

PETRONAS TECHNICAL STANDARDS

HEALTH, SAFETY AND ENVIRONMENT

GUIDELINE

PROCESS HAZARD ANALYSIS

PTS 60.2204

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This revision of PTS **60.2204 – Process Hazard Analysis (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 **60.2204 (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.

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1.0 INTRODUCTION

1.1 OBJECTIVES

This PTS regarding Process Hazard Analysis (hereinafter referred to as “PHA”) has been written to provide the guidance and tools necessary to develop and operate a system for identifying analysing and assessing process hazards and associated risks at PETRONAS HCU/OPU. It follows and is aligned with the principles described in the PETRONAS Health, Safety, and Environmental Management Systems Manual (HSE MS Manual, PTS 60.0101), as well as fully incorporating the requirements of process safety management standards.

This PTS provides:

- a reference for HCU/OPUs and Project Managers needing guidance in implementing a PHA process
- a description of methods which should be deployed and links to other documents and standards with guidance on their application.

It follows and is aligned with the principles described in the PETRONAS Health, Safety, and Environmental Management Systems Manual (HSE MS Manual, PTS 60.0101).

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

Operating Procedures PTS users are expected to be HCU/OPUs and Project Teams. The PTS will either serve as a reference for others to assist in the development of 'in-house' specific reference documents, or will be used as a first-line reference in the case of smaller organizations.

1.2 USING THE PHA 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 companies of the HCU/OPU 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 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. Consequently, users are invited to comment on the PTS to PETRONAS and to suggest changes and additional material which they consider would be useful for inclusion in future revisions.

1.3 RELATIONSHIP WITH OTHER SYSTEMS

This current version of the Process Hazard Analysis PTS has been designed and written so as to include the requirements for OSHA Process Safety Management (PSM), and to harmonize and link back to the higher level document, the PETRONAS Health, Safety, and Environmental Management Systems Manual (HSE MS Manual, PTS 60.0101).

Furthermore, this PTS has been developed to be an integral part and tool to assist in managing risk within the overall PETRONAS HSE MS. Figure 1 below illustrates the elements of the PETRONAS HSE MS and their interactions.

