MARY KAY O'CONNOR PROCESS SAFETY CENTER
TEXAS A&M ENGINEERING EXPERIMENT STATION

19th Annual International Symposium
October 25-27, 2016 • College Station, Texas

So what is a "Facility Level" Hazard Analysis Anyway?

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Abstract

How can a "facility level" hazard analysis be conducted to ensure hazards of the operation are understood and managed, while at the same time optimizing the use of company resources to complete the analysis? Anadarko has framed these issues into a Facility Level Hazard Analysis (FLHA) Program for our Gulf of Mexico (GoM) facility operations. This FLHA program follows Anadarko's Risk Management program guidelines and also meets the requirements of the BSEE Safety and Environmental Management System (SEMS) regulation and is consistent with American Petroleum Institute (API) guidance. Anadarko's GoM FLHA program also provides flexibility to address the initial design, pre-startup, and post-startup hazard analysis needs of the organization.

Introduction

How can a "facility level" hazard analysis be conducted to ensure hazards of the operation are understood and managed, while at the same time optimizing the use of company resources to complete the analysis? Anadarko has framed these issues into a Facility Level Hazard Analysis (FLHA) Program for our Gulf of Mexico (GoM) facility operations and would like to share implementation lessons. This FLHA program follows Anadarko's Risk Management program guidelines and also meets the requirements of the BSEE Safety and Environmental Management System (SEMS) regulation and is consistent with American Petroleum Institute (API) guidance. Anadarko's GoM FLHA program also provides flexibility to address the initial design, pre-startup, and post-startup hazard analysis needs of the organization and would like to share implementation lessons.

Background

Recommended Practice

A series of documents and regulations guide operators in the Outer Continental Shelf (OCS) in terms of when and how to do hazard analysis on production platforms. The American Petroleum Institute (API) first published two Recommended Practices in 1993 in partnership with the International Association of Drilling Contractors (IADC), Offshore Operators Committee (OOC) and the National Ocean Industries Association (NOIA):

- RP 75: "Recommended Practices for Development of a Safety and Environmental Management Program for OCS Operations and Facilities" (Ref 01)
- RP 14J: "Recommended Practice for Design and Hazards Analysis of Offshore Production Facilities" (Ref 02)

Each of these recommended practices play a key role in understanding the legacy hazard analysis environment for existing platforms. In addition, they have multiple reviews, updates and re-affirmations by API committees since their original publication.

RP 75 describes the focus of hazard analysis as:

"...identify, evaluate, and, where unacceptable, reduce the likelihood and/or minimize the consequences of uncontrolled releases and other safety or environmental incidents." (Ref 01)

This hazard analysis should take *"an orderly, systematic approach following one or more methodologies such as those recommended in API RP 14. As a minimum, hazard analysis requirements for production equipment may be met by ensuring that the facility conforms to the requirements of API RP 14C, Recommended Practice for Analysis, Design, Installation and Testing of Basic Surface Safety Systems".* Beyond a 14C requirements, hazard analysis rigor is determined by company management, "dependent on risk". (Ref 01)

RP 14J provides a framework for design and hazard analysis of Offshore Production Facilities, and reiterates the point that hazard analysis rigor for outer continental shelf platforms are *"generally simple, standard processes"* compared to complex industrial plants. Offshore Production Facilities typically have a high level of operating experience and history, and relatively low inherent risk. RP 14J recognizes this by stating,

"*All hazards analysis procedures apply to production facilities; however, the direction and level of effort devoted to hazards analysis should be relative to the inherent risk. In general, the more sophisticated techniques for hazards analysis will be the exception rather than the rule for production facilities. Hazards analysis alone does not ensure a safe operation. For most accidents on offshore production facilities, unsafe work practices, poor operating procedures, poor management of change and poor maintenance and testing have been contributing factors."* (Ref 02)

<u>Regulation</u>

In 2010, 30 CFR250, Subpart S – the Safety & Environmental Management System (SEMS) Rule was published, and went into effect in 2011. The SEMS Rule introduced "facility level" language to delineate the scope of hazard analysis program to the following definition (Ref 03):

> **§ 250.1911 What hazards analysis criteria must my SEMS program meet?**
>
> *"You must ensure that a hazards analysis (facility level) and a JSA(operations/task level) are developed and implemented for all of your facilities and activities identified or discussed in your SEMS. (Ref 03)*

