Bridging the Gap During Petrochemical Losses

Presented by

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Managing Director, Senior Engineer

- Over thirty years of experience performing loss investigations of various types of incidents including fires, explosions, machinery breakdown, workplace accidents, lightning, flooding and other natural catastrophes.
- Have been instructed on claims involving different equipment and systems, including:
  - Power generation, transmission and distribution,
  - Industrial machinery,
  - Medical, pharmaceutical, analytical and other equipment
  - Printing presses, packaging,
  - IT servers, data centres, enterprise computers
  - Communication and broadcasting
  - BMS, PLC, Automation and other control systems
- Acted as expert witness in different jurisdictions giving evidence on multiple engineering issues related to different matters of dispute.

CEERISK
Bridging the Gap

Risk Engineering

Forensic Engineering

Claims Consulting

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Petrochemical Industry

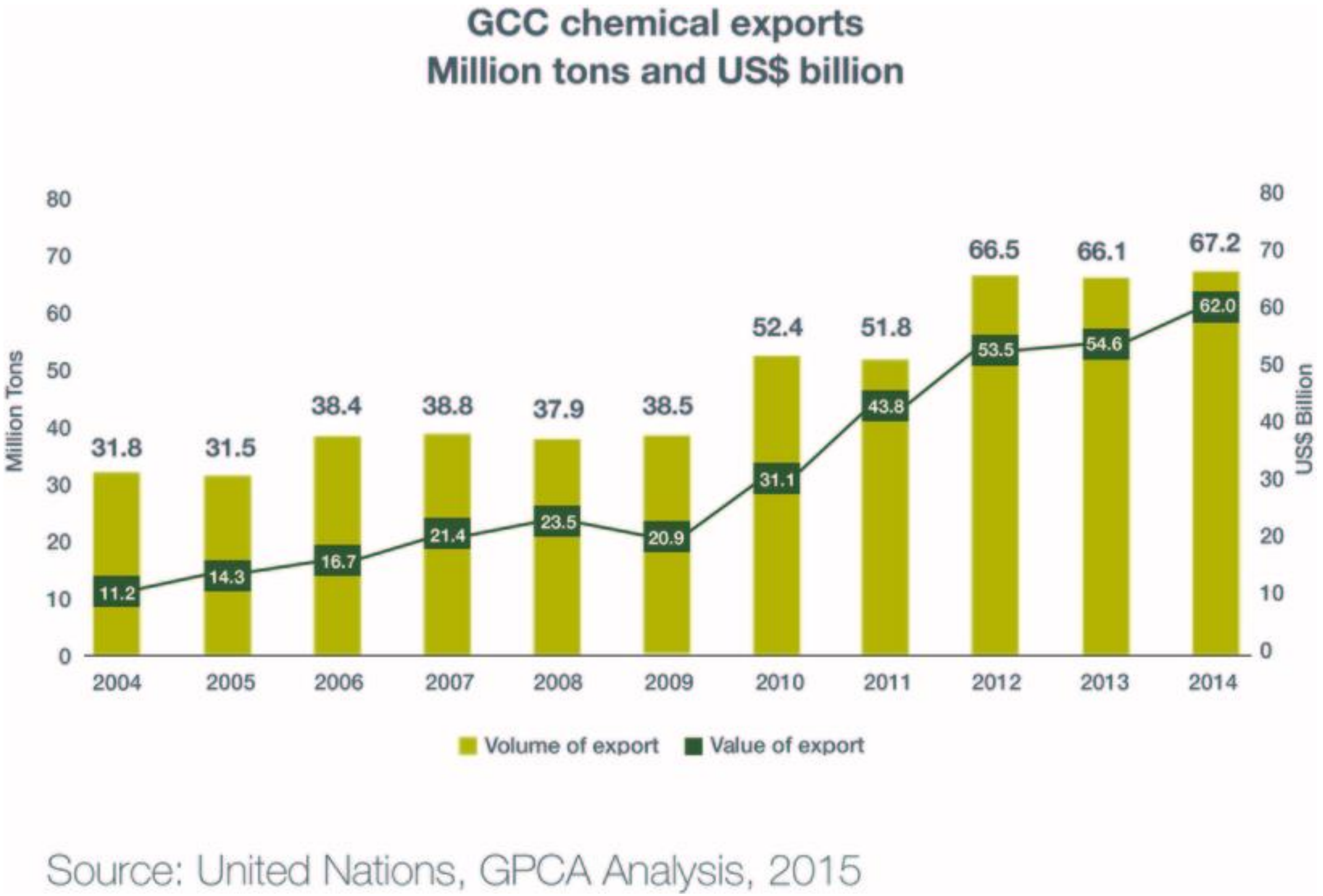
Growth

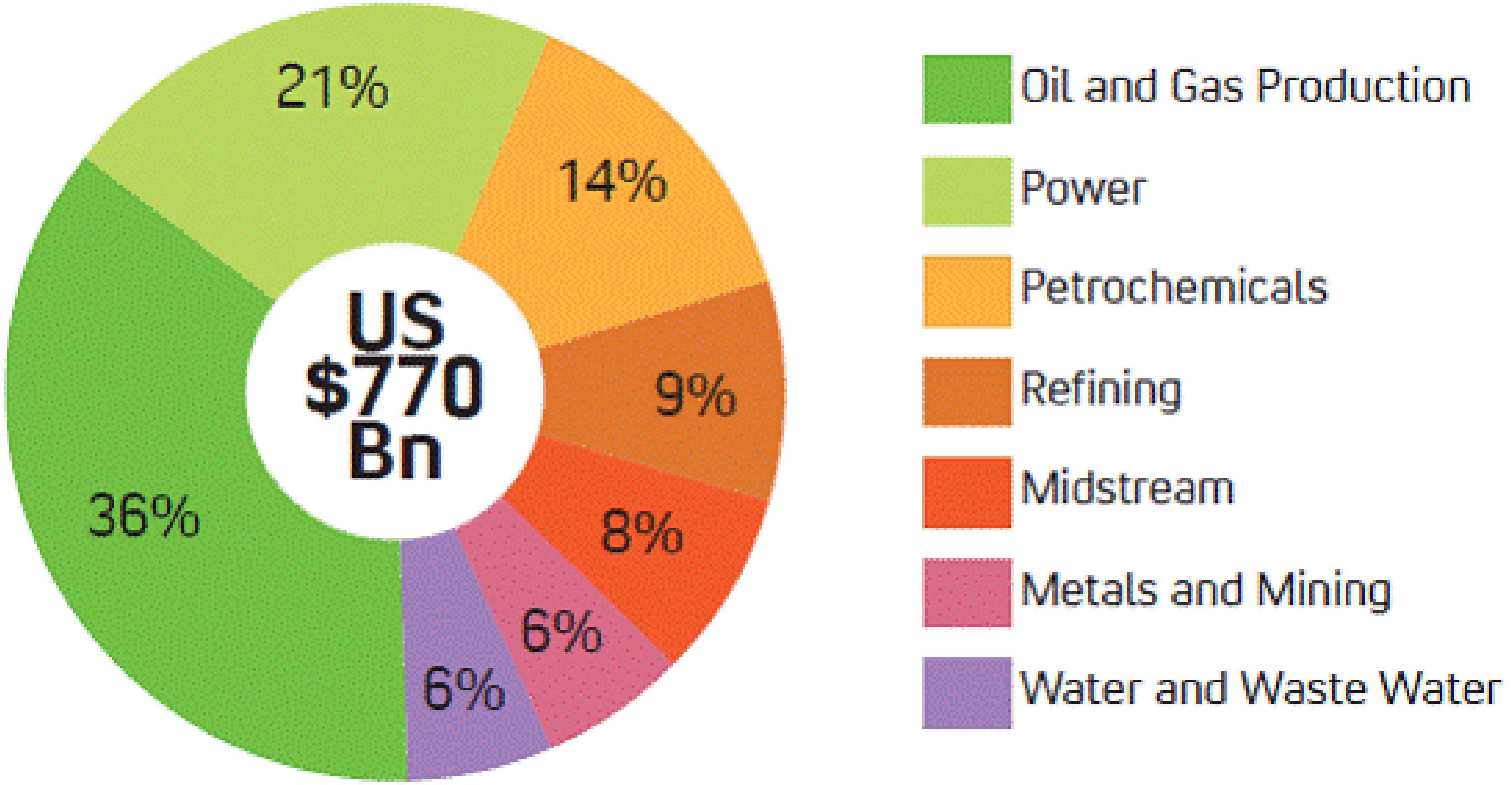
Petrochemical Industry

- The petrochemical industry produces various kinds of chemical products such as polymers, fibres or rubber, from such raw materials as petroleum, LPG, natural gas and other hydrocarbons through many different production processes.

Petrochemical Industry Growth

- The global petrochemical industry has experienced more than 15 years of strong volume growth:
  - Annual ethylene production has risen from around 100 million metric tons in 2000 to almost 150 million metric tons in 2016.
  - In conjunction with this volume growth, value creation has also risen at a 4% compound annual growth rate since 2005.


GCC chemical exports
Million tons and US$ billion
80
70
60
50
40
30
20
10
0
Million Tons
US$ Billion
31.8
31.5
38.4
38.8
37.9
38.5
52.4
51.8
66.5
66.1
67.2
11.2
14.3
16.7
21.4
23.5
20.9
31.1
43.8
53.5
54.6
62.0
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
Volume of export
Value of export
Source: United Nations, GPCA Analysis, 2015



