



UNDERBALANCED AND MANAGED PRESSURE
DRILLING OPERATIONS
- HSE PLANNING GUIDELINES -

Revision 0 – Written and Compiled by: HSE Subcommittee
Date: December 2012 Issue FINAL

1. Foreword	3
2. Introduction	3
3. Planning and Procedures	4
3.1. Performance Monitoring and Review	4
4. UBO/MPD Planning and Implementation	4
4.1. Initial Well Design Phase	5
4.1.1. IADC Well Classification System for Underbalanced Operations and Managed Pressure Drilling.....	5
4.1.1.2. Application Category.....	6
4.1.1.3. Fluid Systems	6
4.1.2. UBO/MPD Hazard Identification.....	7
4.2. Detailed Well Design Phase	7
4.2.1. Risk Management in Design	8
4.2.2. HAZID and HAZOP Studies.....	8
4.2.3. Environmental Impact of UBO/MPD.....	8
4.3. UBO/MPD Planning Phase	8
4.3.1. Operational Procedures	9
4.3.2. Training and Competence Requirements.....	9
4.3.3. Safety Management Support Documents	9
4.4. Pre-execution Phase	9
4.4.1. Training.....	9
4.4.2. HSE Site Management Plan	9
4.5. Execution Phase	10
4.5.1. Learning and feedback.....	10
5. Summary	10
6. Appendix	11
6.1. References	11
6.2. Process Flow Chart for HSE Planning	11 12
6.3. HAZID Process	13
6.4. HAZOP Process	14
6.5. Complementary relationship of the Guidelines	15

1. Foreword

These guidelines contain recommendations from the IADC UBO - MPD Committee and are provided for the use of personnel involved in UBO/MPD drilling operations who may be unfamiliar with the basic risk management requirements.

The mission of this committee is to “promote the safe and efficient execution of underbalanced and managed pressure drilling operations worldwide.” This document is intended for use by integrated project teams involved in the design and implementation of underbalanced and managed pressure drilling operations. It provides information and guidance on *risk management* related activities in the planning phases of an underbalanced drilling operation (UBO) or managed pressure drilling (MPD) project, which have an impact on the hazards and risks of the operation and therefore require detailed care and attention. The principles and recommendations have general relevance, regardless of classification and are applicable to both onshore and offshore UBO/MPD operations.

Each Operator and the Service providers involved in the UBO/MPD project should review and apply the guidelines according to their own policies and experience for the particular area in conjunction with these guidelines, a review of applicable jurisdictional Codes, Specifications, Regulations, Recommended Practices, and Standards is essential.

The guidelines use a number of terms, acronyms, and abbreviations that are in common use in the Oil and Gas Industry. A glossary of terms with appropriate definitions is available on the IADC website. A link to the website is provided in the Appendix. These apply irrespective of any other meaning the words may have in any other context.

IADC publications are available to the general public and may be used by anyone desiring to do so. Every effort has been made by IADC to assure the accuracy and reliability of the data contained in them; however, IADC makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any federal, state, or municipal regulation with which this publication may conflict.

No suggested method, practice, precaution or program set forth in this document shall be deemed to establish a legal standard of conduct or a legal duty, the violation of which would constitute negligence of any degree in any legal proceeding. IADC is not attempting to fulfill any duties or obligations of employers, manufacturers or suppliers to warn, properly train, or equip their employees or others who may be affected by their activities, concerning any health, safety, or environmental risks or precautions.

Nothing contained in this document is to be construed as granting right, by implication or otherwise, use of the IADC name, logo, or trademark, for the manufacture, sale, or use of any method, apparatus, or product.

Suggested revisions to this guidance are invited and will be considered along with future changes to these recommendations. Suggestions should be submitted to the staff representative for the UBO – MPD committee at the International Association of Drilling Contractors, 10370 Richmond Avenue, Suite 760, Houston, TX 77042.

2. Introduction

As with all drilling operations, a comprehensive understanding of the hazards and risks of the activity is necessary prior to planning and organising the work. Therefore, in setting up an Underbalanced Drilling Operation (UBO) or Managed Pressure Drilling (MPD) project, it is critical that the hazards and risks are considered from the very early phases of the project planning cycle.

