# Pitfalls and Challenges in Implementing Mechanical Integrity program

## *A case study*

Session 3 E – Asset Integrity Management, Aging Facilities & Facility Siting

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5TH CCPS GLOBAL SUMMIT ON PROCESS SAFETY

An AIChE Technology Alliance

CCPS Center for Chemical Process Safety

# Presentation Outline

- Todays talk focuses on three key aspects of a Mechanical Integrity (MI) management and sustainable implementation program
  i. Value obtained from implementing robust MI program – risk recognition and risk avoidance
  ii. What challenges and pitfalls exist in various industries for MI
  iii. How to overcome the challenges – actual examples
- Key lessons learned sharing – continuous improvement journey

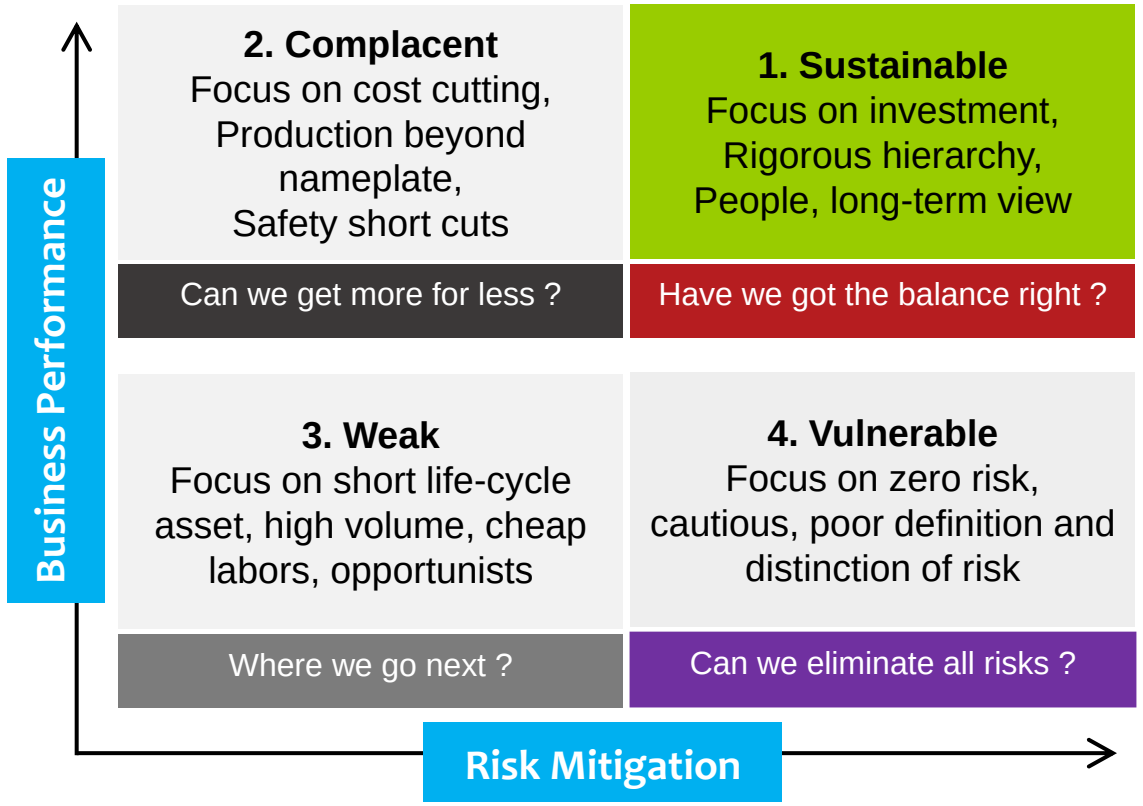
| Industry Type | Region taken for this case study |
|---|---|
| Chemicals, Utilities | Thailand, India, China |
| Mining | South Africa |
| Refining | China, Thailand, Vietnam |
| Power sector | India |

# What is the Value Created ? Role of Mechanical Integrity

Value for Society, the Customer and the Stakeholders can be created through two main strategies:

The reduction of Risk to an "acceptable level" (Protect the Asset)

The increase in Business Performance in a sustainable way (Improve the Asset)




