An Analysis of Common Causes of Major Losses in the Onshore Oil, Gas & Petrochemical Industries

Implications for Risk Engineering Surveys

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Background

- Study carried out of major losses in the onshore oil, gas & petrochemical industries
- Aim was to determine common causes of loss in a way that will be of practical use to insurance risk engineers
- Supports previously released Lloyd's Market Association (LMA) risk engineering guidance documents
  - Guidelines for the conduct of risk engineering surveys (OG&P GRES 2015/001)
  - Key information guidelines for risk engineering survey reports (OG&P IGRES 2015/001)

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Loss Criteria

- Willis Energy Loss Database (WELD) used to develop a list of candidate losses over a 20 year period from 1996 to 2015
- 'Man-made' fire & explosion losses only (natural catastrophe losses not included)
- Major loss classified as a total loss greater than USD 50 million per WELD
  - Total loss = 'ground up' property damage + business interruption net of waiting period and only where cover provided
- 100 losses were identified and analysed from the WELD
  - Including all of the top 50 losses by total loss value

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Loss Information

- Primarily from insurance industry reports as well as public domain sources
- Losses only included where sufficient information available to determine causation to the level required by the analysis methodology
- All losses anonymised within the full report

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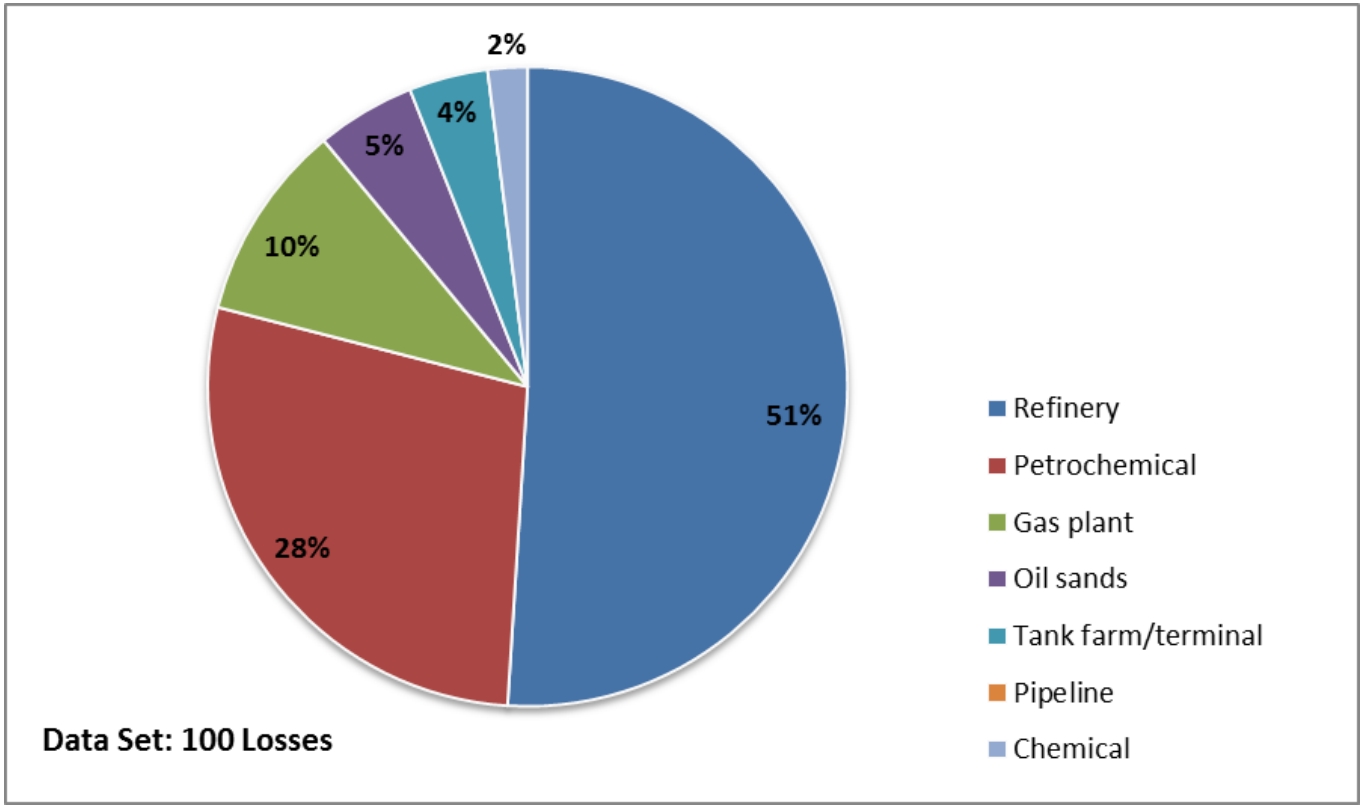
Occupancy Breakdown