SOURCE: MEED PROJECTS, ZAWYA, FROST & SULLIVAN

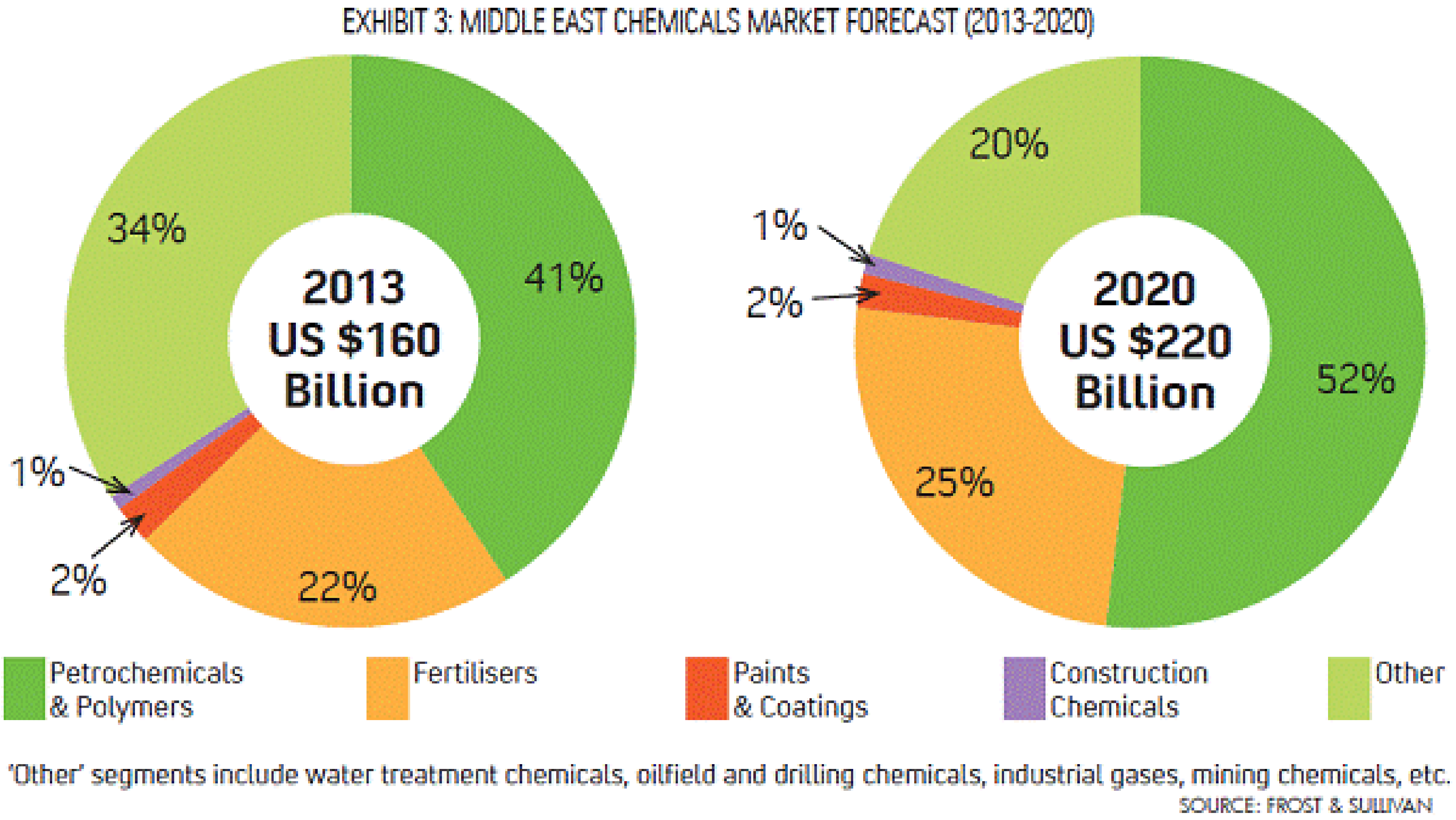


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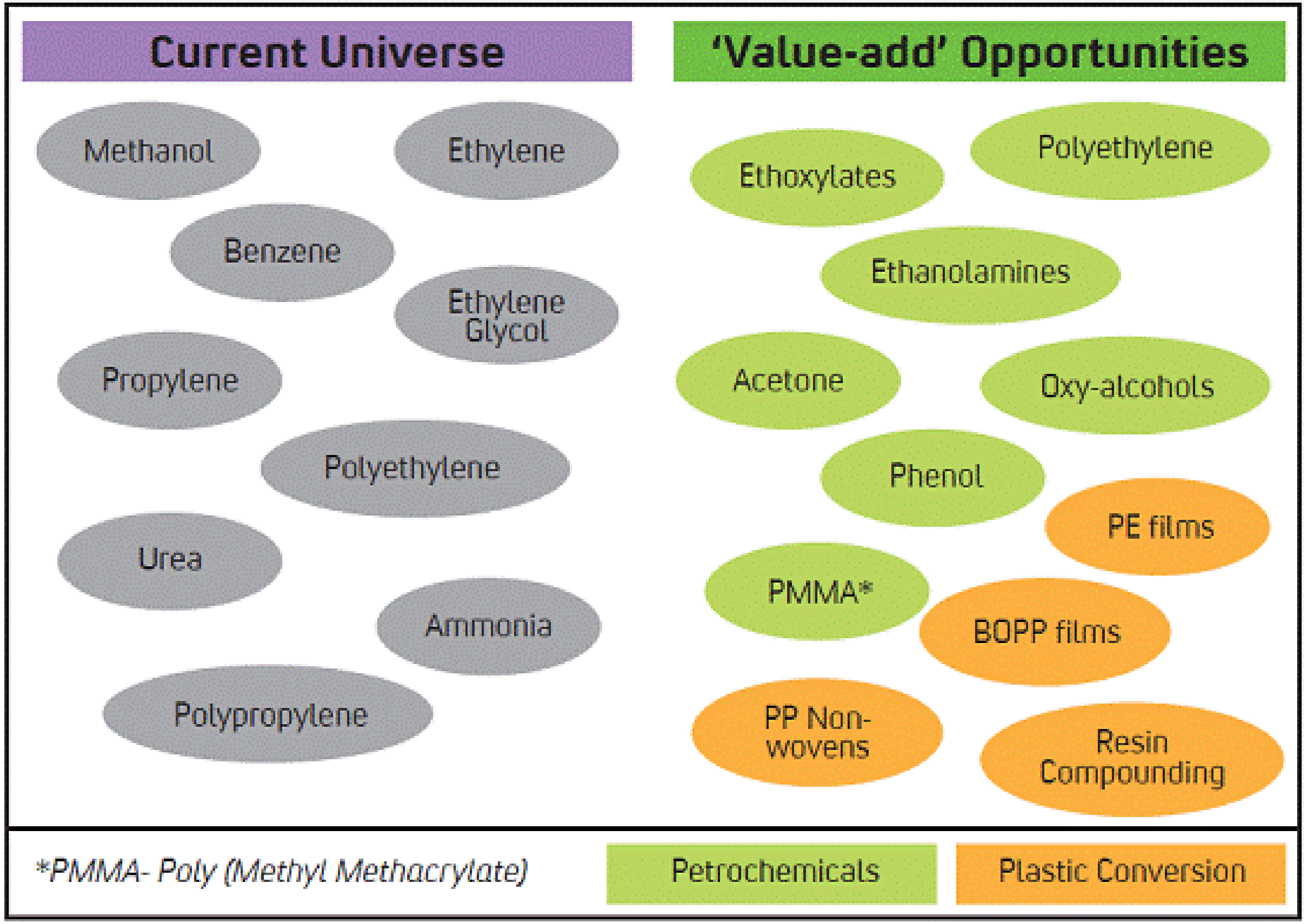
EXHIBIT 4: FUTURE OPPORTUNITIES FOR VALUE-ADDED PRODUCTS



SOURCE: FROST & SULLIVAN

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Incidents, Accidents & Losses

ARCO Channelview

- Wastewater tank was taken out of service so the nitrogen compressor could be fixed.
- While maintenance was being performed, the normal flow of nitrogen purge gas to the tank was at a minimum.
- A temporary oxygen analyser was installed between two roof beams in the tank in order to detect if high oxygen levels were present and if a nitrogen purge was needed.