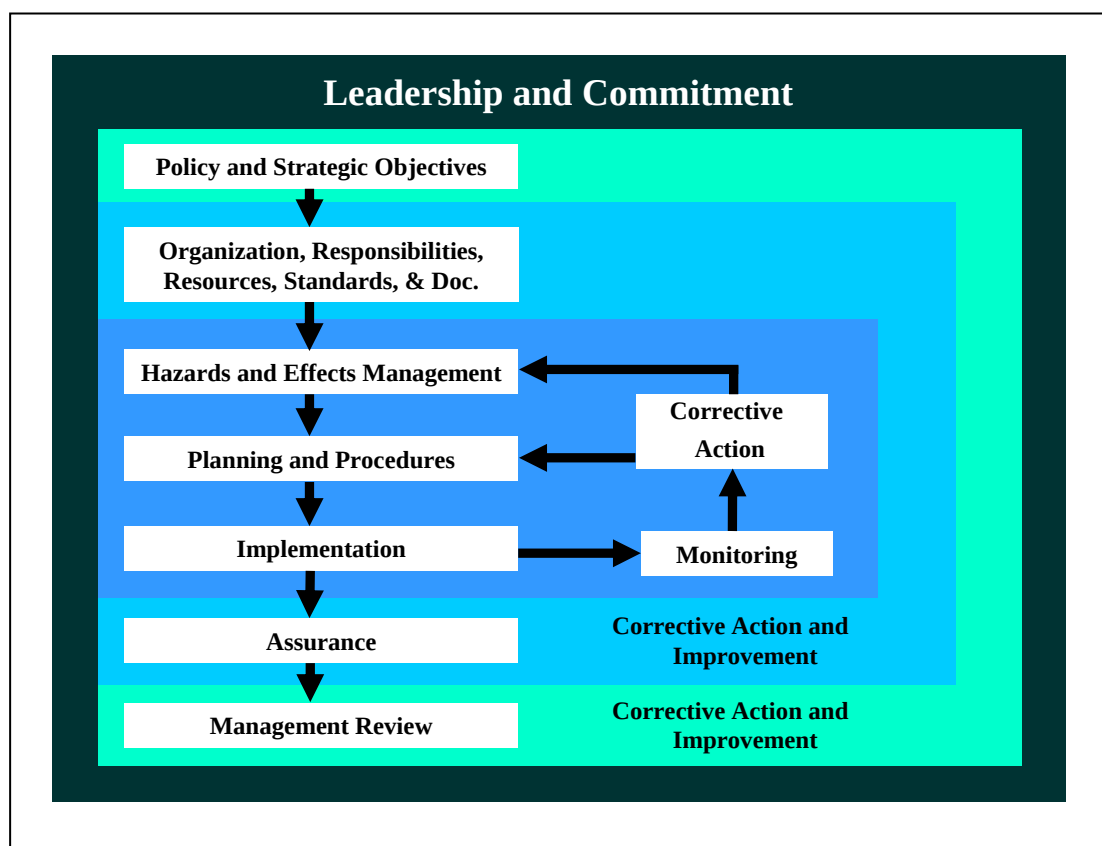


Figure 1: The PETRONAS HSE MS

The activities covered by this PTS fit into the overall PETRONAS HSE MS, and include, but are not limited to, the following examples:

Leadership and Commitment: PETRONAS Management commits and expects all managers to proactively manage risk throughout the lifecycle of facilities in their respective HCU/OPU's.

Organization, Responsibilities, Resources, Standards, and Documentation: HCU/OPU management shall create an organizational structure for managing process hazard. This is to include designation of responsible personnel / Custodians to manage all aspects of the development and implementation process, ensuring suitable communication with users, allocation sufficient resources to the process, develop standards to ensure suitable, adequate, and effective performance of the process on site, and establish both Document and Records Control Management systems to handle management of related documentation.

Hazards and Effects Management (HEMP): The Process Hazard Analysis is one of the methods used to identify and assess process hazards as part of Hazards and Effects Management Process.

Planning and Procedures: Process Hazard Analysis should be planned for, whether commencing a project or under normal operation. If conducted as part of a project, PHA should be integrated into the project specification and sanctioning process. PHA should be subject to periodic review under normal operation and this should included in business plans.

Implementation: Process Hazard Analysis shall be effectively and comprehensively implemented. Training programmes shall ensure that personnel are familiar with and competent in its requirements.

Assurance: From time to time, and based on planned schedules, the Process Hazard Analysis processes shall be subject to PETRONAS Assurance activities.

Management Review: The suitability, adequacy, and effectiveness of Process Hazard Analysis shall be periodically reviewed by the HCU/OPU as part of formal and periodic Management Review processes.

2.0 PROCESS HAZARD ANALYSIS

2.1 OVERVIEW

With increased employee, management, shareholder, and public awareness of safety, people have become less tolerant of risks. This has resulted in increased concern over the health, safety, and environmental impact of a facility and its activities, stronger public opinion, higher litigation, and stricter regulations.

As part of PETRONAS HSE MS program, PHA shall provide a framework for a structured approach to assessing risk. Structured risk assessment ensures that decisions are based by systematic analysis of risks and identification of strategies to reduce risks to as low as reasonably practicable (ALARP).

This PTS documents the PHA guidelines developed specifically for PETRONAS and describes:

- A brief overview of the purpose, benefits, and limitations of PHA.
- Critical Success Factors for a PHA programme
- PHA components and its intent
- Documenting and Using the Results
- Other Hazard Evaluations Techniques and strategy for selection

2.1.1 Aim

The aim of the PHA PTS is:

To evaluate the risks associated with process hazards, assess the performance of safeguards in-place, and make recommendations to ensure risks are managed within tolerable levels.

