Purdue Process Safety & Assurance Center (P2SAC)

Overview

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Purdue University

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PURDUE UNIVERSITY | Davidson School of Chemical Engineering

May 2023 Conference Registration

Sponsors

ACC – Am Chem Council
AcuTech
AMGEN
Chevron
Corteva
CountryMark
Dow
Endress+Hauser
ExxonMobil
Fauske & Associates
GSK
Honeywell
JMJ
Johnson Matthey
Kenexis
Lilly
Marsh Risk
Pfizer
PSRG
SABIC
Vertex
3M

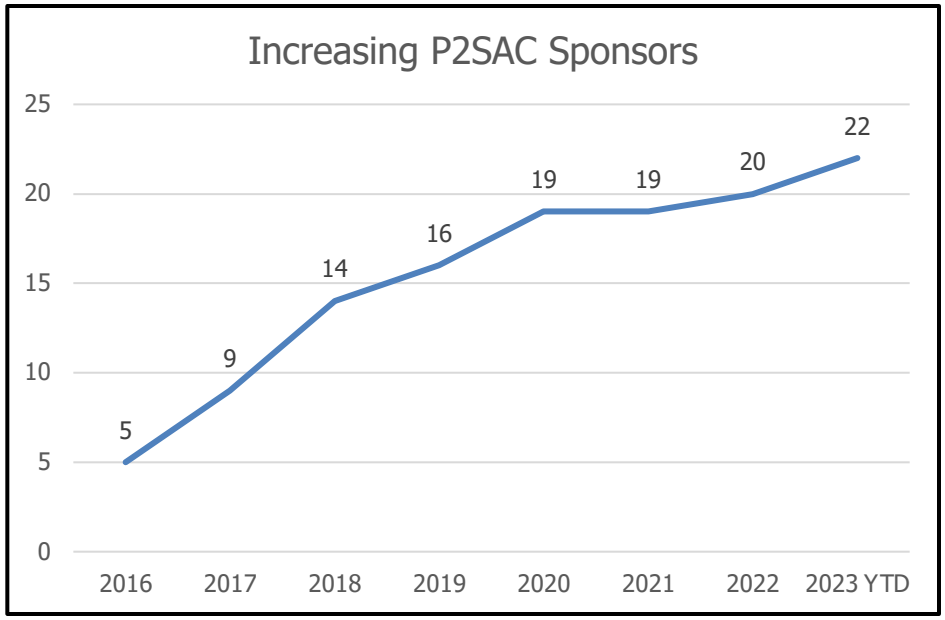
Guests

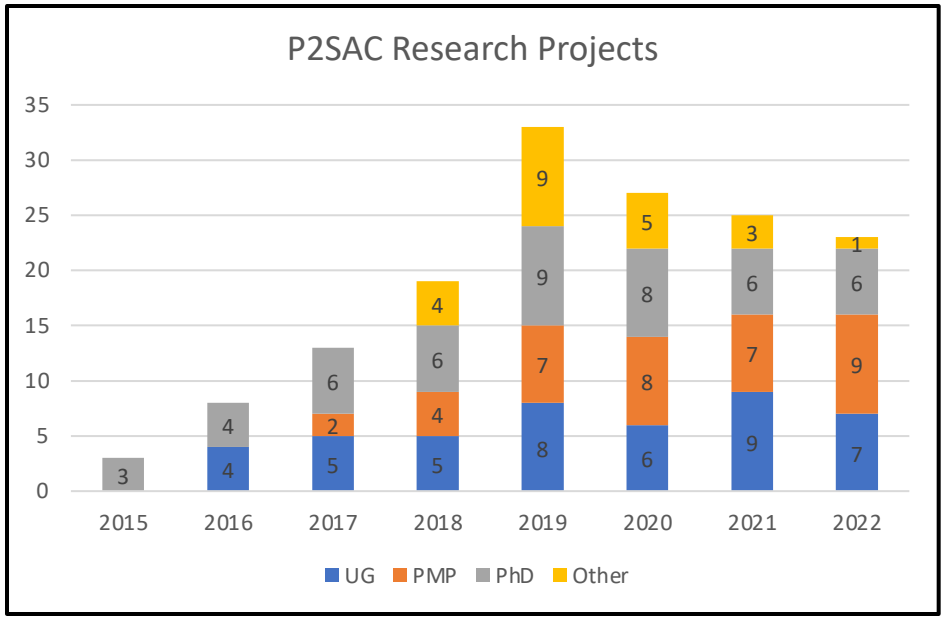
- Abbvie
- Air Products
- Alcon*
- Arg Nat'l Lab
- CCPS
- Cook BioTech
- CSB
- Cummins
- Curia Global*
- Evonik
- Gilead
- Grace
- HEL Group*
- Iowa State Univ*
- Langan Eng & Env*
- Mercer*
- Merck
- Sandia Nat'l Labs
- Tate & Lyle
- Univ of Alberta
- Univ of Camp*