Mechanical Integrity Program can help sustain Risk and Profit

# Interrelation between MI and Maintenance & Reliability

**Maintenance**

Repair Failures

***Efficiency & Effectiveness***

**Reliability**

Eliminate Failures

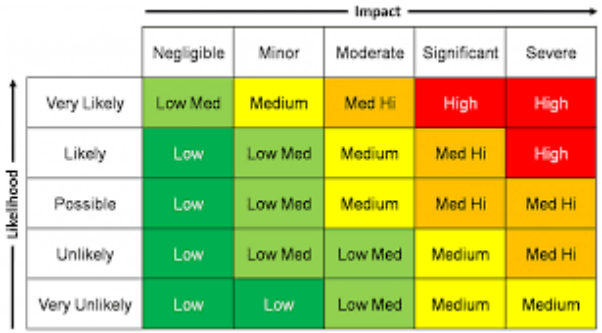
***Improve Performance***

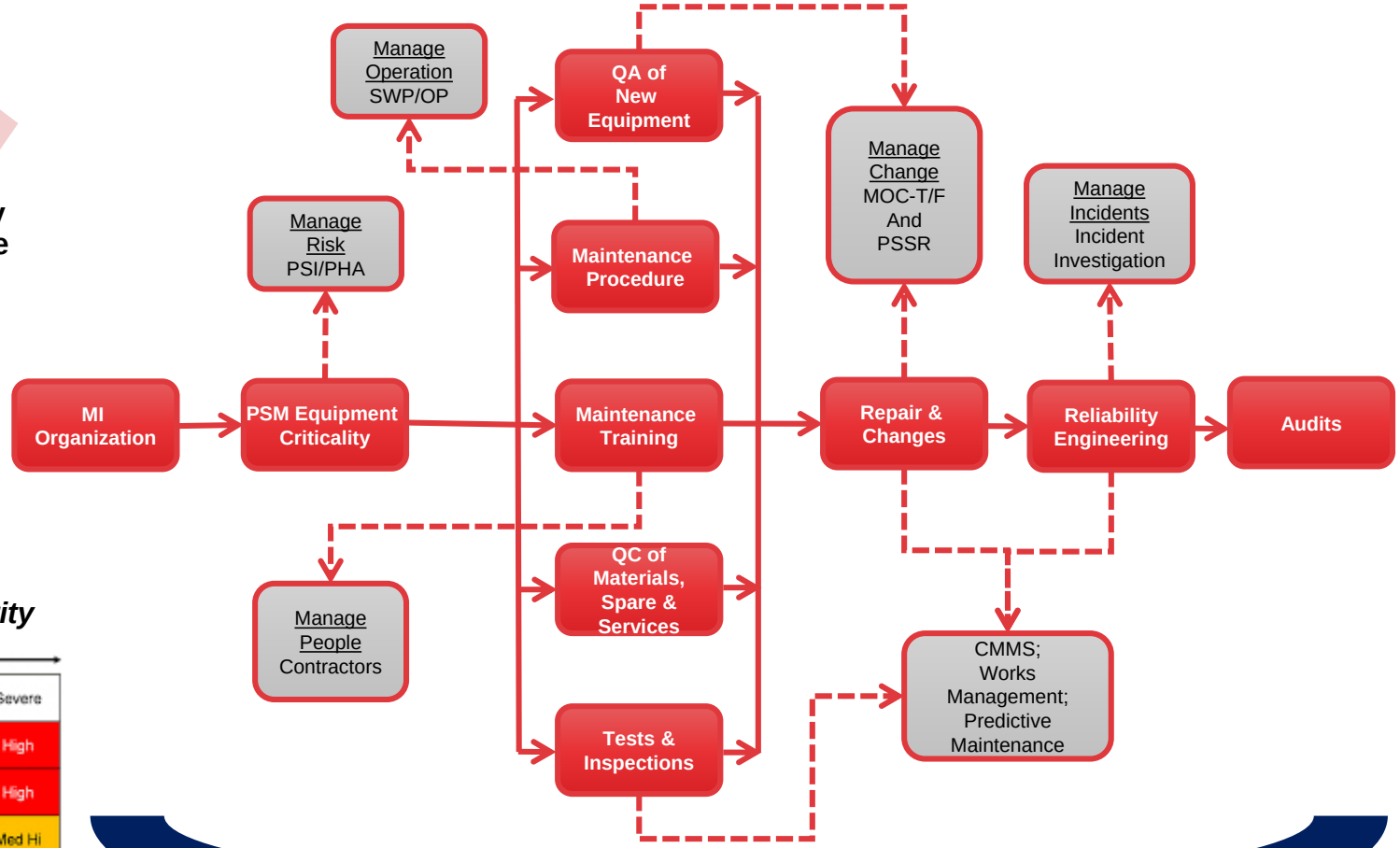
**Mechanical Integrity & Quality Assurance**

* Ensure hazardous energy remain in the pipes

* Protection Layer works -Probability of the protection layer working on demand exceeds industry benchmark

***Assure Process Safety & Integrity***




**Manage Life Cycle Asset Integrity**

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# Categories of Challenges in MI implementation

| Organisational aspects | People aspects | Functional aspects |
| --- | --- | --- |
| • Culture<br>• Leadership & Governance<br>• Risk Management | • Capabilities building<br>• Training and development<br>• Organizational effectiveness<br>• Situational awareness | • Technical grasp (MI & Process Safety Management)<br>• Inspection regime for critical assets<br>• Performance & Data management (KPIs)<br>• Change management |

This paper reviews the Key Challenges in each category

# ORGANIZATIONAL ASPECTS

# Challenges– Organizational aspects

## Culture

- Mindset and Behaviour
- Inspirational Leadership
- Communication: two way, engagement

## Leadership & Governance

- Management Commitment
- Strategic direction: Goals, Objectives and Plans - Charter
- Line Management accountability

## Risk Management

- Risk Management – understand and mitigate
- Implementation of risk reduction measures
- Dashboard: Measurable KPIs