2.1.2 Expectations

When implementing a Process Hazard Analysis, the HCU/OPU shall ensure that the following expectations, as a minimum, are delivered:

All installations handling hazardous materials and conditions shall be assessed using Process Hazard Analysis. PHA provides the mechanism within the HSE MS for understanding the risks associated with process systems. As such, all installations handling hazardous materials and conditions shall be subject to PHA so that effective risk management measures can be applied.

Process Hazard Analysis shall use suitable hazard identification and risk assessment tools. PHA provides a framework within which a range of assessment methods can be applied. The method used shall be suitable for the process unit being assessed.

Fires, explosions, toxic and flammable releases, and major spills shall be considered in relation to equipment, instrumentation, utility systems, routine and non-routine work and other factors affecting the process system. Certain specific requirements apply to the scope of all PHAs.

The analyses shall be lead by competent personnel supported by a team of individuals with knowledge and experience of the process system being considered. The use of knowledgeable personnel from the HCU/OPU in question is essential for the PHA to be comprehensive, accurate and relevant. Leadership of PHAs is a skill that should be developed and recognised within the HCU/OPU.

The results of the analysis shall be reported along with any recommendations for improvement. Reporting of the PHA is essential if the results are going to be communicated and understood. It also provides the historical record of the work done

for future reference. As such, the report should be detailed and specific, and an accurate record of the discussions that occurred within the PHA sessions.

Actions resulting from the analysis shall be logged and tracked to completion. Reporting is not sufficient to reduce risk – the recommendations coming from the PHA and assigned actions have to be tracked to close-out to ensure suitable safeguards are in place and risks are managed.

The Process Hazard Analyses shall be reviewed on a regular basis to ensure they remain current. As the process system changes the PHA should be updated, but the PHA should also be periodically reviewed in-line with industry good practice (normally 5 years) to ensure that the assessment remains up-to-date.

Links with Other System Elements

The following HSE MS processes will normally have a direct link to the Process Hazard Analysis. It is the responsibility of the Custodian of the activity and his/her team to ensure that all suitable links are identified for their relevance on a case-by-case basis, and if affected, appropriate control measures are identified, implemented, and monitored.

- **Hazards and Effects Management Process (HEMP)** – PHA is a tool for systematic identification and assessment of hazards and effects. HEMP provides the risk management framework within which risks can be controlled.
- **Design Integrity (DI)** – Application of PHA allows hazards associated with integrity of equipment and systems to be identified and hence, risk reduction measures incorporated into the design.
- **Operating Procedures (OP)** - Application of PHA allows hazards associated with implementation of procedures and practices to be identified and controls put in place for them
- **Management of Change (MOC)** – PHA is a hazard and effects identification technique that supports the MOC processes. MOC may trigger the application of PHA.
- **Process Safety Information (PSI)** – PSI provides input to the PHA process and the outcome of PHA may require the update of PSI.
- **Mechanical Integrity (MI)** – The PHA process of hazard identification and risk assessment may result in new requirements for MI programmes.
- **Pre-Activity Safety Reviews (PASR)** – PHA may identify certain issues which should be captured and addressed by PASR.

2.1.3 Requirements

This PTS is based on, complies to, and has direct links to several requirements:

- 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.”

Overall Roles and Responsibilities

The roles and responsibilities of individuals involved in the development, application, supervision, monitoring, and review of the Proprietary and Licensed Technology Assessment process shall be defined by each HCU/OPU.

However, ideally roles and responsibilities should be documented as a performance standard defining:

- What is to be done?
- Who is to do it?
- When or how often it is to be done?
- The deliverable(s) expected back.

The Process Hazard Analysis process at the HCU/OPU shall have a Custodian with overall responsibility for managing the development, application, monitoring, maintenance, and review of the process. Custodianship / Custodian positions shall be defined by the HCU/OPU.

2.2 PROCESS HAZARD ANALYSIS (PHA) PHILOSOPHY

A hazard is an inherent physical or chemical characteristic that has the potential to cause harm. PHA is a systematic, efficient and effective methodology to identify and analyze the significance of hazardous situations associated with a process or activity, and the adequacy of associated controls. Distinctively, it identifies design flaws and weakness in the operation of facilities that could lead to accidental chemical release, fires or explosions etc.