Figure 1: Occupancy breakdown



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Mechanical Integrity Failure

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Mechanical Integrity Failure

- Firstly, ‘Mechanical Integrity Failure’ losses were identified

> *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.*

- All other losses simply classed as ‘Non-Mechanical Integrity Failure’
- Secondly, all ‘Mechanical Integrity Failure’ losses then classified
  - Piping internal corrosion
  - Piping external corrosion
  - Equipment internal corrosion
  - Equipment external corrosion
  - Bolted joint/seal failure

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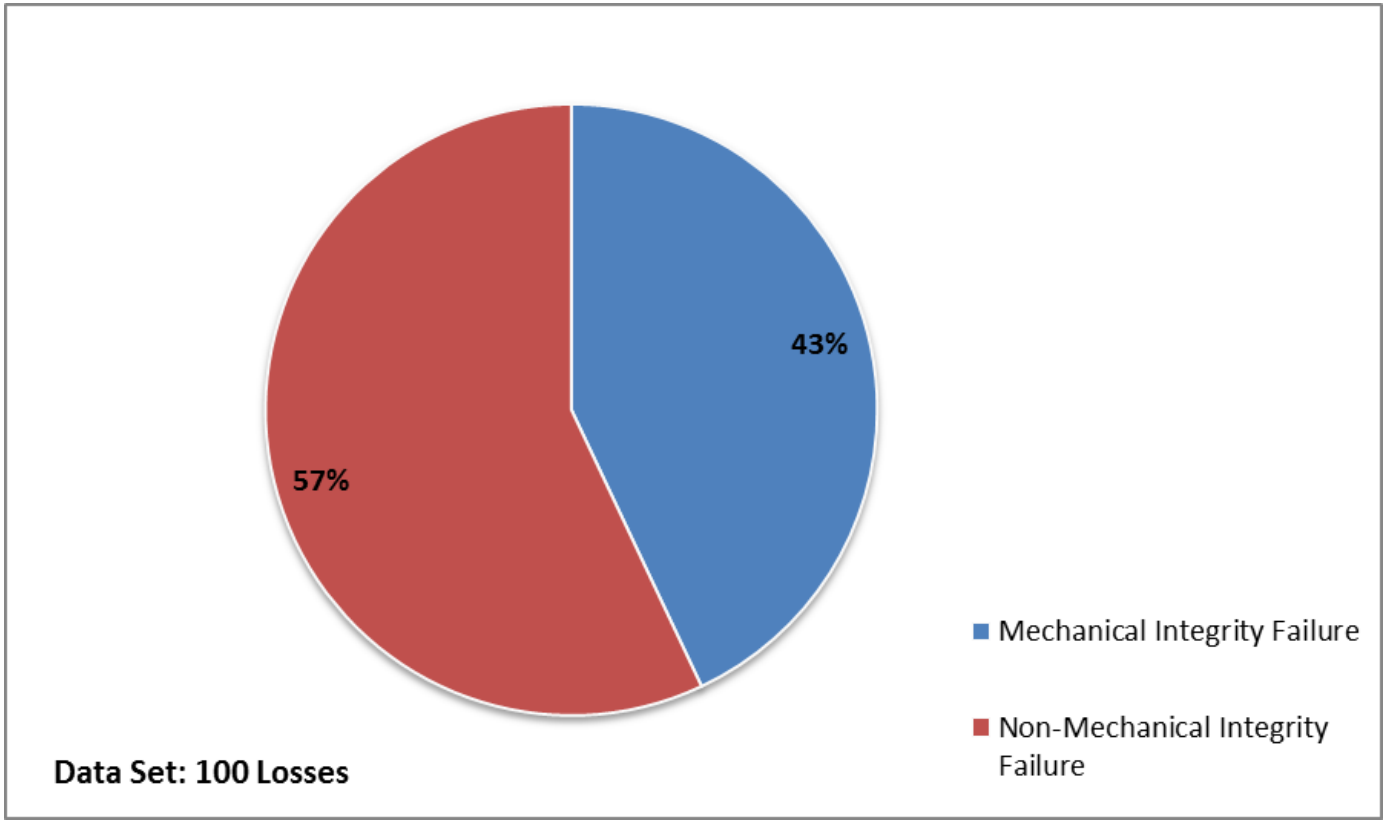
Mechanical Integrity Failure