**Deep dive into organizational aspects**

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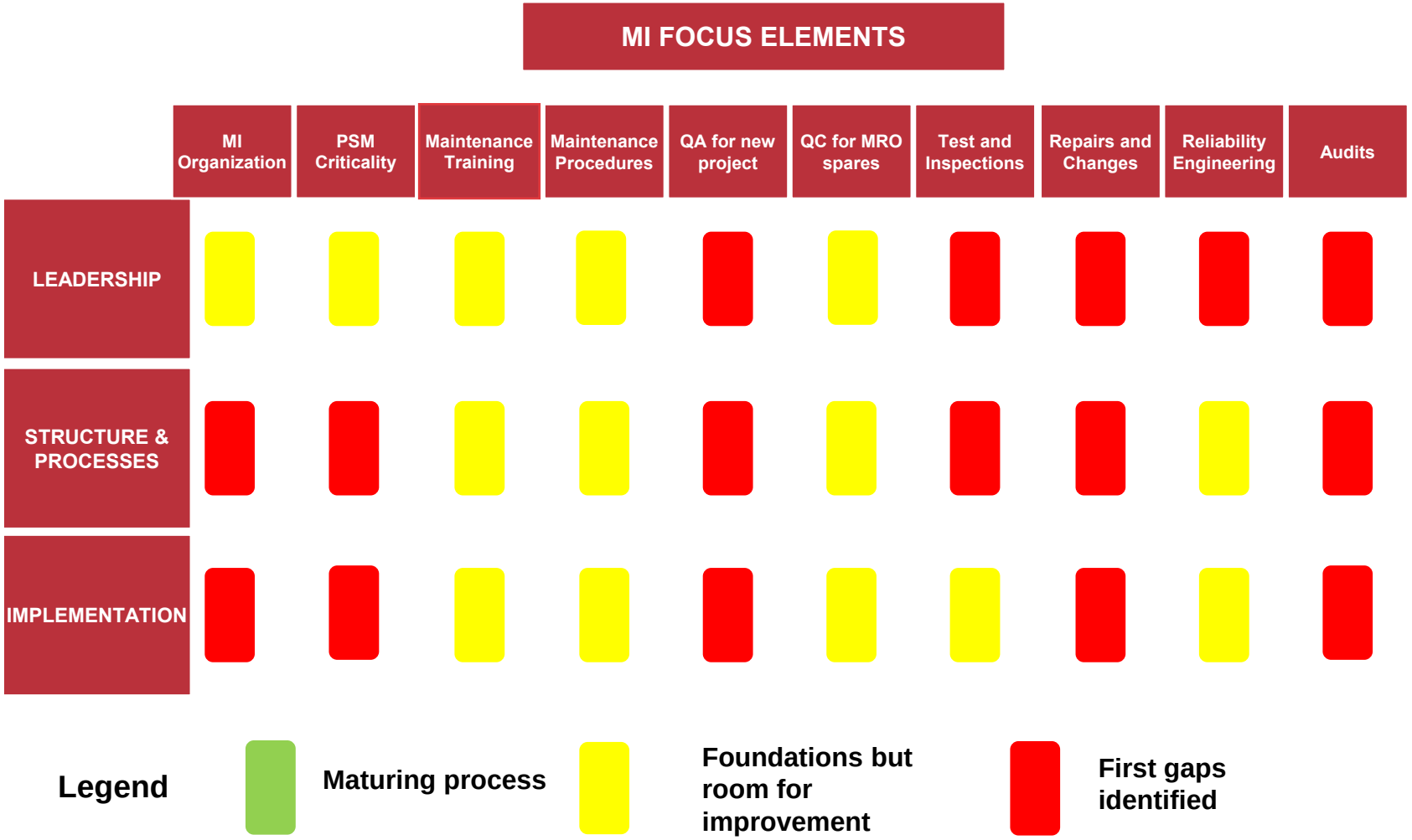
# MI Heatmap – from what we have observed / discussed with a client




## Overcoming Challenges

- ✓ Shift from mindset – get outside-in views
- ✓ Leadership committed to improvement – openness for knowing the gaps
- ✓ Transparent communication

**Actual Heatmap developed for Chemical Client**

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# Mechanical Integrity and Quality Assurance [MIQA] Workstream Charter

**OBJECTIVES**

To develop robust MIQA process per PSM requirements and sustainable implementation effectiveness via:

1. Develop MIQA strategy for <*Client*> site including key roles and responsibility
2. Provide oversight and direction for the implementation of MIQA, recommend suitable resource planning and support
3. Develop systematic KPI - metrics to gauge process & implementation effectiveness
4. Incorporate a cultural shift to adopt the MIQA program
5. To ensure effective monitoring and continuous improvement

**KEY DELIVERABLES**

1. Develop standardized MIQA manual / procedure
2. Mechanical Integrity Organization & team charter and description
3. MIQA Awareness Training Program
4. MIQA KPIs and audit protocol
5. MIQA Coaching Program to sub-teams

**KPIs**

1. % completion of MIQA Documentation
2. % completion of MIQA Implementation Plan
3. % completion of KPIs
4. Audit results

Example

**MIQA WORKSTREAM SUB COMMITTEE**

1. Site Leadership Team members..... <Name>
2. MIQA Program Leader ..... <Name>

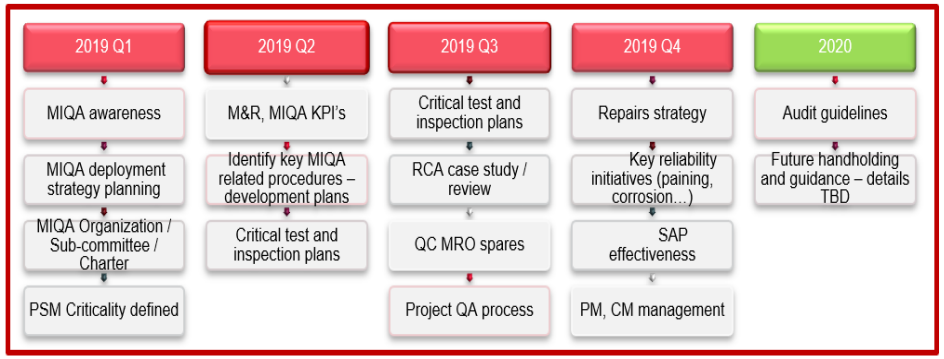
Site Transformation Teams

1. MIQA Leader – Plant1 ..... <Name>
2. MIQA Leader – Plant2 ..... <Name>
3. MIQA team member Plant3 ..... <Name>
4. MIQA team member Plant3.....<Name>
5. MIQA team member Plant1 ..... <Name>
   MIQA team member Plant1..... <Name>
   MIQA team member Department1..... <Name>
   MIQA team member Department2 ..... <Name>

