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Prevention through Design: Taking a Proactive Approach

ASSP Heart of America Chapter
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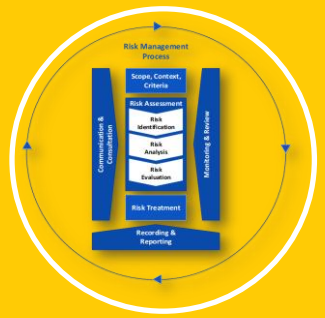
PtD Prevention through Design

UCM Occupational Risk & Safety Sciences

Our Objectives Today

Review the need for Prevention through Design (PtD)



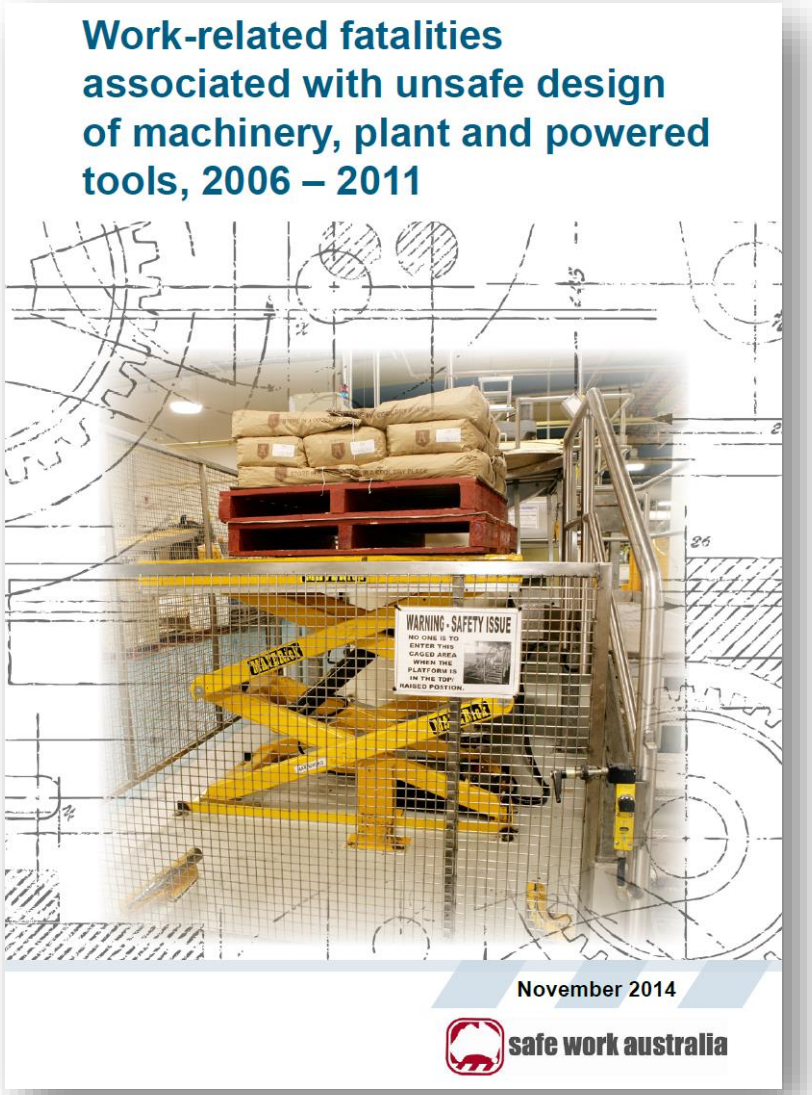
Discuss risk assessment and design safety reviews

Review a PtD case study used to achieve an acceptable level of risk (ALOR)

A Need for Prevention through Design?

Fatalities

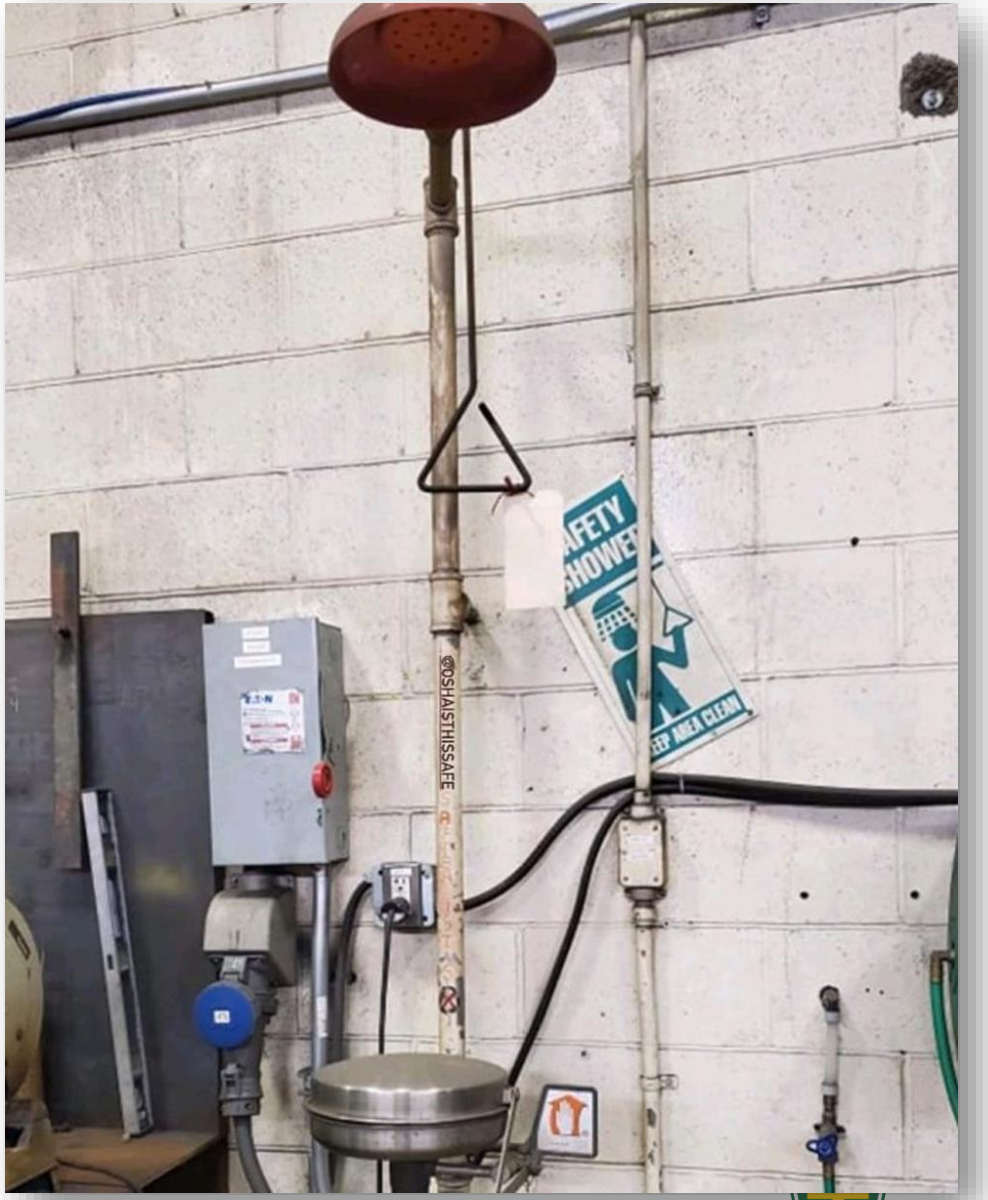
- **U.S.** studies indicate over 40% of construction fatalities are connected to the design *(Behm, 2005)*
- **Australian Study** of work-related fatalities found:
  - 12% *caused* by unsafe design-related factors
  - 24% were *possibly caused* by design-related factors *(Safe Work Australia, 2014)*



PtD Opportunities…?

Emergency shower/eye wash stations placed next to electrical exposures in forklift recharging bays

- *Cookie cutter design in all facilities*



PtD Opportunities…?

Lack of ventilation and local exhaust systems in new facility's QA welding lab performing destructive testing

PtD Opportunities…?

Conveyor systems creating obstacles for emergency evacuation routes

PtD Opportunities…?

No secondary containment for storage tanks to prevent spills from entering floor drains

PtD Opportunities…?

Poor Layout for Forklift / Pedestrian Pathways

- *Multiple blind corners*
- *Bottlenecks*
- *Tight turnaround space*
- *Pedestrian walkways not separate from forklift traffic*

PtD Opportunities…?

Elevated work platforms requiring fixed ladders and stairs and lifting and lowering of materials and equipment

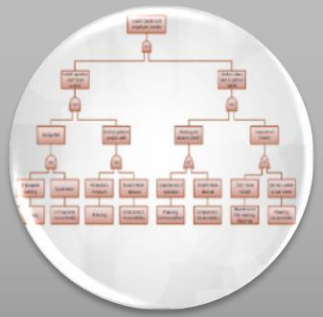
PtD Opportunities…?

