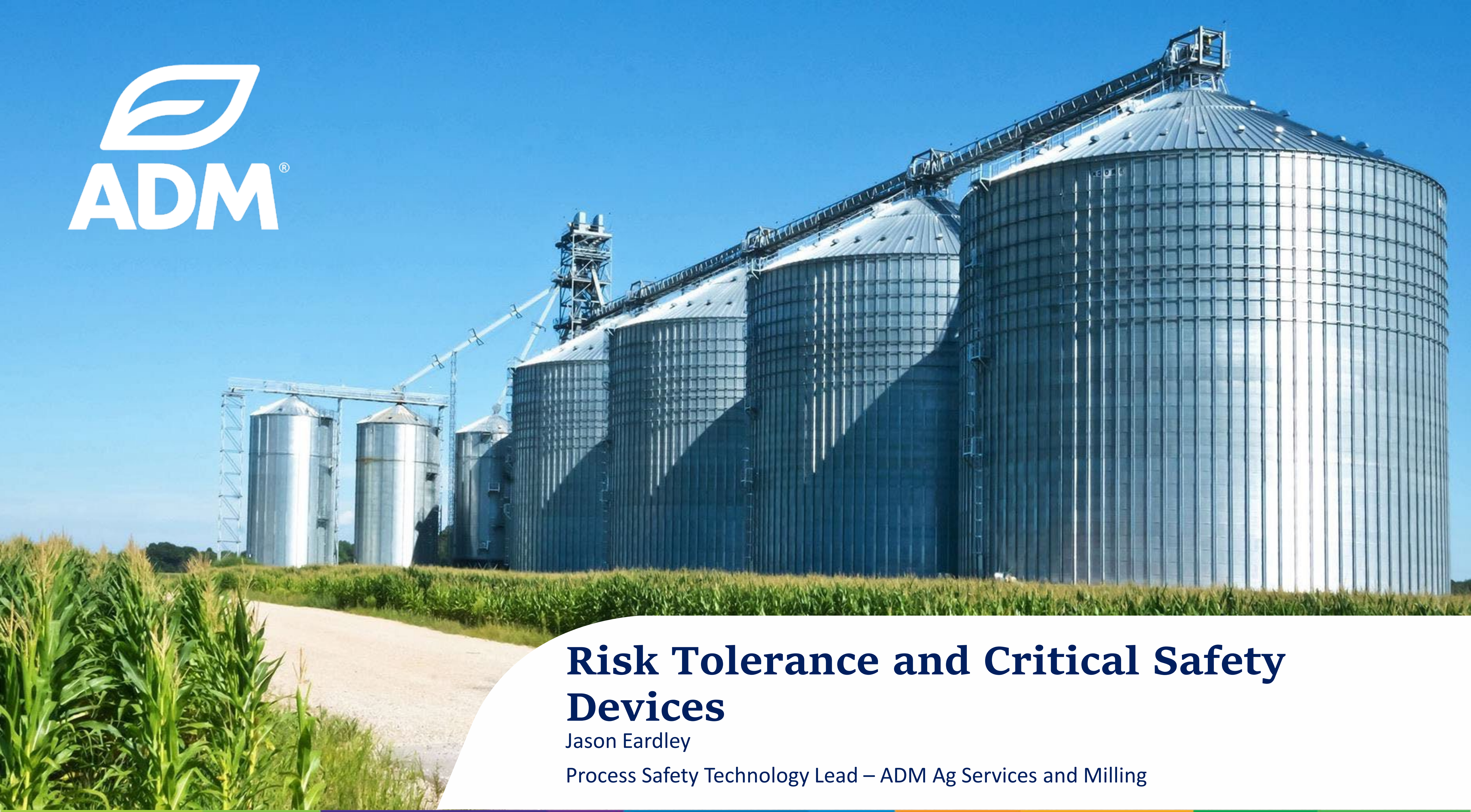


Risk Tolerance and Critical Safety Devices

Jason Eardley

Process Safety Technology Lead – ADM Ag Services and Milling

CSD Topics

- Risk
- Critical Safety Devices (CSD) – my definition
- Layers of Protection (Bow Tie model, Safeguards)
- CSDs to consider
- Events related to CSDs
- Inspection, testing, Preventive Maintenance (ITPM)
- CSD Impairments

How are Risk Tolerance and Obscene Movies similar?

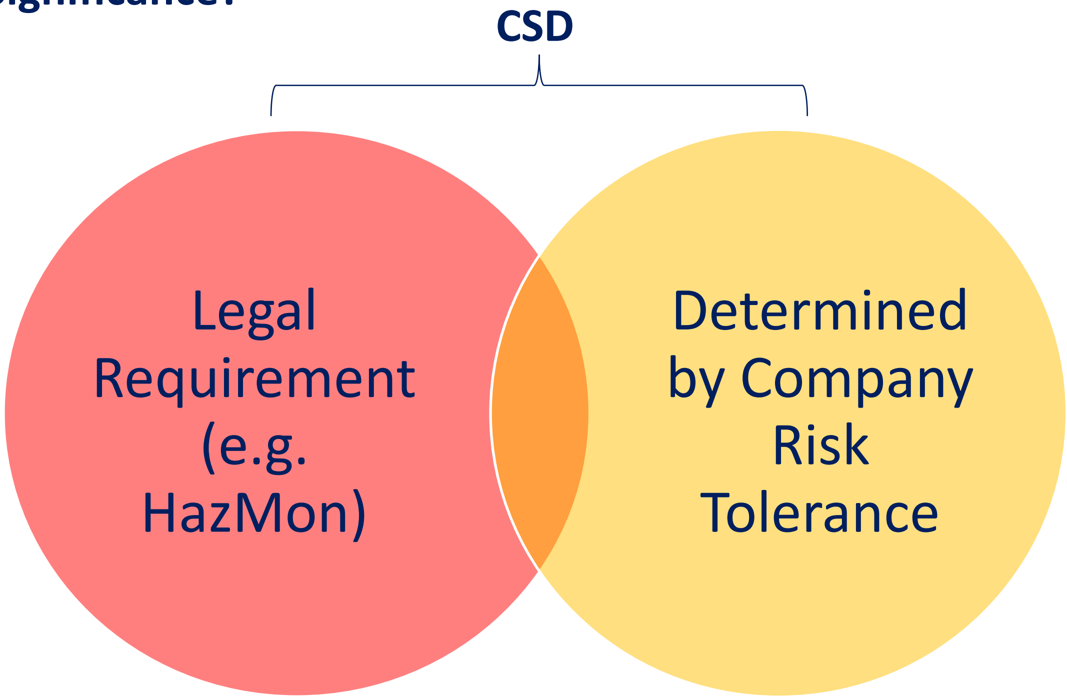
Supreme Court Justice Potter Stewart famously stated in his opinion in Jacobellis v. Ohio, that his method of determining that there was obscenity in a movie:

“But **I know it when I see it**, and the motion picture involved in this case is not that.”

Sometimes it is not easy to determine what critical safety systems we have or need. There can be some subjectivity based on an organization’s risk tolerance.

Critical Safety Devices

Critical Safety Device (CSD): Instrumentation, control devices, or control systems whose failure would contribute substantially to the release of a hazardous material or energy or whose proper operation is required to mitigate or prevent the consequences of such release. These are driven by regulatory requirements and company risk tolerance. **What is their Significance?**



e.g.