**MEETINGS**

1. Monthly program steering committee with plant MIQA task team
2. Ongoing checkpoints with task team and members (as needed)

**KEY MILESTONE**




## Overcoming Challenges

- ✓ Set expectations clearly
- ✓ Define strategic direction and commit resources
- ✓ Ensure all understand the way forward
- ✓ Drive the charter with clear accountability

# Elements of MI workstream charter – actual example

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# Challenges– Organizational aspect

| ❶ PSM Critical Equipment Identification | ❷ Develop MI Strategy | ❸ Training and Implement MI | ❹ Audit – Sustain - Improve |
|---|---|---|---|
| ▪ Develop a list of “critical equipment / elements” based on defined criteria | ▪ Define MI Strategy based on identified PSM Critical Equipment<br>▪ Develop performance standards for critical equipment and tasks<br>▪ Document the strategy in a formal MI manual | ▪ Develop written procedures for all PSM critical tasks<br>▪ Develop training & qualification program for employees and contractors<br>▪ Develop MI KPIs and management reporting program | ▪ Audit as part of PSM audit program – all critical procedures & tasks<br>▪ Sustain via rigorous corrective action tracking program<br>▪ Improve via audit results & adopting new best practices & technologies |

## Overcoming Challenges

- ✓ Leadership to facilitate development of detailed activity workplan with clear responsibilities and timelines
- ✓ Review the progress periodically and support as needed
- ✓ Inspirational leadership and appreciation

## Practical case study – extract of activity plan

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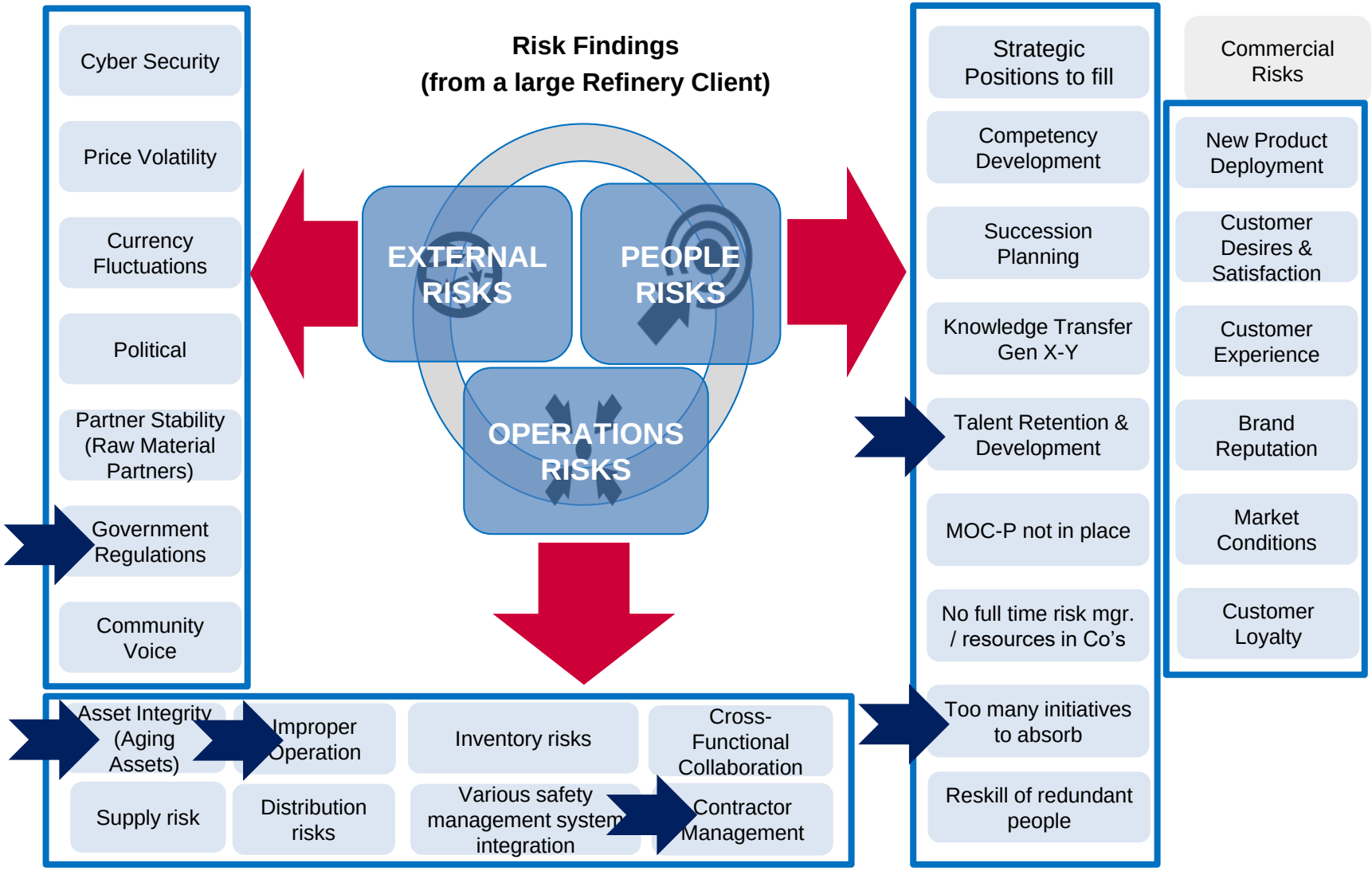
# Challenges– Organizational aspect- Risk Management




