

## **10<sup>th</sup> Annual CCPS Canadian Regional Meeting**

Meeting Hosted by Oviniv

### **AGENDA**

Thursday September 11, 2025, 08:30-16:45

<b>Time</b>	<b>Subject</b>	<b>Speaker</b>
<b>08:30</b>	<b>Check-in</b>	
08:45	Opening	Fred Henselwood (NOVA Chemicals)
08:50	Welcome Comments	Brad Gushlak / Dave MacDougall (Oviniv) Host
09:00	Safety Moment	Danielle Hamilton (Co-op Refinery Complex)
09:25	AI and Process Safety	Rainer Hoff (Gateway Consulting Group)
09:55	20 Years, Looking back on Buncefield	Marcello Oliverio (Olitech Consulting Inc)
<b>10:15</b>	<b>Break</b>	
10:45	CSCHE Process Safety Management Division Update	Connor Murray (CSCHE PSMD)
10:55	Energy Safety Canada Process Safety Update	Glen Worobets (Energy Safety Canada)
11:10	Minerva Canada Update	Marcel Pouliot (Minerva Canada)
11:30	How Can Bow-Tie and LOPA Frameworks Be Adapted into a Practical, Formation-Specific Risk Management Tool for Induced Seismicity?	Laura Salazar (University of Alberta)
11:45	CCPS Update	Michele Horwitz (CCPS)
11:55	Open Sharing	Fred Henselwood (NOVA Chemicals)
<b>12:00</b>	<b>Lunch</b>	
13:00	CO2 Transportation Pipeline, A Hybrid Land Use Planning – Deterministic and Risk-based Approaches	Naser Badri (Risktec Solutions)
13:25	Performance-Based Fire and Gas System Design for Petroleum Storage Tank Safety	Edward Naranjo (Kenexis), Adrian Petre (Westech Industrial)
13:50	Causal Reasoning	Zoe Gulley (P2I Consulting Ltd.)
14:15	Advancing Hospital Energy Systems: A QRA-Based Framework for Safe Hydrogen Combined Heat & Power (CHP) System Deployment	Kanishkar Venkatesan (University of Alberta)
<b>14:30</b>	<b>Break</b>	
15:00	A Graphical Approach to a Multi-Variate Alarming Problem in an Ethylene Furnace	Michael Bell (NOVA Chemicals)
15:30	Mind the Gap: Rethinking Risk Acceptance in HAZOP and LOPA	Shaun Williamson (Watchmen)
16:00	Process Safety Panel looking at the use of Risk Matrices - Glen Worobets (Moderator)	Dharmesh Dalwadi (TC Energy) Josh Wright (Co-op Refinery Complex) Bev Perozzo (Sheritt International)
16:45	Closing Comments	Fred Henselwood (NOVA Chemicals)

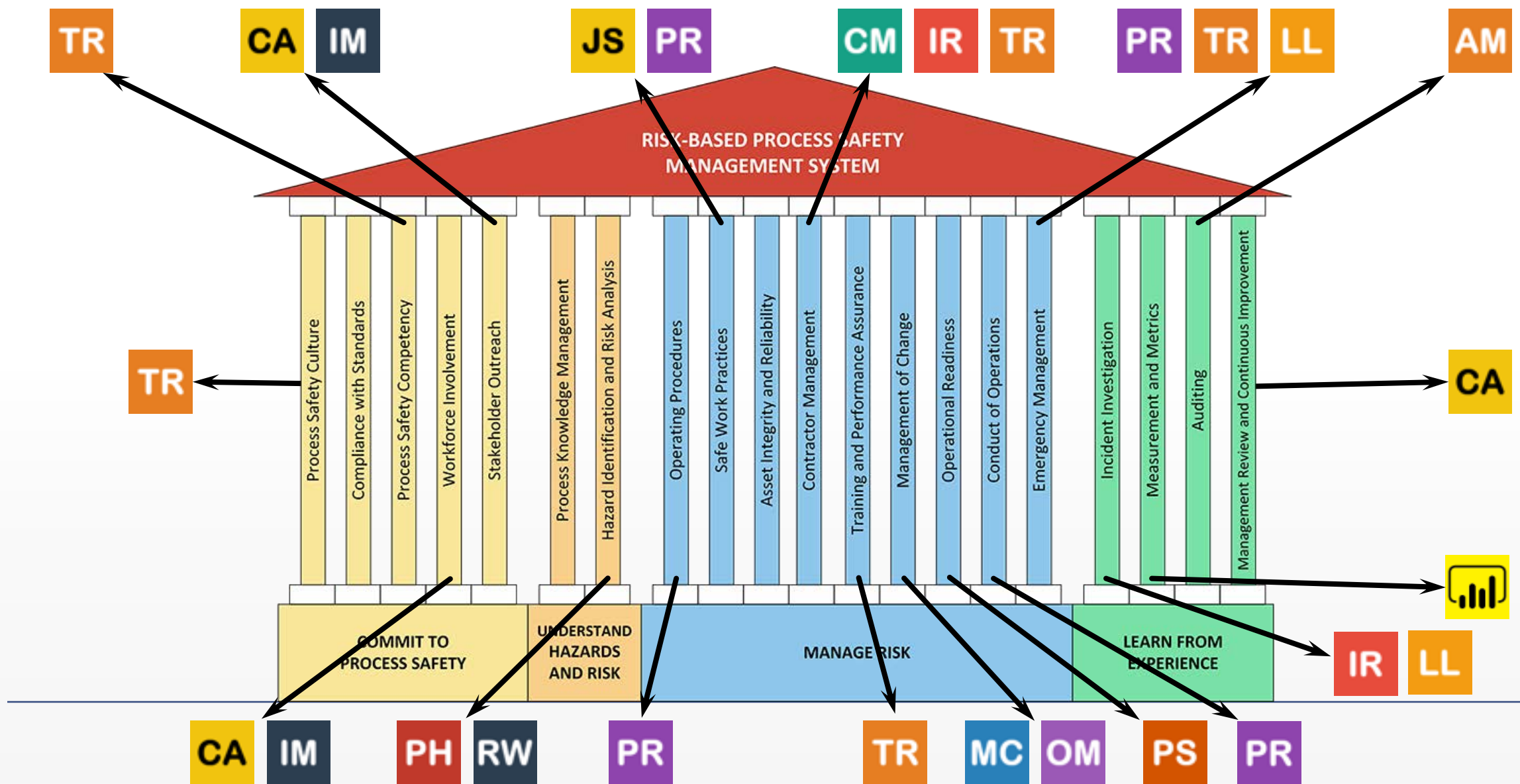
10<sup>th</sup> CCPS Canadian Regional Meeting  
Calgary  
Sep 11, 2025

# AI and Process Safety

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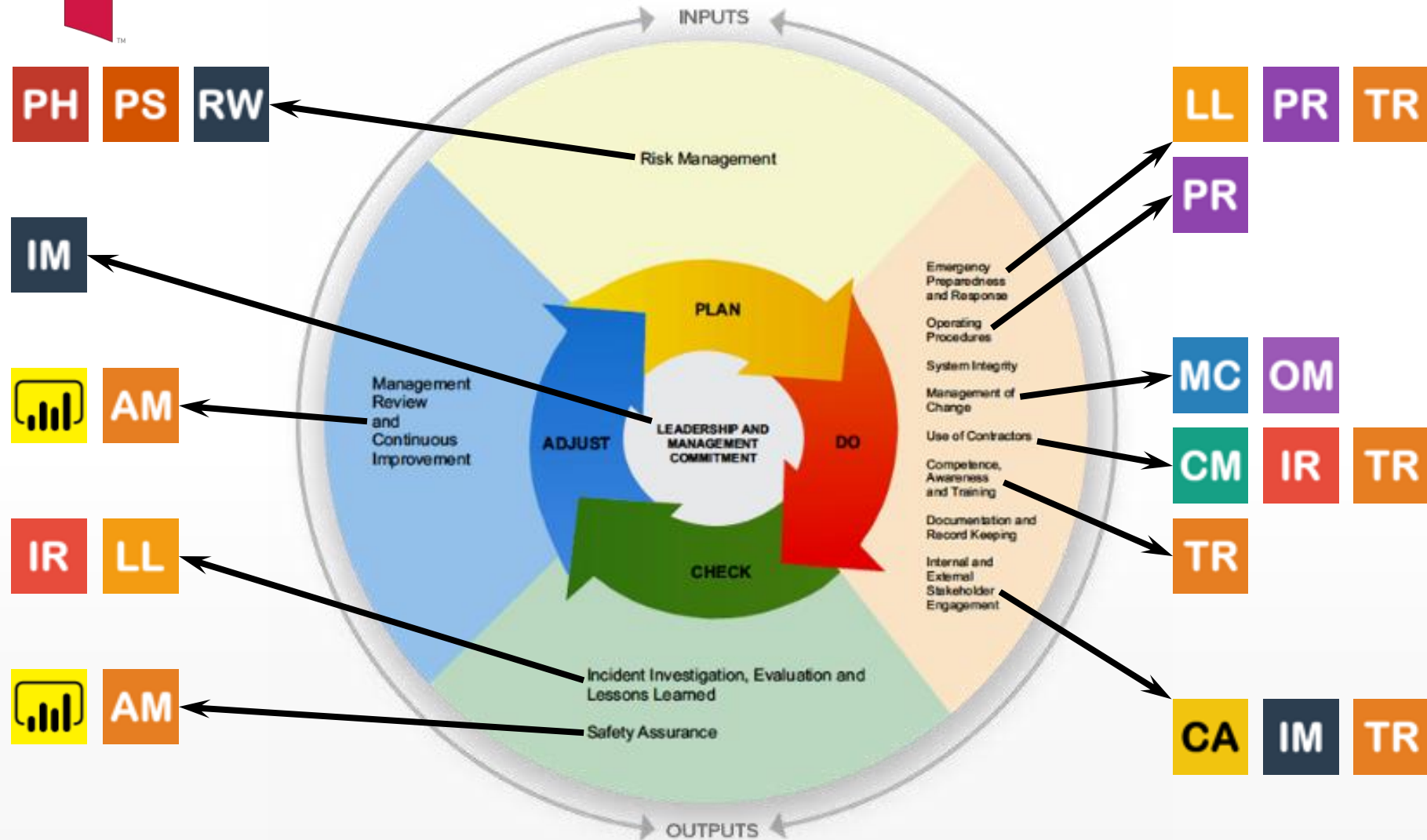
Rainer Hoff, PhD, PEng  
Founder, President  
Gateway Group  
[www.gatewaygroup.com](http://www.gatewaygroup.com)

# FACILEX® Complete RBPS Solution





# FACILEX® Complete API-1173 Solution



# Outline

- Introduction
  - Progress to Date
  - Benchmarking
  - AI Initiatives in Industry
-

# Introduction

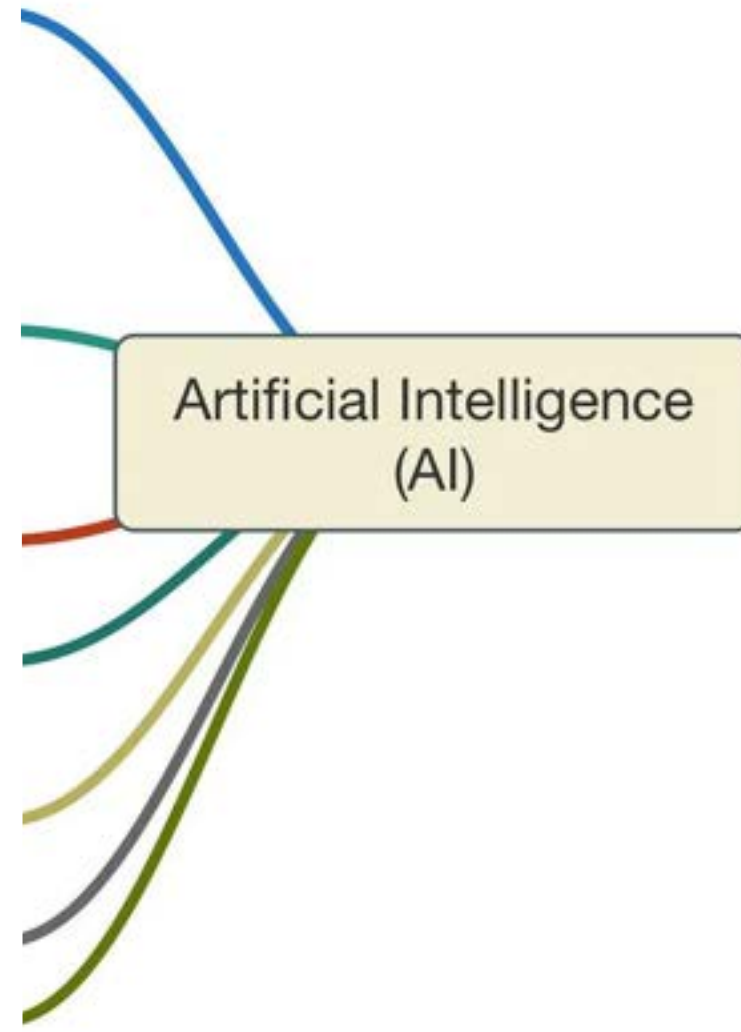
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# What is Intelligence?

The ability to learn

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# Taxonomy of Artificial Intelligence





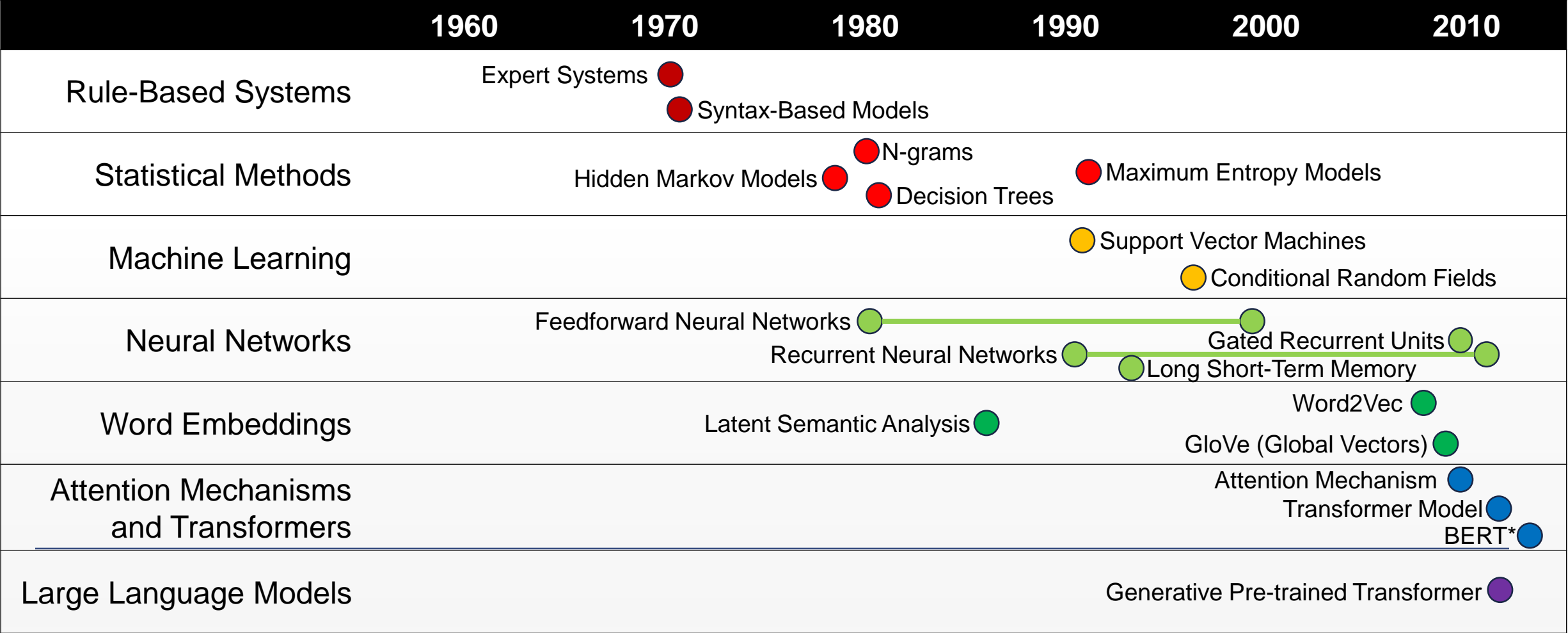
# Walking Robots



## ML: Predictive Maintenance / Incident “Prediction”



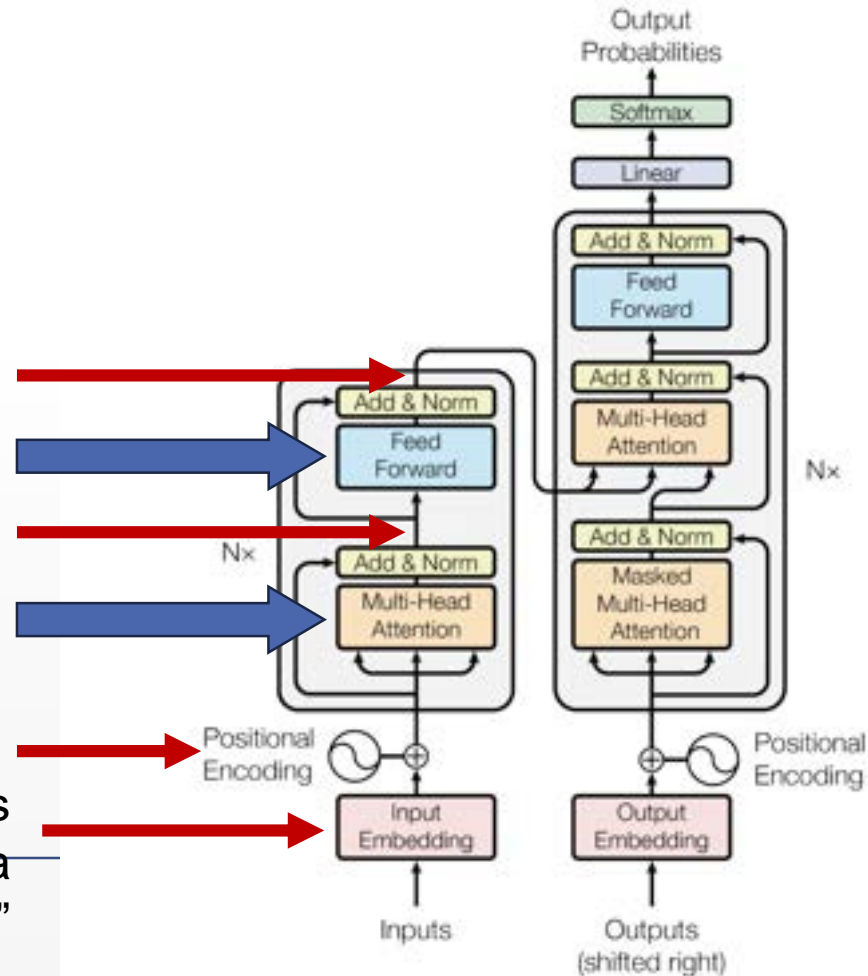
# History of Natural Language Processing





# Transformers

“I’m adding a PSV. Is  
that an MOC or a  
Replacement-in-Kind?”





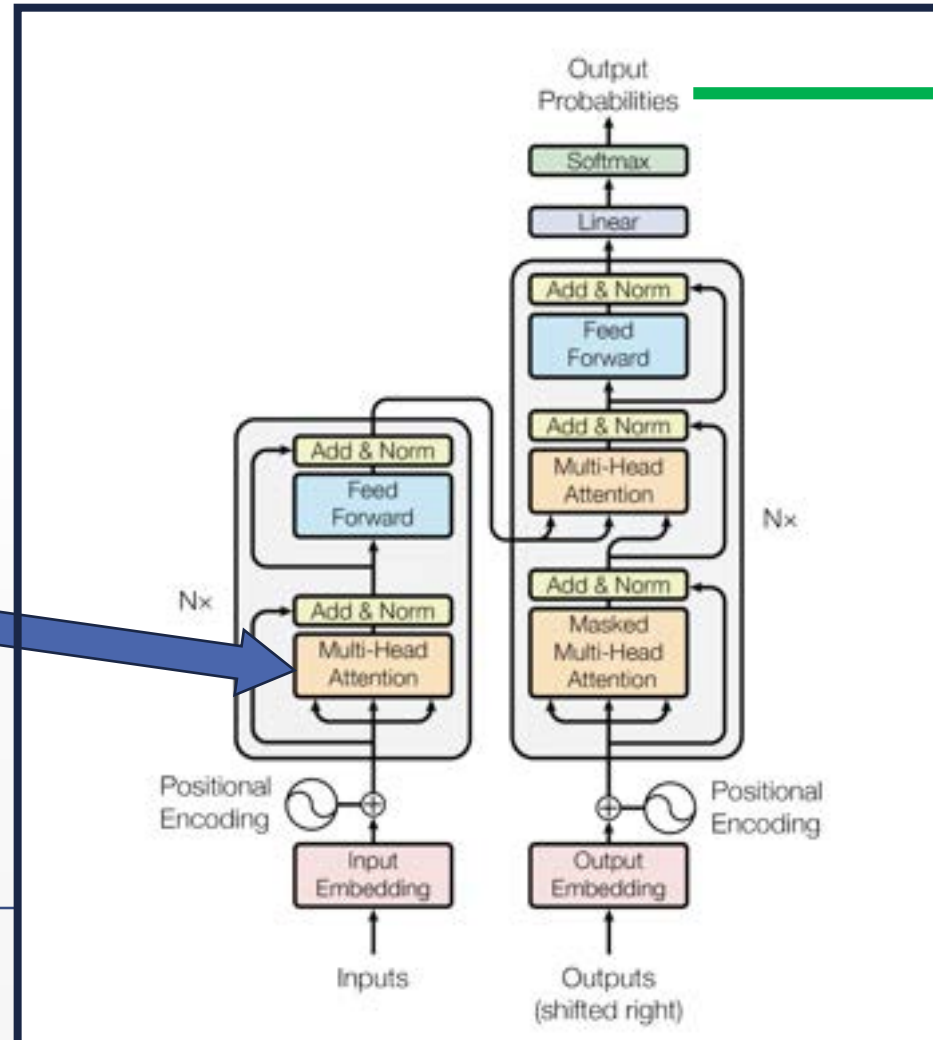
# What is “GPT”?

## Transformer

## Generative

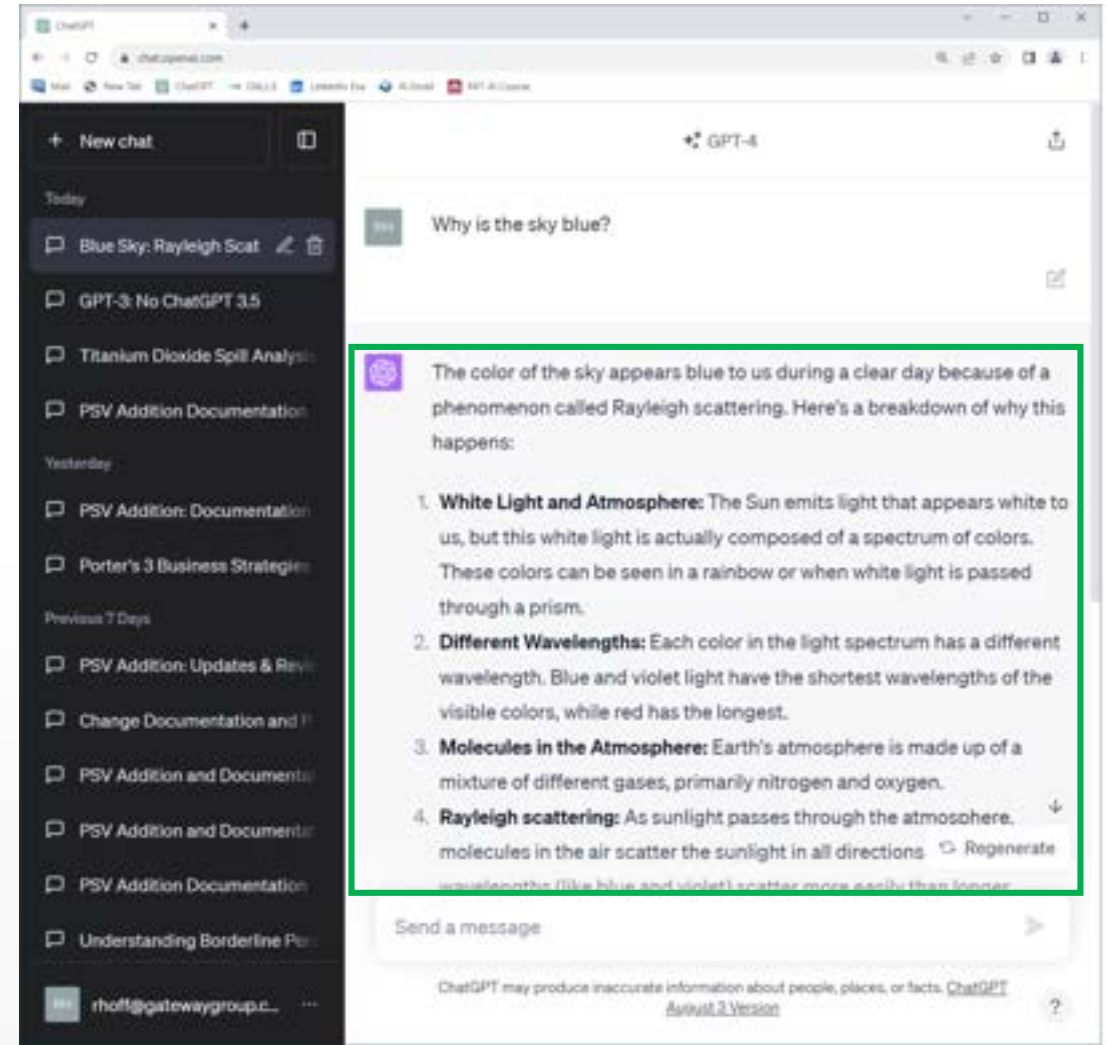
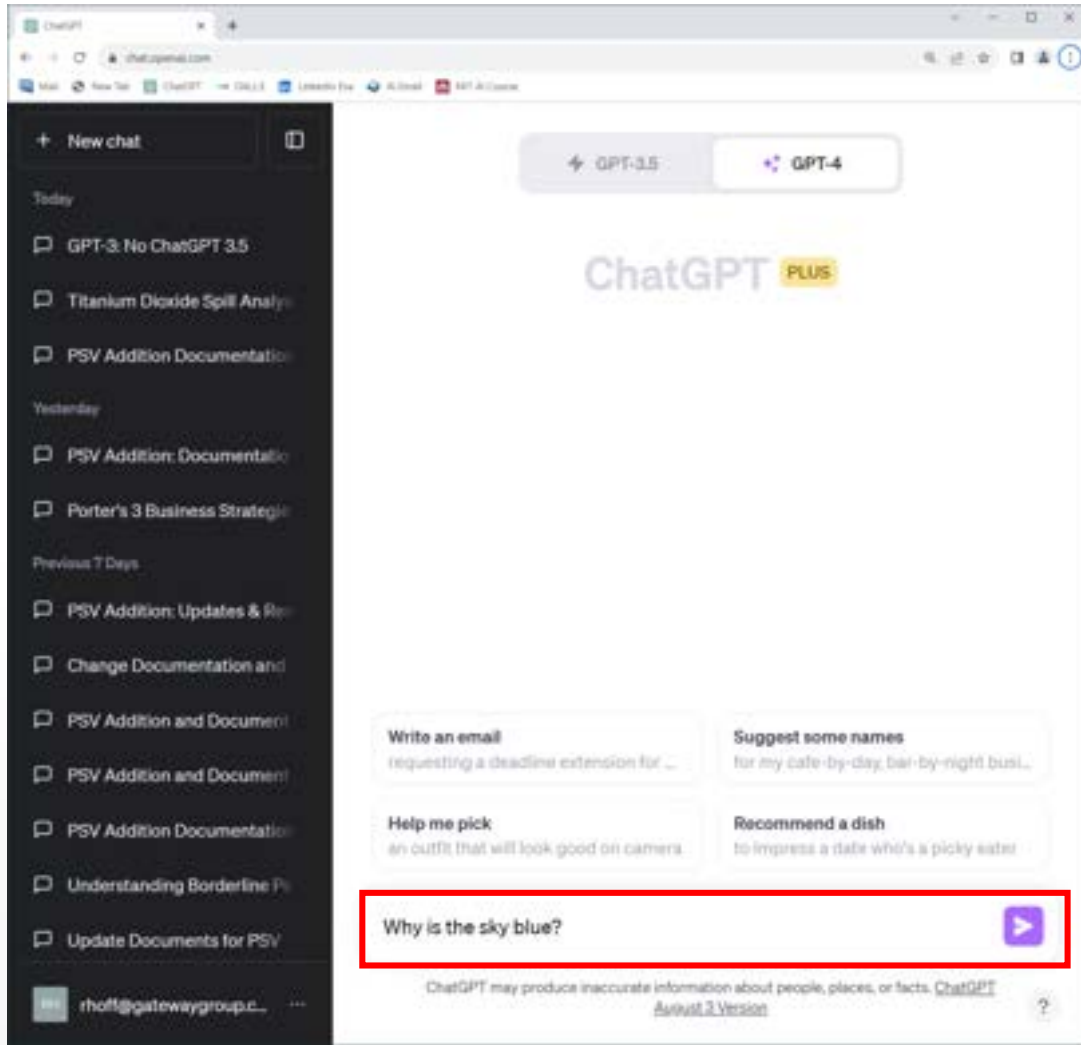
### Pre-Trained

-0.26	0.13	0.29	-0.01	0.24	0.40	-0.30	0.31	-0.07...	0.78
-0.56	0.14	-0.30	-0.51	0.36	1.00	0.69	0.60	-0.35...	0.22
0.20	-0.18	-0.08	0.04	-0.16	-0.08	0.02	-0.43	1.04...	0.17
0.23	0.10	0.05	-0.07	-0.26	0.16	-0.41	-0.70	-0.10...	-0.23
-0.19	0.16	0.00	-0.38	-0.34	-0.09	0.01	0.19	0.71...	0.17
0.32	0.16	-0.02	0.26	-0.07	0.28	-0.40	-0.61	-0.21...	-0.03
-0.34	0.09	-0.44	0.61	0.38	-0.01	0.60	-0.08	0.05...	0.32
0.22	0.06	0.05	-0.31	-0.07	-0.06	0.09	0.26	0.03...	0.04
-0.40	-0.08	-0.24	0.08	0.21	0.00	0.36	0.03	-0.40...	-0.24
...	...	...	...	...	...	...	...	...	...
-0.42	-0.37	-0.14	0.04	-0.02	0.34	-0.35	-0.06	0.11...	0.18



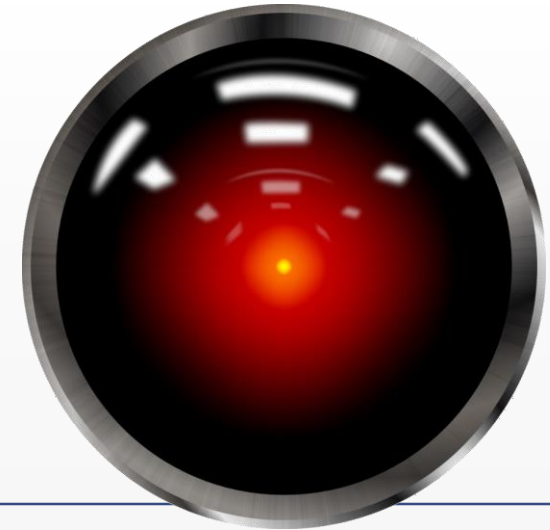
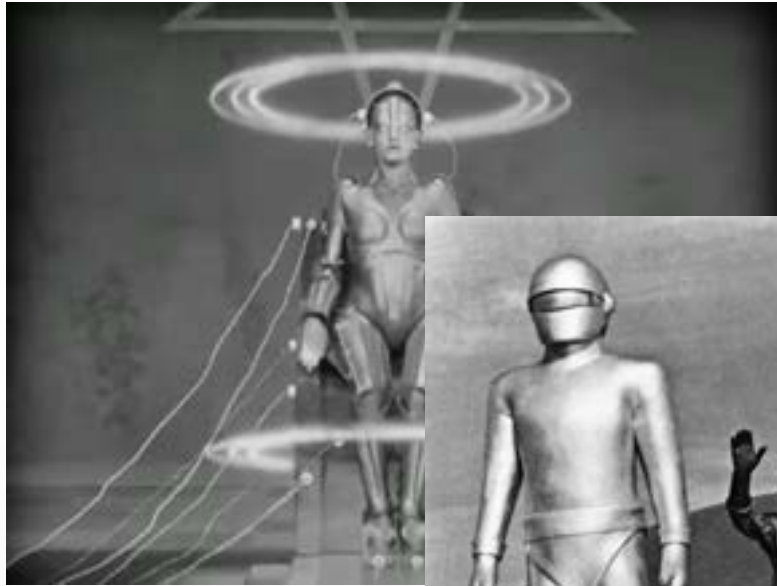
Adding  
a  
pressure  
safety  
valve  
requires  
an  
MOC  
<EOS>

# What Does “Chat” “G” “P” “T” Stand For?



The “Chat” part is the conversational nature of the user interface

# AI in Popular Culture: Fear



# AI in Popular Culture: Fear Again!

Bulletin  
of the  
Atomic  
Scientists

## Could AI help bioterrorists unleash a new pandemic? A

By Matt Field | January 25, 2024

Omaha World-Herald

## It's not just Taylor Swift: AI-generated porn is targeting women and kids all over the world



U.S. Politics World Opinion Media Entertainment Sports Lifestyle Video AI More

Login Watch

## Elon Musk was warned that AI could destroy human colony on Mars: report

LIVE  
NYT/DEALBOOK

The New York Times

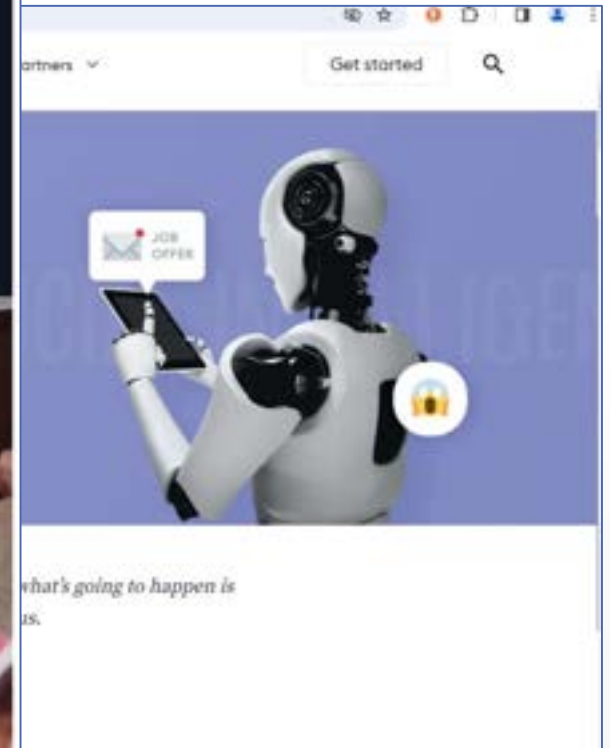
DealBook Summit

Elon Musk



in sexual  
efs merch  
Jihad

Accessed 2024/01/27 15:15





# Here Now!



## How insurance companies use AI to deny claims

47:20

December 18, 2024 By [Willis Ryder Arnold](#) and [Meghna Cha](#)



Supply Chain Management

## How AI Is Reshaping Supplier Negotiations

by [Elena Revilla](#) and [Maria Jesus Saenz](#)

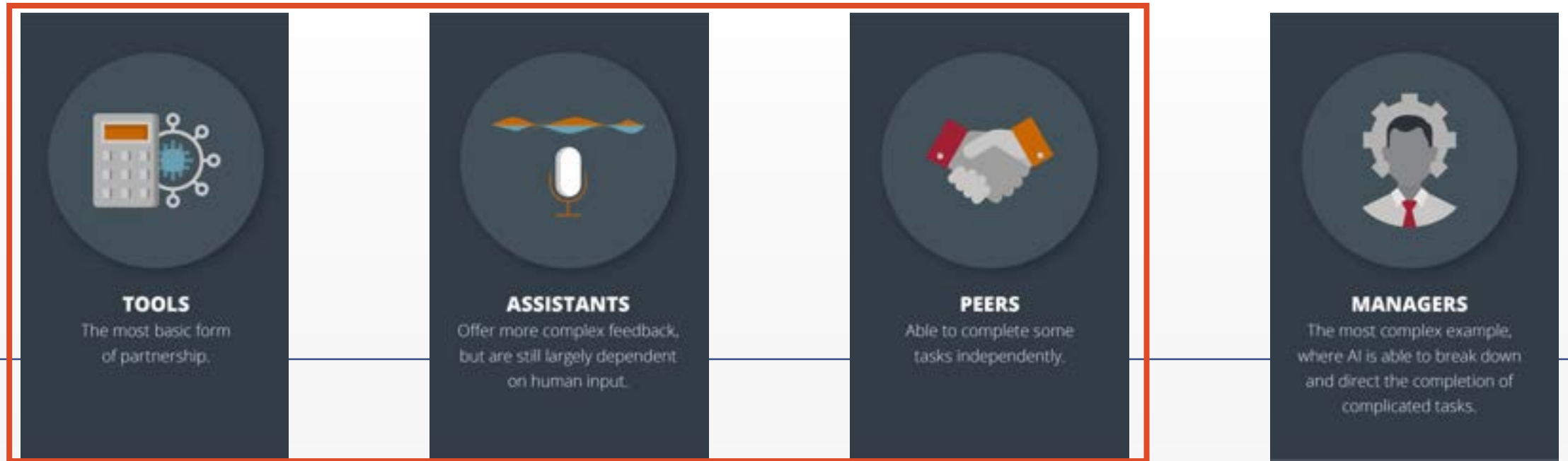
July 24, 2025





# Golden Rules of AI Safety

1. There are 4 basic “roles” of AI in PSM. Use the one that’s appropriate to your circumstances
2. AI can only be safe to use if you have a mechanism to validate its results



# Feel Free to Join the AI-PSM Group on LinkedIn



# **Progress to Date**

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# Major Themes on AI-PSM

- Mathematical problem solving
  - Engineering problem solving
  - Prompt engineering
  - Benchmarking
-

# Mathematical Problem Solving: 2024

RH

What are the roots of " $x^3 - 6x^2 + 11x - 6 = 0$ "



So, the roots of the original cubic equation  $x^3 - 6x^2 + 11x - 6 = 0$  are  $x = 1$ ,  $x = 2$ , and  $x = 3$ .

