



FIRE PREVENTION ANALYSIS (FIREPRAN)

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HSE MANUAL AMENDMENT RECORD SHEET

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1. **INTRODUCTION**

1.1 **OBJECTIVES OF THIS DOCUMENT**

FIREPRAN incorporates a number of changes from earlier versions as follows:

- refinement of the technique to match terminology of the hazards and effects management process (HEMP) approach focusing on inherent safety, causes, control measures and consequence mitigation measures
- simplification of the earlier guideword and expander approach into an objectives and guidance approach
- identification of hazards assisted with a hazard prompt structure
- evaluation of fire and explosion escalation events using hazardous event scenario development sheets
- comparison of threat control (prevention) and recovery (protection) measures with facility Fire and Explosion Strategy (FES)
- incorporation of accepted study recommendations into a Hazards and Effects Register.

1.2 **OBJECTIVES OF FIREPRAN**

Employing FIREPRAN at the design and/or operations phases of a facility or installation, or during a subsequent expansion or redevelopment phase helps to achieve the following objectives:

- overview the role of the facility or installation and its significance to the OPU / JV
- review the facility or installation FES in the context of the role of the facility and its significance to the OPU / JV
- provide clear and systematic identification of fire and explosion related hazards and hazardous events as follows:
 - analyse threats to loss of containment or other potential sources of combustion events
- assess release event consequences in terms of unignited releases as well as fire and explosion scenarios
 - review and assess adequacy of threat control measures
 - review and assess adequacy of mitigation and recovery measures

- make recommendations for risk reduction measures to achieve levels as low as reasonably practicable (ALARP)
- contribute to HSE Case Hazards and Effects Register development and updating.

1.3 RELATIONSHIP BETWEEN FIREPRAN AND HSE CASES

The HSE Case is the prime means of demonstrating that hazards and effects associated with a particular operation or facility have been identified, assessed and threats controlled. It also documents that hazardous events, resulting from loss of containment of a hazard, have been identified, with appropriate mitigation and recovery measures in place.

FIREPRAN effectively generates or reviews a subsection of the facility HSE Case. The integration of information is achieved as follows:

- the study uses relevant parts of the hazards and effects hierarchy as a prompt to assist hazard identification
- if a developed Hazards and Effects Register already exists its sections on hazards related to fires and explosions should be used as a starting point for the study
- the fire and explosion scenario studies permit the consequences of an ignited hazard release to be reviewed and current threat control and mitigation measures to be assessed for adequacy
- where review recommendations are accepted for implementation, the Hazards and Effects Register and HSE Case (of which it forms part) can be updated accordingly.

Successfully implemented, the FIREPRAN technique can encourage the development of appropriate measures that reduce risk to ALARP.

1.4 HAZARDS AND EFFECTS MANAGEMENT PROCESS (HEMP)

1.4.1 General

HEMP provides a structured approach to the analysis of hazards and their potential effects on facility and installation design, construction and operations, right through to decommissioning.

The individual activities that form the HEMP are as follows:

- identify hazards and potential effects (hazardous events)
- evaluate likelihood and severity of consequences, i.e. risk
- record hazards and effects

- assess control and recovery measures
- compare with objectives and performance criteria
- establish measures needed to reduce risk to tolerable levels and demonstrate that no further cost effective risk reduction measures can be found.

HEMP is covered in detail in PTS 60.0401 Hazards and Effects Management Process.

An FES, which in PETRONAS forms an integral part of an HSE Case, records the conclusions of the HEMP as it applies to fires and explosions and determines the measures required to manage the hazardous events and the role of these measures. This is fully described in Appendix V.

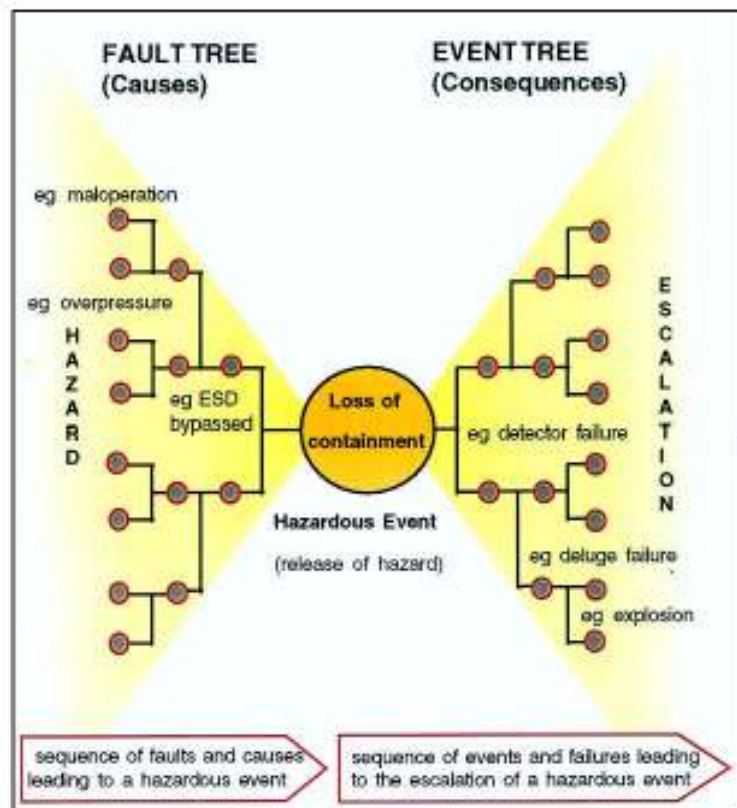
FIREPRAN is one of the techniques available within HEMP and can be used in the establishment or in the review of an FES.

