Digital Innovations in Refinery Safety in a Post-COVID 19 Environment

ERTC 2020

EMERSON™

Speaker

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Emerson Automation Solutions

I bring 30+ years of experience in helping end-users improve and sustain operational performance with a programmatic approach consisting of best-in-class technological solutions, industry consultants and global / local engineering and solutions centers

Some Recent Major US Refinery and Petrochemical Safety Events

2020

- February 25 – Marathon Carson City (CA)
- February 12 – ExxonMobil Baton Rouge

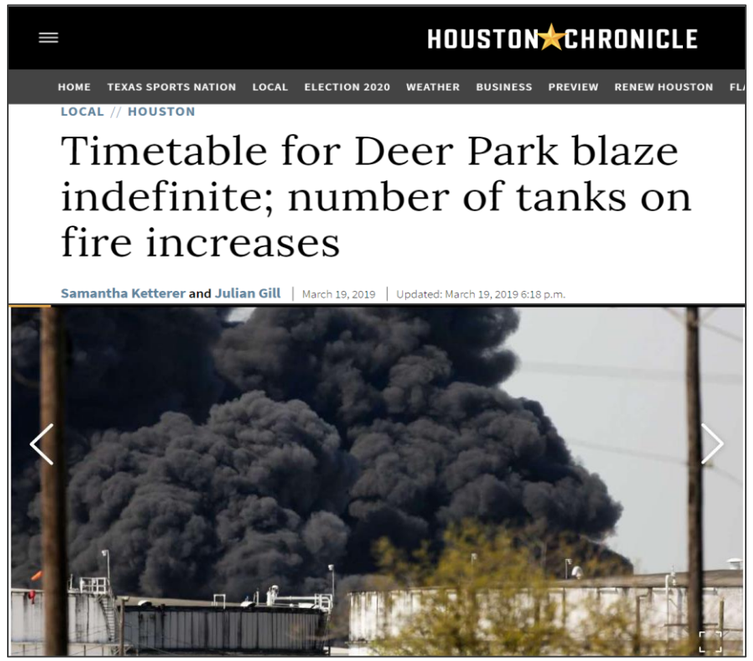
2019

- November 27 – TPC Pt Neches
- October 15 – NuStar Crockett (CA) Refinery
- July 31 – ExxonMobil Baytown
- June 21 – Philadelphia Energy Solutions
- June 3 – Kinder Morgan Carson City (CA) Storage
- March 19 – Mitsui Intercontinental Terminals Company Deer Park
- March 16 – ExxonMobil Baytown
- March 15 – Phillips 66 Carson City (CA)


BEAUMONT ENTERPRISE Local US & World A&E cat5 Sports Business Obits

Officials: Loud boom at 1:45 p.m. was tower falling at Port Neches plant

By Beaumont Enterprise Updated 2:07 pm CST, Wednesday, November 27, 2019


HOUSTON CHRONICLE

HOME TEXAS SPORTS NATION LOCAL ELECTION 2020 WEATHER BUSINESS PREVIEW RENEW HOUSTON

LOCAL // HOUSTON

Timetable for Deer Park blaze indefinite; number of tanks on fire increases

Samantha Ketterer and Julian Gill | March 19, 2019 | Updated: March 19, 2019 6:18 p.m.

Safety Incident – Possible Impact

Safety Performance Metrics

Occupational Safety
- SIF (Serious Injuries/ Fatalities)
- Recordables
- Lost Time Injury

Environmental
- Tier 1, Tier 2 - LOPC Events
- Government Reportable Events
- NOV – Notice of Violations – Fines

Community
- Evacuation alert
- SIP – Shelter in Place alert
- Road Closures
- Media Headlines and Coverage

Financial
- Direct Losses
- Production Losses
- Civil Suits
- High Loss Insurance Rates

Safety Statistics

Figure 2 Number of fatalities by category 2013-2018

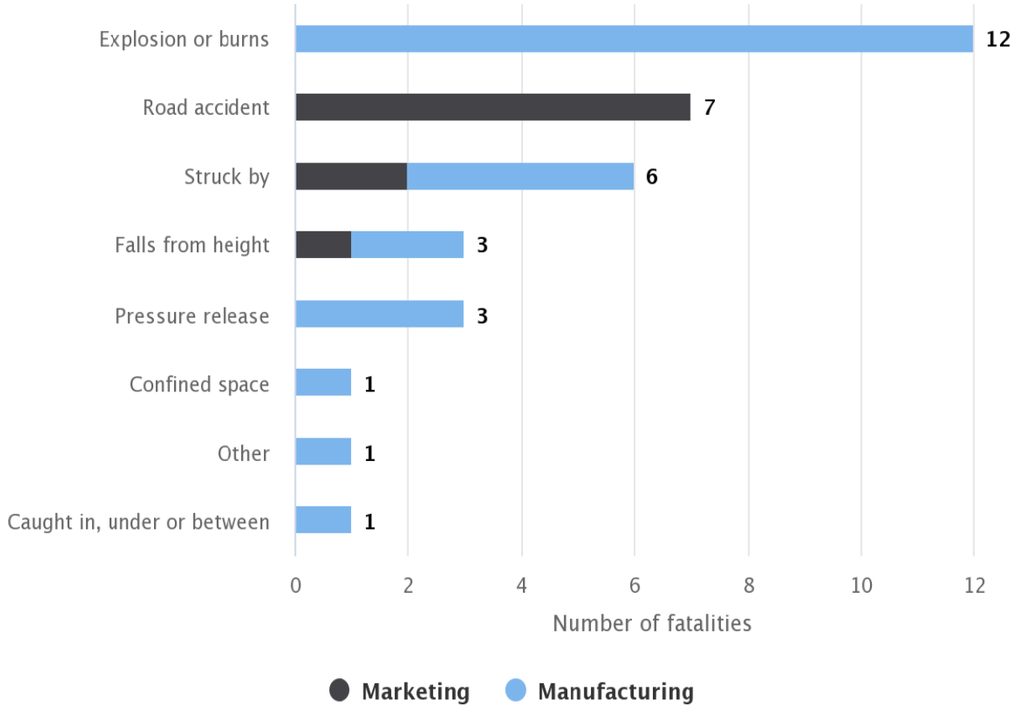
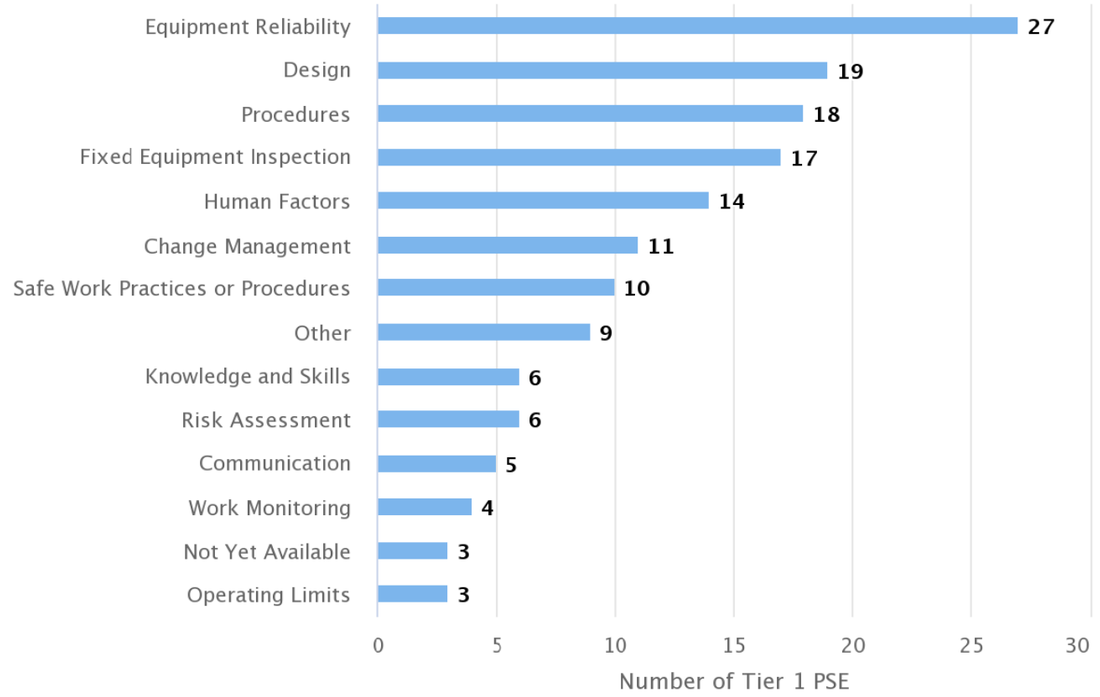
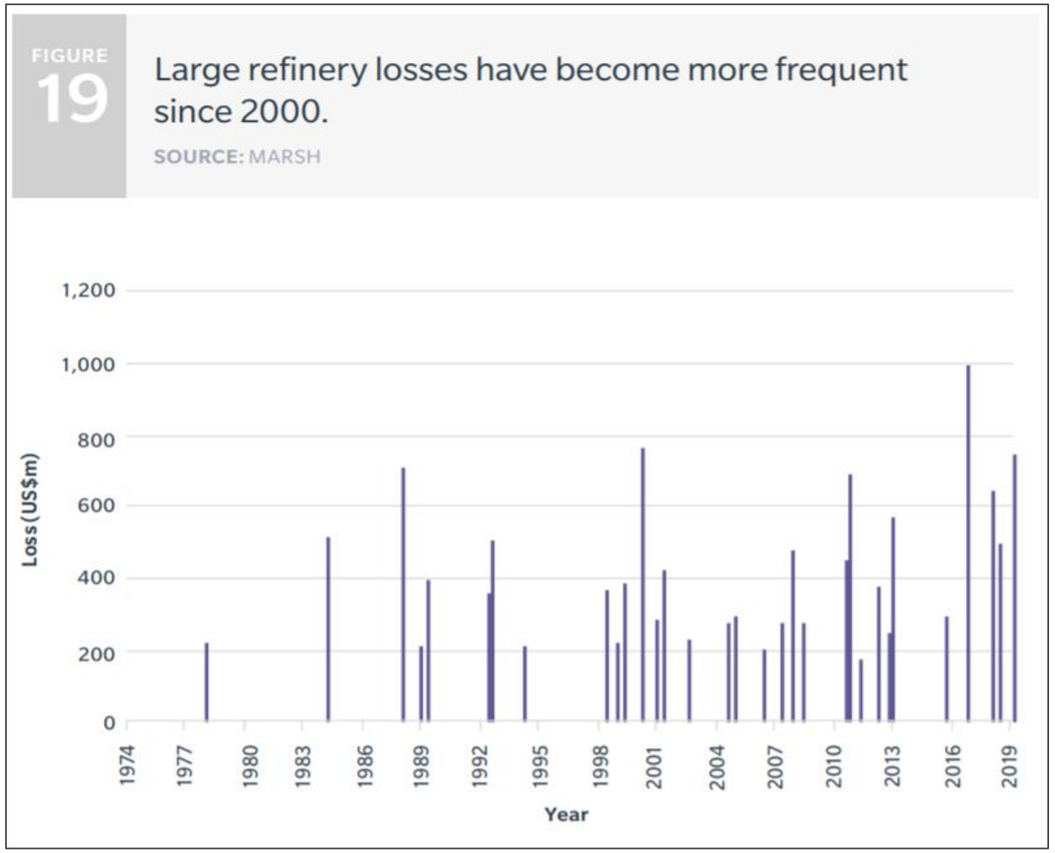