30 CFR Part 250.105 lists "Facility" definition for SEMS application as:

"(5) As used in subpart S of this part, all types of structures permanently or temporarily attached to the seabed (e.g., mobile offshore drilling units (MODUs); floating production systems; floating production, storage and offloading facilities; tension-leg platforms; and spars) that are used for exploration, development, and production activities for oil, gas, or sulphur in the OCS. Facilities also include DOI-regulated pipelines." (Ref. 04)

Given the breadth and variety of operations that these instructions cover, a multitude of hazard studies might make up how "facility level" hazard analysis would best be conducted. For example, on MODUs, many drilling contractors perform IADC safety cases in order to demonstrate that their MODU has hazards under control. With this in mind, Anadarko's FLHA program has a different focus for company operated production facilities than it does for contracted MODUs. For MODUs, it focuses on bridging the MODU hazard analysis with Anadarko's SEMS program provisions. For our company operated production facilities, the FLHA program focuses on the multiple hazard studies and reviews that collectively complete the FLHA.

Anadarko Management System

The Anadarko Management System (AMS) is Anadarko's response to creating and maintaining a Safety & Environmental Management System (SEMS), which is required by BSEE's SEMS Regulation in the GoM. AMS contains a Risk Management framework that aims to avoid or mitigate risks that have unwanted consequences (e.g. accidents, spills, and production interruption). AMS Risk Management activities are intended to help identify and understand hazards, evaluate potential risks, and manage them effectively. Figure 1 illustrates the risk management framework that AMS is built upon:

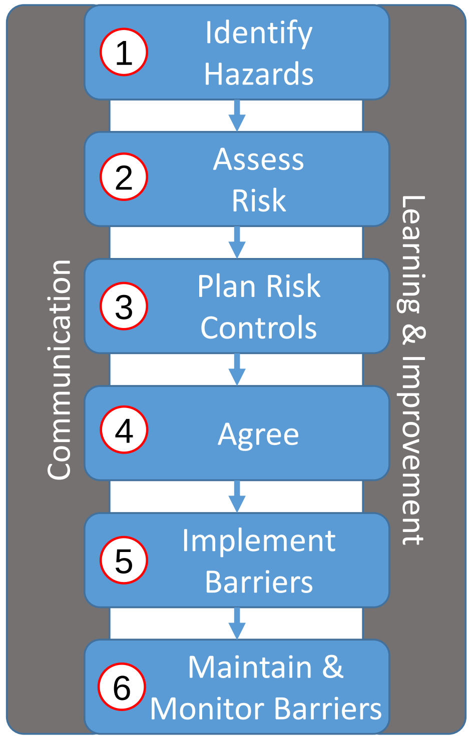

Figure 1: AMS Risk Framework Model

Various Risk assessment methods are used by Anadarko to identify and assess the Risks associated with our operations. Job Safety Analysis (JSA) and Job Hazard Analysis (JHA) are used to identify, assess and mitigate the risks at the task or activity level, and address tasks and activities that cover the span from routine operations and maintenance activities to the most complex, non-routine activity.

The Anadarko GoM FLHA Program is intended to identify, assess and mitigate the risks of a production facility over the full lifecycle of that facility, from design through decommissioning. The Anadarko GoM FLHA process addresses all the steps included in the risk framework model listed above and follows the facility structure boundary defined by SEMS in Ref 04 and hazard boundaries defined by API RP 75 (Ref 01).

Objectives

The FLHA objectives are to identify and assesses potential likelihood and consequence of an uncontrolled release and other serious safety or environmental incidents. Furthermore, the FLHA outlines the Barrier Program, which reduces the likelihood and minimizes the consequence of identified hazard scenarios. The FLHA is not a single hazard assessment but draws upon results of complementary methods to achieve the stated objectives.

