Operational Discipline for High Performance Process Safety

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7TH GLOBAL SUMMIT ON PROCESS SAFETY
Hosted by CCPS and JSSE

AcuTech
PROCESS RISK MANAGEMENT

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- Founder of AcuTech Group, a process risk management consulting firm established in 1994.
  www.acutech-consulting.com
- Over 40 years of experience in process safety management
- MBA (NYU Stern) &
  B.Sc., Fire Protection Engineering (Univ. of Maryland)
- CCPS Fellow
- Chair, Managing Board, AIChE Center for Hydrogen Safety

Process Safety Management (PSM) Performance

- Process Safety Management (PSM) is a "blend of engineering ***and management skills*** focused on preventing catastrophic accidents, particularly explosions, fire and toxic releases associated with the use of chemicals and petroleum products" (AIChE, CCPS, 2010)
  - The entire organization must be aligned and motivated to continually improve PSM performance to excellence
  - More than a collection of technical activities are required for success
  - Performance must be disciplined to succeed

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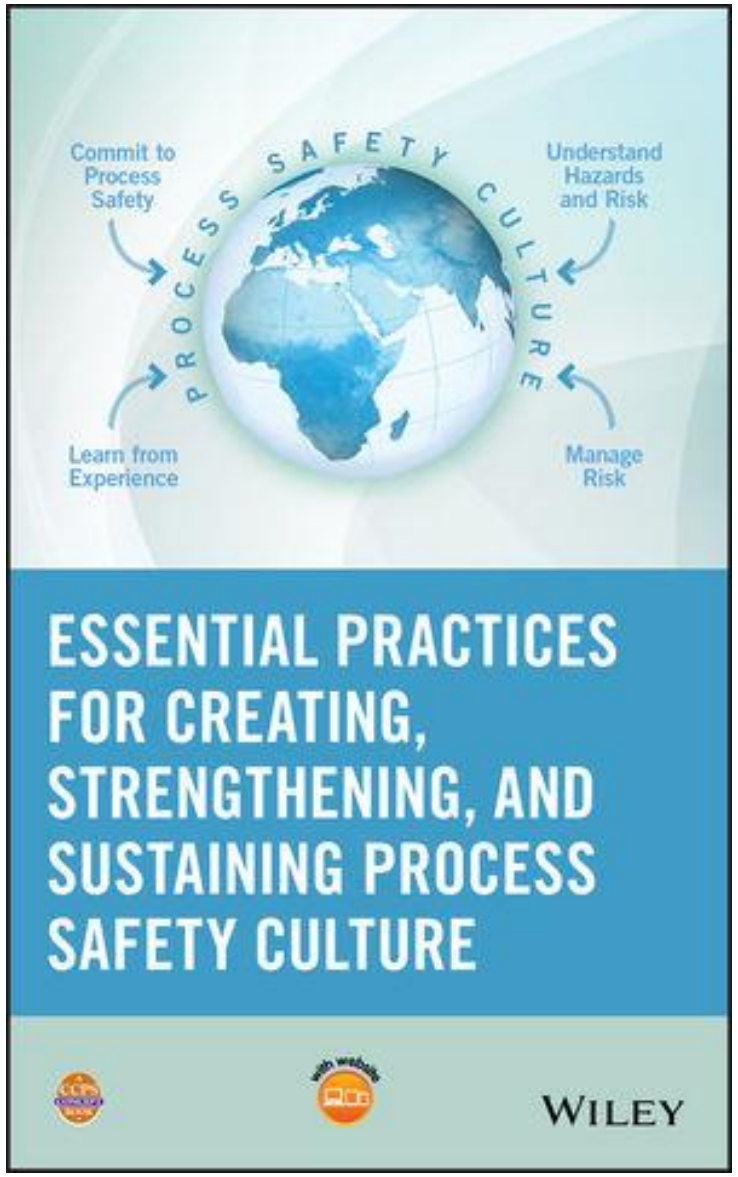
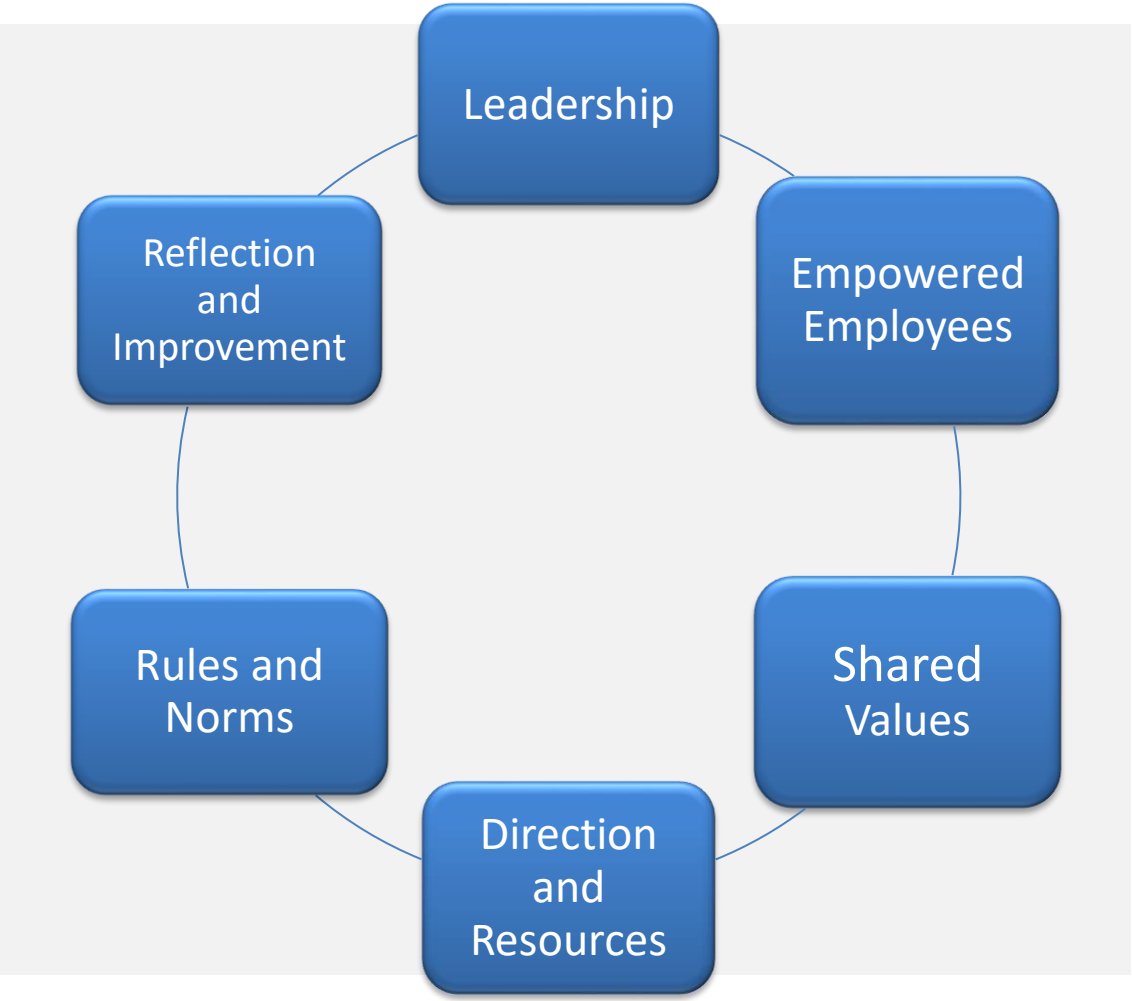


CCPS Guidelines Definition of PSM Culture (2017)

"The pattern of shared written and unwritten attitudes and behavioral norms that positively influence how a facility or company collectively supports the development of and successful execution of the management systems that comprise its process safety management program, resulting in the prevention of process safety incidents."