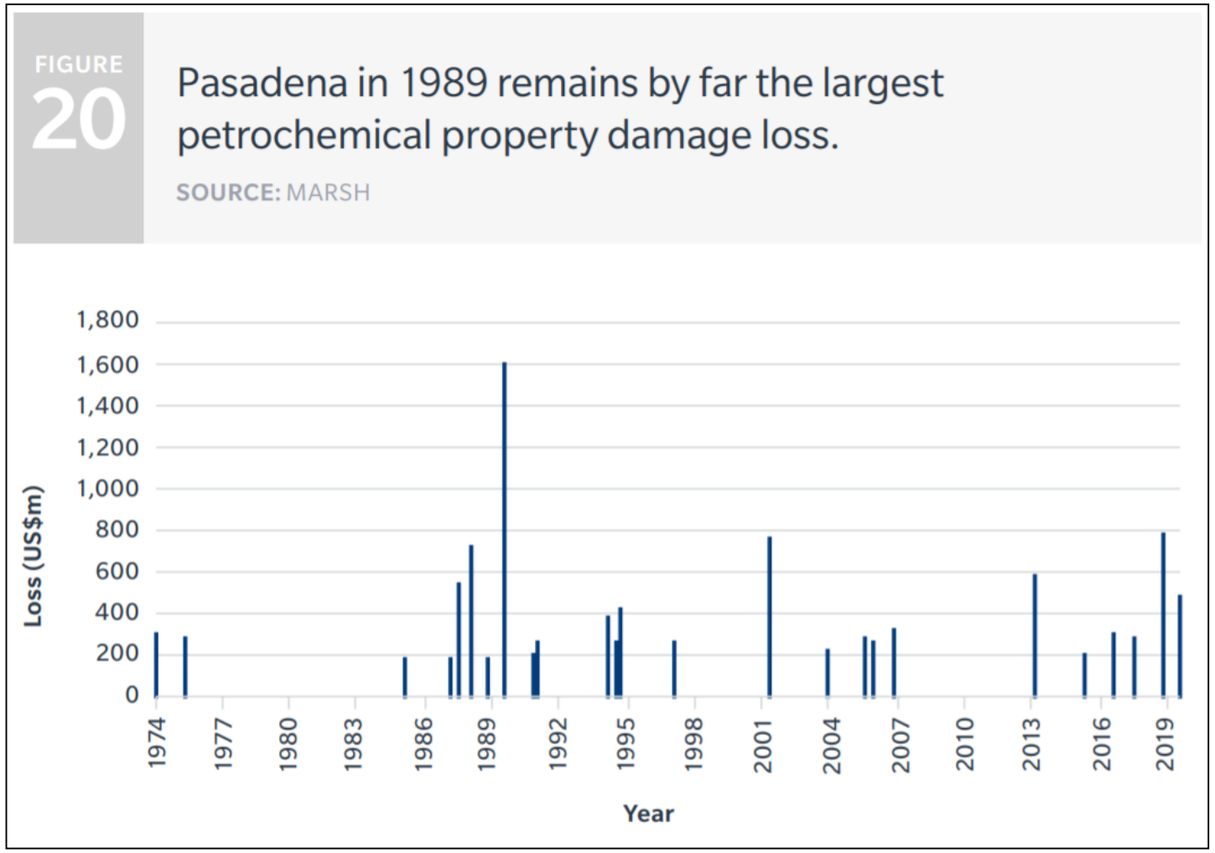
Figure 14 Number of Tier 1 Process Safety Events (Manufacturing and Marketing) reported in 2018 by Causal Factor (note that more than one causal factor may be assigned to an event)



European Downstream Oil Safety performance – 2018 Statistical summary of incidents

Property Damage Loss History





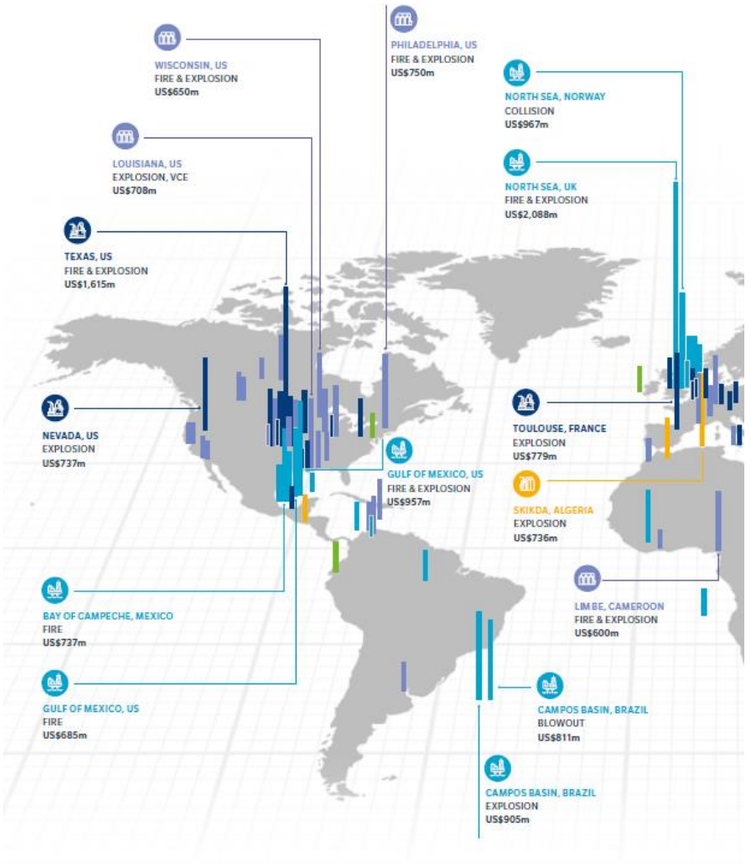
Production Losses are Additional!

Source: Marsh & McLennan; Large Property Damage Losses in the Hydrocarbon Industry 25th edition

Safety issues still in forefront of industry

MARSH JLT SPECIALTY

FIGURE 18 Most 100LL occurred in North America or Europe.
SOURCE: MARSH



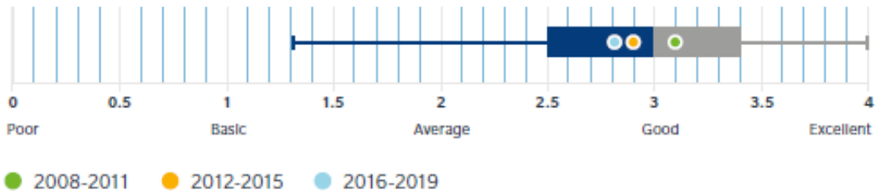
32 •100 Largest Losses in the Hydrocarbon Industry 1974-2019

INSIGHTS | MARCH 2020 | 26TH EDITION

100 Largest Losses in the Hydrocarbon Industry

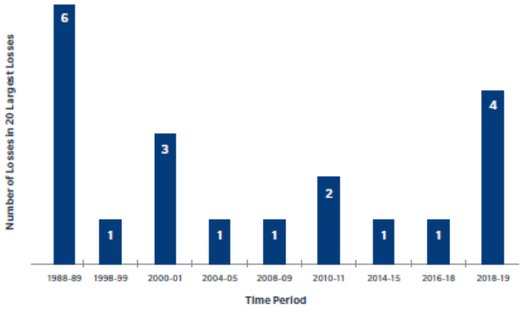
1974-2019

FIGURE 3 Average engineering standards at refineries declined during 2008-19.
SOURCE: MARSH



Deterioration in refining engineering standards (each circle represents the average score for the respective four-year period).

FIGURE 6 An unusually high number of large losses occurred in 1988-89 and 2018-19.
SOURCE: MARSH



Thirty years on, it is worth reflecting on the major contributing factors for these very large losses, and how they compare with recent events.

How Can New Digital Technologies Help with Safety?

- Major Gulf Coast Refinery - “Device diagnostic software (AMS) is key…we identified a problem with a boiler control transmitter that avoided an estimated production impact of $5 million, as well as potential equipment damage.”

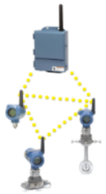
- Major Onshore Oil&Gas Processor – Implemented measurements and data analytics on key pumps. Analytics detected anomalous relationship between changes in pump intake pressure, motor amps and motor temperature and alerted maintenance – difficult to detect manually. Avoided a pump failure that could have created a safety incident and production losses.

- A European refiner operated four similar and parallel amine trains. They retrofitted real-time corrosion monitoring at key locations. It was determined that one of the four had *dramatically* higher corrosion rates which might have led to a safety incident and production losses prior to the next scheduled turnaround. Amine unit feed redistribution was implemented, and the corrosion rate was brought under control.

How can recent technology advances improve safety?

What's New In Plant Digitalization?