The Guidelines provide basic considerations that should be followed prior to conducting a UBO or MPD operation. For the purposes of this document the following internationally applicable terms should be recognized:

1) **HAZARD:**

A hazard is something (e.g. an object, a property of a substance, a phenomenon or an activity) that can cause adverse effects.

2) **RISK:**

A risk is the likelihood that a hazard will actually cause its adverse effects, together with a measure of the effect.

A comprehensive IADC Glossary of Terms can be located on the IADC-UBO website at: <http://www.iadc.org/wp-content/uploads/2011/12/UBO-MPD-Glossary-Dec11.pdf>

3. Planning and Procedures

It is critical that the project team understand the hazards and risks of the project and systematically consider and plan for health, safety and environmental (HSE) control from the very early phases of the project. The primary areas of focus in the planning and design phases should include the development of operational procedures, required safety documentation, equipment footprint, training and potential environmental impact. Safe and cost effective planning and management of UBO or MPD, is essential.

The HSE plan should outline the project objectives, the responsible parties, timelines and methods to achieve them. The HSE plan is typically developed from:

- Lessons learned from previous projects
- Learning's from other UBO/MPD projects, both conducted internally and externally
- Audits, inspections and management reviews
- Incident/accident findings
- HSE suggestions from the workforce
- Information available from trade, industry and regulatory bodies

3.1. Performance Monitoring and Review

Performance monitoring and review is a critical element of any HSE plan as it identifies opportunities for improvement. HSE performance can be monitored and assessed including both proactive (leading) measures taken to prevent accidents and incidents and reactive (lagging), which are measures of actual performance against targets.

4. UBO/MPD Planning and Implementation

In traditional project management, a project can be subdivided into the following phases:

- Initial Well Design Phase (Conceptual Design)
- Detailed Well Design Phase (Front End Engineering and Design)
- UBO/MPD Planning Phase (Detailed Design)
- Implementation Phase (Construction)
- Pre-execution Phase Onsite (Commissioning)
- Execution Phase (Start-up)
- Project Completion (Rig down and clear location)
- Document close out and learning

For more detailed information, see Appendix 6.2.

4.1. Initial Well Design Phase

Risk Management planning begins with the conceptual well design. Various design options will be investigated, discussed and some will be discarded. A number of different options may be considered at this stage of the project. However, the selected option will usually be driven by a desire to minimize the hazards and risk to personnel and the environment.

To assist with the classification of wells drilled using UBO/MPD techniques, the IADC has adopted a system that combines the level of complexity with hazard and the UBO/MPD application type (see section 4.1.1). This classification system provides a framework for defining minimum equipment requirements, specialised procedures and safety management practices.

For further information and examples, please refer to the IADC website (www.iadc.org) and other related documents.

The objective of the initial well design phase is to classify the well(s) and thereby determine the scope of the project, equipment and personnel needs from which the plan can be developed.

4.1.1. IADC Well Classification System for Underbalanced Operations and Managed Pressure Drilling.

The purpose of the IADC Well Classification System is to identify the overall risk, application category and fluid system used in underbalanced operations (UBO) and managed pressure (MPD) drilling. Wells are classified according to:-

- Risk Level (0 – 5)
- Application Category (A, B, C or D)
- Fluid System (1 – 5)

4.1.1.1. Risk Level.

Risk increases with operational complexity and potential well productivity. The examples provided here are for guidance only.