Figure 2: Mechanical Integrity Failure breakdown



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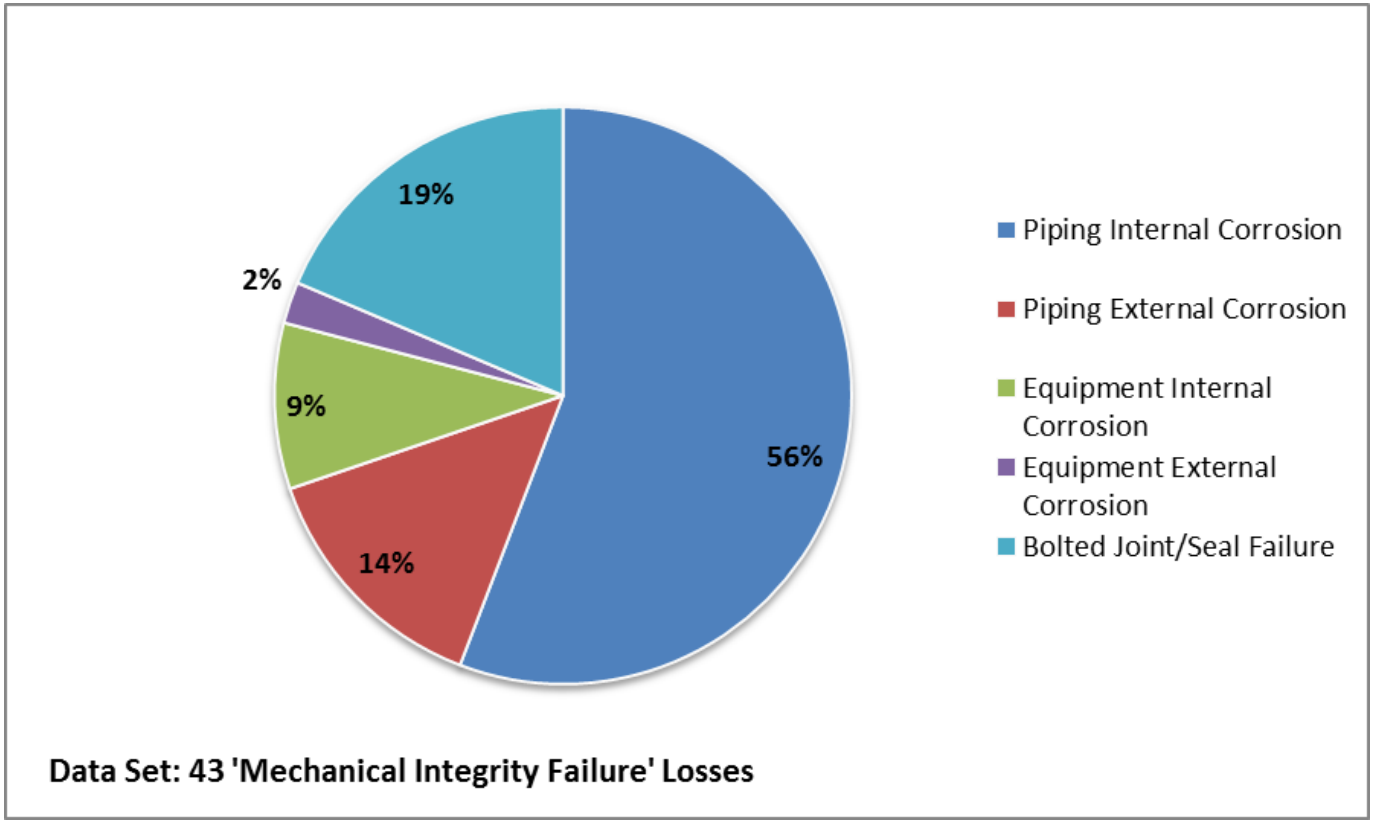
Mechanical Integrity Failure

