[Guidance for Operators]

Assessing the Use of New Technology on the Outer Continental Shelf

Guidance to Assist Operators with Preparing New Technology Submissions Under Title 30 Code of Federal Regulations Part 250

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Technical Direction Letter #001, Deliverable C – Operator's Process Guide

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Acronyms

AIS	Automatic Identification System
APD	Applications for Permit to Drill
APM	Applications for Permit to Modify
BN	Bayesian Networks
BOP	Blowout Preventer
BSEE	Bureau of Safety and Environmental Enforcement
CFR	Code of Federal Regulations
DWOP	Deep Water Operations Plan
ERA	Environmental Risk Assessment
ETA	Event Tree Analysis
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes, Effects, and Criticality Analysis
FTA	Fault Tree Analysis
HAZID	Hazard Identification
HAZOP	Hazard and Operability
HMI	Human Machine Interface
HPHT	High Pressure High Temperature
IPL	Independent Protection Layers
LOPA	Layer of Protection Analysis
MAH	Major Accident Hazard
MORT	Management Oversight Risk Tree
MPD	Managed Pressure Drilling
NDE	Non-Destructive Examination
OCS	Outer Continental Shelf
PFD	Process Flow Diagram
P&ID	Process and Instrument Diagram
PRA	Probabilistic Risk Assessment
PrRA	Preliminary Risk Analysis
QRA	Quantitative Risk Assessment
SERENE	Safety and Risk Evaluation using Bayesian Nets
SME	Subject Matter Expert
TAS	Technical Assessment Section
U.S.	United States

Introduction

The Bureau of Safety and Environmental Enforcement (BSEE) is responsible for the oversight of exploration, development, and production operations for oil and natural gas on the Outer Continental Shelf (OCS). BSEE's regulation and oversight of Federal offshore resources ensures that energy development on the OCS is done in a safe and environmentally responsible manner. The functions of BSEE include oil and gas permitting, facility inspections, regulations and standards development, safety research, data collection technology assessments, field operations, incident investigation, environmental compliance and enforcement, oil spill prevention and readiness, review of Operator oil spill response plans, oversight of production and development plans, and resource conservation efforts. In order to carry out this mission, BSEE establishes requirements for exploration and production activities and publishes these as regulations in the Code of Federal Regulations (30 CFR §250). BSEE continues to expand its role as a world leader in safety and environmental stewardship through innovative regulatory approaches and appropriate collaboration with industry. By doing this, BSEE fosters a culture of safety and compliance among Operators with an aim toward reducing the risk of accidents and hydrocarbon spills.

As the offshore industry moves into deeper, harsher and colder environments, many new and emergent technologies are being proposed to address the operational needs for drilling and production. 30 CFR §250.200 defines *New* or *Unusual* technology as equipment or procedures that:

1. Have not been used previously or extensively in a BSEE OCS Region;
2. Have not been used previously under the anticipated operating conditions; or
3. Have operating characteristics that are outside the performance parameters established by this part.

The request for BSEE's evaluation and acceptance of a proposed new technology by an Operator is typically through the submittal of a project specific Deep Water Operations Plan (DWOP). Conceptual approval of non-project specific new technologies can also be requested through the BSEE Technical Assessment Section (TAS). BSEE expects the Operator to provide supporting information as part of their submittal to demonstrate that the proposed new technology presents an increased or equivalent level of safety in accordance with current OCS practices.

This guidance document has been developed to provide Operators of OCS oil, gas, and sulfur exploration, development and production facilities with a systematic process for preparing submissions to BSEE related to the use of new technology. This guide is the culmination of an extensive review of the applicable regulations, existing processes, forms, and various Notices to Leaseholders (NTLs). The guidance is provided to assist industry in submitting permits, plans and reports in the context of the introduction of new technology.

