

Purdue Process Safety & Assurance Center - P2SAC

Ray A. Mentzer
Visiting Professor
Associate Director, P2SAC

Charles D. Davidson School of Chemical Engineering
Purdue University

December 2018

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

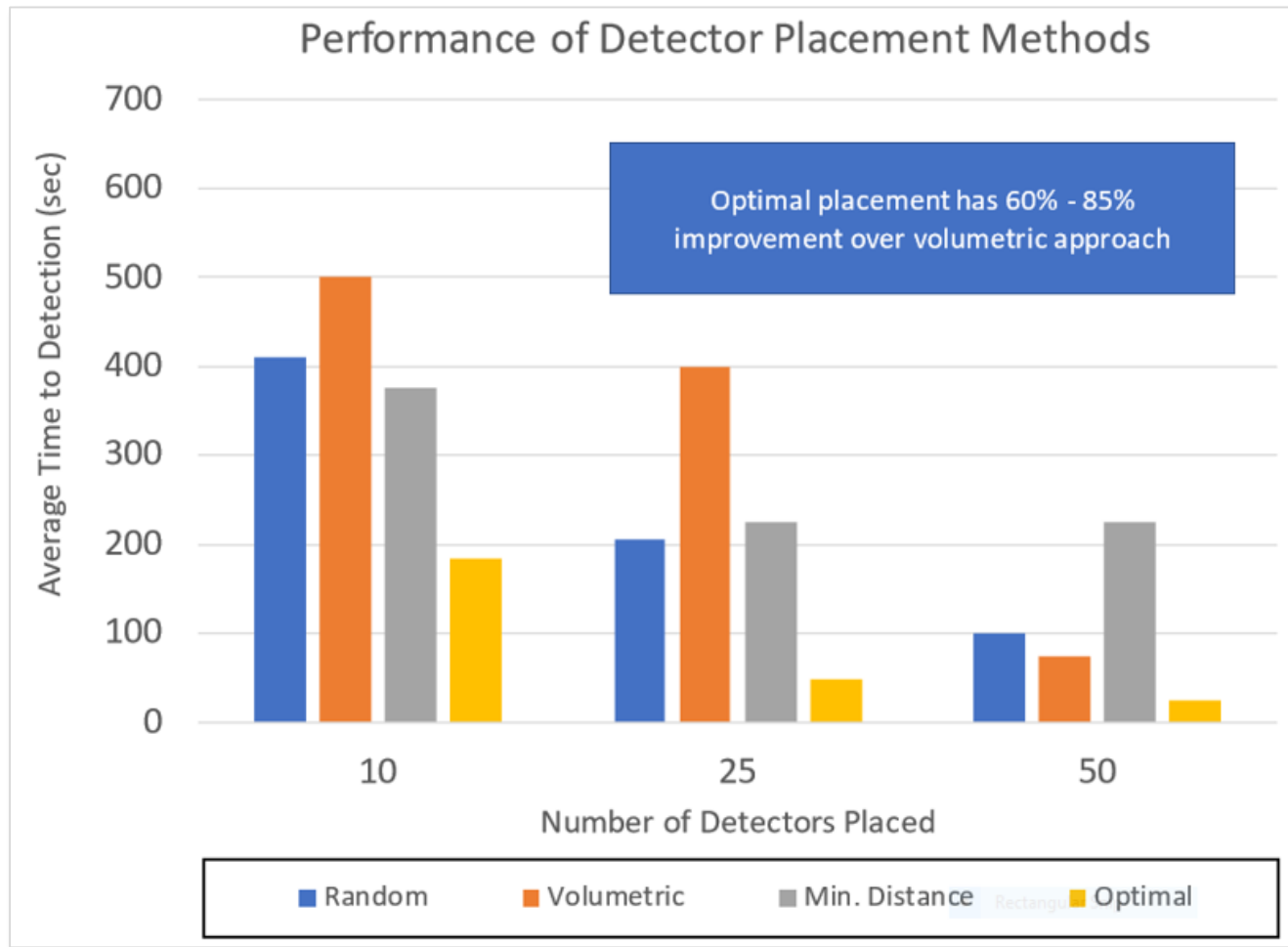
Robust model-based control for safe pharmaceutical manufacturing

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



PhD - Gas & Fire Detector Placement



P2SAC researchers focus on use of quantitative methods for optimal placement of gas detectors under uncertainty using CFD simulations of hundreds of dispersion scenarios. Optimization methods lead to significant improvement in average time to detection over two commonly used approaches, as well as random placement.