It starts with data



You can measure and collect data from almost anything

Connectivity

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You can send the data anywhere

Storage

Cloud
Application
Platform
Data Storage

Or/ And

Server

You can store all data with fast/ cheap access

Analytics

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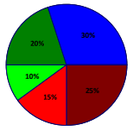

Sophisticated analytics algorithms for model development easier to implement

User Interface

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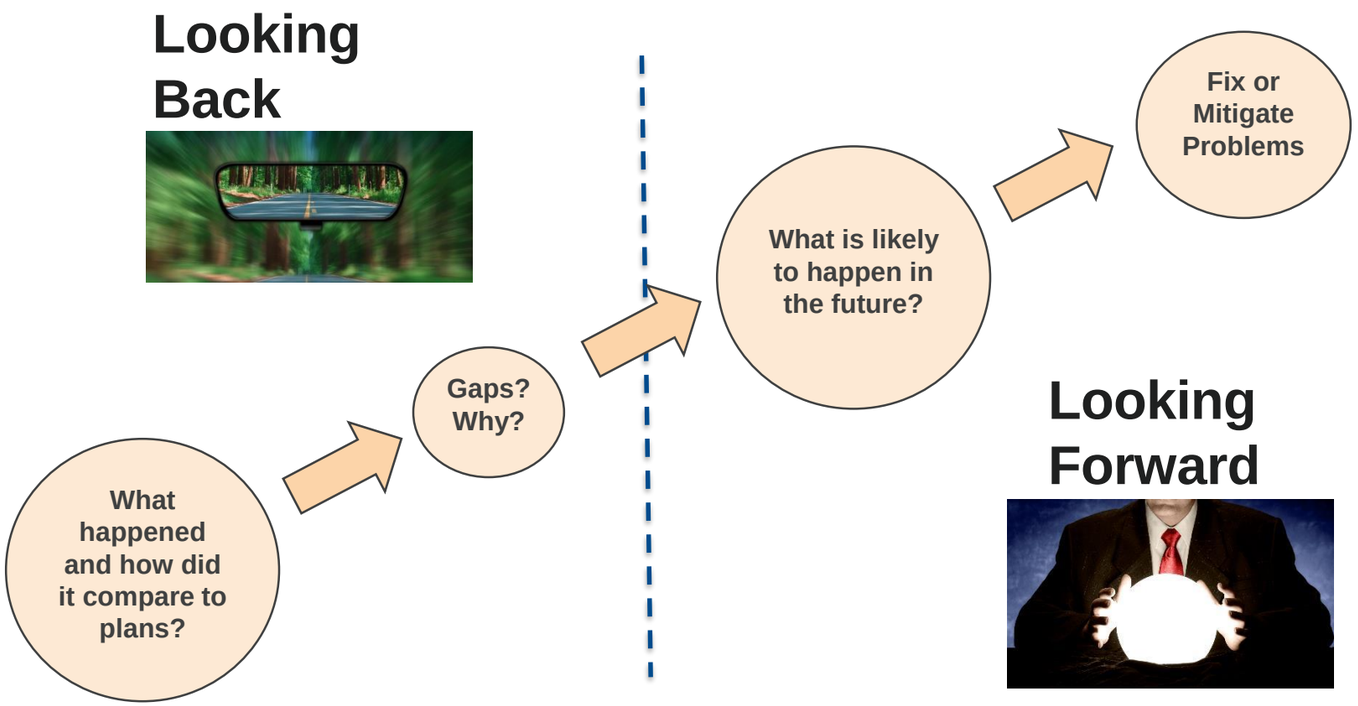
Convenient User interfaces

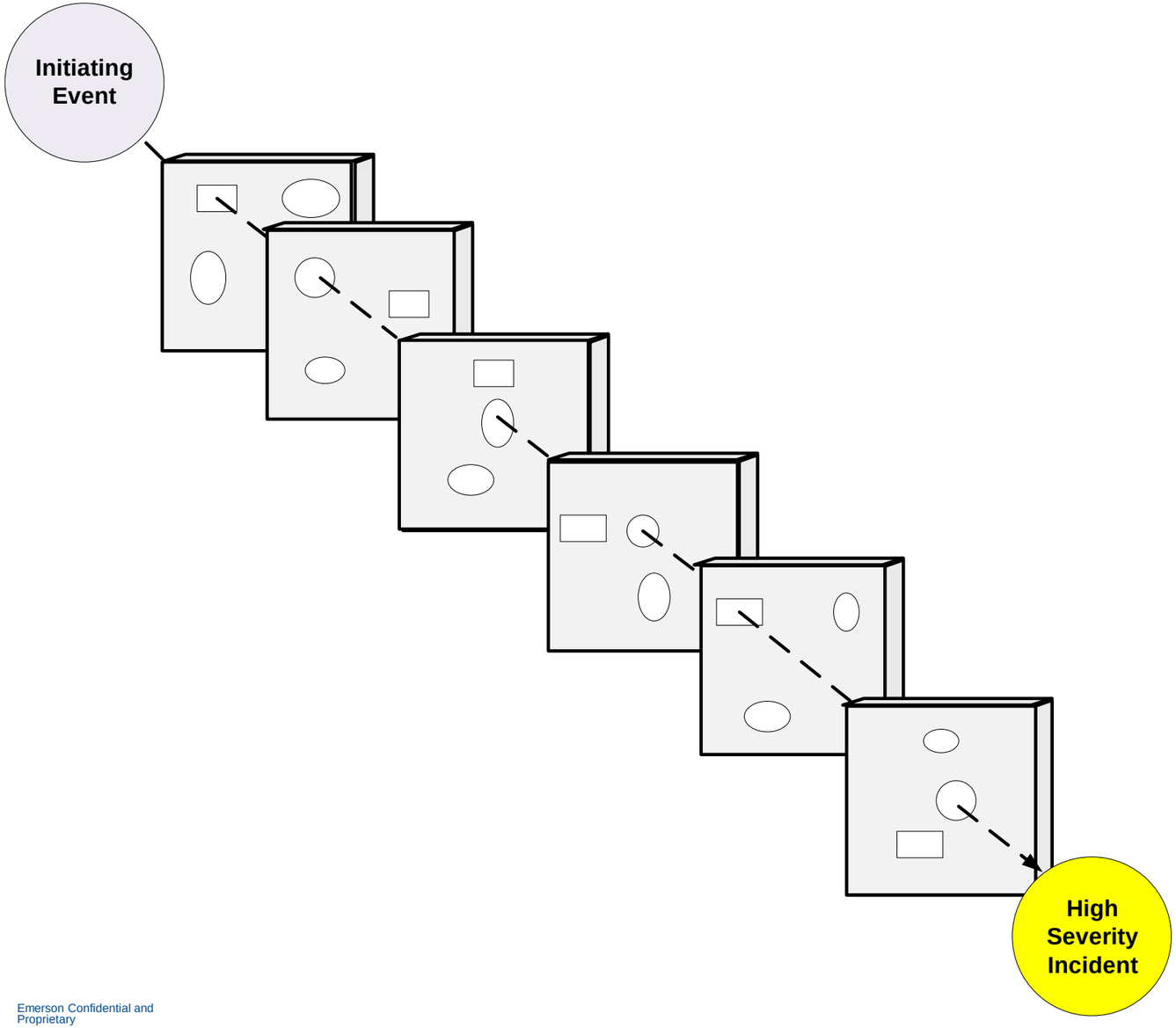
EMERSON

Improving Safety With New Digitalization Technologies - Looking Forward



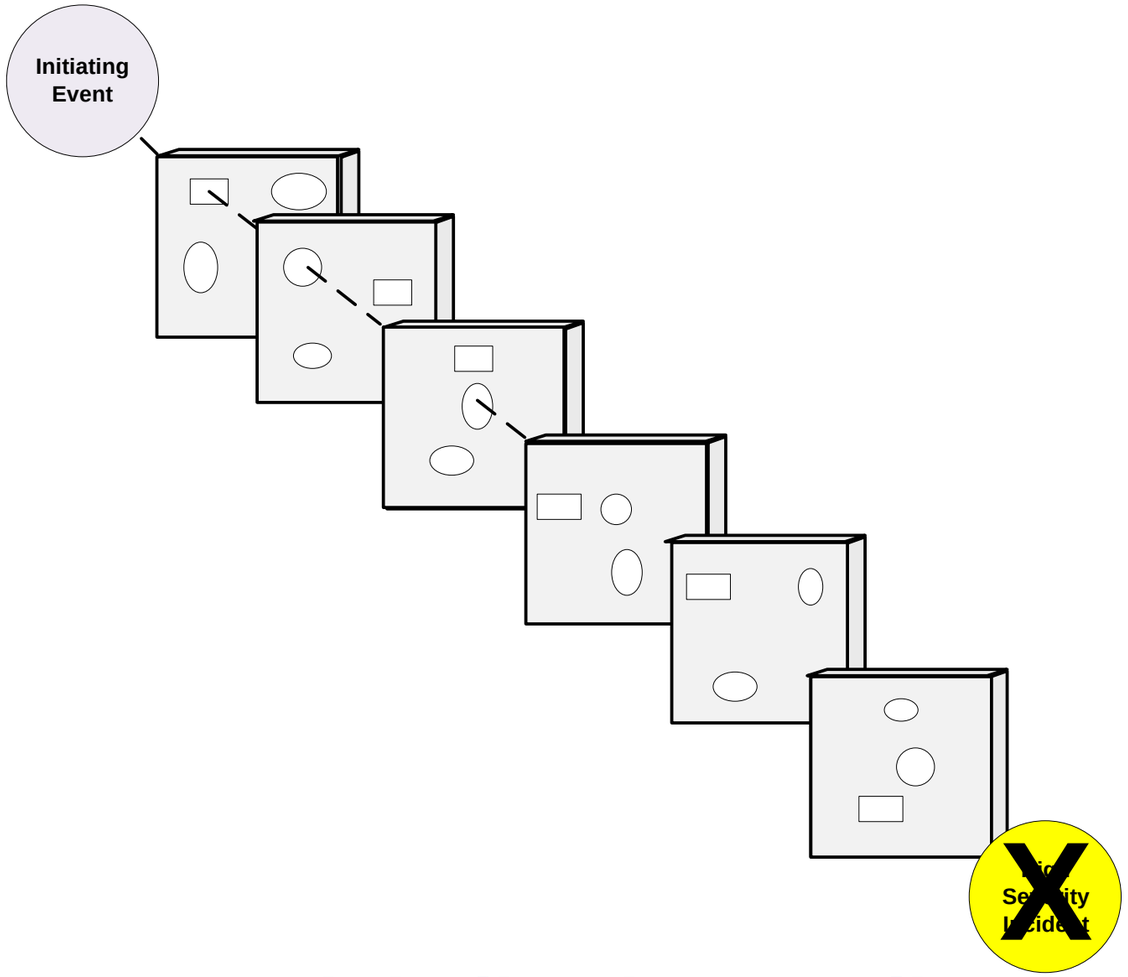
Value from digitalization is an early prediction and mitigation of future potential safety issues