On-going dialog with other Depts:
ABE, CHEM, IE, IPPH & ME

*denotes 1st meeting

Growing Industry Participation & Projects in P2SAC





P2SAC Company Participation in PMP Capstone Projects

	21 - Spring	Summer	21 - Fall	22 Spring	Summer	22 -Fall
ACC	x		x	x		x
AcuTech	x					x
Amgen		x	x	x	x	x
Chevron		x			x	
Corteva	x	x	x	x	x	x
Dow		x				
ExxonMobil			x		x	x
Fauske		x	x	x	x	
GSK		x	x	x	x	x
JMJ			x		x	x
Kenexis						x
Lilly		x	x	x	x	x
Marsh	x					
Merck		x	x	x	x	x
Phillips 66		x				
Vertex		x	x	x	x	x

Projects over prior years also included: BP, Country Mark, SABIC & 3M

Fall ‘22 & Spring ‘23 Undergraduate & PMP Research

Undergraduate

- Energetics of molecules common in pharma industry; comparison of experimental data with CHETAH & TCIT (Purdue) models. (Amgen, Corteva, GSK, JM, Lilly, Merck, Vertex)
- Assess ESG strategies of companies in various industries (oil & gas, chemicals, pharma…) including metrics & process safety (JMJ)
- Comparison of risk assessment methodologies for pipelines, trucks & rail (AcuTech, ACC & ExxonMobil)

PMP

- Compilation & analysis of process safety incidents in bioprocessing industries
- Review existing, proposed and novel methods for hydrogen production. Develop list of hazards / PHAs for most promising new electrolysis developments (AcuTech, ExxonMobil & Kenexis)
- Expand the capability of Purdue’s RHEACT software model for lab and pilot plant safety assessments, to include heat of reaction (Corteva)