RH

What are the roots of " $x^3 - 6x^2 + 11x - 6 = 0$ "



Therefore, the roots of the original cubic equation  $x^3 - 6x^2 + 11x - 6 = 0$  are  $x = 2$ ,  $x = i\sqrt{3}$ , and  $x = -i\sqrt{3}$ .

# Mathematical Problem Solving: 2025

What are the roots of " $x^3 - 6x^2 + 11x - 6 = 0$ "?

The roots of the equation  $x^3 - 6x^2 + 11x - 6 = 0$  are 1, 2, and 3. [\[>-\]](#)

# ChatGPT on the NAEP\* 2022 Math Tests

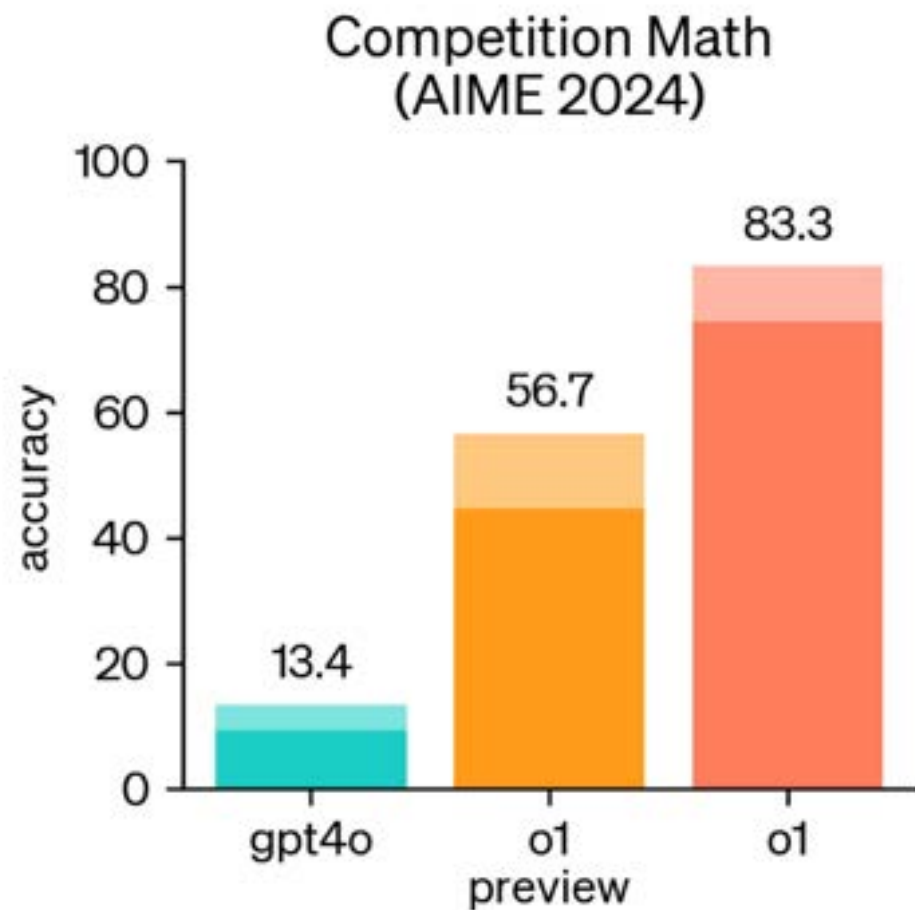
Test Taker:	ChatGPT-4	ChatGPT-4o	Students
%-correct	59%	63%	18%

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\* National Assessment of Educational Progress



# What About the Math Olympiad?



# Engineering Problem Solving: 2024

- Q: What is the  $K_{st}$  of a dust that was
    - tested in a 20 liter test vessel and
    - had a maximum pressure increase rate of 100 bar per second?
  - A: And the results:
    - 20 attempts
    - 13 unique answers
    - All of them WRONG!
-

# Engineering Problem Solving: 2025

The  $K_{st}$  value (the dust deflagration index) is calculated using the equation:

$$K_{st} = \frac{dP}{dt}_{max} \times V^{1/3}$$

$$K_{st} \approx 27.1 \text{ bar m/s}$$

Thus, the  $K_{st}$  value of the dust is approximately 27 bar·m/s, which falls in the **St-1** category (mild explosion hazard).

100% Correct!

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# Prompt Engineering: 2024

Q: What color is the sky?

Q1: It's noon. What color is the sky?

Ans: Blue

Q2: What a beautiful sunset! What color is the sky?

Ans: Red

- Problems:

- Lack of consistency and predictability
  - (Lack of) adaptability across use cases
  - Lack of a standard evaluation metric
-

# AI Agents: 2025

Scientific?

Agents can:

- Set the context of the interaction
  - Ask the user for more information
- 



Artful?

# Progress to Date

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## Benchmarking

# The PSM.1 Benchmark Set



1. MOC Scoping
- 2. MOC Replacement-in-Kind**
3. Incident Evidence Gathering
4. Incident Sequence of Events
5. Incident Root Causes
6. Incident Trending
7. Startup Procedure Creation
8. P&ID Feature Extraction



9. Draw a P&ID for a Single Node
10. Conduct a HAZOP for a Node
11. Conduct a What-If for a Node
12. Initial Risk Level Determination
13. Mitigated Risk Level Determination
14. ORR/PSSR Checklist Selection
15. Audit Streamlining

# RIK Agent: 2025



- Me: (click on the MOC vs RIK agent)
- ChatGPT: This GPT determines whether a proposed change is a Replacement-in-Kind (“RIK”) or a Management of Change (“MOC”) instance.

- Me:
  - This scenario covers a pressure vessel used in the manufacture of acetic acid.
  - The pressure vessel is 5 meters in diameter and 50 meters tall.
  - Acetic acid is manufactured using the Cativa process, running at 200°C with a pressure of 50 bar.
  - In this scenario a pressure safety valve is to be added to the acetic acid tank.



# RIK Agent: 2025



- ChatGPT: It then asks 12 questions for further clarification, which fall into the categories of:
  - Reason for Change
  - Current Pressure Protection
  - Design and Sizing
  - Impact on Process and Equipment
- Me: (I answer all the questions)
- ChatGPT: Based on your responses, this requires a Management of Change (MOC).

# RIK Agent: 2025

Here's why:



✓ **New safety requirement & compliance with ASME B&PV Code** – Even though operating conditions remain unchanged, adding a PSV introduces a new safety device that wasn't previously part of the system.

✓ **Modification to the pressure vessel** – The need for a **nozzle reinforcement** constitutes a physical change to the vessel, which is not a direct like-for-like replacement.

✓ **Change in pressure protection philosophy** – Even though the set pressure and relieving capacity remain the same, moving from a rupture disk-only setup to a PSV + rupture disk introduces a **different relief strategy**, which could impact process safety considerations.

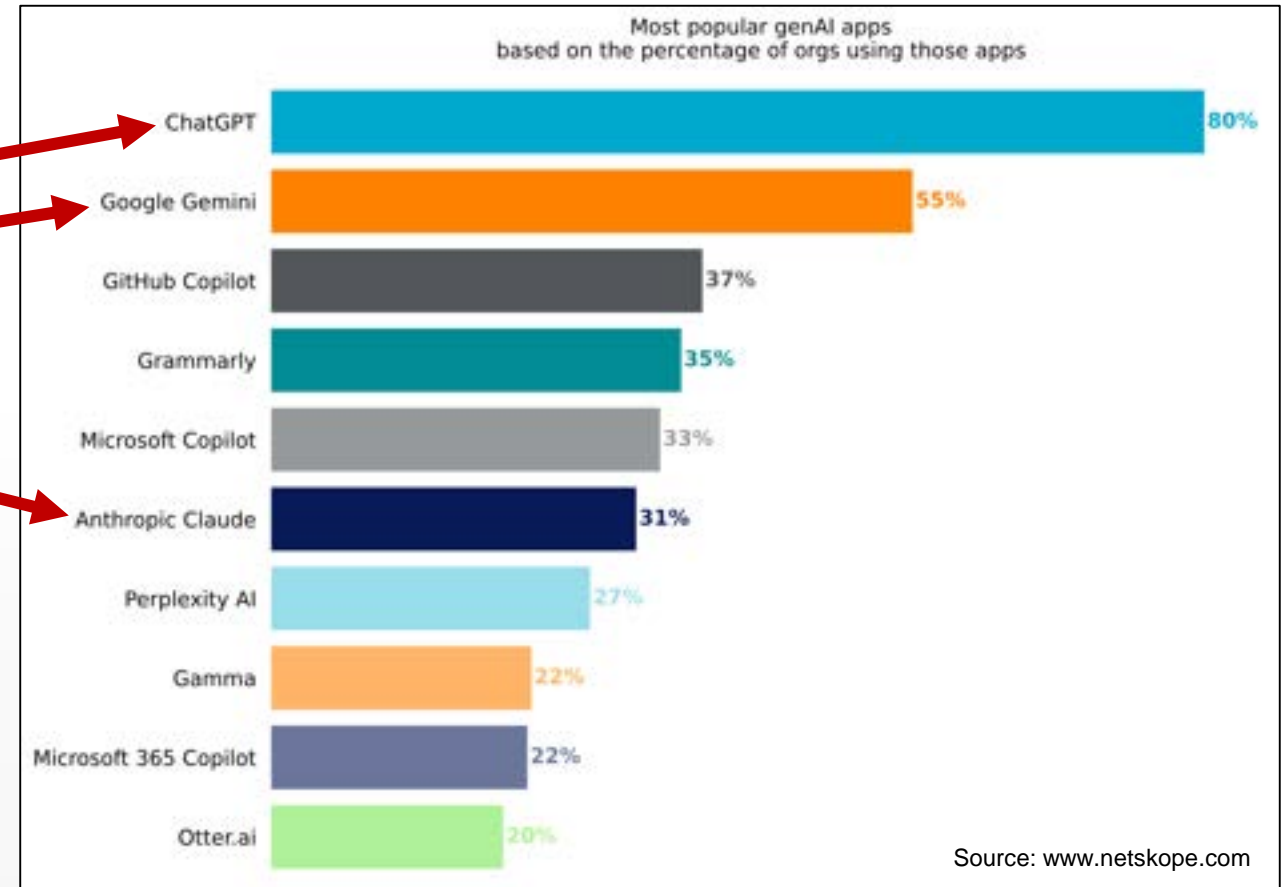
- Since these factors **affect equipment design and safety controls**, an MOC is required to assess risks, ensure compliance, and document the change properly.

# RIK: Reliability Concerns

- Math problems:
    - Originally lacked repeatability
    - Today, have near perfect repeatability for well-understood problems
  - Engineering problems:
    - Originally got incorrect answers—a lot of them!
    - Today, have near perfect repeatability for well-understood problems
  - Q: Is Replacement-in-Kind a “well understood” problem?
-

# RIK: Repeatability

- Testing RIK repeatability:
  - Try different LLMs
- Using the current paid versions of:
  - ChatGPT 5 Thinking
  - Gemini 2.5 Pro
  - Claude Opus 4.1
  - Grok 4 Expert



# RIK: Repeatability Determination Method

1. [Me] Context Setting
  2. [AI] Context Confirmation
  3. [Me] Problem Statement
  4. [AI] Initial Response
    - a) Answer
    - b) Justification
    - c) Caveats
  5. [AI] Assumption Validation
-

# 1. Context Setting

- Are you aware that the Management of Change process, while often necessary, requires resources?
  - If the scenario is a “Replacement-in-Kind”, then the Management of Change process does not need to be followed.
  - Can you determine whether a given scenario calls for a Management of Change process or is simply a Replacement in Kind?
  - You need to state the reasons for your decision.
  - In order to support your analysis, you can ask me as many questions as you wish, and I will answer them correctly.
  - Are you ready?
-

## 2. Context Confirmation



[ChatGPT]

- Yes, I'm ready.
  - Please provide your first scenario, and I'll determine whether it calls for the MOC process or qualifies as a RIK.
  - To reach a sound conclusion, I may ask you clarifying questions, one at a time about the process, equipment, materials, operating conditions or documentation.
-

### 3. Problem Statement: XL-1000 -> XL-1000

Prompt:

- The scenario covers a pressure vessel used in the manufacture of acetic acid.
  - The pressure vessel is 5 meters in diameter and 50 meters tall.
  - Acetic acid is manufactured using the Cativa process, running at 200C with a pressure of 50 bar.
  - The pressure vessel has an adequately sized pressure safety valve that trips when the pressure reaches 60bar
  - The pressure safety valve is a model XL-1000 (fictitious) and needs to be replaced.
  - If the XL-1000 is replaced with another XL-1000, is that a RIK or an MOC?
-



## 4a Answer



- Based on the details provided, this is a Replacement-in-Kind and does not require the Management of Change process.

## 4b Justification



[Gemini]

- My reasoning is that the replacement component (a new XL-1000 pressure safety valve) **is identical** to the component being replaced (an old XL-1000).
  - ...
  - A key principle of RIK is that the change does not alter the documented **Process Safety Information**, such as the relief system design basis or the P&IDs.
-

## 4c Caveats



[ChatGPT]

- Quick confirmation checklist:
    1. Tag match to original PSV spec sheet
    2. Material/trim and soft-seat/hard-seat match
    3. Inlet/outlet ratings and backpressure limits unchanged
    4. No process condition changes since the last verified relief study
    5. PM/inspection records updated; calibration certificate filed
-

# 5 Assumption Validation







[Claude]

1. Is the replacement XL-1000 valve from the same manufacturer as the original XL-1000?
2. Is the model number exactly the same—just “XL-1000” with no changes in suffix, version numbers, or series designation (like XL-1000A, XL-1000-II, etc)?
3. Is the set pressure of the replacement valve the same 60 bar as the original?
4. Does the replacement valve have the same capacity/flow coefficient ( $C_v$  value) as the original XL-1000?

6 more questions!

# Summary: XL-1000 -> XL-1000





	1. Context Setting	2. Context Confirmation	3. Problem Statement	4a. Answer	4b. Justification	4c. Caveats	5. Assumption Validation
 ChatGPT	7	4	6	RIK – 2	15	15	-
 Claude	7	19	6	RIK – 4	6	21	65
 Gemini	7	19	6	RIK – 1	5	28	-
 Grok	7	1	6	RIK – 2	19	3	-

# Problem Statement: XL-1000 -> XL-1000R

Prompt:

- The XL-1000 PSVs are no longer available from the manufacturer.
  - Now they are selling the XL-1000R which is functionally identical to the original XL-1000
  - , except that the XL-1000R is painted red (hence the “R”) with rust-inhibiting paint.
  - Is this still a Replacement-in-Kind?
-

# Summary: XL-1000 -> XL-1000R

	1. Context Setting	2. Context Confirmation	3. Problem Statement	4a. Answer	4b. Justification	4c. Caveats	5. Assumption Validation
 ChatGPT			3	RIK – 2	13	6	3
 Claude			3	MOC – 2	23	n/a	0
 Gemini			3	MOC – 2	28	n/a	0
 Grok			3	RIK – 2	22	0	0

# Some Interesting Comments



[ChatGPT]: adds some helpful advice:

- ❖ Update the spares list
- ❖ File the calibration/cert sheet for the specific device
- ❖ Don't paint gasket faces or threaded connections



[Claude]: "However, this should be a Simplified/Streamlined MOC".



[Gemini]: "The MOC doesn't have to be difficult"









# Problem Statement: XL-1000 -> XL-1000-DR

- It turns out that the XL-1000R isn't available either.
  - Instead, they are proposing the XL-1000DR.
  - The XL-1000DR is functionally identical to the original XL-1000
  - , except that it has a digital readout (hence "DR")
  - , which displays the current pressure on the vessel side of the PSV.
  - Is this still a Replacement-in-Kind?
-

# Summary: XL-1000 -> XL-1000DR

	1. Context Setting	2. Context Confirmation	3. Problem Statement	4a. Answer	4b. Justification	4c. Caveats	5. Assumption Validation
 ChatGPT			4	MOC – 5	22	n/a	0
 Claude			4	MOC – 3	31	n/a	0
 Gemini			4	MOC – 5	32	n/a	0
 Grok			4	MOC – 2	27	n/a	0

# Some Succinct Comments



[Claude]: “Why this requires MOC – Critical concerns:

- ❖ **New instrumentation component**

- ❖ **Fundamental design change:** transforms a purely mechanical safety device into one with electronic components

- ❖ **New utility requirements:** power supply needed, cable routing

- ❖ **Safety integrity concerns:** SIL rating implications if the PSV is part of a SIF

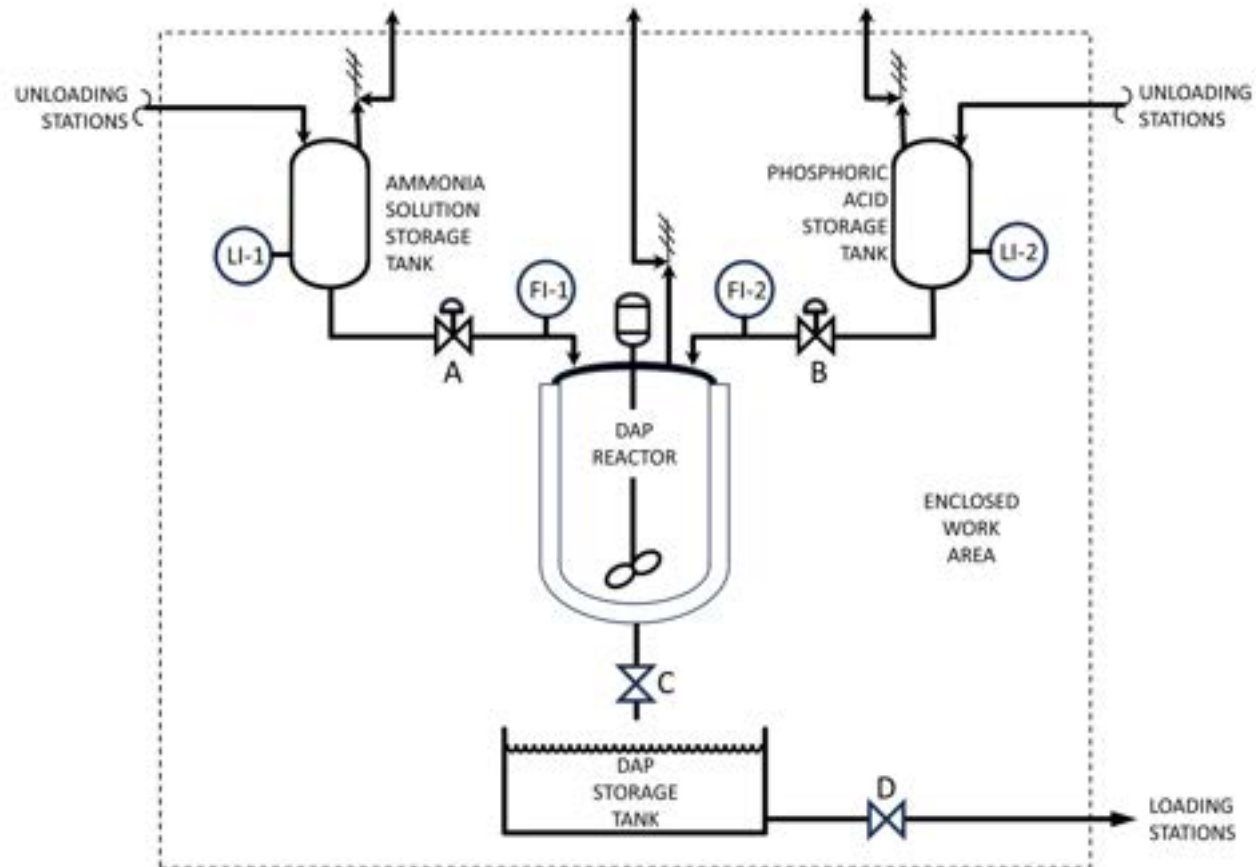
- ❖ **Hazardous area classification:** electronic need evaluation for explosive atmosphere

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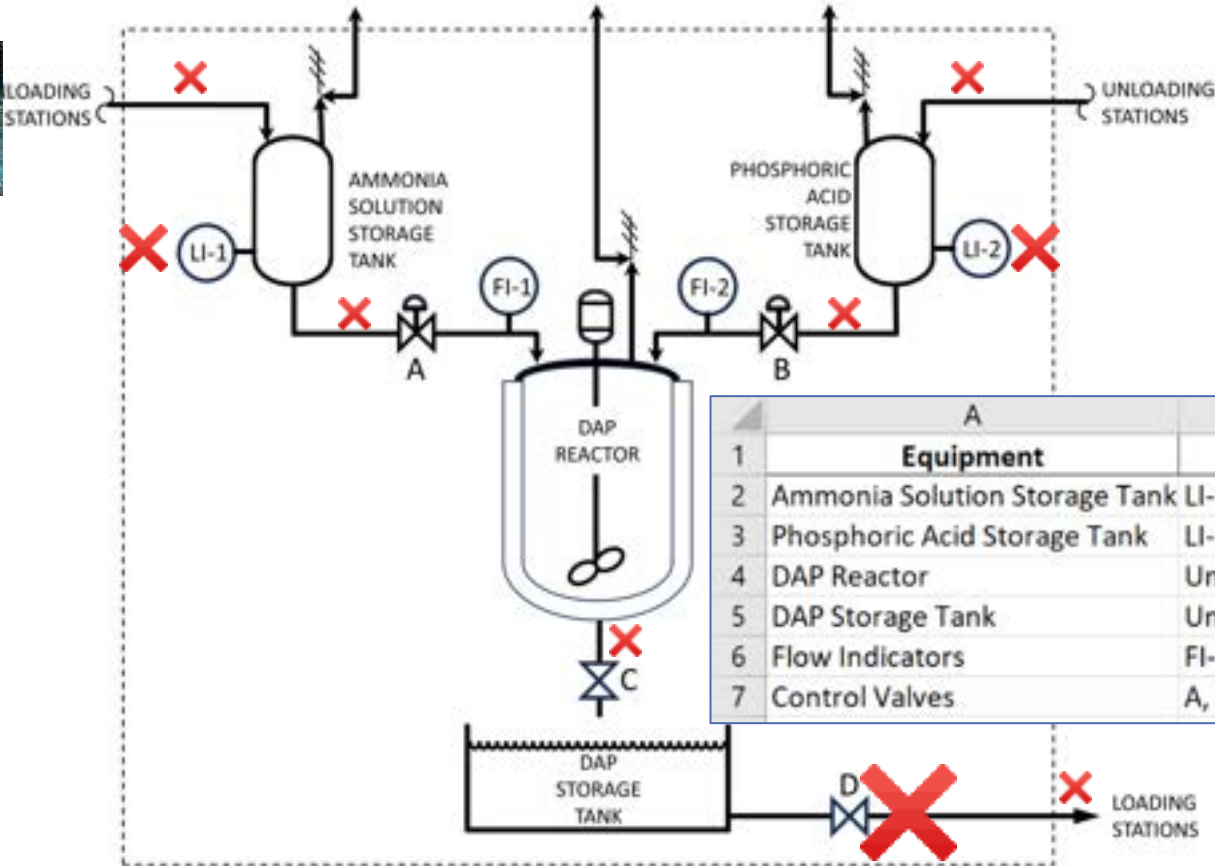
# RIK Reliability Conclusions

- Replacement-in-Kind determination appears to be a “well understood” use case for leading Gen AI tools
  - Results are repeatable; the first step in declaring something “reliable”
  - Excellent consistency between different LLMs
  - Where major LLMs diverge is that some are more conservative than others—generally considered a plus.
  - Replacement-in-Kind is a challenge for everyone, but a greater challenge for less-experienced engineers
  - The Leading GenAI tools can lead a junior engineer through the thought process of qualifying a scenario as RIK or MOC
-

# P&ID Feature Extraction: 2024



# P&ID Feature Extraction: 2024



	A	B	C
1	Equipment	Label	Description
2	Ammonia Solution Storage Tank	LI-1	Stores ammonia solution before fed into the reactor
3	Phosphoric Acid Storage Tank	LI-2	Stores phosphoric acid
4	DAP Reactor	Unlabeled	Central vessel where DAP chemical reaction occurs
5	DAP Storage Tank	Unlabeled	Holds finished DAP product before going to loading stations
6	Flow Indicators	FI-1, FI-2	Measure flow rate of ammonia solution (FI-1) and phosphoric acid (FI-2)
7	Control Valves	A, B, C	Control the flow of materials (ammonia, phosphoric acid, and product)

# P&ID Feature Extraction: 2025



	A	B
1	Category	Description
2	Equipment	Ammonia Solution Storage Tank
3	Equipment	Phosphoric Acid Storage Tank
4	Equipment	DAP Reactor
5	Equipment	DAP Storage Tank
6	Instruments	LI-1 (Level Indicator on Ammonia Solution Storage Tank)
7	Instruments	LI-2 (Level Indicator on Phosphoric Acid Storage Tank)
8	Instruments	FI-1 (Flow Indicator on Ammonia Solution line)
9	Instruments	FI-2 (Flow Indicator on Phosphoric Acid line)
10	Lines	Line from unloading stations to Ammonia Solution Storage Tank
11	Lines	Line from Ammonia Solution Storage Tank to DAP Reactor (via Valve A)
12	Lines	Line from unloading stations to Phosphoric Acid Storage Tank
13	Lines	Line from Phosphoric Acid Storage Tank to DAP Reactor (via Valve B)
14	Lines	Line from DAP Reactor to DAP Storage Tank (via Valve C)
15	Lines	Line from DAP Storage Tank to Loading Stations (via Valve D)
16	Other Items	Valve A (Controls ammonia solution flow to reactor)
17	Other Items	Valve B (Controls phosphoric acid flow to reactor)
18	Other Items	Valve C (Controls outflow from reactor to storage)
19	Other Items	Valve D (Controls outflow from storage to loading stations)
20	Other Items	Enclosed Work Area (Delineates process boundary)



# Hazard Analyzer

By Emer Sweetnam 

Analyzes P&IDs for HAZOP studies with engineering insights.

Analyze this  
P&ID for HAZOP.

Identify potential  
hazards in  
this diagram.

Suggest  
improvements  
for this P&ID.

How does this  
P&ID comply with  
safety standards?



# Hazard Analyzer Agent

Analyze this P&ID for HAZOP.

Please upload the Piping and Instrumentation Diagram (P&ID) and I will analyze it for potential hazards and operability issues using HAZOP methodology.

I will focus on key parameters such as:

- **Flow** (blockages, reverse flow, leaks)
- **Pressure** (overpressure, depressurization)
- **Temperature** (overheating, freezing risks)
- **Level** (overflow, dry running)

If there are any specific concerns or areas of interest in the process, let me know so I can prioritize them in the analysis.

# Initial HAZOP

HAZOP Study – Key Parameters

Node	Deviation	Potential Causes	Consequences	Recommendations
Ammonia Solution Storage Tank	High Level	Overfilling due to uncontrolled unloading	Tank overflow, ammonia release (toxic & corrosive)	Install <b>high-level alarm (LAH)</b> and interlock with unloading
	Low Level	Excessive withdrawal, leak	Reactor feed interruption, possible pump cavitation	Install <b>low-level alarm (LAL)</b> to prevent pump damage
Phosphoric Acid Storage Tank	High Level	Overfilling from unloading	Acid spill (highly corrosive, hazardous)	High-level alarm and automatic unloading shutoff
	Low Level	Excessive withdrawal, leak	Reactor imbalance, potential reaction hazard	Implement low-level alarm and interlock system
Feed Lines (A & B)	No Flow	Blocked valve, pump failure, sensor failure	Reactor starvation, incomplete reaction	Ensure bypass line or redundant pump, install low-flow alarm
	High Flow	Valve malfunction, excessive pressure	Overloading of reactor, possible overpressure	Install <b>flow control valve (FCV)</b> and interlock with reactor

HAZOP Study – Key Parameters

Node	Deviation	Potential Causes	Consequences	Recommendations
DAP Reactor	High Pressure	Excess reactants, improper venting	Risk of reactor rupture, toxic gas release	Install <b>pressure relief valve (PRV)</b> and pressure alarm
	Low Pressure	Vacuum formation due to rapid condensation	Reactor collapse (implosion)	Install <b>vacuum relief system</b>
	High Temperature	Excess ammonia or acid reaction	Thermal runaway, risk of explosion	Install <b>temperature alarm (TIH)</b> and emergency shutdown
	Low Temperature	Insufficient reaction heat	Poor product quality	Install reactor heating system if needed
DAP Storage Tank	High Level	Uncontrolled reactor discharge	Overflow, environmental contamination	Install <b>high-level alarm (LAH)</b>
	Low Level	Excess withdrawal	Air entrainment in transfer line	Install <b>low-level switch (LAL)</b>
Loading Stations	No Flow	Valve closed, pump failure, blockage	Production delay	Redundant pumps, regular maintenance
	High Flow	Overpressure from rapid discharge	Overfilling, spill risk	Install <b>flow control valve (FCV)</b>

# Initial HAZOP

## Conclusion

This system has potential **hazards** related to **pressure buildup**, **chemical exposure**, **flow imbalance**, and **overflowing**. By implementing **safety interlocks**, **alarms**, **relief devices**, and **proper material selection**, the risks can be minimized.

Would you like a more detailed assessment on a specific section? 🚨

Is lack of agitation in the DAP Reactor a potential problem?

## And then some...

- Completed the agitator HAZOP
- Identified agitation design requirements for DAP Reactor
- Identified critical parameters for agitator selection
- Identified potential issues (and hazards)
- Recommended a complete design (including baffles in reactor)
- Calculated power requirements
- Calculated efficiency
- Calculated shear rate and mixing time

# Summary

ChatGPT and mathematical problem solving?



ChatGPT and engineering problem solving?



Prompt Engineering -> Agents



Benchmarks:

- Replacement-in-Kind determination
- P&ID feature extraction
- Conduct HAZOP on Node



# **Thank You!**

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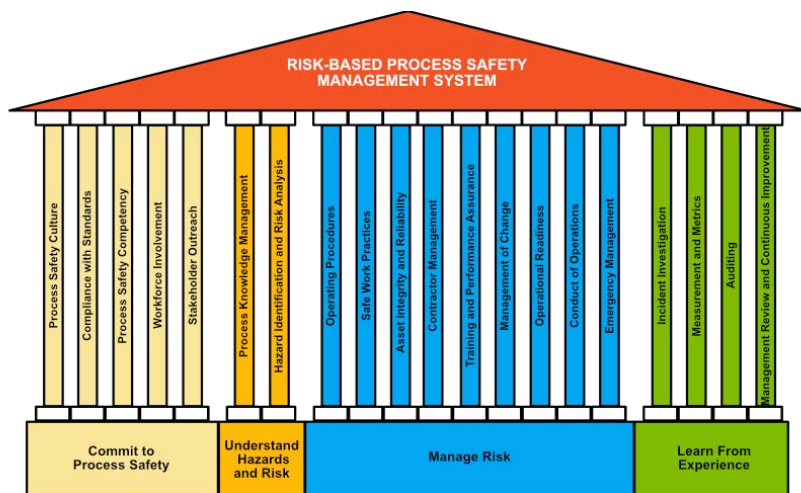
# Questions?

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(or send them to: [rhoff@gatewaygroup.com](mailto:rhoff@gatewaygroup.com))

FACILEX® by Gateway.

A “Complete Solution” for process safety management, as defined by the Center for Chemical Process Safety (CCPS). Solutions for all PSM elements.



[www.GatewayGroup.com](http://www.GatewayGroup.com)



Rainer Hoff, PhD, PEng  
Founder, President, Gateway Group  
AIChE Fellow



# AI-PSM Resources

## AI-PSM LinkedIn Group



<https://www.linkedin.com/groups/12839161/>







**Ian Sutton:**

[https://substack.com/@iansutton?utm\\_source=top-search](https://substack.com/@iansutton?utm_source=top-search)



**Hoff:**

Artificial Intelligence in PSM: First Steps.

<https://www.aiche.org/node/3445321>



**Malone T:**

What Is Collective Intelligence And Why Should You Use It?

<https://www.getsmarter.com/blog/career-advice/what-is-collective-intelligence-and-why-should-you-use-it/>



**White J, et al:**

A prompt pattern catalog to enhance prompt engineering with ChatGPT

<https://arxiv.org/abs/2302.11382>



**Emer Sweetnam:**

Hazard Analyzer

<https://chatgpt.com/g/g-3XdcsYtRD-hazard-analyzer>



# 20 Years... Looking Back At Buncefield

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Watershed Incident

# Buncefield, UK: Sunday, December 11, 2005

- Buncefield site was a major transfer terminal for gasoline (petrol) and aviation fuel in southern England
- Top tier site under the Control of Major Accident Hazards (COMAH) regulation [1999]



# Today's Talk

- Recall what happened
- Identify some PSM related failures
- Throw out an idea on an alternate way of analyzing risk

# What happened?

- Plan to fill Tank 912
  - Pumping rate set around 500–550 m<sup>3</sup>/h, by the British Pipeline Agency remote control room
  - At the start of the transfer, Tank 912 had an available ullage of ~ 5000 m<sup>3</sup>, necessitating a change of receiving tank at around 03:00–04:00 a.m.
- At approximately midnight, the terminal was closed to tankers; final checks completed at 01:30 am – presumably, field staff left for the night??
- At around 03:15 a.m., the level gauge on tank 912 became stuck, and from then on, the automatic gauge system (ATG) recorded a static reading of 12,188 mm (96.4% of the working tank capacity), but the tank continued to fill.
- The ATG only had a single CR display screen. To be able to show detailed information about individual tanks, separate screen windows were required to be nested one on top of the other. On the night of the explosion, four displays were nested in this way; it is not clear how visible tank 912 level had been, but it is believed that it was not the top display in the nest.