The Cause

- Within the tank, the peroxides decomposed creating dangerous levels of oxygen.
- These high levels were not detected due to the fact the air in the headspace was stagnant and the oxygen buildup was in a dead zone so it was not being detected by the analyser.
- Intermittent nitrogen purging was insufficient to prevent the formation of this high oxygen level atmosphere in the headspace and piping to the compressor.

The Loss

- On July 5, 1990 once the maintenance was completed, there was a failed attempt to restart the compressor, which drew flammable vapours in the suction line of the compressor.
- Once the compressor was successfully restarted, the vapours were ignited and flashed back to the tank, causing an explosion.
- 17 were killed due to the explosion, while there was around $100 million dollars worth of damages to the plant

Steps of an Investigation

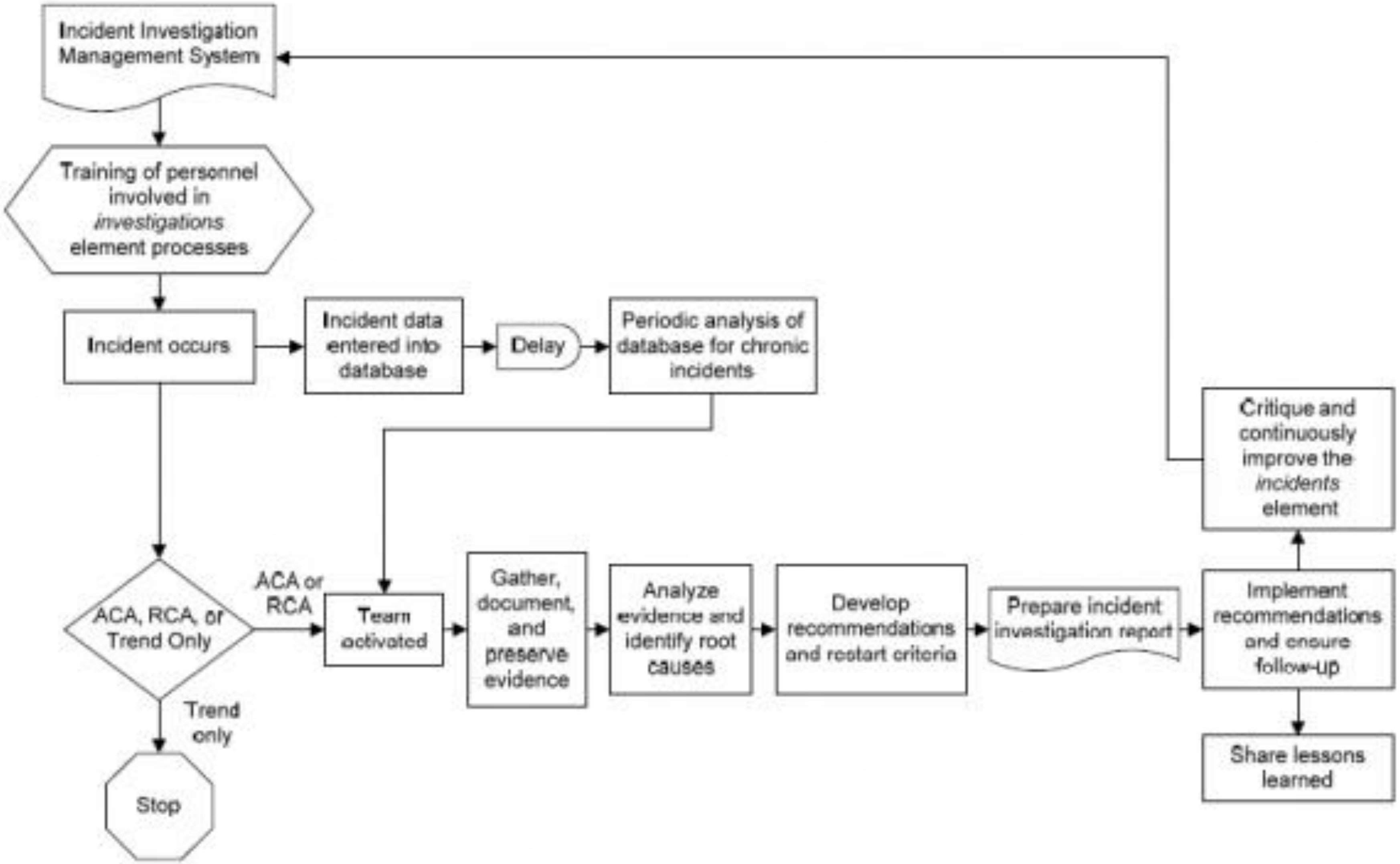


FIGURE 19.1. Incident Investigation Flowchart

Hazardous Material

Hazardous Material

- Some factors which must be considered are:
  - The reasons spills may occur
    - pump or piping failure.
  - The physical properties of the material
  - The operating conditions of the process,
    - Temperature and pressure.
  - The reactivity of process materials.
  - Construction of the building.
  - The passive protection features in the affected area such as:
    - Fireproofing of structural steel and vessel supports.
    - Drainage and diking in the area.
  - Spacing between units or provision of blast-resistant walls.