## Overcoming Challenges

- ✓ Leadership to drive risk management through integrated view of enterprise risks
- ✓ Understand, prioritize and mitigate risks
- ✓ Measure and improve using relevant KPIs

**Can you perceive KEY RISKS for your company**

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# Challenges– Organizational aspect- Risk Management

| Key Challenges | Description |
|---|---|
| **Managing Ageing Assets** | ▪ Many industrial assets are operating at or beyond their design life<br>▪ Ageing assets can develop new and unforeseen failure modes<br>▪ RBI (Risk Based Inspection) is essential to ensure ongoing integrity |
| **Multicultural Workforces** | ▪ Most PSM critical maintenance is done at turnarounds using contractors<br>▪ Often contractors do not speak the language of the client<br>▪ Validating contractor competence can be very difficult |
| **Maintaining Operational Discipline** | ▪ Critical procedures such as making joints require 100% compliance<br>▪ Years without major incidents can lead to complacency<br>▪ MI is applied to thousands of items of equipment |
| **Optimising Cost, Reliability and Integrity** | ▪ Manufacturing organisations are under pressure to reduce cost<br>▪ Maintenance is often seen as a cost rather than a competitive advantage<br>▪ Integrity may be compromised in the drive to extend life and reliability |

**Can you perceive KEY RISKS for your company**

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# PEOPLE ASPECTS

# Challenges– People aspects

## Organisation

- Mechanical Integrity embedded in cross-functional structure
- Adequate staffing for mech integrity
- Active involvement of MI in committee discussions

## Knowledge Management

- Access to RAGAGEPs, SMEs and Company Standards
- Culture of thinking about Mechanical Integrity at all times

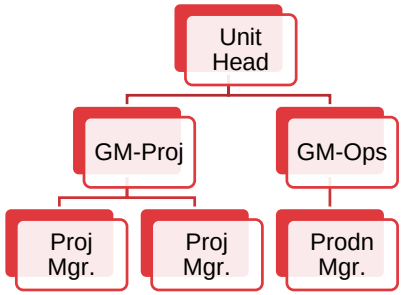
## Training & competency Management

- Process overview & hazards training for MI personnel
- Competency matrix for PSM critical tasks on PSM critical equipment
- Refresher training based on specific criteria

**Deep dive into people aspects**

RAGAGEP – Recognized And Generally Accepted Good Engineering Practices

# Challenges– People aspect




Case Study: A hazardous chemical plant had no maintenance department. The production manager managed both operations & maintenance, with a few maintenance technicians reporting to him. A major incident involving reactor blast triggered the creation of a maintenance department and subsequent programme for PSM implementation.

Case Study: A site had set up PSM committee but MI was not on the PSM committee agenda. MI review was delegated to junior staff.

## Overcoming Challenges

- ✓ Organization structure defined for Mechanical Integrity and integrate into overall organization with clear RACI
- ✓ Committees set up for MI with linkage to PSM committee
- ✓ MI personnel empowered with support of leadership

Practical case study

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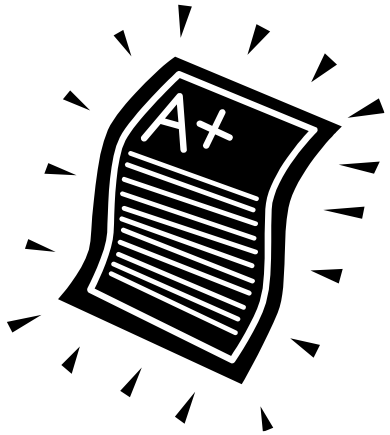
# Challenges– People aspect




Case Study: A chemical plant depended upon vendor specifications without referring to RAGAGEPs and ended up with low cost facilities. Subsequently incidents resulted in increased cost of modifications due to patch work and retrofits in existing facilities. Injuries during repair work resulted from lack of hazard awareness. Root cause was people were not aware of relevant RAGAGEPs and there was no competency management in place.

Case Study: A site had reactive approach to dealing with leaks and barrier failures. A PSM programme helped the team develop the MI thinking and take risk based proactive decisions, and say to “No” to unapproved changes.

## Overcoming Challenges

- ✓ Identify and provide access to RAGAGEPs and SMEs
- ✓ Nurture MI thinking in people by coaching on MI aspects in all activities (e.g. MOC)
- ✓ Competency management for MI personnel with reference to process hazards

