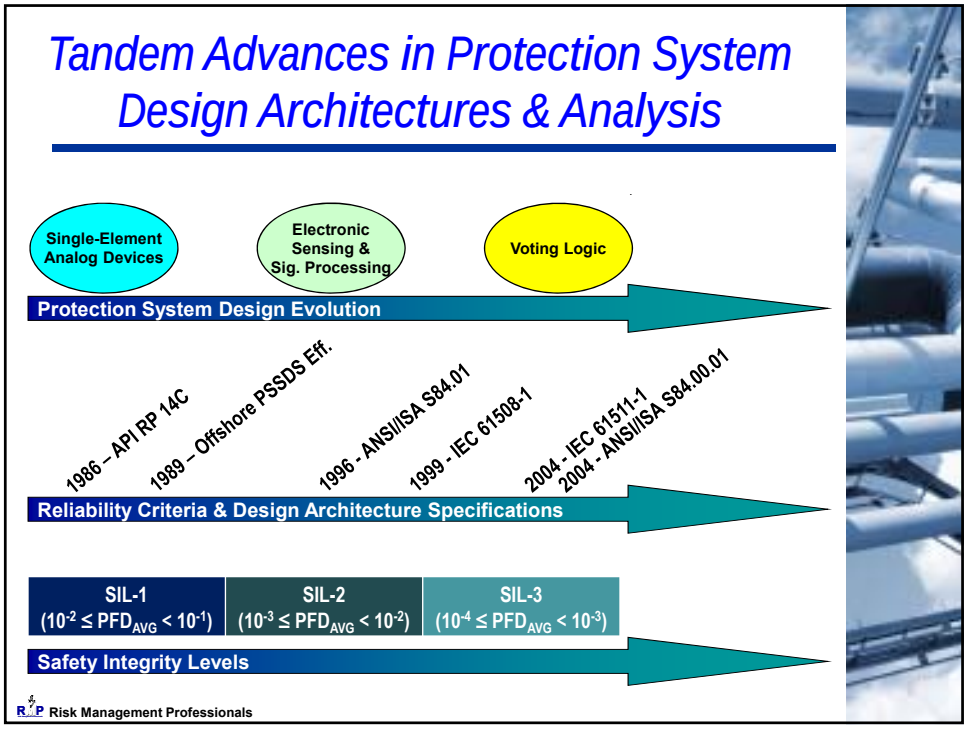
Onshore Process Safety (USA)

1989 – PSSDS
1991 – SEMP Concept
1993 – API RP 75
2004 – API RP 75
2006 – SEMS Concept
2009 – SEMS Prop. Rule
2010 – SEMS Final Rule
2013 – SEMS II

Offshore Safety Management Systems (USA)

1992 – UK Safety Case
2005 – UK SC Update
2009 – MODU HSE Case
2013 – Safety Directive

Offshore Safety Management Systems (UK)