Reference should be made to the IADC UBO/MPD Committee document IADC Well Classification system for Underbalanced Operations and Managed Pressure Drilling (see API 92U @ www.iadc.org)

- Level 0:** Performance enhancement only; no hydrocarbon containing zones
 - Air drilling for rate of penetration (ROP) enhancement
- Level 1:** Well incapable of natural flow to surface. Well is inherently stable and is a low level risk from a well control point of view.
 - Sub-normally pressured oil wells
- Level 2:** Well is capable of natural flow to surface but can be controlled using conventional well kill methods. Catastrophic equipment failure may have limited consequences
 - Abnormally pressured water zones
 - Low flow oil or gas wells
 - Depleted gas wells
- Level 3:** Geothermal and non-hydrocarbon bearing formations. Maximum Anticipated Shut-in Pressure (MASP) is less than the UBO/MPD equipment pressure rating.
 - Includes geothermal wells with H₂S present

Level 4: Hydrocarbon bearing formation, maximum anticipated shut-in pressure is less than UBO/MPD equipment operating pressure rating. Catastrophic equipment failure will likely have immediate serious consequences.

- High pressure and/or high flow potential reservoir
- Sour oil and gas wells
- Offshore environments
- Simultaneous drilling and production operations

Level 5: Maximum anticipated surface pressure exceeds UBO/MPD equipment operations pressure rating. Catastrophic equipment failure will likely have immediate serious consequences.

- Any well where MASP is greater than UBO/MPD equipment pressure rating

4.1.1.2. *Application Category*

Category A: Managed Pressure Drilling (MPD) – Drilling with returns to surface using equivalent mud weight that is maintained at or above the open-hole pore pressure.

Category B: Underbalanced Operations (UBO) – Performing operations with returns to surface using an equivalent mud weight that is maintained below the open-hole pore pressure.

Category C: Mud Cap Drilling – Drilling with a variable length annular fluid column which is maintained above a formation that is taking injected fluid and drilled cuttings without returns to surface.

Category D: Pumped Riser Systems – Drilling with returns to surface through a subsea pump using a mud weight that is maintained at or above the open hole pore pressure, but fluid level in riser is manipulated (lowered) to compensate for Equivalent Circulating Density.

4.1.1.3. *Fluid Systems*

- 1. Gas:**
Gas as the fluid medium, no liquid added intentionally
- 2. Mist:**
Fluid medium with liquid entrained in the continuous gaseous phase, typical mist systems have less than 2.5% liquid content
- 3. Foam:**
Two-phase fluid medium with a continuous liquid phase generated from the addition of liquid, surfactant and gas. Typical foams range from 55% to 97.5% gas
- 4. Gasified Liquid:**
Fluid medium with a gas entrained in a liquid phase
- 5. Liquid:**
Fluid medium with a single liquid phase.

Once the well has been classified, the project design team will finalise equipment requirements, layouts and procedures. The basis of design document, the risk register, and the HSE input to the Tender Process are key documents to be delivered in this phase of the project.

4.1.2. UBO/MPD Hazard Identification

Most companies should have a risk register related to their activities. If they do not, one should be developed that outlines the specific hazards and risks associated with these activities, including the measures and controls taken to eliminate or mitigate risk. Examples of hazards introduced by a UBO/MPD operation include, but are not limited to:

- Change in barrier philosophy
- Drilling fluid medium
- New equipment
- New or modified procedures
 - Well control
 - Normal operating
- High pressure lines at surface
- Personnel training and competence

At this point, a preliminary Hazard Identification (HAZID) study should be undertaken to quickly identify and describe potential hazards associated with the operation. The HAZID study conducted in this phase is sometimes referred to as an initial HAZID. The results are entered in the UBO/MPD risk register. The process may be repeated in the next phase of the project once all service providers for the project are selected and the equipment design is better defined. It is important that an experienced facilitator competent in the application and use of the technique be assigned the role of Team Leader.

A team with the right combination of design and operational expertise in the various processes and sections, especially in the facility section, is important for optimum outcome of the exercise. Large numbers do not generally add value; knowledge and willingness to actively participate and share knowledge does. It should also be remembered that this is a hazard identification exercise, not one for problem solving. Resolution of action items arising should be done outside the HAZID sessions.

A comprehensive and successful HAZID should be based on conceptual well-design schematics, conceptual layout drawings showing the UBO/MPD equipment, the rig and equipment, the hazardous areas/zones and the escape routes, and conceptual procedures. A flow chart describing the HAZID Process is shown in Appendix 6.3.

