

PETRONAS TECHNICAL STANDARDS

HEALTH, SAFETY, AND ENVIRONMENT

GUIDELINE

MECHANICAL INTEGRITY

PTS 60.2202

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This revision of PTS **60.2202 – Mechanical Integrity (October 2009, Revision 1)** has been updated to incorporate PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards. All updates in the document are highlighted in *italic* font.

The previous version of this PTS **60.2202 (September 2006)** will be removed from PTS binder / e-repository from herein onwards.

The custodian of this PTS is: Manager - HSE MS, Standards & Regulations, GHSED.

Please direct any questions regarding this PTS to the above-mentioned.

Document Approval

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PREFACE

PETRONAS Technical Standards (PTS) publications reflect the views, at the time of publication, of PETRONAS OPU/Divisions.

They are based on the experience acquired during the involvement with the design, construction, operation and maintenance of processing units and facilities. Where appropriate they are based on, or reference is made to, national and international standards and codes of practice.

The objective is to set the recommended standard for good technical practice to be applied by PETRONAS' OPU in oil and gas production facilities, refineries, gas processing plants, chemical plants, marketing facilities or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where PTS may not cover every requirement or diversity of condition at each locality. The system of PTS is expected to be sufficiently flexible to allow individual operating units to adapt the information set forth in PTS to their own environment and requirements.

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1. INTRODUCTION

1.1. OBJECTIVES

This PTS covering Mechanical Integrity (hereinafter referred to as MI) has been written to provide the guidance and tools necessary to develop and operate a system for managing and controlling change with respect to business, operational, and HSE matters in PETRONAS HCU/OPUs at the corporate and business activity levels, following and aligning with the principles described in the PETRONAS Health, Safety, and Environmental Management Systems (PTS 60.0101 : HSE MS) which incorporates process safety standards and requirements.

This PTS provides:

- a reference for HCU/OPUs' line managers and senior staff needing guidance in the essential MI requirements of any area of PETRONAS operations.
- a route map and linkage to more detailed references and cross-references with guidance on their application.

Structure and Content

Refer to the Table of Contents for an overview of how this PTS is structured.

Format

This PTS is arranged in either hardcopy or softcopy format, which are available on the PETRONAS intranet for downloading and subsequent reference and usage.

User Base

User of this PTS on MI are expected to be HCU/OPUs and selected contractors. The PTS will either serve as a reference for others to assist in the development of 'in-house' specific referenced documents, or will be used as a first-line reference in the case of smaller organizations.

1.2. USING THE MECHANICAL INTEGRITY PTS

Language

In this document the recommendations for a course of action are made with varying degrees of emphasis. As a rule:

'shall' indicates a course of action with a required, mandatory status within the HCU/OPUs. The English language equivalent or interchangeable term of "shall" is "must."

'should' indicates a preferred course of action.

'may' indicates a possible course of action.

In this PTS document the collective expressions of PETRONAS are sometimes used for convenience in contexts where reference is made to the HCU/OPUs in general. These expressions are used where no useful purpose is served by identifying the particular company or companies.

Application

Should any significant deviations be made from the guideline or recommendations in this PTS document, then users are required to inform PETRONAS of the nature and justification for these if it is intended that the deviations are to be permanent.

Feedback

This PTS document is not intended as a static set of rules, but a growing collection of HSE expertise. Users are invited to comment on the PTS to PETRONAS and to suggest changes or additional material which they consider would be useful for inclusion in future revisions.

1.3. RELATIONSHIP WITH OTHER SYSTEMS

This PTS has been designed and written so as to link back to the higher level document, the PETRONAS Health, Safety and Environmental Management System (PTS 60.0101 : HSE MS). It has been developed to be an integral part and tool to assist in managing integrity and reliability of facilities or equipment within the overall PETRONAS HSE MS. Figure 1 below illustrates the elements of the PETRONAS HSE MS and their interactions.