Poor workstation designs with no ergonomics or human factors engineering

- *non-adjustable surfaces & seating*
- *excessively wide conveyors*
- *excessive material handling*
- *poor placement of storage*
- *high noise areas*
- *poor lighting*

Design-embedded Hazards

Permanently Exist until Removed by Redesign



Root Causes for Fatalities & Serious Incidents

Imped Operations, Quality and Profitability

ANSI/ASSP Z590.3-2021

Prevention through Design

Guidelines for Addressing Occupational Hazards and Risks in Design and Redesign Processes

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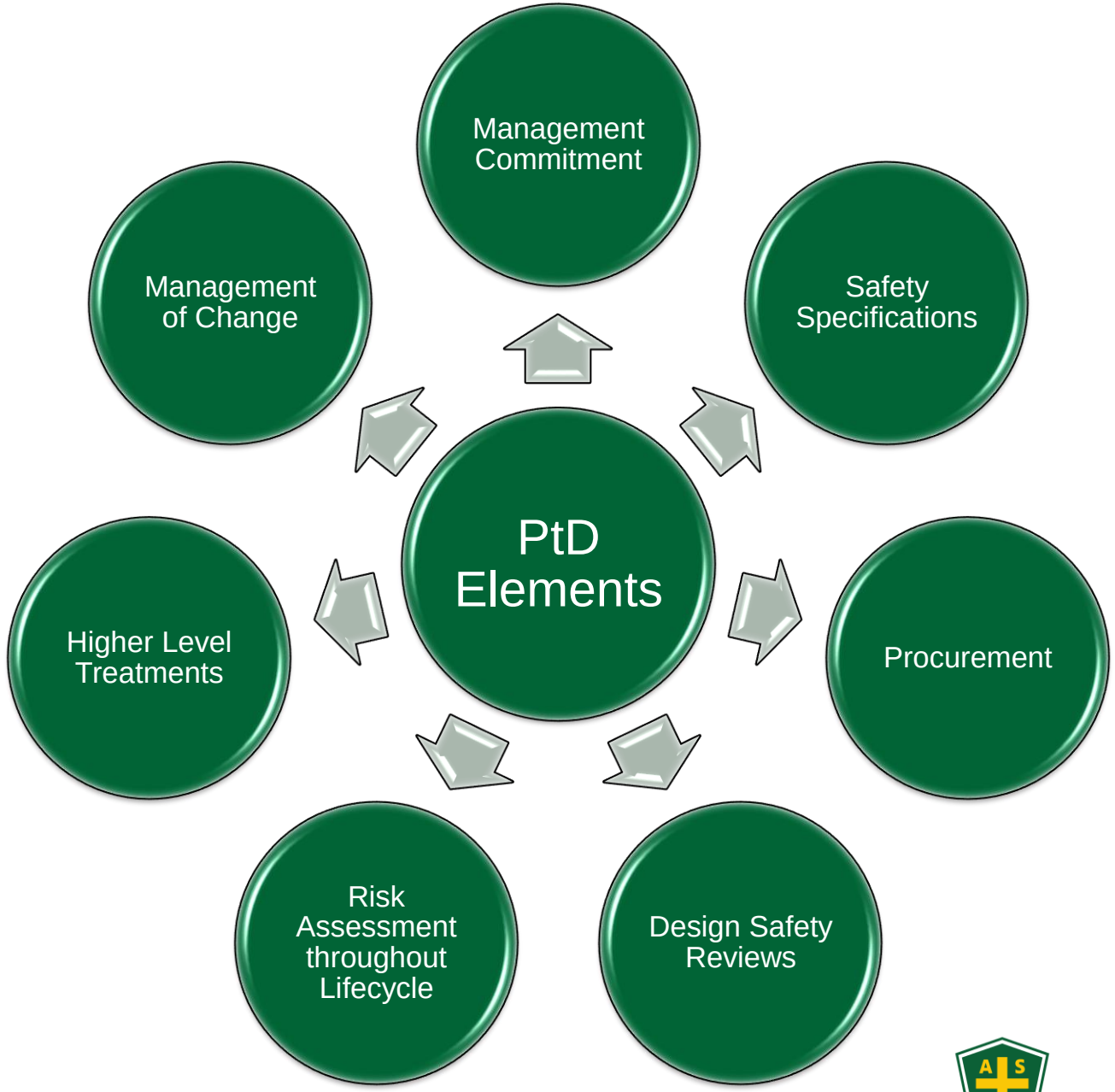
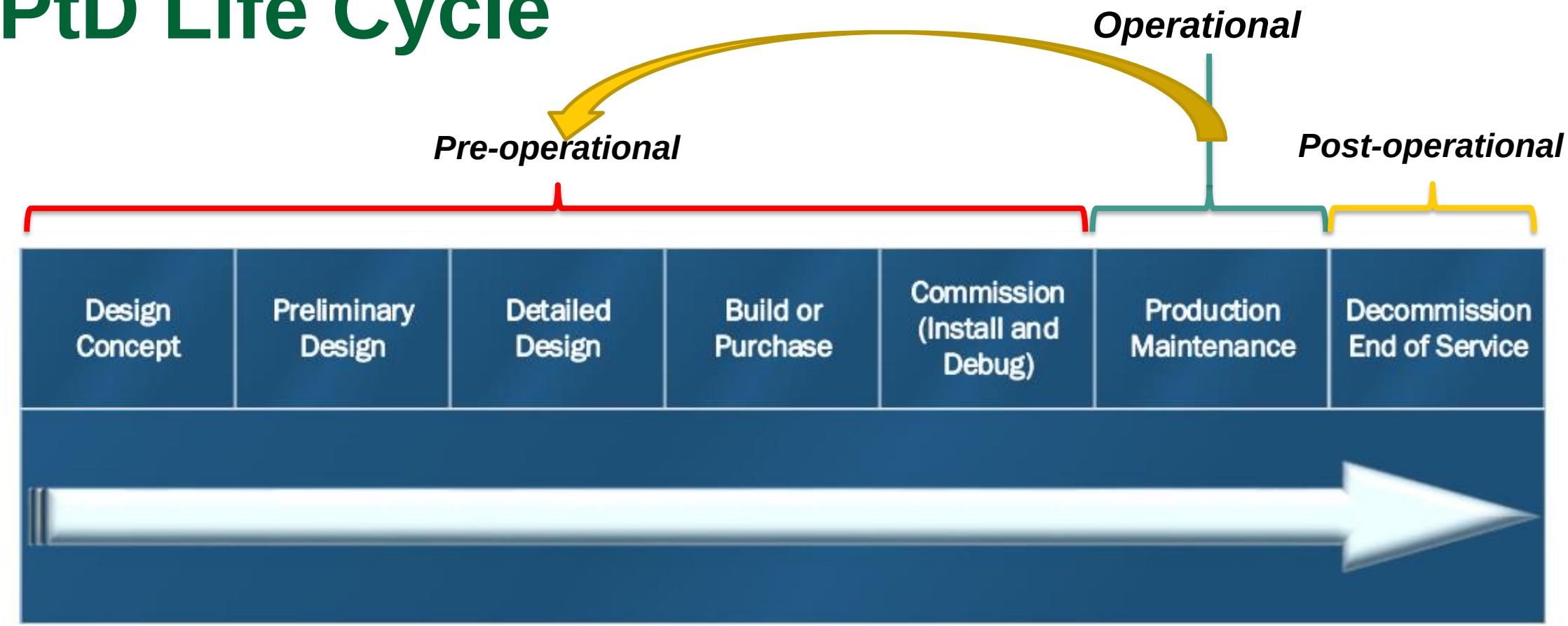
Approved American National Standard ANSI