Table 1: Objectives of FLHA (Ref 03)

Objectives of FLHA
• Address the hazards of the operation

• Integrate lessons learned from previous incidents
• Address risk control technology
• Include human factors
• Qualitatively assess impacts to people & environment
• Utilize people experienced in the operations and the analysis method
• Document and resolve recommendations

By following the precepts of the SEMS Regulation, API recommended practices, and the precepts of AMS, an FLHA program is identified as a set of processes designed to ensure production operation hazards which relate to people, the environment, and assets are identified and appropriately mitigated. The hazards analyses performed are to be appropriate to the complexity of the operation and will identify, evaluate and manage the hazards involved in the operation. Using one or more techniques, the FLHA:

- consistently, systematically and explicitly identifies key hazards and uncertainties along with the associated risks within a Gulf of Mexico (GoM) Facilities; and
- enables better direction of resources toward hazard and risk management during a facility's lifecycle.

Conducting the FLHA Program

Anadarko's FLHA Program requires an initial FLHA to be completed during the design and engineering phase of any new production facility prior to start-up. Anadarko then sets a five-year interval between FLHA reviews and updates. This time interval is primarily driven by factors, which include:

- permanent manning levels(currently, all of Anadarko's GoM Facilities are permanently manned deepwater facilities);
- Simultaneous Operations (SIMOPS) (complexity and frequency of SIMOPs activities);
- hydrocarbon processing (volumes, rates, composition, complexity); and
- potential for spills and releases impacting people and marine life.

Intervals shorter than five years may be warranted if a major Health, Safety and Environment (HSE) incident has occurred, or if major modifications have been made to the facility. Extensions beyond this five-year period must follow a variance program and must prove that the extension is warranted by addressing the time interval factors listed above, and ensuring that a functioning barrier program is in place, monitored, and maintained.

In summary, the intervals for conducting FLHA are as follows:

- prior to start-up; and
- five-year intervals thereafter, or

- less than five-year intervals if warranted by a major HSE Incident or major Facility changes, or
- greater than five-year intervals if supported by an approved Management of Change (MoC) variance with a Barrier Monitoring Program in place.

FLHA Components

The FLHA is not a single hazard assessment but draws upon results of complementary methods to achieve scope and objectives. This also allows the FLHA to be completed in a manner that optimizes the use of company resources.

For example, for existing Floating Production Unit (FPU) structures, a combination of three main hazard analysis efforts make up the FLHA program (see Figure 2):

- Compliance & Technical Reviews
- Major Accident Event (MAE) Review HAZID
- Design Phase Hazard Analysis Update/Review

