

Purdue Process Safety & Assurance Center - P2SAC

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P2SAC Formed in 2014



A challenging quantitative / technical discipline;
scope not widely recognized

Conduct process safety related research focusing on fundamental science

Teach process safety courses and instill Process Safety Management (PSM) considerations in core capstone design projects (*~180 UG and Grad students enrolled Fall '18*)

Engage UG & Professional MS students in process safety research

Source of expertise for industry and other stakeholders regarding process safety related standards & best practices

Focus on oil & gas industry, chemicals, pharmaceuticals, agriculture, and technology including consumer products and manufacturing

Research projects solicited from industry sponsors, as well as other stakeholders such as academia & government labs

Enhance education experience of all Purdue Chem Eng graduates

Process Safety Conference Held Each Semester

Attendees – December 12, 2018 Fall Conference

Sponsors

AMGEN

BP

Chevron

Dow

ExxonMobil

Fauske & Associates

GSK

Honeywell

Kenexis

Lilly

Phillips 66

Pfizer

Shell

3M

Guests

- aeSolutions*
- Air Products
- AMRI–Grafton*
- Baker Eng & Risk*
- CF Industries*
- CountryMark*
- Cummins
- CCPS
- Dow AgroSciences
- Endress+Hauser*
- Evonik
- ICASE*
- Jensen Hughes*
- Marsh Risk Mgmt*
- Occidental*
- SABIC*
- Swift Fuels*

** denotes 1st meeting*

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

Multiple Chemical Engineering Faculty Engaged in Process Safety Related Research

PhD

Re-examine current basis for gas and fire detector placement

Optimal placement of gas detectors in process facilities: bringing optimization-based gas detector placement into practice

Prevention through catalyst design for applications in the petrochemical industry

Robust model-based control for safe pharmaceutical manufacturing

Advanced separation techniques for producing rare earth elements and other chemicals from coal fly ash

Computational analysis of drop coalescence in emulsions to reduce retention times in oil-water separators



ChE Professional Masters Program

- Grown from 9 students in '15 / '16 academic year to 55 this fall
- 2017 Cohort: 34% female; 65% int'l; \$69k avg starting salary, 100% placement
- Five areas of concentration:
 - + Energy Systems Fundamentals & Processes
 - + Kinetics, Catalysis, and Reaction Engineering
 - + Biochemical Engineering,
 - + Polymer Science and Engineering
 - + Pharmaceutical Engineering
 - + *Gas & Petroleum - proposed*
- Program scheduled for one year
 - + Students take 2 core courses; 3 in area of concentration; 3 in Management; followed by summer research project
 - + Additional semester required for those without BS in chemical engineering
- Summer research projects are typically suggested and led / mentored by industry
 - + Students remain on campus with ~30 minute weekly call with industry mentor
 - + Two students per projects noted above; +800 hrs of 'free' research'
- Typical companies hiring graduates: 3M, Cook Pharmica, McKinsey, Nalco, Shire, etc

P2SAC Research Program – MS & UG

MS Projects

Compilation of thermal hazard safety data for amide coupling reagents (Lilly) – ‘17

Validate large scale consequence modeling with Middle East propane release (Kenexis) – ‘17

Quantification of toxicity effects of H₂S ingress into buildings / temporary refuge (Shell) – ‘18

Acoustically-induced vibration of piping systems (ExxonMobil) – ‘18

Develop a scheme for conducting process hazard analyses and develop guidance for automating (Kenexis) – ‘18

A systems engineering approach for managing changes in chemical process R&D labs (Dow AgroSciences) – ‘18

UG Projects – ‘17 & ‘18

Develop database of MIEs of dusts with focus on pharma / mixtures

Review literature on Grignard reagents and use ARSST calorimeter to close gaps

Determine and predict temperature at which time to max rate of reaction is 24 hr

UG Projects – ‘17 & ‘18 – (cont’d)

Review of Benson group data available & ability to calculate thermodynamic properties of molecules

Develop guidance on energy released during testing vs. volume of sample

Compilation of process safety related software commercially available

Risk and reliability of aged natural gas pipelines

Analysis of process safety incidents in the pharmaceutical industry

Experience with corrosion under insulation; detection & mitigation

Experience with LNG metallurgy failures

Comparison of global process safety regulations

Joint NSF Funded Projects with CISTAR – ‘18 & ‘19

Safety in Academic & Industrial Laboratories Inherently Safe & Secure Cyber Physical Systems

Process Safety Related Software Commercially Available - UG

Process Hazard Analysis	Risk Management Software
ABS Group - LEADER PHA	ABS Group - THESIS BowTie
BakerRisk - SafeSite3G	AeSolutions - AeShield
BakerRisk - HACTool-c	AeSolutions - AeFacilitator
CCPS - CHEF	Evergeen
Fauske - Adiabatic Calorimetry & Relief System	BakerRisk - MaxLoss-TM
Gexcon - FLACS	CCPS - RAST
Gexcon - FRED	CGE - BowTieXP
IOMosaic - PSO - PHAGlobal	Evision - Barrier Vision
Kenexis - Open PHA	IOMosaic - PSO - SuperChems
NOAA - CAMEO	
PrimaTech - PHAWORKS RA	
PrimaTech - LOPAWORKS	
PrimaTech - Tracker	

Center for Chemical Process Safety (CCPS)

(Note these are downloadable from the CCPS Website due to generous gifts to CCPS!)