- Dust collector PD

e.g.

- Carbon dioxide detection in basements and boot pits
- Grain dryer burner management system
- Belt Conveyor HazMon
- Air compressor and propane tank PSV

e.g.

- Bucket Elevator speed monitoring

Critical Safety Devices

Legal Requirement (e.g. HazMon)

1910.272(m)(1)(i): Regularly scheduled inspections of at least the mechanical and safety control equipment associated with dryers, grain stream processing equipment, dust collection equipment including filter collectors, and bucket elevators;

29 CFR 1910.272 App A: It is imperative that the prearranged **schedule of maintenance** be adhered to regardless of other facility constraints. The employer should give priority to the maintenance or repair work associated with **safety control equipment**, such as that on **dryers, magnets, alarm and shut-down systems on bucket elevators, bearings on bucket elevators, and the filter collectors in the dust control system.**

Critical Safety Devices

Determined by Company Risk Tolerance

- Risk Matrix
- Hierarchy of Controls
- Specifically identified items
- Dust Hazard Analysis / NFPA / ATEX
- Example is temperature sensors in dryers, pellet coolers

What are Hazards and Risks

What's a hazard

- Hazards are substances or conditions which can cause injury or harm to people, processes, equipment and the environment
- Not **all** potential hazards **will** occur, but **any** potential hazard **could** occur

What's a risk

- Risk is simply the likelihood of any given hazard occurring factoring in the frequency of that hazard and the exposure of people to that hazard

ADM RISK ASSESSMENT TOOL

JSA Work Permit Requirements: **16:** Unacceptable level of risk. Task should not be performed at current risk level. **12:** Requires review from reporting level above plant manager. **8 - 9:** Requires review by management. **4 - 6:** Review by management is recommended. **1 - 3:** Trained participants can perform task without further approval. **Every effort should be made to reduce the risk to below 8.**		**L - LIKELIHOOD (CONSIDERING THE SAFEGUARDS)**			
		Control measure non existent or inadequate	**Control measure exists, but effectiveness is not guaranteed**	**Multiple control measures exist, but effectiveness is not guaranteed**	**Multiple control measures are effective**
		Likely	**Occasional**	**Improbable**	**Very Unlikely**
S - Injury Severity		4	3	2	1
Catastrophic: Fatalities or incapacitating cases.	4	16	12	8	4
Very Serious: Permanent disability, but not incapacitating.	3	12	9	6	3
Serious: Lost or restricted work day cases.	2	8	6	4	2
Minor: Medical treatment or first aid cases (recordable and below).	1	4	3	2	1

Tolerating Risk

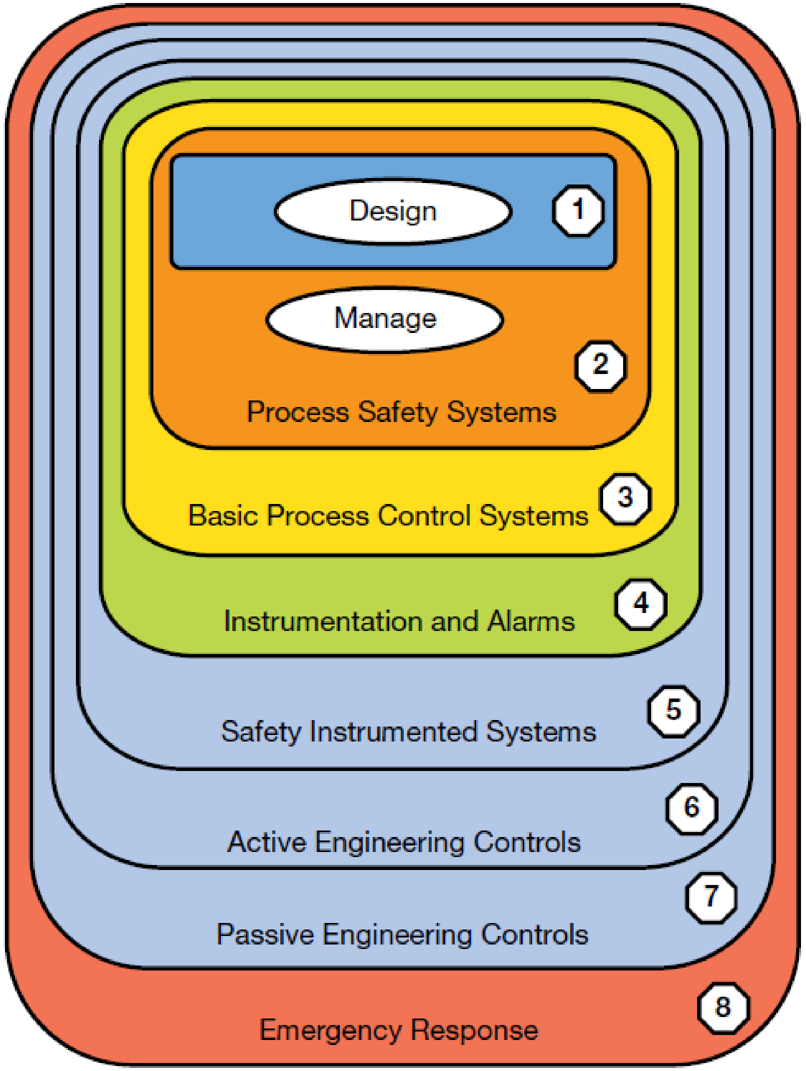
- Risk tolerance is personal
  - Every person has a differing tolerance for every different risk
- Tolerance for voluntary risk is often much higher than for involuntary risk
  - Voluntary Risk is a risk that a person can choose to accept
    - Driving, flying, sky diving
  - Involuntary Risk is a risk that a person has imposed on them
    - Workplace equipment – combustible dust
- Tolerance for risk also changes with the size of the consequence
  - High consequence = low tolerance (plane crashes)
  - Low consequence = high tolerance (driving)

When Risk is Realized

Layers of Protection

- Layers of Protection and the Hierarchy of Controls to prevent the consequences of a Process Safety Event
  - 1. Inherently safe design
  - 2. – 7. Process safety systems
  - 8. Administrative and Emergency response

- **Critical Safety Device (CSD):** Instrumentation, control devices, or control systems whose failure would contribute substantially to the release of a hazardous material or energy or whose proper operation is required to mitigate or prevent the consequences of such release. These are driven by regulatory requirements and company risk tolerance.



▲ **Figure 1.** A hierarchy of protection layers can be used in a process hazard analysis to determine the adequacy of the existing safeguards. This approach identifies design as the first and most crucial barrier. Source: Adapted from *(3)*.