Building Blocks to Great Culture



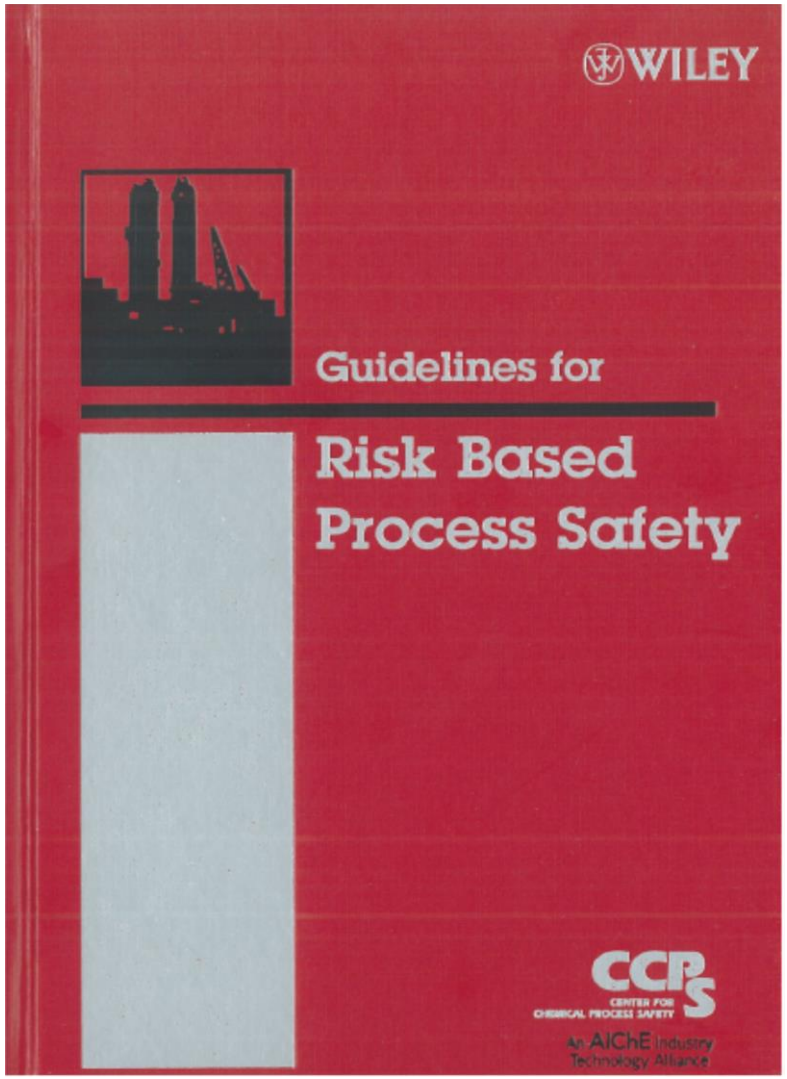
Key Building Blocks of Corporate Culture

Reflection and Improvement

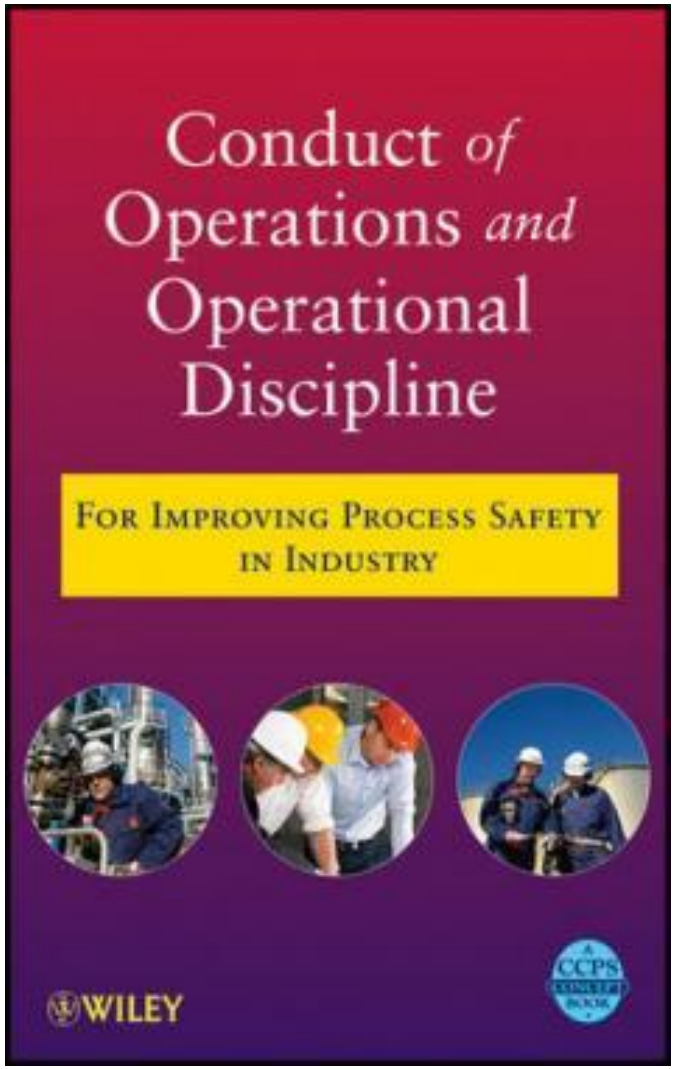
"Sense of vulnerability and goal of excellence"