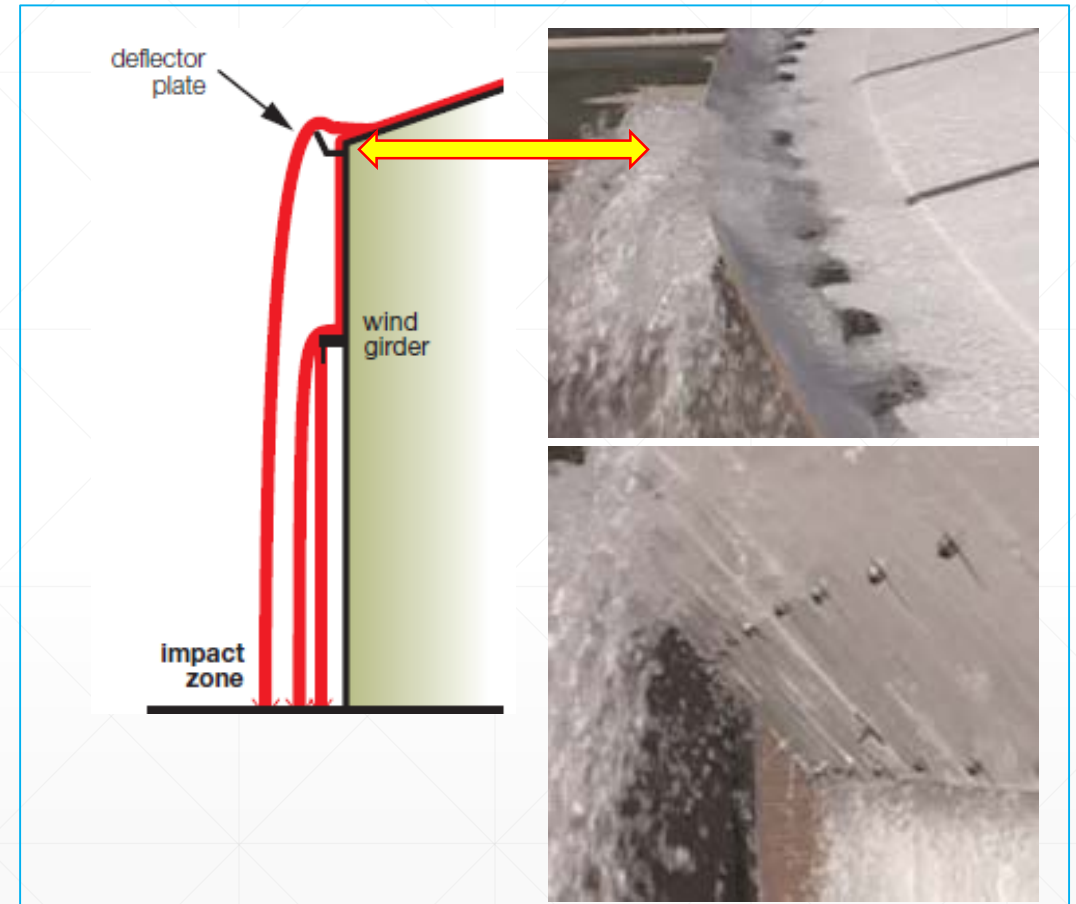
# What happened?

- **No diagnosis of flatlined level on Tank 912**
- During the night, the control room staff were distracted with another matter, prompting the control room supervisor to attend to it
- It was estimated that the level in tank 912 went past the ATG HLA at 03:29 a.m. and past the independent HHLA at 03:34 a.m.
  - **HLA Failure (BPCS) is the initiating cause**
- The independent HHLA protection system which should have automatically closed valves to prevent any more filling did not operate (**HHLA SIF failed**)
- Calculations show that at around 05:20 - 05:30 am, Tank 912 would have been completely full and starting to overflow



# What happened?

- Weather was calm with a light westerly breeze, but it was cold at about 0 °C. The gasoline would have been at around the normal ground temperature through which the pipeline ran of about 10 °C.
  - **Winter fuel containing 10% butane**
- The combination of the flashing of the lighter components in the gasoline plus vaporisation through turbulence and aeration produced a rich fuel/air mixture in bund A
  - Flow over deflector plate plus splashing on ground caused fragmentation / aeration increasing surface area for evaporation
- At 05.46, CCTV footage shows vapour escaping from the bund in all directions – the heavy vapour cloud was about 2 m deep.



# What happened?

- At 06.01, the first explosion occurred, followed by further explosions and a large fire that engulfed over 20 large storage tanks.
- The exact ignition point was not certain, but likely to have been a nearby generator house or nearby pump house ??
- Flammable vapour cloud estimated ~ 350 m in diameter
- By the time the explosion occurred, ~ 250 m<sup>3</sup> of gasoline had spilled from the top of the tank
- The Damage
  - 40 people were injured, but luckily no fatalities
  - Over 20 tanks damaged / destroyed
  - Significant offsite environmental contamination
  - Significant offsite damage, business interruption, including to Heathrow & Gatwick airports



# Watershed Incident

- There was wide interest in what had happened and concern to understand whether similar incidents could occur elsewhere at fuel terminals.
- Over 60 other sites storing gasoline were identified as having similarities to Buncefield.
- Prior to the Buncefield incident, fuel storage sites were generally not considered to be high risk and to present an explosion hazard on the scale that had occurred.
  - Fuels are stored at ambient temperature and pressure, and the only processing done was pumping them into and out of tanks.
- Buncefield changed this worldwide perception.
- During the investigations, it emerged that rather than being unique, Buncefield was only the latest of seven similar incidents identified in the previous 43 years (and there have been others since).

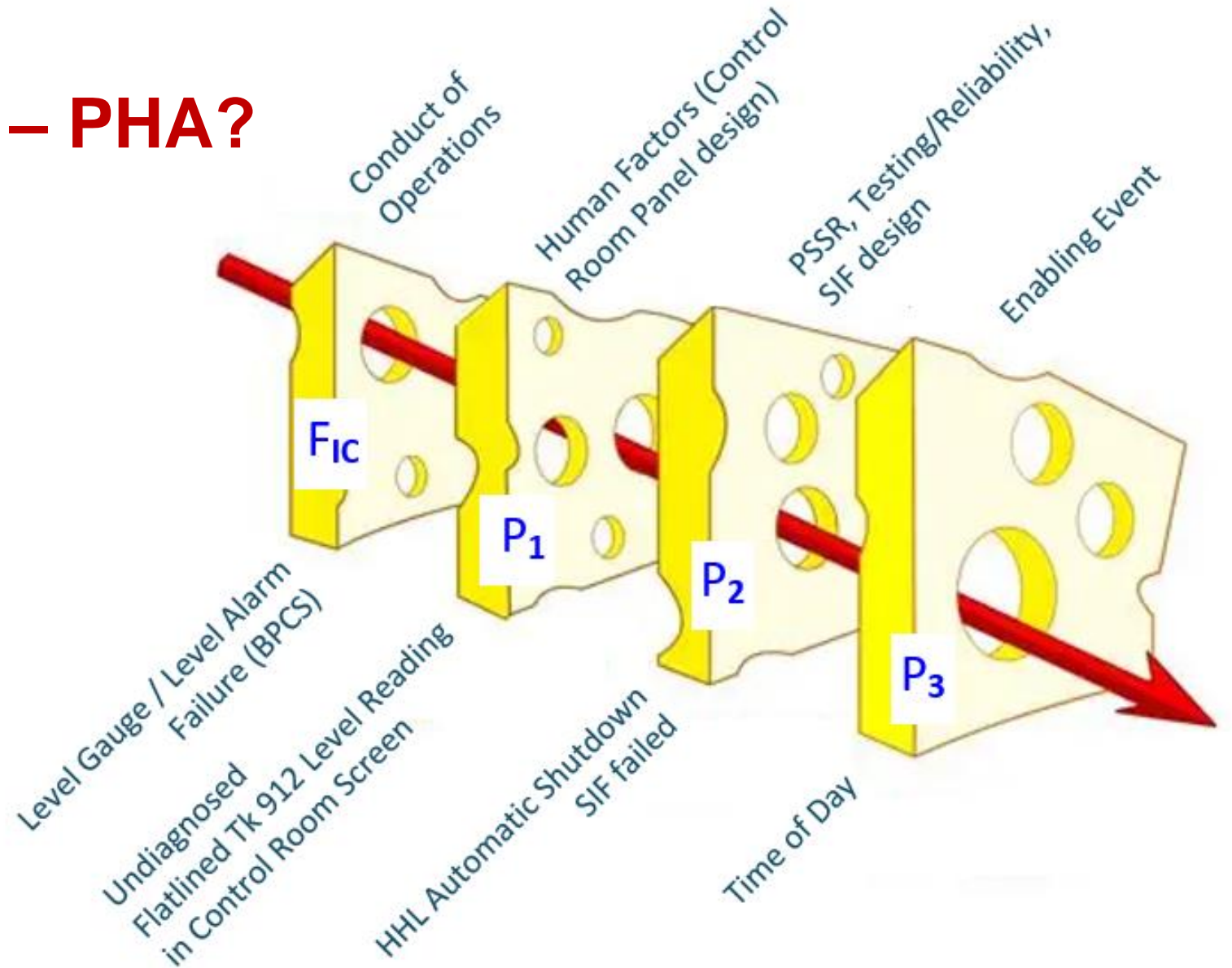
# Process Safety Management

Event	Issue regarding what happened	PSM Elements
Stuck level gauge	Investigation identified that Tk 912 level transmitter had similarly <b>flatlined on at least 14 occasions in the previous 3 months</b> , but no effective action had been taken to find the root cause or repair the fault completely.	Safety culture Incident investigation Equipment integrity Conduct of operations
Flat line level reading	Nested CR screens – no opportunity to diagnose. Did they know which tank they were filling?	Human factors Safety culture Operational discipline
HHL SIF failure	Test lever believed to be in the position that would have disabled the SIF – either (i) left in wrong position after test or fell downwards due to gravity (poor design). Padlock that would have kept the test lever in standby position (in design) was never installed. Test only tested electronic components not the mechanical components.	Inherent safety Poor design PSSR SIF reliability
Identifying hazards & understanding risk	COMAH safety case regulation required a risk assessment. Was it taken seriously? Were people competent? Did it dig deep enough? Was credible worst case consequence uncovered? Regulator approved it – were they competent?	Hazard identification and risk analysis requires care, competence, depth and use of appropriate methods when potential consequences are high.

# Risk Assessment – PHA?

Typical PHA frequency math:

$$F_{IC} \times P_1 \times P_2 \times P_3 =$$
$$0.1/\text{yr} \times 0.75 \times 0.1 \times 0.21 =$$
$$0.0016/\text{yr}$$
$$\sim 0.001/\text{yr}$$



# Analyzing Risk Accounting for HOF ... an Idea

- HOF = Human and organizational factors
  - Safety culture, leadership, conduct of operations, operational discipline, human factors/human error, etc.

$$\textit{Risk} = \textit{Frequency} \times \textit{Consequence} \times \textit{HOF}$$

HOF factor = 1.0 for facilities with good HOF (may in fact be less than 1.0)

HOF factor > 1.0 for facilities with poor HOF

In a PHA, poor HOF could be a negative credit

# Case for SIL Rating for SIFs in PHAs

- Worst credible consequence for Buncefield incident .... Tank overfill.....VCE... reasonable to assume multiple fatalities
- PHA frequency ... established earlier as 0.001/yr
- Should be a high risk in any risk matrix
- First recommendation should be to make the HHL SIF SIL 2 rated
  - A recommendation of the Buncefield Major Incident Investigation Board (as per BS EN 61511)
  - Companies don't like to talk about SIL
- If Buncefield had done a proper reliability assessment for the SIF, weaknesses could have been identified and the incident may never have occurred



# Fundamentals of PSM Course



## *1-Day In-Person Course on Canadian Process Safety Management Principles*

- + Gain Awareness – Understand the Canadian framework, principles, and best practices outlined in Canada's PSM standard.
- + Recognize Process Safety Hazards – Identify and assess risks before they lead to incidents.
- + Enhance Regulatory and Compliance Knowledge – Develop familiarity with industry standards, including CSA Z767 and other applicable guidelines.
- + Improve Safety Culture and Leadership – Strengthen a proactive mindset for continuous improvement.
- + Minimize Operational Risks – Understand how effective PSM can prevent process-related accidents, reduce downtime, and protect personnel, assets, and the environment.



### **Join Us...**

#### **Fundamentals of Process Safety Management for the Canadian Industry**

Jensen Hughes is sponsoring a training course that broadens awareness to Canada's PSM principles, focused on process safety hazard recognition, regulatory compliance, safety culture best practices, and risk minimization.

**University of Calgary, Downtown Campus**  
906 - 8th Ave SW  
Calgary, Alberta Canada T2P 1H9  
November 27, 2025  
9:00 AM - 4:30 PM EST (in-person)



# ***Join Us...***

## **Fundamentals of Process Safety Management for the Canadian Industry**

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# CSChE Process Safety Management Division: Activities and Collaboration Opportunities

Connor Murray, CSChE PSM Division Treasurer

PSM Specialist

Gibson Energy

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Chemical Institute of Canada | ***For Our Future***  
Institut de chimie du Canada | ***Pour notre avenir***



# History & Present

## History

- **Established in 1999** under the Canadian Society for Chemical Engineering (CSCHE) and the Chemical Institute of Canada (CIC).
- **Originated** from the Major Industrial Accidents Council of Canada (MIACC), founded in 1987, in response to address major industry accidents, such as the Bhopal disaster (1984).
- **Mission:** continuation of MIACC's commitment to promoting and enhancing industrial safety.
- **Vision:** no industrial or transportation incidents involving loss of containment of hazardous material or energy; with potential to harm people, environment, or property; occur in Canada.

## Today

- **A HUB for Process Safety in Canada:** fostering a community of volunteers and professionals.
- **Diverse Membership:** includes individuals from industry, academia, government, consults, and students.
- **25+ Years of Leadership:** PSM publications, education, and promotion in Canada
- **Key contributions:** developing PSM guidance documents, hosting symposiums, presenting awards, and providing training.
- **Influence:** shaping industry practices, education in Universities, and Canadian regulations and standards.

# 2025 Networking & Collaboration Opportunities

- **CSCChE 2025 Conference & PSM Division Symposium**
  - October 5-7 in Montreal
  - Two-day PSM technical program
  - Opportunities for networking and collaboration
- **PSM - Virtual Seminars 2025 Series**
  - 1-hour free seminars, the third Thursday of the month, 12 PM ET
  - Seeking speakers who are interested in sharing their PSM knowledge and journeys for 2026
- **Division Meetings**
  - PSMD AGM – October 7<sup>th</sup>
  - PSMD Q4 Meeting – October 9<sup>th</sup>
  - Open to both members and non-members

# Proposed Ideas

- **Goal:** Guidance PSM document(s) useable by all organizations, but targeting small and medium enterprises
- **Ideas We Are Exploring**
  - 1) Roadmap for upper management buy-in to PSM
  - 2) PSM roll-out roadmap based on case study examples
- **Next Step:** seeking connections and contacts to collaborate on these publications
  - Audience engagement survey
  - Peer reviewers

# Thank You! Questions?

**Join Our LinkedIn Group:**  
Canadian Process Safety  
Community to stay up to date



[www.linkedin.com/groups/8146764](https://www.linkedin.com/groups/8146764)

*Never miss a post, turn on notifications  
for all posts from this group.*

**Visit Our Website:** access  
past publications, webinars,  
and conferences materials



[www.cheminst.ca/psm/](http://www.cheminst.ca/psm/)

**Virtual Seminars:** Sign-up for  
upcoming seminars beginning  
September 18<sup>th</sup>



<https://www.cheminst.ca/cic-virtual/seminar-series/psm-virtual-seminar/>

# ENERGY SAFETY CANADA

## Process Safety CoP

CCPS Conference: Sept 11, 2025



# Updates

- What is the PS CoP all about?
- CoP Meetings
- FTF Meeting: Sept 24
- Working Group set up
- Data Collection & Analysis
- ESC Aspiration on PS



# Terms of Reference

## PS CoP Objectives

- Identify common industry needs or gaps. Gather and share PS best practices
- Share learnings from incidents, assurance activities, and successful work
- Identify linkages and opportunities for collaboration
- Gather and share PS resource materials
- Identify metrics, collect data and KPIs

# Terms of Reference

## PS CoP Membership

- Open to energy producers and service companies, and other PS SMEs within Canada
- Chair and Vice-Chair roles will be filled by members
- CoP members will be knowledgeable in Process Safety



# Terms of Reference

## PS CoP Mode of Operation

- Meet quarterly, at minimum
- ESC will coordinate the CoP activities
- Meetings are for open dialogs and focused presentations on PS
- Members to offer sharable resources and their expertise
- Unless otherwise agreed, cost incurred related to CoP activities will be borne by members

# PS CoP Meetings

- Four annually. 2 so far
- Feb 26:
  - Overview of Z767: PS Management
  - Successes & Challenges of Maintaining PS Discipline at Operating Areas
- May 28: Economic Implications of Latent Conditions in Process Risk Management
- Sept 24: FTF Meeting
- Nov 26: Speaker & Topic TBD

# Sept 24 FTF Meeting

- **Objectives**
  - Development of guides, tools and information to improve PS delivery
  - Review the PS CoP mandate and status of outstanding action items. Entertain PS presentations if time permits
  - Development of topics and content within the scope of each Working Group
- **Duration:** Full day
- **Participants:** All CoP members and potential members
- **Outcome:** A more focused CoP meeting the needs of its members

# Working Groups

Name	Purpose
Leadership & Strategy	To define the vision, mission, and strategic objectives of the CoP.
Technical Standards & Practices	To establish, review, and update process safety standards and practices.
Training & Development	To enhance the process safety knowledge and skills of community members.
Incident Review & Learning	To facilitate the sharing and analysis of process safety incidents.
Communication & Engagement	To foster collaboration and knowledge sharing within the CoP.
Metrics & Performance Monitoring	To measure and track the effectiveness of process safety initiatives.

# Data Collection & Analysis

- Repository is the ESC PS Data Gateway
- Registration is required to input data
- Send an email to [Safety@EnergySafetyCanada.com](mailto:Safety@EnergySafetyCanada.com) to get started on registration
- Feedback is required on usability & functionality to improve the app
- Annually renewal is needed for those inputting data to maintain access
- Data input is at any time throughout the year
- Put in your PS data today to conduct viable data analysis for the members

# ESC Aspiration

- Become regional PS Hub
- Supports organization in their PS journey
- Collaborate with global and regional bodies in promoting awareness and education on PS
- Become a member, where needed, to global PS associations to expand knowledge on PS

# Thank you!





## Center for Chemical Process Safety

September 11, 2025  
Calgary, Alberta


**Marcel E. Pouliot** P.Eng MBA  
Minerva Canada - Board Member

[www.safetymanagementeducation.com](http://www.safetymanagementeducation.com)





**Marcel E. Pouliot** P.Eng MBA

- Minerva Board Member for the last 25 years.
- Former Executive for 30 years with Trimac Transportation.
-  **IQTC** (IQ Trucking Consultants Inc.) Lead Consultant



**MINERVA**  
Safety Management Education

- Overview of the Organization
- Online Courses
- Sponsorship Opportunities

[www.safetymanagementeducation.com](http://www.safetymanagementeducation.com)



- Non-profit, volunteer-run organization
- Sponsors
  - Business, professional organizations, academia & government
- Mandate
  - To be a global leader in health & safety management education
- Influence post-secondary health and safety curriculum
- Assist academia and industry with H&S training resources

## FOUNDING ORGANIZATIONS

- **Workplace Safety & Prevention Services**
- **Health and Safety Professionals Canada**
- **General Motors Canada**
- **Imperial Oil Limited**
- **DuPont Canada**

## OTHER MINERVA SPONSORS

- Ontario Ministry of Labour, Immigration, Training & Skills Development
- WorkSafeBC
- Nova Scotia Dept. of Labour, Advanced Education
- Board of Canadian Registered Safety Professionals
- Mitacs
- Engineers Canada
- Chemistry Industry Association of Canada
- Ontario Society of Professional Engineers
- University of Toronto
- University of Calgary
- Rio Tinto
- Chemtrade Logistics
- Service Hospitality
- NOVA Chemicals
- Bruce Power
- CF Industries
- Methanex
- ERCO Worldwide
- H.L.Blachford
- Canada Post
- Corteva Agriscience
- Conference Board of Canada
- Glencore
- BASF

**MINERVA  
CANADA**

Health & Safety  
is a Mindset

BY THE NUMBERS

**1,125**

Engineering/Business  
Professors from 52 post-  
secondary schools have  
attended our Learning Forums

**92%**

of Professors attending our  
Learning Forums use  
Minerva teaching materials

**64%**

of Minerva annual  
revenues come from  
corporate sponsors



**MINERVA**  
Safety Management Education

## Health and Safety Learning Forums

- Organize and fund Learning Forums to provide H&S learning materials for Engineering and Business professors.
- Fully fund the event for Professors to participate.
- Provide Case Studies and learning reference guides to participants.
- Multi-day Learning Forums have been held across Canada since 2004.



## Minerva Canada's Webinar Program

**“Significant interest and participation in the program since 2018”**

- **18 free webinars** held to date in partnership with the Conference Board of Canada.

Speakers and participants from academia, industry, government, professional associations

- **Wide array of topics** covered

H&S leadership, safety culture, management of change, management systems and risk management.

\*Worker Well Being theme in 2024 with AI theme in 2025.

- **Valuable tools** used successfully within industry shared with participants
- **Minerva website** provides recordings, presentations of past webinars<sup>7</sup>



**MINERVA**  
Safety Management Education

## **Minerva Canada Awards**

“More student, young worker awareness generated”

### **Minerva - Rising Star Award**

- Award open to all post secondary students, recent grads.
- Recognizes leadership ability to initiate, implement change on an important health & safety issue
- Winners announced at Canada's Safest Employers venue

### **Minerva – CIAC Case Study Competition**

- New 2023 competition, same eligibility as Rising Star
- Case Study focused on events with health & safety impacts
- Panel Discussion with top 3 finalists
- Awards at Conference Board of Canada Conference



**MINERVA**  
Safety Management Education

## Minerva Online H&S Courses

- Engineering Deans and Minerva industry sponsors endorsed this project.
- Focus areas covered with some of the 9 courses
  1. Applied Safety Fundamentals
  2. Hazard and Risk Management
  3. Personal Safety, Health and Wellness
  4. Law, Ethics, Professional Responsibility
  5. Human Factors, Ergonomics
  6. Occupational Hygiene
  7. Leadership and Systems
  8. Design for Safety
- Interactional online courses complete with quizzes & assignments
  - total of 31 modules representing approximately 60-70 hours of training.
- Courses applicable for use within academia, industry and associations.
- A licensing agreement needed for academia to access the courses.
- Sponsors receive free access to modules for certain number of employees.





# **MINERVA**

## Safety Management Education

<b>Basic Course for Managers</b>	<b>Advanced Course for Managers</b>
<b>Introduction to Health &amp; Safety – Course 100</b>	<b>Professional Ethics &amp; Conduct</b>
<b>Hazard, Risk and Controls – Course 100</b>	<b>Human Factors – Course 300</b>
<b>Legislation, Codes &amp; Standards – Course 200</b>	<b>Incorporating Safety into Engineering Design – Course 300</b>
<b>Mental Health in the Workplace &amp; Academia – Course 200</b>	<b>Health &amp; Wellness – Course 400</b>
<b>Leadership &amp; Management Systems – Course 200</b>	<b>Crisis &amp; Risk Communications – Course 400</b>
<b>Incident Investigation – Course 200</b>	<b>Managing Excellence in Health &amp; Safety – Course 400</b>
<b>The Business Case for Safety: The Role of Engineers &amp; Leaders – Course 300</b>	<b>Effective Committees (Manager - Supervisor)</b>
<b>Management of Change – Course 400</b>	
<b>Effective Communications</b>	



# MINERVA

## Safety Management Education

Basic Course for Practitioners	Advanced Course for Practitioners
Introduction to Health & Safety – Course 100	Leadership & Management Systems – Course 200
Hazard Identification – Course 200	Hazard Identification – A Continuation from Course 200 – Course 300
Risk Assessment & Management – Course 200	Risk Assessment & Hazard Control – Course 300
Legislation, Codes & Standards – Course 200	Codes, Standards & Regulations Overview – Course 300
Mental Health in the Workplace & Academia – Course 200	Human Factors – Course 300
Incident Investigation – Course 200	Crisis & Risk Communications – Course 400
Incorporating Safety into Engineering Design – Course 300	Health & Wellness – Course 400
The Business Case for Safety: The Role of Engineers & Leaders – Course 300	Management of Change – Course 400
Professional Ethics & Conduct	Managing Excellence in Health & Safety – Course 400
Effective Committees (Mgr./Employee)	Effective Communications
	<b>*Process Safety Management</b>



**MINERVA**  
Safety Management Education

## Our Clients

- **University of Toronto** – Faculty of Engineering
- **University of Calgary** – Faculty of Engineering
- **Laurentian University** – Goodman School of Mines
- **George Brown College** – Angelo Del Zotto School of Construction Management and School of Engineering Technologies
- **Ontario Tech University** – Faculty of Engineering & Applied Science
- **University of Windsor** – Faculty of Engineering
- **University of Fredericton**
- **University of Saskatchewan** – College of Engineering & Professional Development
- **Ontario Society of Professional Engineers** – Engineering Academy
- **Health and Safety Professionals of Canada**



**MINERVA**  
Safety Management Education



**Bluedrop Individual access:**

- Access any course
- Pay per use

<https://minervacanada.bluedrop.io/storefront/minervacanada>



**MINERVA**  
Safety Management Education

**Minerva Group access:**

- Licensing agreements available
- Hosting on your LMS,
- Group discounts available

<https://safetymanagementeducation.com/>



**MINERVA**  
Safety Management Education

## Feedback from our Learners...

*“Without health and safety, there is no way of conducting a project. Health and safety training lay the foundation of everything we do and they **both** must be regarded with the utmost importance.”*

*“**My attitude changed.** Before I thought it was not that important but now health and safety are always number one in my mind.”*

*“The content was amazing. I am a **seasoned safety professional** with multiple designations, and I learned a lot from this!!”*



## Become a Minerva Sponsor

- Some free employee access to Minerva online courses through Bluedrop platform along with 25% discounts for other employees.
- Recognition by CRSP on professional development by accessing Minerva online courses.
- Exclusive opportunities to collaborate with Minerva's academic partners and participate in projects, case studies, new online modules. Sponsors will also have access to Minerva case studies.
- Opportunities for classroom training using Minerva course content. Licensing agreement can be negotiated based on needs
- Employee access to Minerva webinars and possible invitation as guest speakers
- New employee participation in Minerva student awards.



# QUESTIONS?

[www.safetymanagementeducation.com](http://www.safetymanagementeducation.com)



**MINERVA**  
Safety Management Education

**THANK YOU!**

**Marcel E. Pouliot** P.Eng MBA  
Minerva Canada- Board Member

[www.safetymanagementeducation.com](http://www.safetymanagementeducation.com)





# MINERVA

## Safety Management Education

### **Course 100:** (6 modules, approx. 11-14 hours)

- Health and Safety 101 – the Fundamentals
- Hazards, Risk and Controls – An introduction
- Applying the above concepts, definitions & controls to:
  - Electrical Safety, Fire Safety, Laboratory Safety, Working at Heights

### **Course 200:** (7 modules, approx. 11-14 hours)

- |   |                     |
|---|---------------------|
| • Hazard Identification                   | Risk Management     |
| • Legislation, Codes, Standards           | Mental Health       |
| • Leadership and Management Systems       | Professional Ethics |
| • Incident Investigation, Causal Analysis |                     |



# MINERVA

## Safety Management Education

### **Course 300:** (7 modules, approx. 11-14 hours)

- Hazard Identification Part 2
  - Risk Management Part 2
  - Business Case for Safety
  - Incorporating Safety into Engineering Design
- Codes and Regs. Part 2
  - Human Factors
  - Professional Ethics Part 2

### **Course 400:** (8 modules, 14-18 hours)

- Process Safety Management
  - Radiation Safety
  - Risk and Crisis Communications
  - Health and Wellness
- Electrical Safety
  - Robotics Safety
  - Management of Change
  - Managing H&S Excellence

# 10<sup>th</sup> Annual Canadian Regional Meeting September 11, 2025

## How CCPS Can Assist Your Process Safety Journey?

### **Michele Horwitz**

Associate Director, CCPS Membership

[michh@aiche.org](mailto:michh@aiche.org)

646-495-1371



# CCPS CANADIAN MEMBERS



# Types of Industries Attending the Canada Meeting



1. **Business, Finance & Law**
2. **Chemicals & Commodity**
3. **Consulting**
4. **Education**
5. **Electronics & Semiconductors**
6. **Energy, Alternatives**
7. **Energy, Bio-Based**
8. **Energy, Nuclear**
9. **Engineering – Procurement Construction**
10. **Food Products & Processing**
11. **Health & Safety**
12. **Instrumentation & Automation**
13. **Natural Gas**
14. **Oilfield Services & Exploration**
15. **Petrochemicals and Petroleum Products**
16. **Petroleum Products and Refining**
17. **Pharmaceuticals**
18. **Process Safety**
19. **Software & IT**
20. **Utilities**
21. **Water Management**

# 70 Organizations in Attendance as of 9/10/25- 195 attendees (20 Member Companies, 3 Gov/Regulators, 2 Education)



- Advanced Innergy Solutions
- AIS Integral Ltd.
- **Alberta Energy Regulator**
- Annetega Consultant Corp.
- **AON Energy Risk Engineering (M)**
- AP Dynamics
- ARC Resources Limited
- **ATCO Next Energy (M)**
- AXA XL
- **BASF Corporation (M)**
- Bechtel
- **Berkshire Hathaway Specialty Insurance (M)**
- BFL CANADA
- **Canadian Natural Resources Ltd. (M)**
- Canlin Energy Corporation
- **Cargill (M)**
- **Cenovus (M)**
- **ChampionX (M)**
- **City of Calgary**
- Cleartech Industries
- ConocoPhillips
- Co-op Refinery Complex
- **Dow Chemical Company(M)**
- Enbridge
- Energy Safety Canada
- EPCOR Utilities Inc.
- FF Process Safety Inc.
- **Fluor (M)**
- **Gateway Consulting Group, Inc. (M)**
- GHD
- Gibson Energy
- Icarus - ORM
- INEOS
- Intact Insurance Specialty Solutions
- Inter Pipeline
- IQ Trucking Consultants Inc.
- **Jensen Hughes (M)**
- KBT Risk Control Inc.
- Kenexis
- Kent PLC
- Keyera Corp.
- Kiewit Energy
- LeanOptions Consulting Inc.
- Liberty Mutual Insurance Canada
- MEG Energy
- NorthRiver Midstream
- **Nova Chemicals Corporation (M)**
- **NWR Partnership (M)**
- Olitech Consulting
- Orano
- Ovintiv
- Paramount Resources
- Pembina Pipeline Corporation
- **Petronas Canada (M)**
- Plains Midstream Canada ULC
- PMO Global Services
- **Qatar Energy (M)**
- **Rio Tinto (M)**
- Risk Alive Analytics Inc.
- Risktec Solutions, Inc.
- **SAIT (Education)**
- Sherritt International PE
- South Bow
- Sovereign General Insurance Company
- Suncor Energy
- **TC Energy (M)**
- **Telluride Engineering (M)**
- Tidewater Midstream
- Timbers Consulting
- **TUV Rheinland Taiwan Ltd. (M)**
- **University of Alberta (Education)**
- Watchmen Instrumented Safety Experts
- **WorkSafeBC, Canada**
- Worley Canada
- Zurich Resilience Solutions



# 295 Member Companies (September 2025)

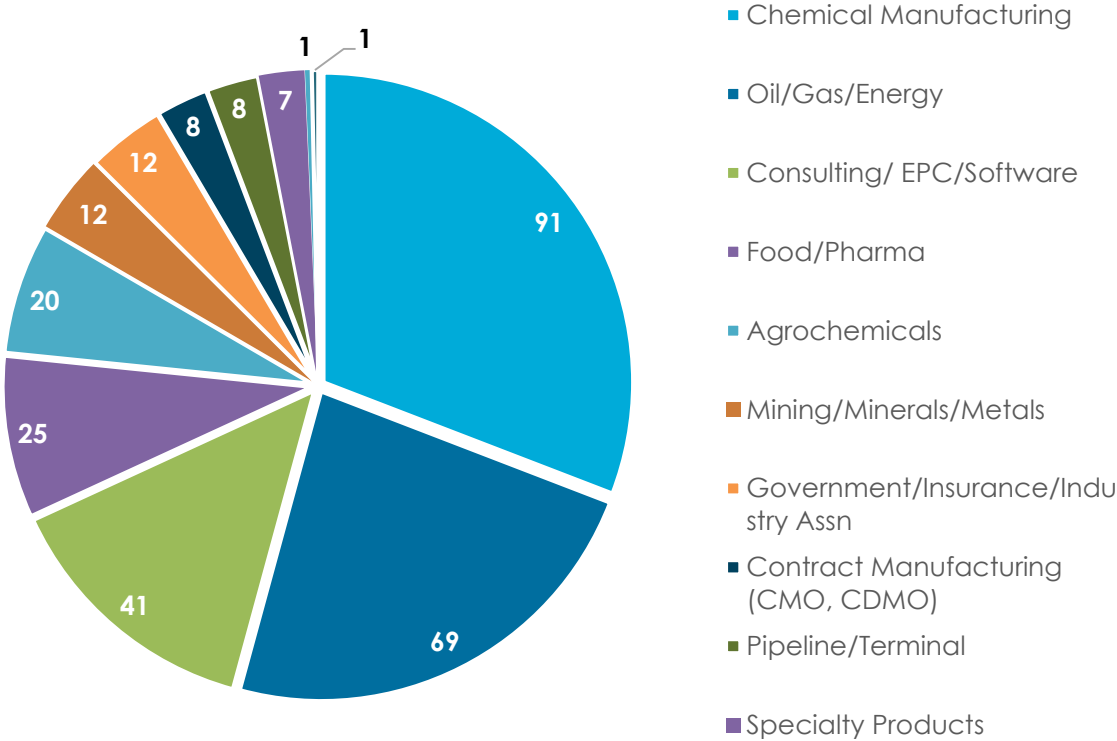


THE GLOBAL COMMUNITY COMMITTED TO PROCESS SAFETY

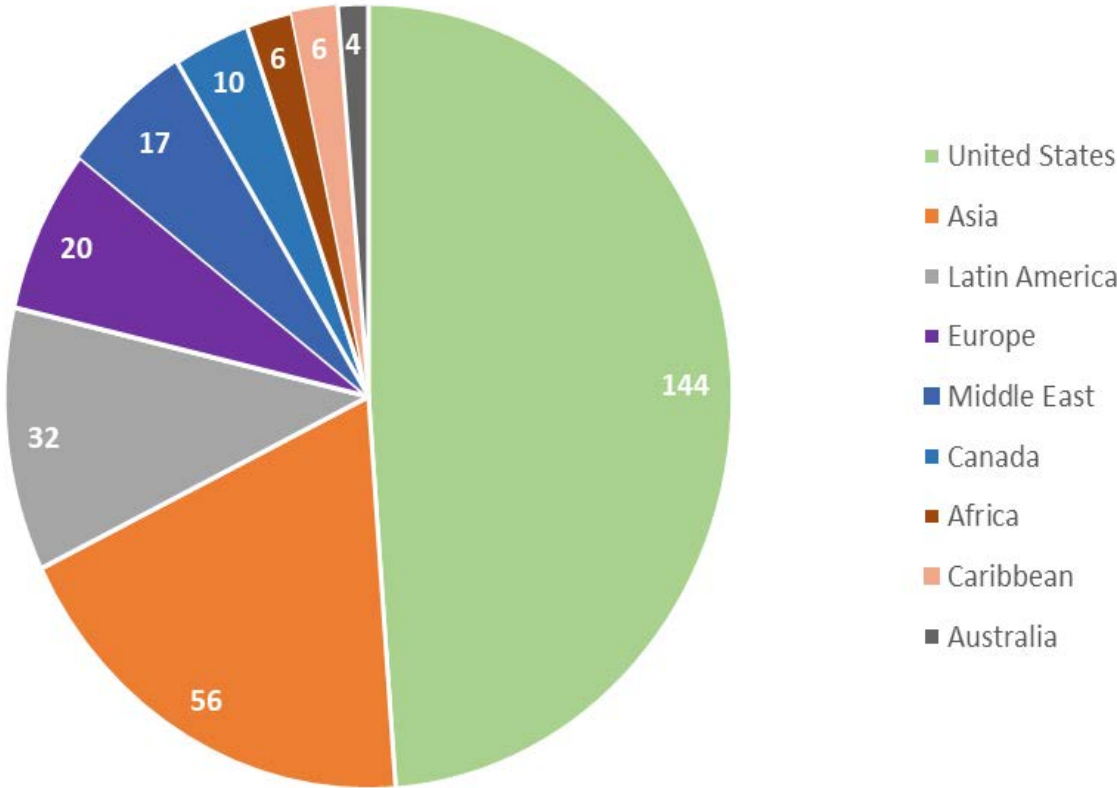
# CCPS Membership by Industry and Region [2025]