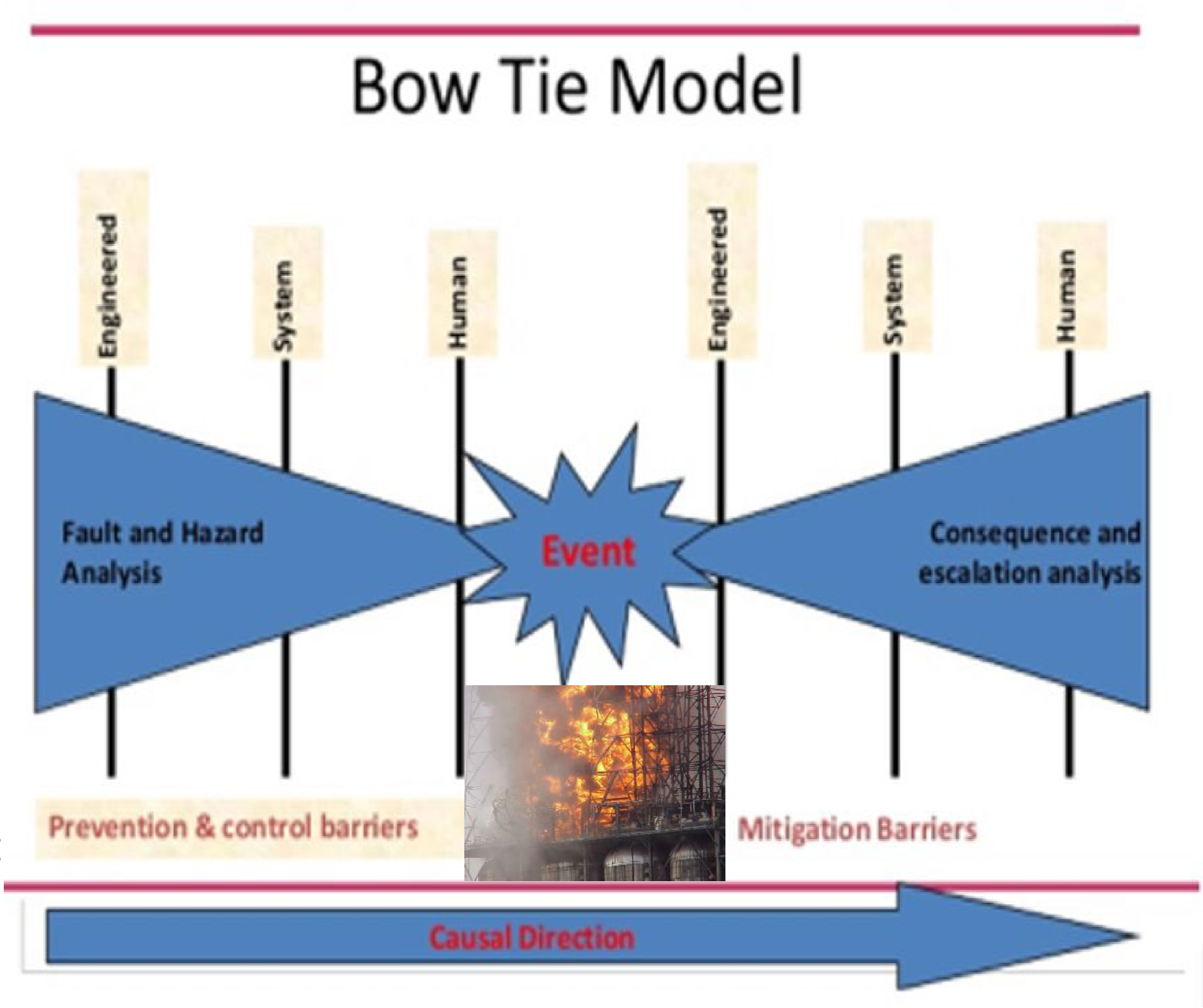
Assess risk

Prevention:

- Inherently safe design
- Operations
- Engineering

Mitigation:

- Fire Extinguishment
- Emergency Plans

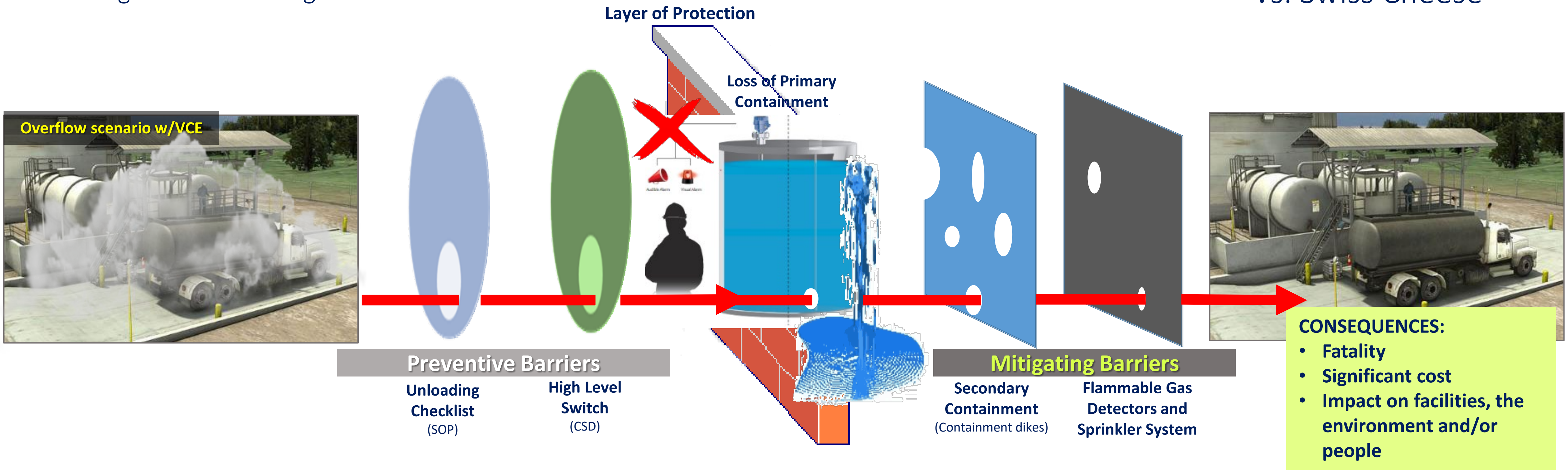


Ultimate Consequences (Injuries, Property damage, Business Interruption, etc)

Layers of Protection

e.g. Gasoline Storage Tank

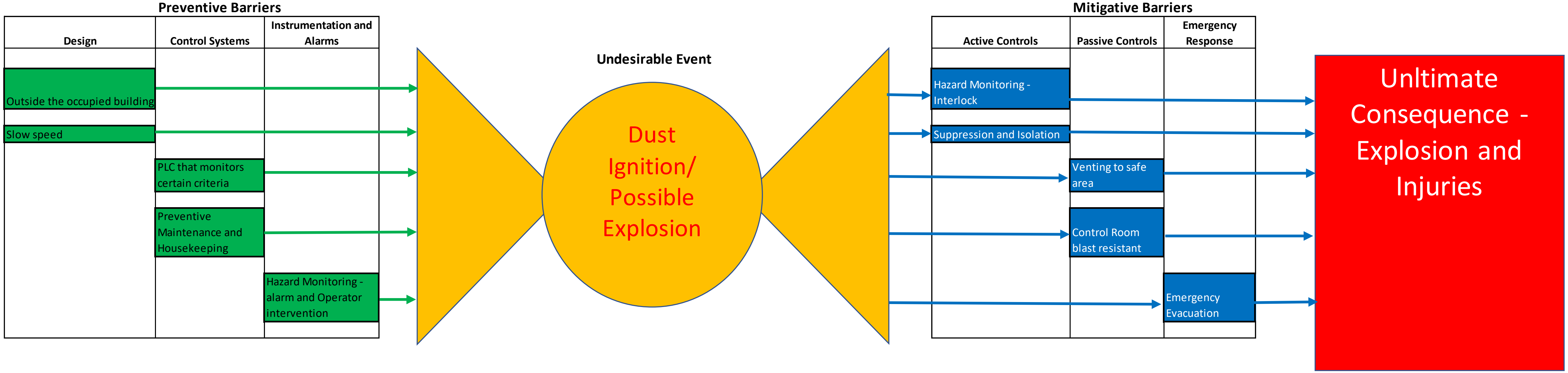
Vs. Swiss Cheese



- Do we **understand** what could go wrong?
- Do we tolerate the risk?
- Do we **know** what our CSDs are to prevent this from happening?
- Do we **have information** to assure us that they are working effectively?