Tandem Advances in Protection System Design Architectures & Analysis
Single-Element Analog Devices
Electronic Sensing & Sig. Processing
Voting Logic
Protection System Design Evolution
1986 – API RP 14C
1989 – Offshore PSSDS Eff.
1996 - ANSI/ISA S84.01
1999 - IEC 61508-1
2004 - IEC 61511-1
2004 - ANSI/ISA S84.00.01
Reliability Criteria & Design Architecture Specifications
SIL-1 ($10^{-2} \leq PFD_{AVG} < 10^{-1}$)
SIL-2 ($10^{-3} \leq PFD_{AVG} < 10^{-2}$)
SIL-3 ($10^{-4} \leq PFD_{AVG} < 10^{-3}$)
Safety Integrity Levels
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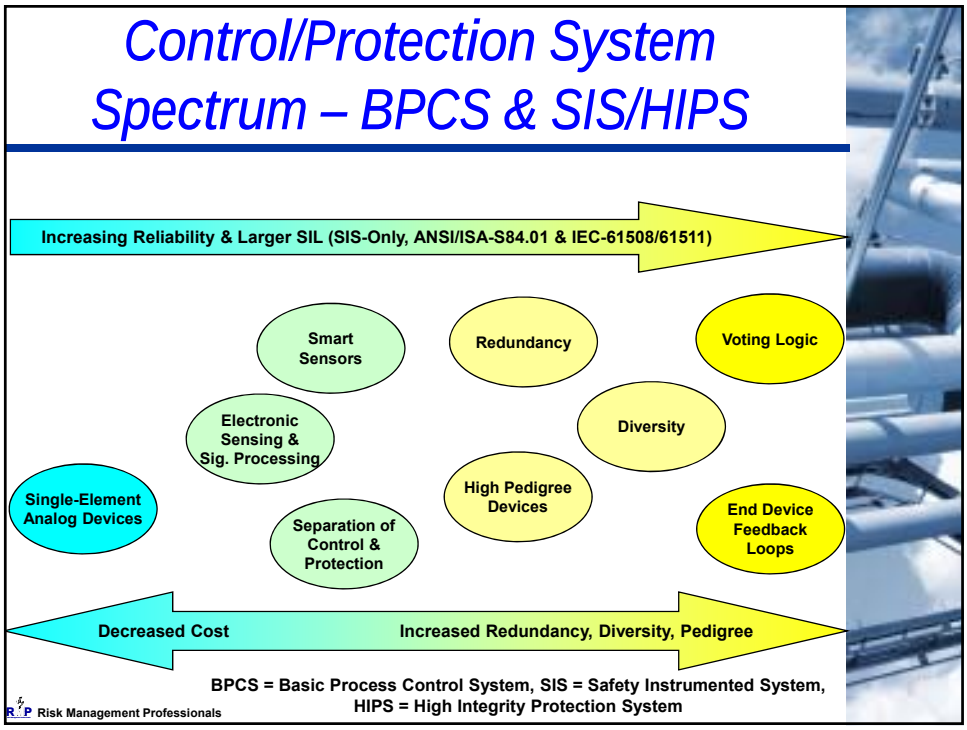
Control/Protection System Spectrum – BPCS & SIS/HIPS
Increasing Reliability & Larger SIL (SIS-Only, ANSI/ISA-S84.01 & IEC-61508/61511)
Smart Sensors
Redundancy
Voting Logic
Electronic Sensing & Sig. Processing
Diversity
Single-Element Analog Devices
High Pedigree Devices
Separation of Control & Protection
End Device Feedback Loops
Decreased Cost
Increased Redundancy, Diversity, Pedigree
BPCS = Basic Process Control System, SIS = Safety Instrumented System,
HIPS = High Integrity Protection System
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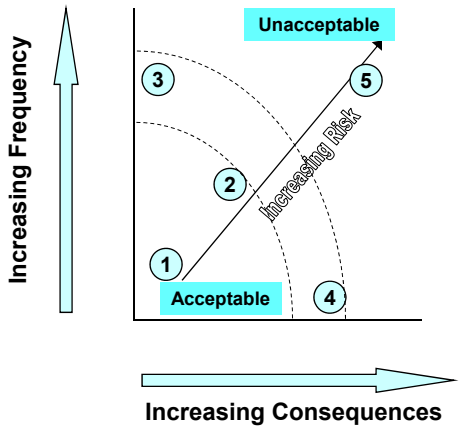
Focusing on the Objective
(The "Big Picture")



- **RISK = PROBABILITY * CONSEQUENCES**
  - **Probability = Likelihood of Occurrence**
  - **Consequences = Effects of Occurrence**
- For Engineered Systems:
  - **Risk = Σ P_i * C_i**

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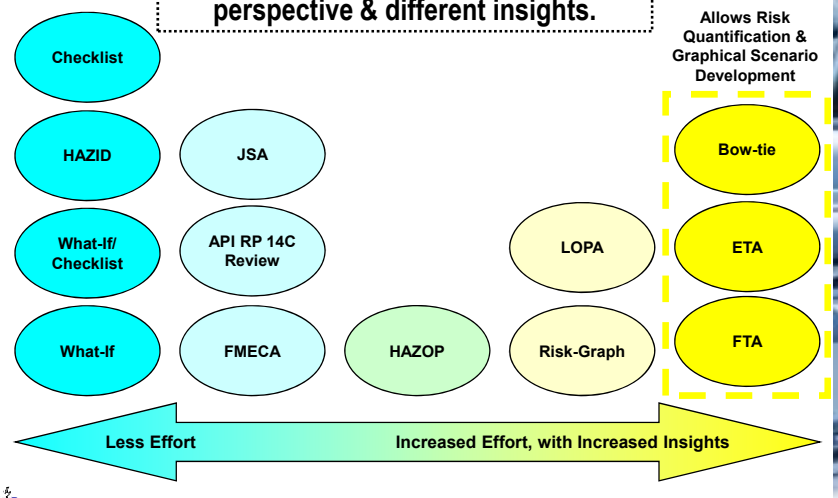
Hazards Analysis Tool Spectrum