At this point in the project, all HSE findings should be documented and modifications made as required.

4.2. Detailed Well Design Phase

Most of the activities in this phase of the project will require input from risk management professionals and experienced UBO/MPD personnel. These activities include, but are not limited to:

- Consultation and briefing of local authorities

It is prudent to consult relevant local authorities early in the project to discuss operational plans and to receive feedback. This may provide direction for the team by identifying potential risk management concerns and allow these to be addressed in the planning phases.
- Concurrent operations review

Simultaneous drilling and hydrocarbon production from the same well is one of the major hazards introduced in UBO/MPD requiring the interface issues to be effectively managed.

- Environmental and health reviews, dropped objects and other hazard mitigating studies as appropriate.

These activities and studies should be completed as early as possible in the design phase to avoid unexpected problems later in the project that might delay or even stop the project.

4.2.1. Risk Management in Design

At this point, generally after the contract award, some UBO/MPD related HSE issues to consider are:

- Management of HSE interface issues between the operator, drilling rig and service provider with a bridging document produced specifically including emergency response roles and responsibilities.
- Drilling fluid assessments
- System design
- Drill string design and BHA selection
- Rig interfacing issues
- Well control principles and practices
- Insurance arrangements
- Operational practices and procedures
- Well site supervision
- Completions design
- Barrier philosophy
- System equipment selection

4.2.2. HAZID and HAZOP Studies

At this stage the team will be ready to conduct detailed Hazard Identification (HAZID) and initial Hazard and Operability (HAZOP) studies. The detailed HAZID should only be undertaken after the initial HAZID has been completed with all findings addressed and closed. It is essential to understand that HAZID and HAZOP are two different techniques, investigating two distinct areas of the operation. The HAZOP process is further detailed in Appendix 6.4.

4.2.3. Environmental Impact of UBO/MPD

One of the products of the UBO/MPD process is the production of hydrocarbons. These can be stored as liquids, burned or flared as gases or transported to a production facility via a pipeline. Regardless of the specific method chosen for handling the produced hydrocarbons, impact to the environment cannot be avoided.

The project team should strive to minimise the total environmental impact from the UBO or MPD operation. The UBO/MPD project team should evaluate the impact of flaring and the feasibility of using compressors to put gas into the production lines (where available). The environmental impact due to flaring may be slightly higher for the UBO/MPD option, but the overall environmental impact and HSE risk, may be less with UBO/MPD due to reduced exposure.

4.3. UBO/MPD Planning Phase

This phase includes the development of procedures, the identification of training requirements and safety critical roles. In addition the system design should be “frozen” to prevent further changes and the HAZOP finalized by the closeout of any actions identified during the study.

4.3.1. Operational Procedures

Comprehensive operational procedures are a key requirement to conducting a safe, efficient UBO or MPD operation.

4.3.2. Training and Competence Requirements

Training of personnel on a rig site is critical to a safe operation. In a UBO or MPD operation, training becomes even more important because of the number of interdependent services and personnel involved.

The training programme should be area, regional and/or well-specific, and, to minimise costs, must be fit for purpose. Due diligence requires that only trained, competent personnel are allowed to work on a UBO/MPD site and/or personnel in the process of becoming competent are properly supervised by competent staff.

In addition to normal requirements for their operational roles, personnel in safety critical roles on a UBO or MPD operation may require additional competencies.

4.3.3. Safety Management Support Documents

To improve the safety of UBO or MPD projects, stakeholders (operator, drilling contractor service providers...etc.) should all be familiar with safety management system bridging documents specifically including emergency response roles and responsibilities. In addition, the site and rigs specific safety cases (where applicable) should also be reviewed to ensure familiarity when they are required.

4.4. Pre-execution Phase

Most of the activities in this phase of the project have a direct impact on risk management performance. The detailed operations plan (drilling program) should be prepared, all personnel trained, and other risk management related documents prepared.

4.4.1. Training

Due diligence requires that only trained, competent personnel are allowed to work on a UBO/MPD site and/or personnel in the process of becoming competent are properly supervised by competent staff.