Practical case study

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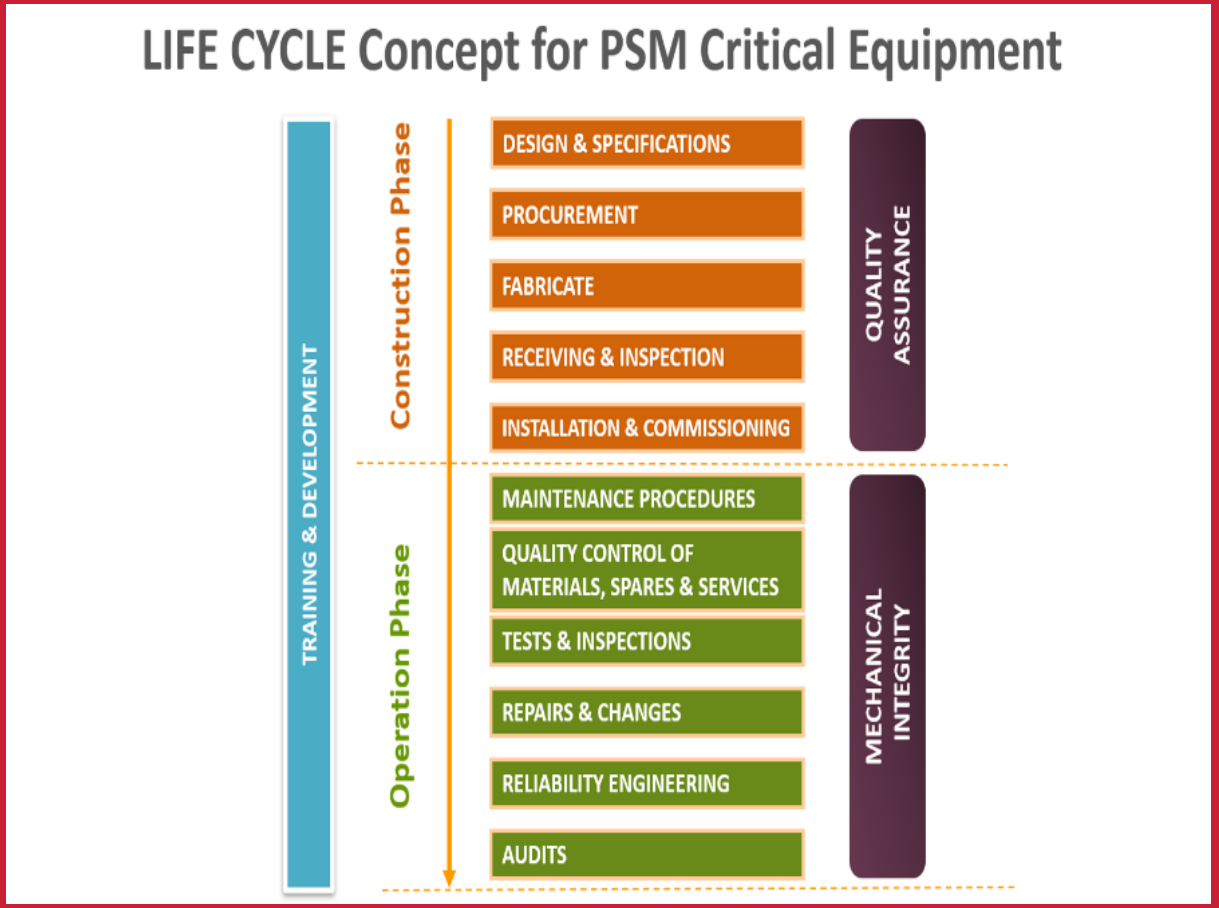
# FUNCTIONAL ASPECTS



# Challenges– Functional aspects

## Technical grasp (MI & process safety)

- Process & Equipment Design basis uptodate
- Integrity of relief, vents, isolations, drains & preservation
- Comprehensive equipment criticality criteria
- Equipment sparing and spare parts philosophies

## Inspection regime for critical assets

- Overarching life cycle integrity programme
- Planning, scheduling & monitoring inspections
- Facilities & resources for implementation
- Feedback into design for correct application

## Performance & data management (KPIs)

- MI KPIs integrated with business dashboards
- Focused barrier health management
- Tracking inspection compliance, non-conformance and deferrals

## Managing change

- Risk assessment of non-conformance, deviation & overdues
- Bypass and / or override authorisation
- Temporary repairs and change

**Deep dive into functional aspects**

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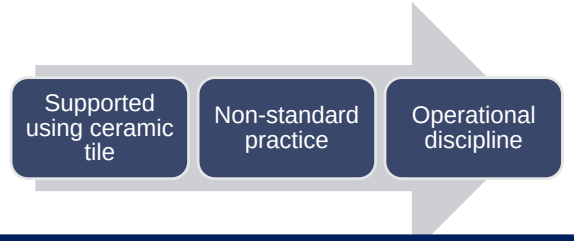
# Chemical Plant – Equipment Integrity

Improper flange guard
Uneven bolting

Pressure Relief Integrity

Acid system support integrity






Uneven bolting is the potential primary cause of loss of containment and the missing flange guards are more of a mitigation measure (and lower in the hierarchy of control).

## Overcoming Challenges

- ✓ Keep Process & Equipment Design Basis up to date
- ✓ Determine and tag equipment criticality consistently
- ✓ Life cycle integrity management of relief, drain, etc.
- ✓ Ensure preservation of equipment not in use

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# Refinery – Fire Water Pump challenges (pump numbers are for illustration purposes only)


Jockey & Firewater Pumps were removed for Maintenance

**Safety risks**

**High Maintenance costs**

**Potential Production loss**

**Critical A Equipment Events**

- Firewater Jockey Pump PxxxA shown in SAP as a High Corrective Maintenance item

**Field Observations**

- Firewater Jockey Pump PxxxB was found disconnected and sitting idle at location
- Firewater Electrical Standby Pump Pzzz was disconnected and out of service
- No Work Order was registered in SAP for these 2 pumps (PxxxB & Pzzz)

**Work Flow Management**

- Who screen/ prioritize/ Authorize Work Order
- No Records of MoC (Management of Change)
- Not able to trace scope of work from owner
- Not able to trace Start and End Date

## Overcoming Challenges

- ✓ Identification of critical equipment using holistic criteria
- ✓ Barrier health monitoring and tracking non-conformance
- ✓ Bypass / override management
- ✓ Risk assessment and Managing change & repair
- ✓ Works Management and RACI
- ✓ Escalation and KPI governance

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# Spares / workshop practices

Relief valve flange dent

Lapping Plate condition

Repair work-bench

## Overcoming Challenges

- ✓ Process safety critical sparing strategy aligned with maintenance decision
- ✓ Incoming receiving inspection framework
- ✓ Procedure to manage local storage of parts with RACI
- ✓ Preservation guidelines for spare parts and unused equipment