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



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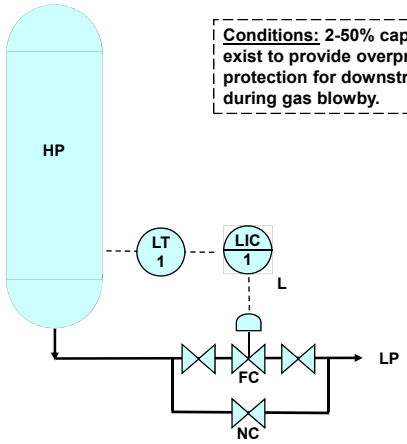
Simple HAZOP Study Example



Conditions: 2-50% capacity relief valves exist to provide overpressure protection for downstream LP vessel during gas blowby.

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Simple HAZOP Study Example

Deviation	Cause	Consequences	Safeguards	S	L	R	Recommendations
More Flow	LV-1 malfunctions open, possibly due to a failure of LT/LIC-1, or bypass valve inadvertently open.	Gas blow-by resulting in overpressurization of downstream equipment and resultant release of hydrocarbons and H2S, Potential for severe injury or fatality.	- LAL-1, if LT/LIC-1 is not the cause of the malfunction. - 2-50% capacity relief valves on downstream LP vessel	B	3	2	Consider evaluating the merits of: - Installing a separate level transmitter and low alarm - Installing a separate emergency isolation valve fed by an independent level transmitter - Reconfiguring LV-1 to include a separate SIS closure feature