Process Safety Risk Mitigation – Layers of Protection

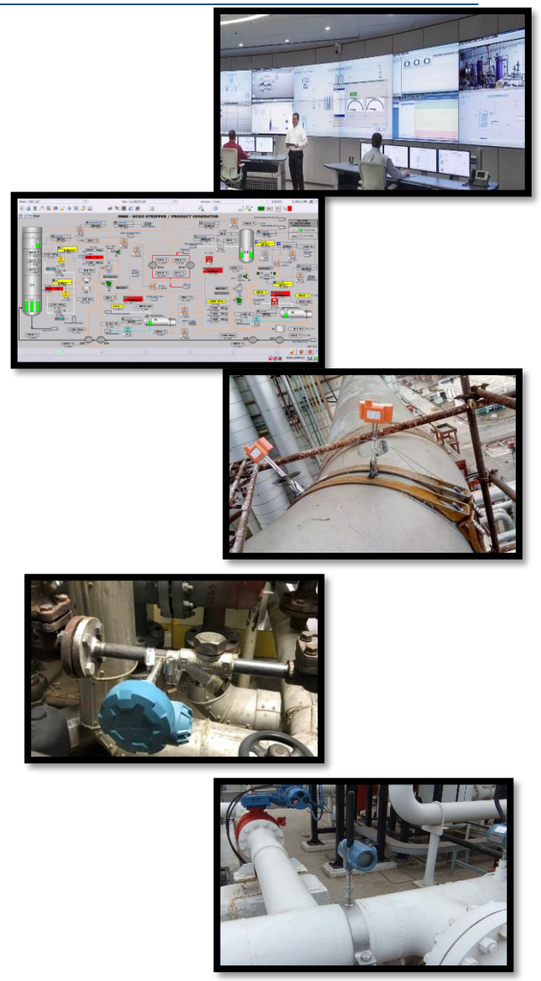


- Basic Process Chemistry and Components
- Process Design
- Staff Training and Procedures
- Equipment Maintenance and Monitoring Practices
- Basic Process Control Systems
  - Alarm Management
- Safety Shutdown Systems
- Relief Systems

Digitalization - Process Safety Risk Mitigation

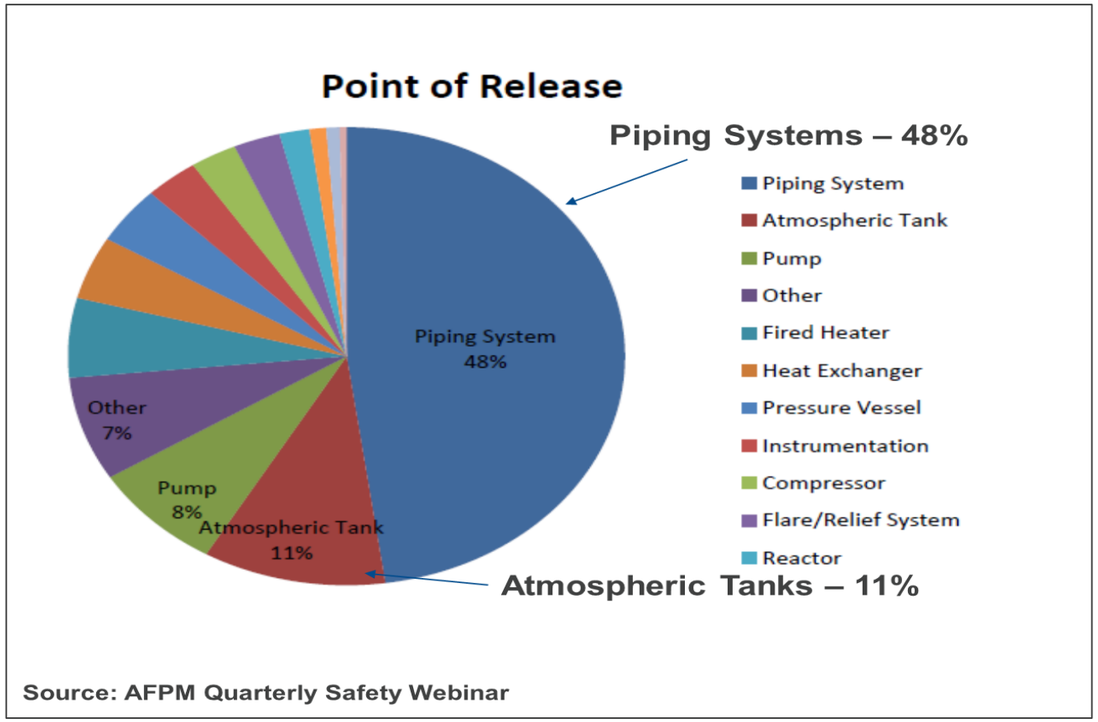


- Basic Process Chemistry and Components
- Process Design
- *Staff Training and Procedures*
- *Equipment Maintenance and Monitoring Practices*
- *Basic Process Control Systems*
  - *Alarm Systems*
- *Safety Shutdown Systems*
- *Relief Systems*

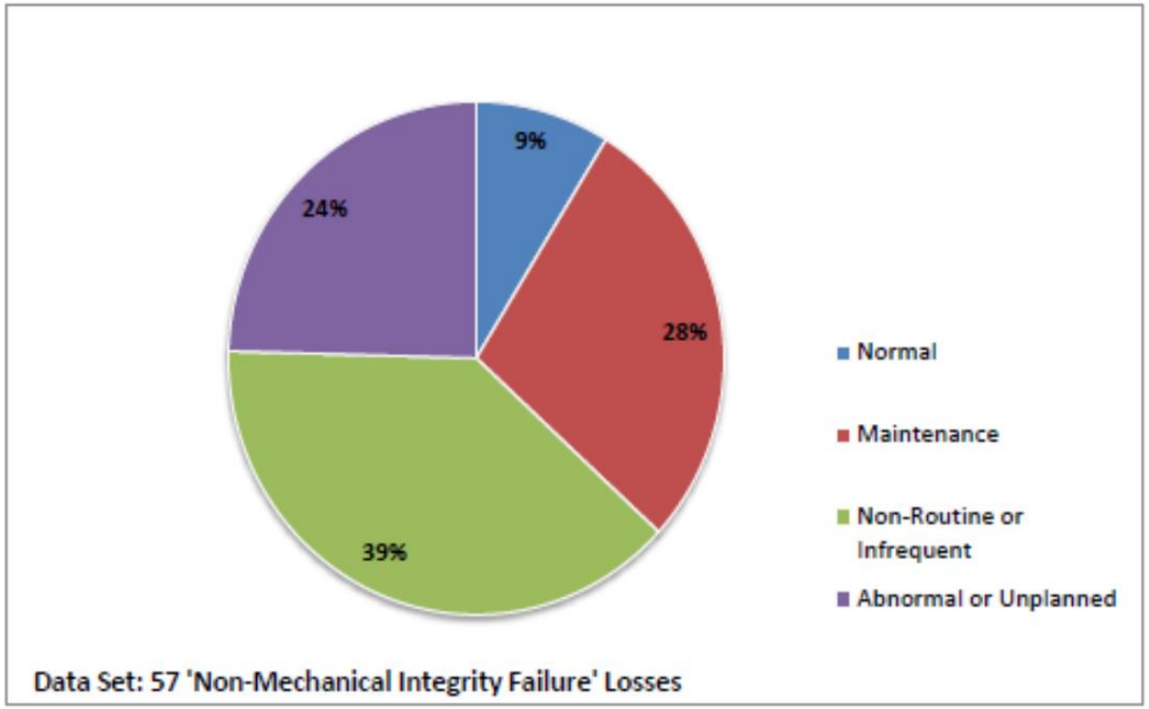


Digitalization applications provide additional risk mitigation

Source of Major Downstream Incident Losses



Source: AFPM Quarterly Safety Webinar



Common Causes:

- Tank Switching
- Bypass Valve Operation
- Manual Clearing of Line Blockages
- Inadequate Equipment Isolation

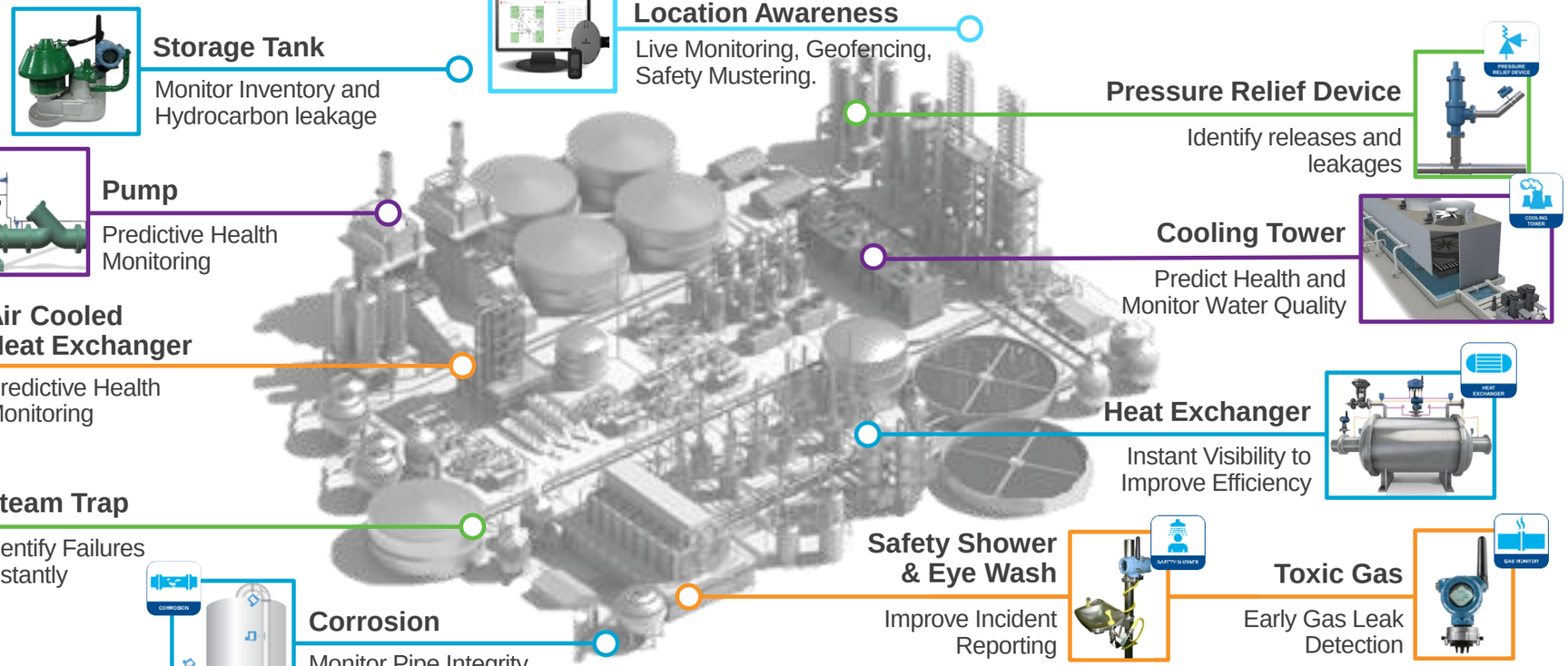
Source: LMA; Common Causes of Major Losses in the Onshore Oil, Gas & Petrochemical Industries; September, 2016 and AFPM Safety Webinar

Emerson Solutions – Available Now – Targeting Known Problems

Operational Analytics

Connect, Analyze, and Collaborate

- **Continuous Catalytic Reforming Unit**
- **Crude Distillation Unit**
- **Energy Performance Expert**
- **Refinery Startup and Shutdown Automated Procedures**
- **Operating Envelope Management**



Storage Tank

Monitor Inventory and Hydrocarbon leakage

Location Awareness

Live Monitoring, Geofencing, Safety Mustering.

