

The background of the slide is a photograph of an industrial facility, likely a refinery or chemical plant, taken at dusk or dawn. The sky is filled with dark, dramatic clouds. In the foreground and midground, there are large white storage tanks, complex piping systems, and structural steel frameworks. Some lights are visible on the facility, suggesting it is operational. The overall tone is industrial and somewhat somber due to the low light.

AIFEMA

Process Safety & Risk Assessment

An introduction for emergency responders



YOUR PRESENTER

Greg Sargent, P.Eng.

Quantitative Risk Program Lead, TC Energy

More than 25 years of experience in process safety across energy, oil and gas, and petrochemical sectors.

Hundreds of risk assessments, from job hazard analyses in the field to process HAZOPs and quantitative risk assessments for large industrial facilities and pipelines.

Led investigations and root cause analyses for incidents ranging from occupational safety events to major equipment failures.

Certified Industrial Firefighter (NFPA 1081) - has served on industrial fire, hazmat, and technical rescue teams.

Process safety

The hazards that do not show up in an injury log.

What it is

Process safety versus personal safety.

How it is managed

The four pillars and the 20 elements.

When it fails

Recent incidents and what they cost.

We'll end with a few key takeaways.

WHAT IT IS

Process safety, in plain language

Process safety is the work a facility does to keep hazardous materials and energy inside the pipes, tanks, and vessels where they belong.

It focuses on low-frequency, high-consequence events

Fires, explosions, and toxic releases — rare, but catastrophic when they happen.

It is about design and systems, not just behavior

Equipment integrity, procedures, alarms, and management decisions.

It protects everyone, not just the worker

Workers, responders, and the surrounding community.



VIDEO

What a process safety event looks like...

Reynosa gas plant explosion, Mexico, September 18, 2012 – 31 fatalities

HOW IT DIFFERS

Personal safety vs. process safety



Occupational (Personal) Safety

Protecting the individual

- Slips, trips, falls, cuts, strains
- Happens often, usually one person hurt
- Measured by injury rates
- Fixed with PPE, training, housekeeping
- A good day: nobody gets hurt



Process Safety

Protecting society

- Fires, explosions, toxic releases
- Happens rarely, can harm hundreds
- Measured by leading indicators and near-misses
- Fixed with design, integrity, and management systems
- A good day: nothing gets out

Both matter. But a perfect injury record tells you nothing about whether the plant is about to blow up.

WHICH IS IT?

Personal safety vs. process safety



Personal safety

The individual in the line of fire. PPE, training, procedures.



Process safety

The whole plant in the line of fire. Design, integrity, systems.

THE FRAMEWORK

Four pillars of process safety

Every process safety program is built on four pillars. Each one answers a different question.

01

Commit to Process Safety

Do we truly care, top to bottom?

02

Understand Hazards & Risk

What can hurt us, and how badly?

03

Manage Risk

How do we keep it under control every day?

04

Learn from Experience

What are we doing about what went wrong?

The four pillars break down into 20 working elements — the next slides.

THE ELEMENTS

All 20 elements at a glance

COMMIT

- Process Safety Culture
- Compliance with Standards
- Process Safety Competency
- Workforce Involvement
- Stakeholder Outreach

UNDERSTAND

- Process Knowledge Management
- Hazard Identification & Risk Analysis

MANAGE RISK

- Operating Procedures
- Safe Work Practices
- Asset Integrity & Reliability
- Contractor Management
- Training & Performance Assurance
- Management of Change
- Operational Readiness
- Conduct of Operations
- Emergency Management

LEARN

- Incident Investigation
- Measurement & Metrics
- Auditing
- Management Review & Continuous Improvement

Commit to safety - Understand the hazards

Seven elements cover leadership commitment and knowing what you are dealing with.

Process Safety Culture

How people behave when no one is watching.

Compliance with Standards

Meeting codes, regulations, and industry practice.

Process Safety Competency

Knowing the hazards — and keeping that knowledge alive.

Workforce Involvement

Operators and technicians have a real voice.

Stakeholder Outreach

Talking honestly with responders, regulators, neighbors.