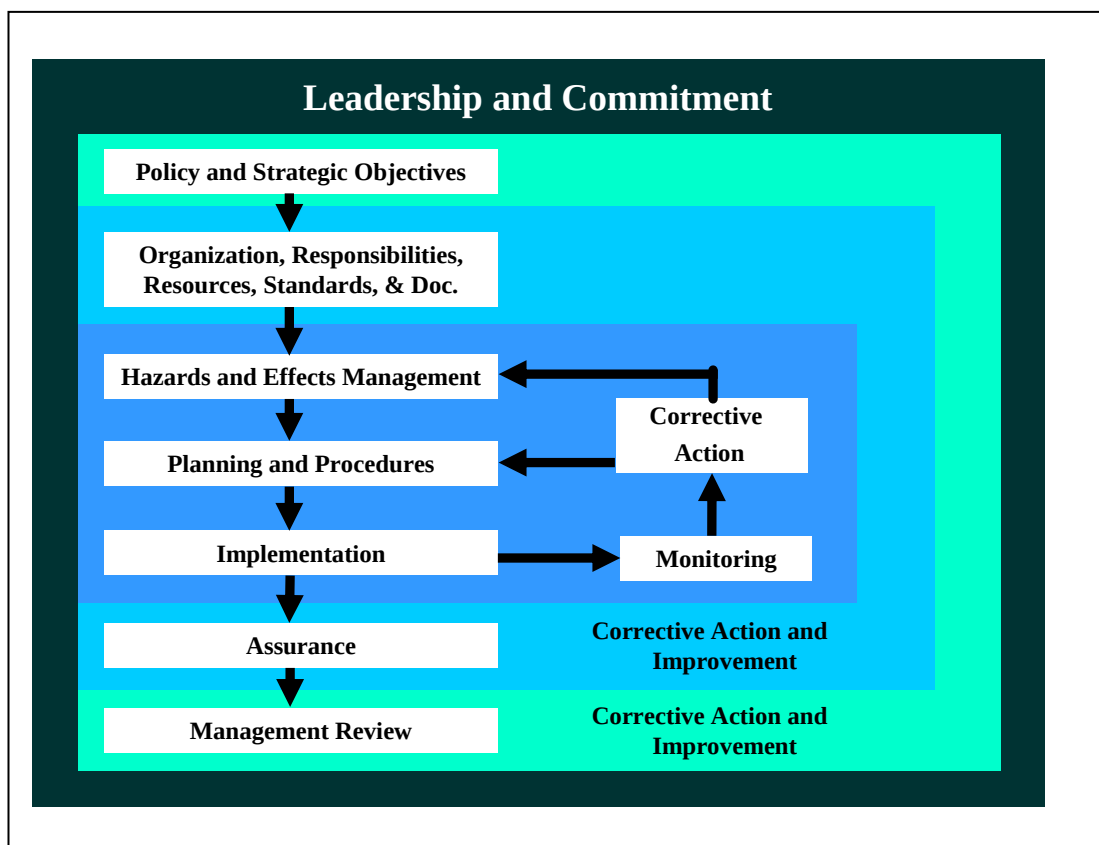


Figure 1: The PETRONAS HSE MS

The MI activities covered in this PTS fit into the overall PETRONAS HSE MS, and includes, but is not limited to, the following examples:

Leadership and Commitment: HCU/OPU Management shall commit and expect all leaders to proactively lead, establish and maintain MI System, programs and initiatives in their respective HCU/OPU.

Organization, Responsibilities, Resources, Standards, and Documentation: The roles and responsibilities for establishing and maintaining MI System and to ensure that it is effective, shall be clearly defined within the HCU/OPU's existing organizational structure. This includes designation of responsible personnel / custodian(s) to manage all aspects of the MI System; allocation of sufficient resources to the system; development of standards to ensure suitable, adequate, and effective performance of the MI System on site; and establishment of both document and records control management systems to handle MI-related documentation.

Hazards and Effects Management (HEMP): MI processes shall be suitably, adequately and effectively integrated into the Hazards and Effects Management Process. This commonly and minimally would require that all MI activities be subject to a relevant and robust risk assessment process prior to such activities being approved.

Planning and Procedures: All business / HSE planning activities shall consider the potential effects of practicing MI at site, and the potential effects of NOT introducing MI at site, where a structured MI System may be necessary. Documented procedures shall be in place to manage and implement mechanical integrity.

Implementation and Monitoring: Evidence of the suitable, adequate and effective implementation of the MI shall be available at the HCU/OPUs.

Assurance: From time to time, and based on planned schedules, the MI system shall be subject to PETRONAS Assurance activities.

Management Review: The suitability, adequacy and effectiveness of the MI System shall be periodically reviewed by the HCU/OPUs Management as part of their formal and periodic Management Review processes at site.