# Findings | Mines | Overall

**The following key areas of risk have been identified and benchmarked following an aggregation of the findings from the five mines within scope**

## Overall Mine "A" Main Areas of Risk

Risk Criticality Heat Map

**Culture, Leadership & Governance**
1- Management commitment
2- Policies and principles
3- Goals, objectives and plans
4- Integrated organization structure
5-Line mgt. resp. & acc.
6- Safety Personnel

**Recognizing & Mitigating Risks**

**Recognizing Risk**
7- Process Safety Information
8- Risk Assessment and PHA

**Mitigating Risk**

**Manage Operations**
9- Procedures & Performance Standards

**Manage Asset Integrity**
10- Mechanical Integrity
11- Quality Assurance

**Manage People**
12- Training & Development
13- MOC - Personnel
14- Contractor Safety Management

**Manage Changes**
15- MOC – Technology
16- MOC – Facilities
17-Pre-start-up Safety Reviews

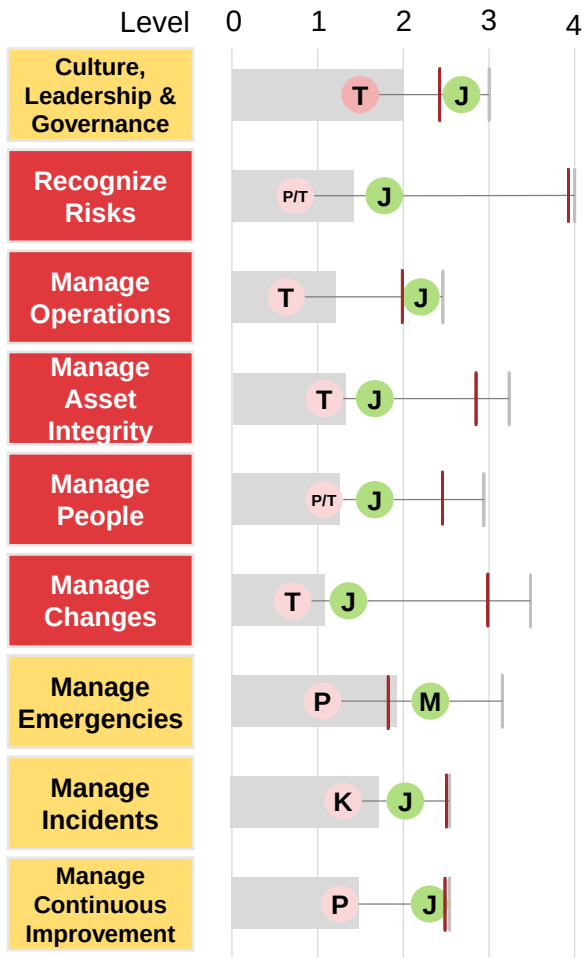
**Manage Emergencies**
18- Emergency Response & Preparedness

**Manage Incidents**
19- Incident Investigation & Reporting

**Manage Continuous Improvement**
20- Audit & Observations
21- Motivation & Awareness
22- Effective Communication

Feedback for Management Review and Action

## Mines Risk Benchmark




*T – T mines | P – mines | J – mines |K – mines| M - mines*

## Overcoming Challenges

- ✓ Technical grasp on Design Basis
- ✓ Focus on risk based integrity management
- ✓ Strong handle on changes to equipment and change of people
- ✓ Barrier health monitoring and assurance
- ✓ Risk assessment of non-conformance, deviations & overdues

** Comparative sample made of risk assessment of 14 mines conducted between 2010 and 2016*

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*Single company Benchmark Best Element* | *External Benchmark Best Element* | *Highest Performing Mine* | *Lowest Performer Mine* | *Mines Average Rating*

# Findings | Bad Actor Analysis

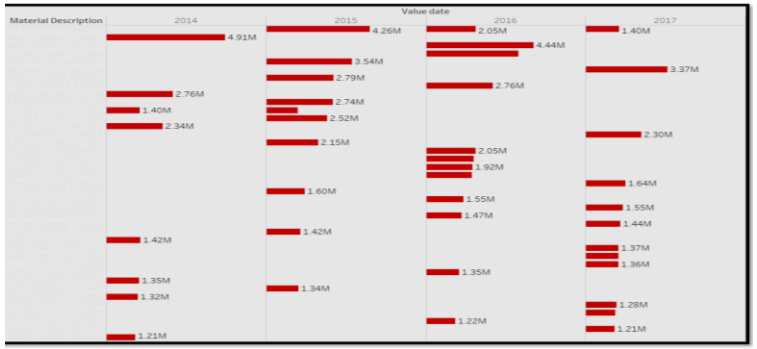
**O&M data of chemical manufacturing company analyzed to identify bad actors. MI being applied on these bad actors for measurable improvement.**

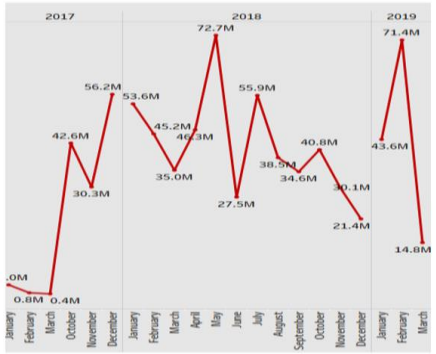
## Background

- 60K+ data points sampled from cost center dataset 2014 - 2018
- 58K+ data points from work order data set 2014 - 2019
- ***Top spends over time periods*** by Cost center, cost of materials, material quantities and controlling area AND ***correlation between cost & work order data*** primarily considered for bad actor analysis.
- Bad Actor Equipment identified and MI actions in progress.