This guide is organized into four Sections to assist the Operator with preparing various submissions to BSEE involving use of new technology. The sections of this guide are as follows:

- Section 1: New Technology Assessment

- Section 2: Risk Assessment
- Section 3: Barrier Analysis
- Section 4: How to Submit New Technology Results to BSEE

Case studies containing different applications of new technology were developed to serve as examples of the type of assessments and analysis that should be conducted while preparing the submission. These case studies afound in **Appendix A: Case Studies.**

Below is a summary of the major sections contained in this guide:

Section 1: New Technology Assessment Section
This section outlines the process an Operator uses to determine if the technology proposed for offshore exploration and production needs to go through a new technology application process. It describes the items that must be met to satisfy requirements of a new technology submittal.

Section 2: Risk Assessment Section
This section outlines a risk assessment framework and related processes and workflows for the Operator to consider when evaluating all new technology submissions. This includes review of the existing practices and submittal requirements in place for the review of these operational submissions/permits.

Section 3: Barrier Analysis Section
This section outlines a barrier analysis framework and related processes and workflows for the Operator to consider when identifying proposed new barriers and identification of the potential effects on other barriers and critical systems. This includes the introduction of the Barrier Model Template that has been developed for Operators to link barrier element life cycles phase attributes to associated success criteria.

Section 4: How to Submit New Technology Assessment Results to BSEE
This section outlines for the Operator a process to develop and validate overall procedures and risk-based criteria for Operators to use to evaluate and develop application submittals involving the use of new technology. These submittals may be associated with, but not limited to, Subsea and other deepwater Blowout Preventers (BOPs), High Pressure High Temperature (HPHT) evaluations and even new technology application in Artic environments. A checklist is incorporated to assist the review process by providing a consistent format and structure that will allow Operators and BSEE reviewers to quickly verify and determine if the Operator has provided all the necessary information.

How to Use This Guide

Operators should first read this entire guide to be familiar with guidance contained herein. Beginning in Section 1, Operators should follow the instructions outlined in each part, which includes “Step/Action Tables” and “Important Definitions” related to that Section. **Figure 1** provides an illustration of the processes outlined in this guide that Operators should follow when preparing their submissions. References to specific sections of this guide are included in **Figure 1.**

It is important to note that many new technology applications will be considered as part of a project specific DWOP or other permits submitted to BSEE, including Applications for Permit to Drill (APD),

Applications for Permit to Modify (APM), Sustained Casing Pressure, Enhanced Recovery, Platform Verification, Pipeline Applications and Structure Applications, among others. Additionally, the use of new technology may also be involved with Alternative Compliance and Departure requests, which must be submitted to BSEE. When considering new technology as part of a required submission (DWOP, APD, APM, etc.), Operators should refer to this guide to facilitate the assessment and analysis of the new technology.