PtD Life Cycle

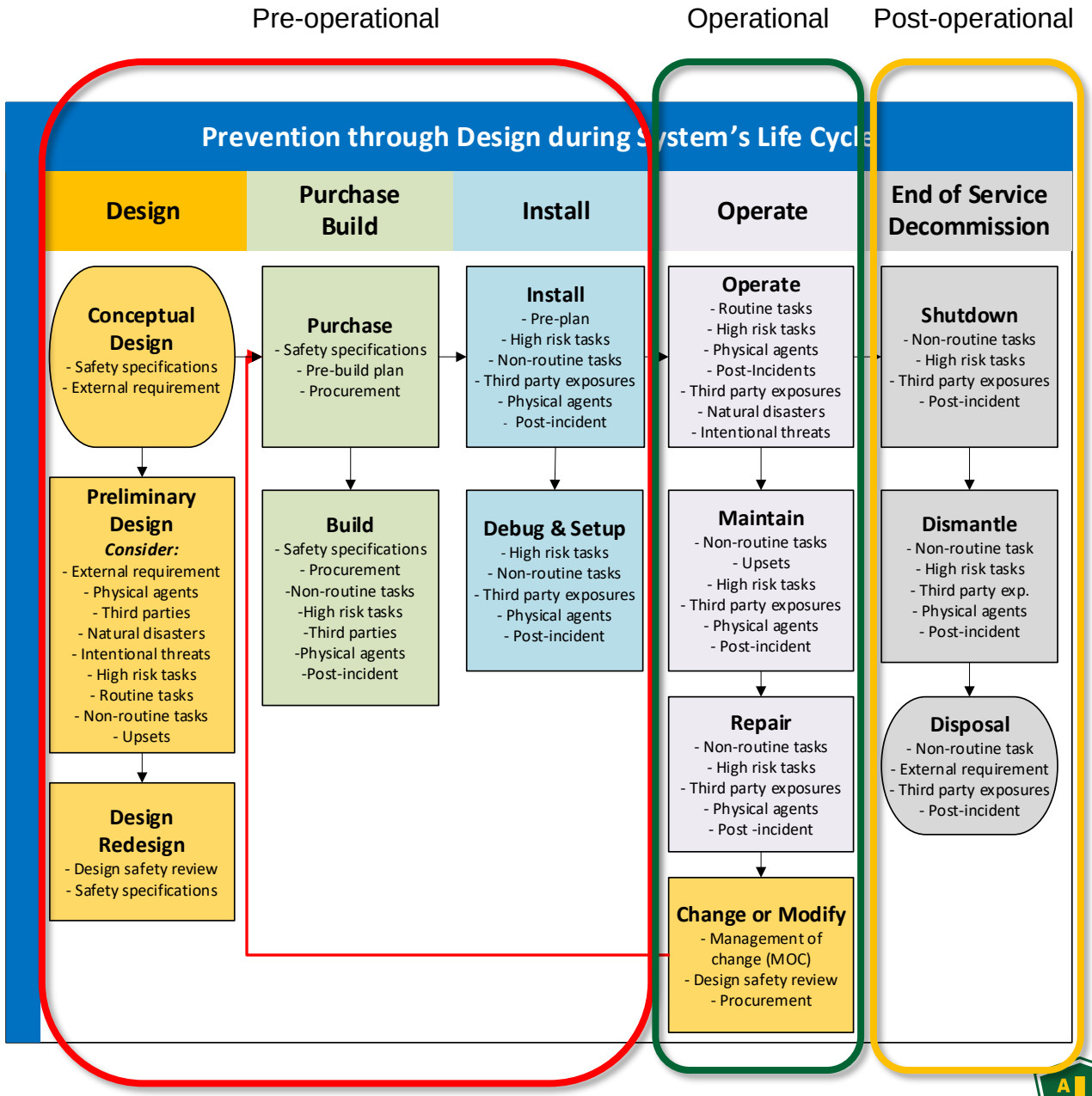


ANSI/ASSP Z590.3-2021 Figure 1

PtD Life Cycle

Three Stages

- **Pre-operational**
  - Design
  - Purchase/build
  - Install/construct
  - Post-incident
- **Operational**
  - Operate
  - Maintain/repair
  - Change
  - Post-incident
- **Post-operational**
  - End of service
  - Shutdown/dismantle
  - Disposal
  - Post-incident



ANSI/ASSP Z590.3-2021 Figure 2

Establish Safety Specifications

To be used in:

- ✓ new designs
- ✓ redesigns
- ✓ procurement
- ✓ MOC

- ❑ no portable ladders (step and extension types)
- ❑ no open chemical systems
- ❑ no manual handling or lifting of products greater than 15 lb in production cycle
- ❑ no chemicals/materials to be used as noted on organization's material of concern list
- ❑ no elevated work without protective guardrails
- ❑ no sharp edges
- ❑ no energized work
- ❑ no exposure to energized parts, including diagnostics
- ❑ energy isolation devices for lock-tag-try at ground or floor level and at point of need
- ❑ no respirator-required tasks
- ❑ no exposure to noise levels above 80 dBA for an 8-hour time-weighted average
- ❑ no pedestrians in warehouse while forklift traffic present

Design Safety Review Process

Design Safety Review Process

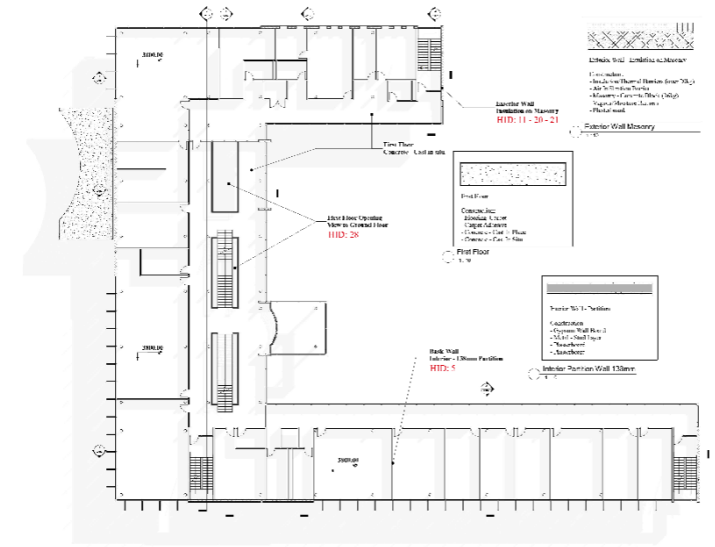


Table A1.1 Example What-If checklist used in evaluating hazards of facility/operational changes

A. Releases via mechanical failure causing emissions, fires, explosions:

Releases of materials to the surroundings that could result in pool fires, flash fires, vapor cloud explosions or toxic vapor clouds, dust clouds, or mist clouds, with significant acute exposure to personnel.

1. Vessel Failure
- ❑ a. Installation
  - 1) vibration
  - 2) fatigue
  - 3) embrittlement (e.g., cast iron/ steel, hydrogen)
- ❑ b. Impingement
  - 1) crane drop
  - 2) heavy equipment impact
  - 3) vehicle impact
  - 4) railcar/barge/tank truck collision
- ❑ c. Overpressure from
  - 1) process upsets
  - 2) common vent header
  - 3) pump/compressor
  - 4) nitrogen supply
  - 5) blowing lines into vessel
  - 6) steaming to clean
  - 7) ruptured tube
  - 8) homogeneous nucleation/ low boilers with high boilers
  - 9) overfill
  - 10) liquid filled/valved-in
  - 11) hydraulic hammer
  - 12) water freezing
- ❑ d. Natural forces
  - 1) lightning
  - 2) earthquake

2. Piping System Failure
- ❑ a. Installation
  - 1) improper material of construction
  - 2) improper installation
  - 3) vibration
  - 4) fatigue
- ❑ b. Impingement
  - 1) crane drop
  - 2) heavy equipment impact
  - 3) vehicle impact
  - 4) third party intervention (e.g., backhoe)
- ❑ c. Natural forces
  - 1) earthquake
  - 2) high winds
- ❑ d. Corrosion/erosion
  - 1) chemical – improper material of construction
  - 2) stress cracking
  - 3) internal wall
  - 4) external wall (e.g., under insulation)
  - 5) lining failure
  - 6) erosion
  - 7) high temperature corrosion
- ❑ e. Overpressure from
  - 1) common vent header