Figure 3: Types of Mechanical Integrity Failure



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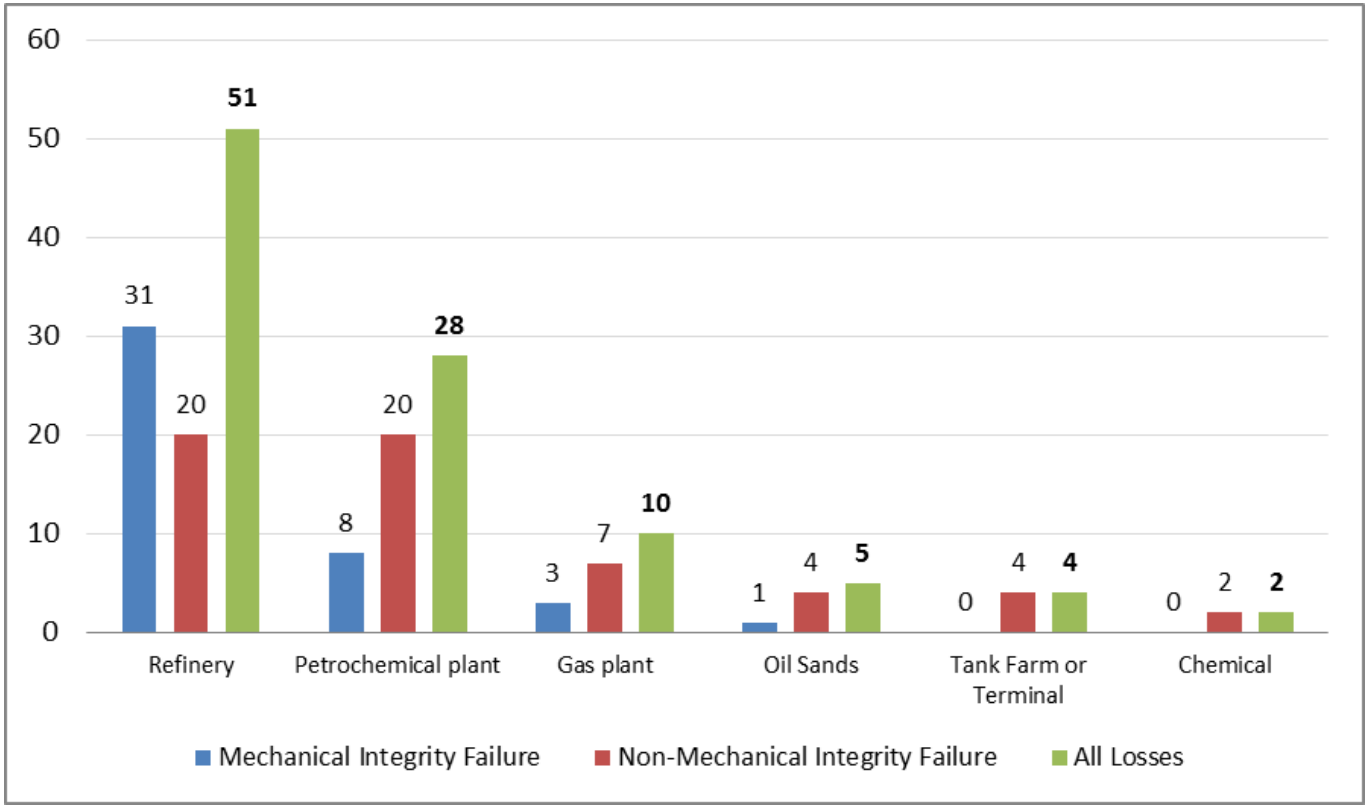
Mechanical Integrity Failure

Figure 4: Occupancy breakdown by number and type of loss



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Operating Mode

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Operating Mode

Operating Mode	Description
Normal	Plant operating under steady state conditions.
Maintenance	A specific maintenance activity ongoing with direct relevance to the loss.
Non-Routine or Infrequent	Start-up, planned shutdown, batch operations, equipment switching etc.
Abnormal or Unplanned	Abnormal is non-steady state or upset conditions through to operation outside safe operating limits. Unplanned operations typically emergency shutdown due to an unplanned initiating event.

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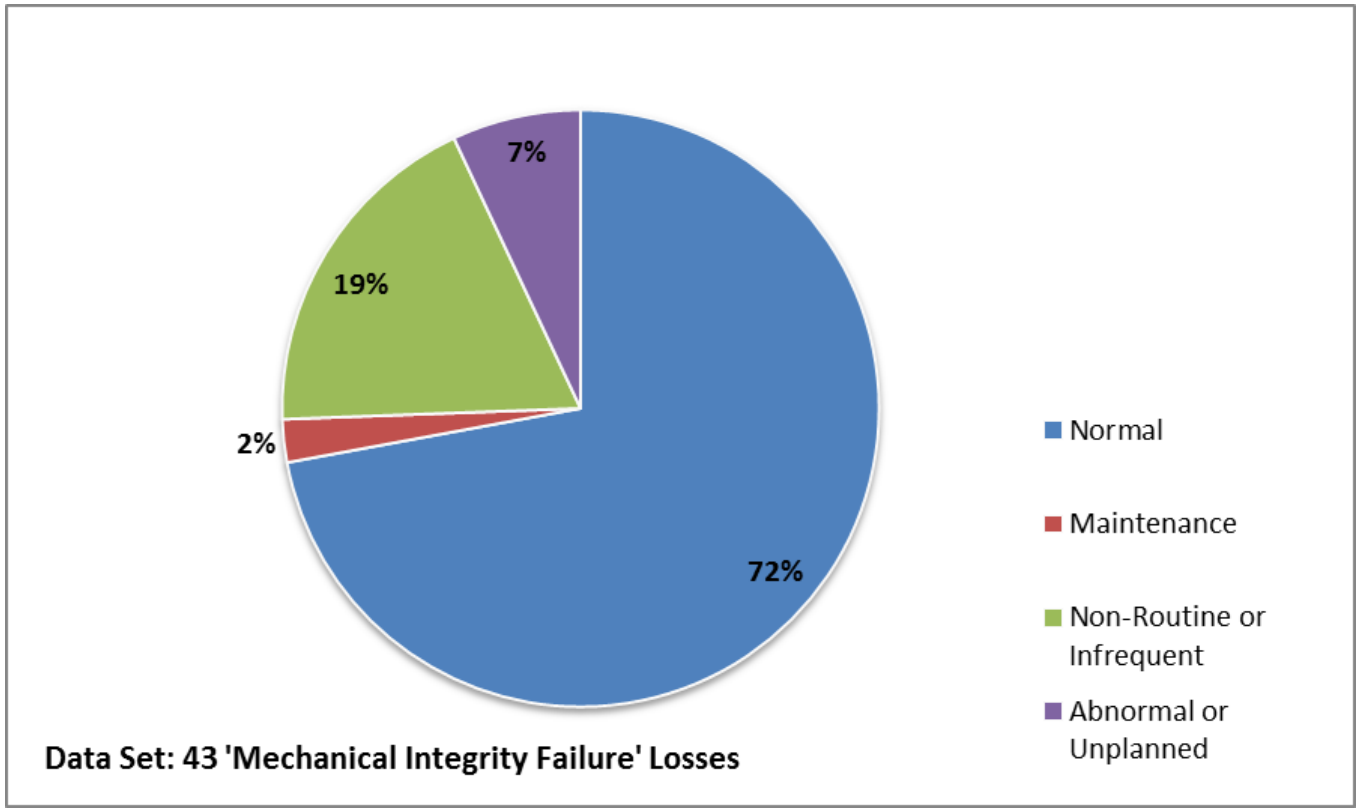
Operating Mode