2. MECHANICAL INTEGRITY

2.1. OVERVIEW

MI system is one aspect of the overall PETRONAS Process Safety Management (PSM), which main focus is on managing loss of containment. The MI System follows and aligns with the HSE and business principles of PETRONAS in preventing and /or minimizing the consequence of major incidents involving hazardous substances or conditions of the operations.

HCU/OPUs shall establish an MI System and review the associated programs and schedules. The MI System encompassing facilities i.e. processing, storing and /or handling hazardous substances needs to be designed, constructed, installed and maintained to minimize the risk of releases of such substances.

MI is a subset of Asset Integrity within the HSE MS PTS 60.0101 which provides documented assurance that equipment and structures remain reliable for continued service.

2.1.1 Aim

The aim of MI is to manage the tests, inspections, and maintenance procedures to assure that equipment has been designed, constructed, installed, and maintained in a way which minimizes the risk of releasing highly hazardous chemicals of facilities.

For HCU/OPUs, this requires the application of effective inspection, maintenance and operational strategies reflecting predictive, risk-based assessment of facility deterioration. This is to ensure that the strategies are properly designed and to keep the hazardous substances contained.

A well implemented MI System ensures that the people, assets and surrounding environment of the HCU/OPUs are not adversely affected by inadequate evaluation of hazards, threats, and other potential undesired events related to failure of facilities.

2.1.2 Expectation

For each HCU/OPUs implementing MI System, there should always be clear expectations and outcomes as a result of such implementation. As a guideline, HCU/OPUs Management shall ensure that the following expectations, as a minimum, are delivered:

- **All process, control and utility equipment and system shall be identified, catalogued and categorized.** The inventory of equipment shall be comprehensive and up-to-date, and should be focused on the needs of the MI System and not adopted from other sources such as registers for financial/depreciation purposes.
- **Risk-based assessment techniques shall be used to determine the priority of facilities with regard to the impact on health, safety, environment and business.** The methods used, such as ECA, FMEA/ FMECA, RCM, RBI, IPF and extent of the risk based techniques should be commensurate with the likelihood and severity of potential hazards. These techniques should be applied comprehensively.
- **Effective operation, maintenance and inspection activities shall be carried out by competent personnel and suitably reported.** Whether the activities are preventative or corrective, the methods used, timing of the

activities and competency of personnel should reflect the identified risk exposures.

- ***Collected data shall be analysed to identify imminent threats to facilities, and to determine trends of deterioration that shall be used to update risk profiles and set future intervention programs.*** The analysis of collected data is vital for improving performance of the equipment.
- ***Where failures occur, these shall be investigated to determine the root causes, recommendations made to prevent recurrence, actions tracked to completion and risk profiles updated.*** Learning from unexpected events is essential to ensure that such events are predicted in future and dealt with in a suitable manner.
- ***The ongoing quality and technical basis for MI activities shall be monitored and corrective actions shall be taken where necessary.*** Continual improvement is a key requirement of the HSE MS.

2.1.3 Link With Other System Elements

The following HSE MS activities will normally have a direct link to the MI. It is the responsibility of the MI Custodian to ensure that all suitable links with other system elements are identified.

- **Management of Change (MOC)** – MOC may be triggered by MI finding or may require revisions to MI program.
- **Design Integrity (DI)** – The design specifications will have significant impact on the operation, maintenance and inspection of facilities. As such, facilities shall be designed to optimize the MI effectiveness and permit MI activities to be undertaken.
- **Process Safety Information (PSI)** – Process Safety Information is essential for effective MI program. Results of MI program may require updating of PSI documents.
- **Operating Procedures (OP)** – Operating procedures and practices are necessary to support the MI programs. Likewise, in developing OP, the input from MI program shall be considered to ensure equipment are operated within Safe Operating Limit.
- **Process Hazard Analysis (PHA)** – The PHA process of hazard identification and risk assessment (HAZOP, FMEA/ FMECA, etc.) may result in new requirements for MI programs.
- **Pre-Activity Safety Review (PASR)** – PASR shall be triggered before and after executing of Major Maintenance activities in order to maintain the mechanical integrity of the equipment and the plant.