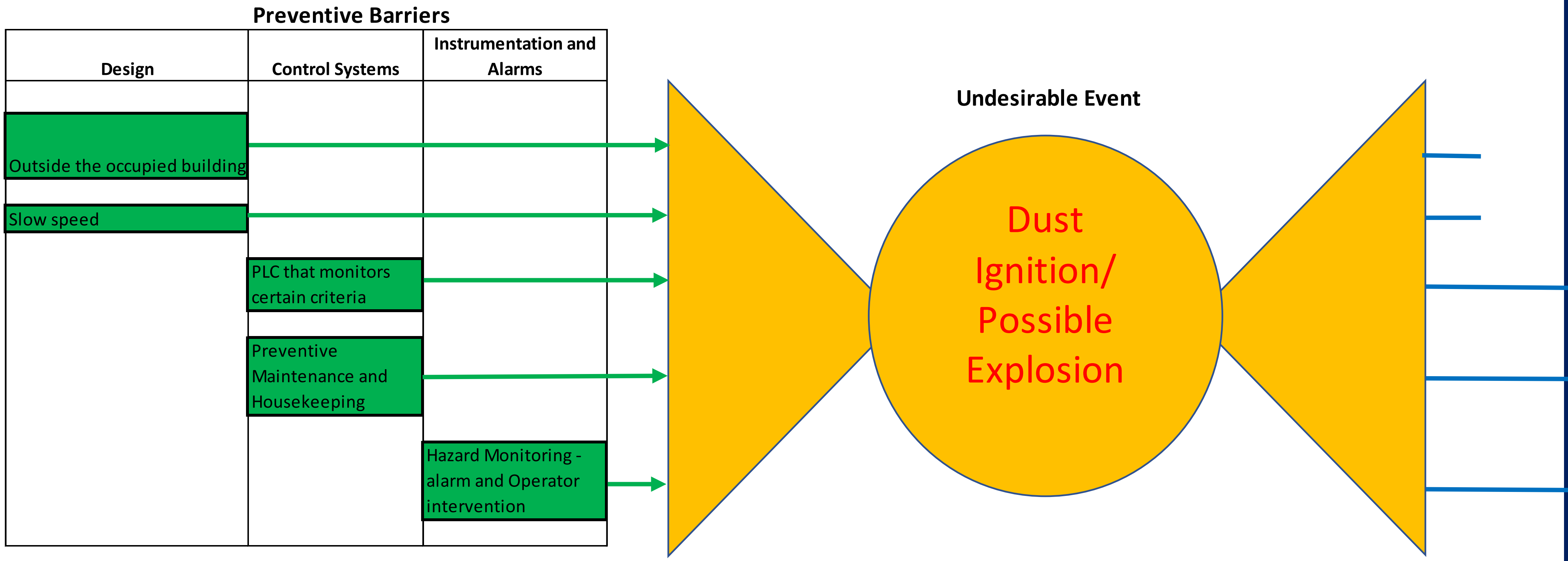
Bow Tie – Determining Layers of Protection/ CSDs

- CSDs can be included in any Layer of Protection in place to prevent or mitigate a consequence. Often we interpret these as being a last line of defense and generally are an automatic function, such as an interlock or activation of a safeguard.
- In this example, a possible Bow Tie with various Layers of Protection



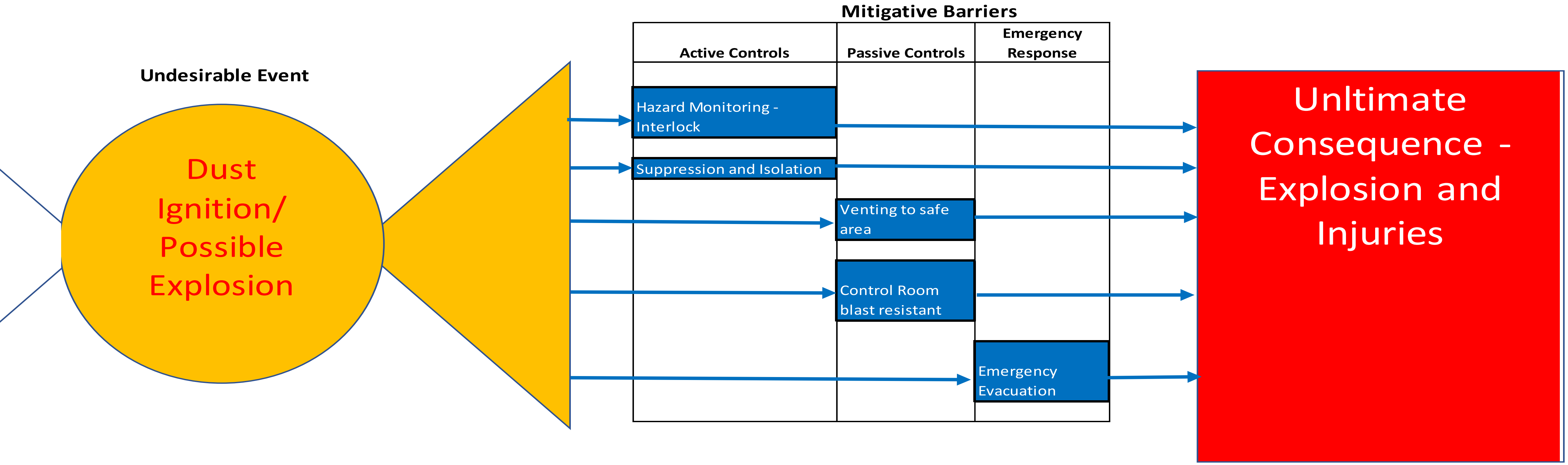
Bow Tie – Determining Layers of Protection/ CSDs

- CSDs can be included in any Layer of Protection in place to prevent or mitigate a consequence.
- Bow Tie preventive Layers of Protection