Process Knowledge Management

Accurate, current drawings, chemical data, and design limits.

Hazard ID & Risk Analysis

Systematically asking what can go wrong, and how bad.

PILLAR 3

Manage risk day to day

Nine elements keep the hazard controlled through normal operations, maintenance, and change.

Operating Procedures

Written, current, and actually used.

Safe Work Practices

Hot work, confined space, lockout/tagout.

Asset Integrity & Reliability

Inspecting and fixing equipment before it fails.

Contractor Management

Contractors held to the same standard as employees.

Training & Performance Assurance

Proving people can do the job, not just that they sat through it.

Management of Change

No modification without a hazard review.

Operational Readiness

Confirming it is safe to start up again.

Conduct of Operations

Doing the right task, the right way, every time.

Emergency Management

Planning, drilling, and responding — with you.



PILLAR 4

Learn from experience

Four elements turn events and data into lasting improvement.



Incident Investigation

Finding root causes, not someone to blame.



Measurement & Metrics

Watching leading indicators, not just injury counts.



Auditing

Independent checks that the system works as written.



Continuous Improvement

Management acts on what the findings say.



WHY THIS MATTERS TO YOU

The plant's process safety is your risk picture

You inherit their weak points

A tank nobody inspected becomes your rescue, your evacuation, your exposure.

Pre-planning depends on their knowledge

Chemical inventories, drawings, and worst-case scenarios come from process safety work.

Emergency Management is one of the 20 elements

You are inside their system — ask to be part of the drills and the hazard reviews.

Their near-misses are your early warning

Ask what has been leaking, over-pressuring, or running past its inspection date.

Three recent incidents

Each one traces back to a missing or failed process safety element — and each one put responders in harm's way.

Longview, WA

Nippon Dynawave · May 2026

11 workers killed

Fort McMurray, AB

Nexen Long Lake · January 2016

2 workers killed

Garden Grove, CA

GKN Aerospace · May 2026

50,000+ evacuated

[Surveillance Footage - Nippon Dynawave G Tank Failure](#)
[2 options remain after toxic chemical leak in California](#)

CASE STUDY 1

Nippon Dynawave Packaging — Longview, WA

11

workers killed

~900,000 gal

hot caustic white liquor
released

10 months

warning went unaddressed

WHAT HAPPENED

- May 26, 2026: a 1.2-million-gallon storage tank failed catastrophically at 7:15 a.m.
- Hot, highly caustic white liquor flooded the area; more workers and one firefighter were injured.
- Recovery was slow — the damaged tank remained unstable.

PROCESS SAFETY ELEMENTS THAT FAILED

- Asset Integrity — a 2025 inspection found the shell below minimum safe thickness.
- Compliance — the report said "not fit for continued service," yet it stayed in service.
- Management Review — two later inspections did not change the decision.



The collapsed white liquor tank at the Longview mill.

FOR RESPONDERS: A single tank can create a mass-casualty chemical incident even with no fire or explosion. Ask facilities when their bulk tanks were last internally inspected.

CASE STUDY 2

Nexen Long Lake — Fort McMurray, Alberta

2

workers killed

19 MPa

Hydrogen gas release

\$450,000

fine after guilty plea

WHAT HAPPENED

- January 15, 2016: Two workers were refitting valves on a hydrogen compressor in the hydrocracker unit.
- Hydrogen released and ignited, destroying the compressor building.
- One worker died at the scene; the second died later in a burn unit.

PROCESS SAFETY ELEMENTS THAT FAILED

- Safe Work Practices — only one stage of a two-stage compressor was isolated.
- Operating Procedures & Training — work went outside the approved scope.



The hydrogen compressor building after the blast.

FOR RESPONDERS: Maintenance windows are when barriers come down. Hydrogen burns nearly invisibly — assume energy is still in the system until isolation is verified.

CASE STUDY 3

GKN Aerospace — Garden Grove, California

50,000+

residents evacuated

~7,000 gal

methyl methacrylate in the tank

5 days

emergency duration

WHAT HAPPENED

- May 21, 2026: the tank's cooling failed and the MMA warmed far past its 50°F storage temperature.
- Relief valves lifted and sprinklers ran, but pressure kept climbing.
- A faulty valve blocked draining; crews faced a possible BLEVE beside homes.