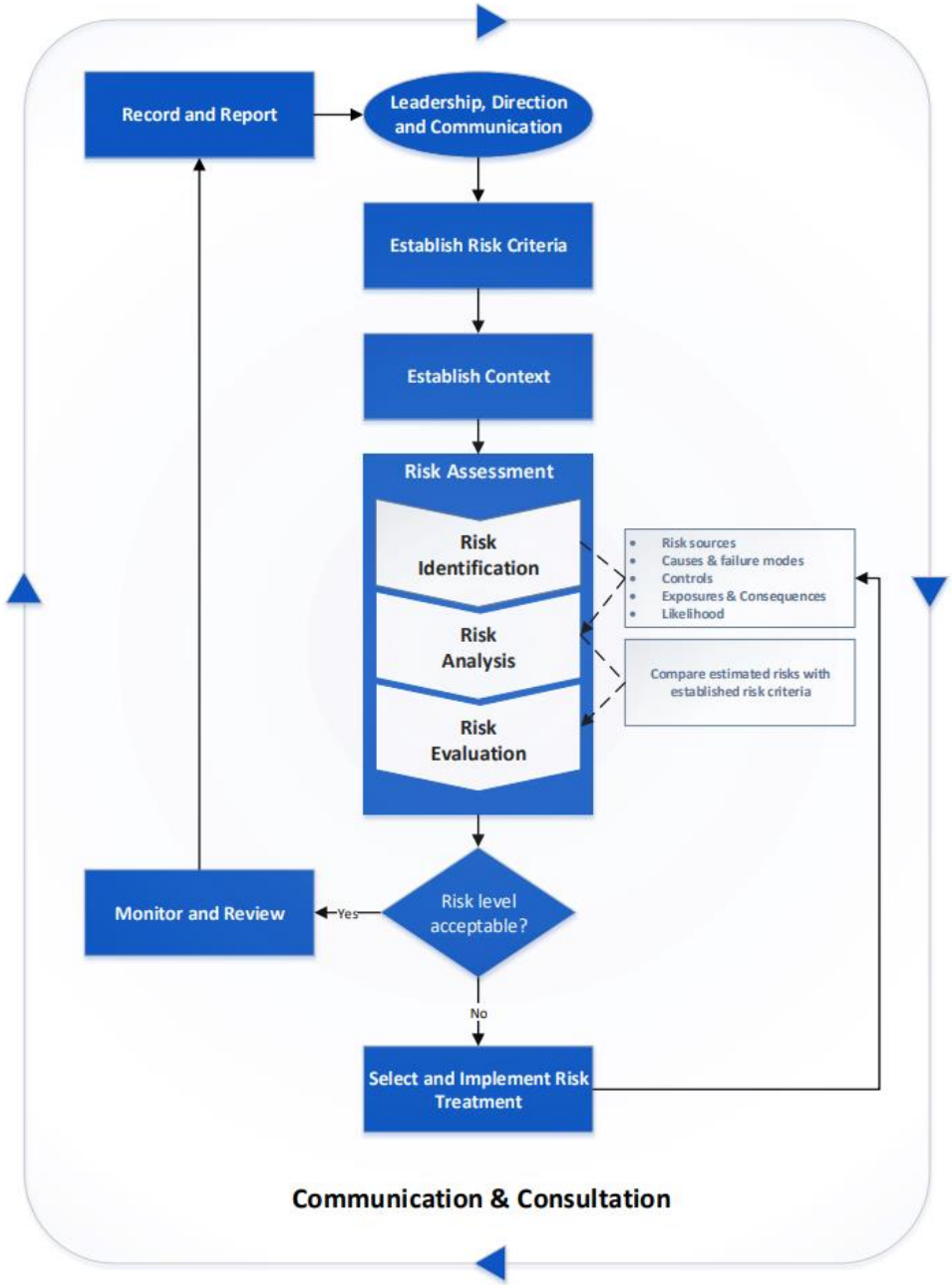
3. Other Releases
- ❑ a. Sight glass b. Expansion joints
  - c. Swivel joints d. Hoses
  - e. Flare outage
  - f. Scrubber breakthrough
  - g. Incinerator failure
- ❑ h. Heat exchanger failure
  - 1) tube rupture – release through heating or cooling system
  - 2) tube rupture followed by jacket hydraulic failure
- ❑ i. Compressed gas cylinder failures
  - 1) valve broken off
  - 2) propelled if unsecured
  - 3) fusible plug melted/dislodged
  - 4) inappropriate heating
  - 5) wrong regulator/tubing used
- ❑ j. Pump failures
  - 1) packing blowout
  - 2) single mechanical seal rupture
  - 3) rupture of both double/tandem mechanical seals
  - 4) deadheaded
  - 5) positive displacement blocked in
- ❑ k. Compressor wreck
  - 1) liquid in suction
  - 2) lubrication failure
  - 3) sudden loss of load

Design Safety Review Process

Figure 1
Inherent Safety Analysis – Checklist Process Hazard Analysis (PHA)

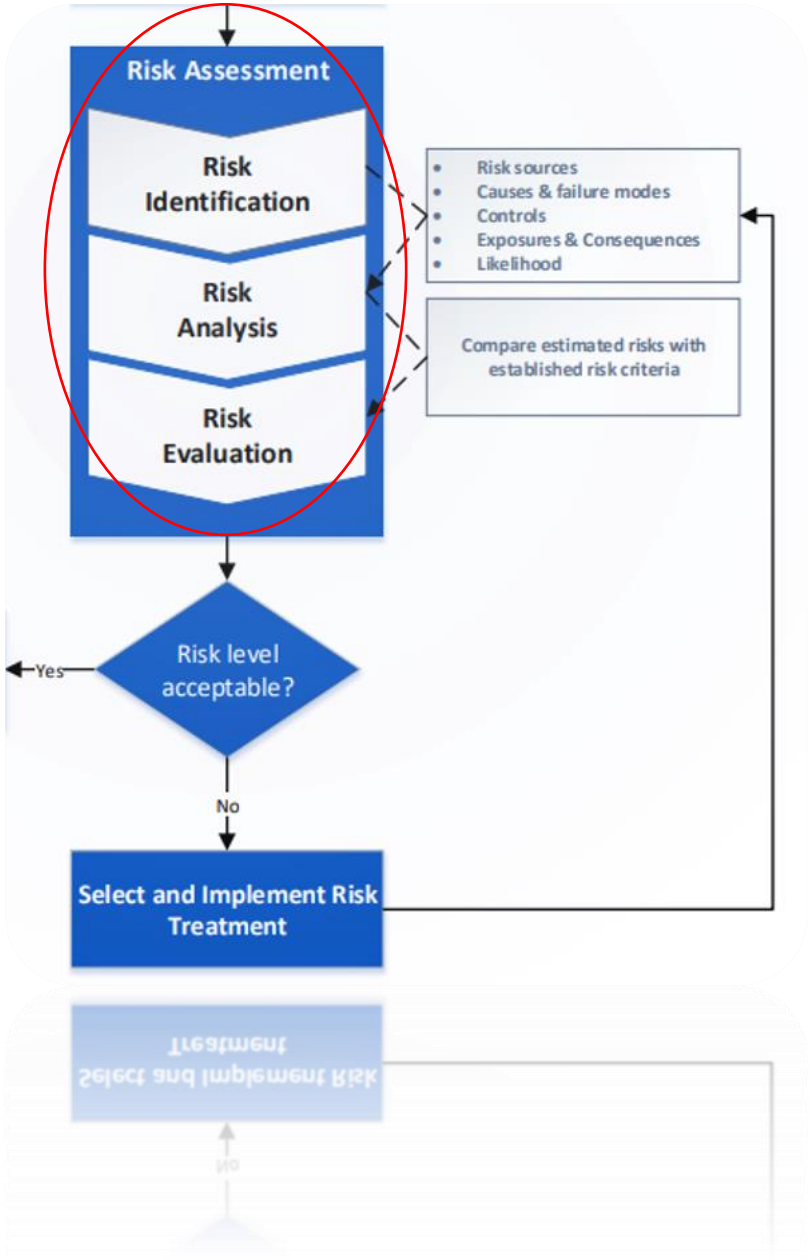
Location:						Risk Ranking			Unit:	Analysis Date:
PFD No.:										
Node::										
Design Conditions/Parameters:										
	QUESTION	POTENTIAL OPPORTUNITIES	FEASIBILITY	CONSEQUENCES	EXISTING SAFEGUARDS	S	L	R	RECOMMENDATIONS	COMMENTS/STATUS
1	Reduce hazardous raw materials inventory									
2	Reducing in-process storage and inventory									
3	Reducing finished product inventory									
4	Reduce hazardous material by using alternate equipment									
5	Minimize length of hazardous material piping runs									
6	Smallest diameter piping									
7	Eliminate hazardous raw materials, process intermediates, or by-products by using an alternative process or chemistry									

PtD Risk Management Process



ANSI/ASSP Z590.3-2021 Figure A-3

Risk Assessment



PtD Risk Assessment Process – 1st Step

Anticipate/Identify Risk

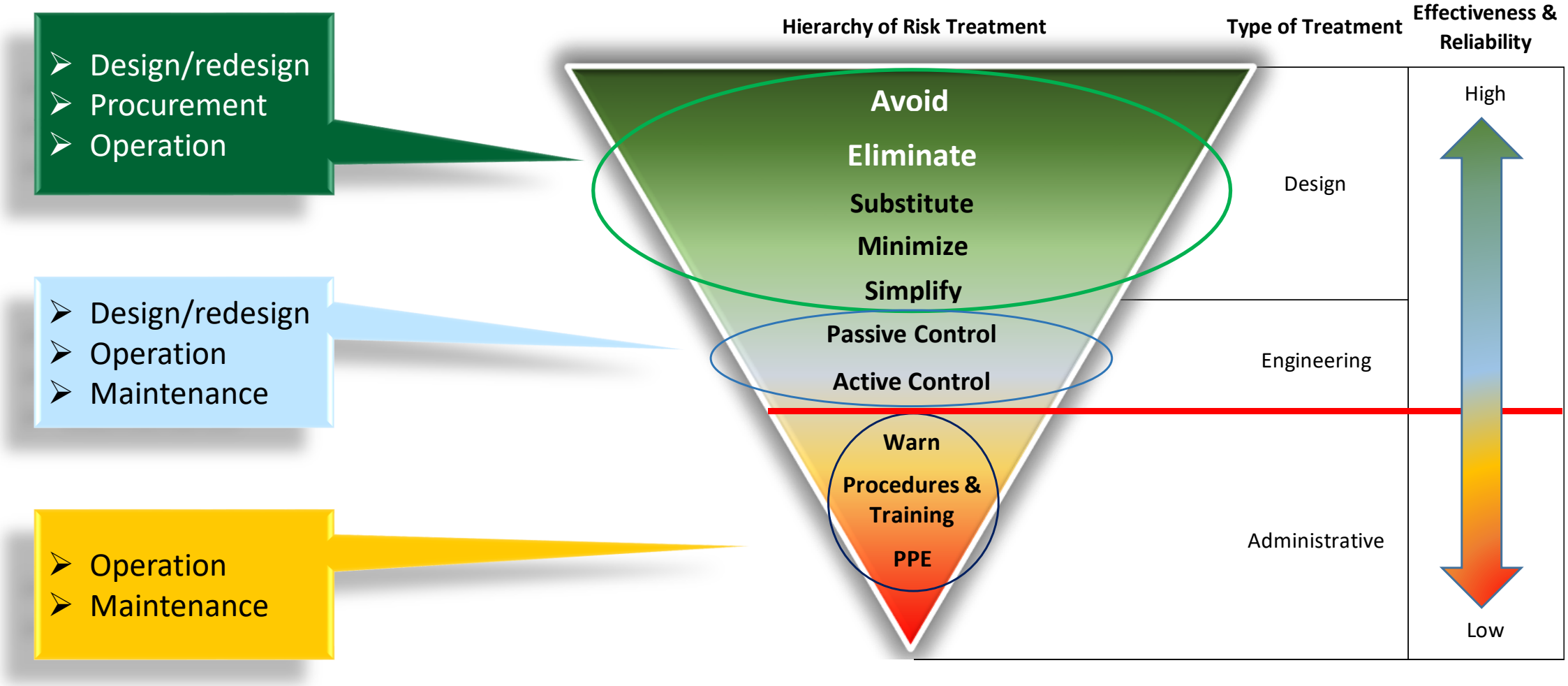
- Application
- **Additive/Synergistic Effects**
- **Hidden Hazards**
- **Hazards Encountered during Non-routine Activities and Maintenance**
- **Causes and Failure Modes**
- Existing Controls
- Exposures and Consequences