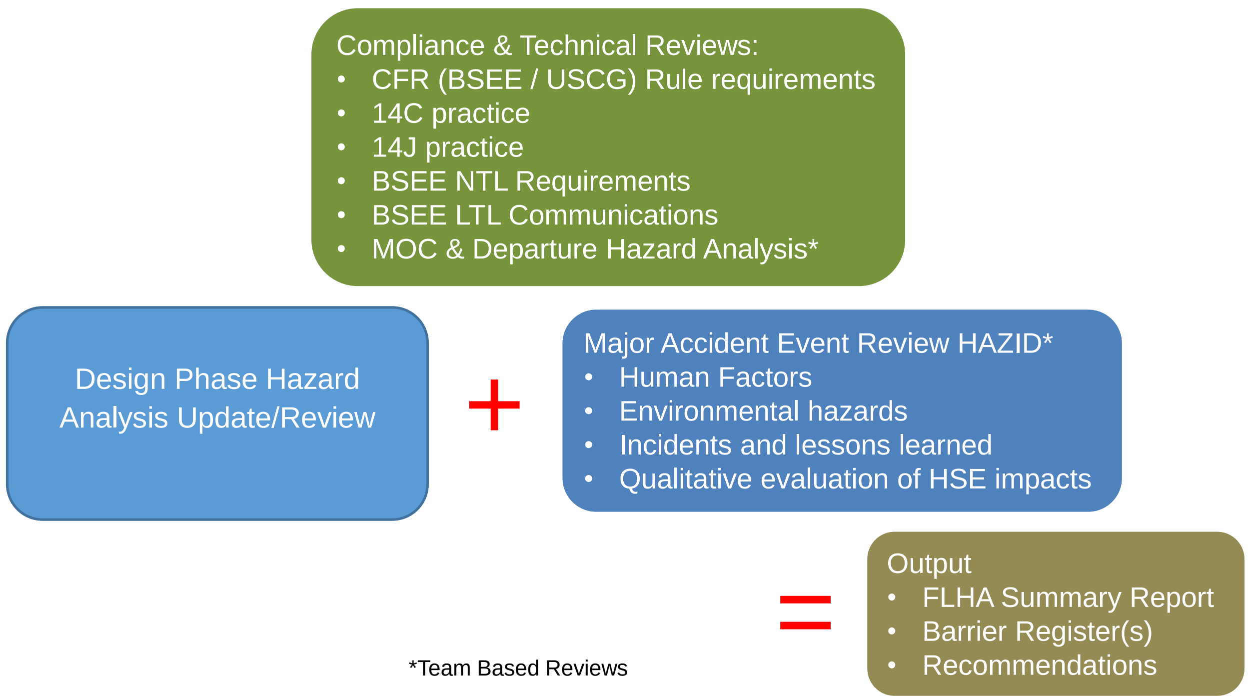

Figure 2: Example FLHA Components for Existing FPU Structures in GoM

Compliance and technical reviews are conducted as changes are made to the FPU to maintain best practice design and operational requirements, and original design philosophy. They provide a constantly evolving representation of MAE Barrier combinations needed to protect against various Hazards addressed by standard design practice.

Compliance and technical reviews utilize applicable checklists to assess coverage of prescriptive requirements. Multiple API Recommended Practices contain GoM best practices that have been adopted by BSEE within the CFR. The CFR, along with supplemental requirements presented by BSEE through Notice to Lessees (NTL) and Letter to Lessees (LTL), also contain design requirements that are checked during the compliance and technical review. After the initial startup, these reviews are conducted as part of the MoC.

A Major Accident Event HAZID is conducted as a baseline during the design phase of a facility and is then periodically reviewed at prescribed intervals to ensure that it reflects the current Hazards on the FPU in terms of present MAE Barriers, threats, and consequences. MAEs are hazard scenarios which have the inherent possibility of high consequence severity per Anadarko's Risk Management program.

Each periodic FLHA review also examines incidents that have occurred on this facility or like facilities that might impact the risk management of the facility.

Design phase hazard analysis update/ review activity is facility specific based upon initial hazard evaluations conducted to reach a safe design basis. Each analysis is reviewed for consistent assumptions and considerations of previous incidents, BSEE communications and facility change over time.

<u>Barrier Program during FLHA</u>

To achieve the FLHA objectives, the Barrier Program intends to assess and monitor the effectiveness or health of existing facility barriers in place. This program is focused on Major Accident Event (MAE) barriers and manages to do so by diagraming MAEs and their associated components such as threat, barrier, top event, consequence, etc.

An example list GoM Floating Production Unit MAEs are:

- Loss of Containment - Subsea, Topsides or Pipelines
- Loss of Station Keeping / Buoyancy
- Marine Vessel Collision
- Helicopter Crash
- Dropped Object / Swinging Load

Each of these events have the possibility of being realized on offshore production facilities but the likelihood or magnitude of effect varies based on various facility and company specific conditions. During the FLHA periodic review, barriers effectiveness is measured by a team. To do this task a barrier effectiveness model (Figure 3) is followed and given a 1 to 4 rating (Table 2) based on how well the model is implemented on the specific facility.

During the interval reviews of FLHA components, the primary focus on activities is to evaluate and understand MAE risks. A key review for an existing facility is the health or effectiveness of its key barriers for MAEs. The first step to this review is defining complete barrier descriptions. Anadarko developed a Barrier Effectiveness model (Figure 3) to define what a complete barrier description is and what components are needed for effectiveness assessment of a barrier.