The process uses primarily the experience and judgement of personnel involved in the design, operation and maintenance of the facility or installation being evaluated. The process is supported by checklists, codes and standards.

1.4.2 Terminology

In order to be consistent with HEMP terminology the traditional terms 'fire hazard' and 'explosion hazard' have in most cases been replaced with the term 'hazards related to fires and explosions'. Within the Petroleum and Petrochemical Industries these are predominantly produced hydrocarbons.

This change in terminology recognises the fact that in all but a very small minority of cases a 'hazard release' does not immediately result in a fire. This sequence of events requires the presence of an ignition source. Control of ignition sources can form part of both threat and escalation controls within the HEMP process. The sequence of events from hazard through to hazardous events is shown in the causation-consequence diagram in Figure 1.1

Figure 1.1 Causation-Consequence Diagram

1.5 UNDERSTANDING RISK

Within the industry risk is defined as the combination of two factors. These factors are:

- chance or probability that a particular event or set of events will occur
- severity of the consequences should the event or events occur.

Any management measures to reduce risk cannot act upon risk directly but can act upon its two factors, chance (often referred to as likelihood) and severity of consequences.

This is done with threat control measures to reduce the likelihood of a release event and with mitigation/recovery measures to reduce the severity of consequences. For this reason, where the words risk reduction is used in this document, they refer to measures that reduce likelihood, mitigate the severity of consequences or both. These measures apply both to an initial release event (usually called a top event) and any subsequent escalation.

Fire and explosion hazard management performance objectives for a facility or installation are normally included in a 'philosophy' or 'strategy' document. This strategy sets the objectives and performance criteria for control and recovery

measures, from corporate goals down to operational criticality, including systems availability and required reliability (refer to Appendix V).

The FES, which is also included in the HSE Case if this exists, includes objectives and screening criteria that permit assessment of the tolerability of consequences. The tolerability of the consequences of major hazardous events (e.g. storage tank boilover) may have to be judged regardless of likelihood. Frequently though, simple threat control measures can be applied to prevent occurrence of hazardous events of this type.

As with other risks, those due to fire and explosion can be presented as a Risk Matrix (refer to PTS 60. 0401) by plotting frequency as one axis and consequences as the other. The consequences can be grouped in terms of people, assets, environment and reputation, including cost.

1.6 SCOPE OF THE FIREPRAN TECHNIQUE

Both onshore and offshore facilities can be evaluated using FIREPRAN although it is important that each OPU/ JV assess whether this qualitative technique meets all their needs. FIREPRAN focuses not only on identifying potential fire and explosion scenarios in a facility but also on whether the prevention and protection measures in place meet the screening criteria in the FES for the facility. Before employing it they should consider what other qualitative and quantitative tools, such as Quantitative Risk Assessment (QRA), Emergency Systems Survivability Analysis (ESSA), Escape, Evacuation, Rescue Analysis (EERA), may be needed, to give a depth of output data appropriate for the decision making process. This is especially true with highly complex or strategically important facilities including large offshore platforms or onshore facilities.

The earlier in the life cycle of a facility the study is carried out (e.g. design stage) the greater the benefits from its use in terms of risk reduction. A limited FIREPRAN could be performed during conceptual design, a more detailed study during the early stages of detailed design and a verification study during the later stages of detailed design.

A FIREPRAN study can therefore be used in the design stage to assist in the preparation of the FES. Where a current Safety or HSE Case exists for a facility, then a FIREPRAN review can become the assessment and verification of the fire and explosion section of the Case.

FIREPRAN focuses on the management of hazards and effects related to fires and explosions. It does not address the following:

- fire system specification and engineering for which information can be found in the relevant PETRONAS TECHNICAL STANDARD (PTS) documents and application of which will require further input from specialists
- quantification of risks and the subsequent influence on the recommendations as in some cases QRA may be required to support the study recommendations for risk

reduction measures

- detailed identification of hydrocarbon production and processing hazards which may need to be addressed with a Hazard and Operability (HAZOP) study before the FIREPRAN study commences
- highly detailed fire response scenarios that can be used by fire brigades and operators directly. These need to be further developed separately along with the appropriate fire and explosion preplanned responses

1.7 RELATIONSHIP WITH OTHER DOCUMENTS

For information on controlling threats to hazards and mitigating fire and explosion hazardous events this team review technique assumes that reference will be made to:

- PTS 60. 0107 Design
This section describes the design, control and recovery measures for prevention of and protection against fires and explosions.
- PTS 60.2303 Fire Control and Recovery
This section describes the measures taken in the operations phase to prevent, control and recover from fires and explosions.

FIREPRAN identifies where the measures in place or in design do not meet the requirements of the FES.

As stated above in 1.4.1, FIREPRAN can be considered as a technique available for the establishment or review of an FES which in PETRONAS forms an integral part of an HSE Case. That part of the HSE Case relating to fire and explosion could therefore be prepared using THESIS or conversely the results of a FIREPRAN exercise can be effectively recorded on the THESIS database together with the result of other investigations and reviews.

2. FIREPRAN OVERVIEW

2.1 INITIAL CONSIDERATIONS

A description of what to do at each stage of the FIREPRAN procedure begins at chapter 3 and each subsequent chapter uses a similar format of objectives and guidance on how to achieve them. Figure 2.1 contains a schematic representation of the complete FIREPRAN process. The findings at each stage of the study should be recorded.