Hazards when combined result in a higher risk level. *(i.e., noise & toluene, cold & vibration, heat stress & lifting, etc.)*

Hazards not always present, obvious or visible. *(i.e., IH exposures, ergo risk factors, psychosocial factors, etc.)*

Hazards encountered during upsets, non-routine activities or deviations from normal operations. *(i.e., clearing jams, adjustments, change outs, repairs, etc.)*

Failures that could result in hazardous situations. *(i.e., failures in equipment, controls, sensing, or misuse, etc.)*



Hierarchy of Risk Treatment

Lyon, Popov, 2019

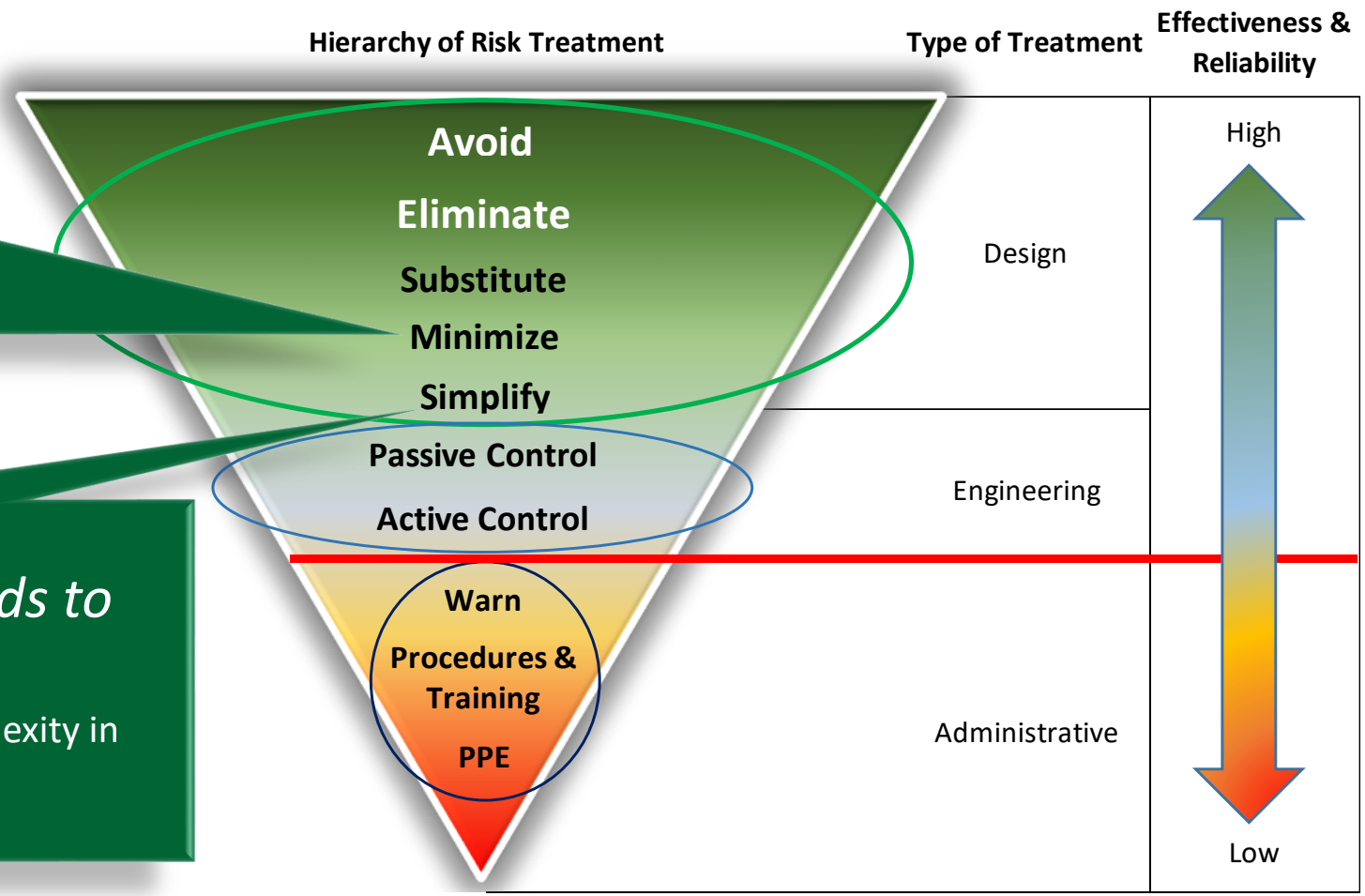
ANSI/ASSP Z590.3-2021
Figure 3

Minimize *quantity of hazard to lower severity*

- Reduce size, weight, or amount of hazardous material, energy, temperatures, pressures, etc.

Simplify *systems and methods to reduce likelihood*

- Simplify controls & displays; reduce complexity in systems; combine and reduce steps