Pump

Predictive Health Monitoring

Pressure Relief Device

Identify releases and leakages

Air Cooled Heat Exchanger

Predictive Health Monitoring

Cooling Tower

Predict Health and Monitor Water Quality

Steam Trap

Identify Failures Instantly

Heat Exchanger

Instant Visibility to Improve Efficiency

Corrosion

Monitor Pipe Integrity and Health

Safety Shower & Eye Wash

Improve Incident Reporting

Toxic Gas

Early Gas Leak Detection

* Illustrative list of applications

Safety

Corrosion Monitoring

Challenges

Personal & Occupational Safety

- ***Personnel*** incidents on ***scaffolding***
- ***Exposure*** to heat and potentially toxic environments

Process Safety (PSM)

- ***Pipe*** Ruptures
- ***Equipment*** Failures
- ***Loss of Containment***

"U.S. refineries supplied more than 18 million barrels per day of refined petroleum products with a total corrosion-related direct cost of $14.8 billion, 45 millions USD average annual per refinery in North America."

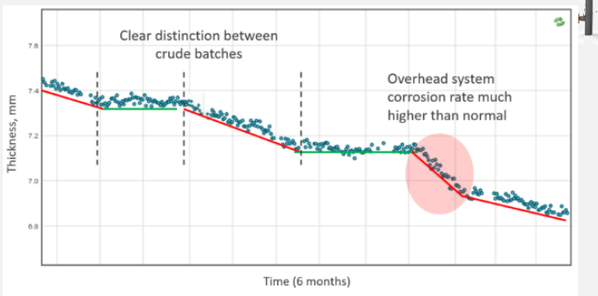
Sources: *Corrosion Costs and Preventive Strategies in the United States", Cost of Corrosion Estimate in United States, Saudi Aramco Journal of Technology*

Value Enabler

Continuous Corrosion Monitoring:
Ensures asset integrity and optimization of inhibitor dosing avoiding Safety risks and costs through corrosion

Typical Locations:

- CDU overheads
- CDU/VDU naphthenic acid corrosion
- FCC erosion, fractionator overheads
- Sour water stripper
- Amine system
- Alky feed driers / fractionator / deprop
- Hydrotreater REAC, stripper overheads
- Isomerization, Reformer stabilizers



Impact on Operations

- Results:
  - First Quartile Availability and increased margin
  - Increasing opportunity crude by 2% leads to: $8.6 Million/yr
- Inhibitor formulation and dosage, optimized based on the feedback from the sensors
- Increased awareness for turnaround schedules

Corrosion rate is stabilized!

Personal & Occupational and Process Safety risks are mitigated!

Avoid Corrosion Process and Personal Safety Consequences

Process Safety (PSM)

- ***Pipe*** Ruptures
- ***Equipment*** Failures
- ***Loss of Containment***

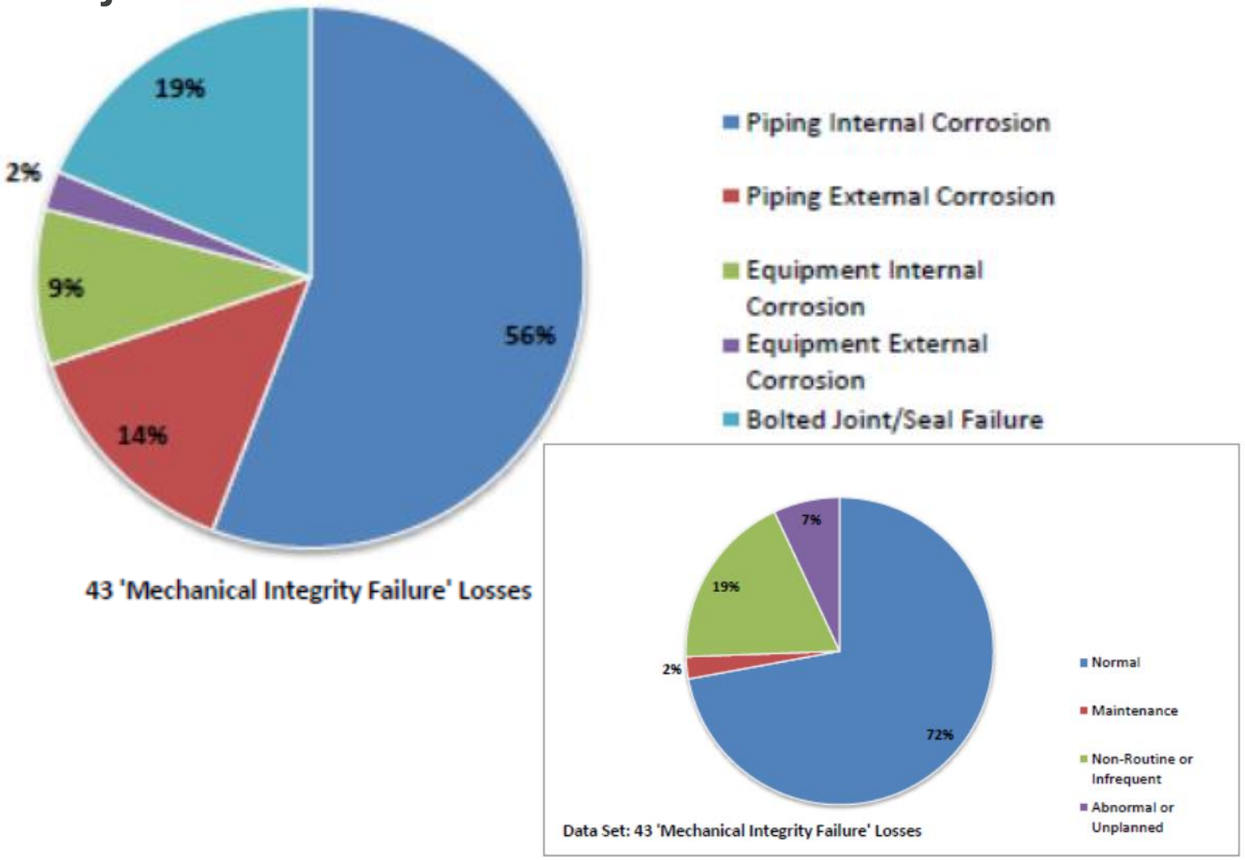
Personal & Occupational Safety

- ***Personnel*** incidents on ***scaffolding***
- ***Exposure*** to heat and potentially toxic environments

Sources: OSHA, Chemical Safety Board (CSB)

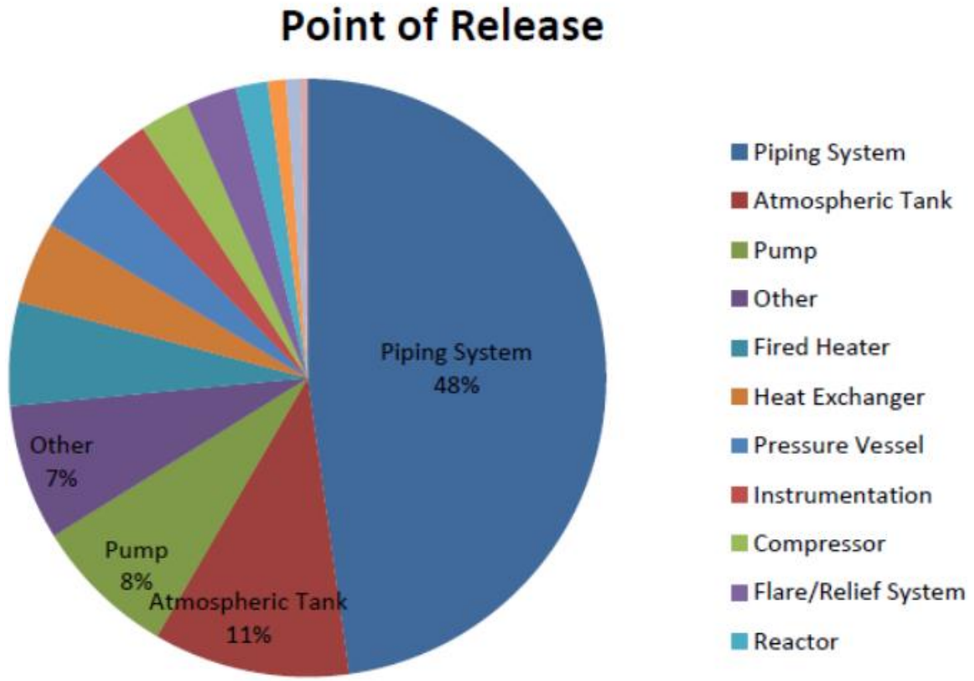
Challenges to Asset Integrity Are Impacting Safety

Major Downstream Incident Losses



Source: LMA; Common Causes of Major Losses in the Onshore Oil, Gas & Petrochemical Industries; September 2016

API 754 Data – Tier 1 and 2 Events



Source: AFPM Quarterly Safety Webinar

Internal Piping Corrosion in Normal Operation is a Large Contributor to Process Safety

Can Higher Capacity and Crude Slate Diversity be Achieved without Increasing Safety Risk or Costs through Corrosion?