Figure 5: Operating Mode – Mechanical Integrity Failure losses



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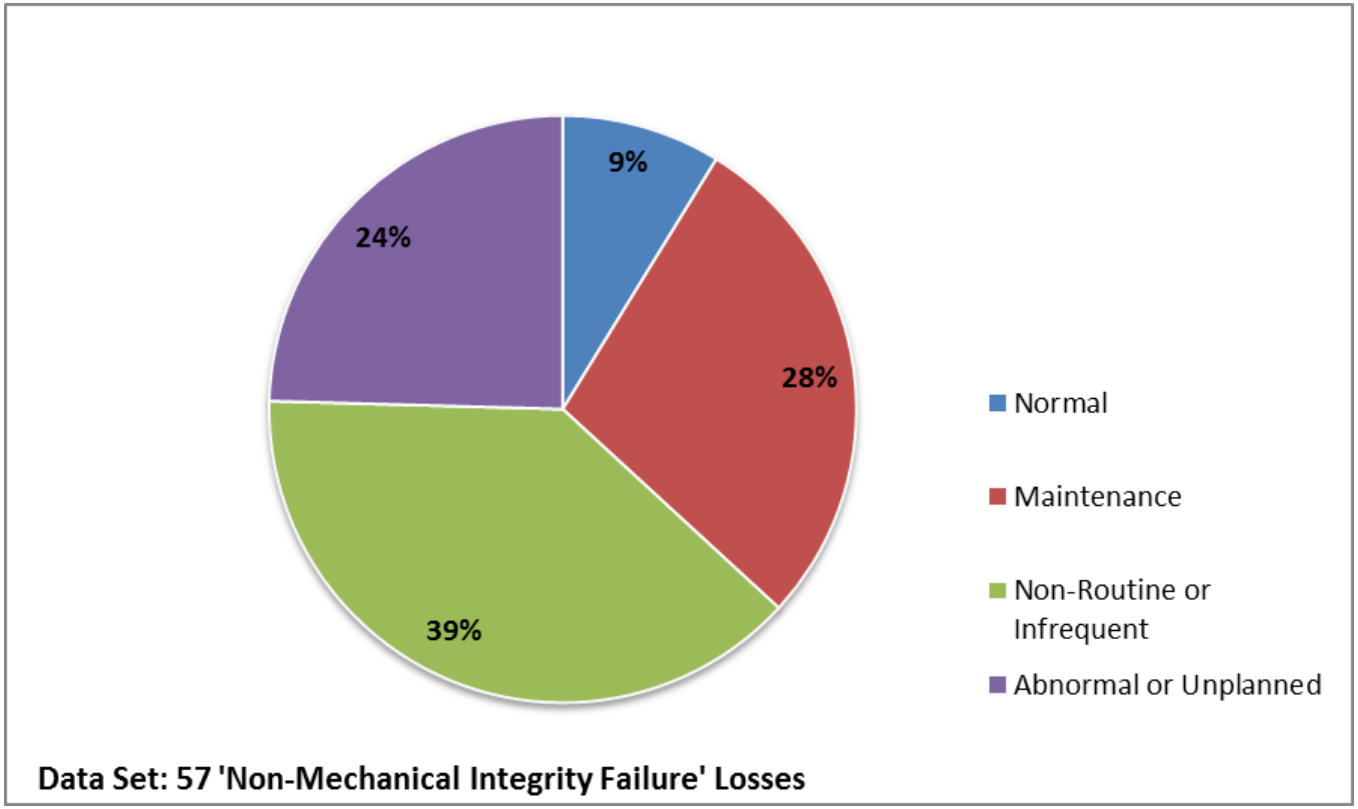
Operating Mode