Details on building a FIREPRAN study team and selecting its members are given in Appendix I. The role of brainstorming in ensuring a balanced and detailed approach to the study is covered in Appendix I (see I.6). This is accompanied by a general list of the information required to start the study with more detailed information in Appendix II.

2.2 SCOPE OF THE STUDY

The technique starts by confirming the scope and boundaries of the study. Interfaces with other plant around the facility or installation should be clearly defined and agreed by the study team. This is dealt with in Chapter 3 of this document.

2.3 REVIEW THE ROLE OF THE FACILITY

The criticality of the facility or installation, to the OPU / JV is examined and interdependencies established. This is dealt with in Chapter 4 of this document.

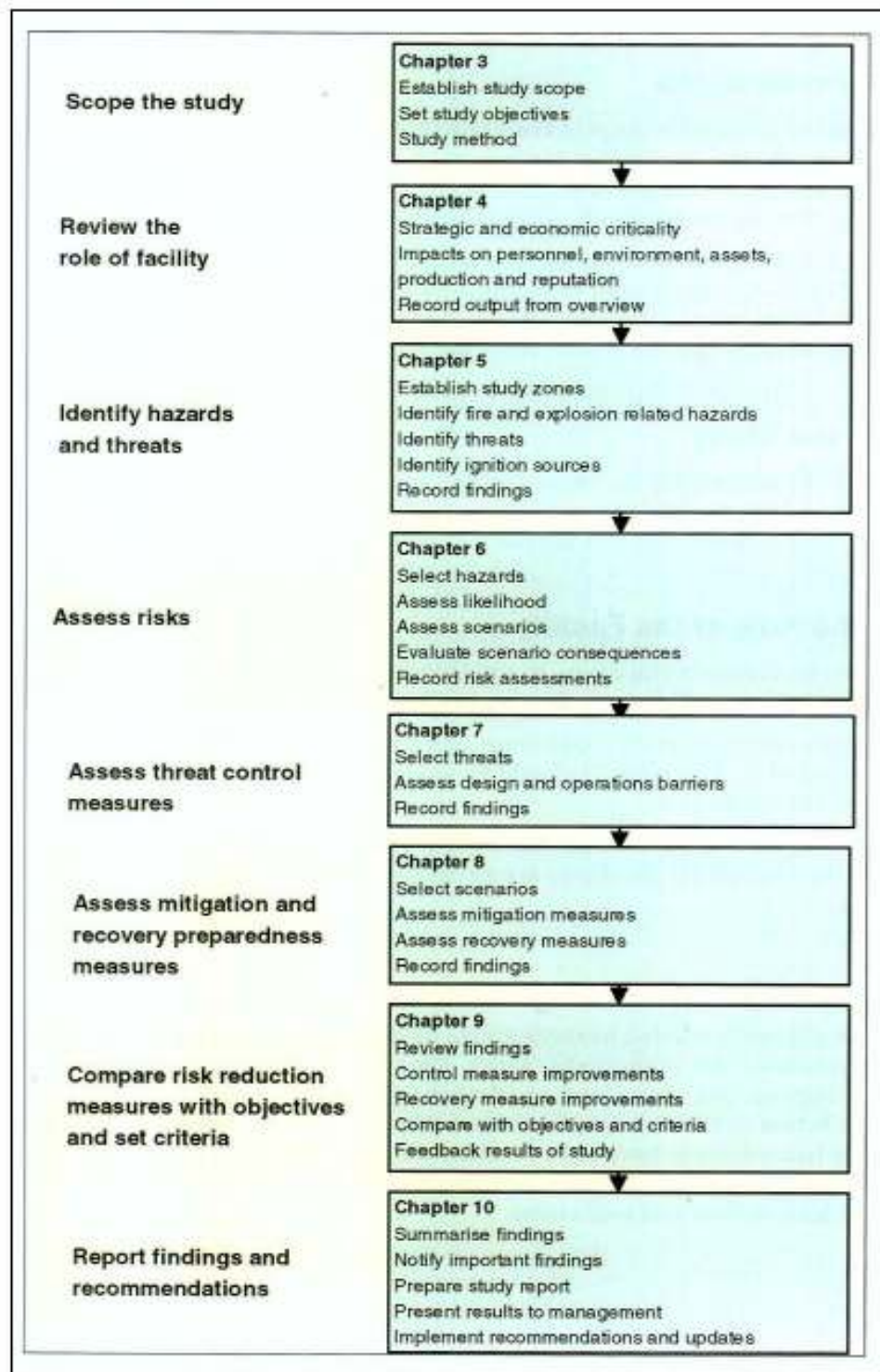
If FIREPRAN is being used as a review technique, then an FES for the facility or installation (as described in Appendix V) should be available. The FES is reviewed in the context of the plant criticality.

If an FES or HSE Case does not exist, then the FIREPRAN review should be postponed until the FES and the underlying objectives are developed and accepted by management.

2.4 IDENTIFY HAZARDS

Identifying fire and explosion related hazards starts by dividing the facility or installation being reviewed into manageable areas. Area boundaries are normally formed by physical segregation of one form or another, a fire barrier, the perimeter of the facility or installation or division may be achieved by identifying areas with similar types of risks. Once hazard areas have been established the hazards they contain should be identified together with causes or threats that could result in hazardous events which could lead to fires and explosions.