- Adherence to rules and norms for process safety
- Sense of vulnerability leads to healthy attitude on risk
- Continual improvement mindset
- Honest appraisal and acceptance of change
- Positive outlook rather than criticism
- Goal oriented to "excellence"

AIChE CCPS Risk Based Process Safety Management



Conduct of Operations and Operational Discipline Guidance by CCPS (2007, 2011)



Conduct of Operations – Principles[1]

- Conduct of Operations (COO) is the embodiment of an organization's values and principles in management systems that are developed, implemented, and maintained to:
  - 1) structure operational tasks in a manner consistent with the organization’s risk tolerance
  - 2) ensure that every task is performed deliberately and correctly
  - 3) minimize variations in performance

1 “Conduct of Operations and Operational Discipline – For Improving Process Safety in Industry”, CCPS, Wiley, 2011

Conduct of Operations – Principles[1]

- COO is the management system aspect of Operational Discipline (OD)
- COO sets up organizational methods and systems that will be used *to influence individual behavior and improve process safety*
- COO involves specifying how tasks (operational, maintenance, management, engineering)
- A good COO program helps visibly demonstrate the organization's commitment to process safety.

1 "Conduct of Operations and Operational Discipline – For Improving Process Safety in Industry", CCPS, Wiley, 2011

Operational Discipline (OD) - Principles

- Operational Discipline is the execution of the COO system by individuals in the organization.
- “Good” Operational Discipline relies on consistent and correct task execution
- Operational discipline includes day-to-day activities carried out by all personnel, not just by Operations.
  - Ensure that all tasks is performed *deliberately and correctly and minimize variations* in performance.
  - The culture is that individuals self-manage but seek wider involvement and expertise to ensure personal and process safety

Conduct of Operations and Operational Discipline Contribution to Major CSB Incidents

Conduct of Operations and Operational Discipline – Primary Findings
A2, A5, A10 C3, C11, C12, C18, C26, C43, C50, C57, C58 D9 J2, J19, J28, J38, J49, J50, J51, J52, J53, J54, J55, J56, J57, J58, J61, J63, J67, J70, J72, J73, J114, J127, J130, J147, J151, J165, J171, J174, J178, J180, J182, J183, J188, J190, J192, J208, J209, J211, J217, J243, J247, J248, J259, J262, J270, J271 S3, S4, S5, S13, S14
Conduct of Operations and Operational Discipline – Secondary Findings
A6, A7 C13, C15, C20, C24, C27, C28, C60, C76 D7, D19 J21, J22, J24, J25, J32, J35, J40, J64, J65, J75, J76, J91, J108, J109, J116, J119, J128, J129, J131, J133, J162, J163, J170, J176, J181, J184, J185, J186, J212, J237, J253, J261 S1, S10, S12, S15