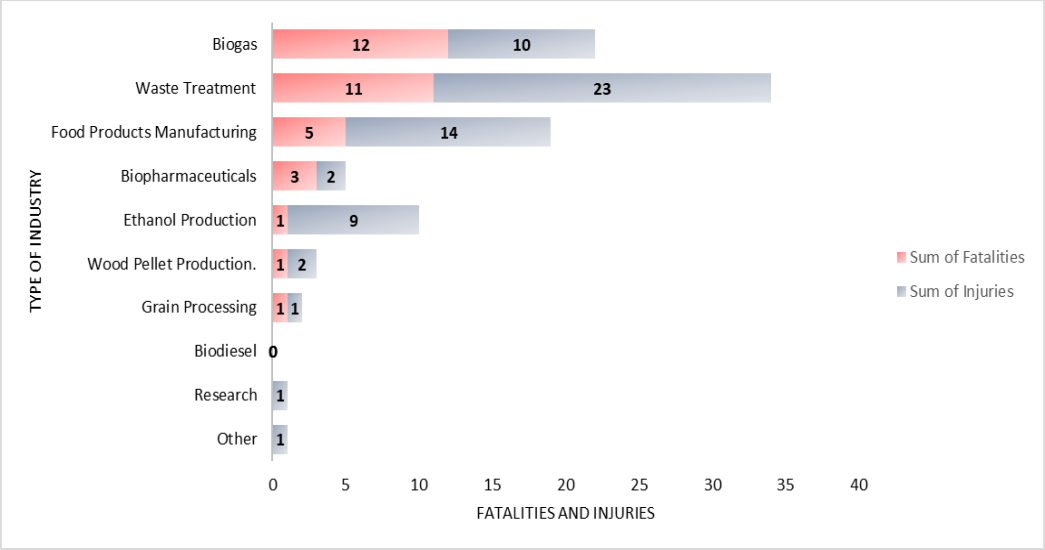
Summer ’23 Industry Projects – PMP

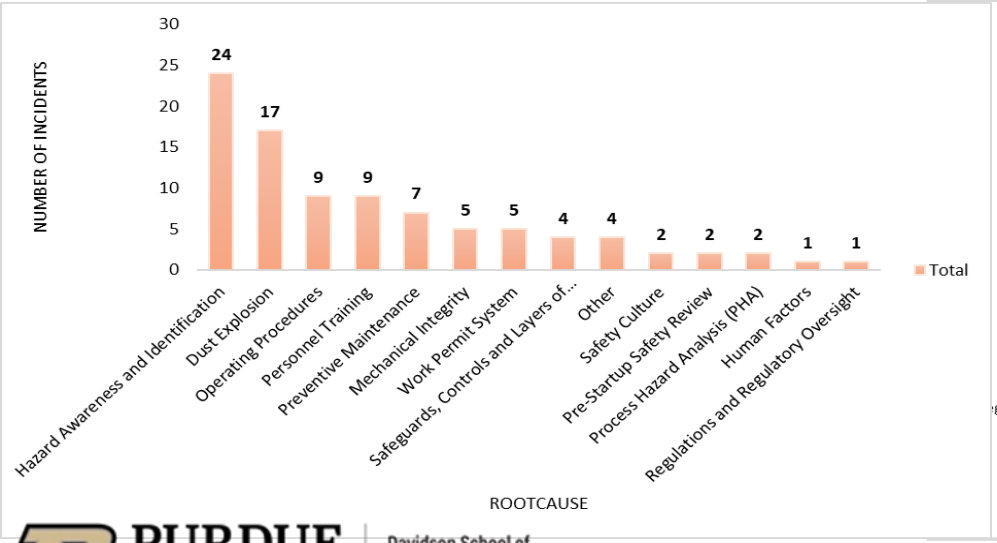
- **Fauske***: Benchmarking Chemical Release Scenarios Using Fauske FATE™ Tool*
- ***GSK:*** *Prediction Tool for Hazardous Gas Evolution (Total & Rate) in Common Reaction Solvents*
- **JMJ:** *Process Safety and Business Performance*
- **Kenexis***: Process Hazard Analysis of Select Hydrogen Production Technologies - continued*
- **Vertex Pharmaceuticals**: *Energetics of Molecules of Interest to Pharma Industry using CHETAH & TCIT - continued*
- ***3M****: Research Current RAGAGEP*

Bioprocessing Technology – Process Safety Hazards – PMP Research

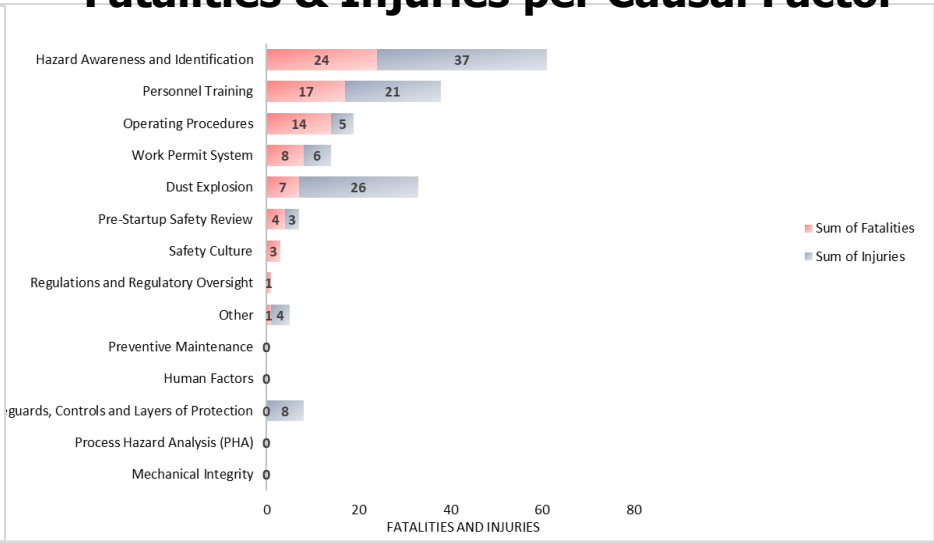
- Major applications: biopharmaceuticals, bioethanol, biodiesel, brewing, biosurfactants, …
- Developed database of 54 incidents:
  - eMARS, ASM, OSHA, …
  - Assessed up to 3 contributing causes for each incident out of 19 causal factors
- Plots of: # inc vs. causal factor; industry vs. # fat & injuries; causal factors vs. #fat & injuries
- Leading cause: Haz Awareness & Identification
  - 17 of 54 incidents were dust explosions