Figure 2.1 Schematic of overall FIREPRAN process



The hazard identification process also includes non-hydrocarbon flammable materials that could be ignited and generate significant fire and possibly explosion scenarios. This is dealt with in Chapter 5 of this document.

2.5 ASSESS RISKS

The likelihood and severity of the consequences, primarily fire and explosion scenarios, should be analysed in detail and their potential impact on personnel, environment, assets, production and reputation, fully evaluated. This is dealt with in Chapter 6 of this document.

2.6 ASSESS THREAT CONTROL MEASURES

Once opportunities for improving inherent safety and designing out hazards altogether have been exhausted, threat control measures should be assessed as the next priority for risk reduction.

Control of ignition sources including hazardous area designation should be reviewed as well as size and control of flammable inventories and other materials. This is dealt with in Chapter 7 of this document.

2.7 ASSESS MITIGATION AND RECOVERY PREPAREDNESS MEASURES

Controls associated with mitigation and recovery preparedness measures proposed in design or currently in place should be reviewed. This process is assisted by using the Fire and Explosion Scenario Worksheets in Appendix IV. The adequacy of these measures should also be evaluated against the objectives and criteria in the FES. This is dealt with in Chapter 8 of this document.

2.8 COMPARE RISK REDUCTION MEASURES AGAINST FES

2.8.1 General

Threat controls and mitigation or recovery preparedness measures that have been identified earlier in the study should be recorded. These should be compared with the requirements of the FES. Improvements and remedial measures should then be recommended. This is dealt with in Chapter 9 of this document.

2.8.2 Inherent safety improvements

Compare the inherent safety of designs with the requirements of the FES. Opportunities for improvement, achieved by designing out hazards altogether should be the first step in achieving risk reduction measures and meeting the requirements of the FES.

2.8.3 Threat control measures

Existing arrangements (whether in design or installed on an existing facility) should be compared against the FES.

Recommendations for improvements in threat control measures can then be made where deficiencies have been identified.

2.8.4 Mitigation and recovery preparedness measures

Existing or design fire and explosion mitigation and recovery preparedness arrangements should be addressed in this phase of the study bearing in mind the performance needed to reduce the consequences of the fire and explosion scenarios developed from the analysis of potential fires and explosions. Existing mitigation/recovery measures should be compared with the FES.

Recommendations for performance-based improvements in mitigation and recovery measures should then be made where deficiencies are identified.

2.9 REPORT FINDINGS AND RECOMMENDATIONS

The study should clearly identify hazards and create an auditable trail to the final recommendations. These should be submitted to management for review and approval.

The approved recommendations from the study should be used to develop a remedial work plan which includes the improvements in threat control, mitigation and recovery measures identified as necessary to meet the requirements of the FES and form part of the facility HSE Case if this exists. This is dealt with in Chapter 10 of this document.

3. STARTING THE STUDY

3.1 ESTABLISH STUDY SCOPE

The technique starts by confirming the scope and boundaries of the study. Interfaces with other plant around the facility or installation should be clearly defined and agreed by the study team.

3.2 SET STUDY OBJECTIVES

Once the scope has been established the objectives of the study should be set as follows:

- review FES to see if it contains objectives and criteria that cascade down from policy to performance and are adequate to serve as a yardstick for the study
- review the criticality of the facility or installation in overview to establish interdependencies and ensure the FES is adequate and appropriate in this respect
- establish convenient hazard areas to facilitate effective hazard identification
- identify hazards and potential causes of top events
- assess the risks in terms of likelihood and consequences of release event scenarios

- review threat control measures
- review mitigation and recovery measures
- compare the review results against the requirements of FES
- identify deficiencies and opportunities for improvement of risk reducing measures
- report findings and recommendations
- note accepted recommendations for update of the facility or installation, Hazards and Effects Register and HSE Case.