In addition to normal requirements for their operational roles, personnel considered to be in safety critical roles on a UBO or MPD operation may require additional competencies.

A verification of the training and competency of all involved personnel should be undertaken to ensure suitability in fulfilling intended operational roles and responsibilities.

4.4.2. HSE Site Management Plan

Some of the issues that need to be addressed in the plan include, but are not limited to:

- Identification, inspection and preventative maintenance of UBO/MPD safety-critical equipment.
- A comprehensive auditing and surveillance plan should be developed that includes project start up and continues through the life of the project.
- A verification of all identified controls required to eliminate or mitigate their risks to ensure suitability and availability. This validation should reference relevant corrective and or preventive actions identified during any previous risk management initiatives or assessments on the project.

4.5. Execution Phase

This phase begins with the arrival of the UBO or MPD equipment on site. Once the equipment is rigged up, the HSE management plan should be executed to ensure the equipment is rigged up in accordance with the Process and Instrumentation Diagram (P&ID) and operations plan (check list recommended). The system will be pressure tested and commissioned consistent with the plan. Procedures must be reviewed to ensure they are still fit for purpose and the crews trained on the critical procedures.

Any identified controls required for the elimination or mitigation of risks should be implemented and strictly adhered to by operations. Any deviations from identified control measures should be subject to, and effectively reviewed and authorized through an approved Management of Change process.

4.5.1. Learning and feedback

The monitoring and review process should address the targets documented in the UBO/MPD Project HSE Plan. It should also address successful close out of action items arising out of activities that produce recommendations, such as HSE meetings, inspections and incident investigations etc. Learning and feedback are critical components in the continuous improvement loop.

Upon the completion of operations, the effectiveness and suitability of the risk management system, processes and controls should be reviewed and improved upon where required to ensure continual improvement and the reduction of all risks to a level As Low As Reasonably Practicable (ALARP).

5. Summary

In summary, these guidelines should be considered as a starting point for the Operating Company, the Drilling Contractor and the UBO/MPD Service Provider in developing their UBO or MPD safety management programs and associated operational plans and procedures.

Each operator and service provider involved in the UBO/MPD project should review and follow these Guidelines according their own policies and experience for the particular area and the appropriate risk level of the operation.