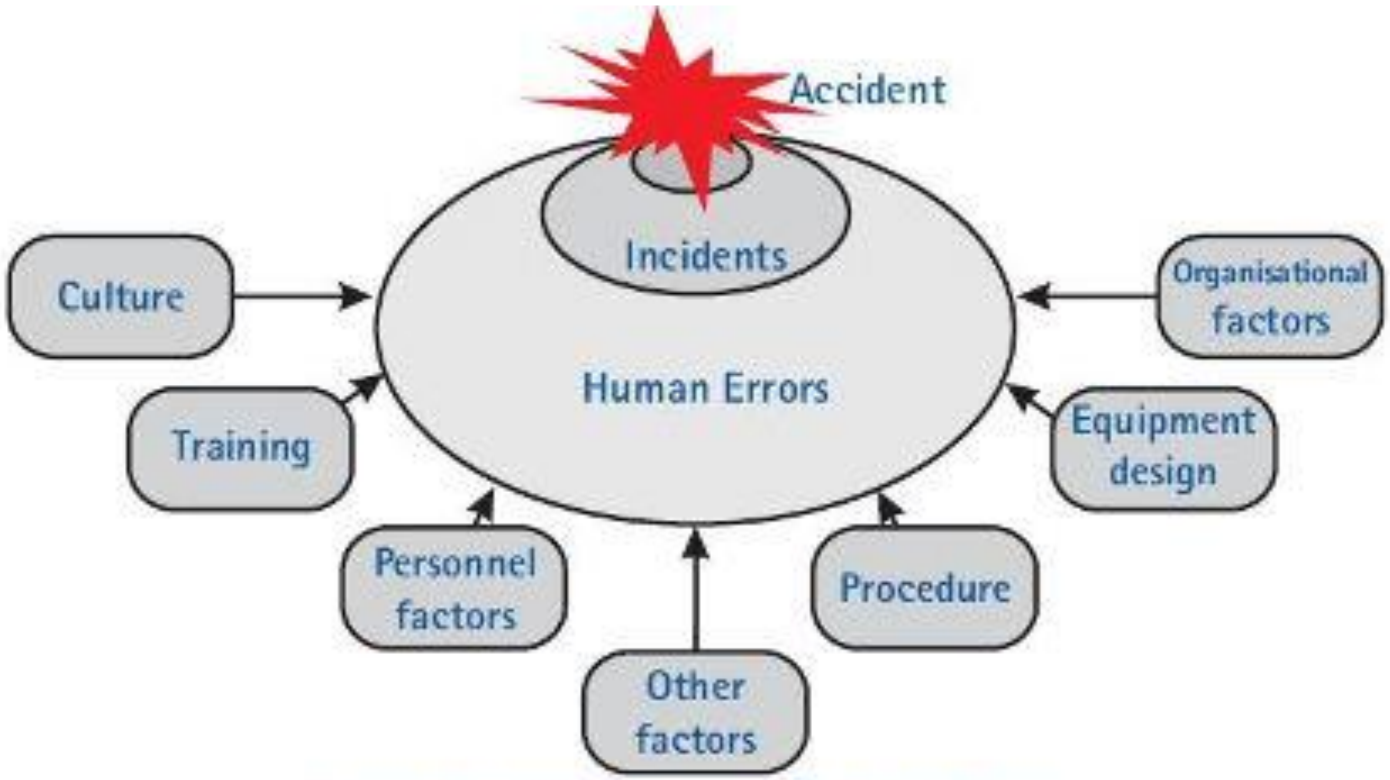
Operators

Operators

- Consider operator as fallible human performing tasks in background

- Design for error tolerance, not just prevention
  - detection
  - correction

Buncefield, UK



Contributing factors to human error

Human behaviour aspects

- People and organizations, don’t intend to have accidents
- Accidents happen because of human behavior, both at the individual and organizational level

Mechanical Integrity Failure

Mechanical Integrity Failure

- Failure of the primary pressure-containing envelope due to a specified failure mechanism.
- This largely relates to corrosion through metal although also includes any bolted joint or seal failures.
- This excludes failures induced by operation outside of safe operating limits.

Figure 2: Mechanical Integrity Failure breakdown

The 100 Largest Losses 1974-2013: Large property damage losses in the Hydrocarbon Industry 23rd Edition, Marsh & McLennan Companies