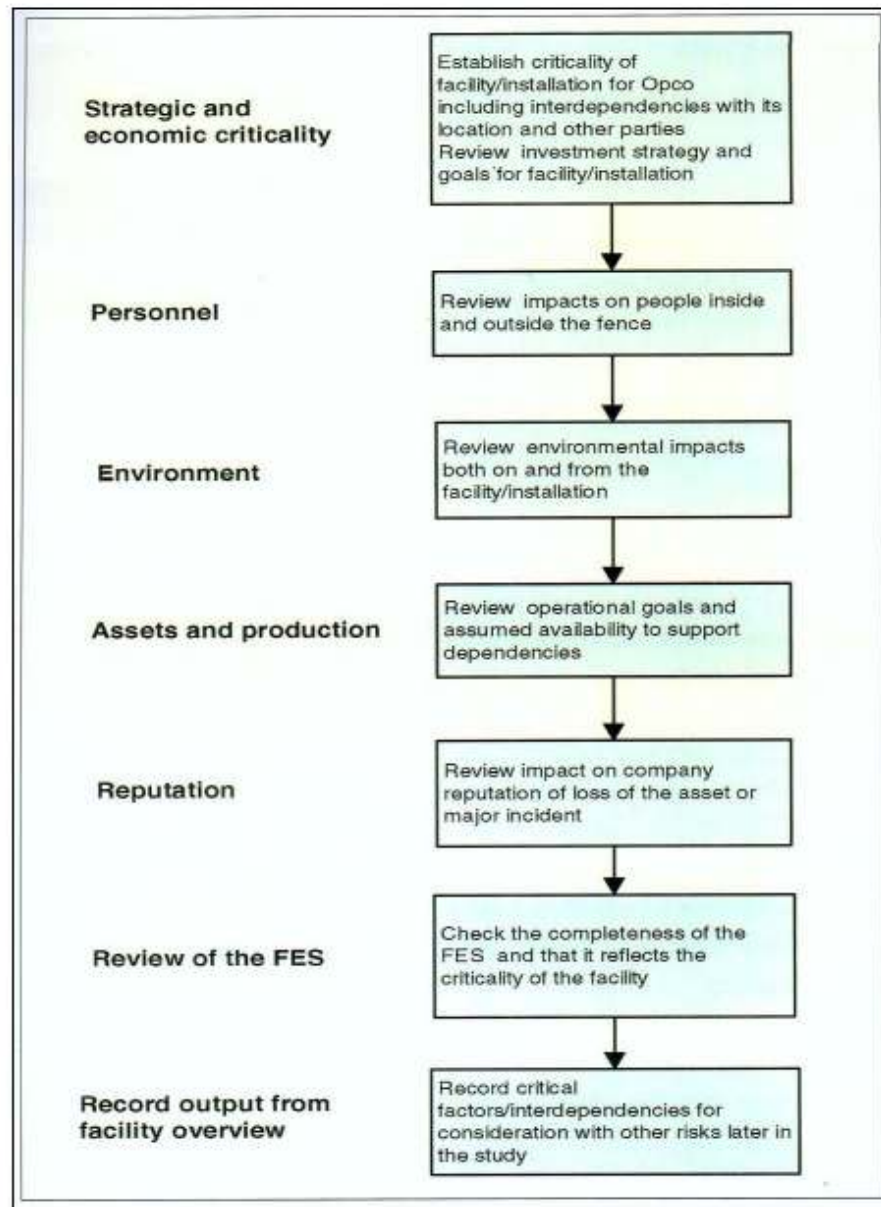
3.3 STUDY METHOD

Once a plant area has been identified for study the 'hazard areas' chosen should be addressed individually. Both threats leading to potential top events and consequences of these events should be thoroughly reviewed before moving on to the next area. When all the areas have been reviewed any interaction between them can be considered. The brainstorming potential of the study team should be employed to ensure all possibilities are covered even though some may be discarded later. Brainstorming is covered in Appendix I.

The selected hazard areas should be entered on numbered Fire and Explosion Scenario Worksheets (see Appendix IV) to permit organised development and tracking of the hazards and risk reduction measures in place or required in each area. These worksheets also facilitate the development of incident scenarios. This allows assessments to be made as to the effectiveness of the risk reduction measures, when compared to the requirements of the FES. The following chapters describe the method in full.

4. REVIEW THE ROLE OF THE FACILITY

The criticality of the facility or installation to the OPU / JV is examined and the interdependencies established. The steps are shown in Figure 4.1 below.

Figure 4.1 Facility or installation overview

4.1 STRATEGIC AND ECONOMIC CRITICALITY

This part of the study has the following objectives:

- establish the reasons for the facility's existence and planned duration of operations
- establish the impact of construction and operation on the OPU / JV, its partners, third parties and the country in which it is located

- establish impact of total loss/long term non-availability of the facility as it affects
 - OPU / JV
 - partners
 - third parties
 - national government.
- establish its contribution to OPU / JV and partner investment and revenue
- review energy inputs and outputs from the facility
- consider any other significant impacts on or from the immediate environment.

The following aspects should also be taken into consideration:

- location
- purpose
- interfaces
- duration
- capacity/throughput
- contractual relationships (e.g. supply of fuel gas to local industry)
- geographical factors (e.g. proximity to a population centre or major shipping lanes)
- political and economic impact (e.g. impact on the local economy)
- insurance coverage.

4.2 PERSONNEL

Once an overview of the strategy for the whole facility has been completed the study should then consider:

- legal and standards framework in which the facility must operate
- groups of personnel at risk from the facility (especially employees and contractors)

- personnel risks to the facility
- risks to and from third parties.

4.3 ENVIRONMENT

This should consider:

- environmental impact of the facility
- environmental impact on the facility.

4.4 ASSETS AND PRODUCTION

4.4.1 Assets

This should consider:

- the value of the asset and its replacement cost
- its importance for the OPU / JV
- national considerations
- time needed to replace it if lost.

4.4.2 Production

This should consider:

- operational objectives and critical performance criteria
- required availability of the facility
- dependence of other facilities on the above availability
- dependence of the OPU / JV facility on external sources of energy or feedstock
- what proportion of the overall OPU / JV production the facility represents
- whether the facility is a basis for future development.

4.5 REPUTATION

This should consider the effect on the way the OPU / JV is viewed by JV partners or shareholders, the public, the host country, etc. if a major incident results in loss of life, environmental damage, loss of jobs and impacts, for example, a national economy.

4.5.1 Review of the FES

If the FIREPRAN is for review purposes then the FES should be checked to ensure that it adequately reflects the criticality of the facility as established in the foregoing steps.

The overall adequacy of the FES, or that section of the HSE Case relating to fire and explosion, should be reviewed to ensure that it contains all the required information (see Appendix V). The FES should include the identified hazards, the risks and the alignment with the overall HSE MS objectives. If the FES is lacking any information then the review should be postponed until it is developed. (see 2.3 above).