	Investigation
C1.	Arkema Inc. Chemical Plant Fire
C2.	Acetylene Service Company Gas Explosion
C3.	AirGas Facility Fatal Explosion
C4.	AL Solutions Fatal Dust Explosion
C5.	Allied Terminals Fertilizer Tank Collapse
C6.	Barton Solvents Explosions and Fire
C7.	Bayer CropScience Pesticide Waste Tank Explosion
C8.	Bethlehem Steel Corporation Gas Condensate Fire
C9.	Bethune Point Wastewater Plant Explosion
C10.	BLSR Operating Ltd. Vapor Cloud Fire
C11.	BP America Refinery Explosion
C12.	BP Amoco Thermal Decomposition Incident
C13.	CAI / Arnel Chemical Plant Explosion
C14.	Carbide Industries Fire and Explosion
C15.	Caribbean Petroleum Refining Tank Explosion and Fire
C16.	Chevron Refinery Fire
C17.	CITGO Refinery Hydrofluoric Acid Release and Fire
C18.	Combustible Dust Hazard Investigation
C19.	ConAgra Natural Gas Explosion and Ammonia Release
C20.	CTA Acoustics Dust Explosion and Fire
C21.	D.D. Williamson & Co. Catastrophic Vessel Failure
C22.	Donaldson Enterprises, Inc. Fatal Fireworks Disassembly Explosion and Fire
C23.	DPC Enterprises Festus Chlorine Release
C24.	DPC Enterprises Glendale Chlorine Release
C25.	DuPont Corporation Toxic Chemical Releases
C26.	DuPont La Porte Facility Toxic Chemical Release
C27.	E. I. DuPont De Nemours Co. Fatal Hotwork Explosion
C28.	Emergency Shutdown Systems for Chlorine Transfer
C29.	Enterprise Pascagoula Gas Plant Explosion and Fire
C30.	EQ Hazardous Waste Plant Explosions and Fire
C31.	ExxonMobil Refinery Explosion
C32.	First Chemical Corp. Reactive Chemical Explosion
C33.	Formosa Plastics Propylene Explosion
C34.	Formosa Plastics Vinyl Chloride Explosion
C35.	Freedom Industries Chemical Release
C36.	Georgia-Pacific Corp. Hydrogen Sulfide Poisoning
C37.	Hayes Lemmerz Dust Explosions and Fire
C38.	Herrig Brothers Farm Propane Tank Explosion
C39.	Hoeganaes Corporation Fatal Flash Fires
C40.	Honeywell Chemical Incidents
C41.	Imperial Sugar Company Dust Explosion and Fire
C42.	Improving Reactive Hazard Management
C43.	Kaltech Industries Waste Mixing Explosion
C44.	Kleen Energy Natural Gas Explosion
C45.	Little General Store Propane Explosion
C46.	Macondo Blowout and Explosion
C47.	Marcus Oil and Chemical Tank Explosion
C48.	MFG Chemical Inc. Toxic Gas Release
C49.	MGPI Processing, Inc. Toxic Chemical Release
C50.	Morton International Inc. Runaway Chemical Reaction
C51.	Motiva Enterprises Sulfuric Acid Tank Explosion
C52.	NDK Crystal Inc. Explosion with Offsite Fatality
C53.	Oil Site Safety
C54.	Packaging Corporation of America Hot Work Explosion
C55.	Partridge Raleigh Oilfield Explosion and Fire
C56.	Praxair Flammable Gas Cylinder Fire
C57.	Pryor Trust Fatal Gas Well Blowout and Fire
C58.	Sierra Chemical Co. High Explosives Accident
C59.	Sonat Exploration Co. Catastrophic Vessel Overpressurization

See www.csb.gov for incident investigation reports

1 “Driving Continuous Process Safety Improvement from Investigated Incidents”, CCPS, Wiley, 2021