PHA focuses on process safety issues and their impact on people, environment, assets and reputation. These studies compliment occupational health and safety activities, for example protection against slips and fall, PPE etc. This is described in figure below.

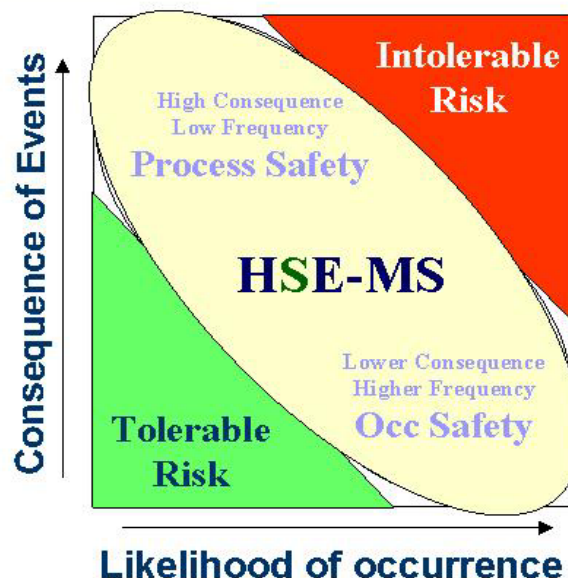


Figure 1 - Process and Occupational Safety

Hazard identification and risk assessment is normally done at various stages of the facility lifecycle by utilising applicable tools. This is to ensure that risk elimination or reduction features are built into the design of the facilities rather than added on after the facility has been commissioned. In addition to the established periodic review, the PHAs shall be reviewed for the following reasons:

- When changes are made to the process system.
- When inadequacies in previous studies have been identified.
- When incident investigations identify unforeseen or high residual risks.
- When monitoring and assurance processes identifies the need to conduct PHA.
- When instructed by regulators.

In managing risk, it is important to understand that it is not possible to eliminate hazards completely. In these cases, controls need to be defined and implemented to manage these residual risks. The process of Risk Management is described in Appendix 3 – Risk Management.