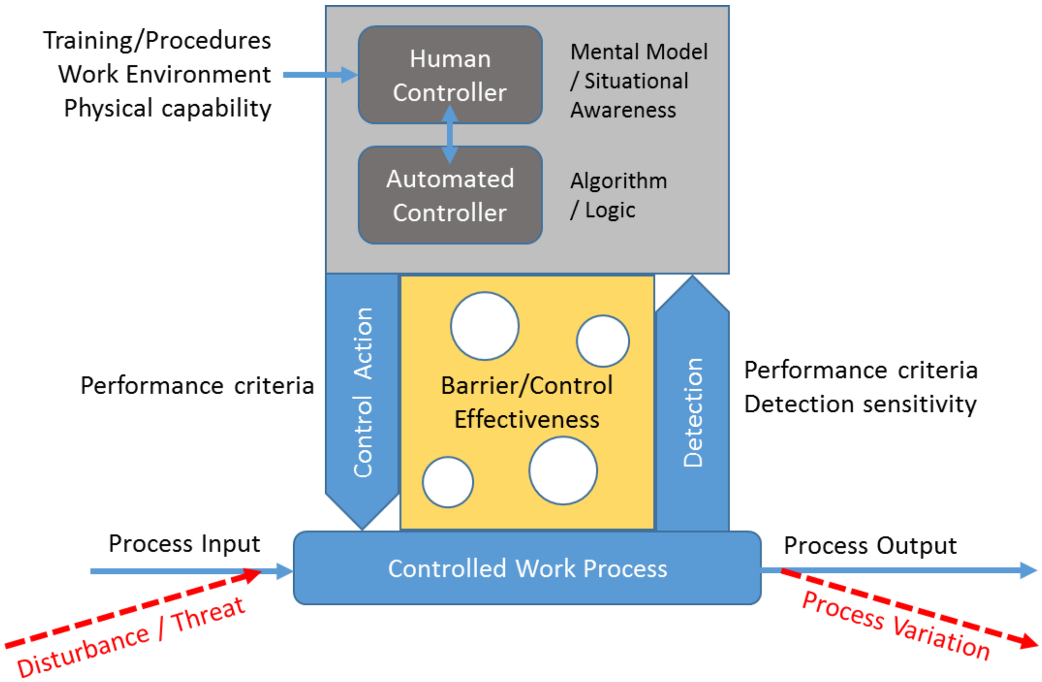

Figure 3: APC Barrier Effectiveness Diagram

Figure 3 illustrates the main components for successful barrier effectiveness. Detection, controller and control action are three core barrier elements for an effective barrier that are used to evaluate effectiveness.

Important lessons to emphasize when implementing this model:

- Barriers should have a defined trigger or criteria to initiate a controlling function/action.
- Humans are controllers; humans are not barriers.
- Procedures, documents, mistake-proofing, training, workplace design, and knowledge are among the factors that improve the human as a controller. By themselves, these factors are not barriers.
- Risk barriers are dynamic. Barriers should not be thought of as static; as the effectiveness of barriers will vary over time. For this reason, barriers should be verified regularly to ensure effectiveness.
- For the barrier to be effective, all components of the barrier model must be effective.
- It is generally preferable to have a few highly reliable barriers rather than many barriers of low reliability.

To measure effectiveness, the team outlines if core barrier elements are in place, as well as, how operational integrity assurance is in place. Table 2 outlines Barrier Effectiveness Rating Criteria in terms of a one to four rating.

Table 2: Barrier Effectiveness Rating Criteria

Barrier Effectiveness is rated as a function of Detection, Controller and Control Action elements in place and functionality assured	
Rating 1	0 to 1 core barrier elements are in place and functional
Rating 2	2 of the 3 core barrier elements in place and functional
Rating 3	3 core barrier elements in place but assurance process not present
Rating 4	3 core barrier elements in place with assurance process present

Figure 4 and Figure 5 provide an example of bow-tie diagrams generated from data recorded during an FLHA workshop. In these examples, threats, barriers and consequences for the "Loss of Containment - Spar Topsides" scenario are reviewed, and associated barrier effectiveness values are decided by a mixed team of operations, engineering and HSE personnel. The actual number of barriers, types of threats and effectiveness of barriers varies from facility to facility.