Hierarchy of Risk Treatment

Lyon, Popov, 2019

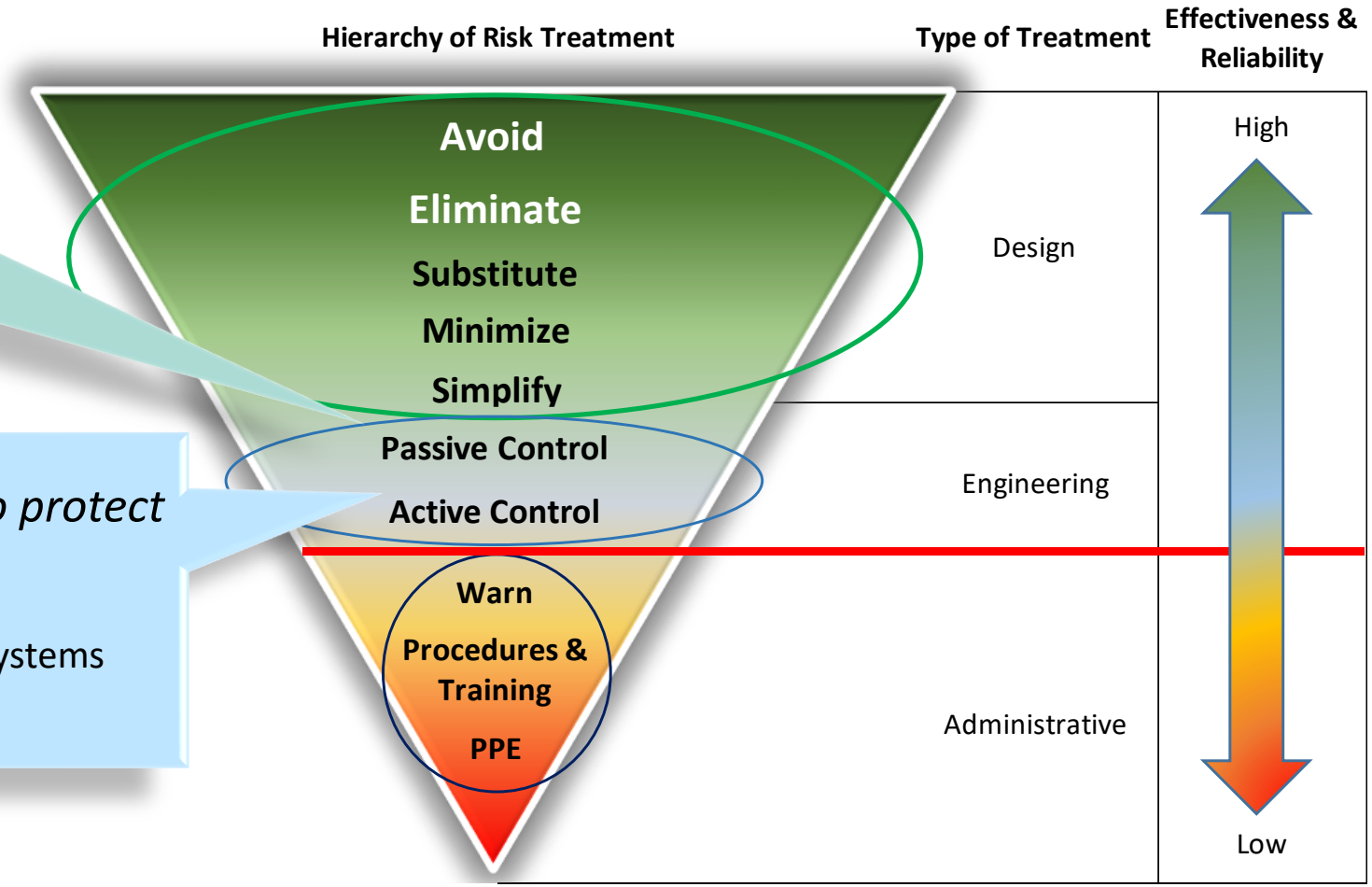
ANSI/ASSP Z590.3-2021
Figure 3

Passive Controls *protect without activation*

- containment dike
- permanent guards
- physical barriers

Active Controls *require activation to protect*

- presence sensing devices
- interlocks
- process controls & safety instrumented systems
- fire suppression systems



Hierarchy of Risk Treatment

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ANSI/ASSP Z590.3-2021
Figure 3

Safety, Health,
Environment, Quality,
Sustainability, Lower Cost, Improved Reputation

Risk Assessment and Prioritization

Prevention through Design

Risk Treatment and Reduction

Risk Management throughout Life Cycle

Design Safety Specifications and Review

Design Safety Review - Case Study

Exhaust pipe manufacturer

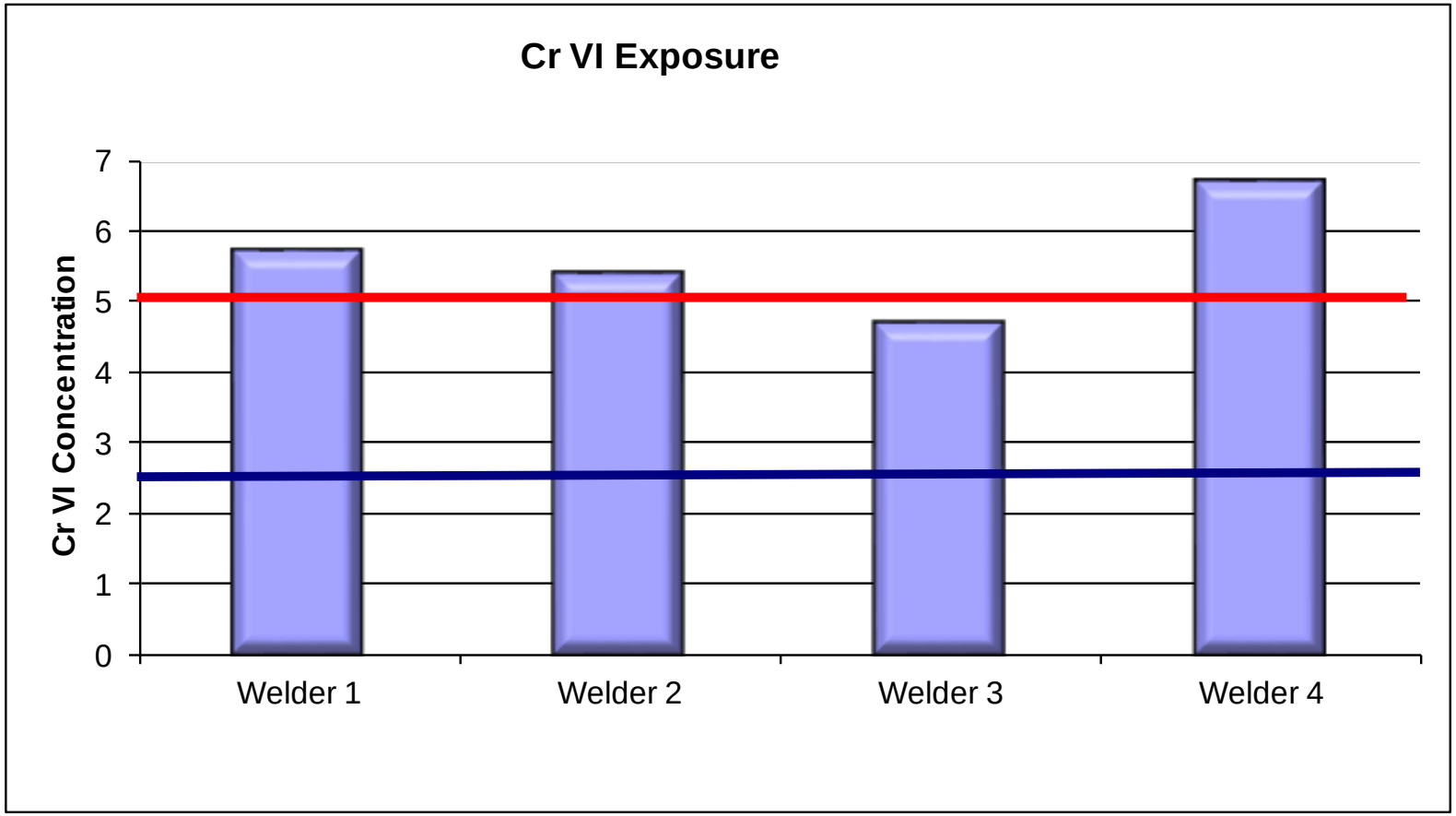
- Adding welding stations
- Current OSH concerns
- No previous Design Safety Reviews

OSH Concerns

- Welding stations design
- Losses and exposure

Welding stations – OSH issues?

Cr VI Exposure Concerns



8 Hour OSHA PEL TWA

8 Hour OSHA Action Level

Before Design Safety Review

Engineers suggested:

- Adjustable workstations
- Local Exhaust Ventilation
- Welders rotation & PPE

- Is this enough?

Design Safety Review proposed

1. OSH convinced Management a Design Safety Review needed
   - Previous losses, exposures, and concerns
   - Affect on productivity, quality and financials
   - Benefits of designing in safety
2. OSH participated in the design process – design team
3. PtD Standard used as a guide
4. Establish safety minimums for design
5. Performed review as a team

Safety Minimums for New Design

Design Safety Performance Specifications
No portable ladders (step and extension types) – P2 devices
No respirator/air supplied welding helmet required tasks
No freely distributed welding emissions in open areas
No manual handling or lifting of products >15 lbs. in production cycle
No exposure to noise levels above 80 dBA for an 8 hour TWA
No chemicals/materials to be used as noted on organizations material of concern list.
No elevated work without protective guard railings
No sharp edges
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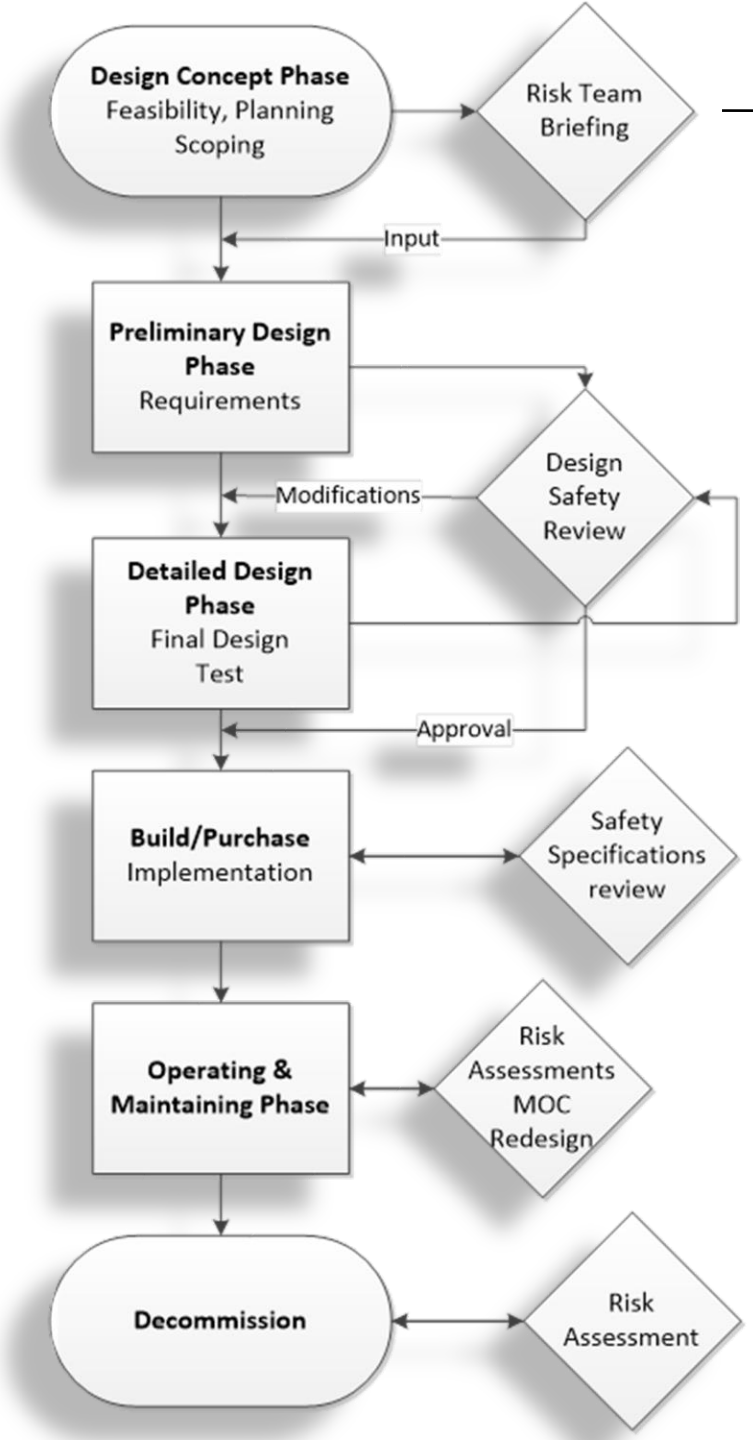
Design Safety Reviews