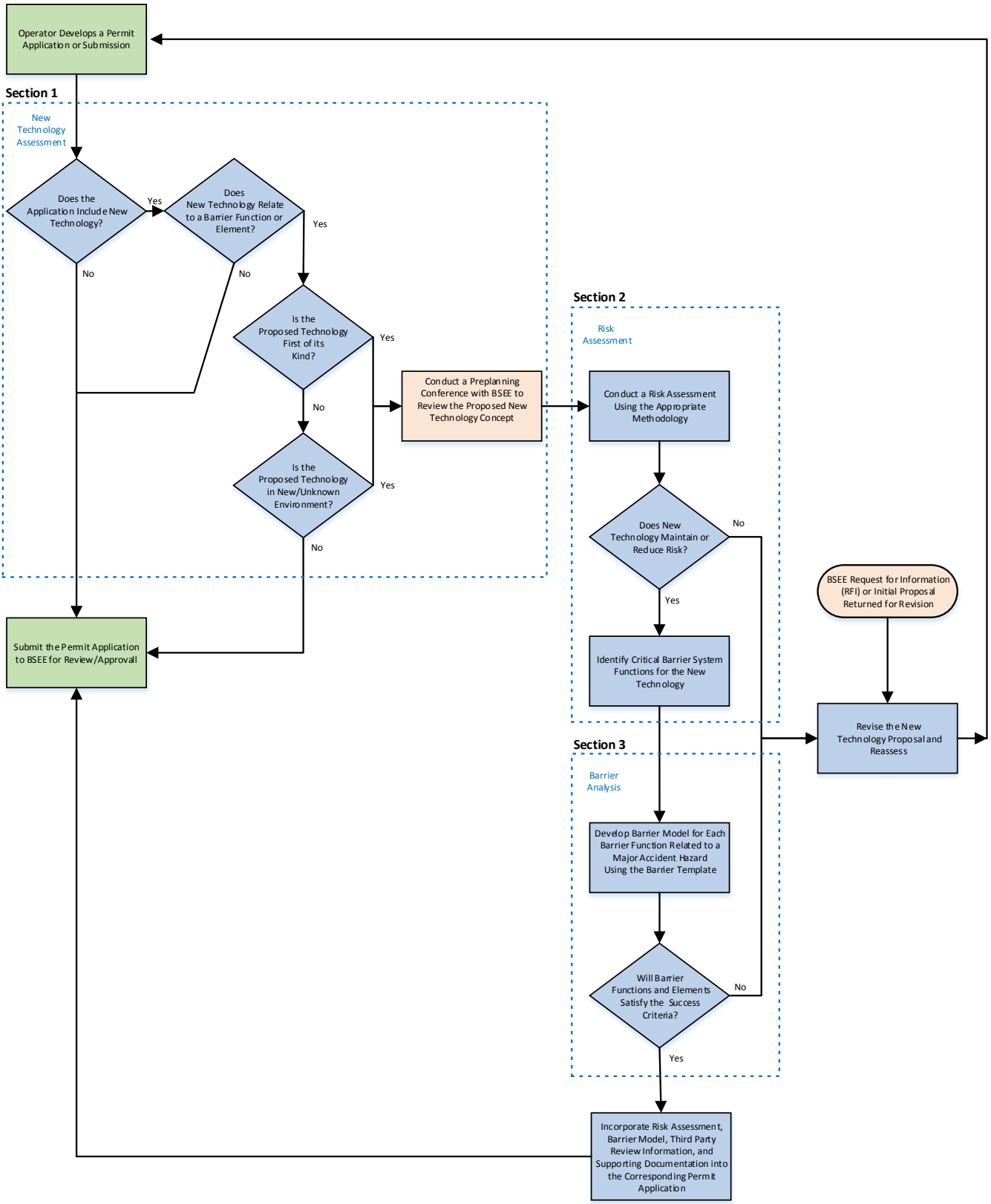

Figure 1: New Technology Proposal Development and Submission Process Flow Diagram

The *New Technology Proposal Development and Submission Flow Diagram*, displayed in **Figure 1,** is the primary visual guide on how Operators are to develop and submit new technology applications. The flow diagram highlights all possible paths a new technology application may take once submitted to BSEE. The purpose of the *New Technology Proposal Development and Submission Flow Diagram* is to provide a quick overview of the most efficient and effective techniques Operators should use while preparing new technology applications, highlighting the key steps taken to ensure new technology applications satisfy or exceed the accepted level of risk.

Overall, this Process Guide provides Operators with a systematic approach in identifying and describing the proposed new technology, steps taken to identify and mitigate potential risks, and helps provide BSEE with the appropriate and required information needed for new technology submittal requests.

Section 1: New Technology Assessment

This section includes guidance on how to determine if your submission involves the use of new technology. The oil and gas industry is continuously developing new technology applications for use in aspects of oil and gas exploration and production. Industry frequently submits request to BSEE to use new technology, often through the permit application process and submittals.

Part 1: How to Determine if your Submission Involves New Technology

The first step in the New Technology Assessment process is to categorize your proposed operation. In 30 CFR §250.200(b), BSEE defines new or unusual technologies as equipment or procedures that:

1. Have not been used previously or extensively in BSEE OCS Region;
2. Have not been used previously under the anticipated operating conditions; or
3. Have operating characteristics that are outside the performance parameters established for this part.