PROCESS SAFETY ELEMENTS THAT FAILED

- Asset Integrity — refrigeration and valve failures on a reactive-chemical tank.
- Hazard ID & Risk Analysis — loss of cooling was not adequately controlled.
- Emergency Management — a five-day, multi-city evacuation with no clear end.



Crews cooling the overheating MMA tank.

FOR RESPONDERS: No one died and nothing exploded — a near miss, not a success. Reactive chemicals can force days-long evacuations; know which ones are stored in your district.

TAKE THIS BACK WITH YOU

Four things to remember

1 Process safety is about what gets out, not who gets hurt.

Low frequency, high consequence — and it reaches past the fence line.

2 A clean injury record proves nothing.

Ask about inspections, overdue work, and near-misses instead.

3 Every major incident traces to known elements.

Integrity, change control, procedures, and acting on findings.

4 You belong in their process safety program.

Outreach, emergency management, and drills are written into the 20 elements.



Risk assessment in an industrial environment

Every decision you make on scene is a risk decision. This section gives you the same language the plant uses to make them.

What risk is

Hazard, context, severity, likelihood.

How we measure it

Tools, the risk matrix, tolerability.

How it ties in

Process hazard analysis inside process safety.

Two worked scenarios and open questions close out the section.

WHAT RISK IS

Risk starts with a hazard

A hazard is anything with the potential to cause harm — a tank of flammable liquid, a pressurized line, a hot surface.

Risk is what the hazard means in a situation

How bad the harm could be, and how likely it is to happen.

Context decides the risk, not the hazard alone

A drum of solvent is low risk sealed within secondary containment, high risk beside a cutting torch. The drum did not change.

In shorthand: Risk = Severity x Likelihood

Severity is how bad; likelihood is how often or how probable.



HAZARD VS. RISK

Four questions to find the risk of a hazard

A hazard is a thing. A risk is a judgment about it. Four questions get you there.

01

What is the hazard?

Name the thing that can hurt people: material, energy, equipment. Find it before you can assess it.

02

What could go wrong?

Context. Who is near it, what is around it, what barriers could fail. Same hazard, different risk.

03

How bad could it be?

Severity. One injury, a crew, a neighborhood. Severity does not change with luck.

04

How likely is it?

Likelihood. How often the conditions line up, and how well the safeguards hold when they do.

Change the situation and the risk changes.

FUNDAMENTALS

The tools we use to assess risk

Different tools, same job: find what can go wrong, and decide what to do about it.

Checklists

Proven questions applied to known equipment. Fast, good for routine work.

What-if review

A team walks through “what if this fails?” for each step. Simple and flexible.

Job hazard analysis

Breaks a task into steps and finds the hazard in each. Common for maintenance and entry work.

HAZOP

A structured, line-by-line study of a process for deviations like more flow, less pressure, no cooling.

LOPA

Counts the independent layers of protection and checks they are enough for the consequence.

Bow tie

Maps one hazard, its causes, its consequences, and the barriers on each side. Very readable for responders.

WHEN THE STAKES JUSTIFY MORE DETAIL

QRA — quantitative risk assessment

Puts numbers on it: how often a release is expected and how far the effects reach. Used where the consequence is severe.

Consequence analysis

Models the size of the fire, blast, or gas cloud — the distances that drive evacuation and staging.

WORKED EXAMPLE

A job hazard analysis, one task at a time

Job step	What can go wrong	Risk	Controls before the work starts
1. Isolate and de-energize the pump	Stored pressure and residual solvent in the line	Major x Unlikely = Medium	Lock out and tag out, verify zero energy, double block and bleed
2. Drain and flush the casing	Skin and eye contact, flammable vapor released	Moderate x Likely = Medium	Goggles and chemical gloves, bonded container, ventilation, gas test
3. Open the pump and replace the seal	Pinch points, awkward lift, dropped parts	Moderate x Likely = Medium	Two-person lift, hand protection, tethered tools, clear work zone
4. Return the pump to service	Leak or spray on start-up, wrong valve lineup	Major x Unlikely = Medium	Valve lineup verified, slow start with the crew clear, extinguisher standby

Task: replace the mechanical seal on a solvent transfer pump.