CCPS Membership by Industry



CCPS Membership by Region





# Global / Regional Engagement

**SPRING26  
+22<sup>ND</sup> GCPS**  
A Joint AIChE and CCPS Meeting

**April 12-16, 2026**

**CCPS Trinidad & Tobago  
Meeting  
Oct 9, 2025  
Co-Host:  
Heritage Petroleum**

**Virtual CCPS 2025  
TSC Meetings  
Sept 24  
10 am-12 noon ET**

**Global  
Conference  
on Process  
Safety &  
Big Data  
Frankfurt  
am Main  
November  
11-12, 2025**

**India Regional  
Mumbai Meeting  
Host: GIDM  
October 9, 2025**

**CCPS Canada  
Regional  
Meeting  
Calgary  
September 11,  
2025  
Co-Host:  
Ovintiv**

**API RP-754  
Implementation  
Workshop  
November 24-25, 2025  
Host: ADNOC  
Abu Dhabi Energy Center  
Time: 07:30 – 16:00  
Abu Dhabi, UAE**

**Middle East Process Safety Event  
Sept 16-17, 2025  
Saudi Arabia**

**Latin America Regional Meetings**

- Latin America Regional Mtg – CHILE,
  - OCTOBER 15-17, 2025
  - HOST: ENAP

**China Meeting  
Qingdao, China  
October 30-31, 2025**

**CCPS South East Asia Regional Meeting, Malaysia  
Host: Petronas  
October 6, 2025**

**Fall TSC Meeting, Houston  
November 5-6, 2025  
The Royal Sonesta Houston Galleria**

**CCPS Europe  
Regional Meeting  
Basel  
Host: Syngenta HQ  
Nov 14, 2025**

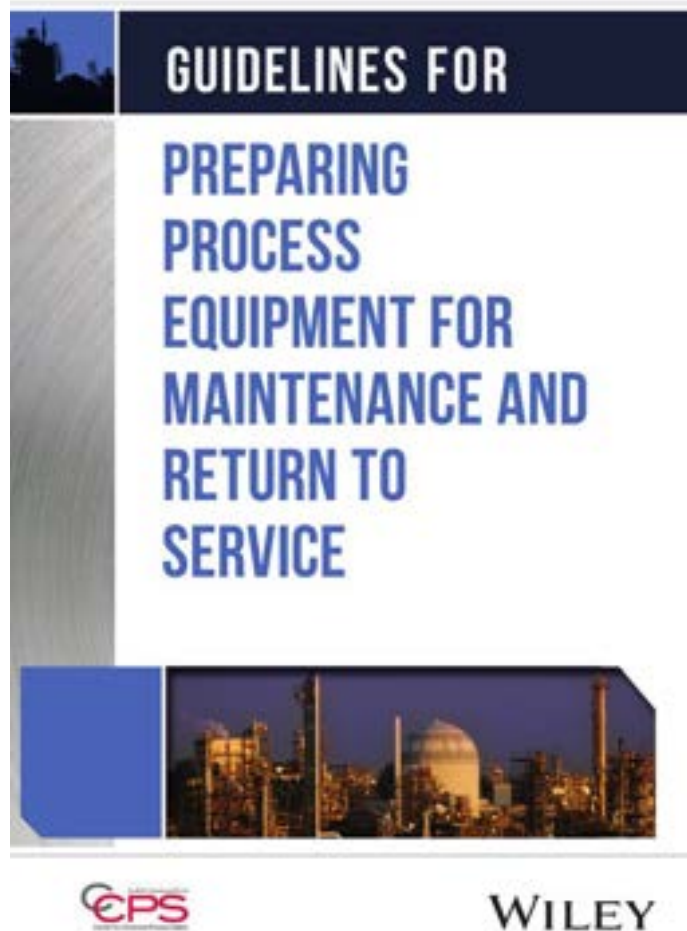
# CCPS Membership Benefits

# Education and Training

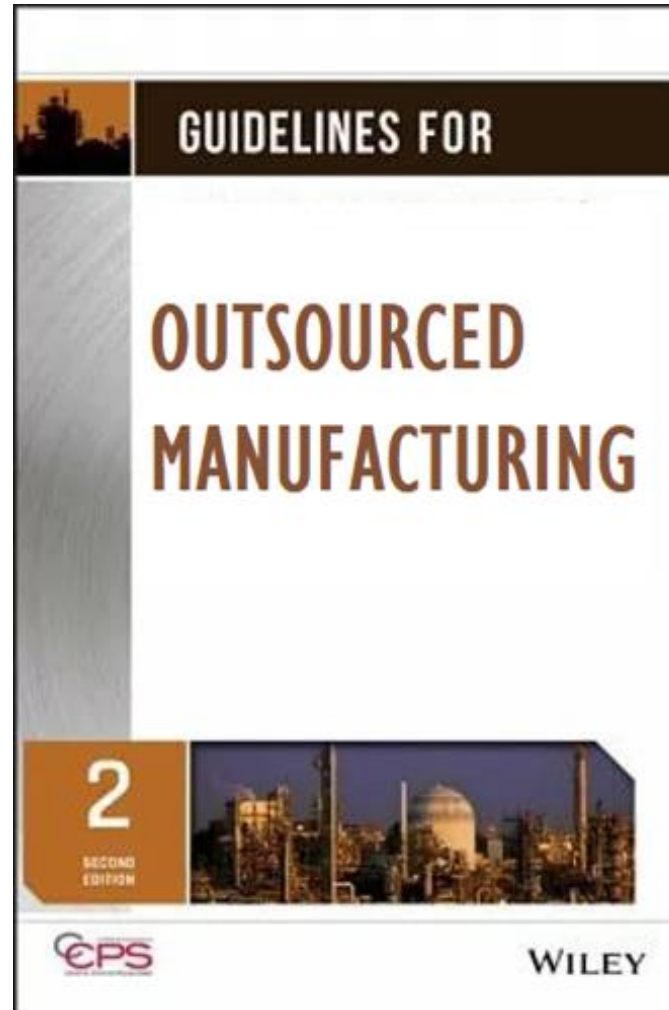


- Classroom and eLearning Content
  - LOPA
  - HAZOP Studies and other PHA Techniques for Process Safety and Risk Management
- In Person Training & Continuing Education
  - Risk Based Process Safety
  - Incident Investigation
  - Human Factors for Safety & Improved Performance
- Boot Camps – Taught by 30+ Year Veterans – Members get \$3K savings on Boot Camps
  - Presented virtual or at company site, related to company goals and objectives
- Free eLearning Courses for New Member Companies
- Free Sponsored Webinars for member companies >90
- Free CCPS course opportunities for newly launched CCPS courses
- Member Discounts on Conference or Education Training

New April 2025



Coming Q4 2025

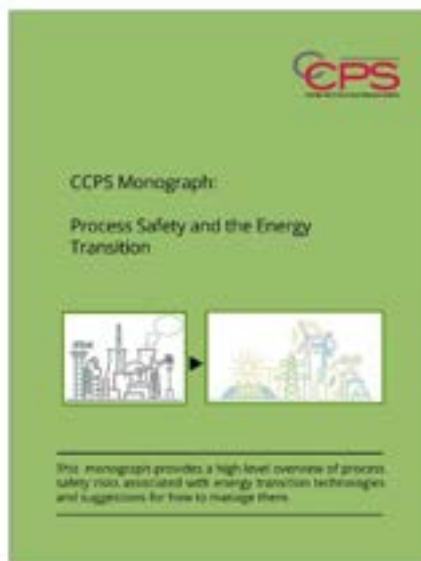
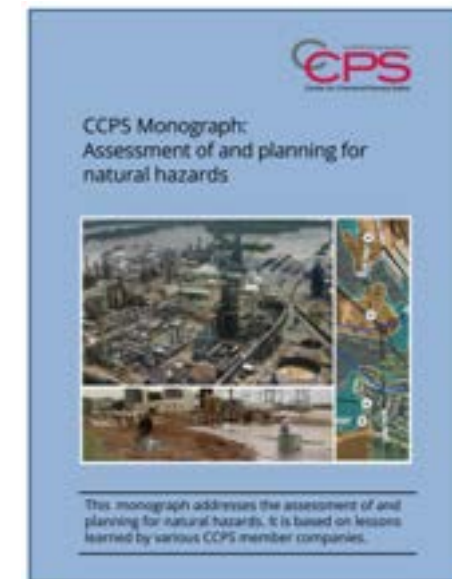
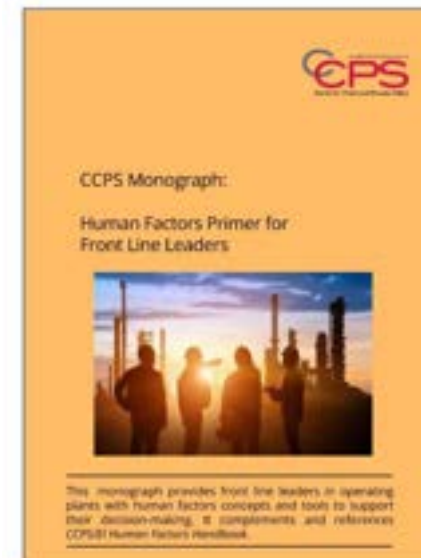
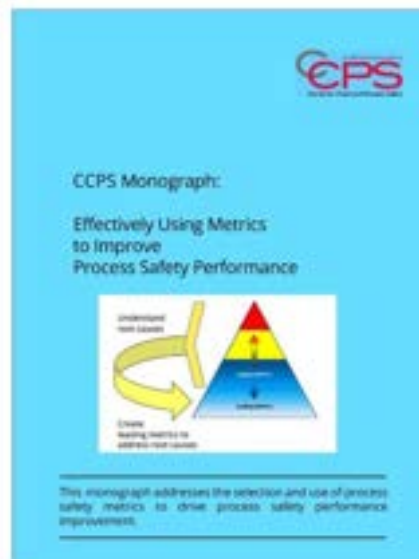
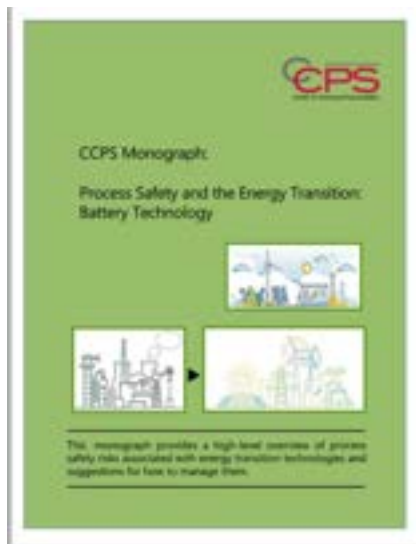


**Members get sent new books FREE**  
**35% discount on previously published CCPS and AIChE books**

**You can also contact Knovel to obtain all CCPS e-book content and Meeting Proceedings for 35% off as a CCPS member. Knovel handles billing. Email [michh@aiiche.org](mailto:michh@aiiche.org) for contact details**

[www.aiiche.org/CCPS/Publications](http://www.aiiche.org/CCPS/Publications)

# Monographs



Available online at CCPS



# Safe Work Practices Available Online

**SAFE WORK PRACTICE**  
ENERGY ISOLATION  
LOCK OUT - TAG OUT - TRY

**SAFE WORK PRACTICE**  
COMMON ELEMENTS  
OF CHASING AND OTHER CRITICAL AND  
Hazardous Practice Areas

**SAFE WORK PRACTICE**  
EXCAVATION

**SAFE WORK PRACTICE**  
LINE OPENING

**SAFE WORK PRACTICE**  
TEMPORARY ISOLATION  
OF RELIEF DEVICES

**SAFE WORK PRACTICE**  
WORKING AT HEIGHTS  
- FALL PROTECTION

**SAFE WORK PRACTICE**  
HOT WORK

**SAFE WORK PRACTICE**  
PROCESS PLANT  
PORTABLE BUILDINGS

**SAFE WORK PRACTICE**  
CONFINED SPACE ENTRY

**SAFE WORK PRACTICE**  
EQUIPMENT  
IDENTIFICATION

**SAFE WORK PRACTICE**  
FIELD REVIEW OF  
PERMITS

**SAFE WORK PRACTICE**  
SCAFFOLDING

**SAFE WORK PRACTICE**  
TEMPORARY  
INSTRUMENTATION AND  
CONTROLS BYPASS

**SAFE WORK PRACTICE**  
HOT TAPPING

**SAFE WORK PRACTICE**  
JOB SAFETY  
ANALYSIS (JSA)

**SAFE WORK PRACTICE**  
PERMIT TO WORK

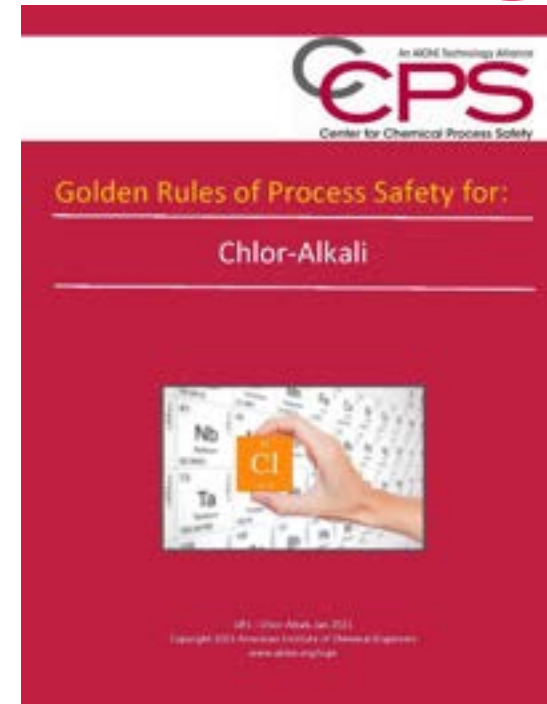
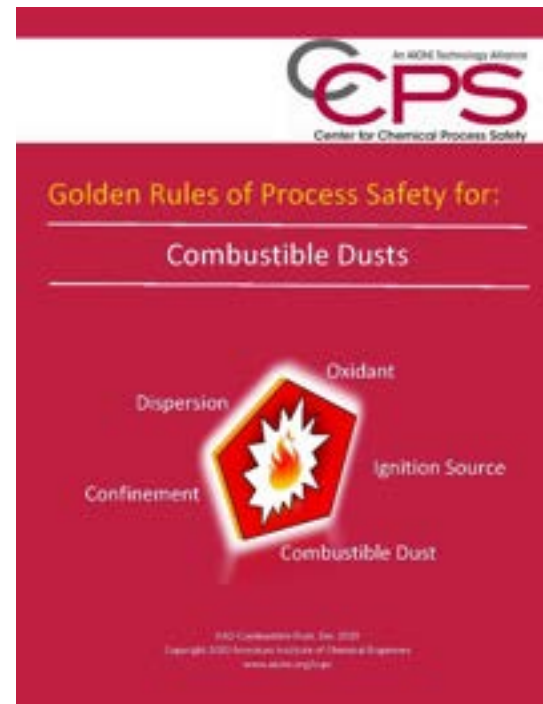
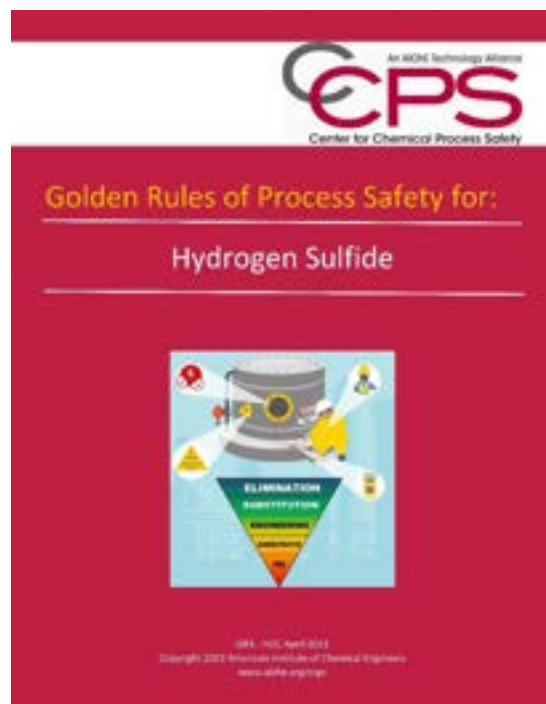
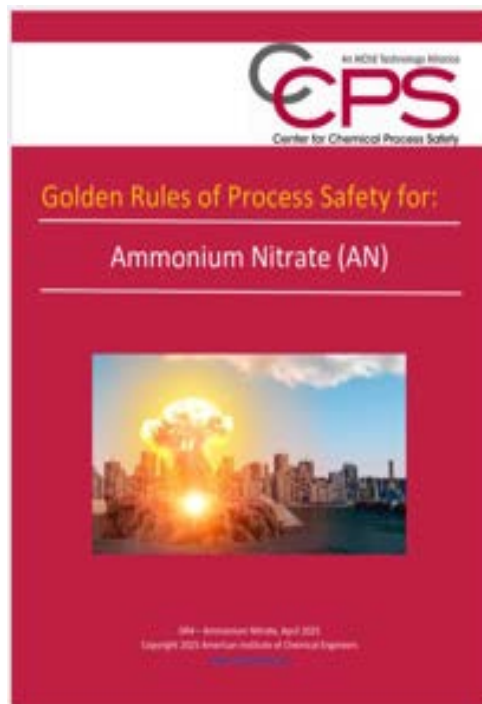
**SAFE WORK PRACTICE**  
SIMULTANEOUS  
OPERATIONS (SOPS)

**SAFE WORK PRACTICE**  
ACCESS TO  
HAZARDOUS AREAS

In Development (peer reviewers needed)	Future
Emergency Response	Return of Equip to Service

If you are interested in volunteering or Peer Reviewing for CCPS Projects, please contact [ccps-projects@aiche.org](mailto:ccps-projects@aiche.org)

# Golden Rules of Process Safety



Available online at CCPS

If you are interested in volunteering or Peer Reviewing for CCPS Projects, please contact [ccps-projects@aiche.org](mailto:ccps-projects@aiche.org)

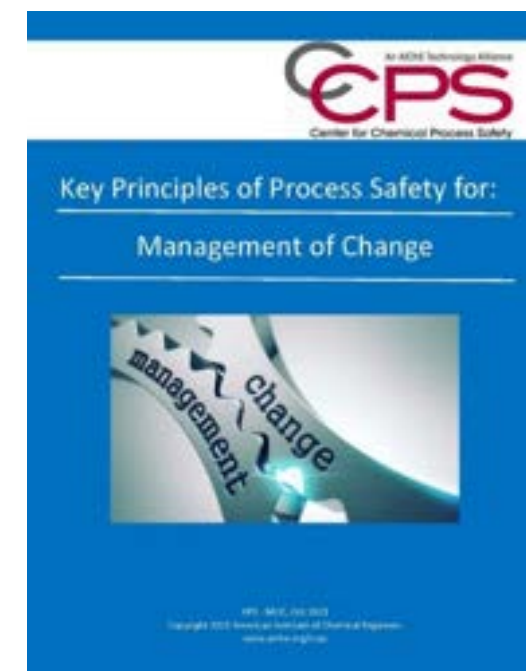
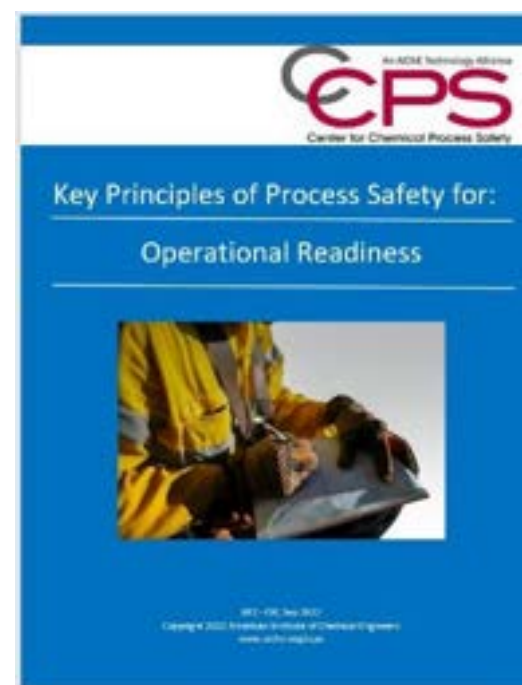
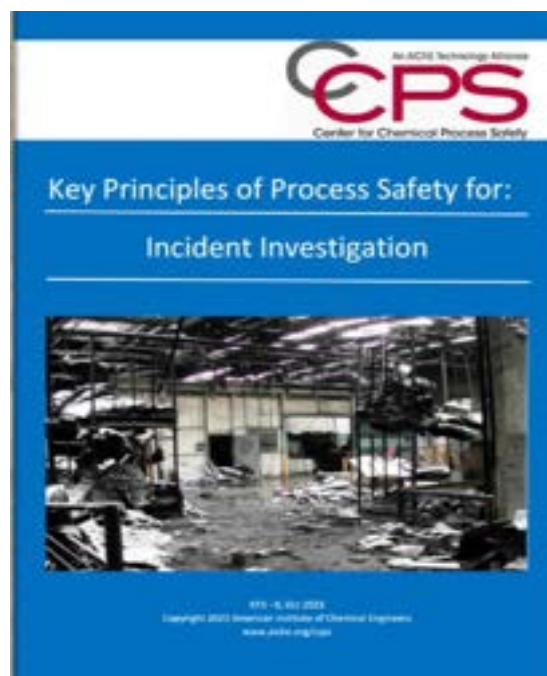
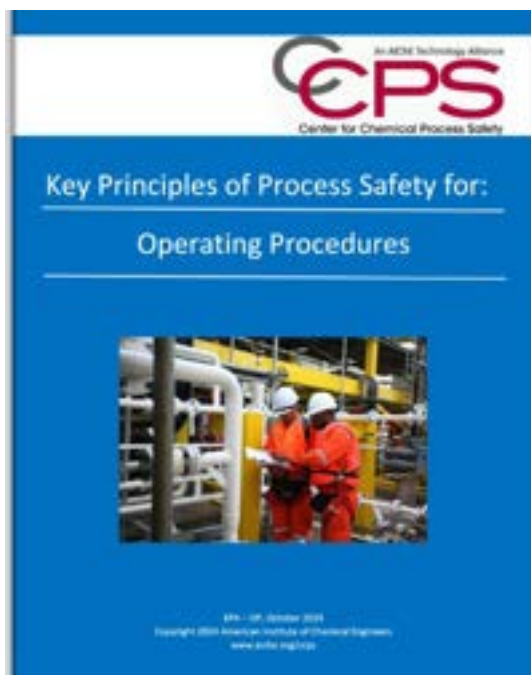
[www.aiche.org/CCPS/Publications](http://www.aiche.org/CCPS/Publications)

## In Development

- Anhydrous Ammonia
- Phosgene
- Ethylene Oxide
- Nitrogen
- Flammable Liquids
- LNG



# Key Principles of Process Safety



- In Development
- Asset Integrity

[www.aiche.org/CCPS/Publications](http://www.aiche.org/CCPS/Publications)

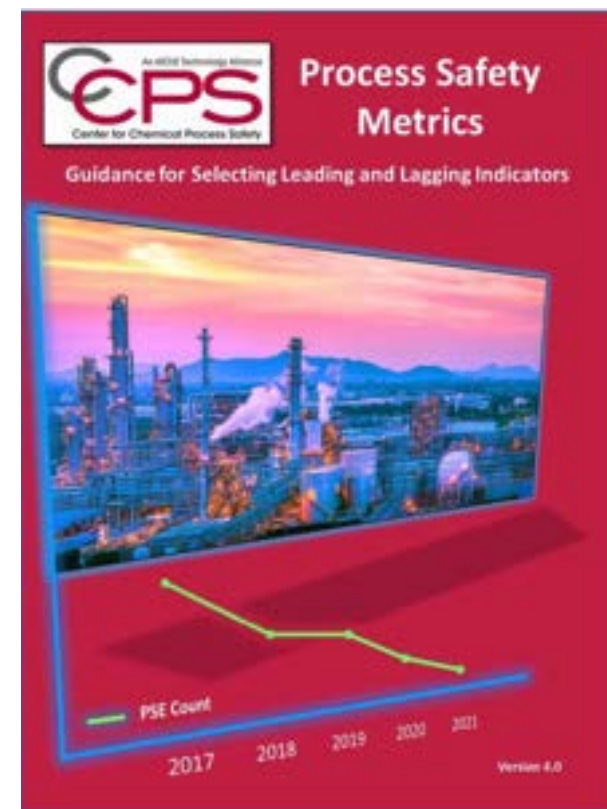


# CCPS Tools

CCPS provides process safety professionals with a variety of free tools that include worksheets, databases, process safety metrics, a glossary, safe work practices, and tools for risk analysis screening and chemical hazard engineering fundamentals.

- [Chemical Reactivity Worksheet](#)
- [Golden Rules](#)
- [LOPA \(MO\)](#)
- [Process Safety Incident Database \(MO\)](#)
- [Process Safety Incident Evaluation \(PSIE\)](#)
- [Process Safety Metrics](#)
- [Process Safety Beacon](#)
- [Process Safety Glossary](#)
- [Professional Services Directory](#)
- [RBPS Resources Web Tool](#)
- [RAST and CHEF \(MO – 20 hr course in Academy\)](#)
- [Safe Work Practices](#)
- [Vision 20/20](#)

**MO = Members-Only**



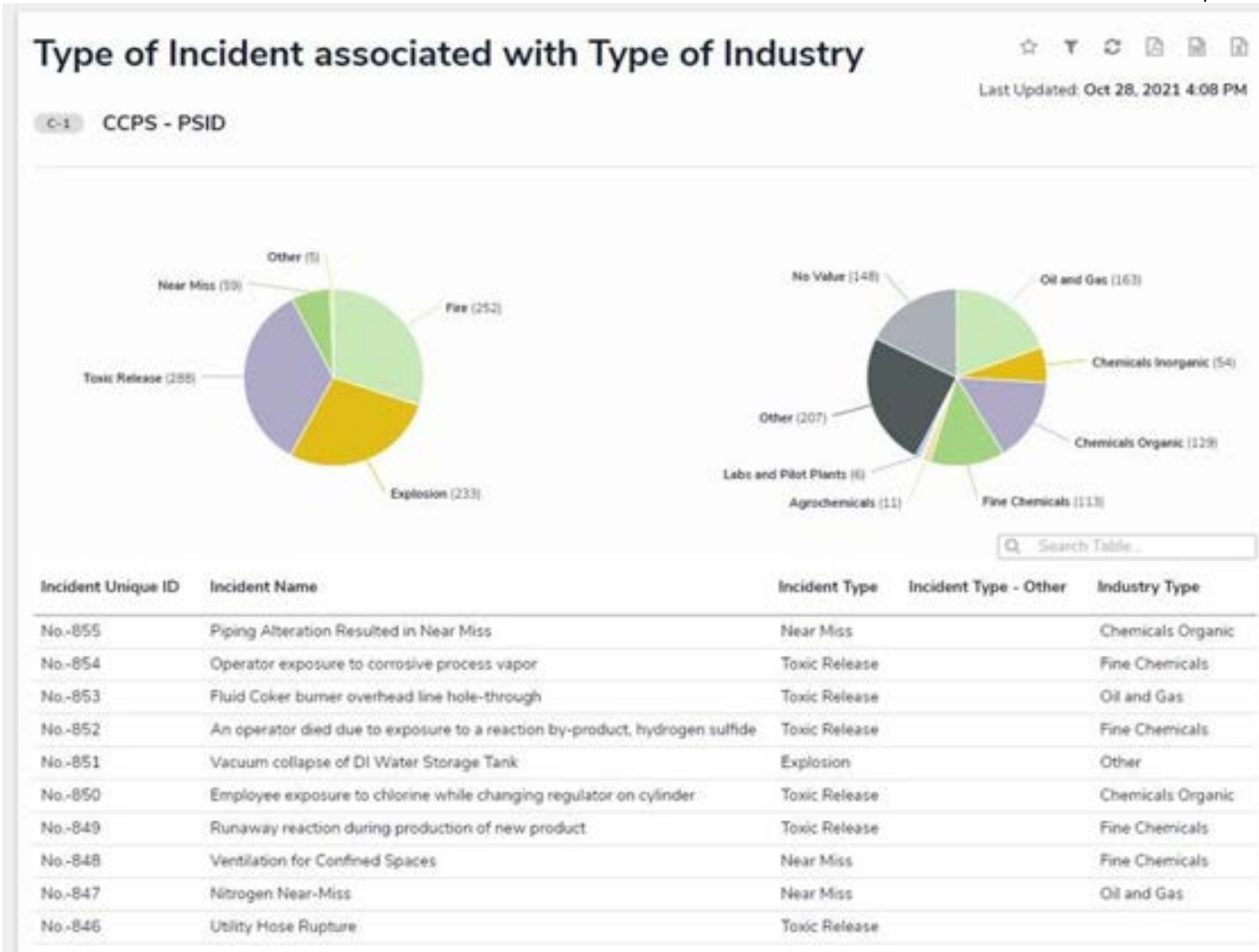
**Available in 41 languages**  
**Used as a training tool**  
**Comes Monthly to your inbox**

# Process Safety Incident Database (PSID)

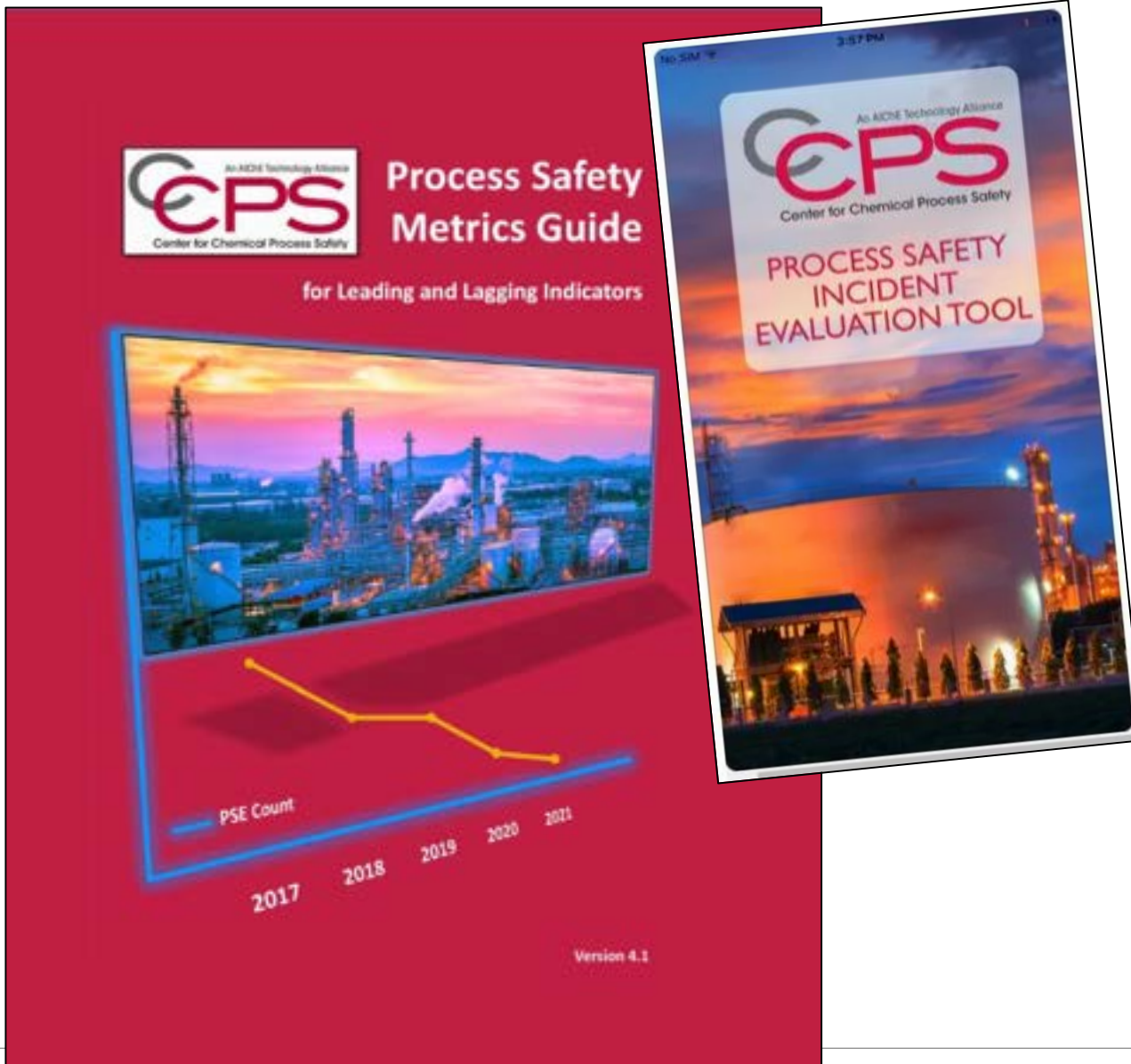


What can I find in the database

- Incident Source
- Country
- Year
- Date
- Incident Name
- Photo (if shared)
- Injuries (Y/N)
- Location
- Short Description (open ended)
- Incident Type (pull down)
- Ignition Source
- Description (open ended)
- Key Learning – Descriptions (Multiple answers)
- Recommendations
- Causes
  - Initiating Cause Details
  - Root Cause and Cause and Causal Factors
  - System Failures
  - Safeguard Failures
  - Impact
- Attributes
- Industry Types
  - Industry Type
- Mode of Operation
- Equipment Categories
  - Equipment Type
- Chemical Hazards
  - Chemical, Quantity, Unit of Measure, Phase, Type of Release



# The Process Safety Incident Evaluation (PSIE) app has been updated!



**The PSIE** changes reflect the updated threshold quantities and calculations provided in the CCPS *Process Safety Metrics Guide (Version 4.1, 2022)*

and API RP 754 (3<sup>rd</sup> Edition 2021)

*PSIE App (Version 2.2(1) 2023)*

The PSIE app has four main features:

- 1) *A database of 2,000 chemicals*
- 2) *A PSIE questionnaire*
- 3) *A Tier 1 incident severity weighting*
- 4) *An enhanced reporting feature*



# CCPS Global Congress on Process Safety Spring Meeting 2026



<https://www.aiche.org/conferences/aiche-spring-meeting-and-global-congress-on-process-safety/2026>

**April 12-16, 2026**

**Hilton Americas & Georgia Brown Convention Center, Houston, TX**

[Submit an Abstract](#) – **Open until October 27, 2025**

<https://aiche.confex.com/aiche/s26/prelim.cgi/ModuleMeetingInfo/0>

## **Become a Sponsor or Exhibitor**

If you're interested in sponsorship and exhibitor opportunities at the 2026 AIChE Spring Meeting & 22nd Global Congress on Process Safety, please reach out to [johnne@aiiche.org](mailto:johnne@aiiche.org)

Thank you



# Risktec Solutions

CO2 Transportation Pipeline – a Hybrid Land Use Planning Approach





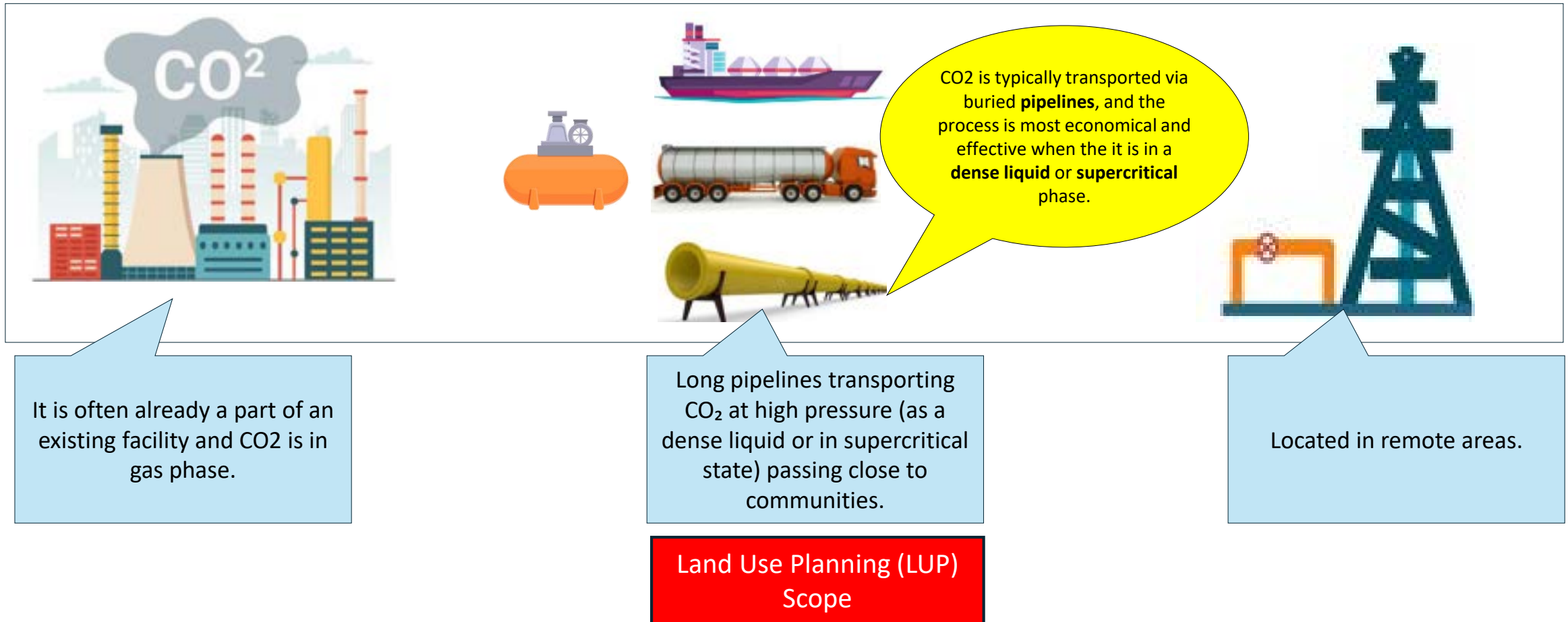
# Land Use Planning (LUP)

Land Use Planning (LUP) in **process safety context** is about controlling how land around hazardous sites is developed, so even if something goes wrong at the facility, the risk to the public is minimized.