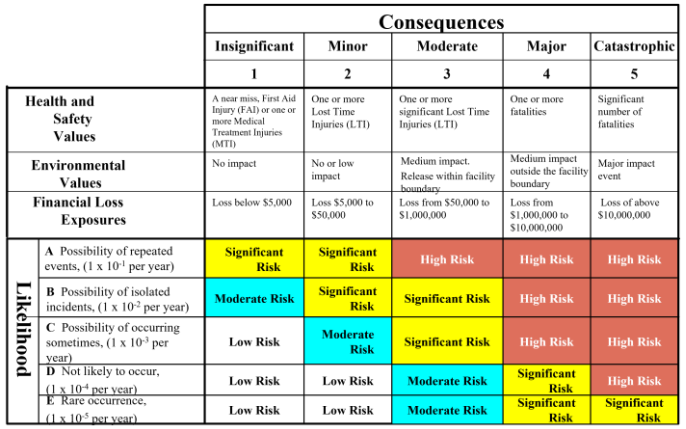
PSM Standards & Key Performance Indicators

- Documenting Process Safety Management Metrics provides the details of how PSM program is performing.
- AcuTech uses 14 PSM KPIs for measuring COO/OD. Examples:
  - Safe upper and lower design limits exceeded
  - Overdue ITPM Tasks and their aging
  - Protective system, device or function bypasses
  - Safety critical equipment failed
  - Open MOC packages and percent MOC PHA completion
  - Overdue PHAs action items per schedule

Overdue Hazard Analysis Action Items Example

Normalized Situation

- PHA action items were casually made during PHAs with a poor risk decision-making process
- Leadership did not ensure action items were carefully made or addressed in a timely manner and assigned to supervisors
- Supervisors' performance was not measured on risk reduction but focused on profitable operational performance
- Action items mounted over the years and were not supported financially nor with adequate personnel resources
- Risk was built up as hundreds of action items were not resolved



		Consequences				
		Insignificant	Minor	Moderate	Major	Catastrophic
		1	2	3	4	5
Health and Safety Values		A near miss, First Aid Injury (FAI) or one or more Medical Treatment Injuries (MTI)	One or more Lost Time Injuries (LTI)	One or more significant Lost Time Injuries (LTI)	One or more fatalities	Significant number of fatalities
Environmental Values		No impact	No or low impact	Medium impact. Release within facility boundary.	Medium impact outside the facility boundary	Major impact event
Financial Loss Exposures		Loss below $5,000	Loss $5,000 to $50,000	Loss from $50,000 to $1,000,000	Loss from $1,000,000 to $10,000,000	Loss of above $10,000,000
Likelihood	A Possibility of repeated events, (1×10^{-1} per year)	Significant Risk	Significant Risk	High Risk	High Risk	High Risk
	B Possibility of isolated incidents, (1×10^{-2} per year)	Moderate Risk	Significant Risk	Significant Risk	High Risk	High Risk
	C Possibility of occurring sometimes, (1×10^{-3} per year)	Low Risk	Moderate Risk	Significant Risk	High Risk	High Risk
	D Not likely to occur, (1×10^{-4} per year)	Low Risk	Low Risk	Moderate Risk	Significant Risk	High Risk
	E Rare occurrence, (1×10^{-5} per year)	Low Risk	Low Risk	Moderate Risk	Significant Risk	Significant Risk