Figure 6: Operating Mode – Non-Mechanical Integrity Failure losses



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Operating Mode

Non-Routine or Infrequent Activities		Unplanned Events		Abnormal Situations	
Start-up	19	Power failure	4	Blockage	4
Equipment switching	9	Equipment trip	2	SOL excursion	2
Shutdown (planned)	0	Steam failure	1	Other	3
Other	2	Cooling water failure	1		
		Other	0		

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Management System Failure

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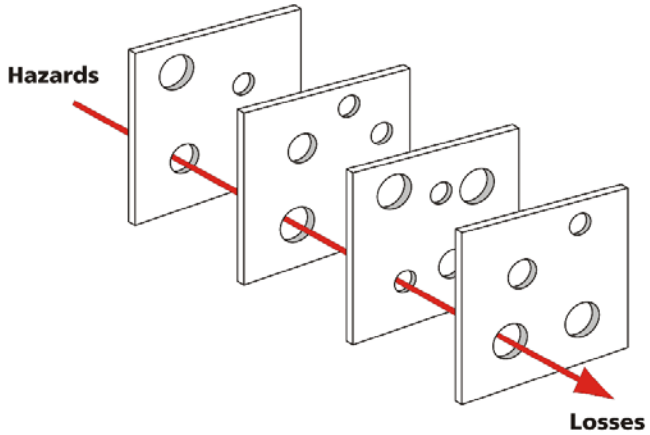
Management System Failure

- Management System Failure (MSF) model developed based upon the *loss prevention barrier principal*



- **Up to 3** MSFs assigned to each loss in order of perceived contribution to the loss; Primary, Secondary and Tertiary

- No attempt made to identify underlying or root causes

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Management System Failure

- Seven MSFs developed and defined:
  - Inspection Programme
  - Materials of Construction & Quality Assurance (QA)
  - Operations Practices & Procedures
  - Control of Work (CoW)
  - Process Hazard Analysis (PHA)
  - Management of Change (MoC)
  - Availability of Safety Critical Devices (SCDs)

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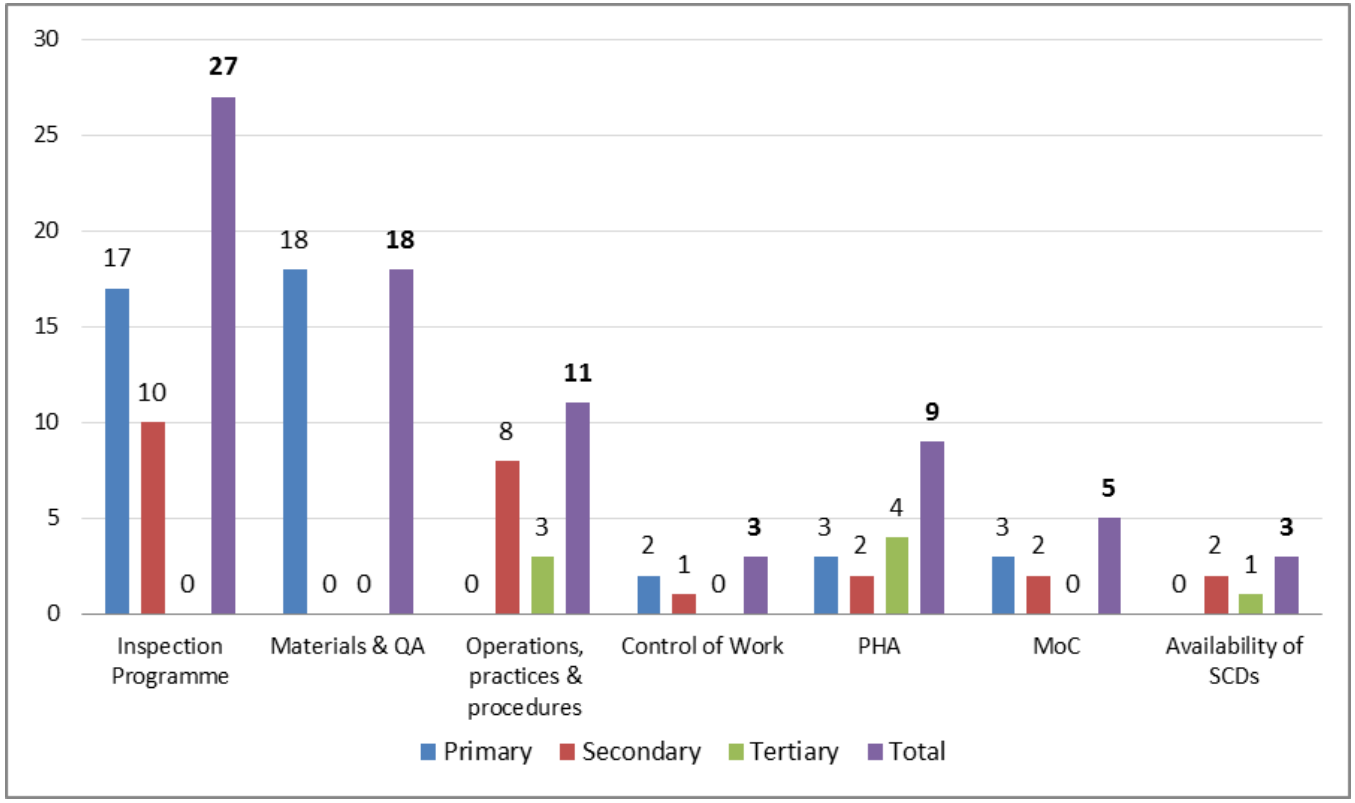
Management System Failure