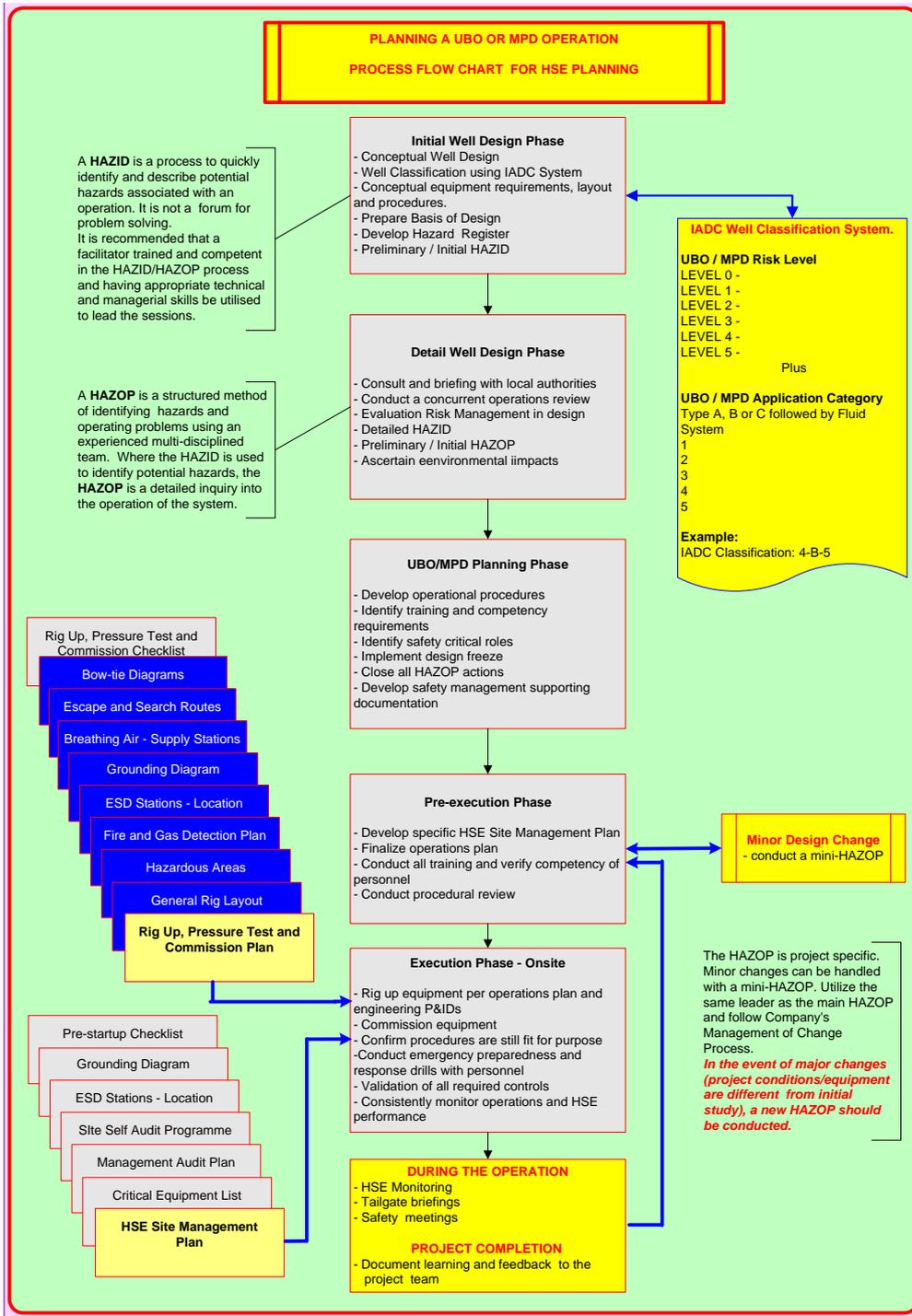
The Industry recognises certain Standards, Codes and Recommended Practices and these guidelines should be regarded as complementary to other requirements, systems, standards and practices as shown in Appendix 6.1 References and Appendix 6.5 Complimentary Relationship of the Guidelines.