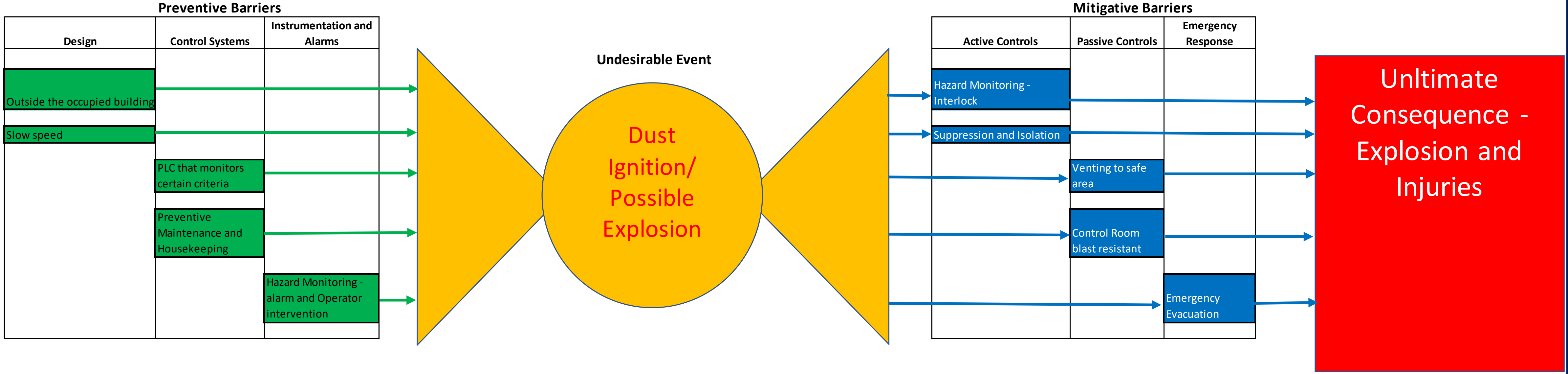


Bow Tie – Determining Layers of Protection/ CSDs

- CSDs can be included in any Layer of Protection in place to prevent or mitigate a consequence.
- Bow Tie mitigating Layers of Protection



Bow Tie – Determining Layers of Protection/ CSDs



Possible Preventive CSDs

- HazMon Alarm and Operator intervention
- PLC – Amps? Speed below 500 fpm? Plug or flow detection?

Possible Mitigative CSDs

- HazMon Interlocks
- Suppression interlock and actuation
- Explosion venting activated
- Evacuation alarm? Sprinkler system Alarm?

Critical Safety Devices

Critical Safety Devices generally will not include every plant alarm or interlock. A critical safety device represents installed hardware that trigger a subsequent response as a last line of defense to prevent or mitigate a very serious or catastrophic event.

Identify the critical safety equipment and controls for purposes of tracking and ensuring the prevention of system failures that could result in very serious and catastrophic incidents.

The critical safety equipment and controls to include the required inspection, testing, and preventive maintenance, (ITPM) and calibration frequency.

Critical Safety Devices – Beyond HazMon

Critical safety equipment and controls relates to those controls, devices or equipment identified by management as critical to the prevention of very serious and catastrophic incidents.

- Any safeguard identified in a Process Hazard Analysis (PHA), Dust Hazard Analysis (DHA) or a Layers of Protection Analysis (LOPA) as required to mitigate risk to a tolerable level according to the ADM PHA Risk Matrix
- Pressure Relief Devices such as pressure safety valves, pressure relief valves and conservation vents.
- Gas detection systems installed to monitor workplace status of toxic or flammable gas concentrations.
- Smoke/Fire detection systems in MCC Rooms or other TPS covered areas.
- Process alarms if they are used to alert an operator to perform a task to prevent a catastrophic incident in lieu of an interlock.
- Uninterruptible Power Supply (UPS) or emergency generator, where the loss of power could result in failure of equipment to perform and cause a catastrophic event.

Critical Safety Devices – Beyond HazMon

Critical safety equipment and controls relates to those controls, devices or equipment identified by management as critical to the prevention of very serious and catastrophic incidents.

- Any Emergency Shutdown Systems (ESDs) meeting applicability and criticality. For example, a panic button installed at egress doors in extraction buildings to stop several pieces of equipment upon building evacuation
- Pressure Systems installed to activate process valving resulting from emergency or fire response scenarios, for example:
  - Flame arrestors and Deflagration prevention devices such as X-Pac, Fenwal, and Gre con deflagration
  - Emergency purge or snuffing systems that directly respond to or mitigate fire scenarios
  - Smoke detection in bag house collectors that triggers the shutdown of a mill
- Burner Management Systems and Combustion Management Systems
- Interlocks that take the process to a safe state without operator intervention
- Temperature sensing and management systems

Examples of Critical Safety Devices to Consider

HazMon sensors	PLC and Equipment Interlocks (Safety Integrity Levels)	Plug or choke sensors	Vibration sensors	Explosion Suppression and Isolation
Gas tank high level indicator	Sprinkler Systems	Burner Management Systems	Smoke detection	CO or CO2 Detection
Vent switches and panels	Pressure Safety Valves (Air, Steam, Propane)	Temperature Cables	Pressure Safety Valves (Air, Steam)	Emergency Alarms and Communication
	Spark Detection (Hammer Mills)	Differential Pressure (Baghouses)	Gas line cathodic protection	

Example Minimum CSD Draft

Total Process Safety
Critical Devices Safety Check

Item No	Process Incident	Critical Device	Area	Description
	Fire/Explosion in Dust Collector	Explosion Vent		Explosion vent - Visual/Activation
		Pressure sensor		Pre-explosion detection system
		Optical sensor		Pre-explosion detection system
		Actuator & isolation valve		Suppression system, testing pressure and relays
		Extinguishing media container		Suppression system, testing pressure and relays
		Dirty Air Fans		Dirty air fans not authorized on new installation ; visual inspection on existing ones
		Bearing sensor		Bearing sensors on high RPM fans
	Chlorine	Fixed Cl2 monitor		Chlorine room Fixed Cl2 monitor (2 sensors)
		Fixed Cl2 monitor		Agitator room Fixed Cl2 monitor (2 sensors)
		Automatic tank valve closure		Chlorine room Auto close tank valves
		Temperature sensor		Chlorine room Temperature sensor on VRPC
		Flow sensor		Flour flow detection on agitators inlet
		Flow sensor		Flour flow detection on agitators outlet
		Automatic valve closure		Auto Close valves (butterfly and chlorinator cabinet)
		PLC & UPS alarm controls		Testing automatic valve closure, visual and audible alar
		Automatic room ventilation		Testing automatic ventilation when Cl2 leak
		Portable Cl2 monitor (??)		
	Fire/Explosion in Bucket Elevators	Explosion Panel		Explosion panels
		Speed sensor		Overspeed/underspeed
		Position sensor		Belt alignment,
		Temperature sensor		Bearing temperature
		Flow sensor		Detect presence of blockage/plug on the outlet
		Loss of communication (??)		It should shut down (interlock)
		Admin & Password protection		Restrict access to admin level for alarm resets/troublesl
	Fire/Explosion in Belt Conveyors	Speed sensor		Overspeed/underspeed
		Position sensor		Belt alignment,
		Temperature sensor		Bearing temperature
		Loss of communication (??)		It should shut down (interlock)
		Admin & Password protection		Restrict access to admin level for alarm resets/troublesl
	Grinding & Size reduction - Hammermill	Temperature sensor		Bearing temperature
		Flow sensor		Plug sensors inlet/outlet
		Vibration sensor		Vibration sensor

CSD Impairment - What do you do if it's not functioning?

- Is it a regulatory or company risk based CSD?
- Can you continue to operate the equipment affected?
- The CSD system is not functioning as designed and engineered (some examples follow)
  - Temperature sensor not functioning
  - Faulted system
  - Dust collector not operational on a bucket elevator
  - A DCS component, associated with CSD function, is set to "override", "off scan", "local" or "force" in the case of a PLC
- The CSD cannot be immediately repaired back to an operational status and intent is to continue operation with an impaired CSD
- Best practice is to perform CSD testing during process shutdown.