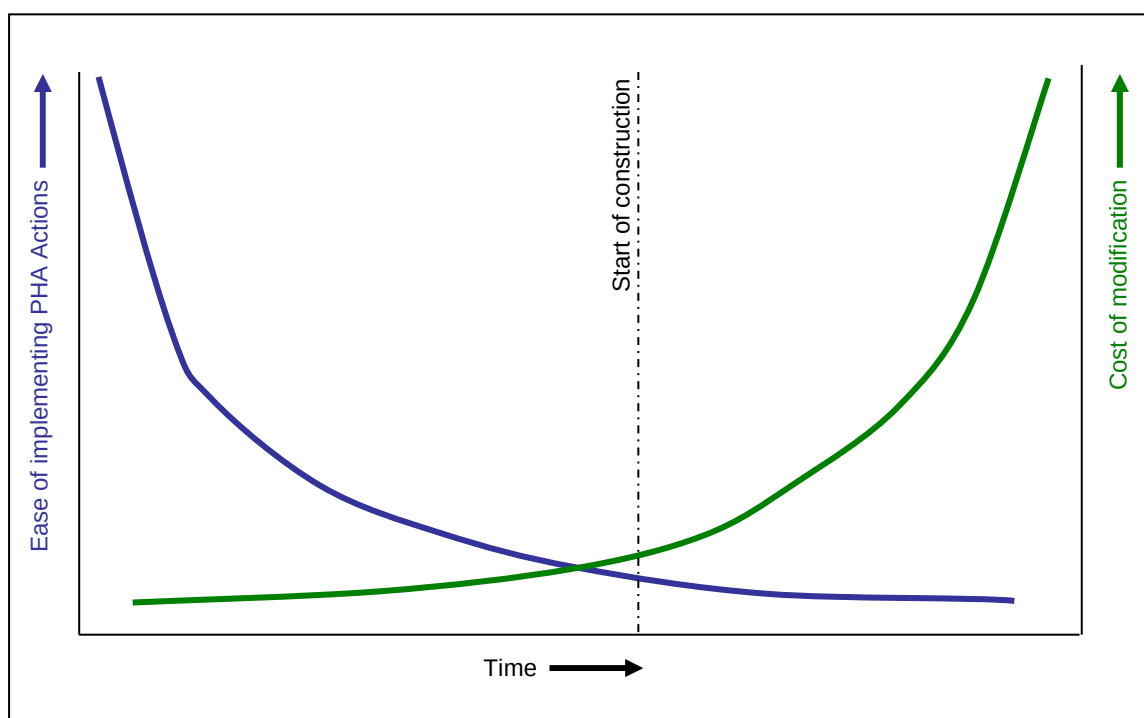


Figure 2 – Time/Benefit/Cost Graph

It is beneficial to undertake PHA early in the lifecycle of the facility as it is easier to change the design of the facility rather than modify it later as shown in below. This does not mean that it is not beneficial to undertake PHA on operational facilities simply that implementing the recommendations are easier during the design stage of the facility lifecycle.

The PHA system shall be designed to ensure the practicality, effectiveness, consistency, and sustainability of the PHA process. This includes the development of standards, procedures, and guidelines for PHA, the selection of PHA tools, the training and mentoring of PHA team leaders and scribes, the development of registers and tracking systems, and the follow-up process.

2.2.1 Objective

The objective of PHA sessions is to ensure that an adequate assessment of risk is carried out in order to meet the following objectives:

- To identify hazards and operability problems
- To identify the consequences and evaluate the risk of hazard events
- To analyse the adequacy of existing safeguards
- To recommend additional safeguards to reduce the risks if necessary

2.2.2 Benefits

The benefits of applying an effective PHA programme are as follows:

- Optimising the residual risk exposure resulting from the design, construction and commissioning of process facilities
- Reduced incidents over the life of asset resulting in improved profitability, plant reliability and company reputation.
- Improved understanding of the process system and inherent hazards
- Understanding of the risk associated with the process system
- Opportunity to reduce the frequency and consequences of hazard events
- Provide assurance to stakeholders that process hazards are being effectively managed

2.3 LIMITATIONS

It should be noted that there are some limitations to the application of PHA. These are:

- Not all hazards, potential accidents situations, causes and effects can be identified although the use of checklists and experienced personnel attempts to address this.
- Generally, the results and benefits of PHA cannot be directly verified. For example the savings from accidents that are prevented cannot be directly calculated.
- PHA is dependent on knowledge of personnel and the team cumulative experience as well as their judgement.
- PHA studies are based on the information available during the study. Poor risk management decision could occur if documents, PEFS's etc are not current.
- Performing high quality PHA does not guarantee that incidents will be prevented but will help to reduce the probability and limit impact of occurrence.

2.4 PHA FRAMEWORK

PHA supports a range of processes within the HSE MS from providing a process safety view within HEMP through to being the basis for the risk review processes within DI. As such it is essential that it is applied in a suitable and successful manner. Successful PHA studies are produced when organisations apply an intensive and consistent effort in delivering them.

This section explains the framework aspects which are required to be in place for the successful implementation of a PHA program. These aspects are:

- Infrastructure
- Objectives and Scope
- Information Available
- Personnel and Experience
- Schedule and Execution

2.4.1 Infrastructure

To achieve the full benefit of PHA, the HCU/OPU management must encourage and provide an infrastructure that that will support the PHA teams as they perform and

implement the results of PHA. Clear commitment to process safety must be emphasised in the application of the site HSE policy and its associated procedures such as those associated with the implementation of Hazard and Effects Management Process.