6. Appendix

6.1. References

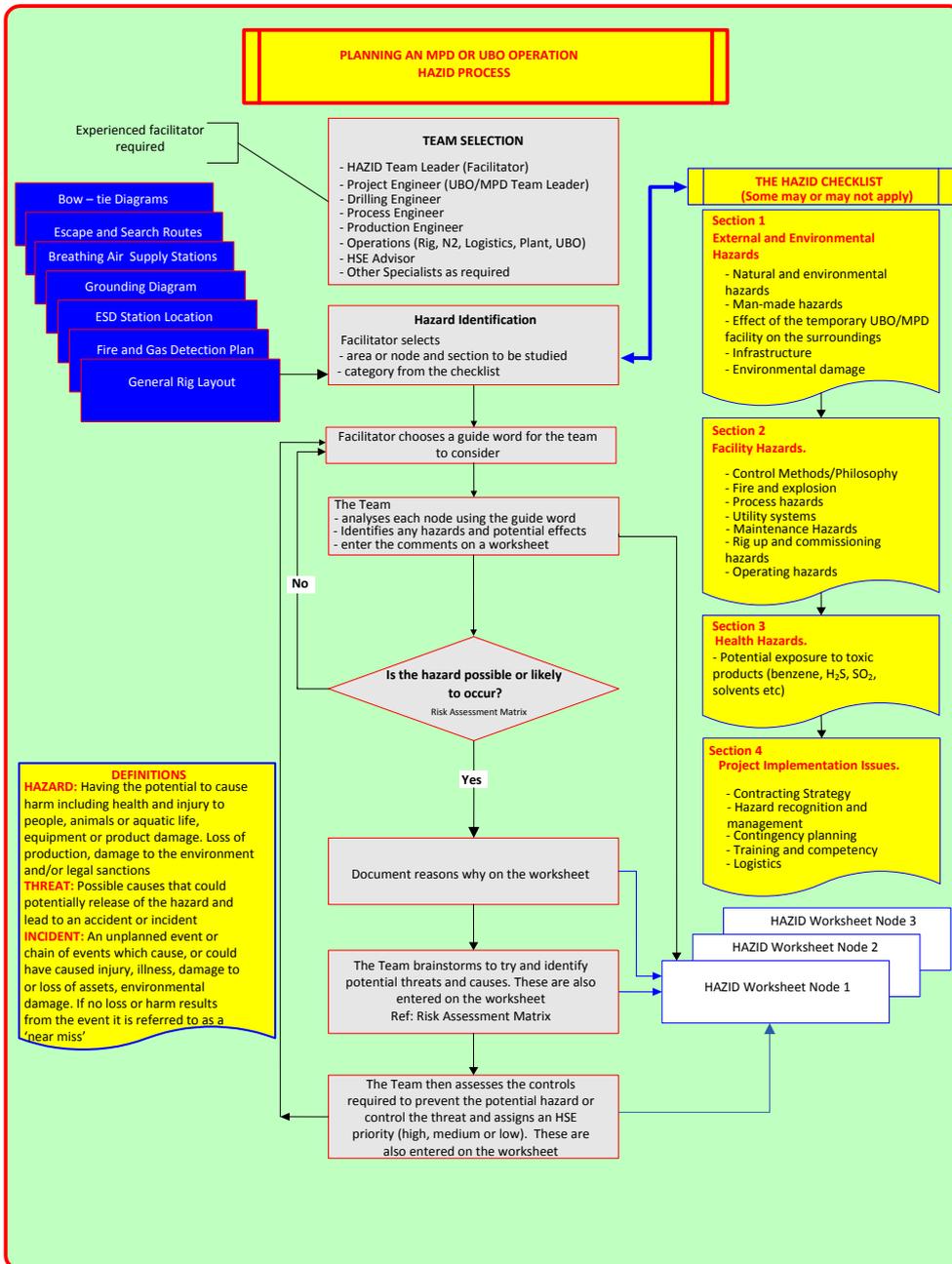
- API 16 RCD: Specification for Rotating Control Devices (RCD)
- API RP49: Recommended Practice for Drilling and Well Servicing Operations Involving Hydrogen Sulfide Third Edition
- API RP52: Land Drilling Practices for Protection of the Environment Second Edition R (2000)
- API RP54: Recommended Practice for Occupational Safety for Oil and Gas Well Drilling and Servicing Operations Third Edition
- API RP64: Recommended Practices for Diverter Systems Equipment and Operations Second Edition
- API RP75: Recommended Practices for Development of a Safety and Environmental Management Program for Outer Continental Shelf (OCS) Operations and Facilities Second Edition
- API RP750: Recommended Practices for Management of Process Hazards First Edition; Erratum - 1990 R(1995)
- API 92U Underbalanced Drilling Operations, 1st edition (2008)
- ISO 14001: Environmental Management Systems - Specification with Guidance for Use First Edition; CEN EN 1996
- ISO 9001 Quality Management systems - requirements
- OHSAS18001: Occupational Health and Safety Management Systems - Specification References
- UK HS(G)65: Successful Health and Safety Management ISBN 0717612767 (UK Health & Safety Executive)
- IADC IADC UBO/MPD Glossary (December 2011) see www.IADC.org