Fatalities & Injuries per Industry





Fatalities & Injuries per Causal Factor

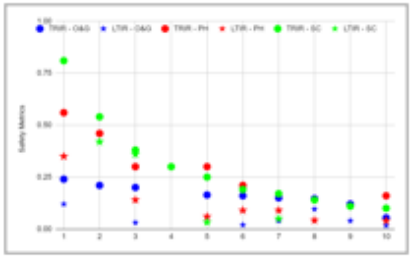


ESG (Environmental, Social & Governance Stewardship) – **UG Research**

- Investigated 10 of the largest companies in Oil & Gas, Specialty Chemicals, and Pharmaceuticals for reported ESG metrics.
- Looked at how available this information was for each company & industry, and then ranked them based on overall reporting – not numerical performance.

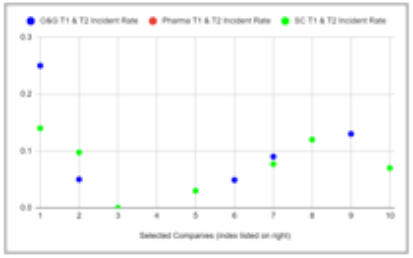
Most Reported Metrics by Industry

TRIR & LTIR



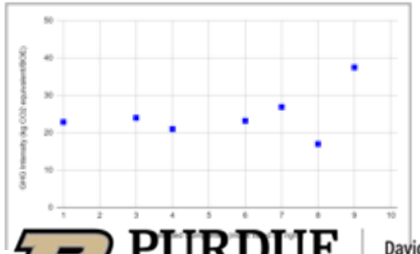
- Most companies provide OSHA Safety metrics
- Oil & Gas companies report consistently lower TRIR/LTIR values than other industries

Tier 1 & Tier 2 Incident Rate



- No Process Safety Information from Pharmaceutical companies
- Half of Oil & Gas and Specialty Chemical Companies report API process safety metrics
- Low correlation between TRIR/LTIR and Tier 1/Tier 2 Incident Rates

GHG Intensity of O&G Companies



- Specialty Chemicals & Pharmaceutical Companies do not provide universal common metric for GHG intensity
- Carbon Neutrality Goal by 2050 was reported, but most companies report they are less than 30% to goal (compared to 2019 baseline)

Blue – Oil & Gas
Green – Specialty Chemicals
Red - Pharmaceuticals

1. Marathon Oil, Eastman, AstraZeneca
2. Valero, Linde, Gilead
3. Chevron, Corteva, Pfizer
4. Shell, BASF, Merck
5. BP, Dupont, Johnson & Johnson
6. ExxonMobil, Evonik Vertex
7. ConocoPhillips, Celanese, Amgen
8. Total, Dow Chemical, Roche
9. Phillips 66, Sabic, Johnson Matthey
10. Saudi Aramco, Chevron Phillips, AbbVie