Consider using a permit system for impairments

Events with CSD Failures

Pellet Cooler Fire – Outlet Temperature Monitoring and Spark Detection

Vaporizer Fire – Burner Management Systems

Dryer Fire – Temperature Monitoring and Burner Management Systems

Flour Mill Entoleter Fire – Bearing Temperature Monitoring

Bucket Elevator HazMon

Ruptured panel

Damaged bonnet

Damaged boot section

Bucket Elevator HazMon – Bearing Temperature monitoring



Silo fires – temperature cables

Dust Collector – Venting / Suppression

Compressed Air Receiving Tank - PSV

https://www.cdc.gov/niosh/face/stateface/ca/05ca010.html

Steam / Water Hammer - PSV

Incident: While filling the 10 Bar steam line with steam the main steam isolation valve failed due to hydraulic shocks (steam hammer). Two operators began the process of warming up the steam header. Then it was noticed that condensate began to come out of the steam valve bonnet gasket. The operator then shut the steam valve and evacuated the building and approximately 1 minute after, the valve body failed entirely, splitting from the steam header and releasing condensate and then steam. Because the break point was in the direction of the outside wall, only the wall panels were damaged.

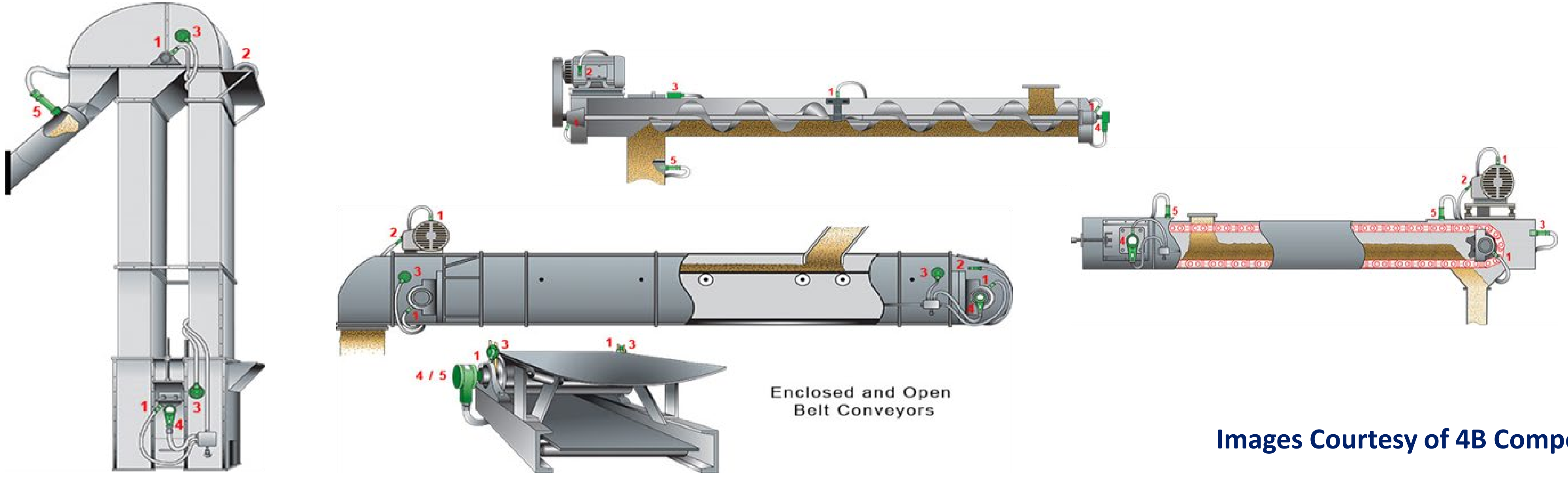
CSD - Hazard Monitoring

Inspection, Testing, and Preventive Maintenance

CSD - Hazard Monitoring

Purpose

- Hazard monitoring systems are essential in preventing malfunctioning equipment from causing a fire, explosion which could lead to catastrophic property damage and death.
- The hazard monitoring systems are designed to provide the operator immediate notification of a malfunction so that the equipment can be shut down, inspected and corrected.
- The systems are wired/programed to automatically shut down the malfunctioning equipment under certain situations and conditions.
- These systems are a critical link in detecting failures and preventing catastrophic events.



Images Courtesy of 4B Components

Hazard Monitoring – Bucket Elevator

Red items determined as CSDs

Green Items are not considered CSDs for outside bucket elevators, but do offer more layers of protection.

Some are legal requirements, and would therefore be considered CSDs. Some are determined as CSDs based on company risk tolerance.