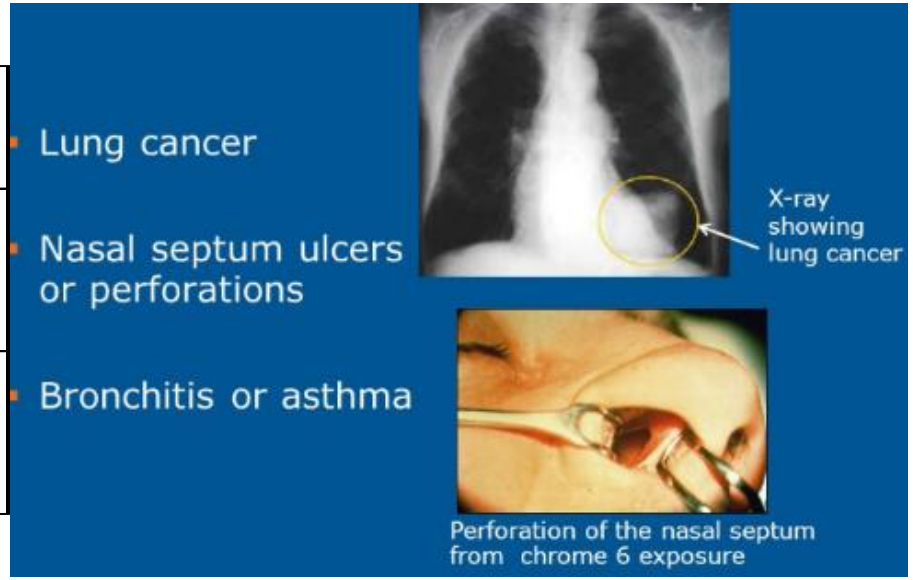
Safety Specifications
Checklists

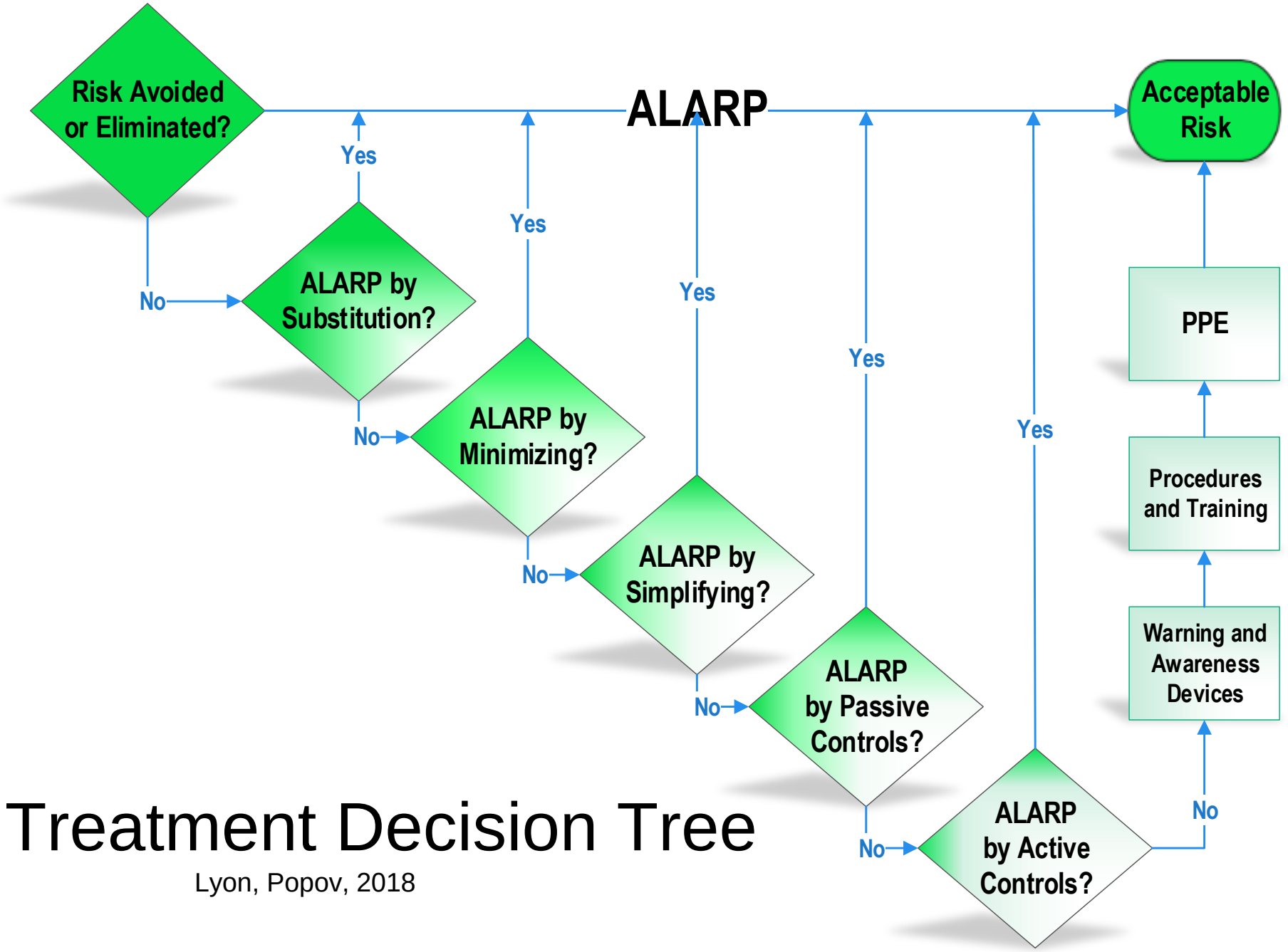
HAZID/Risk ID
What-if Analysis
Preliminary Hazard Analysis

Procurement Specs
FMEA

What if Analysis

What If?	Answer	Human Error & Systems Issues	L	C	Risk Level	Risk Level Acceptable (Y/N)	Additional Controls	L 2	C 2	Risk Level 2	% RR
Welders are overexposed to CrVI?	Lung cancer; nasal septum perforations	Task complexity or **design**	4	4	16	**No**	Re-design the welding process completely. Robotic welding.	2	3	6	63%
50% of the welders develop lower back disorders?	Reduced production rate	Task complexity or **design**	4	3	12	**No**	Re-design the welding process completely. Robotic welding.	1	4	4	67%