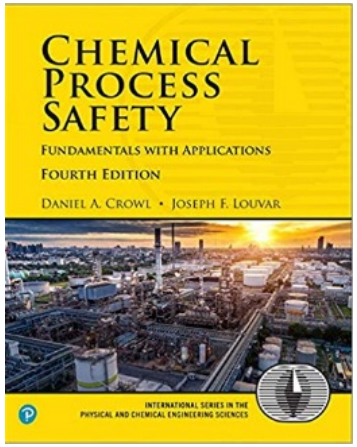
Metrics Evaluated for ESG & Safety*

		O&G	Specialty Chemicals	Pharmaceuticals
Environment	GHG Emissions	100%	90%	100%
	GHG Intensity	70%	60%	20%
	VOC Emissions	80%	70%	10%
	Progress to Carbon Neutrality	60%	80%	70%
	% Waste Deferred from Landfill	20%	40%	60%
Social	% Women in Leadership	100%	90%	100%
	% Minorities in Leadership	70%	80%	70%
	Community Investments	70%	40%	50%
	Employee Volunteerism	10%	20%	50%
Governance	Independent Board Members	70%	60%	70%
	Corporate Political Contributions	30%	40%	40%
	% Shares represented in Annual Meeting	10%	0%	0%
	Reported Completion of Compliance Audits	30%	40%	60%
Safety	Total Recordable Incident Rate	100%	100%	60%
	Loss Time Incident Rate	80%	40%	70%
	Fatalities	90%	90%	70%
	Serious Injuries	20%	60%	0%
	T1&T2 Process Safety Rate	80%	70%	0%
	Tier 1 Incidents	70%	50%	10%
	Spills Reported	100%	20%	10%

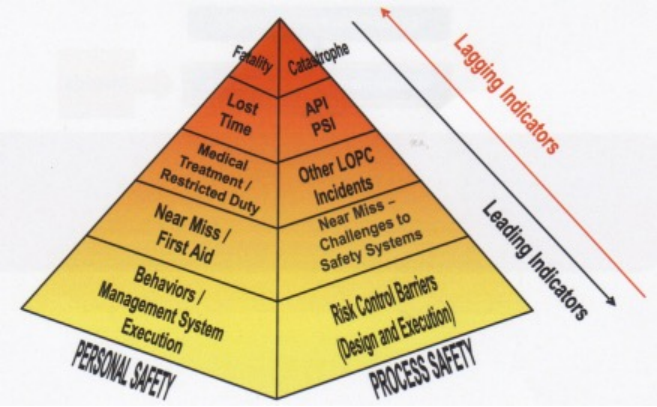
*Percentage based on amount reported, not the numerical value

Chemical Process Safety – Core Class

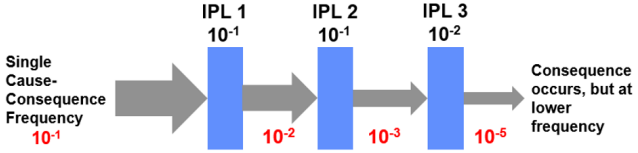
- Personnel vs. Process Safety & Metrics
- Applicable regulations: OSHA PSM, EPA RMP, etc
- Source Term Modeling
- Toxicants & Industrial Hygiene
- Toxic/Flammable Gas Release
- Dispersion Modeling
- Fire & Explosion Protection
- Chemical Reactivity
- Relief System Design
- Hazards Identification (HAZOP, ..)
- Risk Assessment (Matrix, QRA, ..)
- Accident Investigations



Process Safety Metrics



LOPA Frequencies



HAZOP

Node # _:
Design Intent:

Parameter	Guide Word	Deviation	Causes	Consequences	Recommendations

Typical 4x4 Risk Matrix

		Likelihood			
		Frequent	Possible	Rare	Remote
Severity	Major	Very High	Very High	High	Moderate
	Serious	Very High	High	Moderate	Low
	Minor	High	Moderate	Low	Low
	Incidental	Moderate	Low	Low	Low

Benefits from Joining P2SAC

- Direct engagement in suggesting & selecting process safety research projects at all levels – PhD, PMP and UG.
- Priority in serving as mentor for process safety related Professional Masters Project of your choice.
- Attendance at biannual meetings to review research progress and learn from outside expert presentations.
- Sharing among companies of process safety learnings and challenges.
- Contact with students as they develop process safety expertise and enhance the science.

P2SAC Sponsors

Chevron
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Honeywell
DOW
VERTEX
KENEXIS
GSK
FAUSKE & ASSOCIATES, LLC
Pfizer
3M
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سابك sabic
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Endress+Hauser People for Process Automation
CORTEVA agriscience
American Chemistry Council
ExxonMobil
JM Johnson Matthey Inspiring science, enhancing life
PSRG Process Safety and Reliability Group