The commitments required to meet this aspect:

- i. To provide suitable and current PSI essential for the PHA exercise.
- ii. To provide competent and experienced personnel to be involved in PHAs.
- iii. To ensure the timely and adequate closure of PHA recommendations.
- iv. To maintain the ongoing relevance of the PHA studies through periodic review and update.
- v. To ensure the effectiveness of the PHA system through the application of an assurance and management review process.

In other words, the organisation should apply a comprehensive risk management process to support the PHA activity. This process is described in PTS 60.0401 Hazard and Effects Management Process although additional information is given in Appendix 3 – Risk Management.

2.4.2 Objective and Scope

An essential part of a successful PHA program is the definition of objectives, scope and schedule. Objectives ensure efficient analysis and avoid the tendency to focusing on matters that are of minor concern. The scope of the study minimises overlaps between studies and ensures interfaces with other studies are addressed. Schedules provide a sense of purpose within the study team and help to drive completion.

The definition of the objective and scope of the study also allows selection of the relevant risk assessment technique. PHA can and should use a range of risk assessment techniques to ensure that risks are effectively understood.

Techniques can be categorised as qualitative, semi-quantitative and fully quantitative, although PHA will normally employ a technique from the first two categories. A list of risk assessment techniques is given in Appendix 3 – Risk Management.

When selecting techniques the following three aspects need to be considered:

- Identify available inputs and required deliverables
- Determine the level of detail required of the assessment
- Identify the competency available

More information on selection of techniques is given in Appendix 3 – Risk Management.

An important aspect of setting the objective and scope of the study is the definition of risk acceptance criteria so that the identified risks can be assessed for their tolerability. A description of such criteria including recommendations of values is given in Appendix 3 – Risk Management.

2.4.3 Information Available and its quality

In general terms, the more information and knowledge available to the study, the more comprehensive the PHA will be. This demands that the relevant PSI is current, well organised, available and complete.

An information package shall be prepared to support the study. All information must be verified to confirm its accuracy and validity. This will include but not be limited to the following:

- PEFSS
- PFSs

- Cause and effect diagrams
- Instrument and alarm summary
- Operating manual
- Plot plan
- List of recent modifications
- Organization chart
- Equipment data sheet
- Chemical/ Material Safety Data Sheet
- Design philosophy/basis
- Past PHA reports
- Incidence reports (internal and external)
- Past maintenance and inspection records

2.4.4 Personnel and Experience

To produce good PHA results, the team composition and its experience are critical. The leader should have good interpersonal and leadership skills as well as a thorough knowledge of the PHA tools and techniques being applied. Other participants must be able to provide detailed knowledge in their area of expertise. The size of the team and its composition will depend on the complexity of the process system considered and assessment technique selected. Typically, team composition can be separated into 3 categories: Leader, Scribe and Members. The attributes and role of assessment teams is discussed in more detail in Appendix 3 – Risk Management.

The PHA Leader shall be identified by the PHA System Custodian from a pool of competent PHA Leaders. The PHA System Custodian shall identify team members (core and non-core members) and a Scribe (full-time scribe or another PHA team leader as scribe). The PHA Custodian shall confirm availability of team members within the proposed schedule and approach the team members' managers for their agreement to release the team members for the required period. Based on this, the schedule shall be finalised and issued.

2.4.5 Schedule and Execution

The PHA activity should be executed with minimum interruptions and the desire to meet the schedule should not compromise the quality of the study. Appropriate location, and well equipped meeting rooms are also important to promote and support the discussions.

PHA involves the review of whole facilities and is generally resource intensive. Therefore, it requires more elaborate planning and preparation to ensure success. It also presents a challenge for the PHA Leader to keep the team members focused and involved throughout the meetings, in addition to ensuring a conducive environment for the meeting. It requires an active follow-up process to ensure effective implementation of PHA recommendations.

The HCU/OPU shall designate a focal person to review and issue the projected PHA schedule on a yearly basis and revise the schedule on a quarterly basis. This will allow ample time for notification and preparation of the PHA. The focal person shall coordinate the completion of the PHA studies in line with the annual plan.