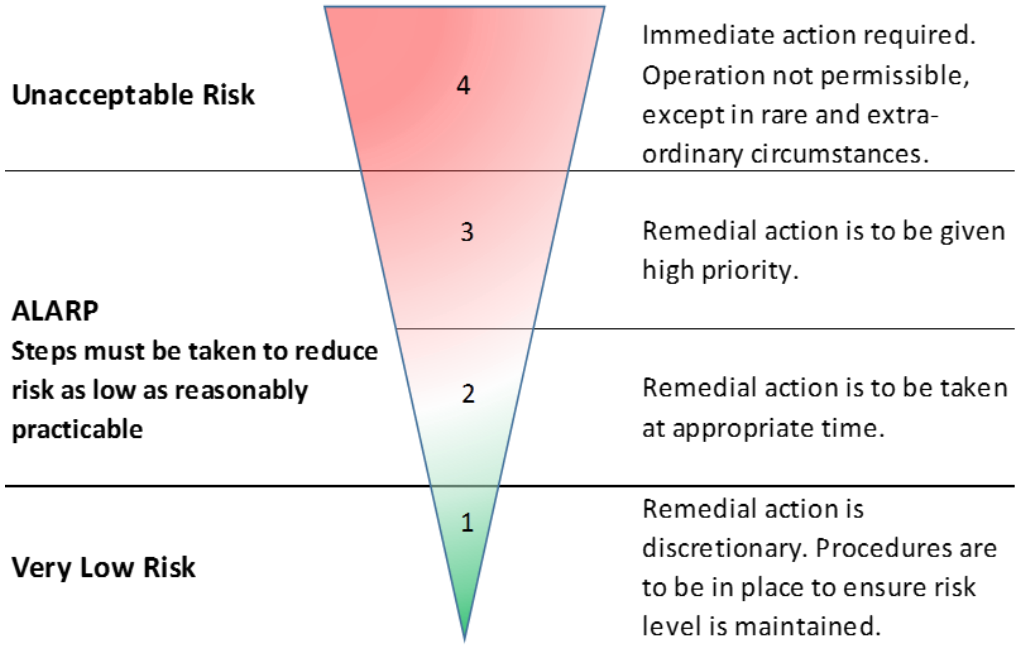




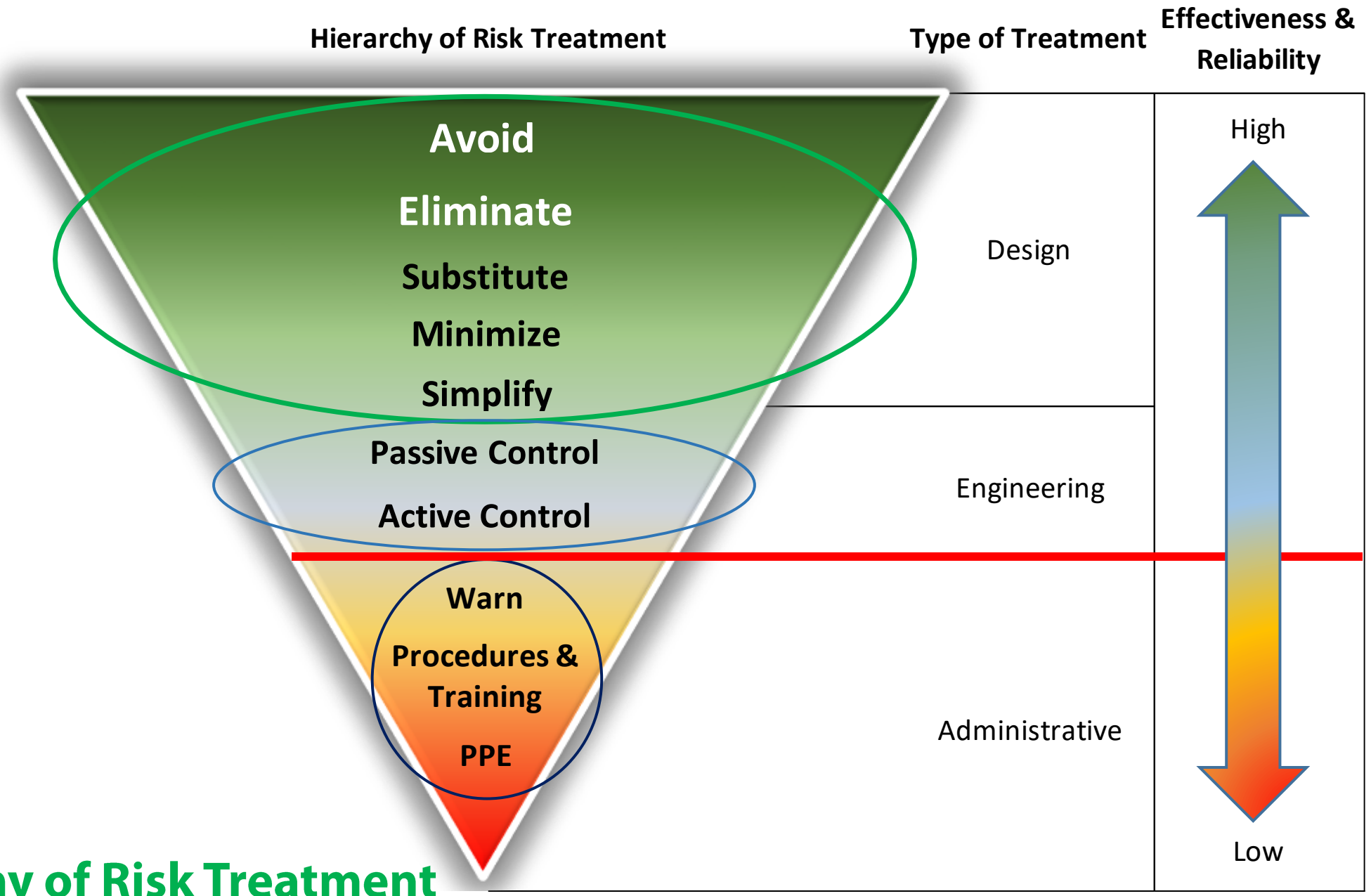
Risk Treatment Decision Tree

Lyon, Popov, 2018

How is Risk to be treated?



Risk Action Levels	
Risk Level	**Action**
Unacceptable	Immediate action required. Operation not permissible, except in rare and extra-ordinary circumstances.
High	Remedial action is to be given high priority.
Moderate	Remedial action is to be taken at appropriate time.
Low	Remedial action is discretionary. Procedures are to be in place to ensure risk level is maintained.



Hierarchy of Risk Treatment

Lyon, Popov, 2019

ANSI/ASSP Z590.3-2021 Figure 3

PtD Solution

No statements

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No respirator/air supplied welding helmet required tasks
No freely distributed welding emissions in open areas
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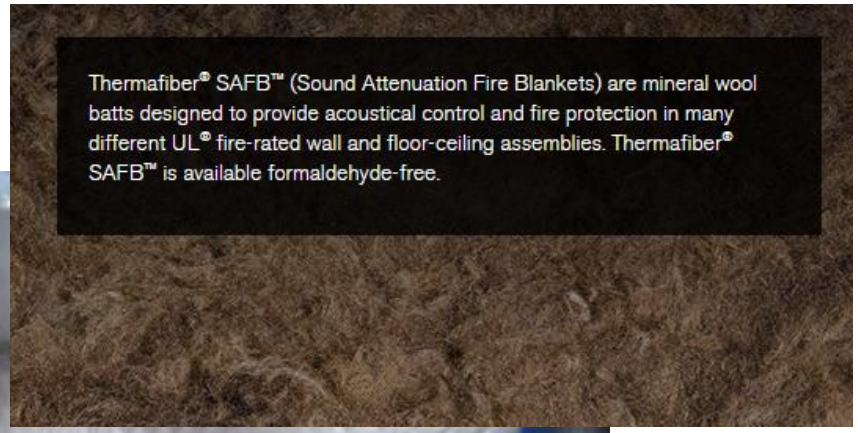
No exposure to noise levels above 80 dBA for an 8 hour TWA

Additional controls



https://www.owenscorning.com/insulation/products/thermafiber-safb-sound-attenuation-fire-blanket

PtD Solution

Financial Assessment					
	Year				
	0	1	2	3	4
Cash Flows					
Intervention Investment	-280,575.00	-15,800.00	-16,274.00	-16,762.22	-17,265.09
Risk Management Operations (Process):					
Safety and Health Function		0.00	0.00	0.00	0.00
Business Operations (Process):					
Operational Unit of Solution		0.00	0.00	0.00	0.00
Other Operational Units of Interest		0.00	0.00	0.00	0.00
Incident Impacts:					
Occupational Injury or Illness		86,104.00	88,687.12	91,347.73	94,088.17
Other Incident impacts		42,048.62	43,310.08	44,609.38	45,947.66
Revenue or Profit					
New Profit		12,155.00	12,519.65	12,895.24	13,282.10
Total	-280,575.00	124,507.62	128,242.85	132,090.13	136,052.84

Cash Flow Summary					
	0	**1**	**2**	**3**	**4**
Net Cash Flow	-280,575.00	124,507.62	128,242.85	132,090.13	136,052.84
Cumulative Cash Flow	-280,575.00	-156,067.38	-27,824.53	104,265.60	240,318.44
Discounted Cash Flow	-280,575.00	118,578.69	116,320.04	114,104.42	111,931.01
Discount Rate=	0.05				

Financial Metrics					
NPV=	$180,359.16				
Simple ROI =	85.65%	Discounted ROI=	64.28%		
IRR=	29.76%				
Payback (Years)=			**2.211**		

Summary

Take a proactive approach to managing safety and risk

Integrate PtD and risk management into the safety management system

Establish a design safety review and risk assessment process

Thank You

Questions or comments?


BEER
FLOWCHART
DO YOU WANT SOME BEER?
YES!
NO
SURE YOU DO!
COME ON DOWN AND TRY OUR SELECTION!
BROADWAY BREWERY