4.5.2 Record Output from Facility Overview

The facility overview establishes the following:

- pulls together global considerations that may not have been evaluated as an integral package
- acts as a reminder for interdependencies that have been overlooked
- assists the focus of the more detailed hazard identification studies
- helps assess the suitability of the FES
- provides part of the basic justification for the FIREPRAN study.

This output should be recorded for later reference.

5. IDENTIFY HAZARDS AND THREATS

The required steps for this aspect of the FIREPRAN review are given in Figure 5.1. Identifying fire and explosion related hazards starts by dividing the facility or installation being reviewed into manageable zones or areas. Zone boundaries are normally formed by physical segregation of one form or another, a fire barrier, the perimeter of the facility or installation or division may be achieved by demarcating zones with similar types of risks. Once hazard zones have been established the hazards they contain should be identified, together with threats that could result in release events leading to fires and explosions.

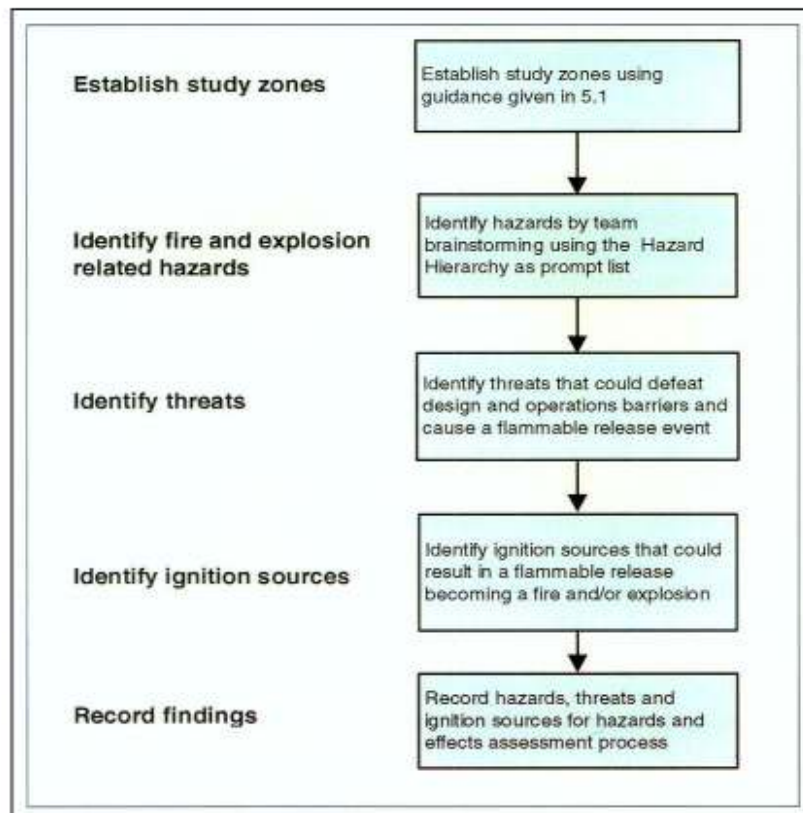
5.1 ESTABLISH STUDY ZONES

Establish study zones with the potential for fires and explosions as follows:

- divide the facility or installation into manageable zones for analysis and assessment
- focus the team on particular zones in sequence
- establish the criticality of the plant and equipment in each zone.

The zone boundaries can be set for convenience as follows by:

- identifying similar zones (e.g. compressor trains) and dealing with them as generic cases to avoid excessive repetition
- focusing particularly on main processes, major equipment, activities and normally manned areas.
- using physical segregation of one form or another, e.g. a fire barrier, different type of plant or the perimeter of the facility or installation
- using boundary definitions in the available drawings, where studies are carried out at the design stage
- choosing different types of plant such as production, process plant and utilities
- agreeing the criticality of equipment (which should take into account short term alternative production arrangements, future spare capacity, etc)
- looking at major activities and normally manned areas.

Figure 5.1 Identify fire and explosion related hazards

Once the nominal, facility or installation hazard zones have been established, the process of hazard identification can start. Hazards will not, of course, all be of the hydrocarbon type although these are likely to be the major ones. Other hazards relating to fire and sometimes explosions are found in control rooms, transformer rooms, switchgear rooms, turbine enclosures and even accommodation modules.

A zone can be set aside for 'general' hazards. The list below can assist in the discussion on hazards, threats, top events and recovery preparedness measures which are generic to a particular site as follows:

- ignition sources such as lawn mowers, electrical equipment/fittings faults, hot work, vehicles, lightning, lighters, matches, static electricity, off-site fires, hot surfaces, mobile communications equipment, etc
- migration of potential gas clouds outside designated non-hazardous zones, vehicle traffic on and offsite, manual sampling and drainage related events
- threats to the firewater supply and distribution system
- hazards associated with construction
- hazards and threats from concurrent operations.

5.2 IDENTIFY HAZARDS

The steps for the hazards and threats identification process are as follows:

- identify those features with a significant potential for harm (e.g. hydrocarbons under pressure)
- identify potential ignition sources that could result in ignition of a release
- identify non-hydrocarbon sources of flammable materials capable of generating significant fire and explosion scenarios
- identify potential ignition sources of non-hydrocarbon flammables, e.g. cable insulation, electrical equipment, lube oil, etc.

5.2.1 Guidance on hazard identification

A FIREPRAN study is primarily concerned with hazardous materials that can be the source of fires and explosions as follows:

- hydrocarbons (gas and liquid)
- combustible solids (especially small particles or dusts)
- combustible non-hydrocarbon gases and liquids
- cable insulation and electronic equipment.