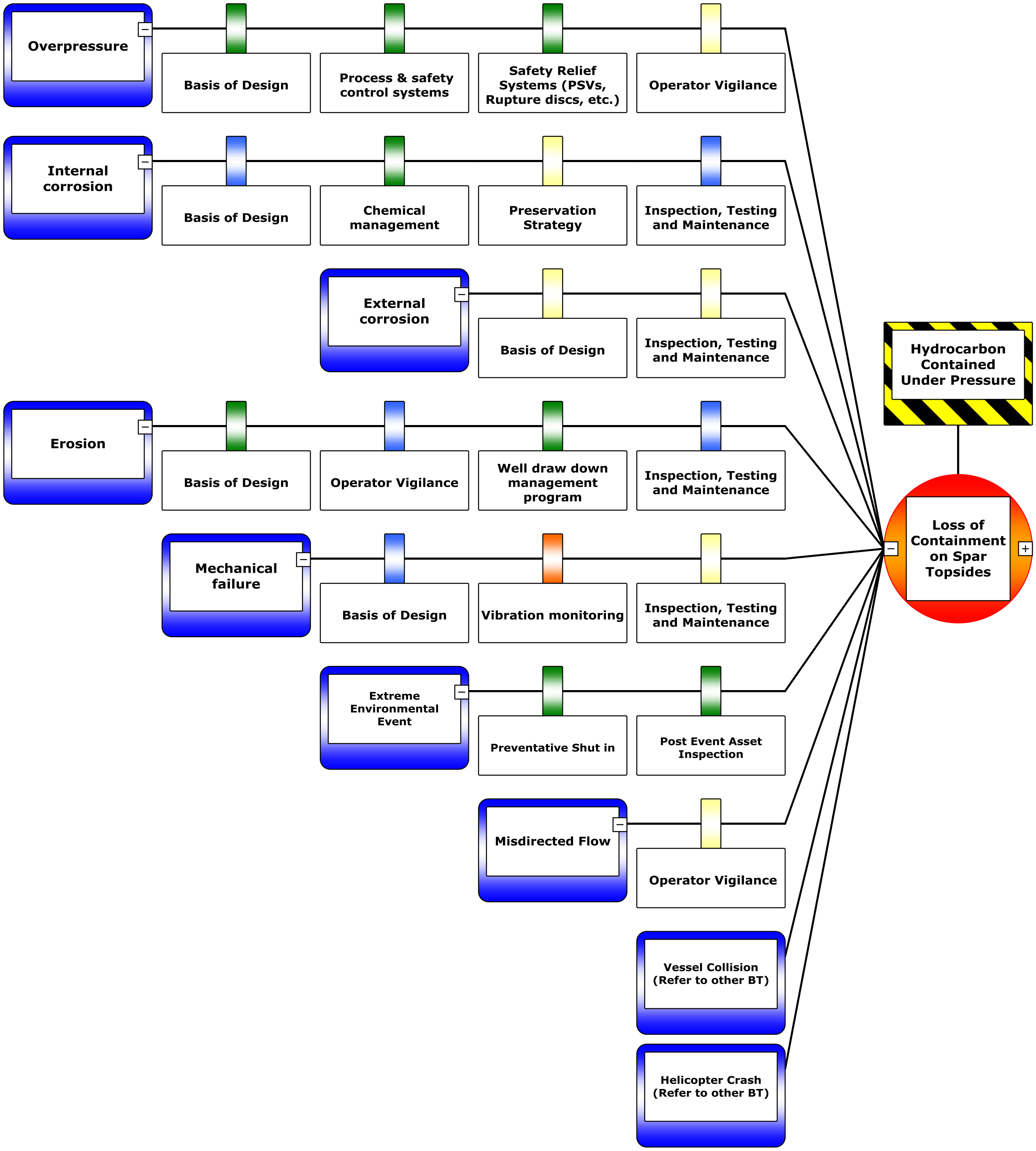

Figure 4 Example Topsides Loss of Containment Prevention Barriers & Effectiveness Ratings