- RAST (Risk Analysis Screening Tool)
 - RAST assists with hazard identification, scenario development, consequence evaluation, and risk analysis. As a part of this screening, RAST assists users by providing a comprehensive Layer of Protection Analysis (LOPA), as well.
 - <https://www.aiche.org/ccps/resources/risk-analysis-screening-tool-rast-and-chemical-hazard-engineering-fundamentals-chef>
- CHEF (Chemical Engineering Hazards Fundamentals) Calculation Aid
 - CHEF documentation provides the theoretical details of the methods, techniques, and assumptions which are used in RAST
- CRW (Chemical Reactivity Worksheet)
 - CRW has data on thousands of hazardous chemicals and can be used to evaluate the compatibility between chemicals and the equipment's materials of construction.
 - <https://www.aiche.org/ccps/resources/chemical-reactivity-worksheet-40>

CGE Risk Management Solutions

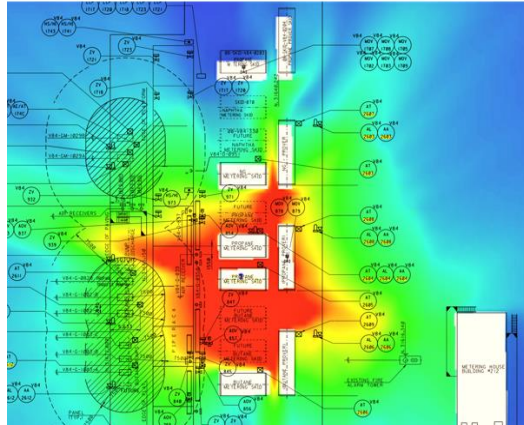
- BowTieXP: Risk Assessment software based on bowtie method
 - Provides an overview of multiple plausible incident scenarios and shows the barriers that have been place to control these scenarios

PMP & UG Research Suggested by Industry

CFD Hazardous Release Modeling Validation - PMP



FDS Base Model: No wind

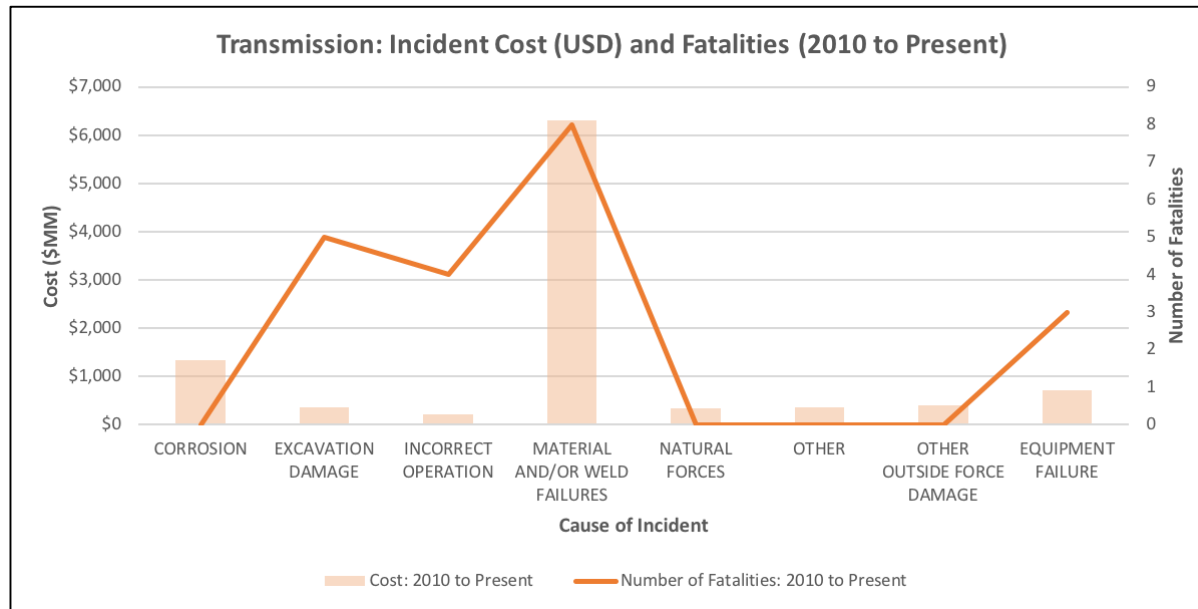


Corrosion Under Insulation – UG & Class

Table 1: Qualitative comparison of CUI detection method strengths and weaknesses.