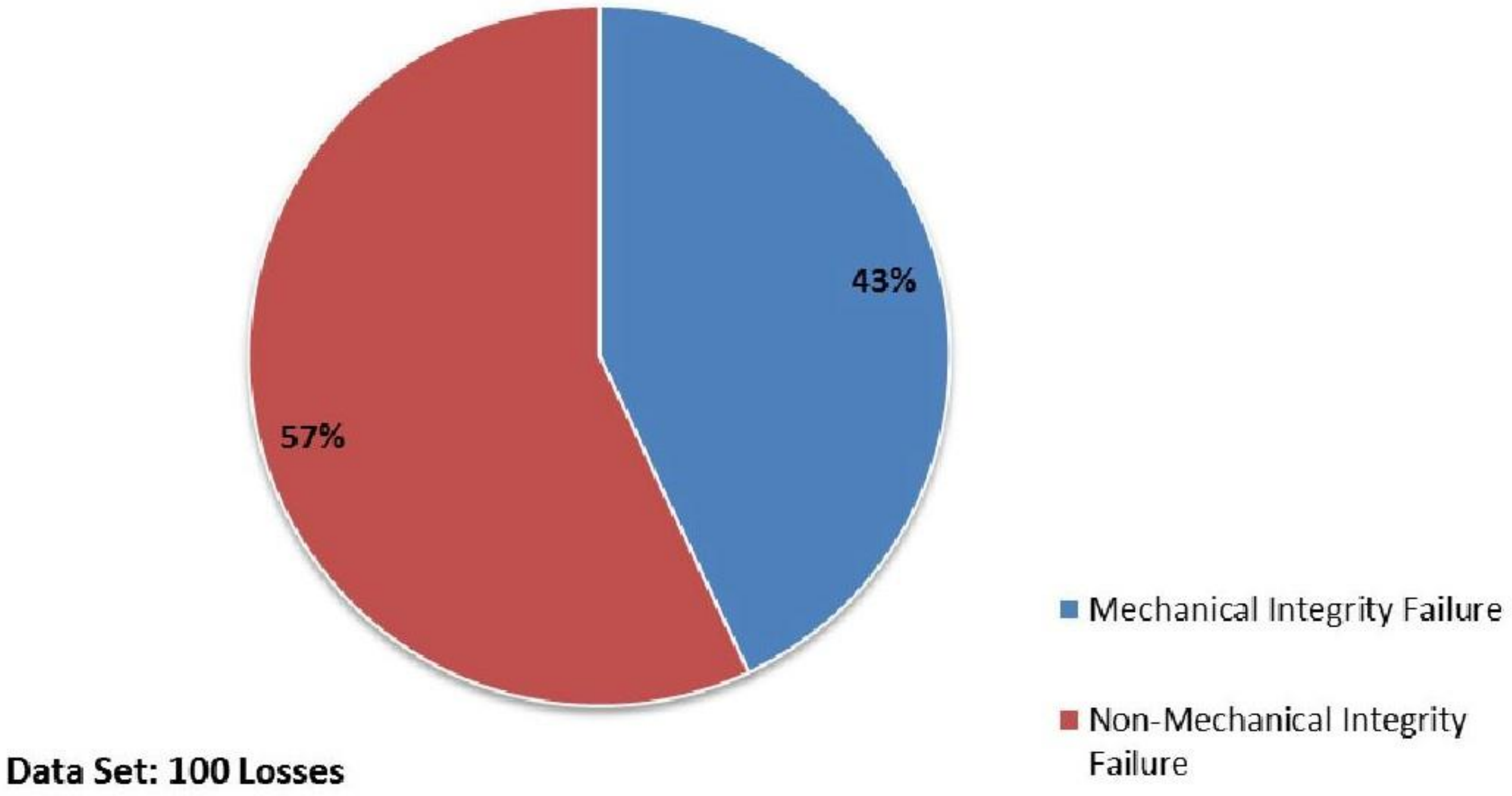
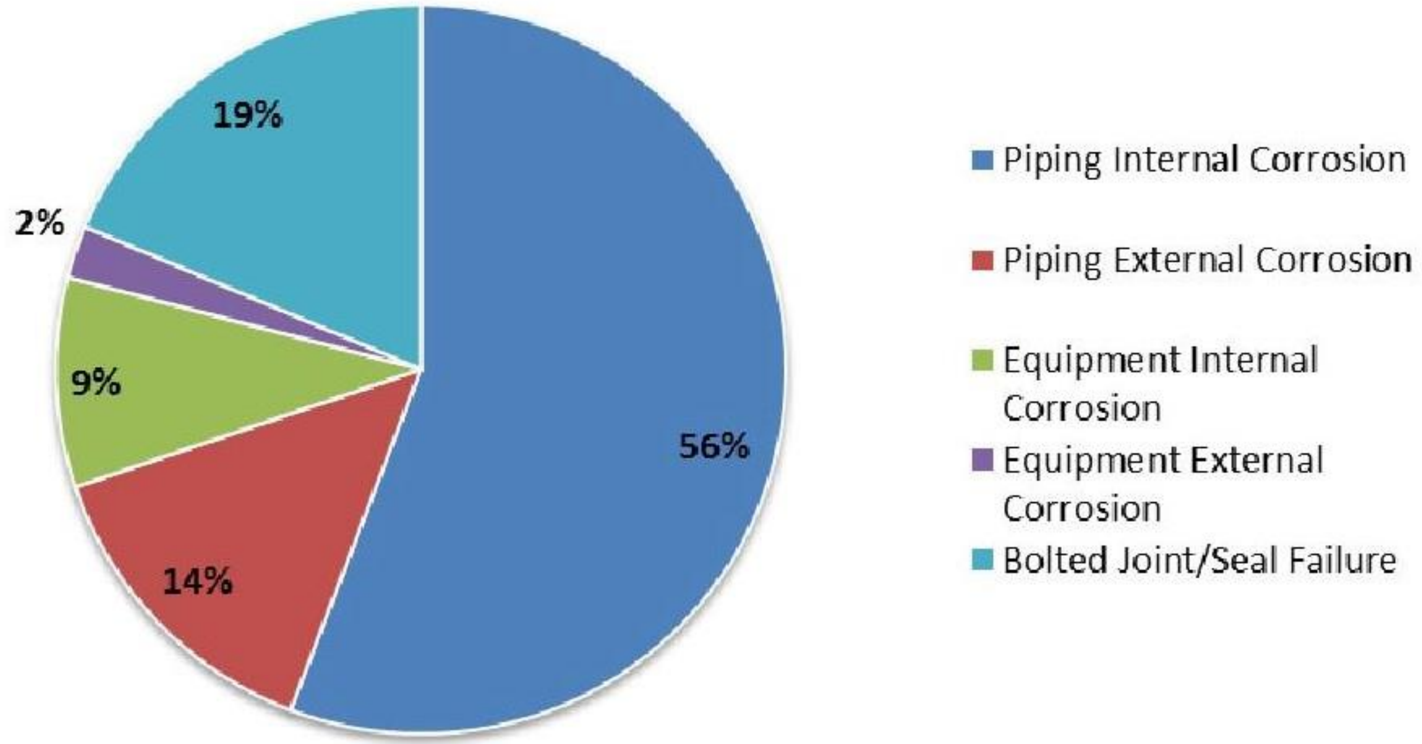