2.1.4 Basis and Compatibility

This PTS:

- 1) Supports PTS 60.0101, HSE MS Manual, which provides “global” HSE management system guidance for PETRONAS companies,
- 2) Recognises the need for compliance with corporate and legal regulatory requirements.
- 3) Is compatible with ISO 14001:2004 Standard for Environmental Management Systems and the OHSAS 18001:1996 Specification for Occupational Health and Safety Management Systems
- 4) Incorporates internationally accepted “best management practices.”

2.1.5 Scope of Mechanical Integrity

The MI system is defined and implemented in line with the HCU/OPUs HSE policy. Strategic elements of the programmes include the following provisions:

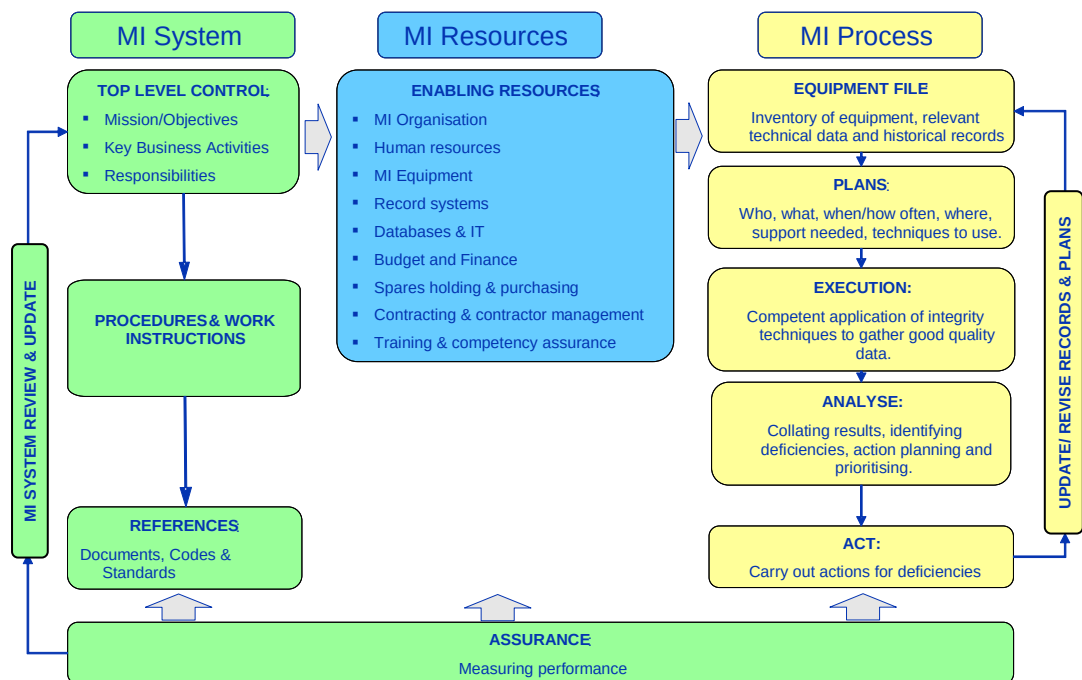
- **Management System:** The management of an important activity requires the implementation of policies, procedures, work instructions and documentation. It is imperative to ensure roles and responsibilities are assigned, authority is given, supervision is provided, resources are made available, and people are held accountable for MI activities.
- **Applicable Facilities:** The term “MI-applicable” facilities shall apply to all equipment and systems that is managed under the MI program. The MI program shall include mainly equipment which may cause or contribute to a loss of containment of hazardous substances. Rationale for excluding any equipment shall be documented. Refer Appendix 2 for guidance to determine MI-Applicable equipment.
- **Codes and Standards:** All referenced codes and standards e.g. API, ASME and IEC that apply to MI shall be documented.
- **Maintenance, Inspection and Testing:** Appropriate programs that ensure proper and systematic maintenance, inspection and test plan shall be developed using risk-based approaches such as the RBI and RCM methodologies. Specific Equipment Reliability Plan (SERP) shall be established, and scheduled for execution as planned; routine or turnaround. See Appendix 3 for guidelines on preparation of SERP.
- **MI Procedures:** Written procedures shall be developed and implemented for MI activities, covering the lifecycle of the equipment and facilities.
- **MI Training:** All personnel, including contractors, involved in MI shall be competent for the tasks they will perform. Suitable training and assessment programs covering relevant procedures and safe work practices shall be defined and implemented.
- **Operational Deviation:** Safe Operating Limits and parameters shall be established and monitored. This should include deviation reporting and investigation.
- **Controlling and Managing Deficiencies:** A process shall be implemented for identifying, evaluating, and correcting deficiencies in MI-applicable equipment that are outside acceptable limits.
- **Quality Assurance (QA):** A QA system shall be in place to ensure that process equipment is suitable for its intended process service. The QA system includes appropriate process to assure that service provider, equipment, material and spare are in compliance with the acceptance criteria during the design, procurement, fabrication, construction, and installation phases. System shall be in place to handle any non-conformance. Where appropriate, service provider or vendor quality systems should be assessed.