YES! With real-time corrosion measurements…

Conservative production limits ***optimized*** into regionally adapted ***incentivized*** crude slate

Seasonally adjusted product ***capacities*** maximize refinery ***margins***

Reduced dosage of costly corrosion ***inhibitors*** and downstream process issues ***avoided***

Scaffolding and ***Manual Inspection*** in elevated and risky locations reduced and adequate monitoring ***frequencies*** facilitated

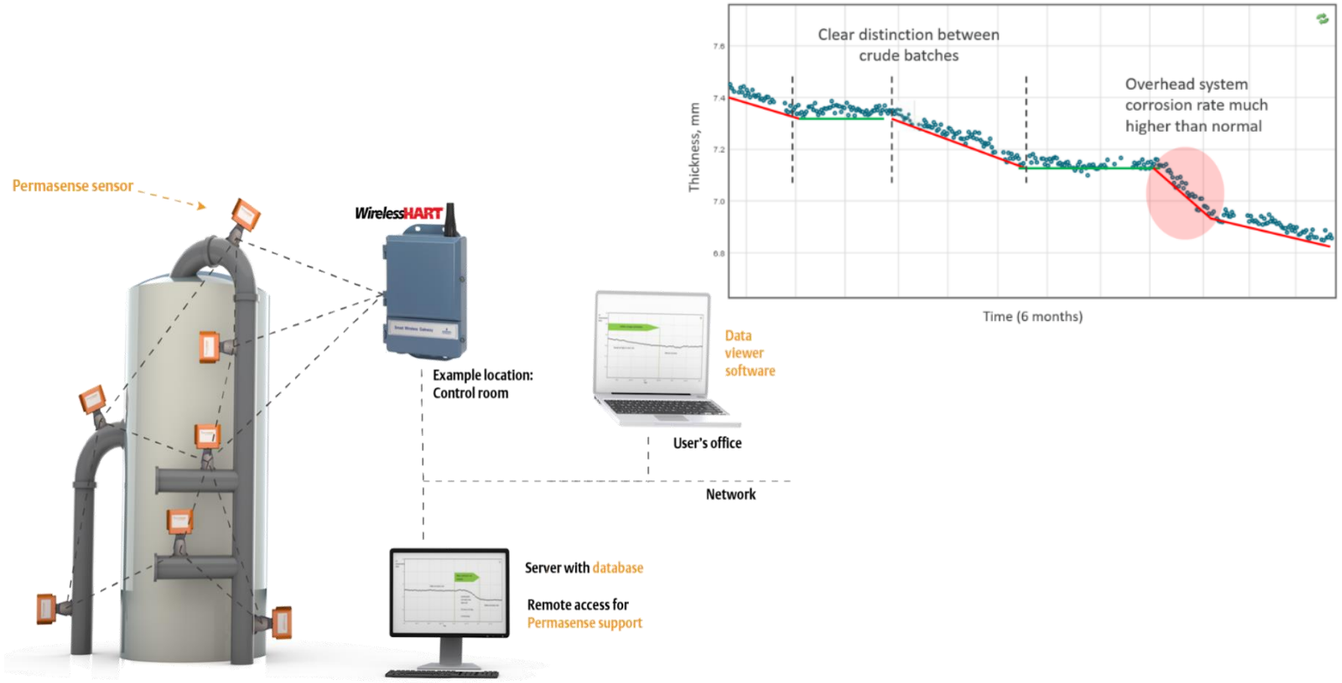
Implementing High Accuracy Wall Thickness Measurement

Increase crude slate diversification ***potential***

Increase capacity while ***reducing*** process safety ***risk*** and ***improving*** wall thickness measurement ***accuracy***

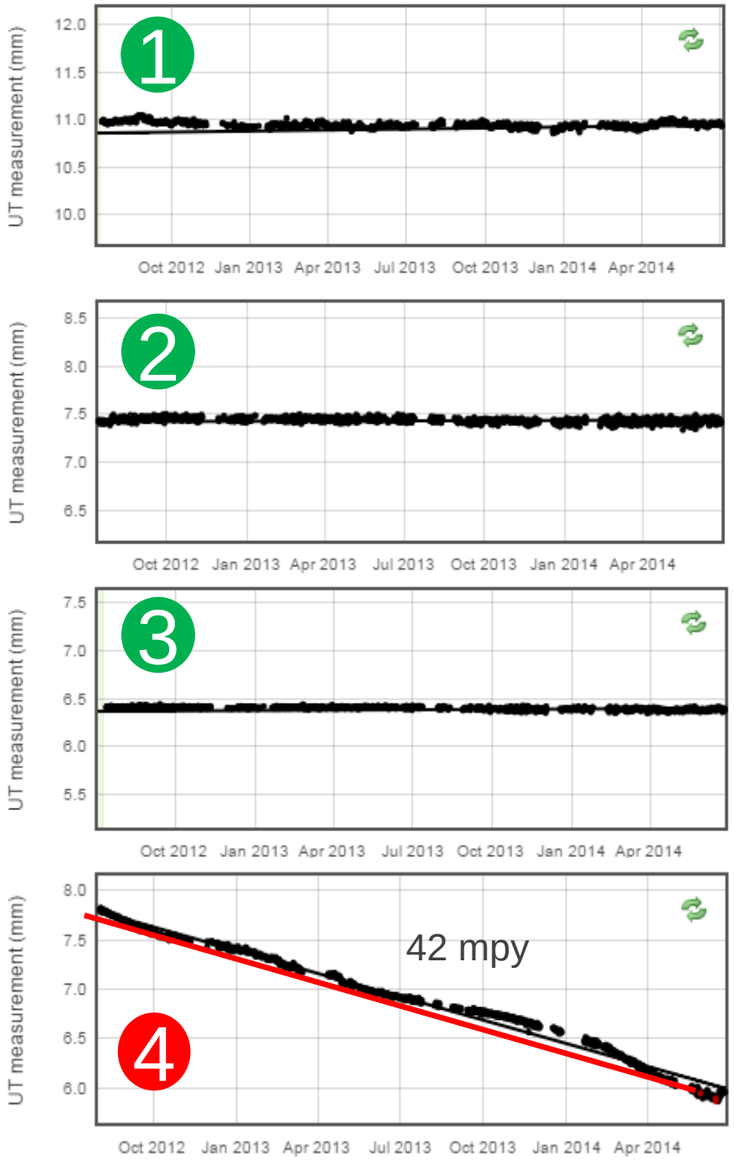
Reduce OPEX, by lowering ***scaffolding*** maintenance, ***refocusing*** staffing and ***automating*** previously manual tasks

Reduce CAPEX by evaluating material upgrades



Automated Asset Integrity Monitoring System Can Increase Operational Efficiency Allowing for Refineries to Gain a Commercial Advantage

Safety Improved with Online Corrosion Monitoring: Unplanned Outage Avoided, Refinery Slowdown Prevented



Amine Unit

- Four amine absorber trains
  - Similarly configured
  - All stainless steel
  - Corrosion NOT expected
- **Accelerated corrosion** in Train 4
  - 1 year to retirement (stainless steel)
  - Carbonic acid attack mechanism identified
  - High CO_2 content feed from FCC off-gas
  - Preferential routing found as root cause
- **Corrosion Mitigation Solution**
  1. **Installed** online monitoring alerted premature deterioration
  2. **Action taken** to redesign feed distribution system
  3. Corrosion **mitigated** by diluted effect of CO_2 across trains
  4. **Improved process safety**, extended run length and facilitated by real-time monitoring

	Lost Revenue
Refinery Throughput	200 kbd
Refinery margin	$7
Production slowdown	10%
Slowdown period	5 days
Total	**$700k**

Safety

Personnel Location Awareness

Challenges

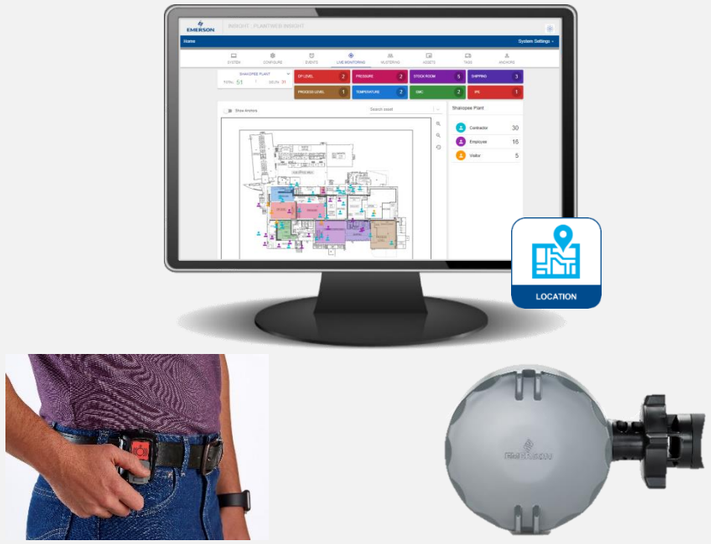
Current location technologies are not always suited for industrial environments. If they are suited, they require extensive engineering, design, and have a high cost of installation.

- Known hazardous zones
- Reaction time is critical in emergencies
- Injured personnel may need to request help

Value Enabler

Location Awareness enables the digital transformation of the safety of your facility.

- Fully wireless Anchors
- Rechargeable Personnel Tags
- Flexible infrastructure options



Impact on Operations

Provide a **safer work environment** for all personnel

Have confidence your personnel are **accounted for** in an emergency

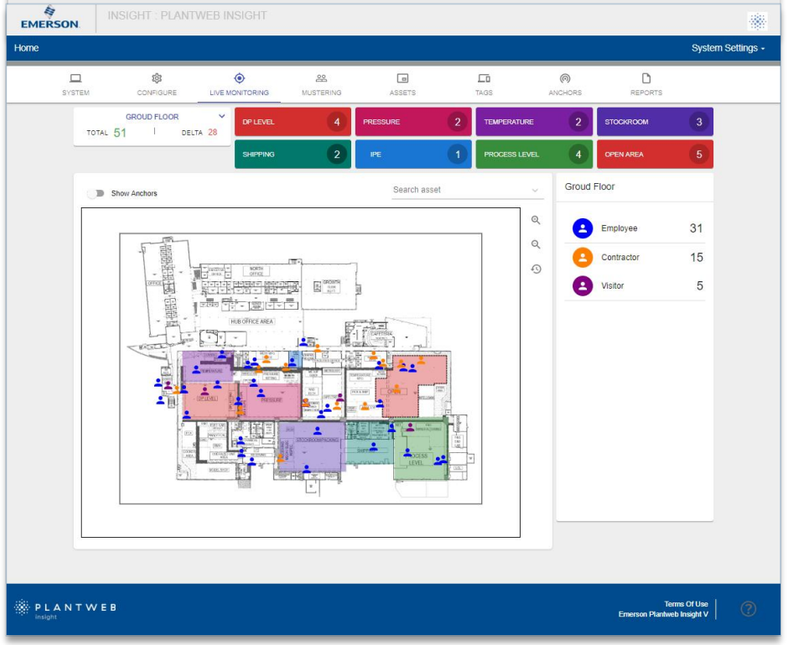
Significantly **reduce the response time** during an emergency

*Wireless*HART infrastructure provides the **foundation** for digital transformation and safety