Figure 3: Types of Mechanical Integrity Failure

The 100 Largest Losses 1974-2013: Large property damage losses in the Hydrocarbon Industry 23rd Edition, Marsh & McLennan Companies



Data Set: 43 'Mechanical Integrity Failure' Losses

Figure 5: Operating Mode – Mechanical Integrity Failure losses

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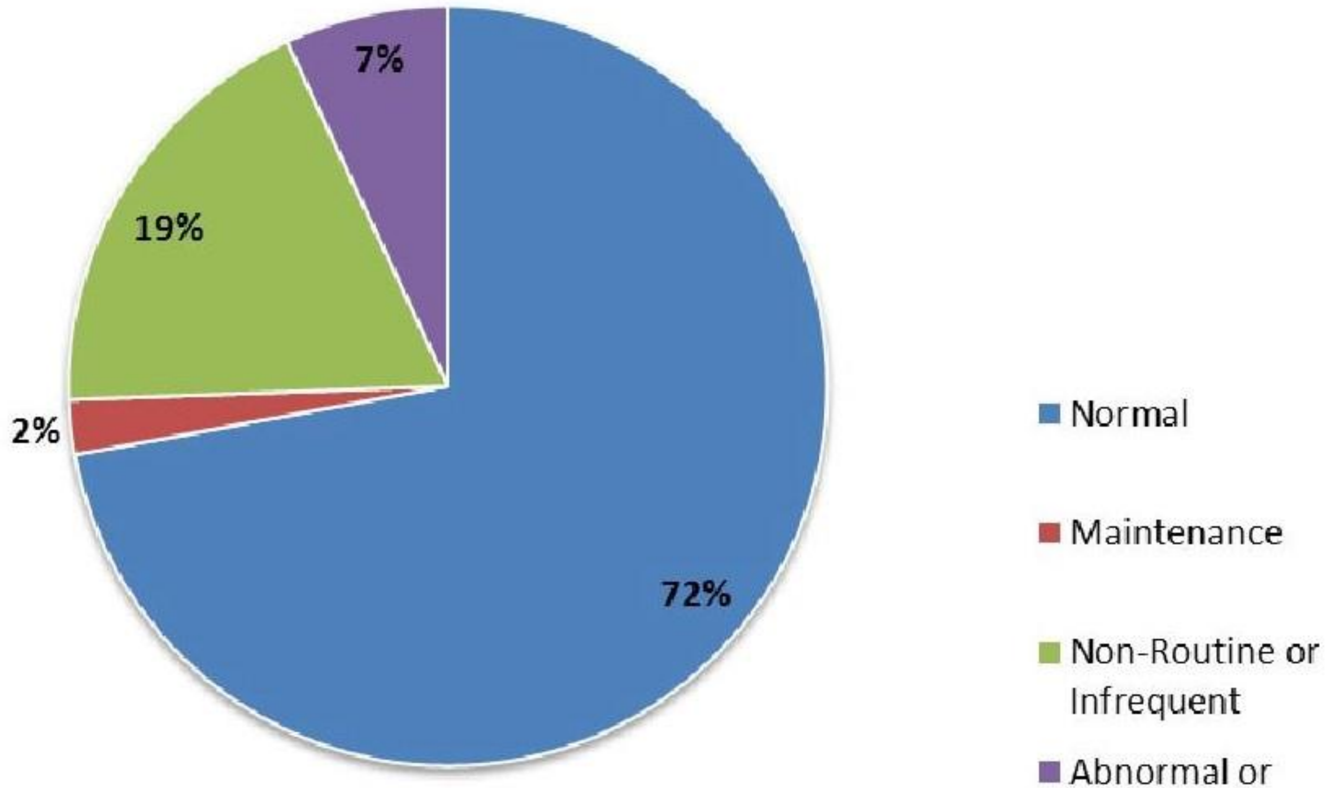