2.5 PHA COMPONENTS

Conducting the PHA is time consuming particularly with regard to the analysis section. The timetable for conducting the PHA for a facility is generally measured in weeks rather than days.

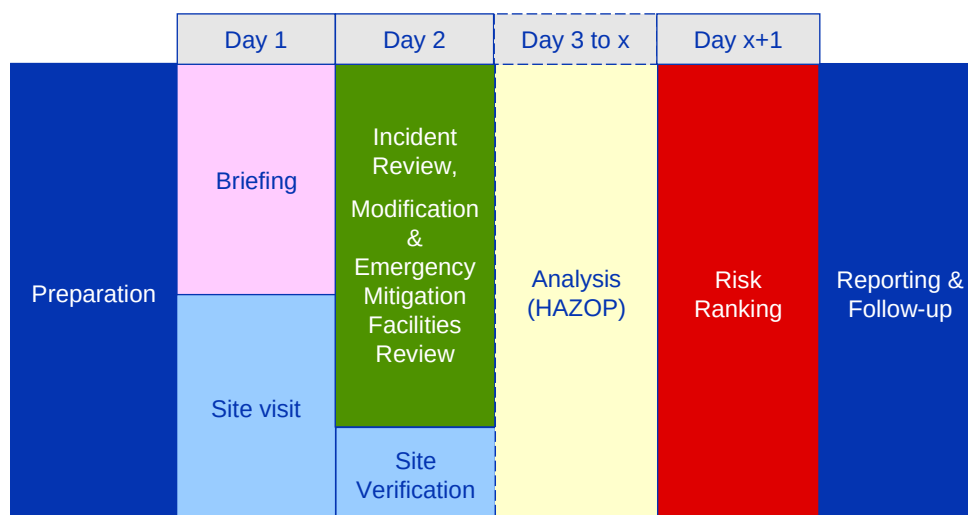


Figure 3 - PHA Components

2.5.1 Preparation

In preparing for a PHA attention should be paid to:

- Administration of the PHA – The room, the equipment needed, daily programme, refreshment availability, etc.
- Notification and availability of personnel
- Availability of suitable documentation – Readable, available and identifiable.

Typically, the team leader shall conduct this activity, but in some cases, such as where the team leader is from outside the HCU/OPU, this may be completed by another person nominated by the PHA System Custodian.

The team leader shall make himself familiar with the process system in question and prepare the documentation required to proceed with the PHA. This should include the information to enable the chosen PHA technique to be applied, such as checklists and guidewords, and the development of a plan to apply the technique in a coherent consistent manner for the duration of the PHA. This may include the segmenting the process system to facilitate assessment.

2.5.2 Briefing and Site Visit

The team leader should brief the team members on the purpose, objective, and scope of the PHA. Ideally this should be performed on the first day of the study and will influence the content and emphasis of the study, setting clear expectations of the PHA outcome. It also allows the team leader to introduce the team members to the PHA process and risk assessment technique.

This will be followed by a site visit to the facility. The objective of the site visit is to enable the team members to visualize the system during the analysis. It involves general observation of the unit, looking for potential sources of leakages such as vibration, hammering, etc., and siting (accessibility, boundary, spacing, etc.)

2.5.3 Modification Review

The purpose of the modification review is to identify any changes to the process system that have not been reflected in the available documentation and to ensure that the PHA team is aware of the extent of the changes. Generally this will be achieved by reviewing the applicable MOC Change Log.

The team leader should keep in mind that changes affecting the process system in question may have occurred outside the boundary of that process system, typically upstream, and so should question knowledgeable personnel accordingly.

2.5.4 Incident Review

This step is necessary to focus attention on any incidents that have occurred internally in the facility and externally in similar facilities. The objective is to determine that the recommendations arising from these internal incidents have been implemented and are in-place. The team will also look into the external incidents and discuss whether the recommendations from the external incidents need to be incorporated. The PHA Leader will take note and ensure any points are addressed later during the analysis of the affected section.