Location Solutions to Provide a Safe and Secure Environment

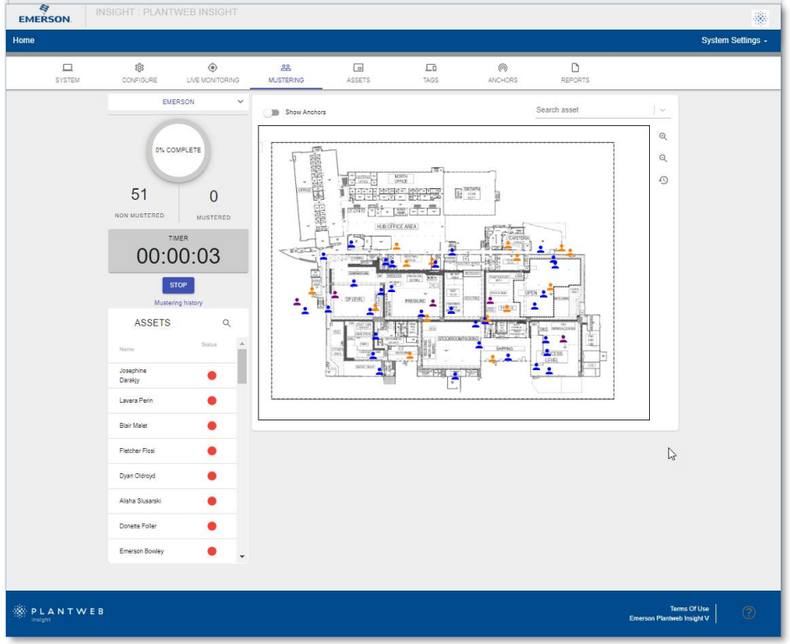
GEOFENCING

Keep contractors safe and efficient with designated work zones. Keep workers safe by creating zones of known hazardous locations



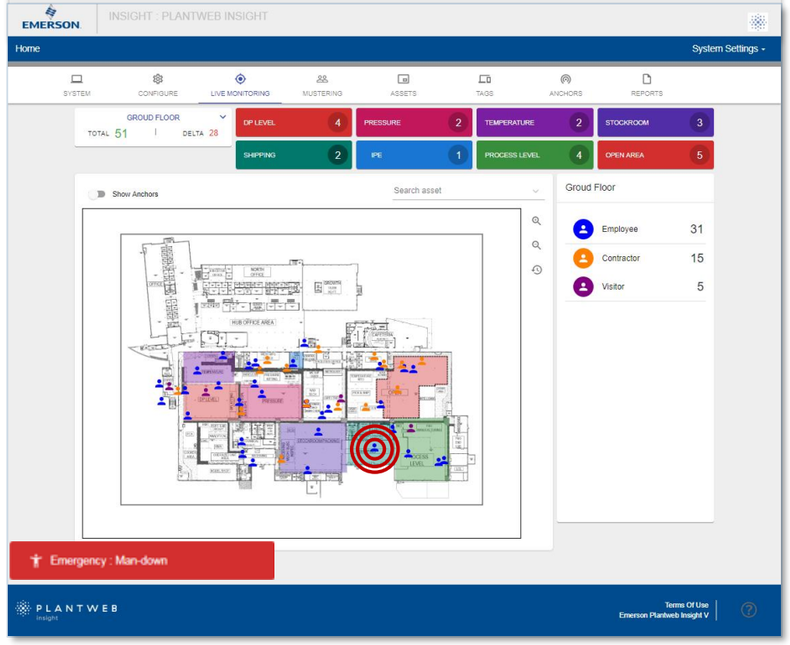
SAFETY MUSTERING

In an emergency, know that your personnel are safe and accounted for at designated muster points

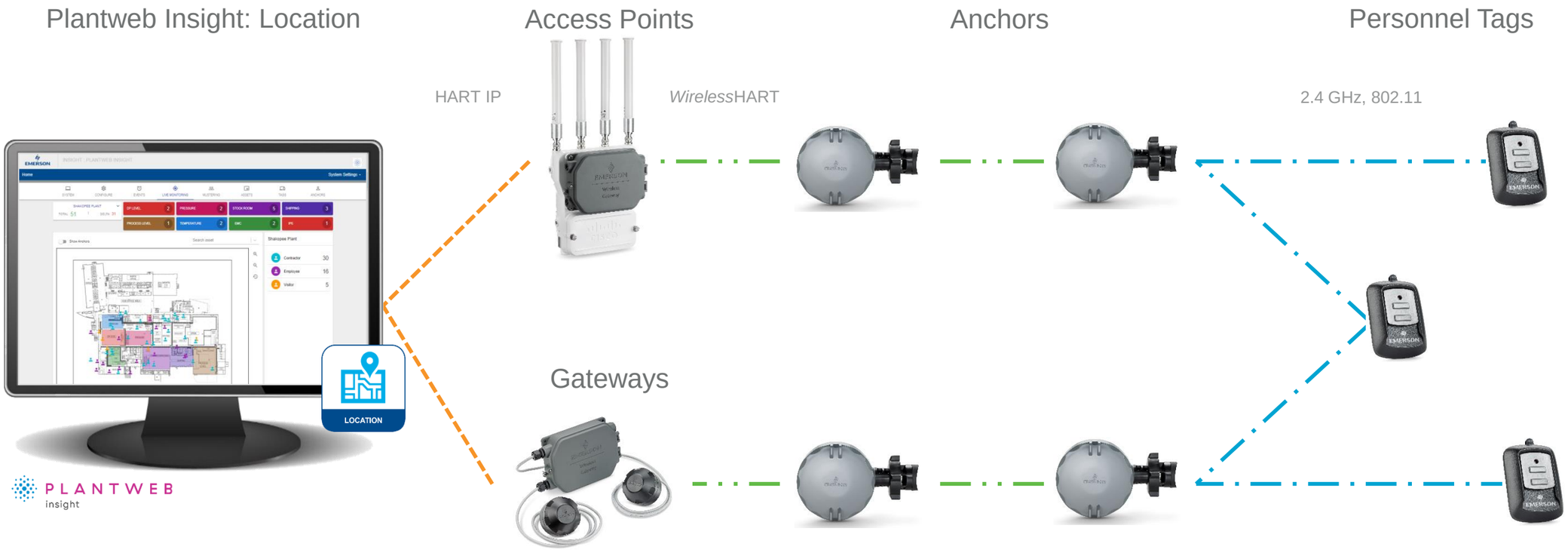


SAFETY ALERTS

Know where fallen personnel are located to quickly dispatch emergency responders

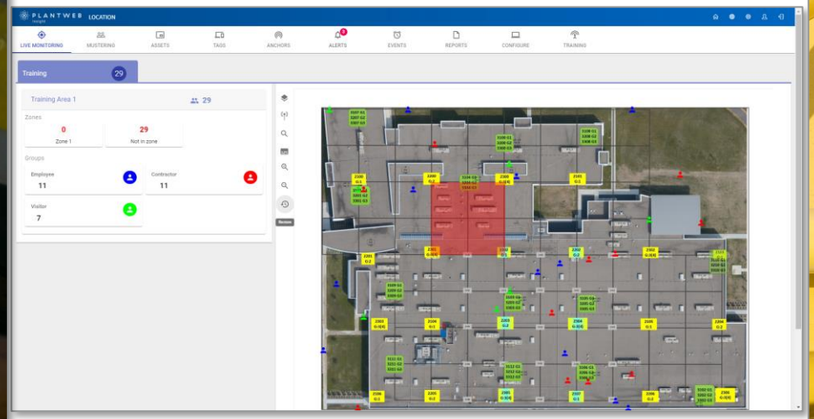


Emerson’s Location Awareness



Post-COVID 19 - Know When Contractors Have Arrived At Site to Start Work for Assigned Permits, Stay in Area, Social Density and Contact Tracking

Set time and zone of work permit → **Receive alert** → **Start work**



- Create a geofence zone for work permits
- Start and end time
- Number of contractors

- Receive alert that all contractors have arrived
- Site supervisor can arrive and sign permit

- Start work once planned contractors have reached work permit zone

Assign a rule of a maximum number of people allowed in a zone based on Social Density calculation and an alert will be triggered when the maximum has been surpassed

Generate records or reports of personnel movement in the facility if needed for contact tracing

Safety

Pump Monitoring with API RP 682 for Dual Seal Pumps

Operational Challenges

Protect operators and process avoiding **Hydrocarbon leaks** due to mechanical **seal failures**

Leaking hydrocarbons can catch fire and possibly lead to an explosion, fires & dangerous fumes, compliance violation, reduced operations or shutdown, and unexpected repairs…

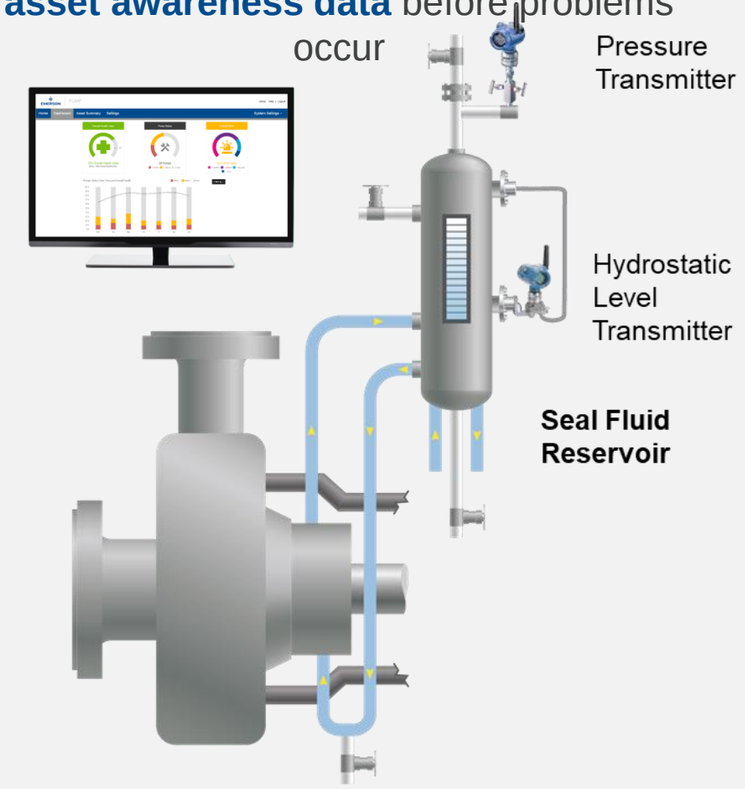
Eliminate the process of monthly **manual rounds** without compromising Safety's Indicators

How to prevent hydrocarbon leakage with **new technologies** instead relying on mechanical switches to monitor reservoir?