The hazard identification process should consider hazards arising from plant as follows:

- production (wellheads, conductors, flowlines, storage, piping systems, etc)
- process plant
- utilities
- power generation
- control rooms
- accommodation modules etc.

And from activities as follows:

- drilling activities (e.g. blow-out)
- operations activities (e.g. operator error)

- maintenance activities (e.g. incorrect isolation)
- construction activities (e.g. welding, dropped objects)
- transport activities (e.g. vehicle collision with a flowline)
- marine activities (e.g. ship collision with a riser).

Ignition sources may ignite combustible materials causing fires and/or explosions. Since FIREPRAN deals with the management of hazards related to fires and explosions it is logical to identify the potential sources of ignition at the same time as potential flammable releases.

The initial hazard identification exercise is assisted by using sections of the hazards and effects hierarchy found in Appendix III. Not all sections of the hierarchy will be applicable but it does provide a good checklist to improve identification of hazards related to fires and explosions. The hazard categories related to fires and explosions in the hazards and effects hierarchy are as follows:

- H-01 hydrocarbons (flammable hazard)
- H-02 refined hydrocarbons (flammable hazard)
- H-03 other flammable materials (combustion potential)
- H-04 explosives (potential explosion)
- H-05 pressure hazards (initiation of hazardous events or escalation)
- H-06/09 potential initiating events
- H-10 hot surfaces (ignition source)
- H-11 hot fluids (possible ignition source)
- H-14 open flame (ignition source)
- H-15 electricity (ignition source from sparks)
- H-16 electromagnetic radiation (possibility of induced electrical energy)
- H-27 potential initiating events

Occasionally other categories may be applicable, e.g. where a physical pressure explosion could damage hydrocarbon plant.

Hazard identification should be as wide-ranging as practicable and make full use of the brainstorming process, exploiting the experience of the study team.

Some parts of the facility may be more likely to produce ignited release events than others. A wide-ranging review of a facility's design and activities, from the perspective of different disciplines, helps to identify where significant risks exist.

HAZOP studies that have preceded a FIREPRAN review can be useful in helping to identify plant or process equipment units that are most sensitive to process upsets, or other threats, that may breach the control barriers in place. Two points to bear in mind are as follows:

- hazards are not always as easy to identify as they seem at first sight and looking for the hidden or the unusual should be part of the team's activities
- success in hazard identification rests upon a rigorous but realistic approach by the study team guided by the team leader.

5.3 IDENTIFY THREATS

In the course of identifying hazards, threats to plant integrity should also be analysed.

HAZOP studies should be a useful source of information on the process and production parts of an installation or facility. Typical examples of sources of threats can be obtained from the following information:

- age of the equipment in service
- service type such as sweet or sour hydrocarbons
- service that is different from equipment's original design intent
- failure mode and effects analysis studies
- maintenance records and failure frequency data sheets providing information on component failure rates
- incident reports from the site studied.

5.4 IDENTIFY IGNITION SOURCES

Examples of typical ignition sources are as follows:

- thermal, e.g. hot exhausts
- mechanical, e.g. friction sparks
- electrical, e.g. electrical sparks or arcs

- chemical, e.g. oxidising agent
- arson/sabotage, e.g. explosives
- natural causes, e.g. lightning.

Ignition sources may be found in a number of locations as follows:

- on site, e.g. electrical switchgear, hot exhausts, hot work, etc
- off site, e.g. motor vehicles, hot exhausts, electrical equipment, etc
- non-certified electrical equipment used in hazardous areas

transient sources, e.g. hot work, construction work, vehicle access to the plant, etc.

Identifying ignition sources forms part of the logical sequence of the study, which includes flammable material releases, ignition sources, subsequent fire scenarios and the escalation that can potentially result from them.

5.5 RECORD FINDINGS

Once the above study sections have been carried out, the hazards and threats, as well as potential ignition sources identified, should be recorded. This information forms the starting point for scenario development. It should be entered on the Fire and Explosion Scenario Worksheets shown in Appendix IV.

6. ASSESS RISKS

The likelihood and severity of release event consequences, primarily fire and explosion scenarios, should be analysed in detail and their potential impact on personnel, environment, assets, production and reputation, fully evaluated. The steps involved are shown in Figure 6.1. The qualitative risk assessment information is used later in the study to see if threat control (Chapter 7), mitigation and recovery measures (Chapter 8) are adequate to meet FES.