WORKED EXAMPLE

A HAZOP, one deviation at a time

Deviation	Possible cause	Consequence	Risk	Safeguards in place	Action
More flow	Control valve fails open	Tank overfills, solvent to the dike, vapor cloud at grade	Catastrophic x Unlikely = High	High-level alarm; independent high-high trip	Prove the high-high trip on a set schedule
No cooling	Cooling water pump trips	Reactor temperature runs away, relief lifts to the flare	Catastrophic x Unlikely = High	Temperature alarm; spare pump on auto-start	Add low-flow alarm on the cooling loop
More pressure	Blocked outlet with the pump still running	Line or seal ruptures, release at the pump house	Major x Unlikely = Medium	Relief valve sized for blocked discharge	Confirm relief testing is current
Reverse flow	Pressure upset upstream	Incompatible material back into the feed tank	Major x Unlikely = Medium	Check valve; procedural valve lineup	Inspect check valve at next turnaround

Node: solvent feed line into the day tank. A team asks “what if there is more, less, none, or reverse?” for every parameter in the node.

WORKED EXAMPLE

A bow tie: barriers on both sides of the event

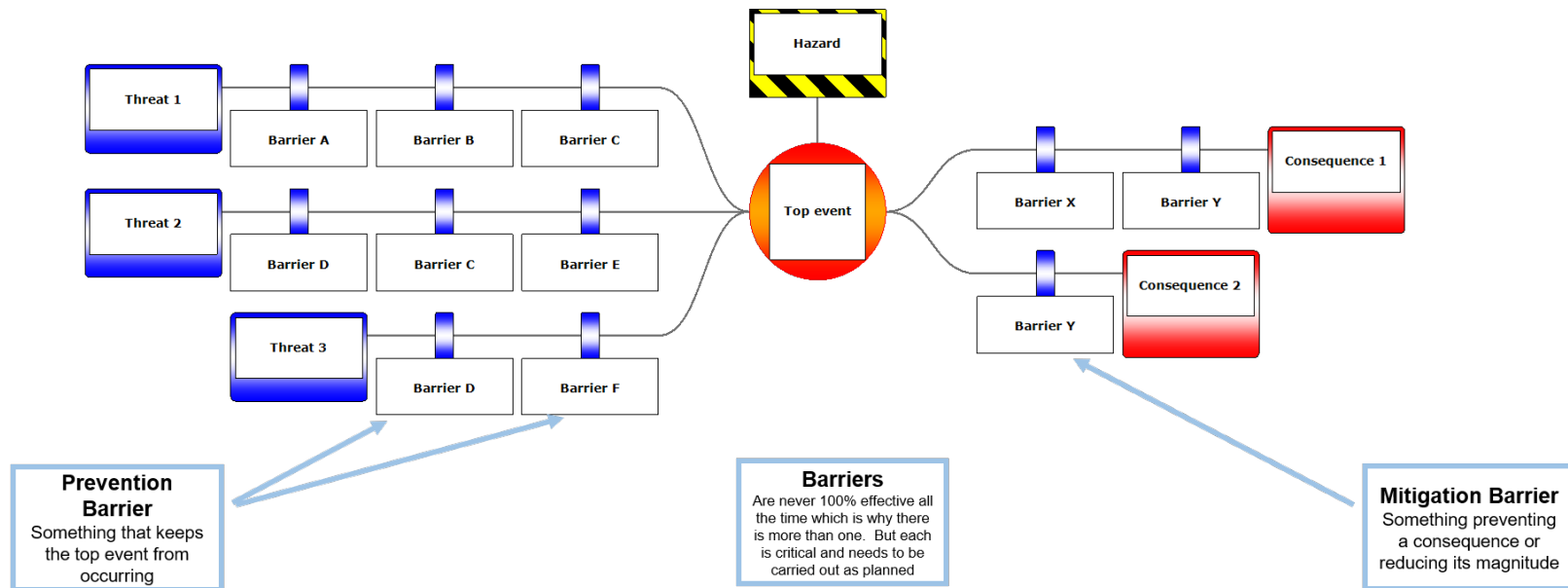


Threats on the left, the top event in the middle, consequences on the right. The red bars are the barriers — every one of them has to hold.