Figure 7: MSF breakdown for Mechanical Integrity Failure losses



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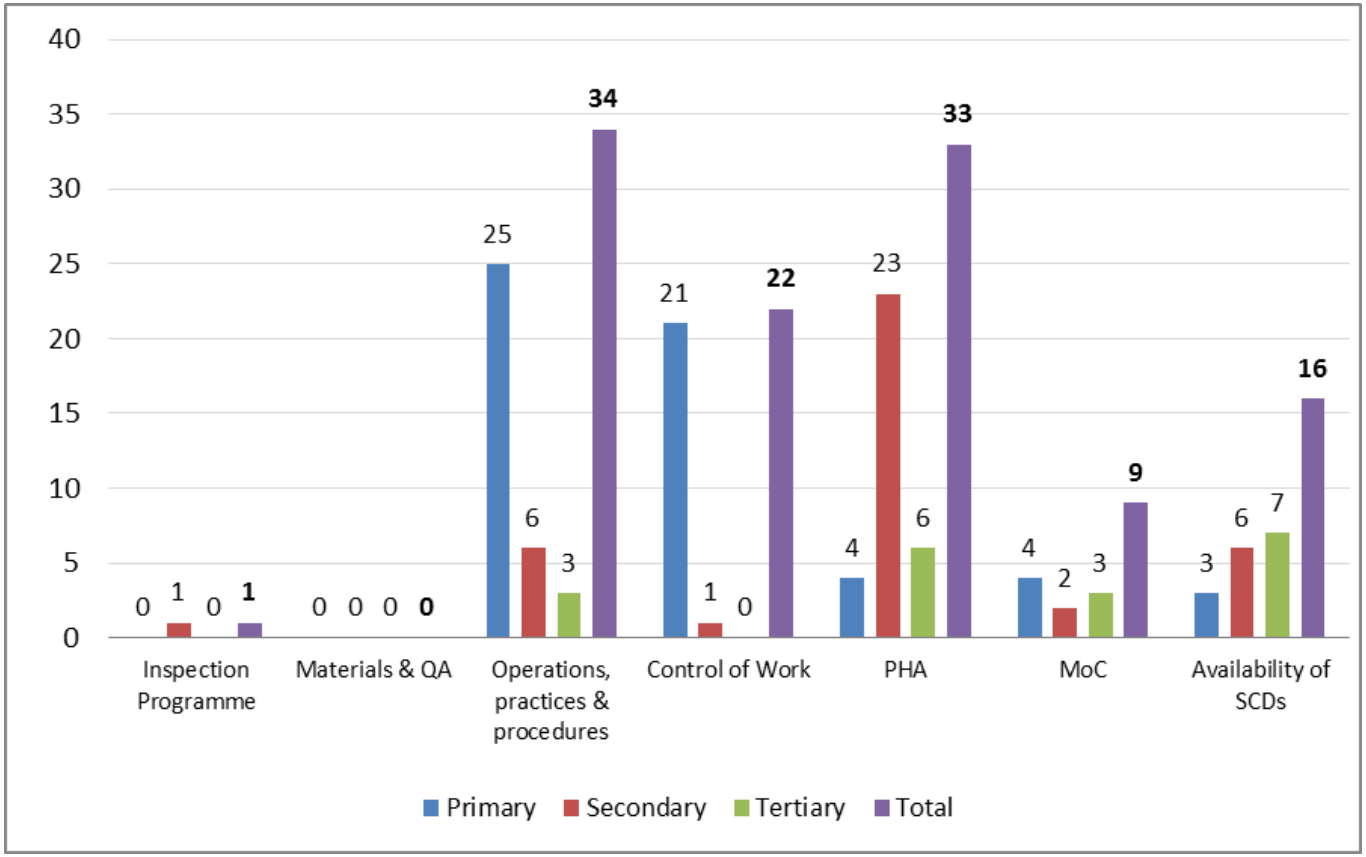
Management System Failure