2.1.6 MI Model

The model defines the means to assure and document that equipment systems, especially those in highly hazardous services, are designed, installed, and maintained properly through the application of:

- Inspection
- Testing
- Preventive maintenance, and
- Quality assurance

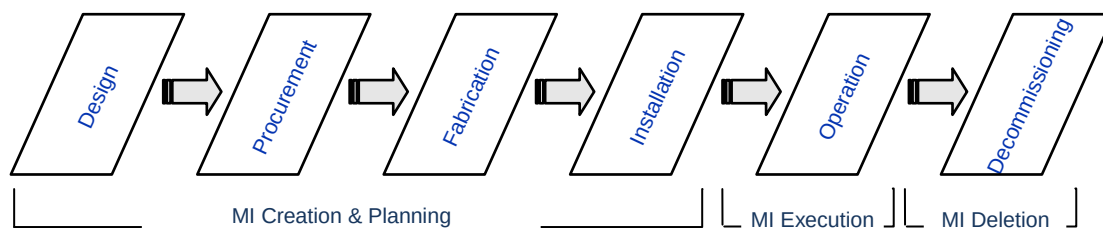
The requirements within the model are described in the diagram below and explained in the following sections.



Mechanical Integrity involves a lifecycle process with multiple checkpoints to verify:

- The equipment complies with applicable codes and standards
- The materials of construction are compatible with the process service
- Manufacturer's recommendations for installation are being followed
- The equipment specification is appropriate for the process service
- All installations (including spare parts installations) are suitable for the process application
- Personnel involved in installation are qualified to carry out the work
- Systems or equipment are operated within SOL
- Systems or equipment are inspected and maintained as per SERP
- MI documents updated or revised to allow proper and safe decommissioning of systems or equipment

The various stages of an equipment lifecycle are depicted below.



The critical list of typical requirements or issues that need to be addressed in order for the Mechanical Integrity Programme to function as intended is given in Appendix 4.

2.1.7 Deliverables from Mechanical Integrity

The deliverables from the MI process are both tangible and intangible, but both forms are important because they support other activities within the HSEMS and other management systems. The main purpose of the deliverables is to demonstrate good governance of the equipment integrity and provide assurance of the same to management and relevant stakeholders. Key deliverables include:

- Updating Equipment Inventory**

This is an important document for understanding the extent of risk exposure as it will include the type, service and age of equipment. It will be useful in supporting studies under HEMP (such as RBI, PHA, HAZOP) by defining the extent, nature and identity of equipment on site. It also supports the financial management function in determining capitalisation and depreciation of equipment of insurance purposes.
- Condition Assessment Results**

These results give management an understanding of exposures and support strategic and tactical decision making on ongoing equipment operation, budgeting and resourcing, risk mitigation options, product reliability and quality, future expansion, construction of similar facilities, etc.
- Reliability Analyses Data**

This sets a standard for the expected, achievable, reliability of equipment. This helps define intervention activities – e.g. inspection & maintenance
- Equipment Performance History**

The consistent, comprehensive, competent and timely collection of data provides a clear picture of the performance of the equipment. This demonstrates good management of the company assets and supports other processes such as purchasing, operational planning and risk assessment.

2.2. POLICY AND CHARTER

Policy and Charter defines the infrastructure needed to manage the MI system on site which includes communicating, reporting, and decision-making. It lays out a blueprint for conducting business for the acquisition and defines how the team works in an empowered manner, including setting out responsibility and authority.