HOW TO READ A BOW TIE

What will prevent the **Threat** from causing the **Top Event**

What will prevent the **Top Event** from leading to a **Consequence**



NOTHING has happened

SOMETHING has happened

Passage of Time

THE RISK MATRIX

A ruler for risk: how bad x how likely

Severity × Likelihood	Rare	Unlikely	Likely	Frequent
Catastrophic - multiple fatalities	Medium	High	Extreme	Extreme
Major - fatality or serious injury	Low	Medium	High	Extreme
Moderate - injury	Low	Low	Medium	High
Minor - first aid	Low	Low	Low	Medium

The matrix is only a ruler. It provides a shared language, and sets the criteria for what risk is tolerable, and what requires action.

TOLERABILITY

How much risk is acceptable?

A matrix tells you how big a risk is. Tolerability tells you what to do about it.

Extreme

Unacceptable

Stop. The activity does not run at this risk level, whatever the benefit. Fix it, redesign it, or shut it down.

High, Medium

Tolerable if ALARP

Allowed only while you keep driving the risk down *As Low As Reasonably Practicable*. Most real industrial risk lives here.

Low

Broadly acceptable

Low enough to accept without further action, but still monitored so it does not drift back up.

Who decides

Regulators set the floor; the company owns the judgment. Ask a plant where their line sits.

Tolerability is how you decide whether you need to do more.

FUNDAMENTALS

How we reduce risk

Almost everything we call a control changes how likely the consequence is — not how bad it is.

Controls act on likelihood

A trip, an interlock, a permit, a procedure. They make the release less likely to happen.

The severity stays the same

The tank still holds what it holds. If the barrier fails, the consequence is the one you already sized.

Barriers can fail

That is why there is more than one, and why each has to be tested, inspected, and actually used.

Layers have to be independent

Two safeguards sharing a sensor, a power supply, or one busy operator are really only one layer.

It moves you left, not up

Add good layers and the risk slides down the likelihood axis. It does not move on the severity axis.

Watch for drift

Overdue tests, bypassed alarms, temporary repairs. Likelihood creeps back up quietly.