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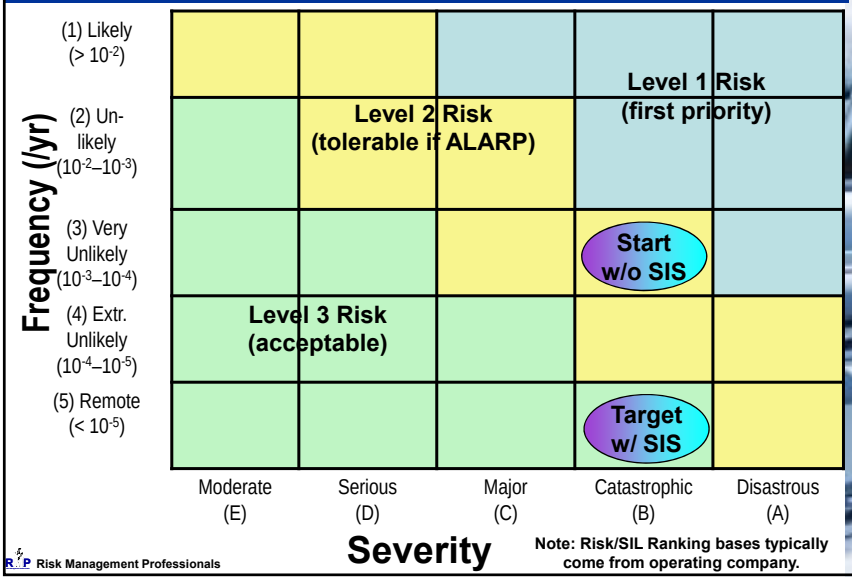
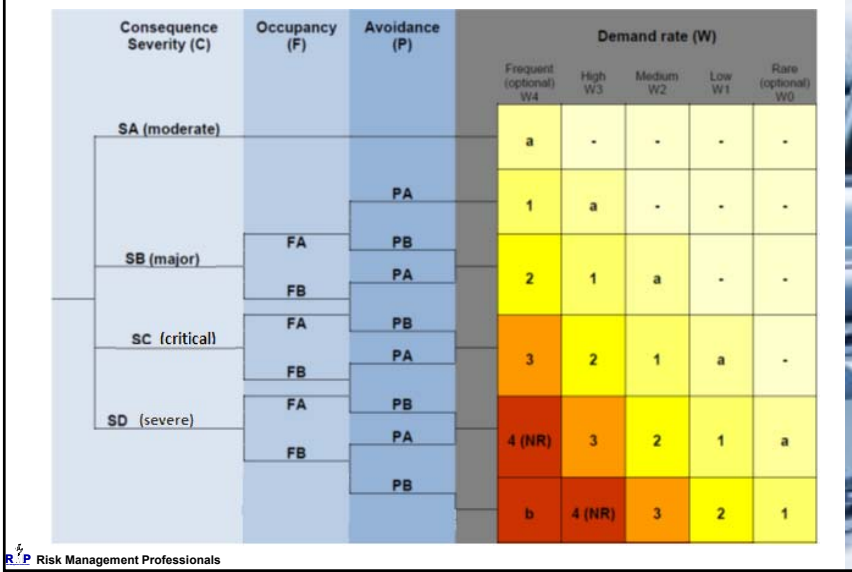
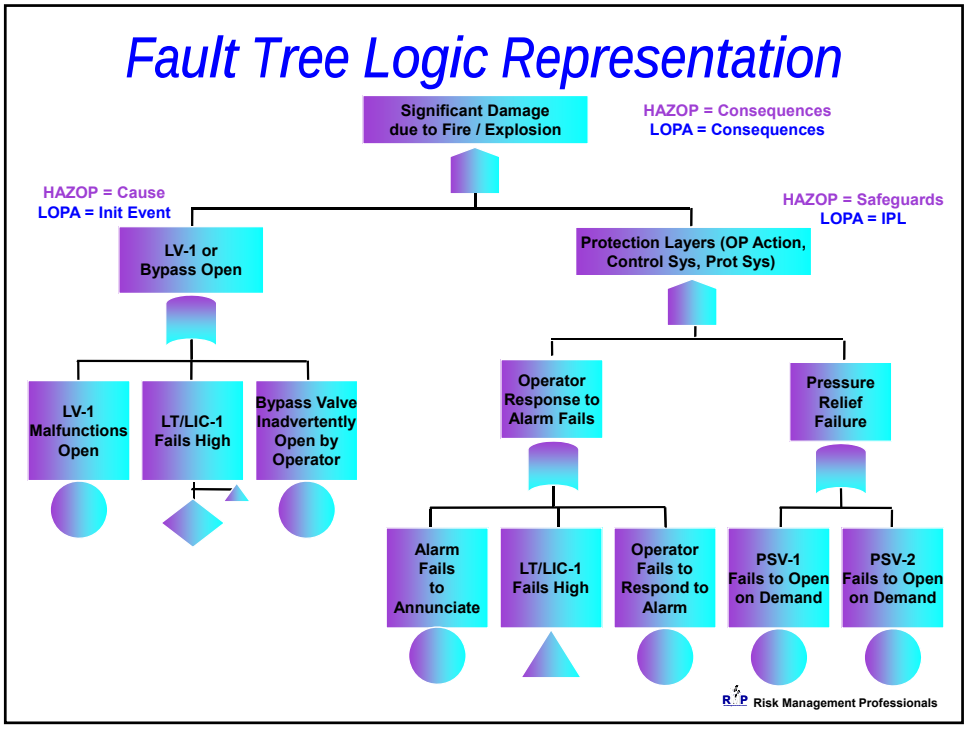
Risk/SIL Ranking