**Bad Actor Analysis based on multi-dimension KPIs**

| Cost / Time / Frequency Metrics | Reliability Metrics | Availability Metrics | Maintenance Metrics |
|---|---|---|---|
| • Annual total cost/hours/frequency<br>• Average corrective cost/hours/frequency for a given period<br>• Total average cost/hours/frequency by equipment type<br>• Total corrective cost/hours/frequency per functional location | • MTBF (MTBR, unscheduled repairs)<br>• Most downtime (lowest equipment availability) over a given time period<br>• Number of emergency WOs vs. Number of routine maintenance WOs | • % Availability<br>• % Asset Utilization | • MTTR<br>• Preventative maintenance hours vs. Total maintenance hours<br>• Reactive/emergency vs. Planned work |




**ACCESS DATA (CMMS / BUSINESS RECORDS / REPORTS)**

**FOCUS ON THE TOP 10 BAD ACTORS**
**…. FIX THEM AND THEN NEXT 10**
**…. FIX THEM AND THEN NEXT 10**

## Overcoming Challenges

- ✓ Specific & well defined Mech Integrity KPIs
- ✓ Reporting culture
- ✓ Data quality
- ✓ MI KPIs integrated with business objectives

# Real time case study – Chemical manufacturing

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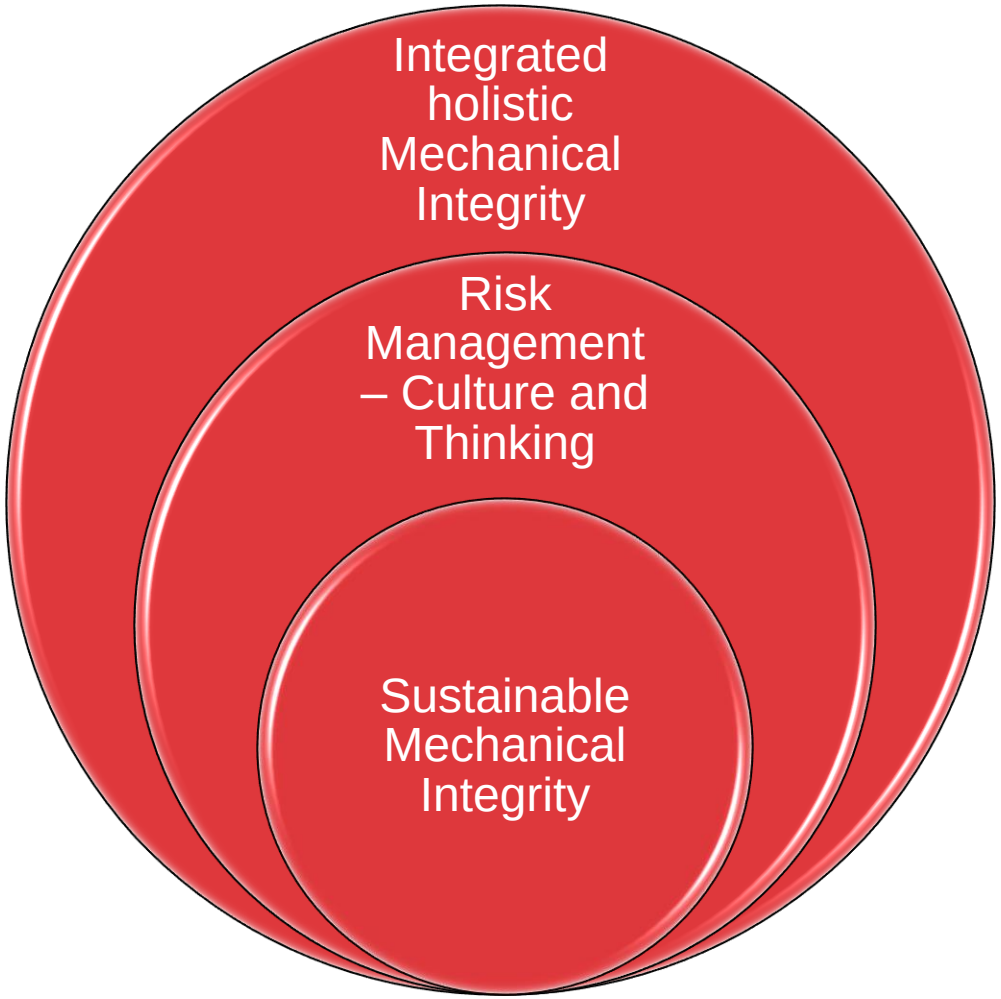
# CONCLUSION

# Summary




- Recognize asset integrity risks as integral to overall business risks
- Be transparent and open; nurture people and culture
- Go beyond regulation to achieve best-in-class process safety performance from assets and sustain through the life cycle
- Leaders to invest quality time and resources, and push for continual improvement in systematic and holistic asset integrity management for manufacturing operational excellence through the asset lifecycle
- Prioritize asset integrity management a prerequisite for safely generating value from physical assets

# Speaker Bio – Krishnan  Shrikanth

- 33 years in industry, Practitioner and Senior Consultant
- Field of Expertise: Maintenance and Reliability Management, Mechanical Integrity and Quality Assurance
- Industries: Chemicals, Petrochemicals, Refining, Mining, Steel, Renewable energy, Power and Utilities
- CMRP (Certified Maintenance and Reliability Professional)
- Mechanical Engineering with MBA from Western Michigan University, USA
- Lean Six Sigma Black Belt in field of Maintenance and Reliability
- Presented technical papers in USA, Singapore and Shanghai
- Published in SMRP journal and LinkedIn sharing

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