THE ONE WAY TO CUT SEVERITY

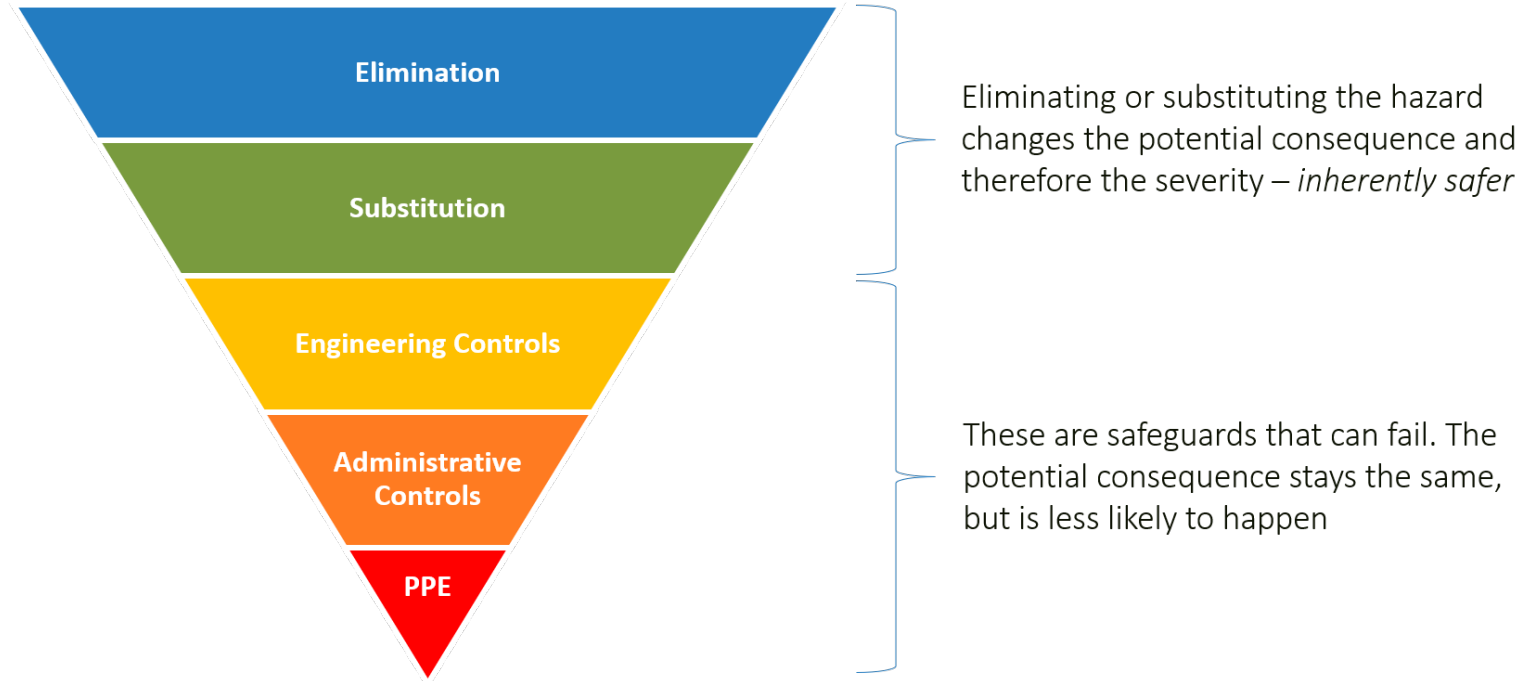
Change the hazard itself

Less inventory, a safer chemical, lower pressure. Eliminate or substitute and the potential consequence actually shrinks.

Inherently safer design

The only route down the severity axis. Everything else buys reliability and time.

The hierarchy of controls



WHERE IT FITS

Risk assessment drives process safety

Earlier we covered 20 elements of process safety. Risk assessment is what makes many of them work — you cannot manage a risk you don't understand.

The formal version is the Process Hazard Analysis

A team studies a unit, finds how it can fail, judges consequence and likelihood, and checks the safeguards.

A PHA is revalidated on a schedule

And again whenever the process changes — which is why management of change matters so much.

For you, the PHA is a map

It names a site's worst-case scenarios and the barriers meant to stop them. Ask before the incident.



EXAMPLE SCENARIOS

Two scenarios, two kinds of risk

Same plant, same day. One risk threatens a person; the other threatens everyone around it.

Occupational · The scenario

A millwright changes a pump seal. The line is drained but not locked out, and he is kneeling in a cramped space.

Occupational · The risk judgment

Severity: major, one serious injury. Likelihood: likely on a rushed shift. That is High on the matrix — but contained to one person.

Occupational · The controls

Lock out and tag out, isolation verification, PPE, a permit, and a second set of eyes.

Process safety · The scenario

Cooling water on the same unit is degraded and a relief valve is overdue for testing while the reactor runs hot.

Process safety · The risk judgment

Severity: catastrophic, past the fence line. Likelihood: unlikely — but unlikely and catastrophic still lands High.

Process safety · The controls

Asset integrity testing, alarms and interlocks, management of change, and a PHA that sized up the scenario.

TAKE THIS BACK WITH YOU

Four things to remember

- 1 A hazard is a thing with the potential to cause harm.**
Same hazard, different risk — context decides. Change the situation, and the same hazard can mean different risk.
- 2 Risk is how bad *and* how likely.**
Risk is about the consequence, not the hazard.
- 3 Pick the tool that fits the job.**
Checklist, what-if, JHA, HAZOP, LOPA, bow tie — and QRA when the stakes justify it.
- 4 A matrix is a ruler for risk; tolerability decides action.**
Ask a plant where their line sits, and which barriers hold it there.

Risk is severity times likelihood – context decides both.



Q & A

Questions?

Do you have any scenarios, hazards, or plans you want to discuss?