Example Risk-Graph




Fault Tree Logic Representation
Significant Damage due to Fire / Explosion
HAZOP = Consequences
LOPA = Consequences
HAZOP = Cause
LOPA = Init Event
HAZOP = Safeguards
LOPA = IPL
LV-1 or Bypass Open
Protection Layers (OP Action, Control Sys, Prot Sys)
LV-1 Malfunctions Open
LT/LIC-1 Fails High
Bypass Valve Inadvertently Open by Operator
Operator Response to Alarm Fails
Pressure Relief Failure
Alarm Fails to Annunciate
LT/LIC-1 Fails High
Operator Fails to Respond to Alarm
PSV-1 Fails to Open on Demand
PSV-2 Fails to Open on Demand
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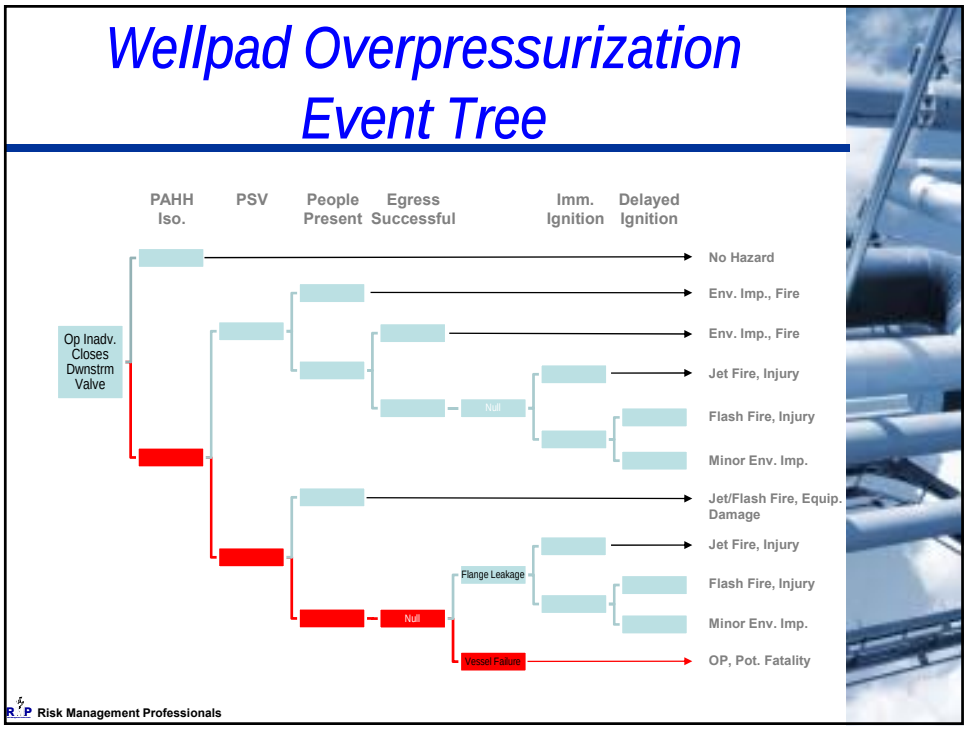
Wellpad Overpressurization Event Tree
PAHH Iso.
PSV
People Present
Egress Successful
Imm. Ignition
Delayed Ignition
Op Inadv. Closes Dwnstrm Valve
Null
Flange Leakage
Null
Vessel Failure
No Hazard
Env. Imp., Fire
Env. Imp., Fire
Jet Fire, Injury
Flash Fire, Injury
Minor Env. Imp.
Jet/Flash Fire, Equip. Damage
Jet Fire, Injury
Flash Fire, Injury
Minor Env. Imp.
OP, Pot. Fatality
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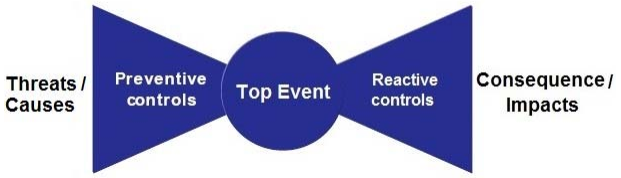
What is a Bow-tie?



- Visualization of Key Hazard Relationships
  - Threats / Causes
  - Preventive Controls / Proactive Controls
  - Top Event
  - Reactive Controls
  - Consequences / Impacts

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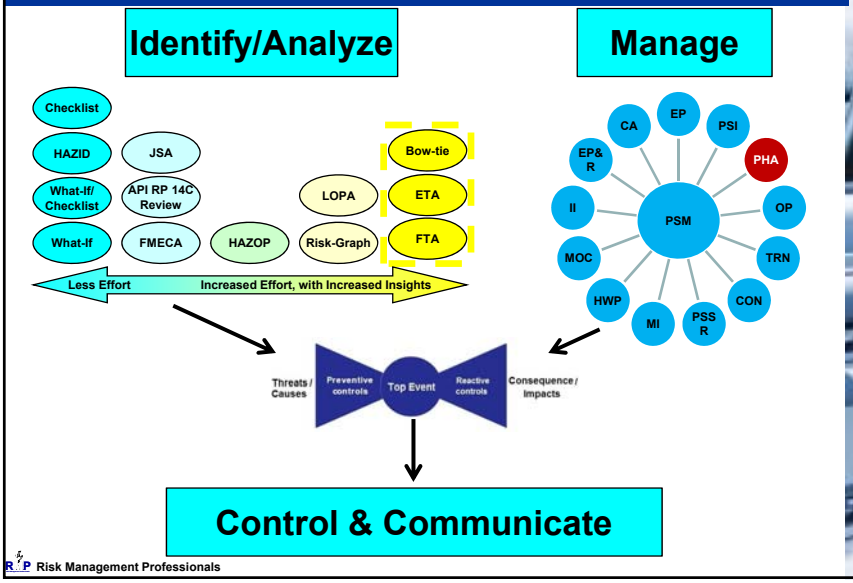
Reference: "Lessons Learned from Real World Application of the Bow-tie Method" by Steve Lewis and Kris Smith