Land Use Restrictions

# Carbon Capture, Utilization & Storage (CCUS)





# Outlines



Carbon Storage (Now & Future)



CO2 Safety Concerns (Pipeline Loss of Containment)



Land Use Planning (LUP) Approaches (and Hybrid Version)

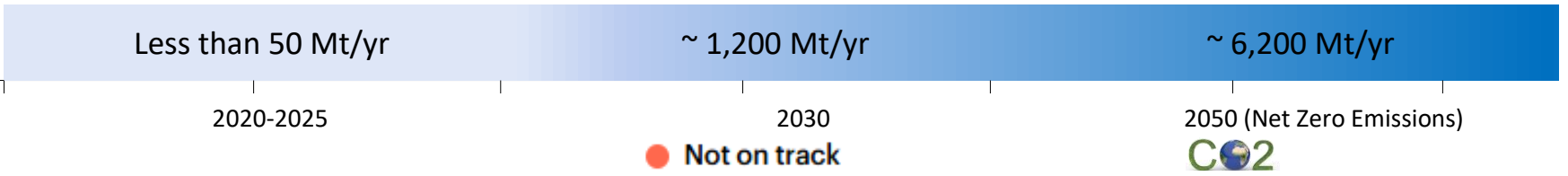


LUP Zones for Early Planning Stages

# Deployment of CCUS Projects



*IEA, An updated roadmap to Net Zero Emissions by 2050*



*CCP, Carbon Capture, Utilization and Storage in Canada*

CCUS Project (In Operation)	Capacity (Mt/yr)
Weyburn–Midale CO <sub>2</sub> –EOR / Dakota Gasification	1.70
Enhance Clive CO <sub>2</sub> –EOR Project	1.60
NWR Sturgeon Refinery Capture	1.30
Shell Quest	1.20
Boundary Dam	0.80
Cenovus Lloydminster Ethanol Plant	0.25
NOVA–Joffre CO <sub>2</sub> –EOR / Ethylene Plant	0.07
MEGlobal–Chigwell	0.06
Advantage Glacier Gas Plant	0.05

CCUS Project (In Future)	Capacity (Mt/yr)
Air Products Hydrogen Energy Complex	3.00
Strathcona Resources	2.00
Caroline Carbon Capture Power Complex	1.00
Dow Fort Saskatchewan Ethylene	1.00
Shell Polaris CCS Project	0.65
Entropy Athabasca Leismer	0.44
Bow River Carbon Hub	0.40
Co-op Ethanol Complex	0.25
Shell Polaris CCS Project	0.65
Co-op Refinery Complex	0.25
Advantage Glacier Gas Plant	0.16

# CO2 Pipeline (Safety Concerns) - Statistics



Pipelines (In Operation)	Length (km)
Souris Valley Pipeline	61
Cardinal Energy Midale CO2 pipeline	25
Bounday Dam To Weyburn CO2 Pipeline	74
Quest	64
Alberta Carbon Trunk Line (ACTL)	240

*[Canada Energy Regulator: Market Snapshot: Canada is expanding its CO2 pipeline network](#)*



In the U.S., pipelines have been in operation for over 50 years, with more than **8,000 km** currently in use. However, to meet net-zero and mid-century climate goals, estimates suggest that this infrastructure will need to expand by up to **110,000 km (2050)**.

*[UD Department of Transportation](#)*



The CO2 transport network extends to 16 countries and the total length amounts to about **6,700 km**. The European CO2 pipeline network could reach a considerable length up to **15,000 to 19,000 km (2,050)**.

*[European Commission, Shaping the future CO2 transport network for Europe](#)*

# CO<sub>2</sub> Pipeline (Safety Concerns) – CO<sub>2</sub> Behaviour



Although rare, in the event of a rupture, large quantities of CO<sub>2</sub> could be released.

CO<sub>2</sub> displaces oxygen and creating an asphyxiation hazard.



**Colorless & Odorless:** You can't see it or smell it. People may not realize they are in danger until symptoms start (dizziness, confusion).



**Heavier than Air:** CO<sub>2</sub> tends to sink and collect in low-lying areas, valleys, trenches, or basements. This makes it harder to disperse compared to lighter gases like methane.



**Stored at High Pressure & Low Temperature (dense/supercritical state in pipelines):** If released, it can rapidly expand developing huge clouds.

# CO2 Pipeline (Safety Concerns) - Bowtie



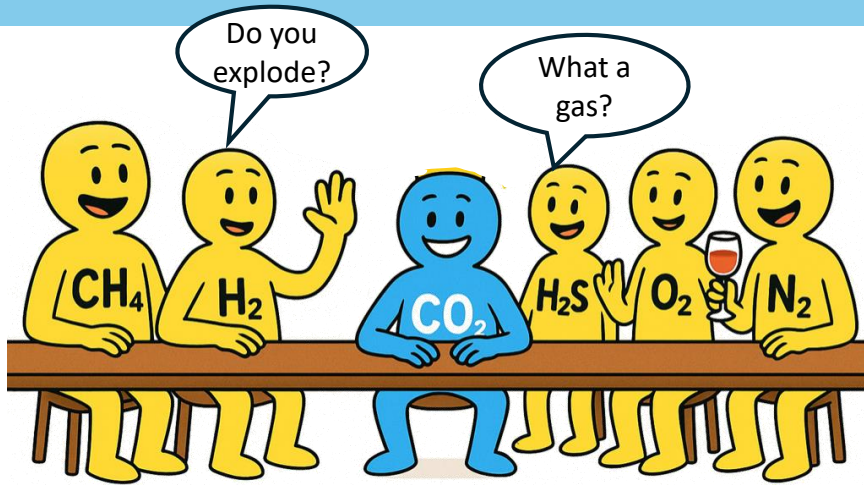
- **Date:** February 22<sup>nd</sup>, 2020.
- **Pipeline:** 24-inch (96 barg) supercritical CO<sub>2</sub> pipeline ruptured near Satartia, Mississippi.
- **Cause:** Rain-soaked soil slid on hilly terrain, breaking a weld.
- **Impact:** CO<sub>2</sub> plume spread and Satartia (a mile away) was affected.
- **Response:** ~200 people evacuated from the areas surrounding the rupture location, 45 sought medical care.

[U.S. Department of Transportation's Pipeline & Hazardous Materials Safety Administration](#)





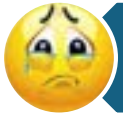
# CO2 Pipeline (Safety Concerns) - Simulation



## Engineering Disciplines Nightmare



Process



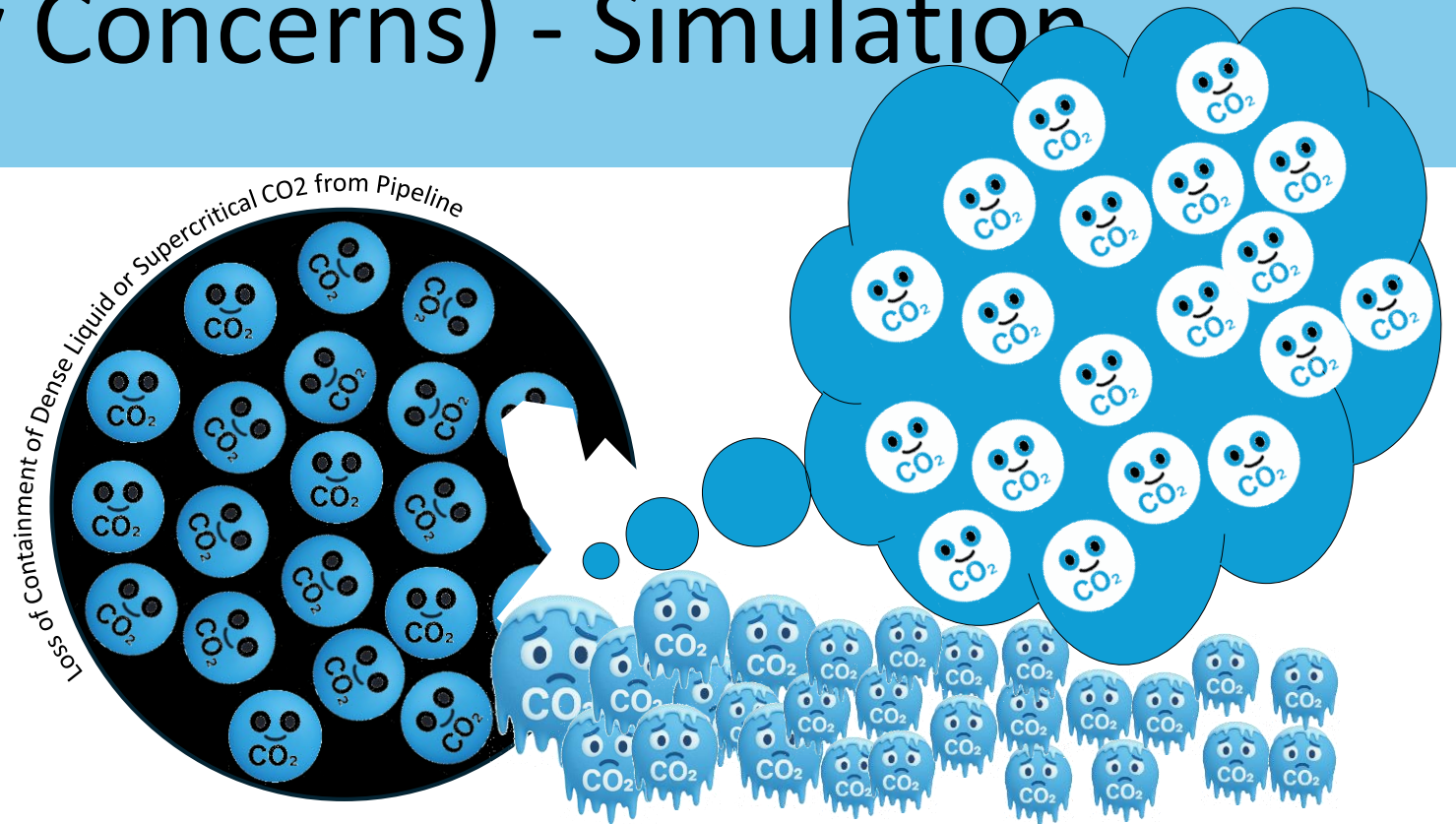
Material & Corrosion



Reservoir



Process Safety



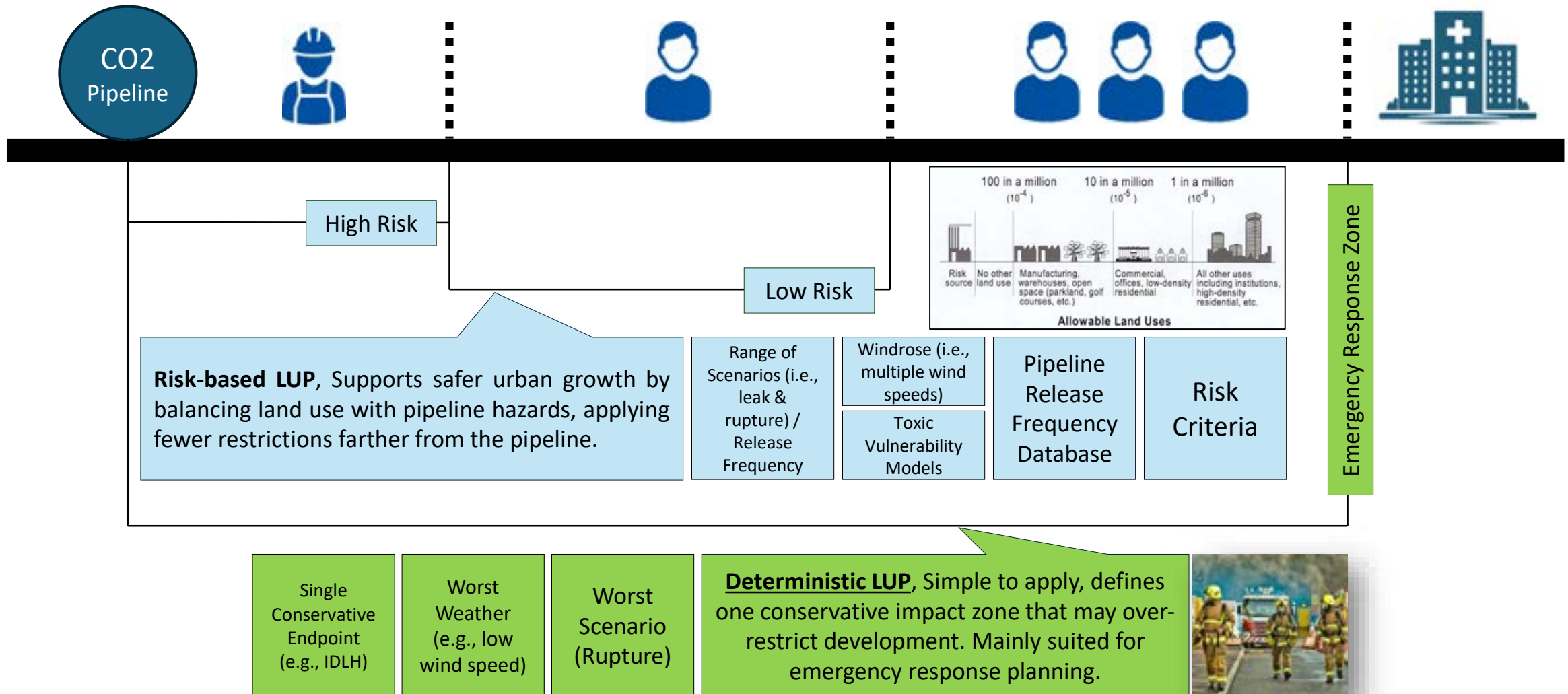
- Calculation of thermodynamic properties in the critical region is non-trivial, requiring specific equations of state.
- Unlike methane or natural gas, CO<sub>2</sub> doesn't rise and dilute. It forms ground-hugging clouds that can travel far, depending on wind and terrain.

# Land Use Planning (LUP) Approaches

Deterministic Approach	Risk-based Approach
Dispersion Modeling (i.e., Rupture)	Dispersion Modeling (i.e., Leaks & Rupture)
Representative Weather Data	Windrose Analysis
-	Release Frequency Analysis
Impact Zone Calculation (Single) (CO <sub>2</sub> Concentration Endpoint, e.g., IDLH)	Risk Zones Calculation (Multiple) (Risk Criteria, e.g., MIACC*)
Single Zone	Zone Range

\*MIACC (Major Industrial Accidents Council of Canada)

# Land Use Planning (LUP) – Hybrid Approach





# Land Use Planning (LUP) – Case Study

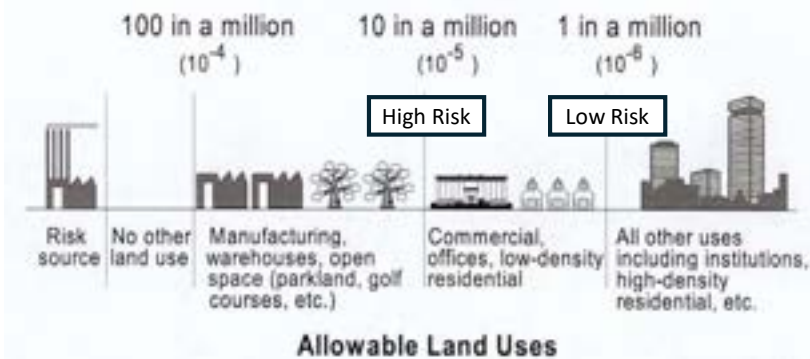


Early design stages should address these safety issues, influencing pipeline routes to avoid populated areas. This study calculates the expected land use planning (LUP) zones using both deterministic and risk-based approaches for a range of typical CO<sub>2</sub> pipeline.

Risk-based Approach

Deterministic Approach

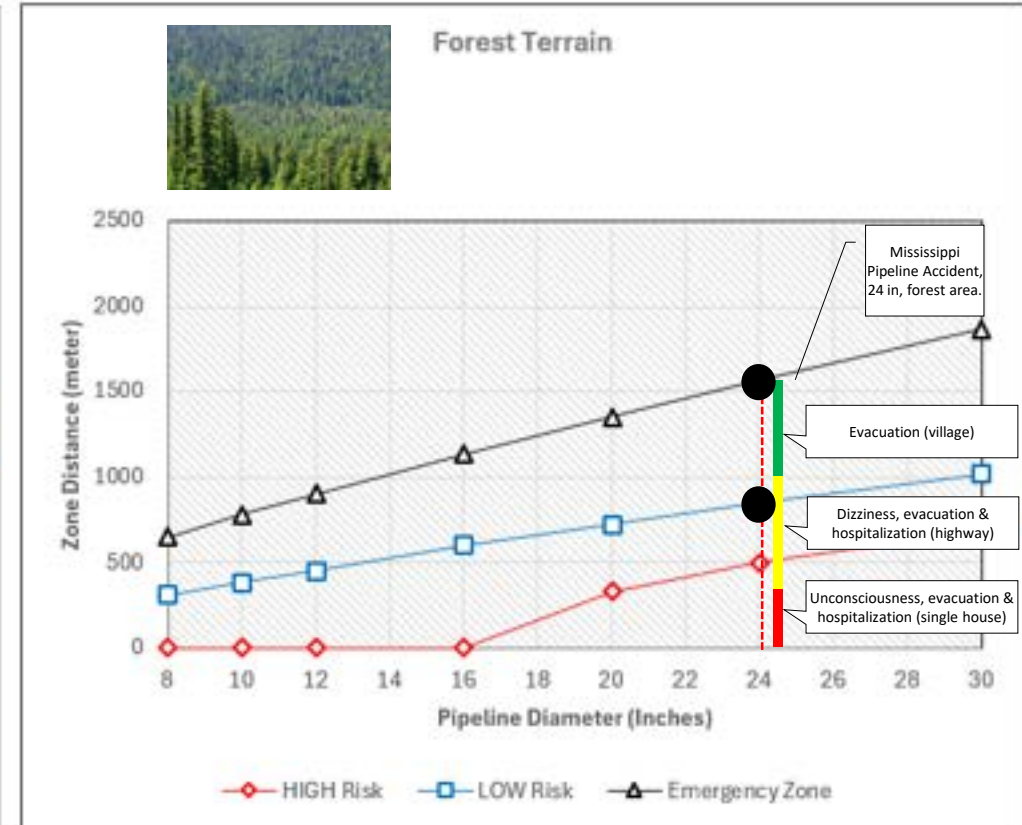
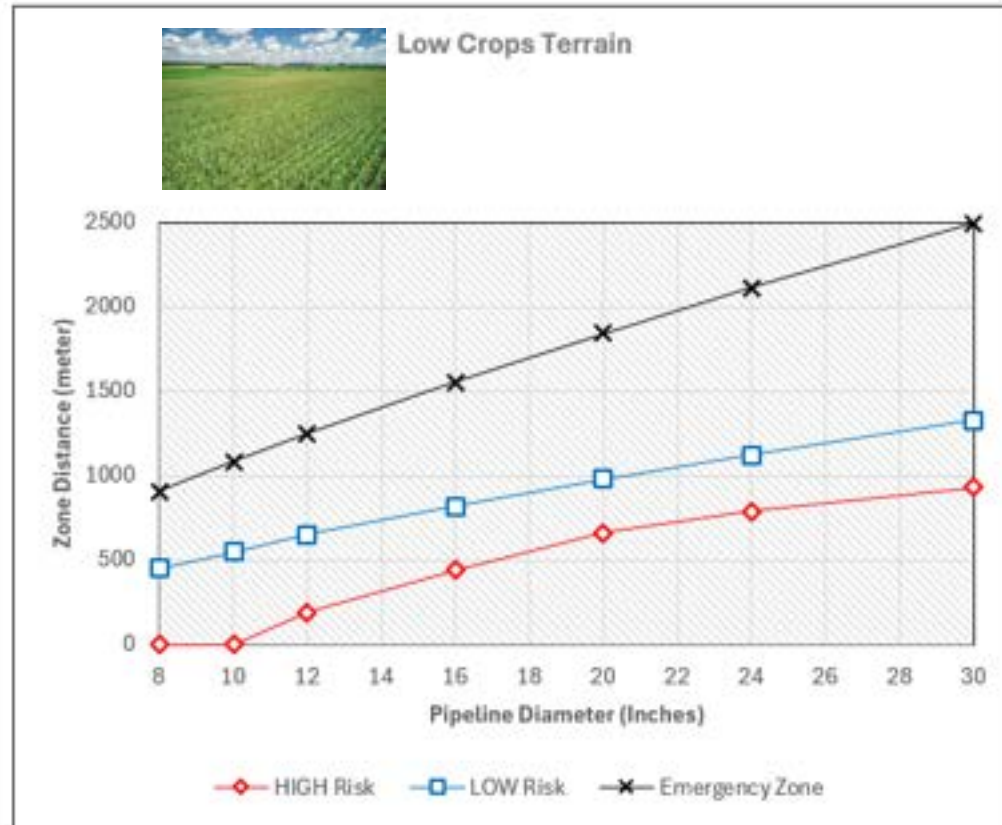
- **Phase:** Dense Liquid CO<sub>2</sub>
- **Size:** ~ 15 km in length, with diameters ranging from 8 inches to 30 inches
- **Operating Condition:** 150 bar and 15 C
- **Depth of Cover:** CO<sub>2</sub> is transported via buried pipelines, typically 1m depth of cover.
- **Terrain Type:** low crop / forest.
- **Weather:** Stable (F) with a low wind velocity of 2 m/s and Neutral (D) with a medium wind velocity of 5 m/s (15 °C ambient temperature).
- **Concentration Endpoint:** IDLH (40,000 ppm)
- **Windrose:** Equal probabilities have been assumed for two weather categories - stable (low wind speed) and neutral (medium wind speed) - with a uniform wind rose applied to both categories.
- **Release Frequency:** Gas pipeline failure frequency data reported by the European Gas Pipeline Incident Data Group (EGIG) for the period from 2010 to 2019 was used.
- **Risk Criteria:** MIACC (Major Industrial Accidents Council of Canada)



*Statistical analysis of incidents on onshore CO<sub>2</sub> pipelines based on PHMSA database*

The incidents reported in PHMSA database related to CO<sub>2</sub> onshore pipeline from 1968 to 2021 have been analyzed. Results show that the estimated release frequencies for CO<sub>2</sub> pipeline are in the same range of failure rates reported for hydrocarbon pipelines.

# Land Use Planning (LUP) – Case Study



The primary aim is to provide designers with initial estimates of potential impact zones for their proposed pipelines during the early stages of design.

# Recap

CCUS is expected to significantly grow to help meeting Net Zero goals by 2050.

CO2 pipelines may raise public acceptance and regulatory approval issues.

CO2 loss of containment and dispersion modeling has long to go (i.e., terrain type and wind speed).

Land use planning (hybrid approach) seems to be a fit to purpose approach to respond both public safety and land limitation issues.

High level conservative LUP zones have been estimated for a practical range of CO2 pipelines that can support the early stages of CCUS planning projects.

# Questions



## **Risktec Solutions**

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Calgary, AB T2P 5C5

Tel: (403) 401-5990

E-mail: [Naser.Badri@risktec.tuv.com](mailto:Naser.Badri@risktec.tuv.com)





# Performance-Based Fire and Gas System Design for Petroleum Storage Tank Safety

Edward Naranjo and Adrian Petre

# Edward Naranjo

- Director of Sales, Kenexis
  - Process safety at MSA, Emerson, and Honeywell
  - ISA Fellow
  - Ph.D. chemical engineering, University of California Santa Barbara



# Adrian Petre

- Director for Quality and Technical Services
  - Electrical engineer
  - Contributor to ISA TR84.00.07 and ISA 85

# Agenda

- Hazards of storage tanks in petroleum and petrochemical facilities
- Challenges in detector placement
- Heuristic approaches in practice
- Performance-based approach (ISA TR84.00.07-2018)
- Fire and gas mapping at tank farms
- Conclusion



# Hydrocarbon Fire at ITC's Deer Park, TX, USA

- On March 17, 2019, a fire erupted at ITC's Deer Park terminal, starting at Tank 80-8 (naphtha/butane) and spreading to 14 other tanks over three days
  - 15 storage tanks (80,000 barrels each) destroyed
  - \$150 million in property damage
  - Release of 470,000–523,000 barrels of hydrocarbons, foam, and contaminated water into nearby waterways
  - Shelter-in-place orders, school and business closures, and a major highway shutdown

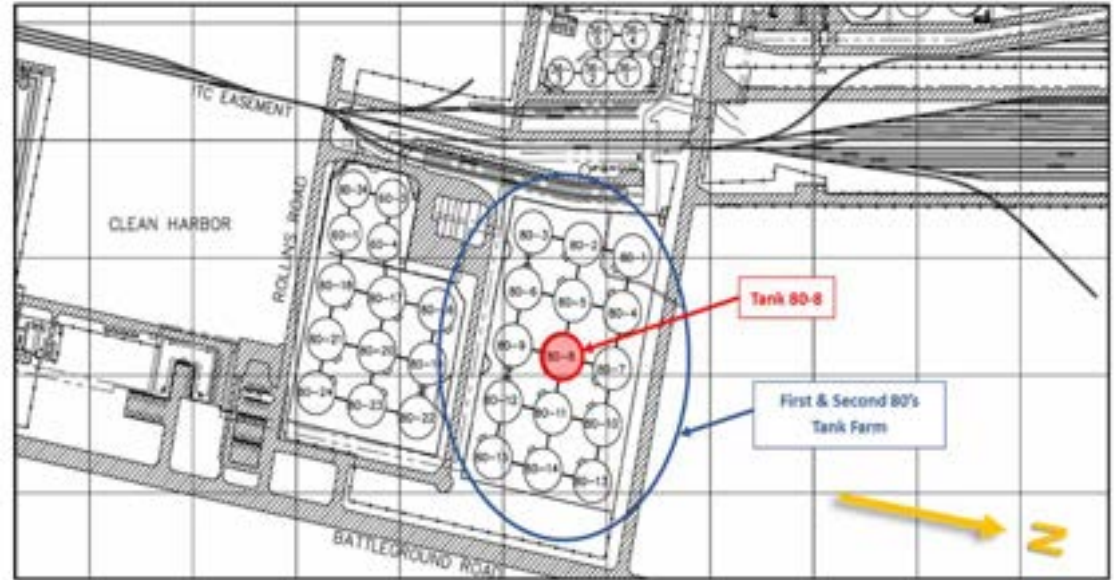


Figure 3. Plot plan of tank farm. Excerpt from overall plot plan for the ITC Deer Park terminal showing the location of the First & Second 80's Tank Farm. (Credit: ITC, annotations by CSB)

U.S. Chemical Safety and Hazard Investigation Board. Storage Tank Fire at Intercontinental Terminals Company, LLC (ITC) Terminal, Deer Park, Texas, Incident Date: March 17, 2019. [ITC Report - FINAL \(July 6, 2023\).pdf](#), accessed 27 August 2025.

# Incident Caused by Undetected Hydrocarbon Release

- Release of flammable butane-enriched naphtha vapor from the failed Tank 80-8 circulation pump, which accumulated in the area and ignited, resulting in a fire
  - Tank 80-8 was not equipped with a flammable gas detection system to warn personnel of a hazardous atmosphere resulting from loss of containment from the tank or its associated equipment
  - ITC did not implement a 2014 hazard review team's recommendation for addition of flammable gas detection systems near Tank 80-8



*“Contributing to the severity of the incident were the absence of a flammable gas detection system to alert the operators to the flammable mixture before it ignited approximately 30 minutes after the release began...” – U.S. Chemical Safety Board.*

# Limits of Fire and Gas System (FGS) Effectiveness

- The chemical process and automobile manufacturing and testing facility environment are complex, presenting challenges for FGS design



## Variable Conditions

- Harsh and changing outdoor environments



## Hazard Variety

- Wide range of potential hazards



## Complex Dispersion

- Travel and spread of airborne releases



## Multiple Leak Sources

- High number of potential leaks in plants



Detection cannot be guaranteed in all scenarios.

# Addressing Detection Coverage Using Prescriptive Methods

Detector Placement Approach	Description	Prescribed Arrangement of Detectors with Different IR Absorption Characteristics
Volumetric monitoring	3D array of detectors (point, beam) assures that a gas cloud, described in terms of a sphere of specified diameter, cannot exist without contacting a sensor	Same number of detectors is required to cover the space
Source monitoring	Detectors are placed around potential release sources with intent of detecting leaks as they migrate away from it	<ul style="list-style-type: none"><li>• Possible to segregate detector if sources are well separated</li><li>• If there are several sources of gas with different IR properties within close proximity to each other or several sources that are spread over an area, the same number of detectors of each gas is required</li></ul>
Path of travel and target receptor monitoring	Detectors are placed where personnel are expected to travel or congregate on a regular basis	Normal path of travel must be protected by detectors configured for each target gas

# Limitations of Prescriptive-Only Fire & Gas Detection

## Operational Drawbacks



- Uneven protection
- Over- or under-deployment of detectors
- Higher installation and maintenance costs
- Larger spare parts inventory

## New Hazards



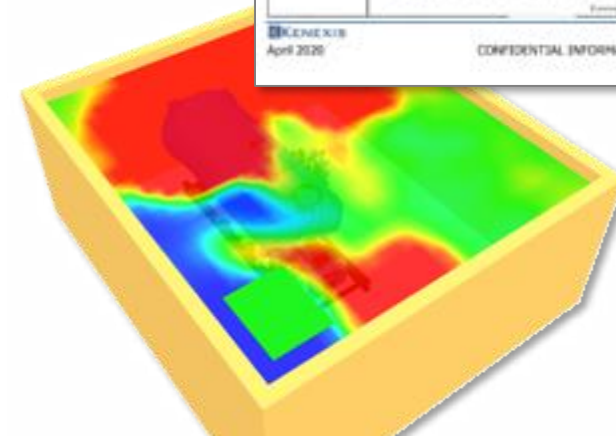
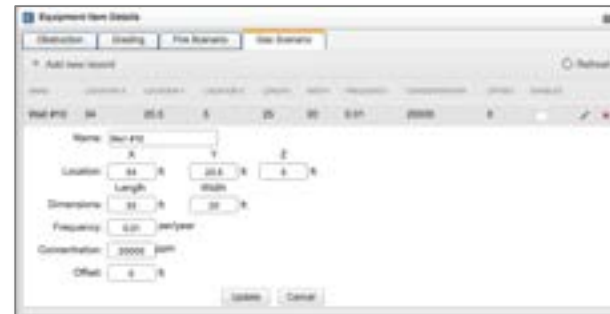
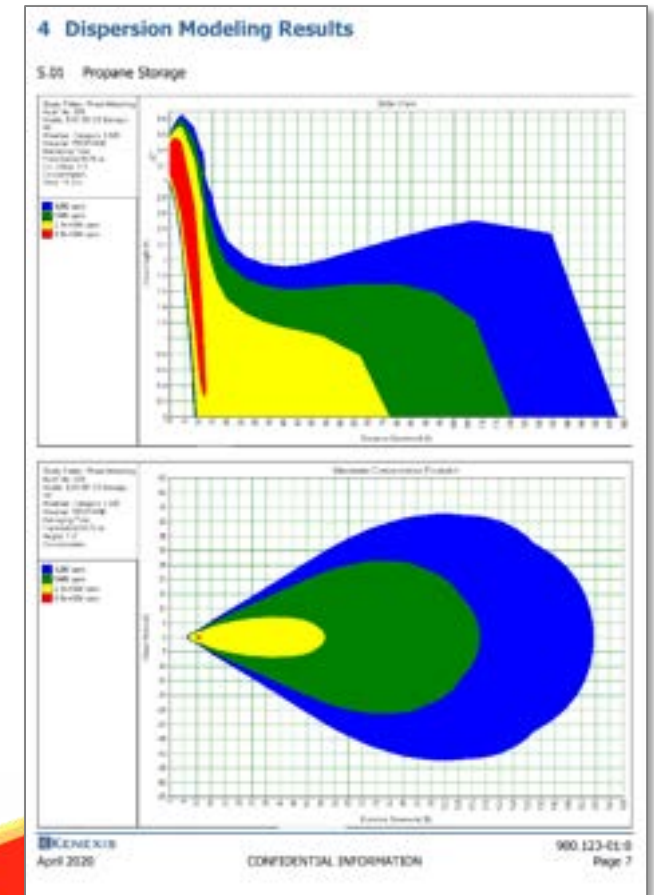
- Over- or under-trust in the system
- Improper operator response to alarms
- Inappropriate control or safety system actions



These issues can be mitigated by adopting a **holistic, risk-based approach** to fire and gas detection system design and management.