HCU/OPUs shall establish the Policy and Charter which cover the team's purpose and clearly define individual roles, responsibilities, and protocols. HCU/OPUs Management shall appoint an MI Custodian for establishing the MI System and coordinating the MI programs. To ensure MI programs are carried out in accordance with the established procedures, HCU/OPUs shall form a team to assist in the development of MI programs and the roles and responsibilities of the team shall be defined and include the following:

- Top Level Document for managing MI system
- Determine the equipment for MI
- Establish equipment files
- Establish inspection, testing and preventive maintenance programs
- Perform activities
- Updating Plans and Records
- Responding to Deficiencies
- Assurance

2.3. ORGANISATION, INFRASTRUCTURE AND STANDARDS

2.3.1 Roles and Responsibilities

- The *Head of HCU/OPUs* shall demonstrate leadership and commitment in ensuring that all reliability and integrity matters are systematically and structurally managed, discussed, implemented, monitored and communicated.
- The *Facility Owner* is accountable for ensuring that the jurisdictional requirements relating to MI are met.
- The *MI Custodian* is accountable for implementing the MI System, and responsible for coordinating the MI activities and ensuring that the MI programs are being carried out in accordance with the established procedures.
- *Line Management* is responsible for ensuring that activities required to support the application of the MI System are in place and operational, and that the MI System is adequately implemented in their area of responsibility.
- All relevant personnel are responsible for understanding the requirements of the MI System, identifying deficiencies in facilities that are outside acceptable limits, recommending changes of the MI System, and performing MI activities in a safe manner.

2.3.2 Ensuring Equipment Integrity

In ensuring the process equipment integrity programme is successful, the Mechanical Integrity system is appropriately supported by these 8 elements shown in the Figure 2 Below.

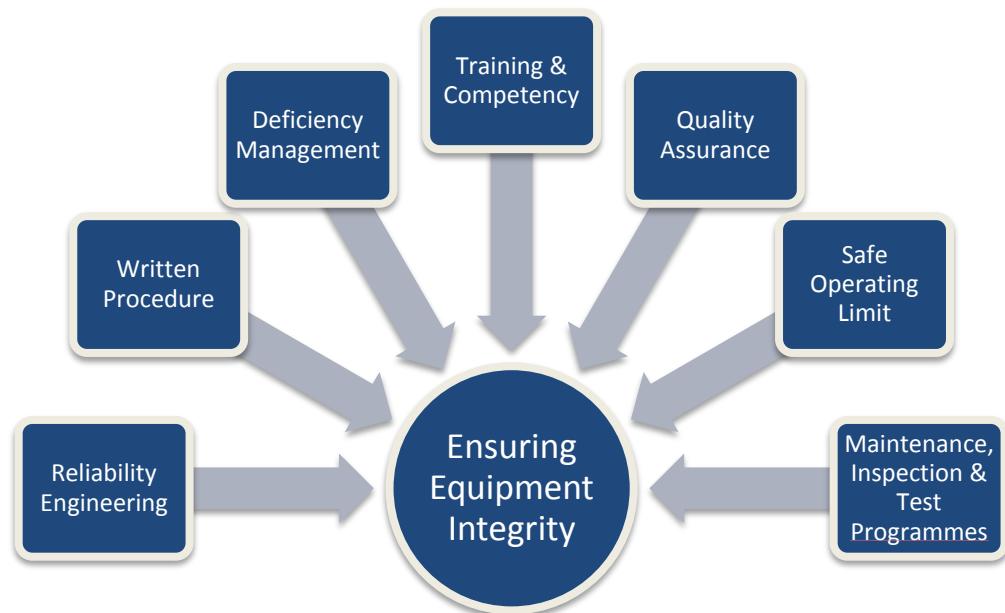


Figure 2: Ensuring Equipment Integrity

The following basic elements shall be managed:

- **Written Procedures:** Documents / procedures needed to manage the MI program shall be identified and developed, made accessible and cross-referenced to the relevant MI work processes and MI equipment. This is to ensure consistency of approach and correct application of tools & techniques, improved retention of maintenance knowledge. Once these documents are approved, they shall be implemented and maintained.
- **Quality Assurance (QA):** Verification process shall be established to assure that service provider, equipment, material and spare are in compliance with the acceptance criteria during the design, procurement, fabrication, construction, and installation phases. This is to assure the technical integrity and capability of services provider and the availability of the equipment, material and spares complies with the specification which is consistent with manufacturer's recommendations, codes and standards and good engineering practices.
- **Safe Operating Limits (SOL):** Managing and monitoring of deviation of MI-applicable equipment to ensure they are operating within the SOL. This is to prevent catastrophic failures and adequate assessment of risk is conducted if equipment is operated beyond SOL so that appropriate control measures can be put in place. The limiting parameters shall be mapped, recorded and communicated to the relevant personnel.