The Operator has the responsibility to suggest to BSEE, and get acceptance to use, new technology for exploration, development or production activities on the OCS. The Operator must also get acceptance from BSEE for their request to use known technology in an unknown condition. Initially, the new technology does not have to meet the definition of 30 CFR §250.200(b). It is only necessary that the equipment or procedures meet the new technology application per 30 CFR §250.292(n). BSEE requires a review of all equipment or procedures that meet this requirement. This ensures that all new technology applications are properly screened and a correct determination was made regarding barrier application. There are four categories to consider in the first part of the new technology assessment:

1. Known Technology, Known Conditions
2. Known Technology, Different or Unknown Conditions
3. New Technology, Known Conditions, and
4. New Technology, Different or Unknown Conditions.

The Operator should follow the steps in the **Table 1** to categorize their proposed operation.

Table 1: Step/Action Table – How to Categorize Your Proposed Operations

<table>
<tr><th>Step</th><th colspan="2">Action</th></tr>
<tr><td></td><td colspan="2">Based on the technology you are considering for your operation, review the four categories below.</td></tr>
<tr><td></td><td colspan="2">Category 1 – Known Technology, Known Condition. For this workflow, there are no expected changes from traditional submissions. This falls inside the current conditions and no additional work is necessary from the Operator's perspective. No additional risk assessments or barrier assessments are required for this workflow.</td></tr>
<tr><td></td><td colspan="2">Category 2 - Known Technology, Different or Unknown Conditions. For applications concerning well-known and established technology in different or unknown conditions, this workflow will be followed by -Operator to evaluate the application. Unknown conditions can include highly corrosive well fluids or low temperatures that the applicant will need to assess further in the Barrier Analysis. It is important to note that Unknown condition does not necessarily mean the Operator is not aware of the conditions, but it may indicate the Operator does not have experience in the subject environment. The process will follow a HAZARD Identification (HAZID), review, assessment and analysis, and screening and acceptance. These additional steps include barrier and risk analysis that was not included in the Category 1 workflow. The applicant is required to provide these additional documents to BSEE before review. Examples of Known Technology, Different or Unknown Conditions include:
• HPHT and Sour Well Production with SCSSV (Case Study 4, Appendix A: Case Studies)
• Ultra-Deepwater Drilling (Case Study 1, Appendix A: Case Studies)</td></tr>
<tr><td></td><td colspan="2">Category 3 - New Technology, Known Conditions. Applicants should follow this workflow when new technology is applied in known conditions. Examples of Known Technology, Different or Unknown Conditions include:
• Deepwater Drilling with a Surface BOP from a Floating Facility (Case Study 2, Appendix A: Case Studies)
• Managed Pressure Drilling in the Gulf of Mexico (Case Study 3, Appendix A: Case Studies)</td></tr>
<tr><td></td><td colspan="2">Category 4 – New Technology, Different or Unknown Conditions. Operations in this category include unknown factors related to both technology and conditions. This is anticipated to be the most complex submittal type, both for the owner/ Operator, as well as for BSEE review.
• Arctic Drilling with a Capping Stack (Case Study 5, Appendix A: Case Studies)</td></tr>
<tr><td>2.</td><td colspan="2">Select which category best represent your proposed operation.</td></tr>
<tr><td></td><td>If</td><td>Then</td></tr>
<tr><td></td><td>Category 1</td><td>STOP – no additional risk assessments or barrier analysis is needed.</td></tr>
<tr><td></td><td>Category 2, 3 or 4</td><td>Schedule a preplanning conference with BSEE to review the proposed use of new technology.
Proceed to Part 2 of this guide.</td></tr>
</table>

Figure 2 illustrates the workflow based on the category of new technology. Additional risk assessment and barrier analysis will be needed for all new technology classified as category 2, 3, or 4. Category 1 may not require any additional assessment or analysis.