# ISA-TR84.00.07: A Risk-Based Framework for Fire and Gas System Design

- Complements best practices to enhance system effectiveness
- Ensures coverage targets are met for each fire or gas zone
- Uses hazard modeling to define incident outcomes
- Evaluates consequences via dispersion or consequence modeling
- Quantifies release likelihood using failure data
- Considers site-specific mitigating factors
- Compares calculated risk against defined tolerability thresholds



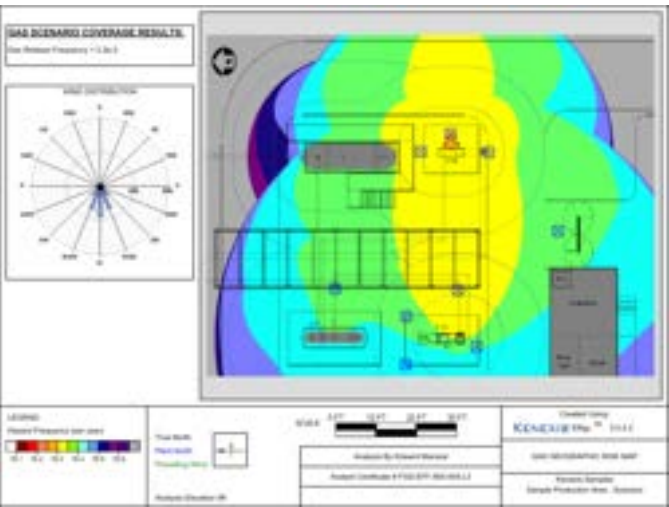


# Geographic and Scenario Coverage Are Calculated for Fire and Gas Mapping

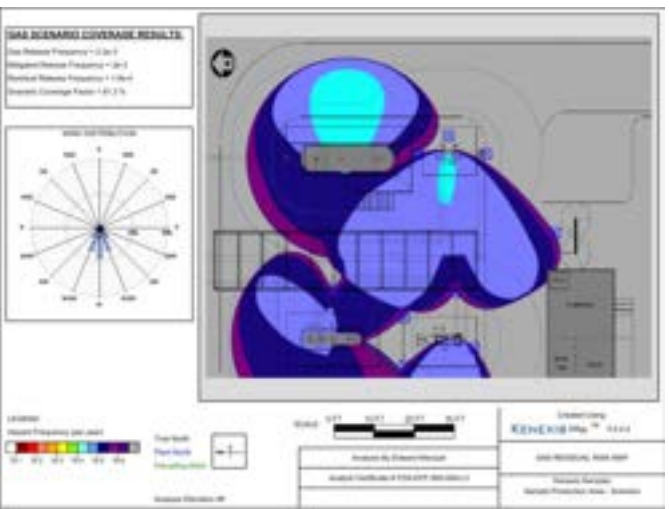
Geographic Coverage – Flame Detection



Gas Scenario Coverage – Unmitigated Risk



Gas Scenario Coverage – Mitigated Risk

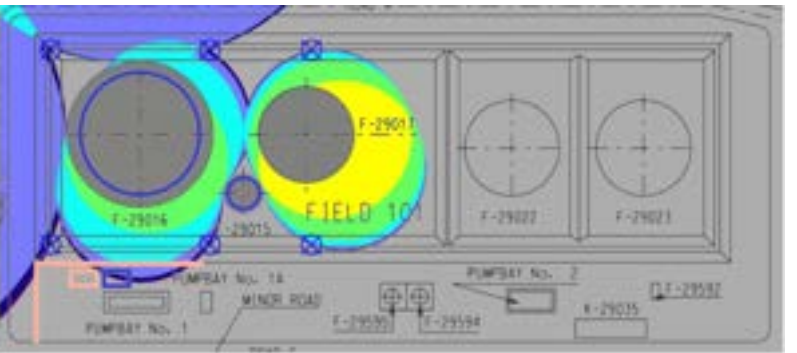
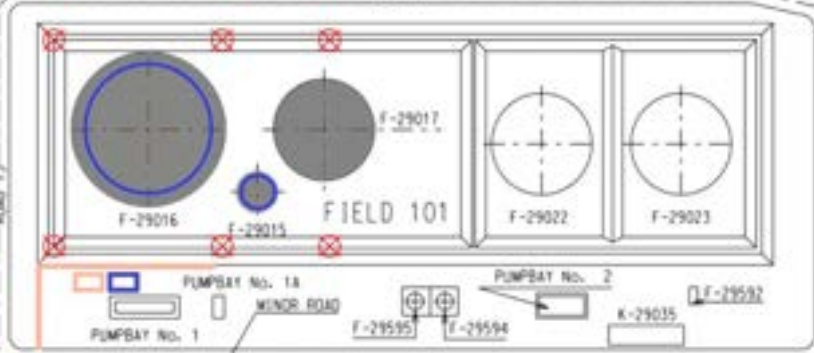
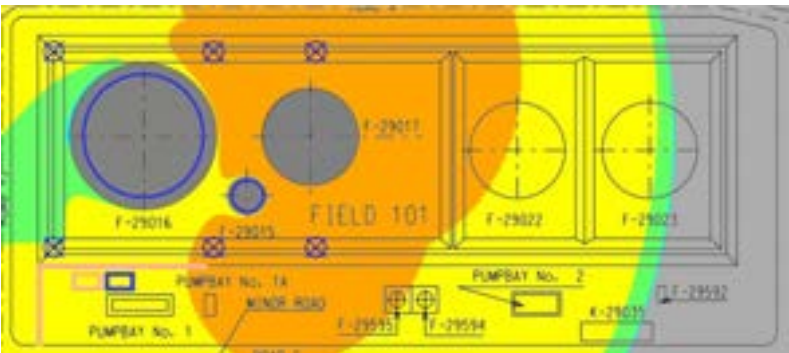
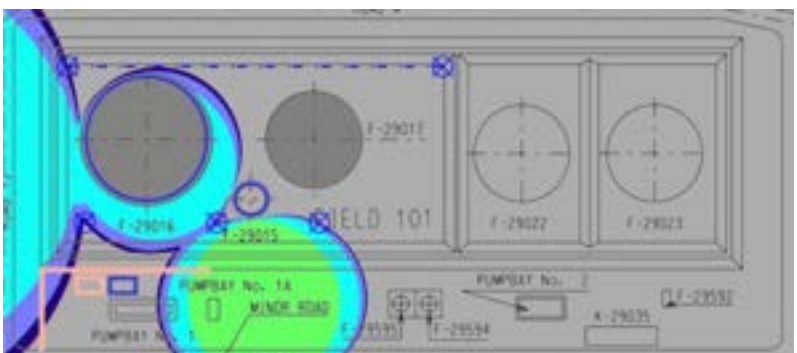
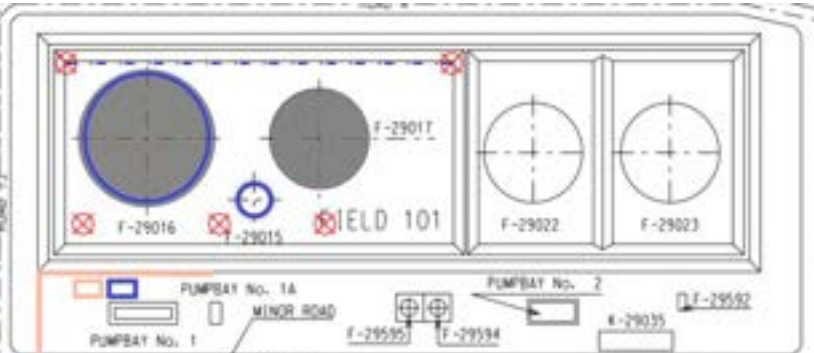
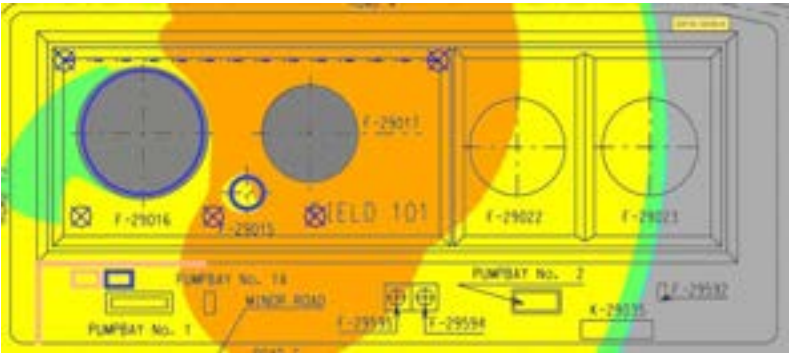




# Gas Mapping Reveals Optimum Layout of Gas Detectors in Oil Refinery

Gas Scenario Coverage Accounting for Overfill Event    Proposed Gas Detector Layout (Scenario Coverage of 96%)

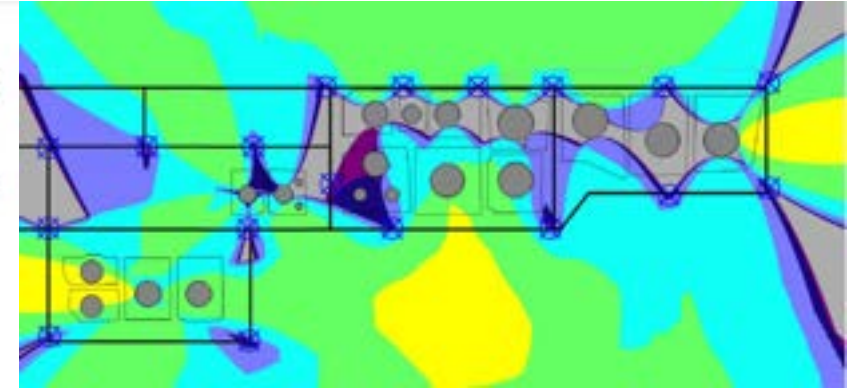
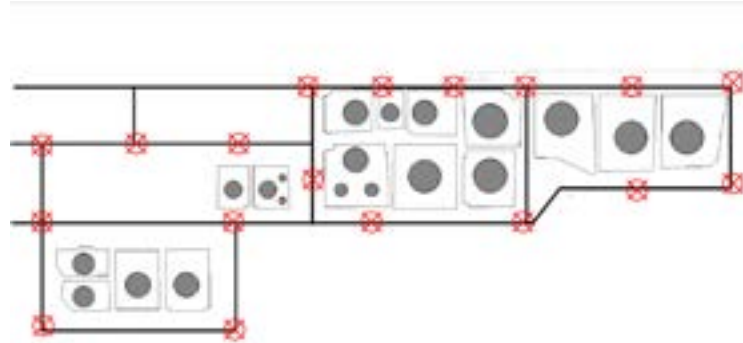
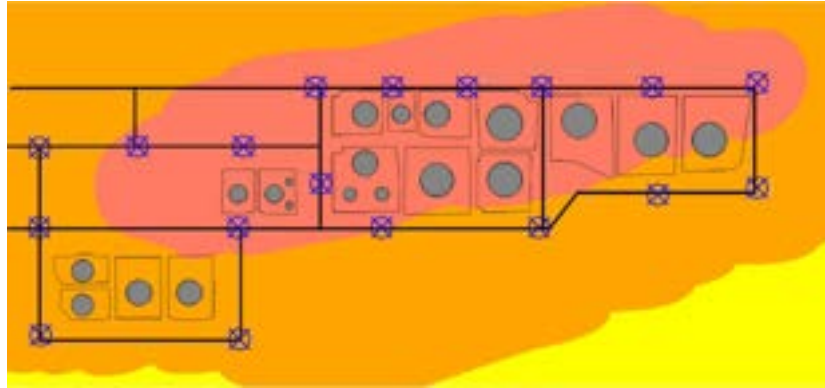
Residual Risk



# Gas Mapping and Proposed Gas Detector Layout for Naphtha and Crude Oil Tank Farm

Gas Scenario Coverage Accounting for Overfill Event    Proposed Gas Detector Layout (Scenario Coverage of 90%)

Residual Risk



# Conclusion

- Fire and gas mapping is an established methodology for determining placement of field devices that maximizes fire and gas system effectiveness
  - Provides quantitative verification, aligning protection with defined safety targets
  - Leverages performance-based, risk-informed design (ISA-TR84.00.07)
  - Is part of holistic, risk-based approach that often reduces detector count, lowers costs, and increases confidence in safety outcomes
- Prescriptive and heuristic methods alone are insufficient for today's large, complex process facilities
- Adoption of modern performance-based design represents the current state-of-the-art and best practice for fire and gas detection



## Appendix



# References

- *Continuous Monitoring for Hazardous Material Releases*, Center for Chemical Process Safety (2009), Wiley: Hoboken, NJ.
- *ISA-TR84.00.07, Guidance on the Evaluation of Fire, Combustible Gas, and Toxic Gas System Effectiveness* (2018), ISA: Raleigh, NC.
- Bryan, A., Smith, E., and Mitchell, K. *Kenexis Fire and Gas Systems Engineering Handbook* (2013), Kenexis: Columbus, OH.





# Causal Reasoning

The way we think  
can influence  
performance  
improvement

Leaders create  
the system

Learning informs  
actions

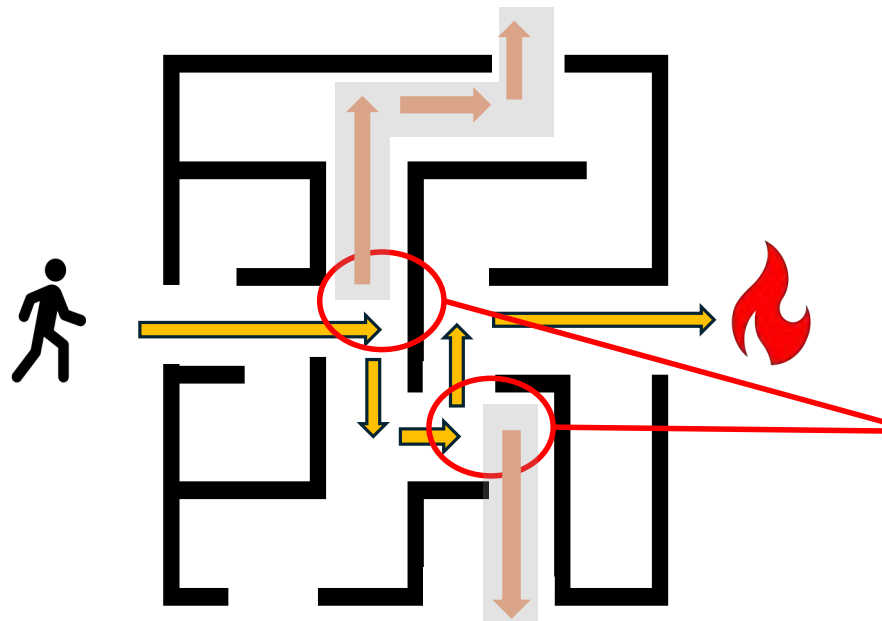
Solutions disrupt  
cause and create  
system

---

# Hindsight Bias

Hindsight bias is one of the most challenging biases to overcome when setting out to investigate problems. This bias underpins all other biases and removes the objectivity from the work.

In foresight, the individuals make decisions and take actions they believe will lead to success



Hindsight enables us to examine the information through the lens of the outcome

Limits objectivity as we now can see the better choices



# Reasoning Bias

Two reasoning types show up in investigations. Negative is the most common of all as it is easy, quick and normal for us humans.

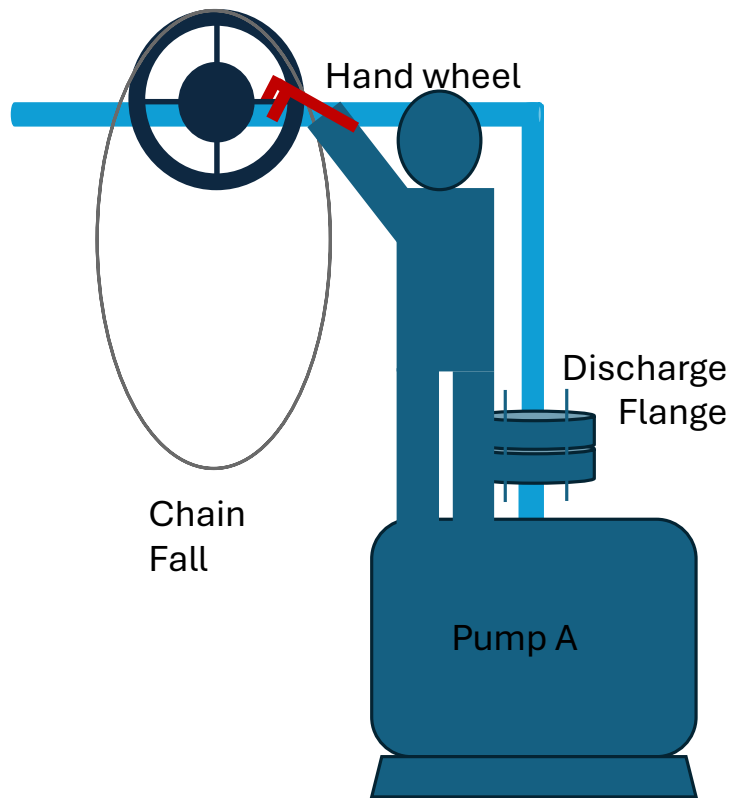
## Negative

- What was missing or absent; what people didn't do or should have done
- Our judgement in hindsight of their actions and better options
- Cannot explain the system

## Causal

- Searching for cause
- How and why we got into the problem in the first place
- Based on logic and data
- Exposes the system and 'how work is done'

## Incident: Broken Wrist



*At approximately 10 am on May 9<sup>th</sup>, 2013, a significant amount of propane solvent was released from an open flange in a hydrocarbon refinery. During the emergency response by an operator, the operator sustained an injury to his hand resulting in a broken wrist.*

- Pump 10P3A was prepared, locked and tagged and permitted as per isolation procedure on the night shift of May 8, 2013 for maintenance on May 9.
- At approximately 10 am, the board operator directed the field operator to investigate the alarm.
- The field operator used an 18" pipe wrench to attempt to close the valve.
- On the second attempt to close the valve further, the wrench slipped off the valve wheel and the field operator's hand struck the pipe assembly behind him, resulting in a broken hand.

## Incident: Broken Wrist

Negative	Causal
Operator used an improper tool	Operator was using an 18” pipe wrench as that was the tool endorsed by leaders to deal with sticky valves
Operator didn’t recognize the hazard	Operator believed that a release of propane for a few more minutes would result in a detonation or a plant shutdown / evacuation
Operator didn’t learn from past failures	Leaders had decided to leave the valve in place after being informed it was sticky as they believed the operators could figure out how to deal with it
The valve was faulty	The valve was passing when maintenance removed it because the night shift operator believed the the system was isolated after checking to see if the open drain port was releasing any propane (later discovered it was blocked)



# What Happened as a Result?

## *The learning*

- The leaders realized they helped set up the operators to fail
- They had accepted that the process was deteriorating over time, and they were relying on operators to fix it for them however they could
- They realized that their isolation procedures can create illusions as well as successful outcomes

## *The Consequence*

- The operator's job was saved but they chose to leave anyway

## *The Change*

- They started working on how to create more reliable and safe processes rather than fire the 'bad operator' or provide mitigations (like valve wrenches that keep breaking) that don't work for the operators



Thank you!



## For More Information:



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- Website: [www.p2iconsulting.ca](http://www.p2iconsulting.ca)
- Linked In: Zoe Gulley

In partnership with Energy Safety Canada, I am facilitating a workshop to build skills in this work using causal reasoning in October this year. The workshop is scheduled for Oct. 1 and 2 in Calgary, AB. Registration is now open and can be accessed through the Energy Safety Canada Webpage.

# A GRAPHICAL APPROACH TO A MULTI-VARIATE ALARMING PROBLEM IN AN ETHYLENE FURNACE

CCPS Canadian Regional Meeting – Sept. 11, 2025

Michael Bell



# Advanced Alarming in an Ethylene Plant Furnace

- Multi-variate Alarm Display



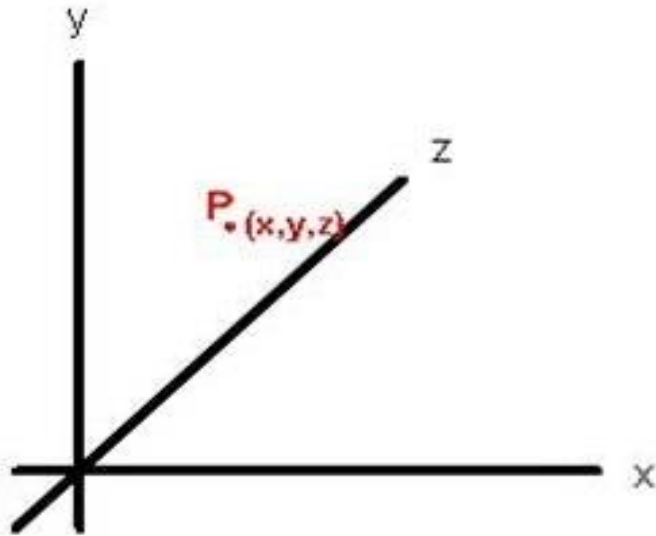
# The Engineering Tool

C Visual Explorer (CVE)

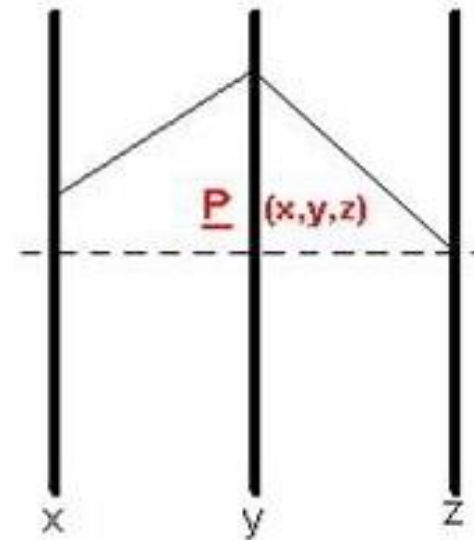
# Advanced Alarming in an Ethylene Plant Building a Model

## The transform

- A New Way of Modeling – Geometrically
- Parallel Coordinate Plotting



Orthogonal  
Coordinates

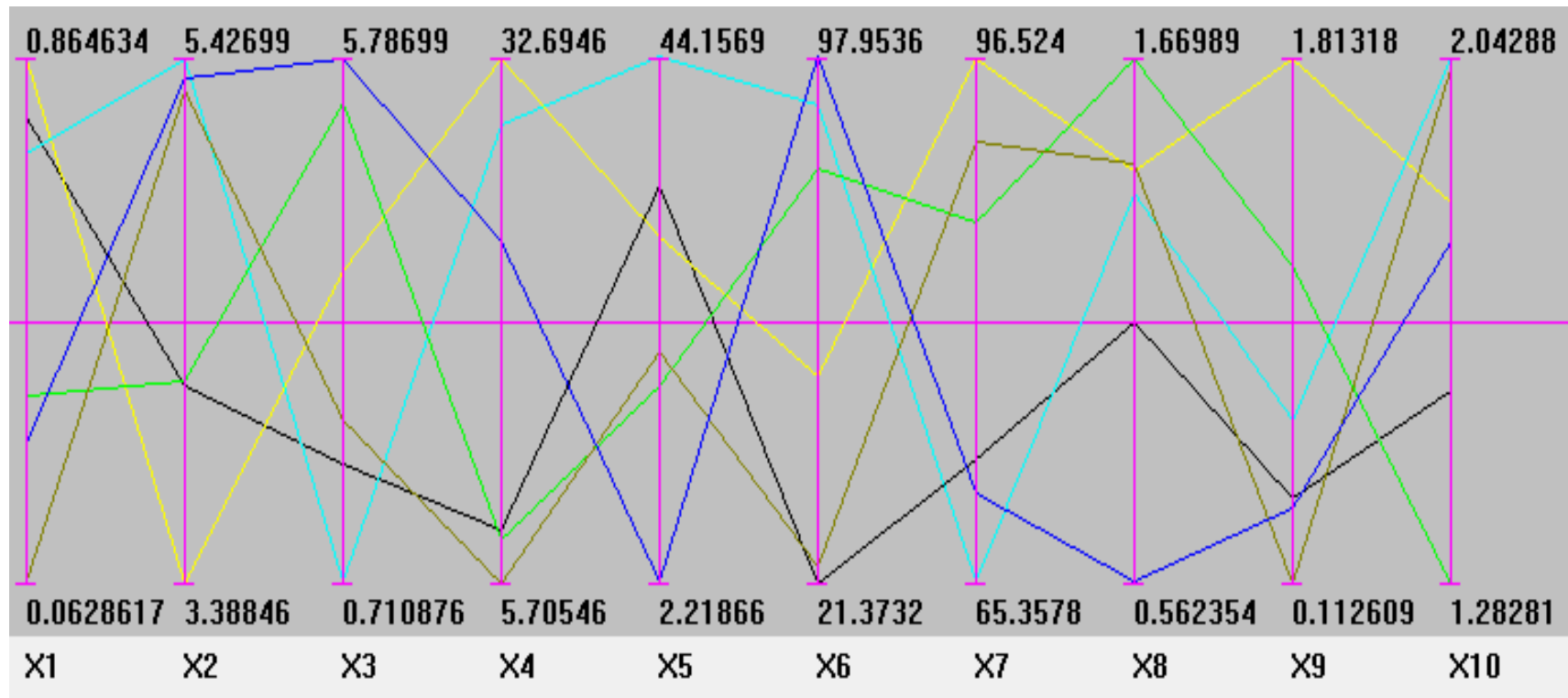


Parallel  
Coordinates

# Geometric Process Modeling

## A 10 dimensional plot with 6 data points

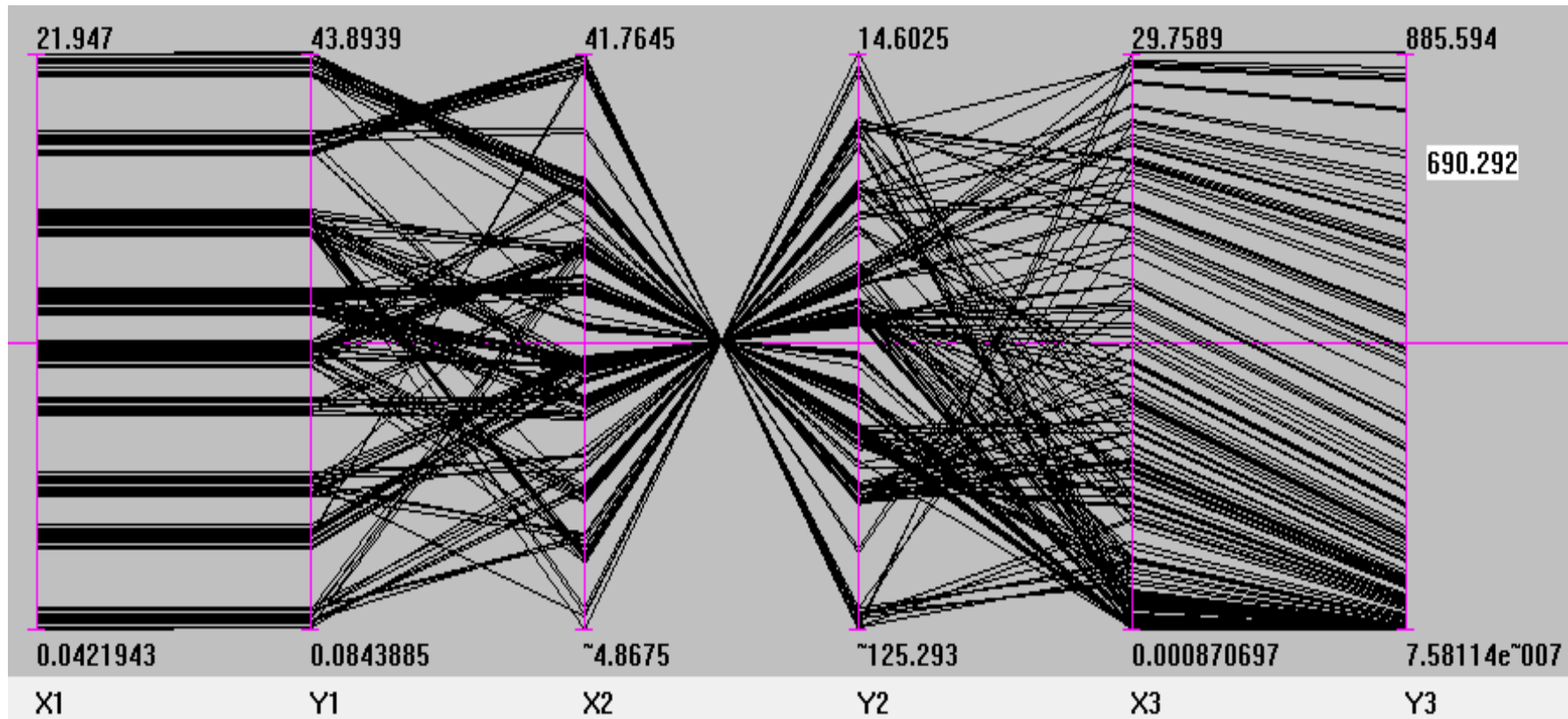
- A New Way of Modeling – Parallel Coordinate Plotting



# Geometric Process Modeling

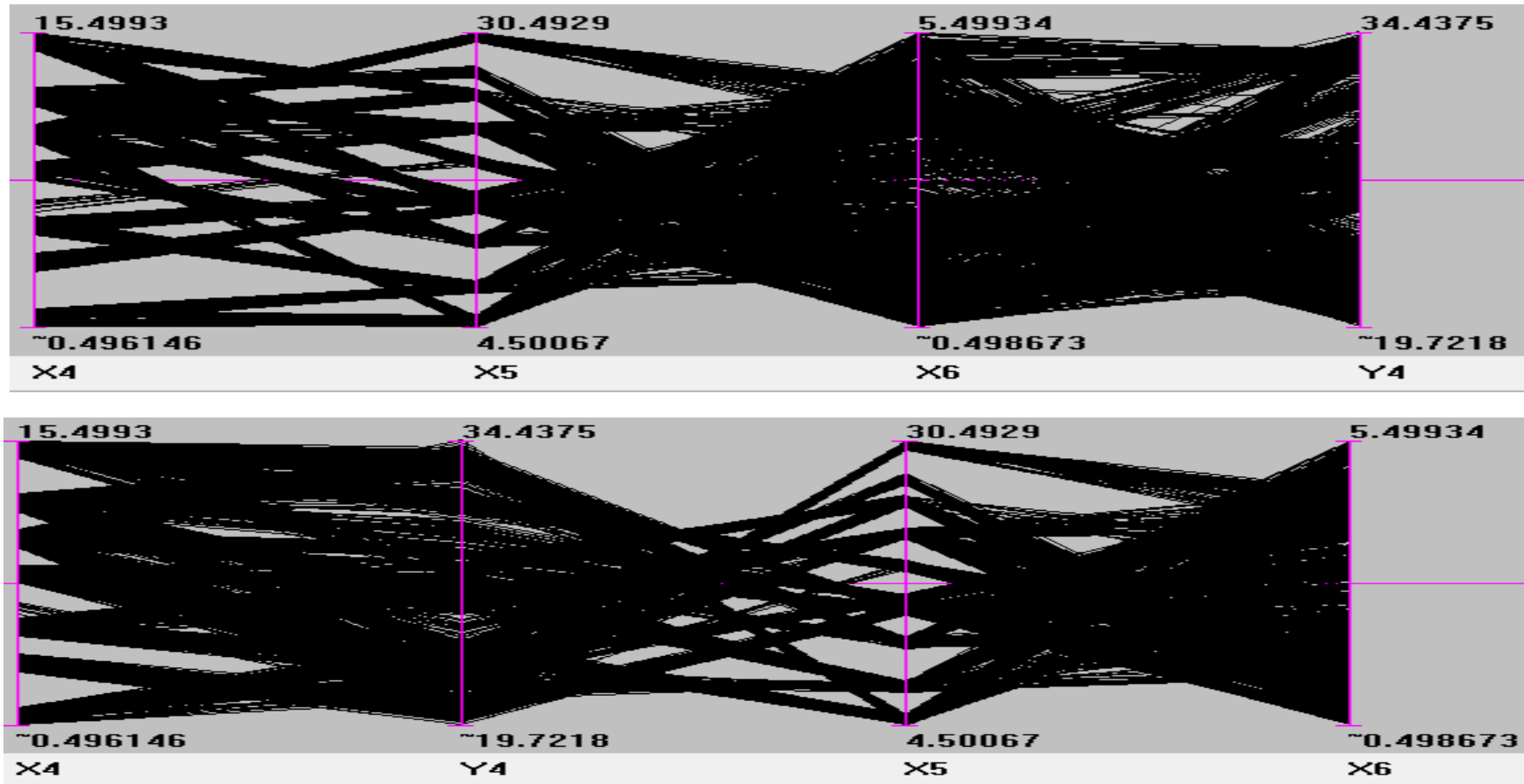
## A New Way of Modeling – Parallel Coordinate Plotting Data Analysis Tool

- Lots of data – patterns begin to appear



# Geometric Process Modeling

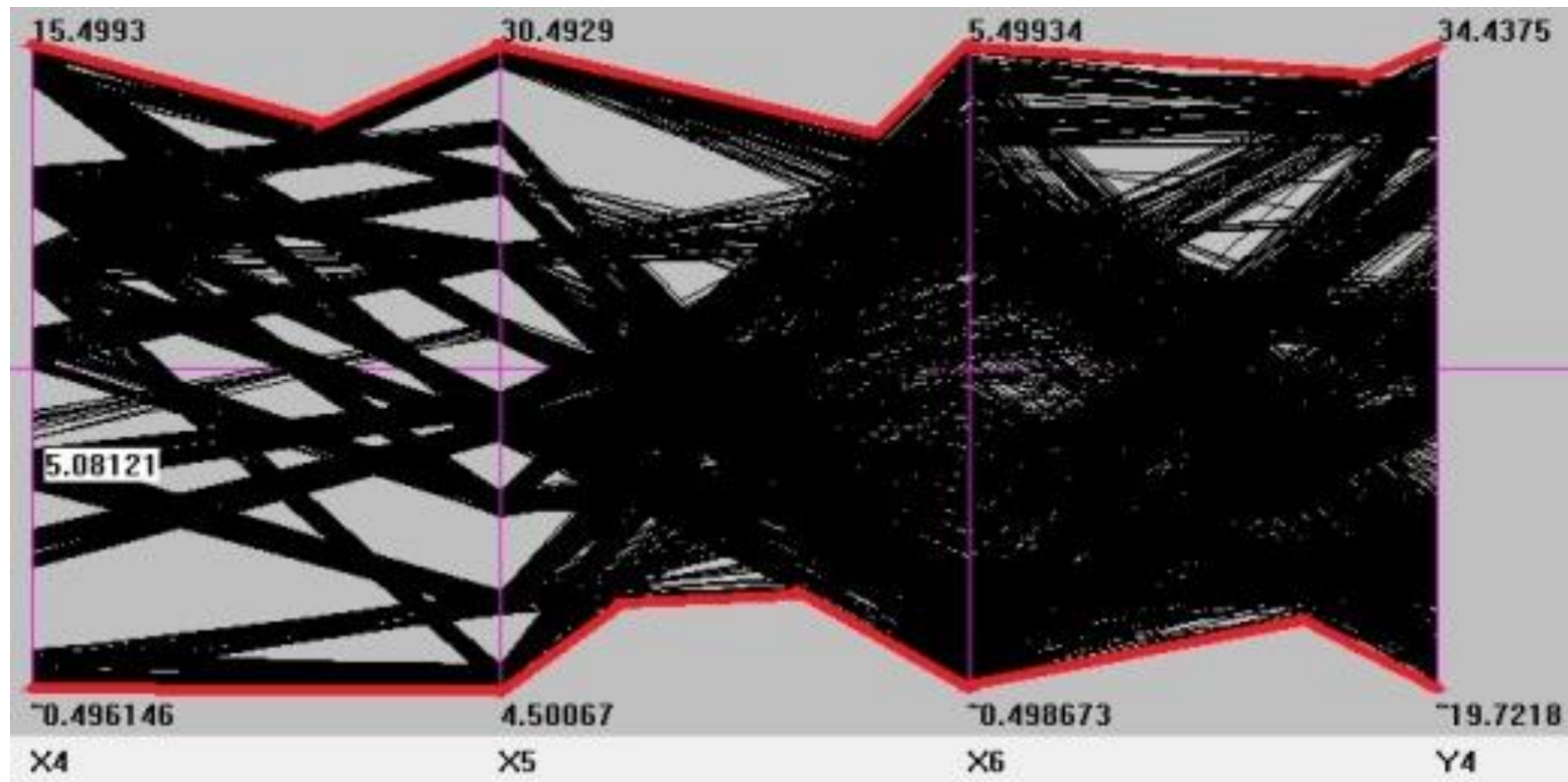
## Parallel Coordinate Plotting – Shifting the Variables