Data Set: 43 'Mechanical Integrity Failure' Losses

Types of Mechanical Integrity Failures

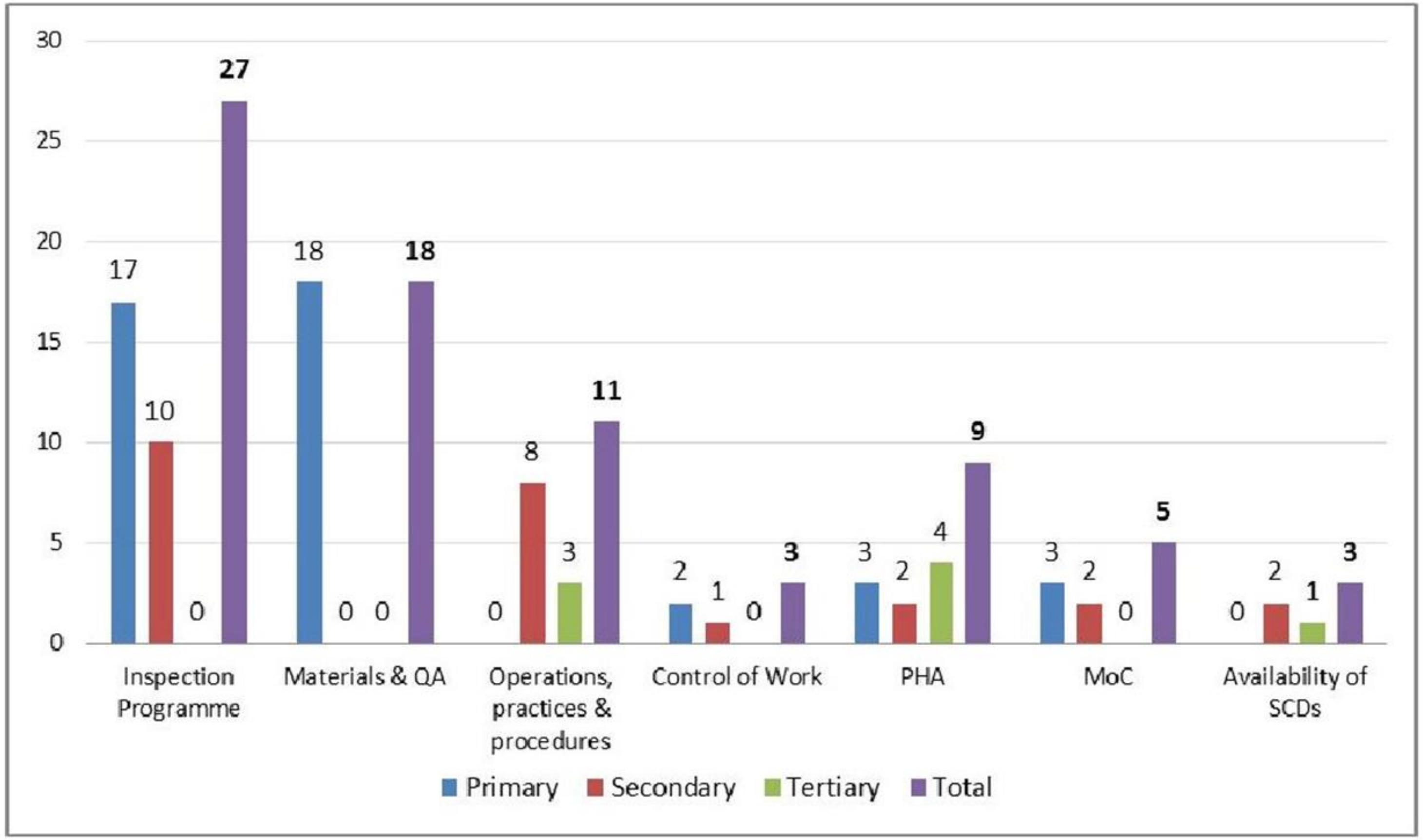
- The types of 'Mechanical Integrity Failure' were classified as follows:
    - Piping internal corrosion
    - Piping external corrosion
    - Equipment internal corrosion
    - Equipment external corrosion
    - Bolted joint/seal failure
- Corrosion is considered to include all damage mechanisms that lead to mechanical integrity failures of equipment and piping

Management System Failures

Management System Failure Model

- Major losses are considered to occur because of simultaneous failures of loss prevention or mitigation barriers, in line with the 'Swiss Cheese’ accident model
- Rather than attempt to analyse all of the barrier failures associated with each particular loss analysed, those loss prevention barrier failures perceived to have made the most significant contribution to the loss, were identified.

Figure 7: MSF breakdown for Mechanical Integrity Failure losses



The 100 Largest Losses 1974-2013: Large property damage losses in the Hydrocarbon Industry 23rd Edition, Marsh & McLennan Companies

Management Safety Failures

- In general, when the plant is running in normal or steady state conditions, losses due to Operations Practices & Procedures MSF are unusual. Losses tend to occur during infrequent activities or unsteady state conditions.

Inspection Programme

- Intended to cover all aspects of a static equipment and piping inspection programme including identification and risk assessment of damage mechanisms.

Materials of Construction & QA

- Intended to cover deficiencies in mechanical design, fabrication and installation of equipment during original construction or subsequent change e.g. during maintenance.
- The following are examples:
  - incorrect materials installed,
  - installation not as per design specification,
  - fabrication defect,
  - mechanical installation fault.

Operations Practices & Procedures

- Cover all aspects of operational management.
- Examples include:
  - manning,
  - shift communications,
  - supervision,
  - training,
  - competence assurance,
  - Standard Operating Procedures (SOPs),
  - Emergency Operating Procedures (EOPs),
  - response to alarms etc.

Control of Work

- Any work activity which would ordinarily require a Permit to Work (PtW) and/or safe isolation procedure.
- The scope includes hazard identification and risk assessment, process preparation, work execution and return to operation.
- The work activity could be undertaken
  - by maintenance or contractors during operational or shutdown periods (e.g. turnaround and grade change), or
  - by operations (e.g. operators switching equipment using operational blinds).

Process Hazard Analysis

- Covers items which should be addressed through the plant's PHA programme including:
  - process design weaknesses,
  - inherent safety and
  - learning from losses.

Management of Change

- This is applied whenever a failure in change management contributed to the loss
- Change defined in the broadest sense including 'non-hardware-related' changes such as organisational and operational change.
- The change could have occurred during the original construction, subsequent projects or operational plant changes.

Availability of Safety Critical devices

- This is applied whenever a SCD is unavailable or fails on demand during a loss scenario.
- The failure could be due to a lack of maintenance or the equipment had been consciously defeated (or bypassed).

Process Safety Management

Process Safety Management Systems

- Process safety management (PSM) is a system for managing the use of highly hazardous chemicals during plant processes and activities to prevent risk for accidental releases.

Process and Equipment Integrity

- Equipment is typically designed to handle ideal or typical conditions.
  - Can it handle ALL foreseen conditions?
  - Can all conditions be foreseen?
- What is designed is different than what was constructed and installed?
  - Conditions on the ground can mandate changes to design?
  - Installed may be different than designed?
- Has the design been validated by rigorous testing?
- Make sure it stays that way
  - Preventative maintenance
  - Ongoing maintenance
  - Review
- ***Be especially careful of automatic safeguards***

Questions

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Thank you for your attention