Technique	Damage to Insulation	Detection of Hotspots	Screening Ability	Applicable to Vessels	Applicable to difficult geometry
Insulation Removal	Not Applicable	Yes	No	Yes	Yes
Neutron Diffraction	No	No	Yes	Yes	Yes
X-Ray Scanning	No	Yes	No	No	Limited
Ultrasonic Thickness Measurement	Minor Damage	No	Limited	Yes	Yes
Pulsed Eddy Current	No	No	Yes	Yes	No

US Natural Gas Pipeline Failures - UG



Industry Suggested (& Progressed) Research - 2017

Human Factors

Human Performance of Control Room Operators (BP & ExxonMobil); UG Research

Personnel competence in the major hazards industry (Phillips 66); UG Research

Analysis of how past engineering design criteria accounted for normal human error mechanisms (Phillips 66)

Pharmaceutical

Conduct a process safety related benchmarking survey of the pharmaceutical industry (Lilly); UG research

Compilation of thermal hazard safety data for amide coupling reagents (Lilly); MS (Lilly sponsor)

Small-scale predictive tool for combustible dust prediction (Lilly)

Develop a 'Safety by Design' concept incorporating lot-to-lot variability of reagents or solvents (Lilly)

Metallurgy / Corrosion

Experience with LNG metallurgy failures (ExxonMobil); UG research

Experience with corrosion under insulation and detection methods (BP); UG Research

Risk and reliability of aged gas and product pipelines (ExxonMobil, Laird); UG Research

Extend Charpy impact curves for brittle fracture of pipelines to different metallurgies (ExxonMobil)

Modeling

Re-examine current basis for gas & fire detector placement (BP); PhD Research

Validate large scale consequence modeling (BP); MS (Kenexis sponsor)

Re-examine common cause models (BP, Honeywell)

Other

Impact of modern personal electronic devices as potential ignition sources in process areas (ExxonMobil)

Address validation of the use of water sprays to mitigate overpressures (ExxonMobil)

Technology to detect subsea leaks (BP)

CHEN 420 / 597- Chemical Process Safety – core UG course

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

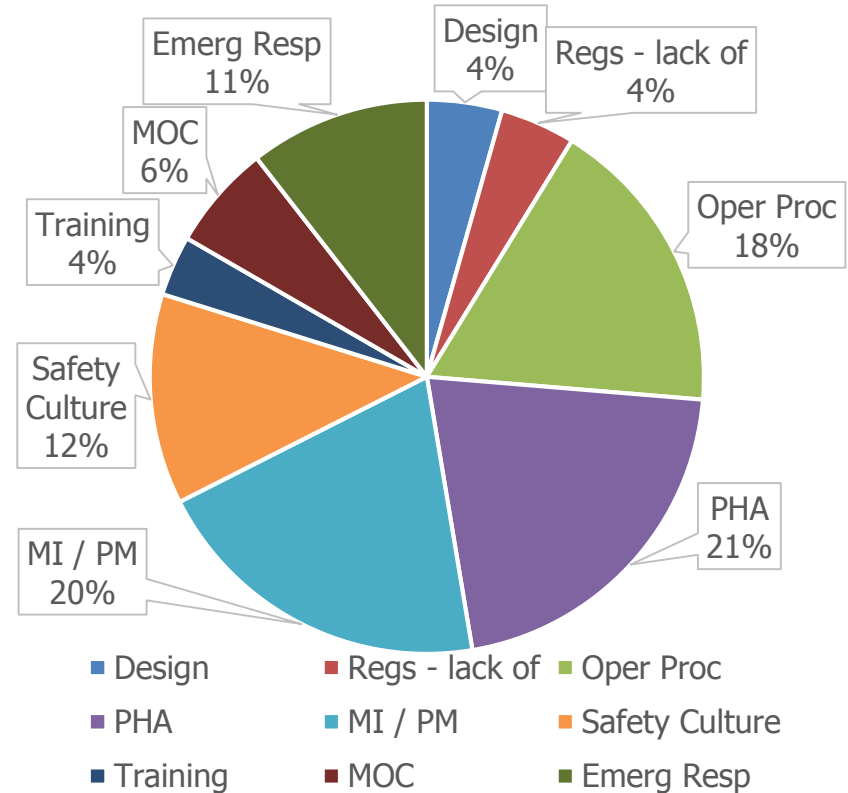
Relief System Design

Hazards Identification (HAZOP, ..)

Risk Assessment (Matrix, QRA, ..)

Accident Investigations

Root Causes – 59 Incidents Analyzed



		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

2018 P2SAC Highlights / Plans

- Five new company Sponsors
- Progressed 6 PhD / 4 PMP / 8 UG research projects
- Six P2SAC related PMP projects suggested to date for summer '19
- Installation & initial testing with Fauske donated ARSST calorimeter
- Paul Amyotte graduate student seminar on '*Dust Explosions: Myths, Realities, and Challenges*'
- Scoping opportunities to explore application of Big Data to process safety
- Three day process safety conference planned in Spring
 - May 7 – Process safety in the Pharmaceutical Industry; keynotes by EVPs of Biogen and Purdue
 - May 8 – Regular spring P2SAC conference
 - May 9 – Flow assurance conference
- Department effort seeking to name / endow P2SAC, as well as process safety chair / professorship

Current P2SAC Sponsors



Typical Sponsor agreement is \$25k / year for 3 years

Spring conferences: May 7 – 9 addressing pharma industry, regular spring P2SAC meeting, and flow assurance conference.