Figure 8: MSF breakdown for Non-Mechanical Integrity Failure losses



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Management System Failure

Based upon the **total number** of Primary, Secondary and Tertiary MSFs the relative importance is as follows:

1. Inspection and Materials & QA (combined mechanical integrity related MSFs)
2. Operations Practices & Procedures
3. Process Hazard Analysis (PHA)
4. Control of Work (CoW)
5. Availability of SCDs
6. Management of Change (MoC)

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Inspection Programme MSF

- Contributed to over 60% of Mechanical Integrity Failure losses
- Piping failures – primarily due to internal corrosion with some external Corrosion Under Insulation (CUI)
- Identification of damage mechanisms and Integrity Operating Windows (IOWs)
- Accessibility for inspection
- Bolting practices
- Independent technical review of the Inspection function

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Materials & QA MSF

- Contributed to over 40% of Mechanical Integrity Failure losses
- Various types of failure often related to original construction:
  - Incorrect materials installed (x8)
  - Weld defect or material out of specification (x7)
  - Valve component failure (x3)
- In some cases, Inspection *could* have identified the latent defects
- Effective QA/QC for construction and maintenance including Positive Material Identification (PMI)
- Retrospective PMI where appropriate for existing plant

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Operations Practices & Procedures MSF

- Contributed to nearly half of all losses
- Heavily influenced by plant operating mode
- Non-Routine or Infrequent activities
  - Startup – Standard Operating Procedures (SOPs)
  - Equipment switching - SOPs
- Abnormal or Unplanned events
  - Blockages – hazard awareness/risk assessment
  - Unplanned events – Emergency Operating Procedures (EOPs)
  - Loss of containment – leak response protocol/emergency shutdown

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Process Hazard Analysis MSF

- Contributed to nearly 60% of Non-Mechanical Integrity Failure losses
- Failure to identify hazards and/or provide suitable safeguarding controls
- Consideration of all operating modes during HAZOP reviews
- Identification and review of Safety Critical Tasks (SCTs)
  - Procedural HAZOPs, SCT analysis etc.
- Quality of PHAs?
  - Quality assurance process

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Control of Work MSF

- Contributed to nearly 40% of Primary MSFs of Non-Mechanical Integrity Failure losses
- Safe isolation of equipment for maintenance
  - Use of remotely actuated valves within an isolation scheme
  - Use of operator controlled line blinds
- Permit to work
  - Hot work near combustibles
  - Handback procedures – verification of work quality
- Safe work practices

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Availability of SCDs MSF

- Contributed to nearly 20% of all losses
- Failure to identify and designate SCDs a precursor to failing to manage SCDs
- Maintenance-related (68%)
  - Development and implementation of SCD Inspection, Testing & Preventive Maintenance (ITPM) programmes
- Operational-related (32%)
  - Bypass control (particularly when bypass required as part of SOP)
- Identification of non-Safety Integrity Level (SIL) rated critical process instrumentation

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Management of Change MSF

- Contributed to less than 15% of all losses
- Adequacy of hazard identification and risk assessment
- Control of change during project development and construction
  - In particular change in materials
- Failure to apply the MoC procedure
- Largely ‘hardware related’ losses but some ‘non-hardware related’ losses
  - Catalyst change
  - Organisation change

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Emergency Isolation

- Additional consideration was the ability to isolate the loss of containment and thus limit the extent of property damage
- For 25% of the losses a delay in isolation resulted in some escalation of the event
- Remotely Operated Emergency Isolation Valves (ROEIVs) an important loss mitigation feature
- ROEIV design standard
  - Construction projects
  - Retrospective application to existing plants

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Closing Remarks

- Review recommended critical focus areas and apply during surveys
- Review survey approach and market report content in line with findings
- Existing LMA risk engineering guidance documents to be reviewed and updated where needed
- Learnings for industry
- Full report and presentation slides can be found on
  - Onshore Energy Business Panel (OEBP) section of the LMA website
  - LMA section of the Oil, Petrochemical & Energy Risks Association (OPERA) website

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Q&A

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