Value Enabler

API RP 682 has evolved to include **Pressure and Level transmitters** rather than switches

Plantweb™ Insight Pump application provides **asset awareness data** before problems occur



Impact on Operations

Maintaining **Safety KPIs optimized,** mitigates potential ensuing **safety incidents**

Avoid negative media, which can impact investors decision making

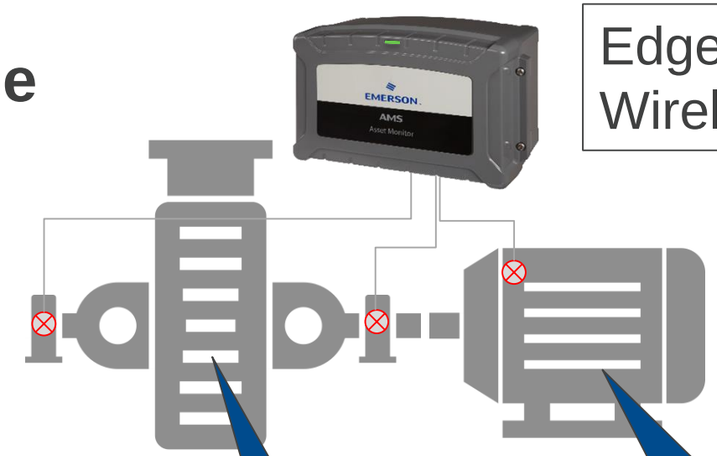
Minimize **unnecessary rounds**

Extend Pump's **MTBF** (from 2 to 10 years)

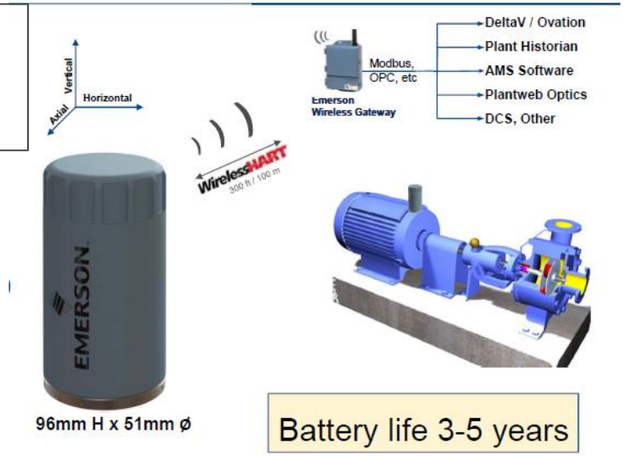
Potential **premium** insurance, as seen on LPG Pumps with up to $100K savings

Pump Monitoring - Embedded Prescriptive Automated Analysis

- **Selectable by asset type**
- **10 common faults:**
  1. **Balance**
  2. **Alignment**
  3. **Looseness**
  4. **Blade Pass**
  5. **Flow Turbulence**
  6. **Gear Mesh**
  7. **Hunting Tooth**
  8. **Bearing**
  9. **Lubrication**
  10. **Motor**



Edge Device or Wireless



Battery life 3-5 years

Pump
1. Balance
2. Alignment
3. Looseness
4. Blade Pass
5. Flow Turbulence
6. Bearing Fault (PeakVue)
7. Lubrication (PeakVue Plus)

Electric motor
1. Balance
2. Alignment
3. Looseness
4. Bearing Faults (PeakVue)
5. Lubrication (PeakVue Plus)
6. Motor Faults

Health scores and meaningful alert messaging allow all personnel to understand asset health condition

Pump Monitoring - Business Results

	Improved Pump Mechanical Availability	Reduced Costs of Repairs for Pumps	Mitigated Recordable Incidents
	CITGO Lemont Refinery	**Major Refinery in North America**	**Major Refinery in North America**
			
CHALLENGE	The client needed to monitor the flashed crude pumps behavior. These pumps consume a larger share of time and effort since manual inspections became more frequent.	Operators take manual temperature and pressure measurements in coker unit pumps, which is considered time consuming, not frequent enough, and introduces human error.	Vibration data for pumps that moved hydrocarbon products was collected by *sending plant personnel to potentially hazardous area*; data wanted to be collected remotely
SOLUTION	Wireless devices and Pump Health Monitoring from Emerson to allow operations to take action and inform maintenance that a problem mat be developing.	Smart Wireless network from Emerson consisting of wireless temperature and pressure transmitters and Gateway to notify operators when filters needed to be replaced.	Emerson Wireless vibration transmitters were installed with continuous data sent directly to reliability personnel to monitor.
RESULTS	Continuous data is being used to understand the systems, analyze data, set alarm levels, address and understand unknown problems.	Improved availability of coking operation by reducing unplanned failure of pumps. Up to 90 percent reduction in installed cost over traditional wired network.	Plant personnel could *monitor vibration of pumps without having to walk into a potentially hazardous area*; data available more often than before.

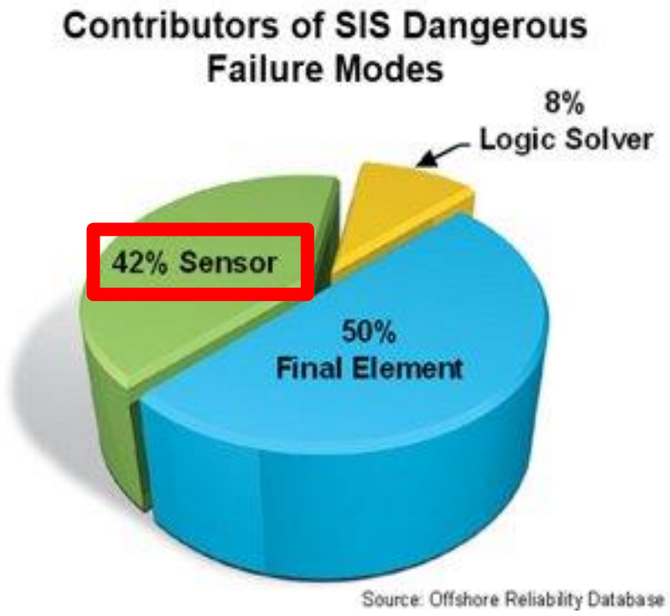
In an average-sized refinery, we are able to see $ 1.3 million margin improvement benefit with pump monitoring

Safety

Safety Instrumented Measurements

Challenges

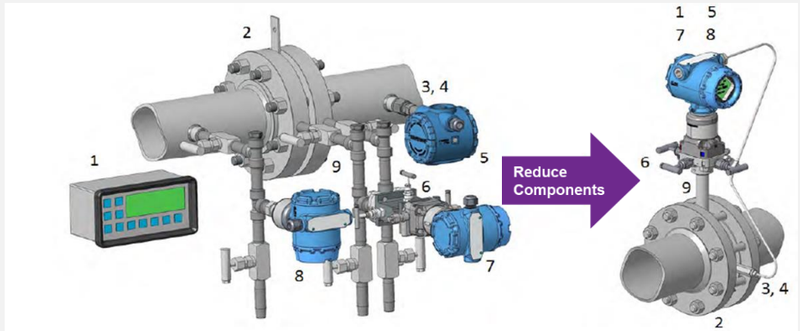
- Traditional instrumentation required significant maintenance due to leak points, impulse lines
- Lack of redundancy due to cost or space limitations
- Trips of SIS due to false readings, unreliable measurements or inability to detect sensor issues pre-failure



Value Enabler

Smart, robust multi-variable instruments

- Newly Integrated, more robust instrumentation reduce number of leak points, welds, and components compared to traditional installations by 80%
- Diagnostic capabilities to detect process or sensor impacts that can result in failure or misreading



Impact on Operations

- Reduce personnel time in field to perform maintenance on traditional instruments
- Increase SIL level and redundancy with more robust and compact measurement technologies
- Detect measurement or sensor issues pre-failure

Safety

Digital Isolation Technologies (ESD Valves)

Challenges

- Regulations are becoming harder to meet and insurance rates are climbing up to 100%
- To maximize production in favorable market, refiners are extending outages to 10 years
- Low-demand SIS valve assemblies require periodic testing to prove safety functionality
- Process shutdown to proof test to meet IEC 61511 requirements costs millions $/day

Sources: U.S. refiners, chemical makers pare insurance coverage as accidents boost costs, *Reuters*

Value Enabler

Scheduled Partial Stroke Testing run during normal plant operation

Documentation to support IEC 61511 compliance

Fully engineered Final Element assemblies tested to ensure performance of the safety function.

Impact on Operations

- Required safety integrity level (SIL) is maintained until planned maintenance interval increasing uptime
- Increased reliability to perform the safety function without increasing complexity decreases insurance premiums
- Minimized late stage product changes during SIL verification activities

Summary

- New digital technologies have the potential to provide early detection of potential safety incidents and to mitigate the consequences
- Cybersecurity incidents are a growing threat and counter-measures need to be implemented
- Emerson has a comprehensive set of equipment and services to help you improve the safety at your site

Emerson Client Safety Solutions

Customer	World Area	Application	Industry
BP Wytch Farm	EU	**Safety**-Eliminated operator rounds & used to improve wellhead monitoring	O&G Production
ADNOC	MEA	**Safety**-Eliminate hourly clipboard rounds to check fire safety system	Oil & Gas
Technochem	AP	**Safety**-Monitor tanks and are easily moved for multiple applications	Chemical
Croda	NA	**Safety**-Safely monitors temperatures in moving railcars	Chemical
Total Petrochemicals	EU	**Safety**-Monitors boiler condition of steam cracker to indicate. Increased safety due to reduction of movement of personnel into and around at-risk areas	Chemical
Boise	NA		
BP Port Allen	NA		
We Energies	NA		
Dow Chemical	NA		

Customer	World Area	Application	Industry
Severstal Wheeling	NA	**Safety**-Reduce product losses, update fire safety system	Metals - Steel
Severstal Wheeling	NA	**Environmental**-Eliminate environmental regulation violations	Metals - Steel
Dyno Nobel	NA	**Safety**-Avoid safety situation by monitoring temperatures on ammonium nitrate pumps	Chemical
San Diego Gas & Electric	NA		
Sun Chemical	NA		
AOC	NA		
Harcros Chemical	NA		
CalPortland	NA		

Customer	World Area	Application	Industry
Lenzing Fibers	EU	**Environmental**-Monitor river water temperatures to meet government regulations	Pulp & Paper
StatOil Hydro (Gullfaks)	EU	Safety-Manual measurement in hazardous areas reduced. Automate flow monitoring on offshore	Offshore
CHS	NA	**Environmental**-Improve product tank monitoring across large facility (Spill prevention) & Fire system monitoring	Oil & Gas
Lion Oil	NA	**Environmental**-Check product inventory, prevent overfill & remediation costs, & monitor UPS power for the radio tower	Oil & Gas
Lion Oil	NA	**Safety**-Monitor safety shower use	Oil & Gas
ADNOC	MEA	**Safety**-Eliminate hourly clipboard rounds to check fire safety system	Oil & Gas
MET-MEX Peñoles	LA	**Environmental**-Improve accuracy of sulfur dioxide emissions data collection	Metals & Mining
Elkem	LA	**Safety**-Eliminate manual temperature & level data collection on product storage tanks	Metals & Mining
Ternium	LA	**Safety**-Improve blast furnace energy efficiency, process stability and safety	Metals – Steel

Questions

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