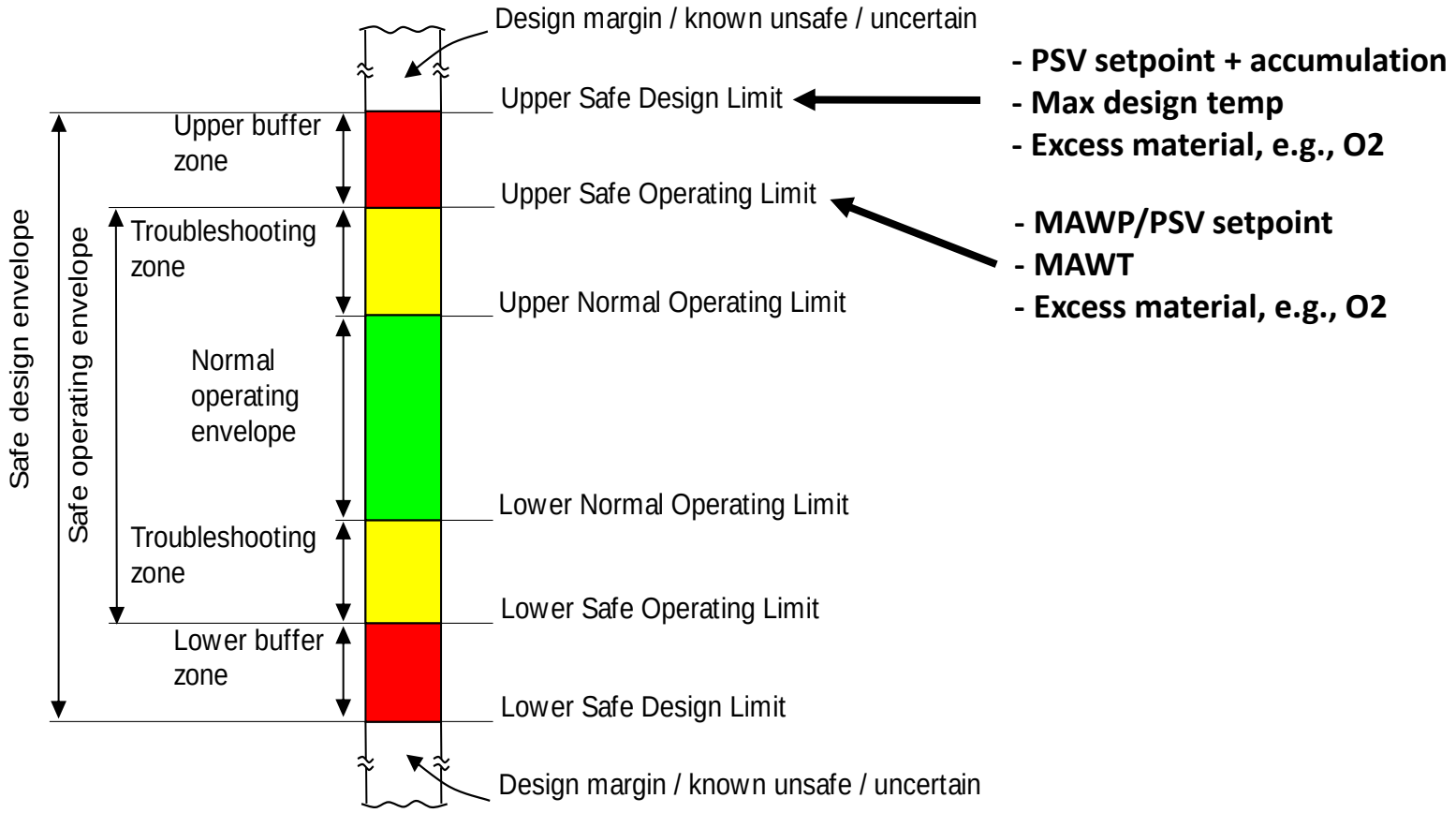
Solutions

- Improve the workflow and risk tolerance process for the risk decision-making tools
- Educate PHA teams on their proper use
- Give supervisors the duty to execute on action items with from mandatory to recommended approaches and reward good decision-making and performance
- Monitor action item resolution and put KPIs on delinquent items
- Establish a rule that action items cannot be deferred continuously
- Budget for these activities and provide adequate resources to address them in a risk-based and timely manner

Field Survey

- Unlocked safety isolation valves in the field
- Shown in operating procedures, training, and process hazards analysis as required to be locked closed

Adherence to Safe Operating Envelope



Adherence to Safe Operating Envelope

- Adhering to the Safe Design Envelope and Safe Design Envelope ensures that:
  - design conditions for the equipment are not exceeded
  - processes stay within the operating limits necessary to ensure product quality and process efficiency
- If these limits are not followed a serious incident is nearly inevitable.

Normalization of Deviation

- **Normalization of deviations is the most common process safety cultural deficiency.** Many major incidents have included this attribute as a contributor.
- The normalization of deviance means that out-of-specification conditions, i.e., deviations, are allowed to remain in place without any action being taken to correct them.
- If, over time these uncorrected conditions result in no negative consequences, they can then become “normalized” or part of the normal status of facility equipment or operations.