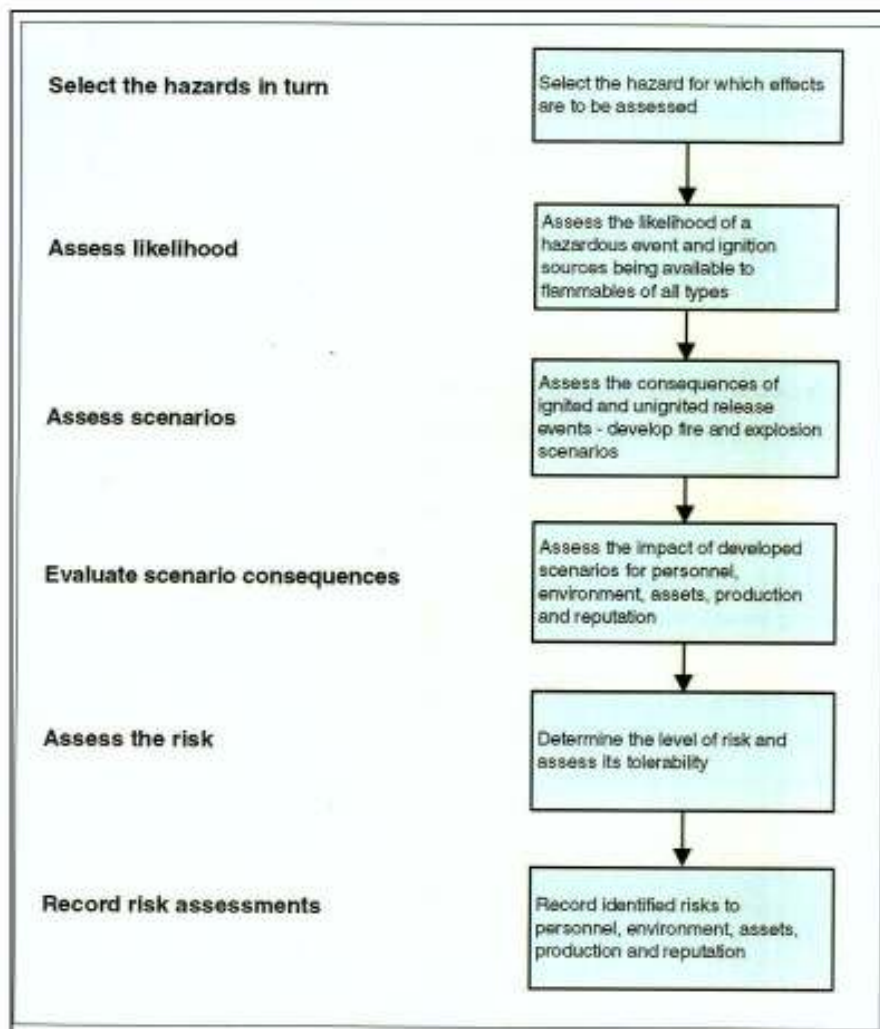
6.1 METHOD

The method for the qualitative risk assessment exercise is as follows:

- select hazards individually from those identified
- assess the likelihood of a top event (usually a release event in the case of hydrocarbons)
- assess the likelihood of ignition of combustible materials available as a result of the event

- assess the severity of ignited release events including potential escalation (develop potential fire and explosion scenarios, see Appendix IV)
- assess the consequences of the developed scenarios for people, environment, assets, production and reputation
- assess the risk from the developed scenarios
- record qualitative assessment (ranking) of risks for later use when assessing threat control, consequence mitigation and recovery measures against the FES.

Figure 6.1 Assess risks



6.2 SELECT HAZARDS

This section of the study commences by selecting hazards in turn from those recorded in 5.5.

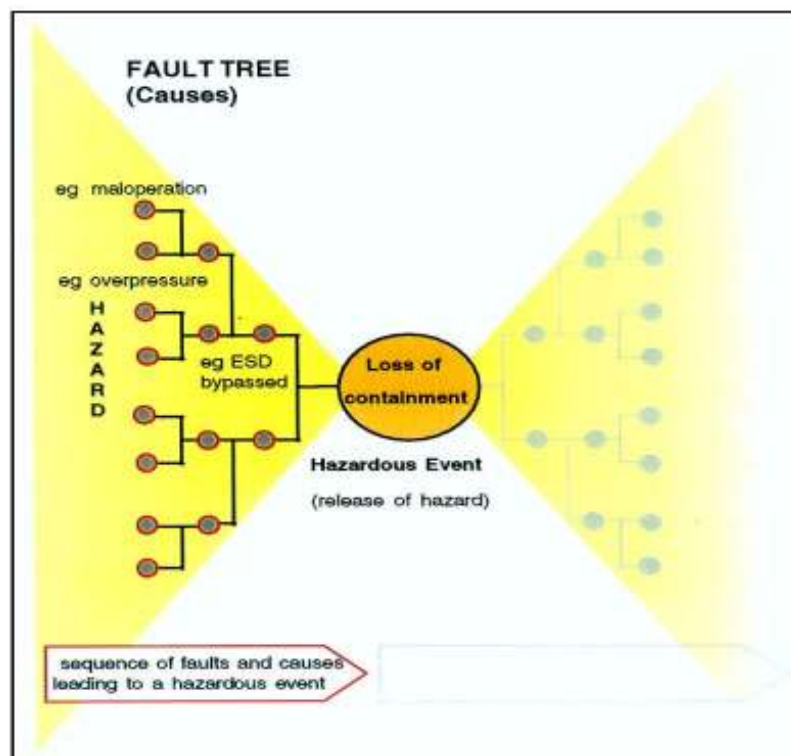
6.3 ASSESS LIKELIHOOD

6.3.1 Release of flammables

Once hazards and threats related to fires and explosions have been systematically identified, the likelihood of threats releasing a hazard and producing a failure should be assessed.

A fault tree approach is useful in tracking failure sequences that could result in a top event. Figure 6.2 illustrates the general approach.

Figure 6.2 Fault tree



Typical failure scenarios resulting in hazardous or top events are as follows:

- flange gasket leak
- small bore pipe failure
- pump seal leak
- pump overheating
- hose failure, etc.

The likelihood of a top event can be qualitatively ranked using the categories for frequency given in the Risk Matrix (Figure 6.4). This allows consideration to be