6.2. Process Flow Chart for HSE Planning

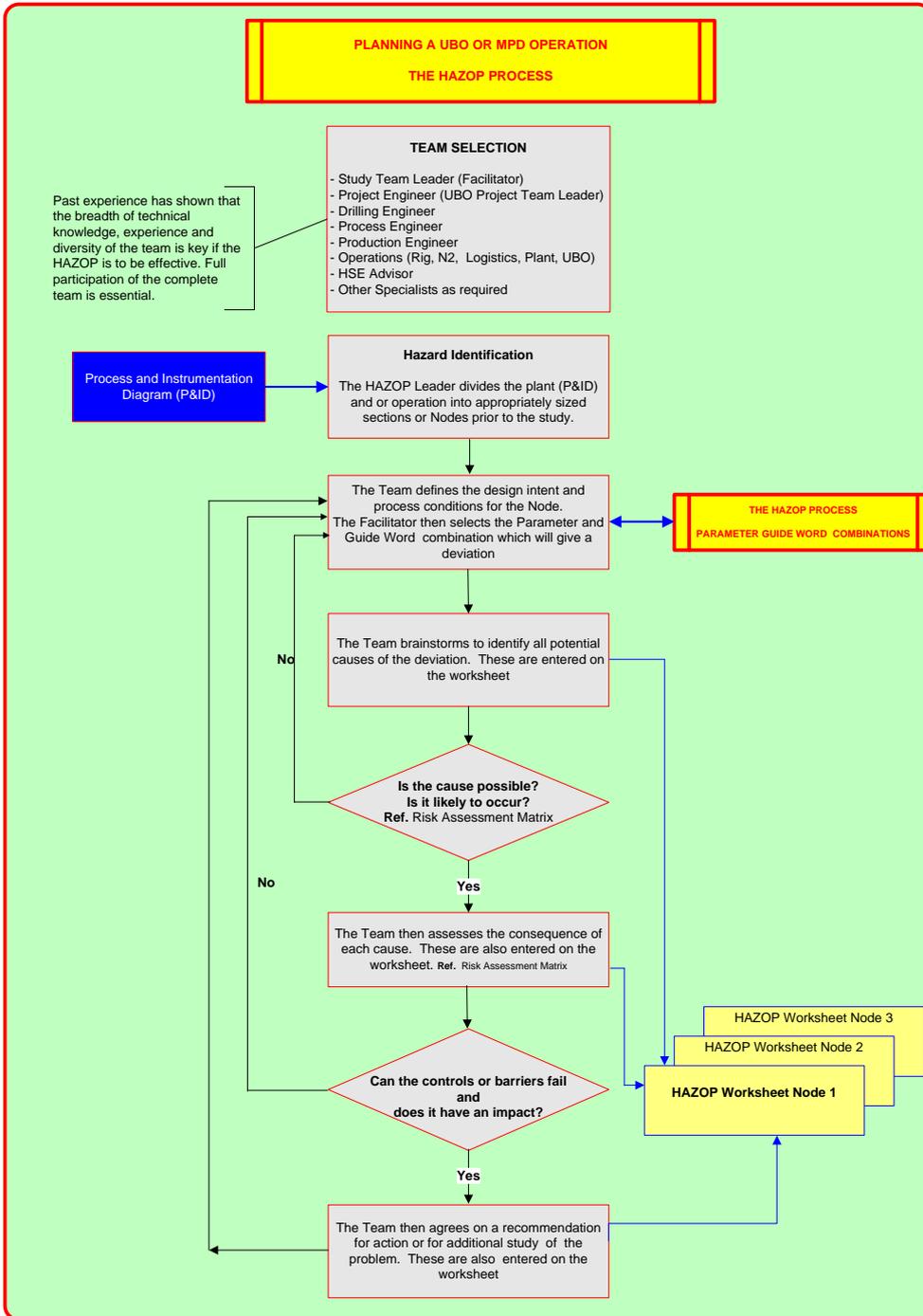


Comment [SM1]: Committee requested that the term MPD be added to the IADC Well Classification System

6.3. HAZID Process



6.4. HAZOP Process



6.5. Complementary relationship of the Guidelines

The purpose of this illustration is to provide examples of typical documents, standards and industry practices that have been considered in the formulation of these guidelines, it is not meant to be an exhaustive list, detailed description of relevant documents or, their interrelationship to the UBO/MPD HSE Guidelines.

It is the responsibility of each organisation involved in UBO/MPD Operations to ensure that all relevant documents in their specific working environment or region are consulted for applicability.