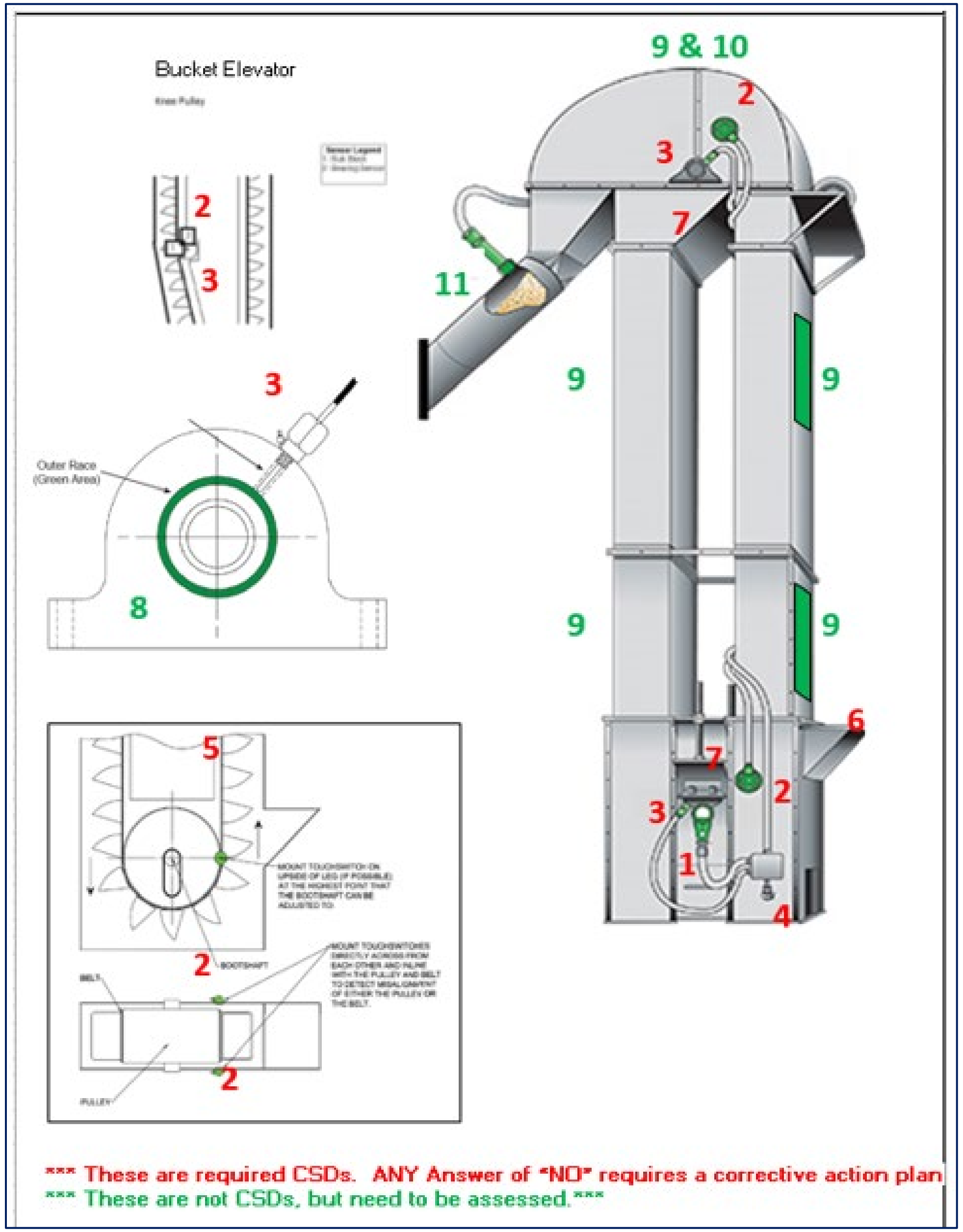


Image Courtesy of 4B Components

ADM

Hazard Monitoring – Inspection and Testing

Establish a frequency of inspection and PM, stick to it, and document it

Hazard Monitoring system sensors are considered Critical Safety Devices and must be inspected per preventive maintenance program.

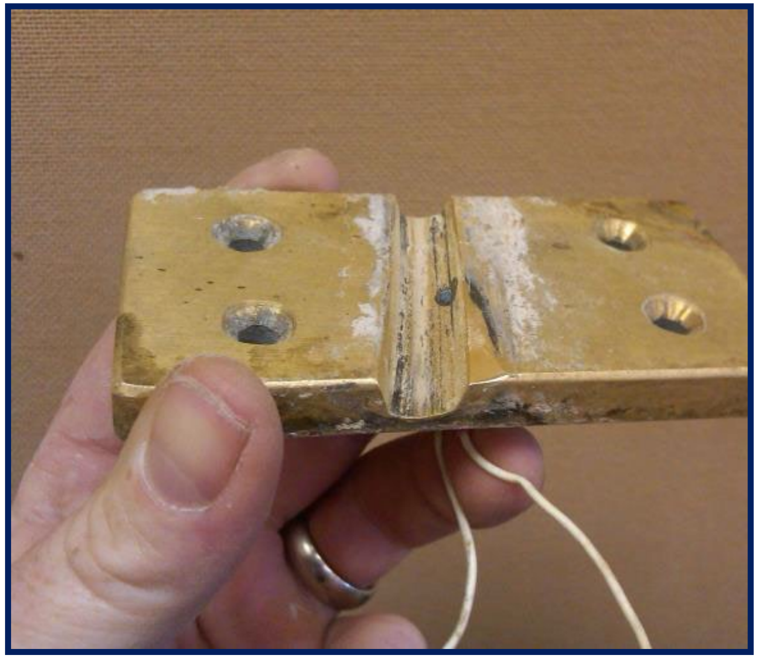
Every sensor needs to be inspected to verify that it is still installed properly (still securely tightened).

Every temperature needs to be looked at to verify that it is reasonable for its location.

All conduit and liquid-tight fittings visually inspected for broken fittings, loose fittings, broken liquid-tight, missing covers or plugs etc.

All temperature sensors should be tested to verify proper location.

Sensor – Placement and condition?



Hazard Monitoring Commissioning Report and Routine Maintenance Inspection

Equipment Name: **HazMon System Type:** **Equipment Type:**

Sensor Name	Group # (CMC) Sensor # (4B)	Sensor Type BRG, RUB, Lug, TS	Temps verified With Controller	Touch Switch Shutdown Test	Verify Location	Rub/TS Condition Good/bad/worn	Proper Placement First point of contact	*(if used)* Relative setpoint temp	*(if used)* Comparison Sensor Location	Relative Alarm Shtdwn Verify	Absolute Setpoint temp	Warning Alarm Signal Verify	Absolute Alarm Shtdwn Verify	*Comm Loss* Shtdwn Verify

Motion Sensor

Sensor Location	Shaft RPM	Observed Sensor RPM as displayed	Speed Calibrated By	10% Alarm Test Test	20% Shutdown Test	Zero Speed Test	Sensor Communication Loss

Document all information in the space provided and initial areas once complete.

Here are some quick reference tips, please use the attached instructions.

Touch Switch test
Verify when switch is activated that sensor is in proper location and system alarms and shuts down equipment

Proper Placement
Sensor is properly secured to bearing, rub block, lug placement.
Rub blocks/TS is placed to be the first point of contact with belt and pulley.

Motion Sensor
Speed must be calibrated initally when the equipment is running under no load and observed to be at full speed.
10% and 20% alarms must be verified by using Speedmaster (4B), CMC Emulator, or controller Test Function.
Zero speed will be tested by removing the sensor from the shaft or blocking the target with a metallic object.
Speed sensor communication loss will be tested by removing the plug from the Field Interconnect box or Node. This does not apply to hard wired sensors.

Verify Location
See attached Instructions.

Warning, Absolute, and Relative Verification
Test system logic to prove Warning alarms are activated at setpoints and Absolute/Relative alarms and shutdown occurs .
Verify temperature of sensor is within reason of ambient.