Normalization of Deviation

Examples:

1. Operating outside the defined safe operating envelope (SOE).
2. Safety systems/features that remain bypassed beyond the time limits specified or are continually extended.
3. Chronic nuisance alarms.
4. Operators do not believe their indications because the instrumentation is chronically not calibrated or inaccurate.
5. Chronically overdue ITPM tasks.
6. Growing lists of equipment deficiencies and the increasing aging of these deficiencies.

Maintaining the Capability of Safety Systems

- **An extremely important attribute of Operational Discipline is the maintenance of the capability of safety systems.**
- Safety systems consist of protective features such as:
  - Alarms
  - indications
  - Trips
  - Interlocks
  - pressure relief devices and systems
  - critical utilities (i.e., utilities whose failure could cause or contribute to a process safety incident, e.g., cooling water systems in a refinery)
  - fire protection equipment
  - other equipment that are critical to process safety.

Safety Critical Equipment

HAZOP Study Worksheet

Causes

Safeguards

Node: 1. VHT Feed and Preheat

Drawings / References: A-950-B-1004; A-950-B-1003

Deviations	Causes	Consequences	CAT	Unmitigated Risk			Safeguards				S	Mitigated Risk		HAZOP Recommendations		Residual Risk			Remarks
				S	L	RR	Tag	Description	Tag - COPY	Description - COPY		L	RR	HAZOP Recommendations	Responsibility	S	L	RR	
1. Low/ No Flow	1. 3" Manual valve closed from FGRU Initiating Event1.2.1.1 Initiating Event1.3.1.1 Initiating Event1.4.1.1	1. Decreased flow of FGRU gas to VHT, decreased flow of paraffinic gas to R-901, slight increase in exotherm, not expected to cause runaway, operability issue, no hazardous consequences identified to VHT LOPA Scenario: 1.2	H&S	C3	5	15 VH C3-L5	PAHH-XXXX	on compressor discharge with action to S/D	2. PAHH-XXXX	on compressor discharge with action to S/D	C5	5	25 VH C5-L5			C 5	1	5 M C5-L1	
		2. Decreased flow increased level overpressure, personnel injury LOPA Scenario: 1.3	H&S	C4	4	16 VH C4-L4	PAHH-XXXX	on compressor discharge with action to S/D	2. PAHH-XXXX	on compressor discharge with action to S/D	C4	4	16 VH C4-L4			C 4	1	4 M C4-L1	
		3. Decreased flow of FGRU gas to VHT, potential blocked outlet of FGR compressors C-1180/ 81, increased flaring, potential overpressure of discharge piping > 3.5 x MAWP, piping rupture, release of untreated flare gas, potential fire/explosion or H2S exposure, personnel injury, environmental impact, asset damage LOPA Scenario: 1.4	H&S	C5	3	15 VH C5-L3	PSV Copmressor	set at 250 psig	1. PSV Copmressor	set at 250 psig	C5	3	15 VH C5-L3	1. See LOPA Scenario		C 3	1	3 L C3-L1	
							PAHH-XXXX	on compressor discharge with action to S/D	2. PAHH-XXXX	on compressor discharge with action to S/D				4. HAZOP Rec:.Evaluate installing a PAHH on C-1180/81 FGRU Compressor discharge to shutdown the compressors and protect against a blocked discharge scenario.					
							PIC-9080	Spillback controller	3. PIC-9080	Spillback controller									
		4. Decreased flow of FGRU gas to VHT, potential blocked outlet of FGR compressors C-1180/ 81, increased flaring, environmental impact	H&S	C2	2	4 M C2-L2	FI	Flow meter on flare	4. FI	Flow meter on flare	C2	2	4 M C2-L2			C 2	1	2 L C2-L1	
							AI	analyzer on flare	5. AI	analyzer on flare									
							CCTV	with operator monitoring and troubleshooting	6. CCTV	with operator monitoring and troubleshooting									

Maintaining the Capability of Safety Systems

Operational Discipline Summary

- Operational Discipline is adherence to safety operating practices and norms
- This is critical to have a process safety management system that is performing to full potential
- It requires teamwork and agreement that these rules and norms are critical to follow
- A formal process safety management element of conduct of operations/operational discipline is required to adequately manage the issue

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