Closing the Loop



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Tips for Addressing 2013/2014 Evolving PHA Guidelines

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PHA – Evolving Guidelines & Best Practices

- Chemical Safety Board (CSB)
- Federal Occupational Safety & Health Administration (OSHA)
- California Division of Occupational Safety and Health (Cal/OSHA)
- California Accidental Release Prevention (CalARP) Program
- U.S. Environmental Protection Agency (EPA)

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1 – Damage Mechanism Hazard Review

- Reference
  - CSB Recommendation 2012-03-I-CA-9
- Focus – California Oil Refineries
- Objective
  - Improve Identification of Mechanical Failure Vulnerabilities
  - Minimize Failure Potential
- Stated Requirements
  - Conduct Damage Mechanism Hazard Review
  - Include MI Review During PHA
- Tips

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2 – Effectiveness of Safeguards

- Reference
  - CSB Recommendation 2012-03-I-CA-6
  - CSB Recommendation 2012-03-I-CA-12
- Focus – CalARP Facilities
- Objective
  - Validate Effectiveness of Safeguards
- Stated Requirements
  - Document "recognized methodologies, rationale, and conclusions used to claim that safeguards intended to control hazards will be effective"
  - Qualitative, Quantitative, or Semi-Quantitative Basis
- Tips

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3 – Action Item Completion Status

- Reference
  - CSB Recommendation 2012-03-I-CA-10
  - OSHA RFI Topic 6
- Focus – PSM Facilities, California Oil Refineries
- Objective
  - Support Action Item Implementation
- Stated Requirements
  - Report Action Item Completion Status
- Tips

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4 – Revalidation

- Reference
  - CalARP Proposed Changes to Section 2755.2
- Focus – CalARP Facilities
- Objective
  - Ensure Quality/Completeness of Revalidation Efforts
  - Hazard review revalidation can only occur once between full hazard reviews
- Stated Requirements
  - Alternate Revalidations Should Perform a Redo
- Tips

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5 – Inherently Safer Designs

- Reference
  - CSB Recommendation 2012-03-I-CA-7
  - CSB Recommendation 2012-03-I-CA-13
- Focus – CalARP Facilities
- Objective
  - Minimize Risk to the Public, Personnel, and the Environment
- Stated Requirements
  - Perform an Inherently Safer Systems (ISS) Analysis Triggered by Al MOC and PHA Reviews
- Tips

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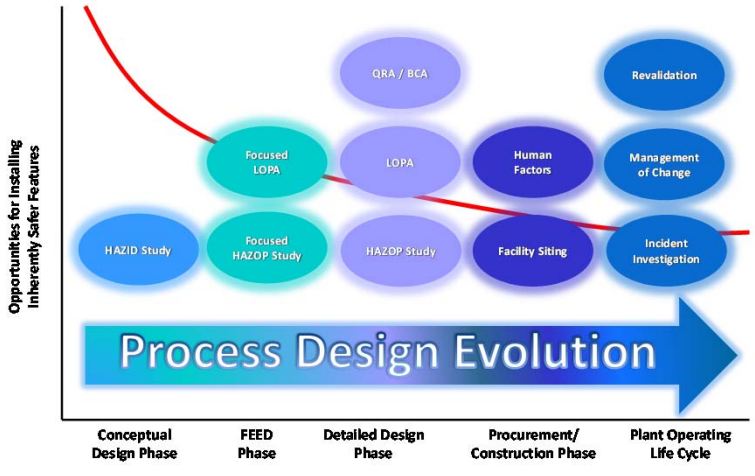
Implementation of Inherently Safer Design Features During Process Design



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Questions?

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