2.5.5 Emergency Mitigation Facilities Review

The purpose of conducting an Emergency Mitigation Facilities Review is to identify critical issues with regards to the process unit capability to handle an incident. It focuses on the facilities available to manage the effects of a process hazard event such as fire, explosion, toxic release, and spillage. These facilities may include fire fighting equipment, detectors, evacuation routes and muster points, containment and isolation devices. The HCU/OPU shall develop a checklist for conducting EMFRs to address their specific situation, environment and emergency response strategy.

The EMFR may result in recommendations regarding the emergency response facilities considered. These recommendations should be included in the results of the PHA for tracking and close-out.

An example of an EMFR is included in Appendix 1 – Example of Emergency Mitigation Facilities Review.

2.5.6 Physical Verification of Process Area

The physical verification activity is intended to establish the facilities capability to deal with an incident and to confirm that assumed safeguards are present and operational. Factors that are taken into considerations are conditions of the equipment, accessibility, egress and ingress issues, design issues, illumination etc. A checklist, PFS and plot plans should be made available. A fire officer or HSE Representative shall be present during this stage. This should be done in conjunction with the EMFR.

2.5.7 Detailed Analysis

A range of assessment techniques are available to the study team, and guidance on the selection of techniques is included in PTS 60.0107 Design, and in Appendix 4 – Risk Assessment Techniques and Appendix 5 – Application of Risk Assessment Techniques. Whatever methodology is used the PHA team leader shall be experienced as defined in Appendix 3 – Risk Management and the team should have awareness of its use.

HAZOP has been a widely used PHA technique throughout PETRONAS. However, in certain circumstances other tools should be applied as they are more appropriate. Therefore PHA Leaders should be experienced in more than one technique and aware of a range of techniques.

Indeed, in some cases it may be necessary to use more than one technique within a PHA. For example a SIL/ LOPA assessment may be necessary to support the HAZOP on a facility including a furnace as the furnace control system may be a critical safeguard.

Suitable recording formats shall be used to ensure the results are captured in a concise, accurate manner. Sufficient notes should be taken to support the findings and recommendations made by the study team. The use of specific software tools may be preferable, but only if the scribe is proficient in their use. See Appendix 3 – Risk Management for more information.

2.5.8 Risk Ranking

Risk ranking shall be done at the end of the study once all the existing and proposed safeguards have been identified. The objectives of risk ranking are to measure risk associated to the facility which has been defined by PETRONAS and provides links between likelihood of occurrence and the impact/consequence. The method and acceptance criteria for risk ranking are defined in PTS 60.[HOLD] Risk Assessment Matrix.

Risk ranking is a qualitative exercise using the team members' collective judgement. The value of the session depends greatly on their experience in PETRONAS or in a similar organisations and their knowledge on similar facilities through networking, external incident or lessons learnt databases, etc.

The risk ranking shall include impact on people, asset (including loss of production), environment, and reputation. For the purposes of explanation the PETRONAS Risk Assessment Matrix is reproduced in the following section. However, the actual PTS 60.[HOLD] should be referred to for the purposes of completing the risk ranking.

2.5.9 Consequence Analysis

When analysing consequence, the credible worst case consequence on any category (people, asset, environment, or reputation) shall be taken (example 1). Existing safeguards that would have eliminated or minimised the consequence are assumed to be non-existent (example 2). Refer to PTS 60.[HOLD] PETRONAS Risk Assessment Matrix for more information.

2.5.10 Probability Analysis

When analysing probability, the availability of existing safeguard(s) which reduce the likelihood or frequency of the hazard from occurring shall be taken into account. This judgement shall be made based on incidents within the PETRONAS group and the industry. The failure rate of the existing safeguards shall also be taken into account when analysing probability. Refer to PTS 60.[HOLD] PETRONAS Risk Assessment Matrix for more information.

2.5.11 Recommendations

Although the identified risk can be a basis for the prioritisation of the associated recommendations, other factors need to be considered such as:

- Compliance with legal and other requirements
- Ease of implementation
- Resource availability
- Cost/ budget