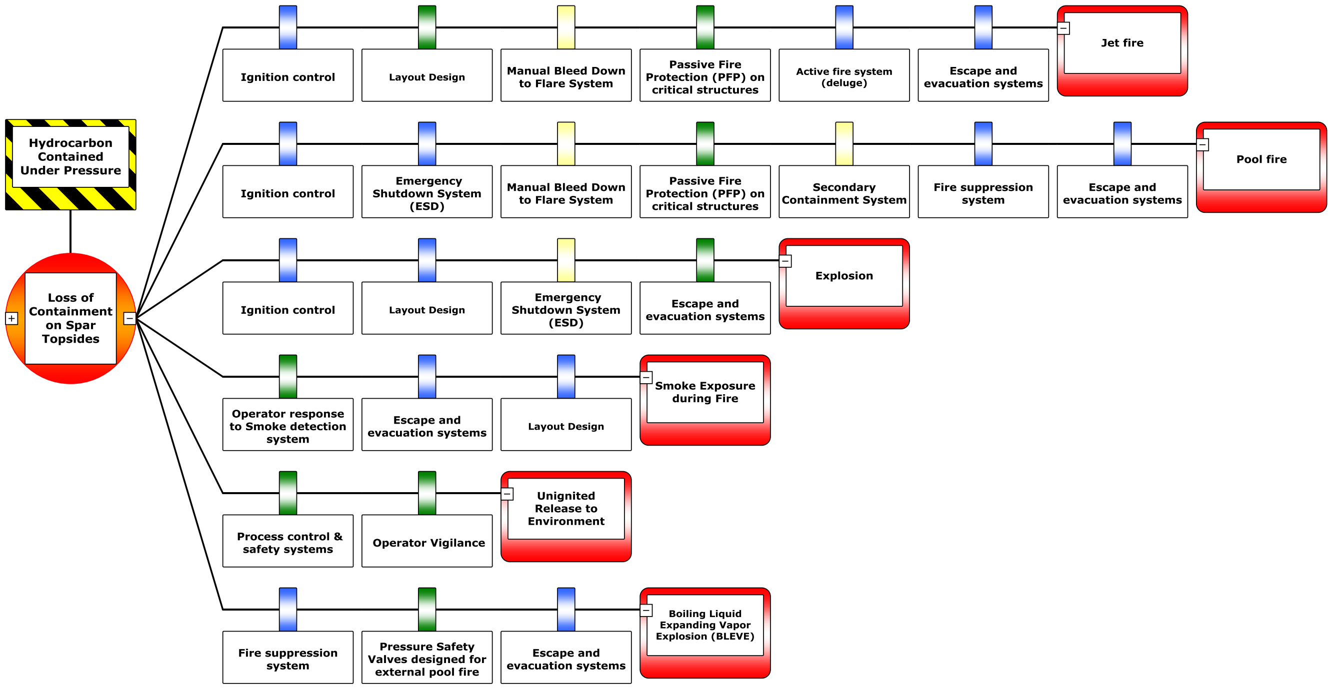

Figure 5: Example Topsides Loss of Containment Mitigation Barriers & Effectiveness Ratings

<u>FLHA Summary Report</u>

Each facility will have a specific list of major accidents based on present hazards and general facility characteristics. Based on the outcome of FLHA components outlined above, likelihood drivers and consequence drivers are identified and summarized to management.

Table 3 is a highly simplified example executive summary of risk drivers listed to support a resulting risk ranking for the “Loss of Containment - Subsea Systems” scenario.

The drivers for likelihood and consequence are primarily dependent on operations experience, industry experience or other hazard identification knowledge learned. MAE Rankings are performed on these based on company risk ranking criteria.

Table 3: Executive Summary Risk Ranking Format Example

Major Accident Events	Likelihood Drivers	Consequence Drivers	Risk Ranking
Loss of Containment - Subsea System	(-) Internal Corrosion, CO_2	(+) Low production volumes limit consequence potential	Medium

Lessons & Conclusions

The AMS FLHA program has assembled multiple hazard analysis components to ensure hazards at the facility level, as defined by SEMS, are identified, assessed, mitigated and monitored through the full lifecycle of the facility.

A key feature developed within the FLHA program is to measure barrier effectiveness during the periodic FLHA facility review. This barrier effectiveness ranking uses operating experience to help focus on where risk is present. Once this effectiveness ranking is complete, historical incidents from Anadarko and the industry assist in consistently ranking MAEs specific to each facility per Anadarko's risk matrix. The use of consistent barrier effectiveness and risk ranking criteria allows management to more easily understand the risk profile of their portfolio. With leadership support, these studies are successful in applying the results of a FLHA to generate tangible recommendations and heighten safety awareness.

Another outcome and conclusion from the FLHA program is a vetted Facility-Level Barrier Register. The barrier register and associated bow-tie diagrams become tools that can be used during hazard analysis, asset integrity activities, and during the MOC process.

References

01 RP 75: "Recommended Practices for Development of a Safety and Environmental Management Program for OCS Operations and Facilities", American Petroleum Institute, 3rd Edition, May 1, 2004.

02 RP 14J: "Recommended Practice for Design and Hazards Analysis of Offshore Production Facilities"", American Petroleum Institute, 2nd Edition, May 1, 2001.

03 30 Code of Federal Regulations Part 250, Subpart S - Safety and Environmental Management Systems (SEMS)

04 30 Code of Federal Regulations Part 250, Subpart A - Oil and Gas and Sulphur Operations in the Outer Continental Shelf