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

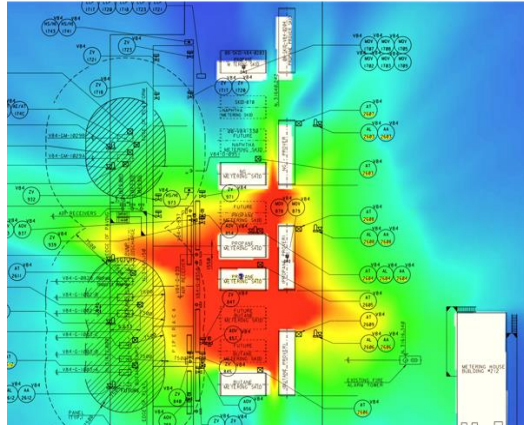
Safety in Academic & Industrial Laboratories Inherently Safe & Secure Cyber Physical Systems

PMP & UG Research Suggested by Industry - *Examples*

CFD Hazardous Release Modeling Validation - PMP



FDS Base Model: No wind

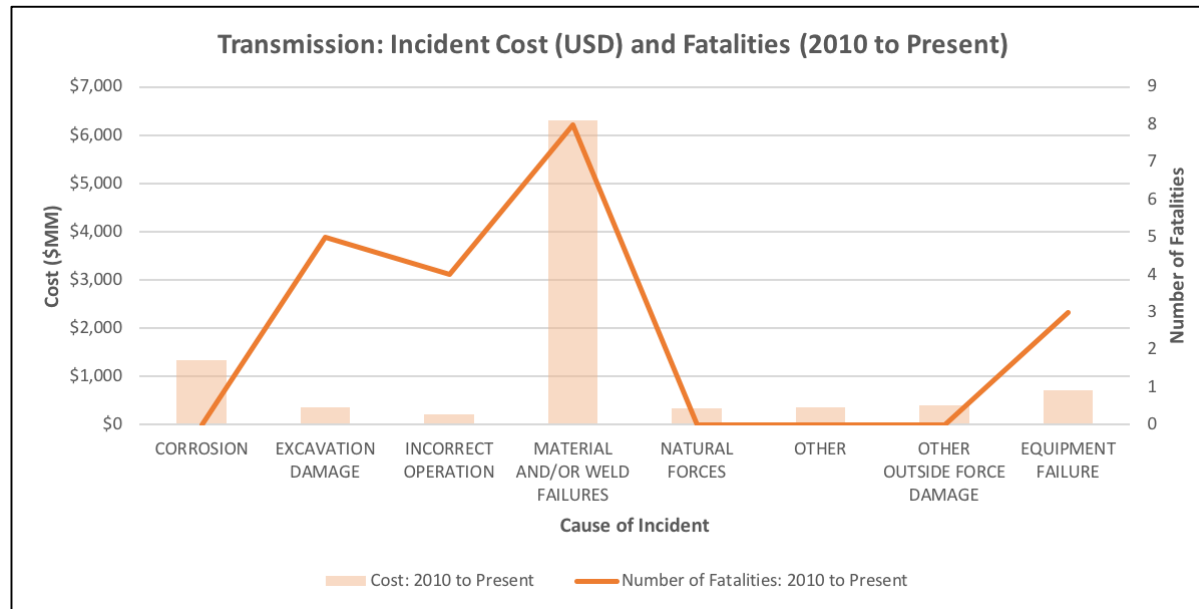


Corrosion Under Insulation – UG & Class

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



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

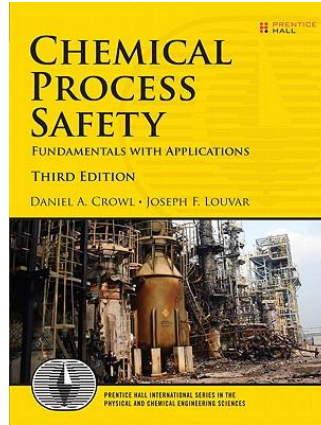
Chemical Reactivity

Relief System Design

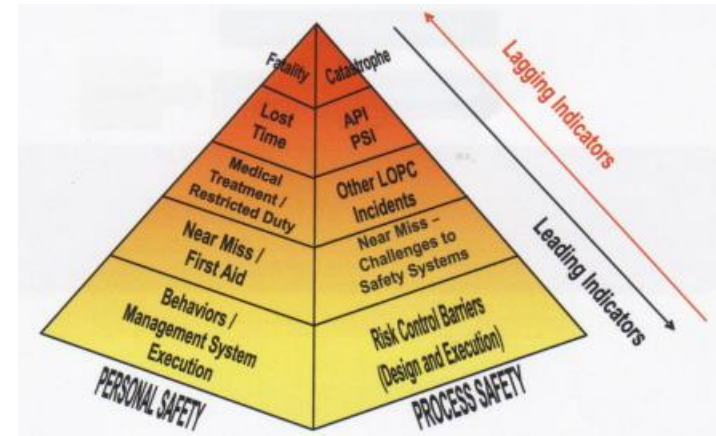
Hazards Identification (HAZOP, ..)

Risk Assessment (Matrix, QRA, ..)

Accident Investigations



Process Safety Metrics



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

HAZOP

Node # _ :
Design Intent:

Parameter	Guide Word	Deviation	Causes	Consequences	Recommendations

Benefits from Joining P2SAC

Direct engagement in suggesting & selecting process safety research projects at all levels – PhD, MS 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.

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

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.