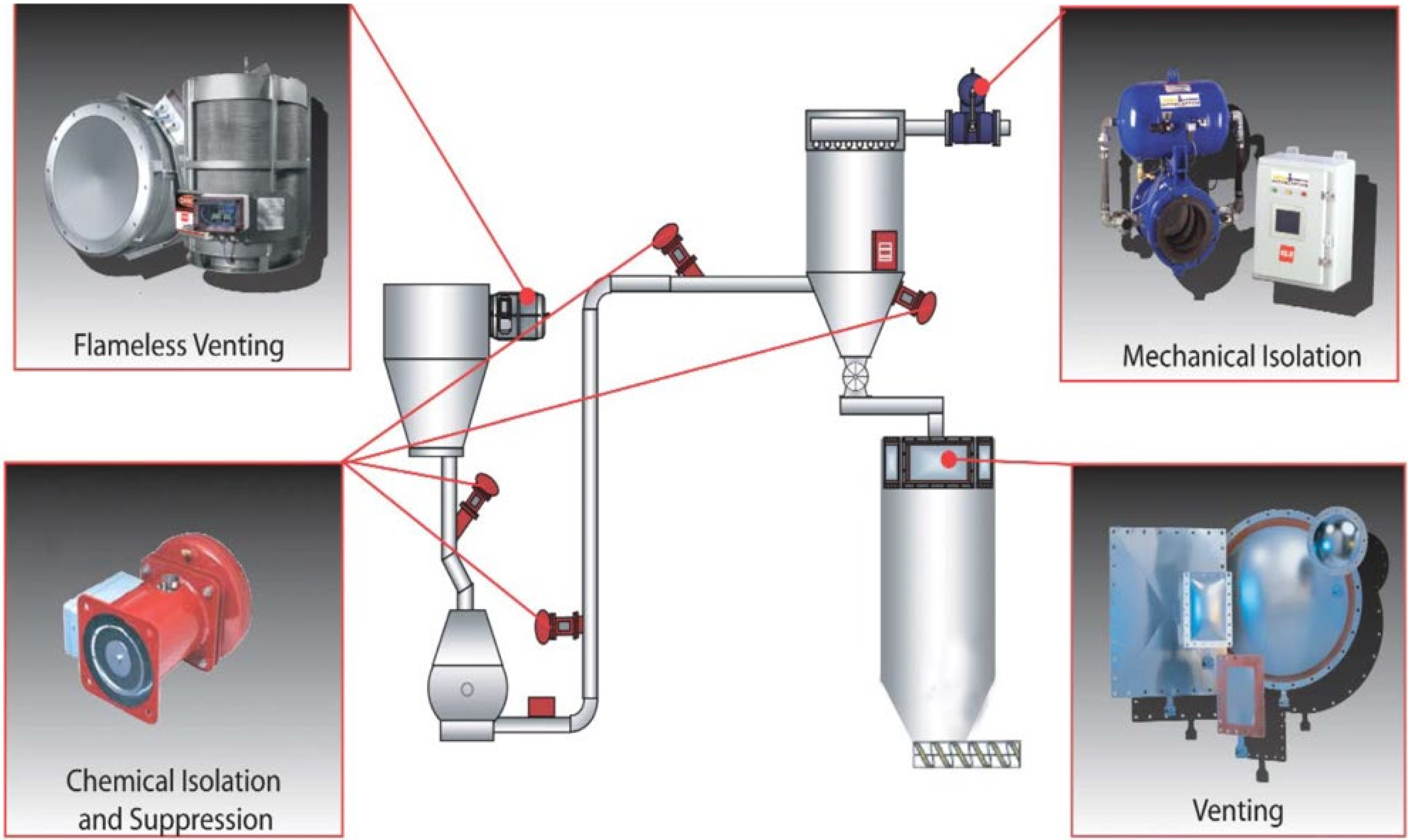
Communication Loss on the system
Verify a communication loss on the entire system will shutdown all equipment.
Systems using a PLC must have logic in place to monitor communication loss.

This equipment has been fully tested and verifyied to be functioning properly

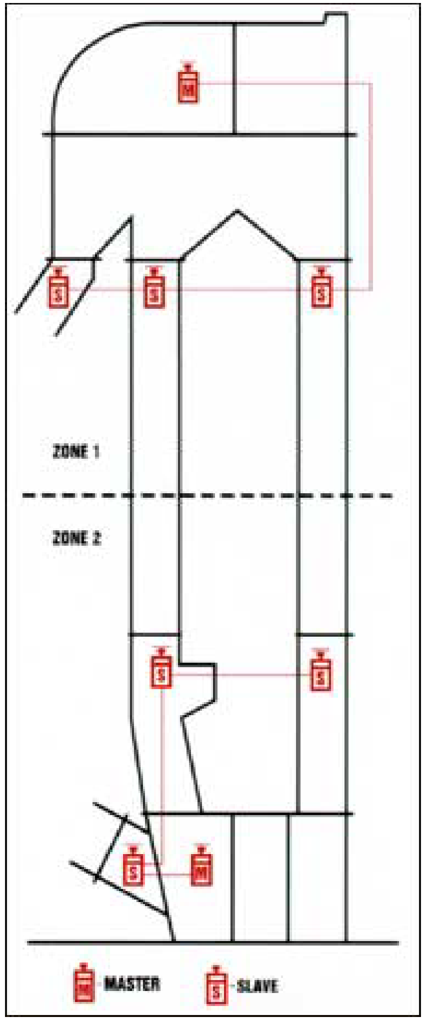
lazMon installer Rep Name:______________________ Location Rep Name:______________________

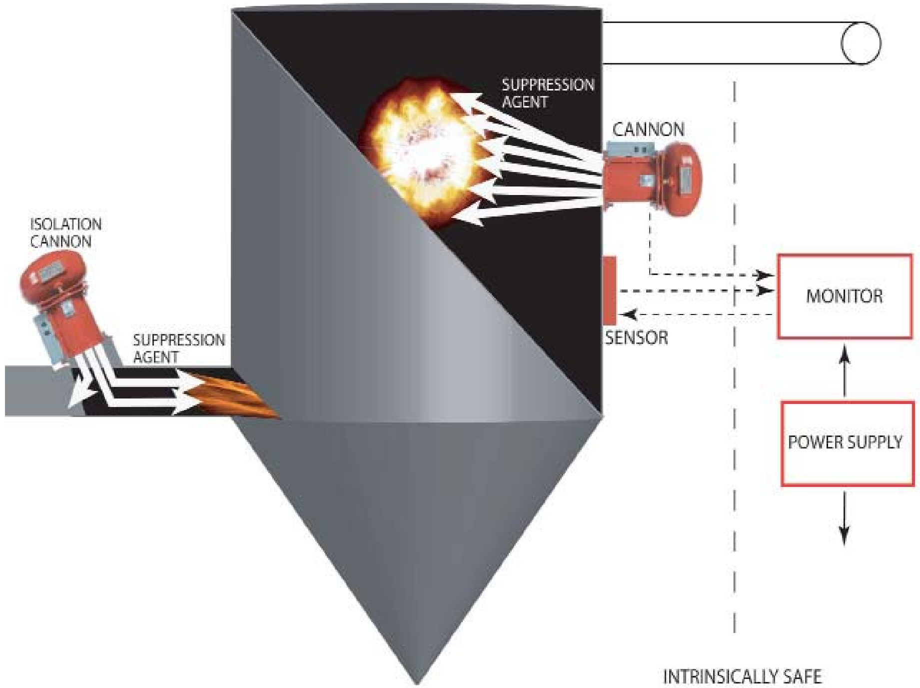
Date:______________________ Date:______________________

CSD – Suppression and Isolation



Common Placement





CSD – Suppression and Isolation PM

- Weekly checks need to be completed to ensure systems are in good repair
  - Manufacturer specific instructions
  - Proper mounting and cleanliness
  - Check pressure
  - System displays – circuit checks

- NFPA 69 15.7 specifies inspections and testing at 3 month intervals (with few exceptions). Systems to be inspected by personnel trained and authorized by the system manufacturer. Authorized personnel varies by manufacturer.

Criminal Indictment – Dust Collectors and Falsification of Documents 2022

Company Faces Federal Charges for Fatal 2017 Explosion
The company has been charged with nine crimes, including fraud, conspiracy and two counts of willful safety violations, causing 5 deaths.

Accused of Failure to clean up dust, maintain baghouses
According to the indictment handed down, the company failed regularly clean dust accumulations from inside the mill it owned and operated in order to prevent both food safety and quality issues and to remove accumulations that could fuel combustible dust explosions. They were also required to operate and maintain the baghouses to reduce emissions of grain dust into the environment.

Employees charged with conspiracy
The alleged conspiracy included an agreement to falsify cleaning logs and baghouse monitoring logs, submit false environmental compliance certifications, and provide false testimony on matters within the jurisdictions of the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA).

Allegations, include Differential Pressure monitoring on baghouses was falsified and the inside dust collectors were not fitted with venting or suppression.

Key Learnings, Causes, Actions:

- Preventive maintenance program is necessary on dust handling equipment to prevent leaks
- Monitoring the condition of the equipment is necessary
- Accurate documentation required

Thank You