- **Reliability Engineering:** Systematic assessment of integrity and reliability requirements based on risks in terms of people, asset, environment, reputation (PEAR) and business interests. It is the application of available reliability engineering methodologies in developing the SERP. Reliability engineering is intended to assess equipment risk and develop appropriate proactive plan to prevent occurrence of an equipment failure. Various techniques or tools such as RCM, RBI, IPF etc. are available to systematically assess the reliability requirements of equipment.
- **Deficiency Management:** A work process to manage failures or degradation of performance that will adversely affect the intended function of MI applicable equipment. It is intended to rectify the failures of the MI applicable equipment and prevent recurrences and coordinate and focus the resources to rectify the failures. All deficiencies or defects shall be managed. This includes setting the acceptance criteria to place a limit on tolerating equipment deficiencies.
- **Training and Competency:** All personnel (staff and contractors) involved in operating, inspecting, testing and maintaining the integrity of equipment shall be competent for the tasks they need to perform. Suitable training, assessment and evaluation programs covering relevant competencies, procedures and safe work practices shall be defined and implemented. Typical Training and Evaluating MI Related Competency of Personnel is given in Appendix 5
- **Maintenance, Inspection and Test Programs:** This is a high-level activity to manage the maintenance task arising from all Equipment Reliability Strategy (ERS). It covers a comprehensive maintenance task which includes Operator Driven Reliability/EBC, Preventive Maintenance, Predictive Maintenance, and Corrective Action. This is to ensure that the maintenance task is consistently performed over the equipment life cycle and provide the detailed work method and identify other resources required to execute the tasks.
- **MI Planning and Scheduling:** Application of the planning tools to effectively manage the execution of the MI Applicable Equipment's maintenance tasks. This is to ensure smooth execution of the tasks, optimize resources, monitor and track the progress of the tasks and analyse the results of the proactive maintenance program.

2.3.3 Management of equipment files

Equipment files shall be established and shall include the following information (where applicable):

- Original and current design information.
- Process fluid composition and inventories.
- Location and layout.
- Safe Operating Limits.
- Relevant control and safeguarding systems description and operation.
- Maintenance, inspection, test and change history.

Equipment files shall contain links to the relevant PSI document. An example checklist for managing equipment files is given in Appendix 6

2.3.4 Managing MI Applicable Equipment Data

HCU/OPUs shall develop, maintain and update the MI applicable equipment data. To facilitate the implementation of MI System, it is highly recommended that suitable computerised software be used to provide:

1. Equipment Data
 - With asset hierarchy that allows for comprehensive cataloguing of equipment/equipment types
 - Provide standard datasheets that include information on design, materials and manufacturing and operation parameters for each equipment
 - Search function to allow search of specific equipment by key words
2. Document Link
 - Allows PSI, such as technical documents, images, scanned files, pictures and site drawings, to be attached for online reference and viewing
 - Provide information about the design and construction of the equipment including details of original vendors, and suppliers of consumables.
 - Record information of technical and work history such as findings, recommendation and work-done with reason and date, and view of change history
3. Scheduling and Execution Tool
 - Computes fitness for services calculation and provides basis for MI plans using accepted approaches
 - Establishing standard work items for MI schedules and register tags for MI Activities by generation of automatic work-list and next inspection, testing and maintenance date based on schedule
 - Recording of MI work history on job done and creates management reports to analyse technical results.
4. Monitoring Data
 - Defines measurement points and allows transfer of bulk data from monitoring devices.
 - Produce customised reports for management, technical specialists and field engineers
5. Technical Software Interface
 - Interfaces with RBI/RCM analysis packages to automatically update asset, degradation rates information
 - Allows reports and graphics from interfaced software packages to be viewed by all authorized users online
6. System Administration and Security
 - Define organization and provide level of access by user groups by only permitting access to user related work items, working content and operating menus
 - Provide capability for users to define additional fields for local customisation.
 - Provide multiple language user interface if required