# Geometric Process Modeling

A New Way of Modeling – Parallel Coordinate Plotting Data Analysis Tool

- **Concept of Exterior Data Points or “Skin”**

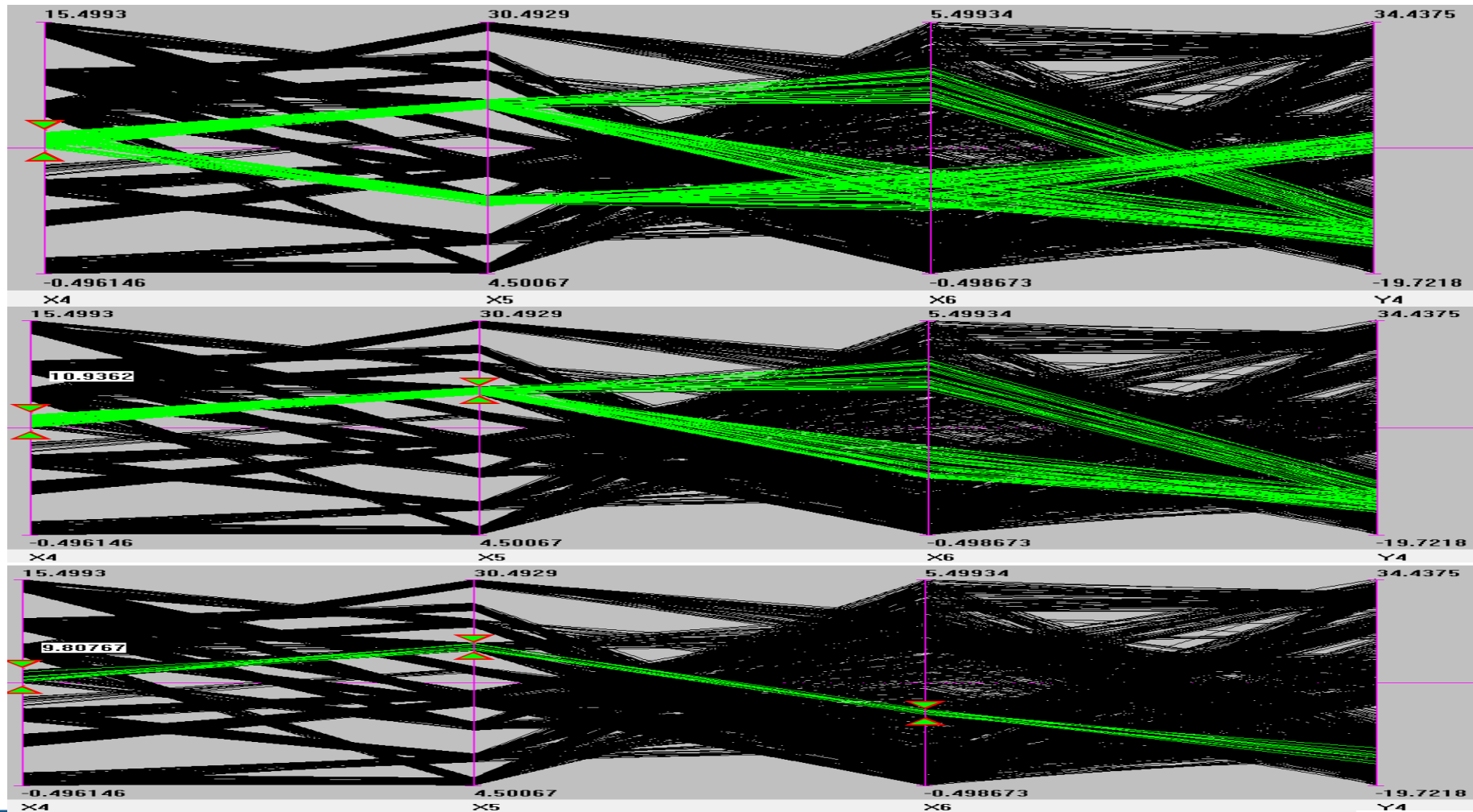




# Geometric Process Modeling

## Parallel Coordinate Plotting

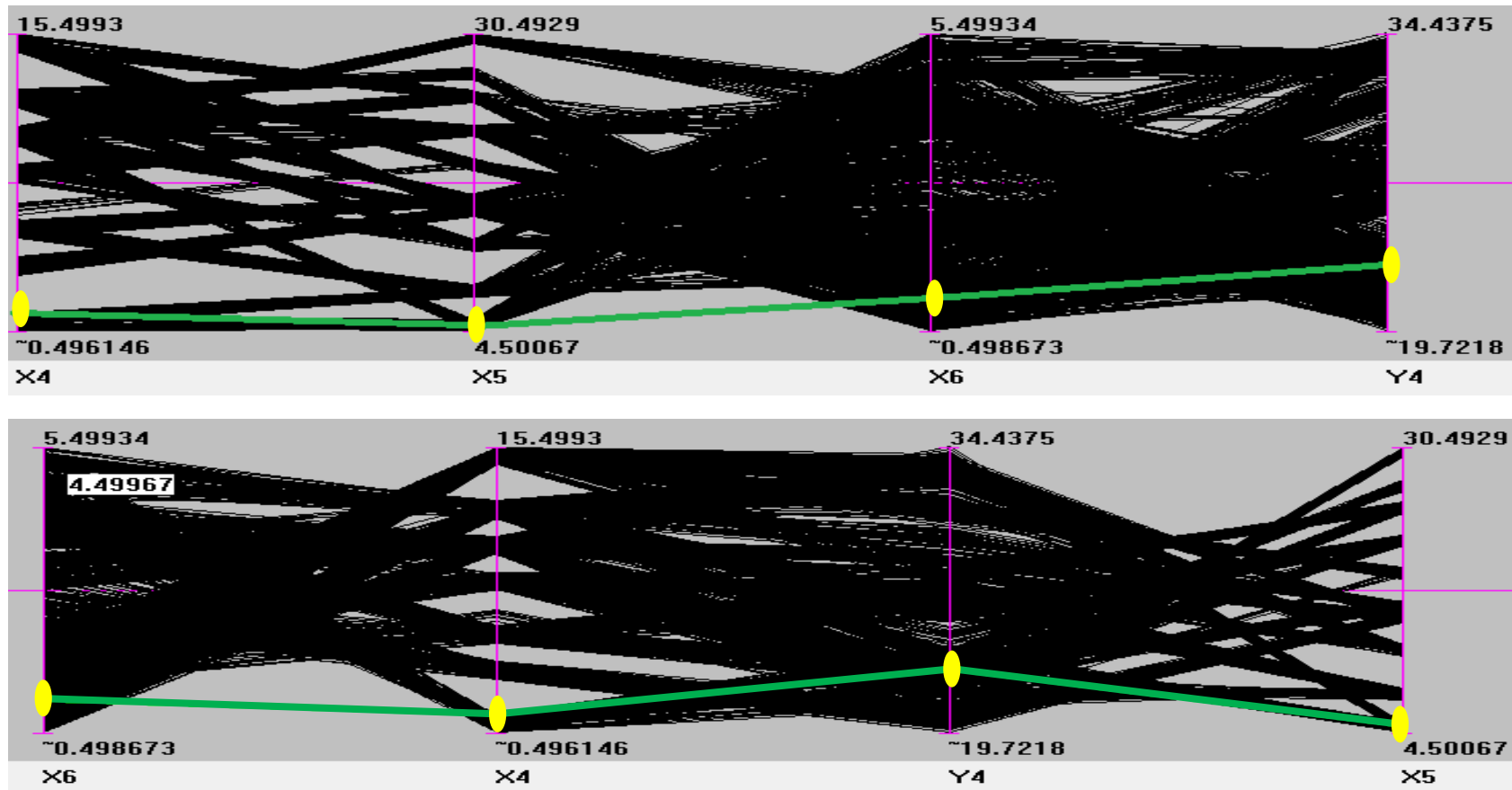
- Concept of Operating Control Region



# Geometric Process Modeling

## Parallel Coordinate Plotting

- Finding abnormalities – breaking the pattern

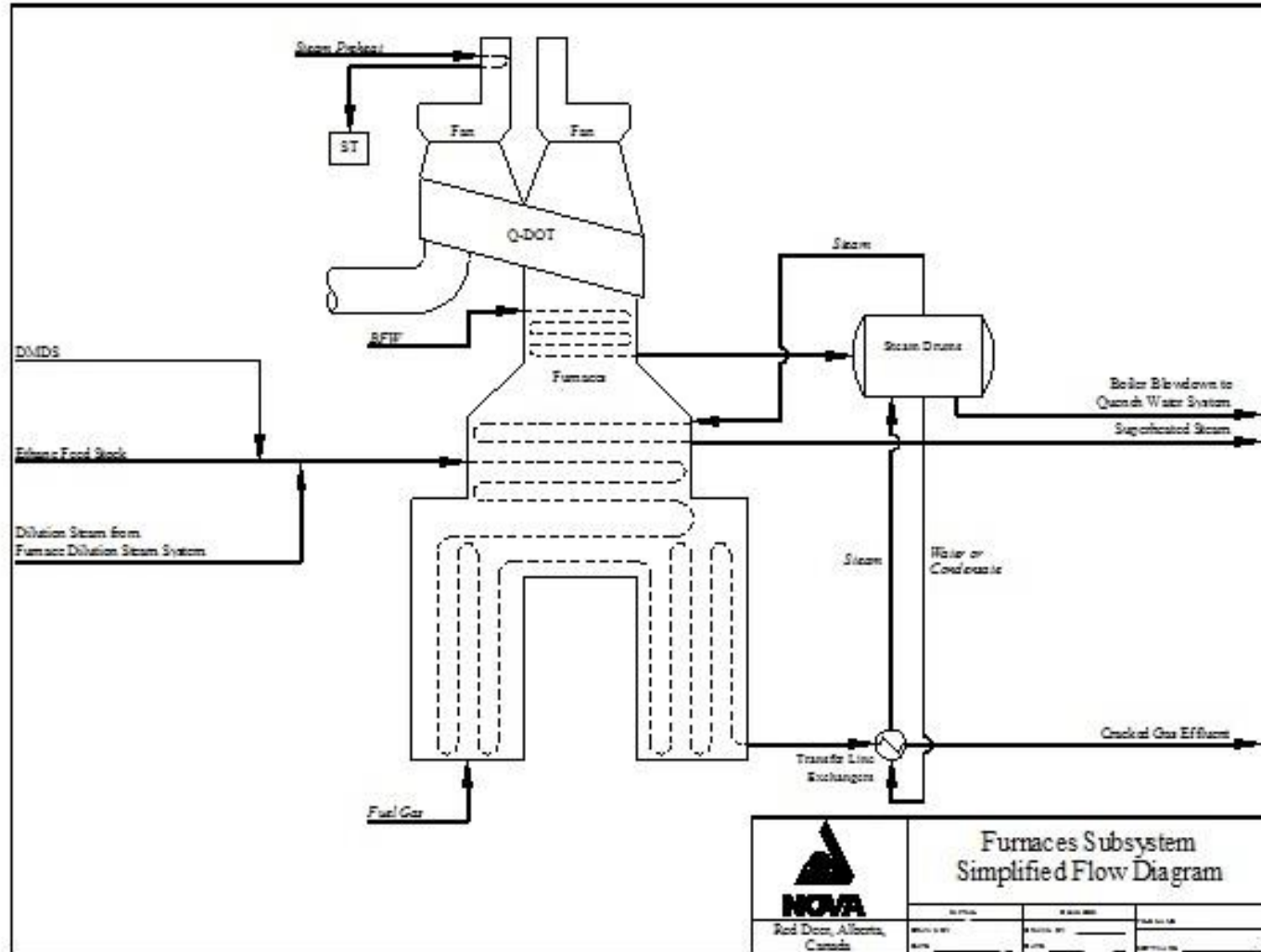


# Building the Furnace Model

(CVE and C Process Modeler - CPM)

# Geometric Process Modeling

## H109 Furnace



# Geometric Process Modeling

## Selecting The Data

- **The rules:**
  - **PV's, and OP's (valves) only**
  - **No SP's, or controller modes and no calculated variables if the inputs are also in the data set**
  - **Data should contain all normal operations**
  - **If plant has had significant changes, data needs to start after the change**
- **The H109 model:**
  - **95 variables**
  - **17 years of 2 hour snapshot data**
  - **Runs once per minute**

# Geometric Process Modeling

## What is Abnormal?

### Any time the plant is not running as desired!

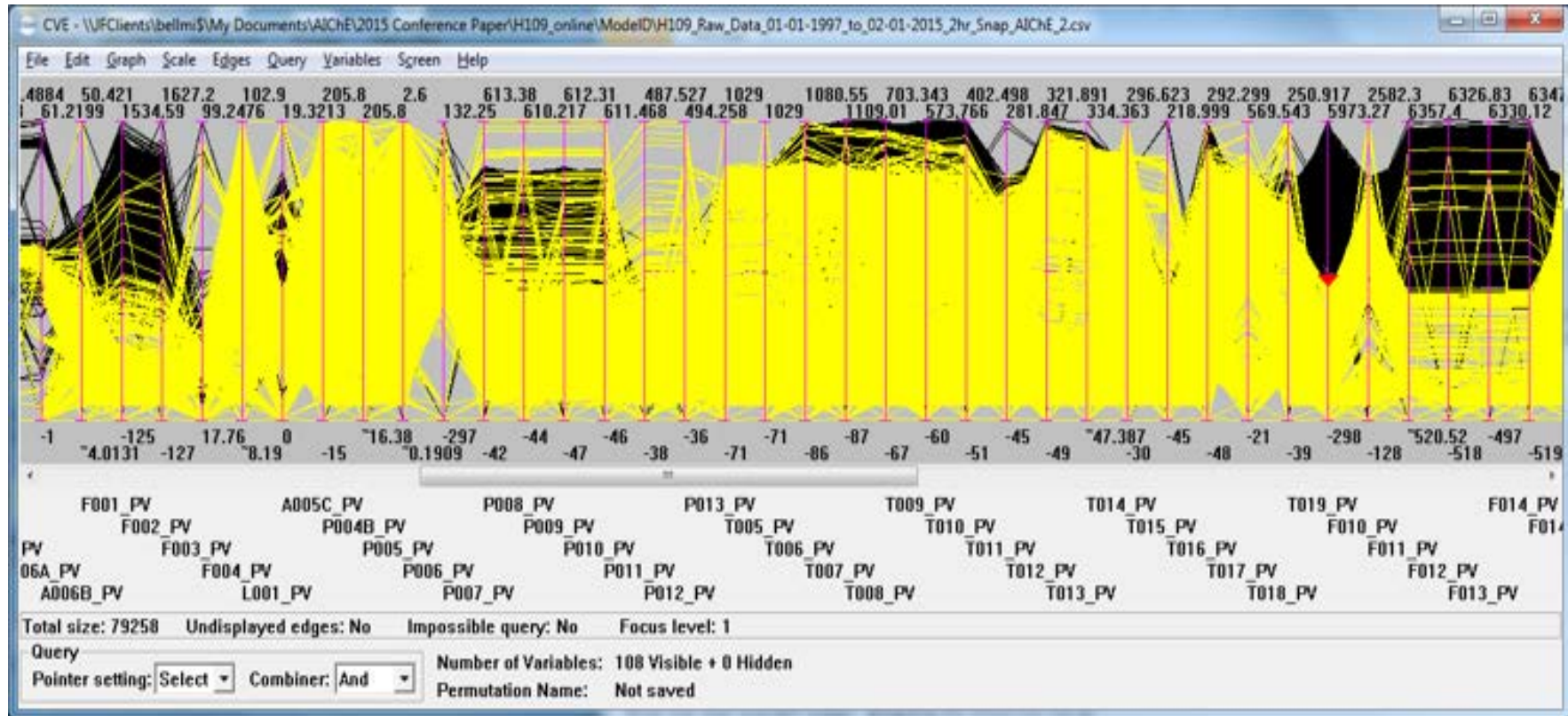
- **Three useful definitions:**

- **Alarmed Event** - a time when something abnormal is actually occurring
  - Includes low rates, variables in alarm, high variability in key process variables, etc.
- **Pre-cursor Time** - the time just before the event
  - Amount of time should be selected carefully so as to include potential causes of the event.
  - Amount of time chosen will likely change for the type of event
- **Recovery Time** - the time where the plant is still in a state of flux after the event has occurred
  - Amount of time chosen will likely change for the type of event

# Geometric Process Modeling

## Cutting the Abnormal Data with CVE – The Query

- **Yellow** is H109 low rate data – to be removed

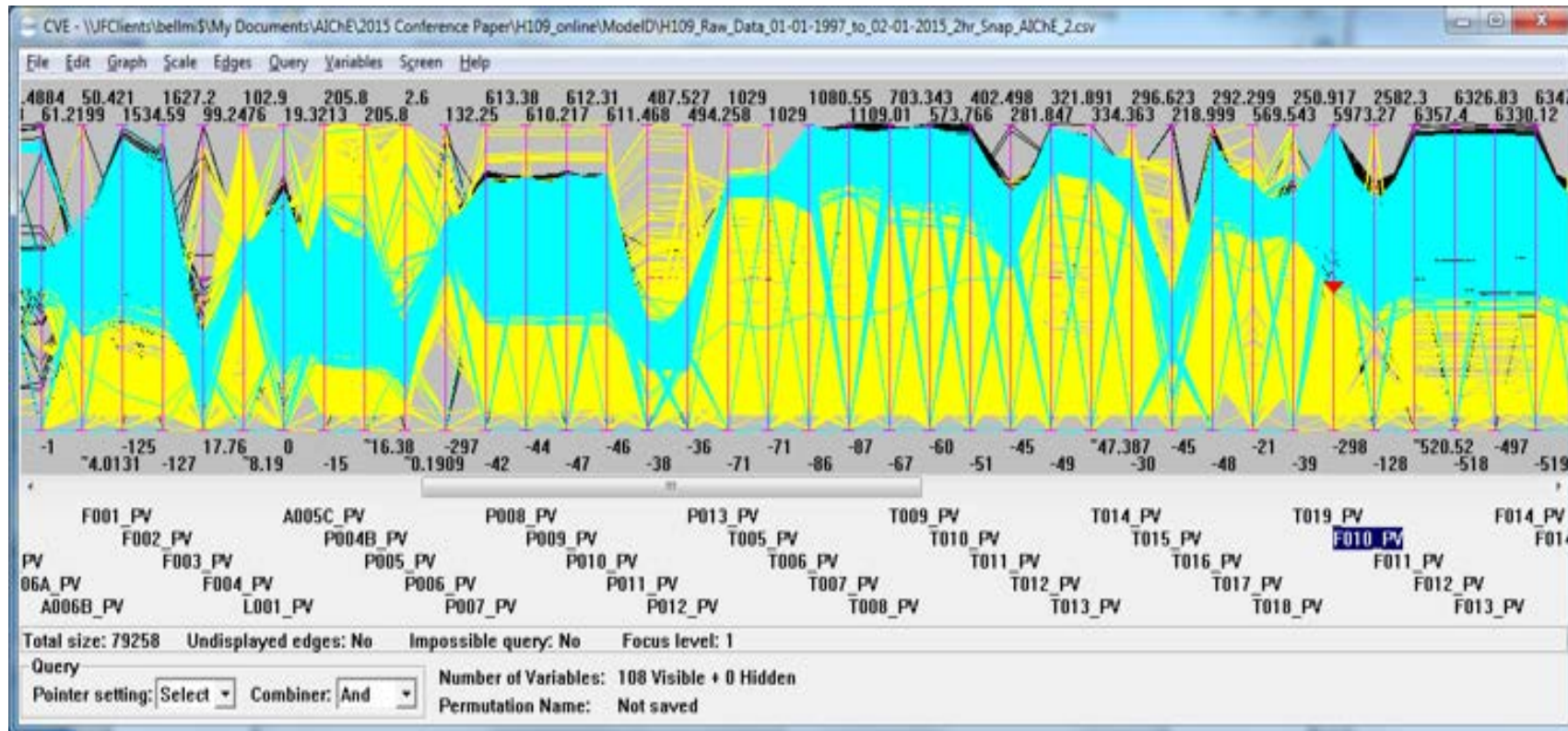




# Geometric Process Modeling

## Cutting the Abnormal Data with CVE – Multiple Query

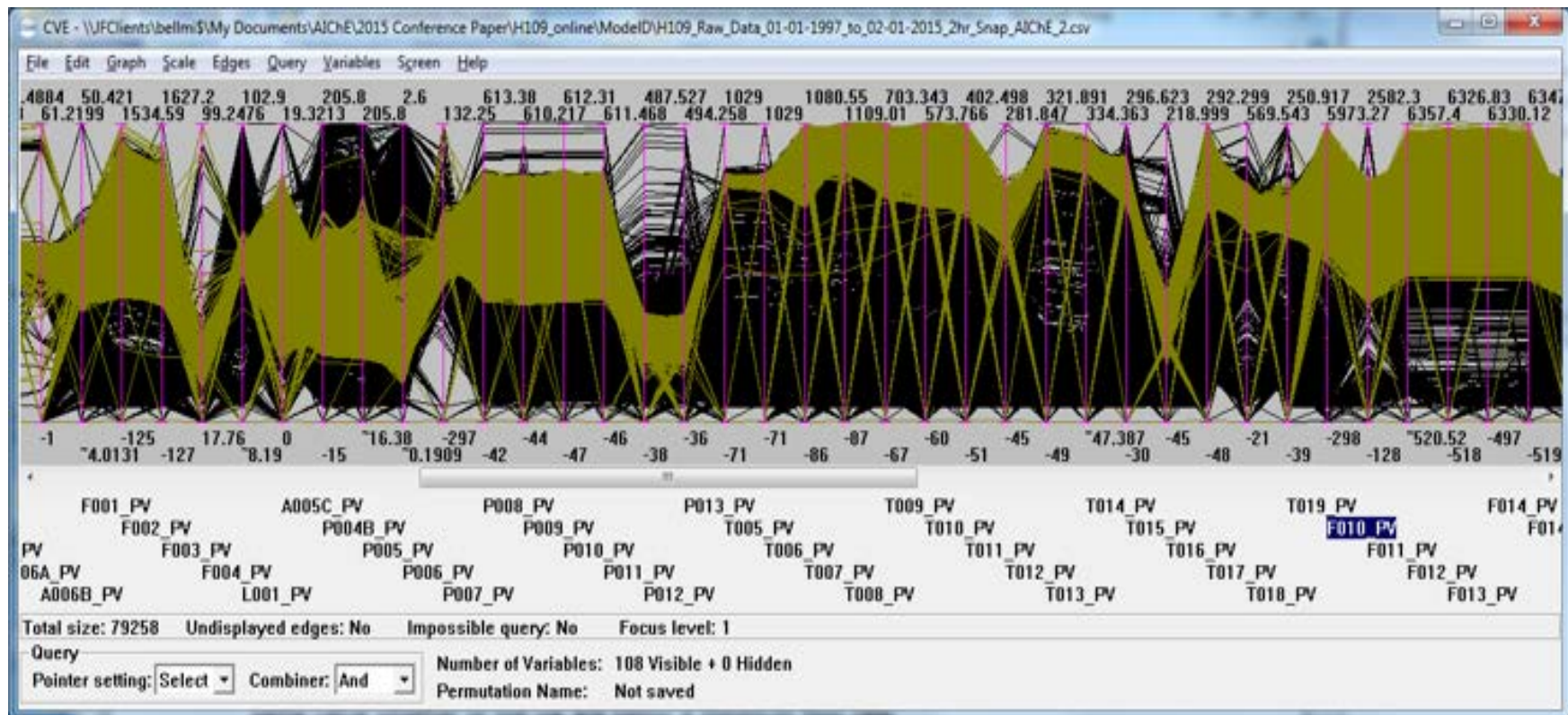
- Added Recovery Time in Blue



# Geometric Process Modeling

## Normal Data – Low Rates Removed

- Leftover normal data after Event, Precursor and Recovery times have been removed - Brown

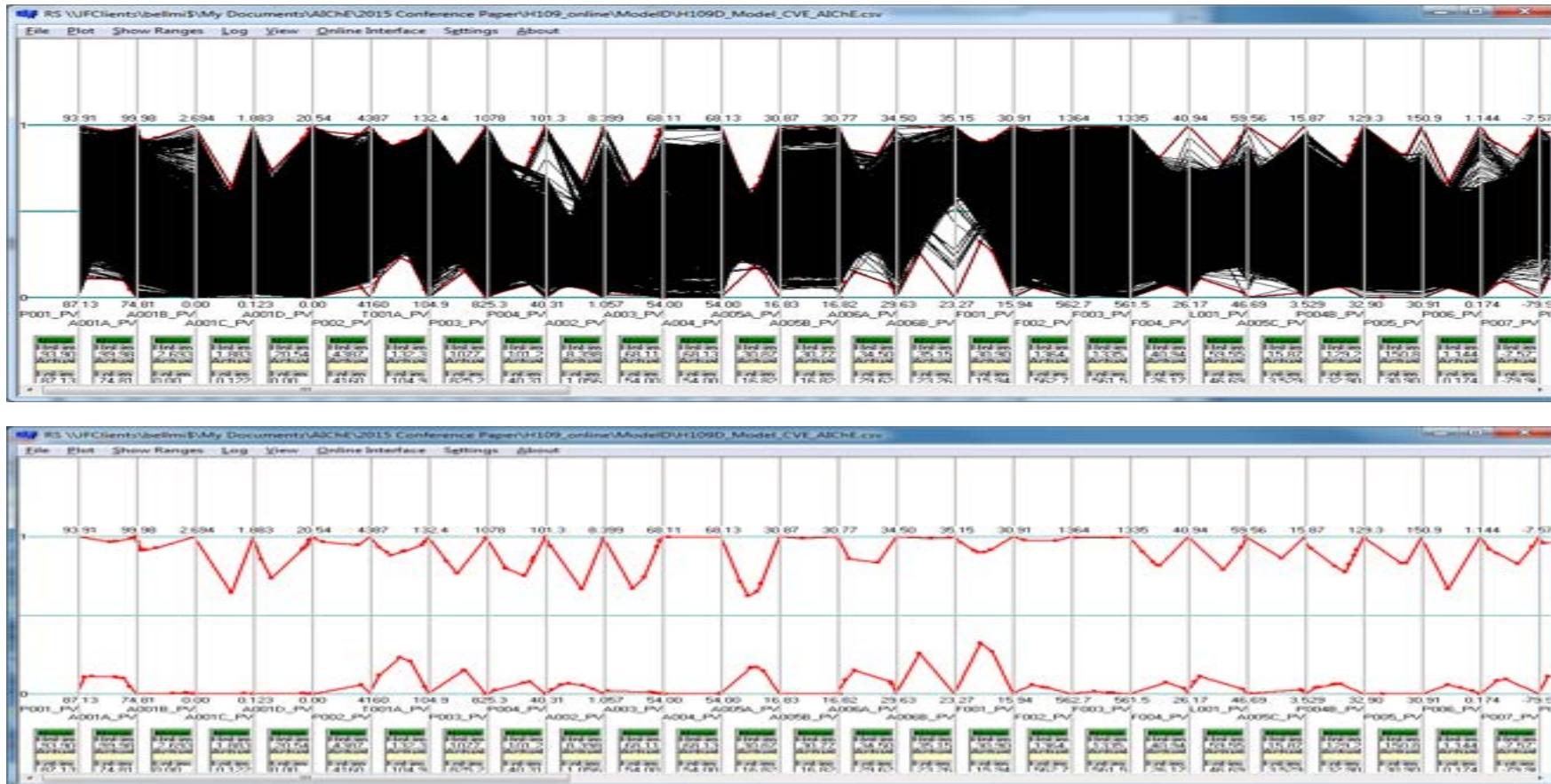




# Geometric Process Modeling

## CPM Full Data Model

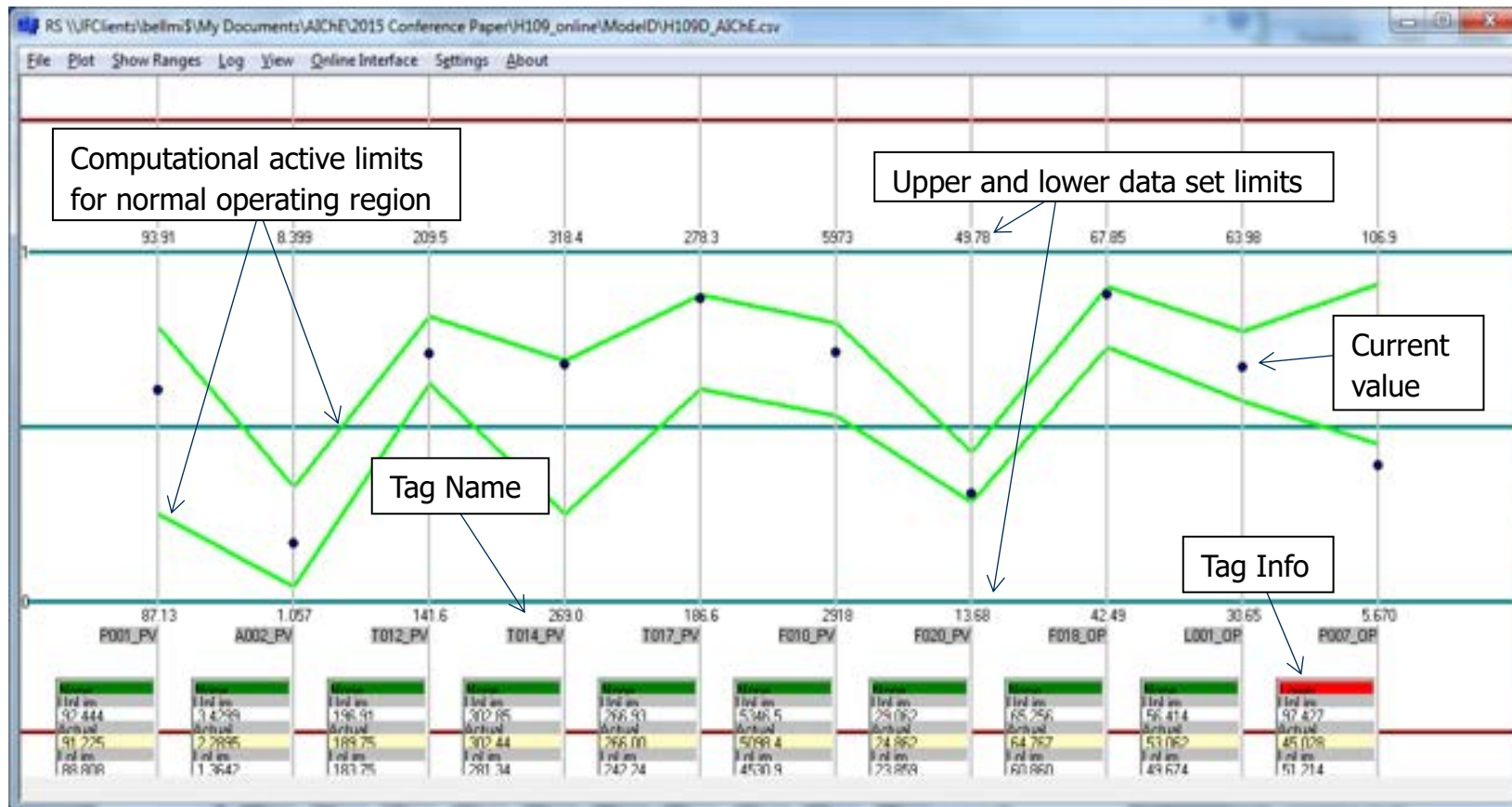
- Exterior “skin “with all model data



# Geometric Process Modeling

## Graphic Details

- Reading the CPM Plot (normal operating region)



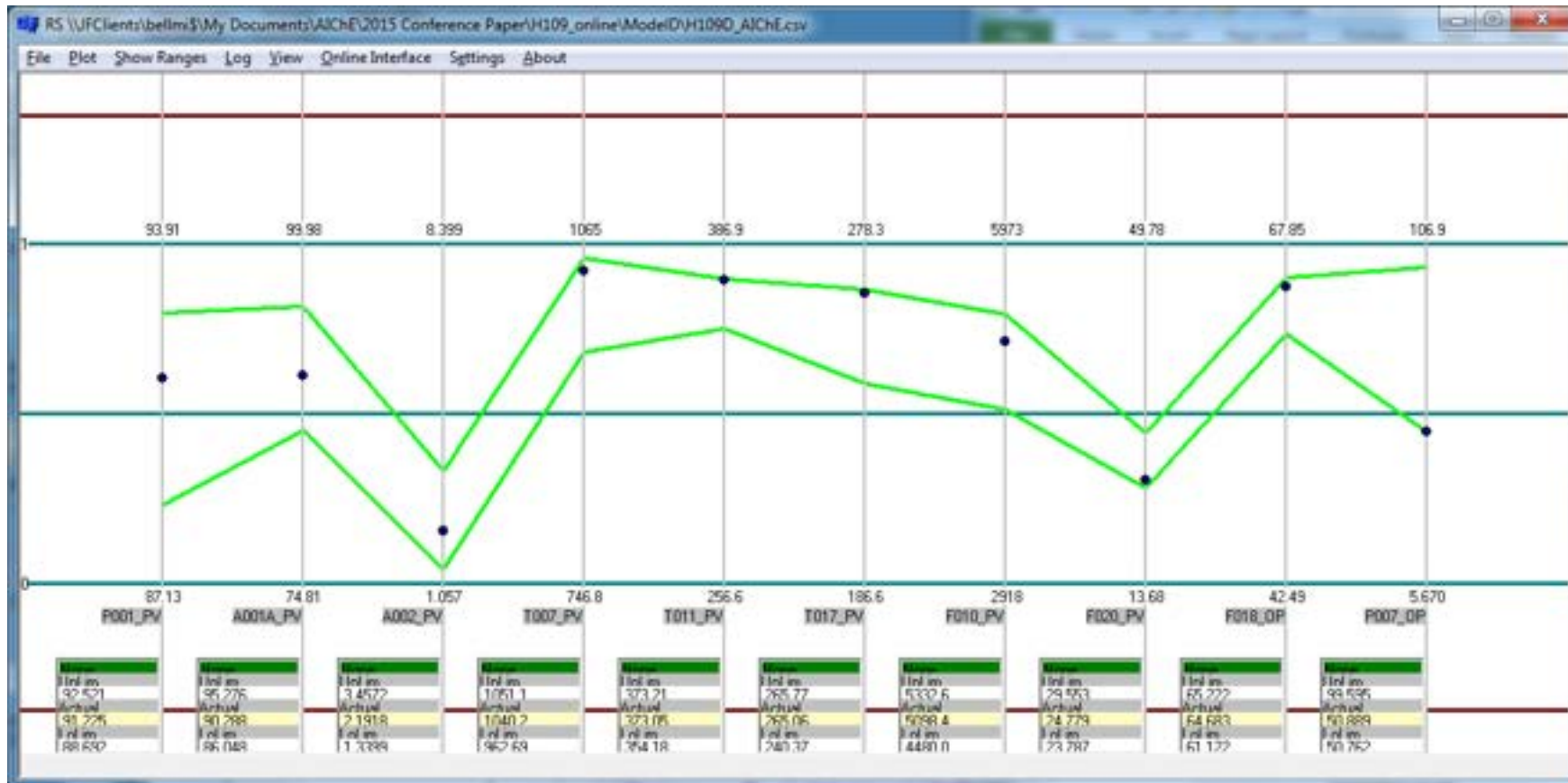
# Abnormal Situation Prediction Example

(How it works)

# H109 Historical Event

## Graphic Details

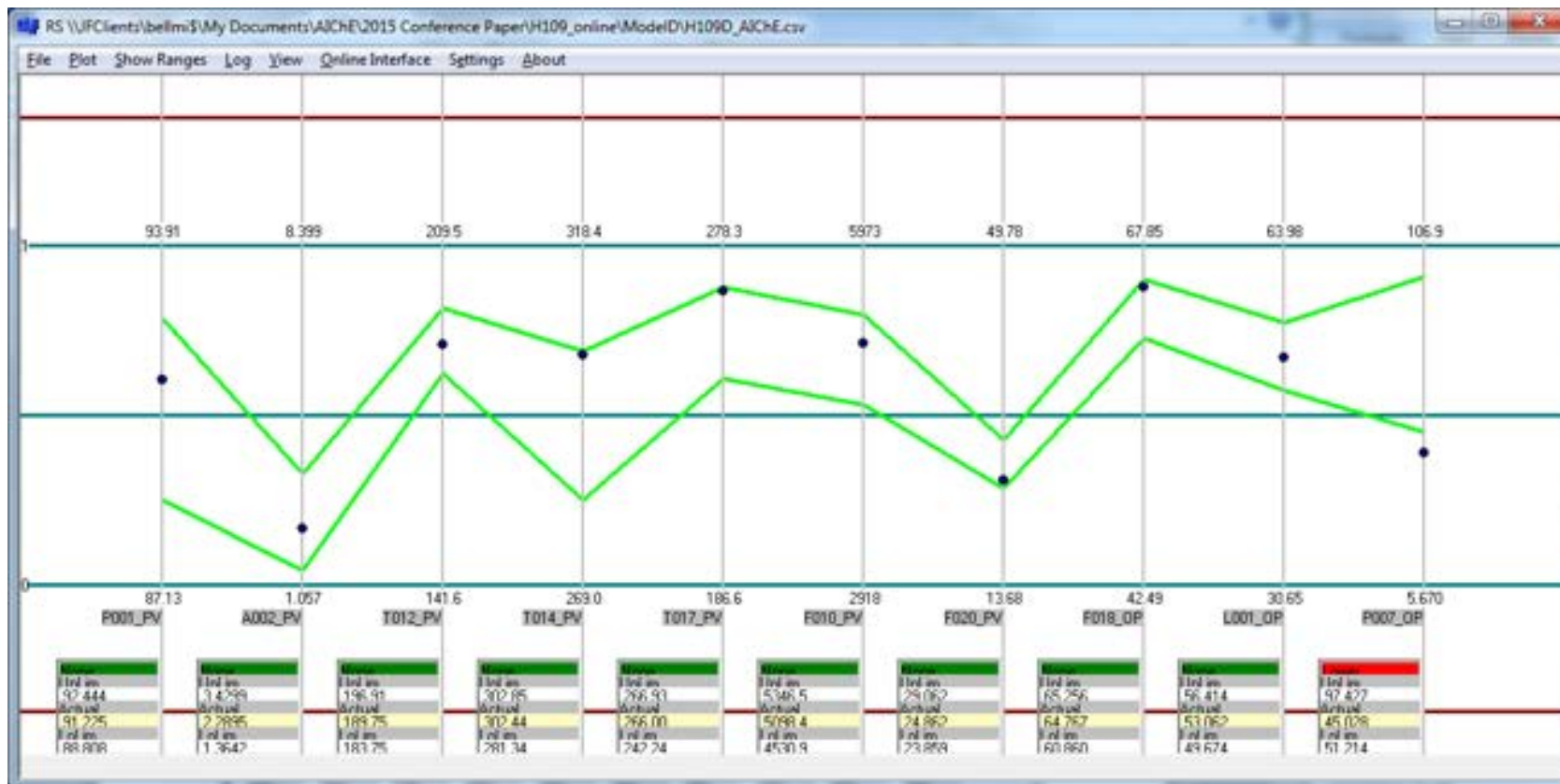
- 2 ½ days before event - Normal



# H109 Historical Event

## Graphic Details

- 2 days 11 hours before event – Alert rings in – Small deviation from normal

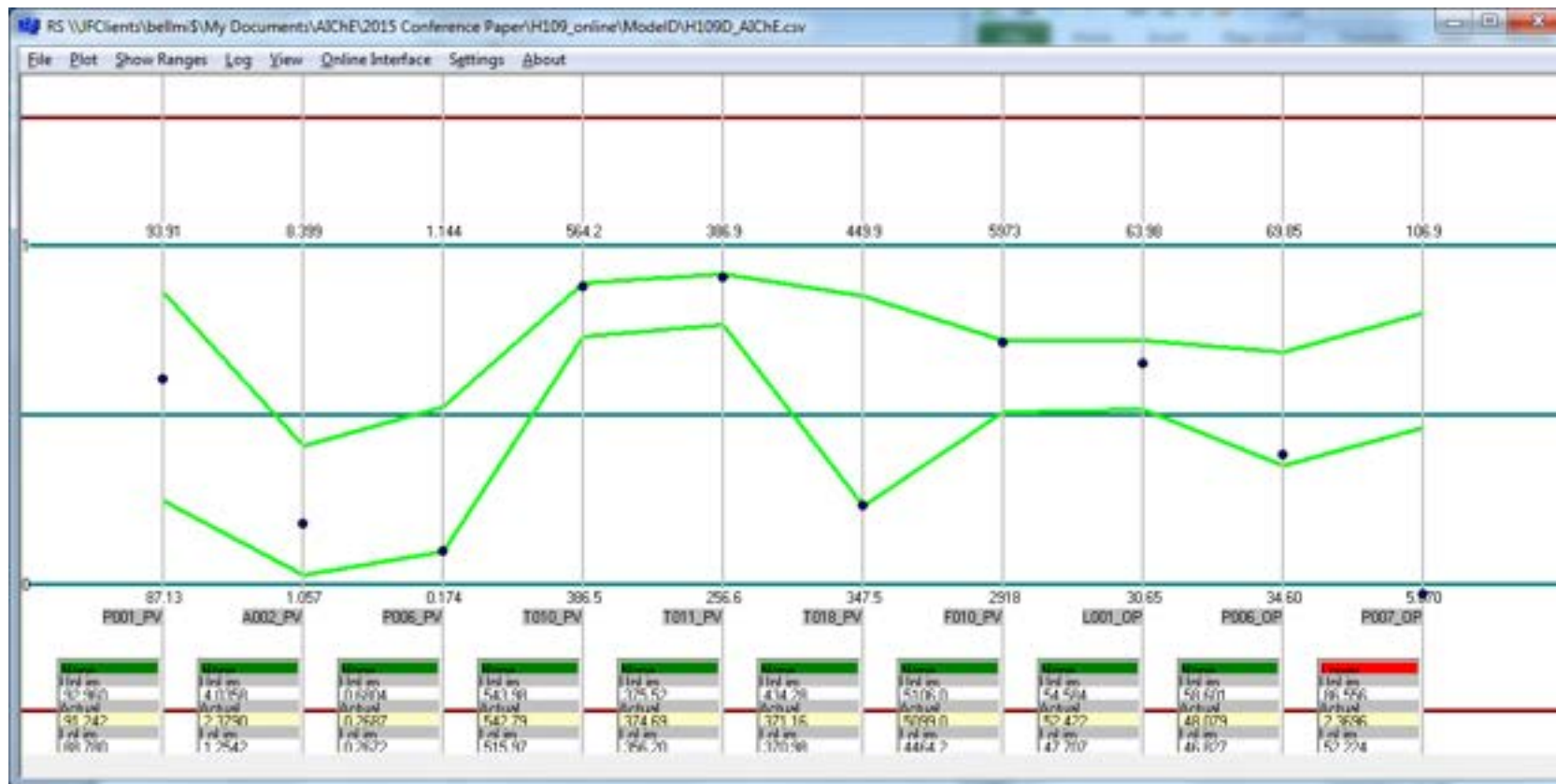




# H109 Historical Event

## Graphic Details

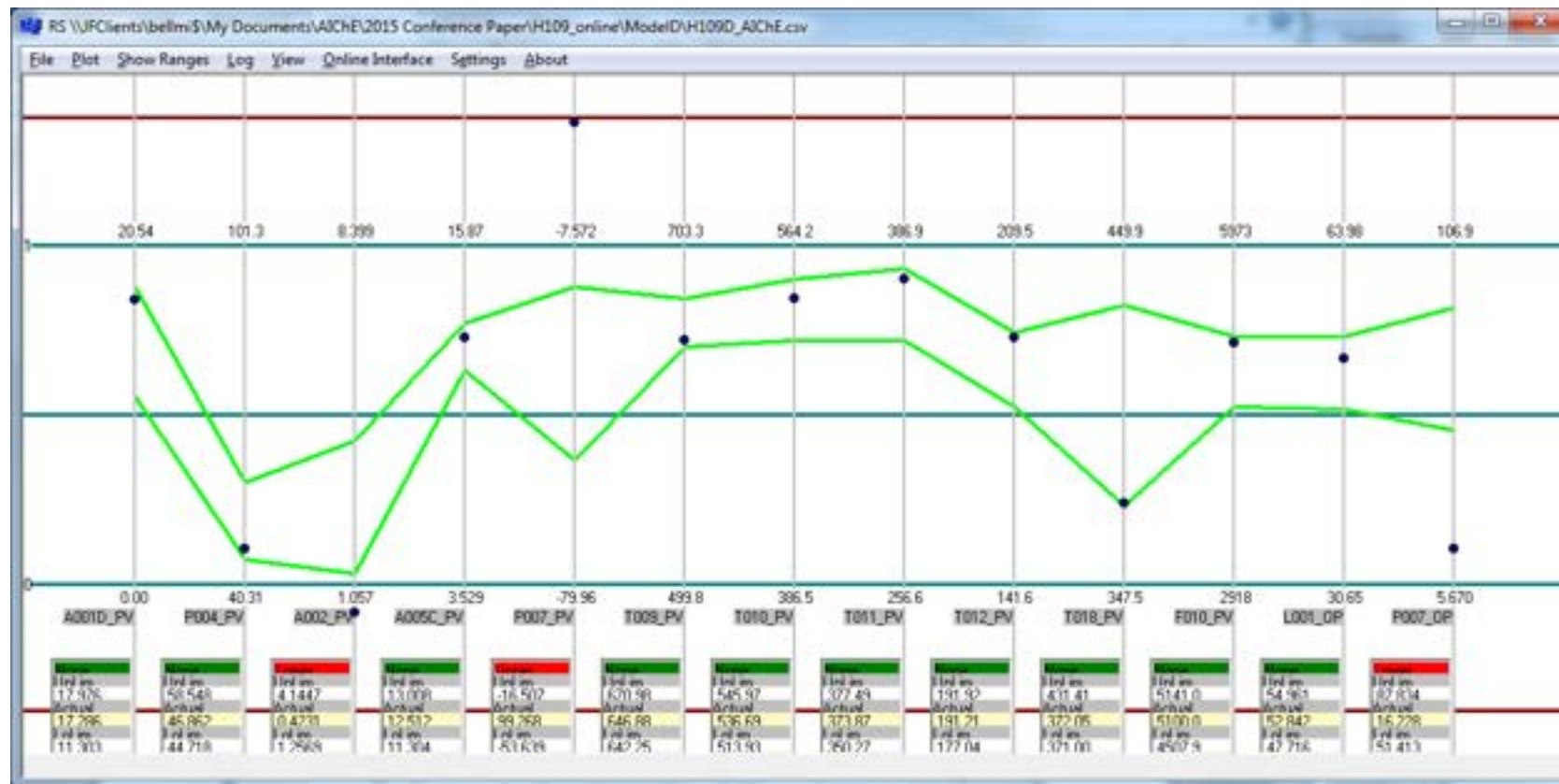
- 1 Day before event – Alert continues - Large deviation from normal



# H109 Historical Event

## Graphic Details

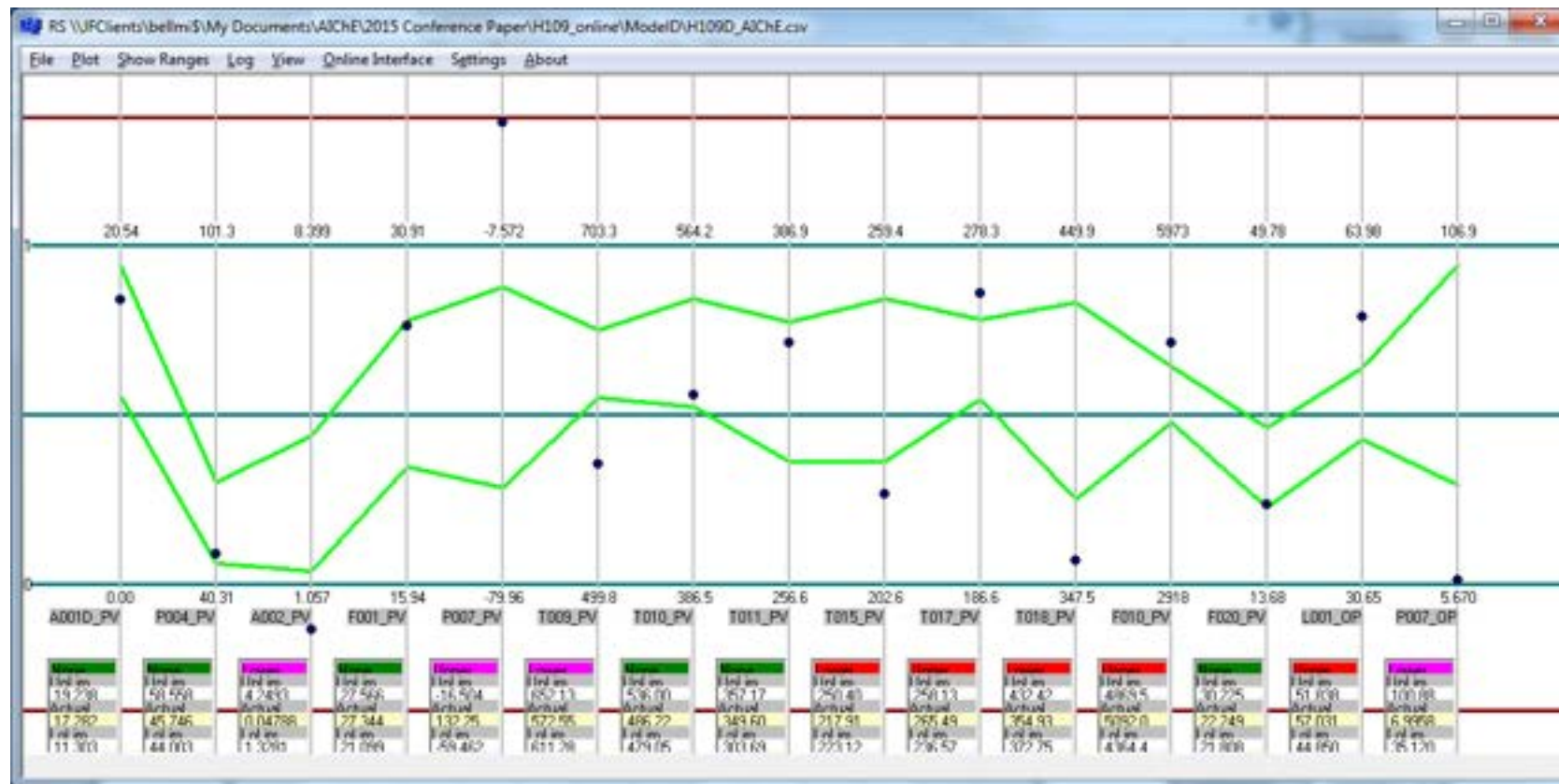
- 2 mins before event – 3 Alerts



# H109 Historical Event

## Graphic Details

- Event is occurring – Multiple Alerts as operator is bringing furnace down



# H109 Historical Event

## Results

- Since its commissioning, the H109 model has identified the following events:
  - Feed preheat exchanger outlet temperature fluctuations
  - Convection section exchanger running hot
  - Air preheat temperature running poorly
- Operators have the ability to “Ignore” variables which are due for repair
- Some difficulties with the model (some of which we have now fixed)
  - Alerts on transients (furnace swings)
  - Would get extra alerts when a furnace is just coming out of decoke
  - Optimization group sets the furnace to run in a place we have never been before.
  - Operators accidentally turn model off or errors collecting data turns the monitor program off.
  - Software allows for multiple operational mode based models (Eg. Propane cracking)

# Future Work

## New Strategy for Panel Operators

- NOVA now has 35 plant monitors in 3 olefins plants. Monitoring all furnaces and assorted finishing end columns and compressors
- Beginning of shift operator to scan each models to look for:
  - **RED**. How do I make it good again? Look at trends. CPM does supply some hints.
  - If all variables **GREEN** go to next model. 15 second scan of each model and move to the next.
  - Ignored variables that are now inside the **green** lines – put them back active
  - Ignored variables which are still outside the limits – Why? Notification needed?
  - See if there are any variables close to their limits – Why?
- Periodically scan each model (every 3-4 hours) as above.

**This tool is early warning for operators is does not take control action!!**



RESHAPING PLASTICS

[novachemicals.com](https://novachemicals.com)



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# CCPS Presentation

**Mind the Gap: Rethinking Risk Acceptance in HAZOP and LOPA**  
**September 11, 2025**







# WATCHMEN OVERVIEW

- Expert services include HAZOP/LOPA Facilitation, SIL/SIS Consulting, Alarm Management, Fire and Gas Engineering
- Proud member of ISA-84 Standards Committee, helping shape U.S. and international SIS lifecycle requirements
- Serves on the CFSE (Certified Functional Safety Expert) Advisory Board, promoting certified competence in safety system professionals
- Process safety training courses provider





# WATCHMEN PRESENTER

## SHAUN WILLIAMSON

- Certified Functional Safety Expert (CFSE)
- TÜV F.S. Engineer
- Professional Licensee with APEGA and APEGBC
- 25+ years of combined Process Safety, Instrumentation/Controls, experience
- ISA84 working group committee member
- CFSE Advisory Board Member
- Supported applications in industries including:
  - Oil & Gas
  - Petro-Chemical
  - Bio-Fuels & Renewables
  - Pulp & Paper
  - Waste Water Treatment
  - Food & Beverage
  - Commercial and Light Industrial



DIRECTOR OF  
ENGINEERING

# SALES AND SUPPORT

## DAVE SUMMERS

Director of Corporate Development  
Email: [dsummers@watchmenise.com](mailto:dsummers@watchmenise.com)



## PRESENTER PROFILE

PROFESSIONAL  
PROFILE

### Expert in:

- HAZOP and LOPA
- SIS/SIL Consulting
- Alarm Management
- Fire and Gas Systems



# Our Mission

To be trusted guardians of process safety, ensuring that every worker goes home safe through our excellence in engineering, leadership, and execution



# MIND THE GAP: SETTING THE STAGE

*In process safety, identifying risk gaps in PHA is only the beginning — what we choose to do about them reveals the strength of our safety culture and sets the tone for every future decision.*

*Accepting undue risk without robust justification can signal to teams that risk management is negotiable, eroding confidence in the overall safety program.*



# MIND THE GAP: THE ISSUE

## The Issue

- Companies face difficult choices when risk gaps are identified in HAZOP and LOPA
- Medium risk (Yellow) typically identified as ALARP region is often misunderstood and incorrectly treated as “broadly acceptable”
- Accepting a LOPA gap, especially for personnel hazards is risky and contradicts industry standards and engineering logic
- Confusing “close enough” with “safe enough” leads to under-protected facilities
- Today we will explore how to avoid these pitfalls and apply these tools as intended



*Meeting the target means meeting it, not waving at it as you fall past.*

# WHY IT MATTERS

HAZOP and LOPA are not simply to generate paperwork

- They are tools to expose weaknesses and prioritize improvements
- Ignoring their findings leaves risk leaving hazards uncontrolled

Risk acceptance decisions define safety culture

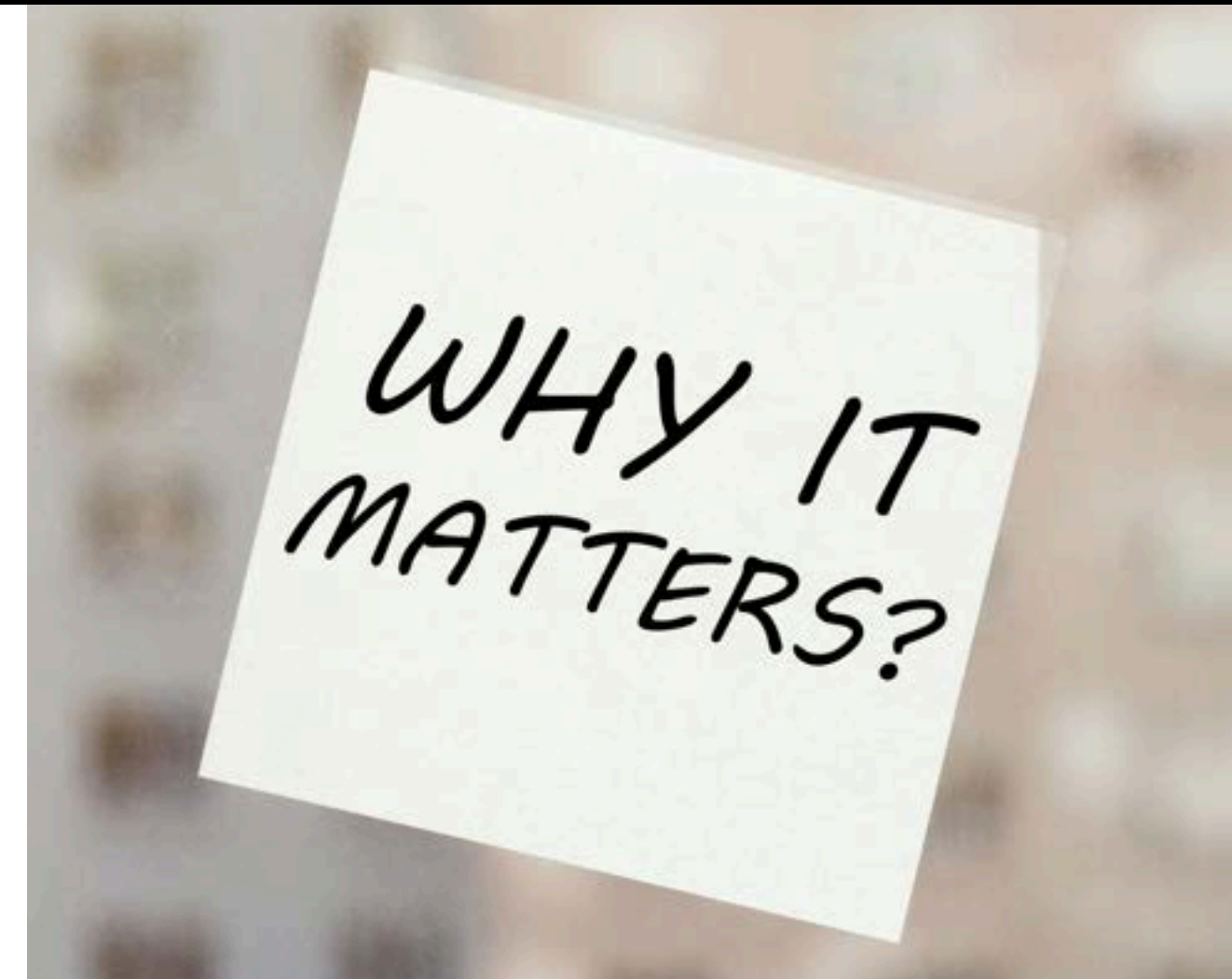
- What management accepts (or rejects) signals the companies true values
- Tolerating gaps undermines confidence in the safety program

Broader impacts across the organization

- A “close enough” mindset can ripple out to other decisions
- Normalizing partial solutions erodes discipline in future assessments

Bottom line

- If we fail to address identified gaps, the entire risk management process loses credibility



*Measured risk without action, is not managing risk. Its just recording it.*

# UNDERSTANDING THE “WHY”

Widespread practices, shallow understanding

- Industry commonly adopts practices simply because “this is how its done”, and often the reasoning why it is done is lost.

Why understanding matters

- Without knowing why a principle exists, it is easy to apply it incorrectly
- Misapplied practices lead to unmanaged risk and a false sense of safety

How this applies to ALARP

- ALARP is not a checkbox, and it’s not a loophole
- It is a decision making framework based on engineering analysis
- Industry would benefit from a refresher on:
  - Why ALARP is used
  - When it is appropriate
  - How to apply it for maximum benefit



*Understanding the “why” behind risk practices is essential to apply them correctly to manage risk effectively*



# THE ALARP PRINCIPLE

What does ALARP mean?

- As Low As Reasonably Practicable
- Risk reduction required unless cost is grossly disproportionate to the benefit

To Apply ALARP correctly"

- Its not about doing nothing - its about doing enough
- Requires analysis of further risk reduction options
- Evaluate costs and feasibility
- Only accept risk when further controls are unreasonable

Key considerations

- Align with recognized standards, not personal opinion



*Without analysis, you're not applying ALARP -  
You're just avoiding action.*

# USING THE RISK MATRIX CORRECTLY

Purpose of the risk matrix

- Helps categorize risk consistently
- Drives proportionate action based on severity and likelihood

Risk bands must drive decisions

- Broadly acceptable region (Green) → no action required
- Unacceptable region (Red) → immediate action required
- ALARP region (Yellow) → judgement is needed

Calibration matters

- If organization routinely accepts risk in ALARP region, the matrix is likely miscalibrated (erodes credibility)
- The matrix should trigger risk based decisions



*The risk matrix is a tool for action, not a scorecard to file away*

# LOPA AND RISK REDUCTION FACTOR (RRF) GAPS

## Why RRF matters

- Each scenario is assigned a required tolerable frequency that must be achieved based on potential consequences
- It is not unusual to see team recommend acceptance of small risk reduction factor (RRF) gaps
- Often done to avoid the need to implement a SIF.

## The problem with partial RRF acceptance

- The gap remains, and safety functions are expected to achieve integrity they are not designed to.
- Partial risk reduction is not supported by standards like IEC 61511 or CCPS

## Design, don't approximate

- Avoid acceptance of gaps (i.e. RRF 3 with IPL credited RRF 10 - should be a SIL 1 SIF designed to RRF 30).



*Design to meet or exceed the required RRF -  
Always*



# ORGANIZATIONAL CHALLENGES

Management rejection of recommendations

- In some organizations, ALARP-region improvements commonly rejected as “not required”
- Creates perception that safety is optional

Cultural impacts

- Signals that shortfalls and partial solutions are okay
- Undermines confidence in the risk management process

Ripple effects

- Sets a precedent for tolerating gaps in other safety-critical systems
- Weakens risk discipline throughout the organization
- Disciplined safety leadership means closing gaps, not normalizing them.



*Consistently addressing risk gaps builds a culture of trust, accountability, and strong safety leadership*

# BEST PRACTICES & RECOMMENDATIONS

Meet or exceed risk targets

- Treat risk targets as minimums, not suggestions
- Design SIFs to fully achieve required risk reduction

Apply ALARP properly

- Analyze additional risk reduction options
- Only accept risk if grossly disproportionate to the benefit

Establish clear process for risk acceptance

- Clear procedures and documentation
- Consistent and transparent justification for decisions

Strengthen safety culture

- Consistently act on risk gaps
- Reinforce that safety is a non-negotiable priority



*Build a culture that values safety - not just in policy, but in practice*

# HAZOP EXAMPLE - OPPORTUNITY LOST IN THE ALARM REGION

- Residual risk assessed as Moderate (Yellow / ALARP region)
- A low-cost risk reduction option was identified that would reduce the risk to Low (Green)
- The proposed action was reasonable and feasible during the design phase
- Instead of implementation, the recommendation was rejected outright, or soft-rejected by de-prioritization — delayed by years

Causes	L	Consequences	CAT	Inherent Risk		Existing Safeguards			Current Risk		LOPA Yes/No	PHA Recomme
				S	RR	Safeguards	Safeg Cat	Safg PL	L	RR		Recommendation
1. LV-001 (Inlet to P-100 Transfer Pump) malfunctions closed.	3	1. Eventual damage to P-100 Transfer Pump; potential seal failure; lost containment of produced water; lost production.	Asset	3	Mode rate	16. None		0	3	Mode rate	No	1. Implement a new protection layer that provides pump protection (P-100 Transfer Pump) in the event of blocked suction which can result in pump failure and lost containment. Options include a low level or low flow trip.
			Environment	1	Low				3	Low	No	

## Key Reflection:

- ALARP decisions should be based on analysis — not convenience
- Early design phase is the ideal time to act on low-cost risk reduction



# LOPA EXAMPLE - STARTING WITH RISK IDENTIFICATION IN HAZOP

Three separate HAZOP causes identified, all leading to the same consequence

- Each cause classified as Moderate (Yellow / ALARP region)
- Team proceeded with LOPA to:
  - Remove conservative assumptions
  - Account for cumulative risk of all causes together
  - Considers scenario modifiers and more granularity on IPL credits

Key Insight:

- ALARP zones in HAZOP may mask a real risk gap when evaluated in isolation

Causes	L	Consequences	CAT	Inherent Risk		Existing Safeguards			Current Risk	
				S	RR	Safeguards	Safeg Cat	Safg PL	L	RR
1. PV-100 (Separator Inlet) malfunctions open. <a href="#">LOPA Scenario - Initiating Event: 2.1.1</a>	3	1. Overpressure of V-100 Test Separator; lost containment; fire and explosion hazard; lost production. <a href="#">LOPA Scenario: 2.1</a>	People	4	High	15. PI-001 (HH) trips XV-001 (pipeline inlet).	BPCS - V	1	2	Significant
			Environment	3	Moderate	13. PSV-001 set @ 1034; no credit since flare system no sized to handle continuous relief from pipeline.	MECH	0	2	Moderate
			Asset	3	Moderate				2	Moderate
2. PV-101 (Separator Gas Outlet) malfunctions closed. <a href="#">LOPA Scenario - Initiating Event: 2.1.2</a>	3	1. Overpressure of V-100 Test Separator; lost containment; fire and explosion hazard; lost production.	People	4	High	15. PI-001 (HH) trips XV-001 (pipeline inlet).	BPCS - V	1	2	Significant
			Environment	3	Moderate	13. PSV-001 set @ 1034; no credit since flare system no sized to handle continuous relief from pipeline.	MECH	0	2	Moderate
			Asset	3	Moderate				2	Moderate
3. ESDV-100 (downstream pipeline isolation) malfunctions closed <a href="#">LOPA Scenario - Initiating Event: 2.1.3</a>	3	1. Overpressure of V-100 Test Separator; lost containment; fire and explosion hazard; lost production.	People	4	High	15. PI-001 (HH) trips XV-001 (pipeline inlet).	BPCS - V	1	2	Significant
			Environment	3	Moderate	13. PSV-001 set @ 1034; no credit since flare system no sized to handle continuous relief from pipeline.	MECH	0	2	Moderate
			Asset	3	Moderate				2	Moderate

## LOPA Result:

- After combining all three causes and crediting the existing BPCS interlock, an RRF gap of 3 remained

Scenario	Consequence					Initiating Event				UEF (events per yr)	Safeguards (Non-IPLs)	Independent Protection Layers		Current LOPA GAP			
	CAT	Severity Rating	TEF (events per yr)	Conditional Modifier		Initiating Event	Freq. (events per yr)	Enabling Events or Condition				IPL Description	PFD	Scenario MEF (events per yr)	CAT	PFD	RRF
				Description	Prob			Description	Prob								
<b>1. V-100 Separator Overpressure</b>  Overpressure of V-100 Test Separator; lost containment; fire and explosion hazard; lost production. <a href="#">Deviation/Subsystem - Cause: 2.1.1.1</a>	People	4	1.00E-04	1. Occupancy: in the area < 10% of the time.	0.1	1. PV-100 (Separator Inlet) malfunctions open. <a href="#">Deviation/Subsystem - Cause: 2.1.1</a>	0.1	1. Test Separator in operation <10% of the time.	0.1	3.00E-03	17. PSV-001 set @ 1034; clean service; no credit applied since flare system unable to handle relief event.	3. PI-002 (HH) trips XV-001 (pipeline inlet).	0.1	3.00E-04	People	3.33E-01	3
						2. PV-101 (Separator Gas Outlet) malfunctions closed. <a href="#">Deviation/Subsystem - Cause: 2.1.2</a>	0.1	1. Test Separator in operation <10% of the time.	0.1		17. PSV-001 set @ 1034; clean service; no credit applied since flare system unable to handle relief event.	3. PI-002 (HH) trips XV-001 (pipeline inlet).	0.1				
						3. ESDV-100 (downstream pipeline isolation) malfunctions closed <a href="#">Deviation/Subsystem - Cause: 2.1.3</a>	0.1	1. Test Separator in operation <10% of the time.	0.1		17. PSV-001 set @ 1034; clean service; no credit applied since flare system unable to handle relief event.	3. PI-002 (HH) trips XV-001 (pipeline inlet).	0.1				

## Key Message:

- HAZOP suggested ALARP... but LOPA revealed underprotected risk

# TREATING THE RISK - NOT TOLERATING THE GAP

Appropriate risk treatment options may include:

- Add an independent protection layer in the BPCS
- Add a self contained shutdown (i.e. electric, pneumatic, hydraulic)
- Upgrade existing BPCS interlock to a SIL 1 SIS function ( $RRF \geq 30$ )

Avoid this approach:

- Accepting a 3x RRF gap
  - Scenario involves a potential fatality
  - No standards support accepting this level of underperformance
  - No technical justification to override the required RRF

Take Note:

- Choosing not to treat the risk, does not remove the risk

Safeguards (Non-IPLs)	Independent Protection Layers		Current LOPA GAP			
			Scenario MEF (events per yr)	CAT	PFD	RRF
17. PSV-001 set @ 1034; clean service; no credit applied since flare system unable to handle relief event.	3. PI-002 (HH) trips XV-001 (pipeline inlet).	0.1	3.00E-04	People	3.33E-01	3
17. PSV-001 set @ 1034; clean service; no credit applied since flare system unable to handle relief event.	3. PI-002 (HH) trips XV-001 (pipeline inlet).	0.1				
17. PSV-001 set @ 1034; clean service; no credit applied since flare system unable to handle relief event.	3. PI-002 (HH) trips XV-001 (pipeline inlet).	0.1				



# FINAL TAKEAWAY - BRIDGING THE GAP

## ALARP Do's

- Analyze risk gaps
- Meet or exceed risk targets
- Apply ALARP with documented, justified decisions
- Use the risk matrix as a tool for action

## ALARP Don'ts

- Treat ALARP as a get-out-of-jail-free card
- Accept partial solutions that leave risk in place
- Normalize risk gaps through repeated rejection of recommendations

If you feel unsure about implementing a SIF, take heart — training builds competence, and even an imperfect safeguard can be refined. What cannot be ignored is an unaddressed risk, which stays dangerous by design.



*Risk gaps are meant to be closed, not explained away. That's how we protect our people - and our integrity*



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