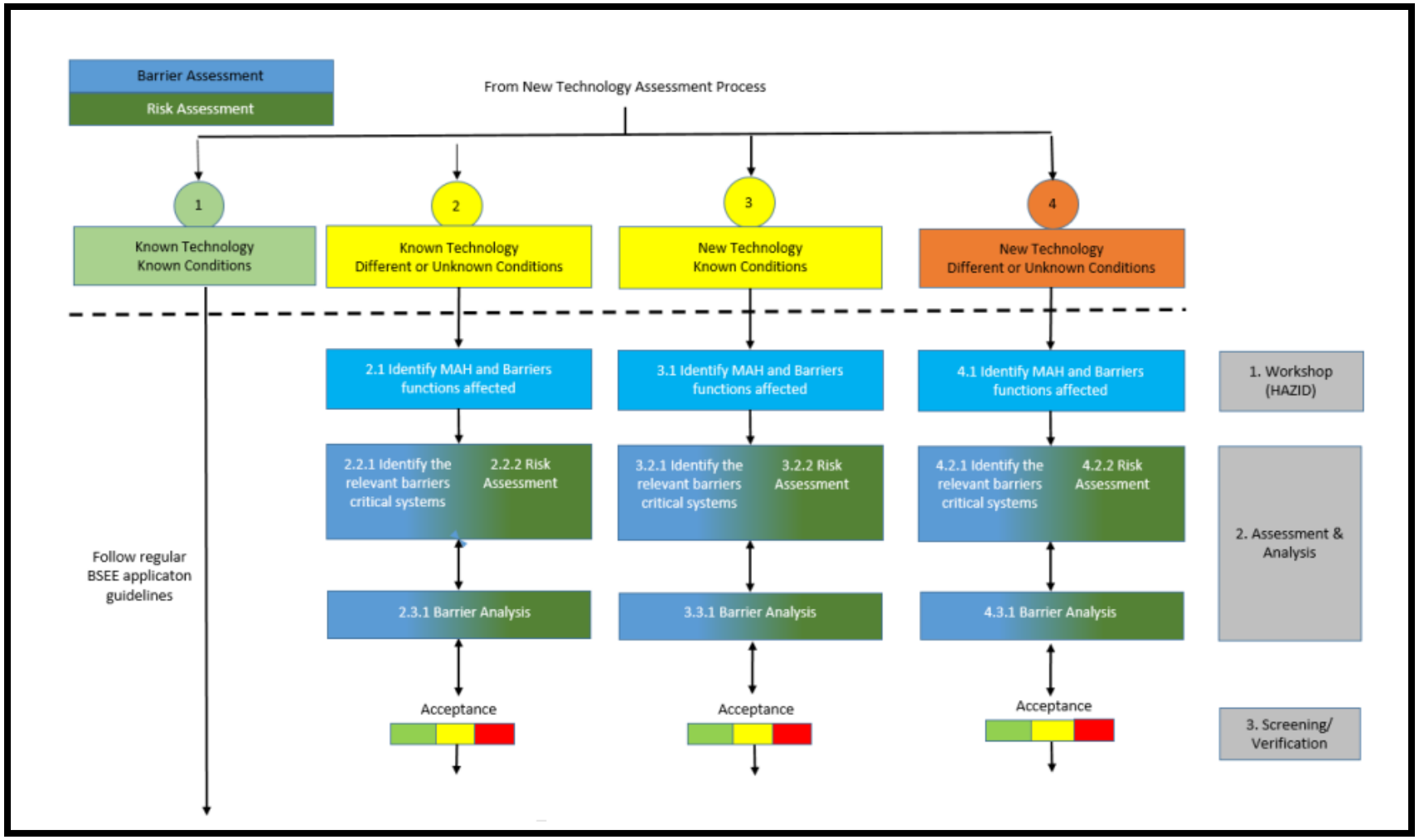

Figure 2: New Technology Assessment Framework

Part 2: How to Prepare for the Preplanning Conference with BSEE

After a preliminary determination of the new technology category, the Operator should prepare for a Preplanning Conference with BSEE to discuss the proposed new technology. This preliminary discussion will help the Operator discuss their new technology concept with BSEE and facilitate the identification of any additional information or actions that may be required for their application. The main objectives of the preplanning conference are to:

- Discuss conventional and novel aspects related to the new technology so focus can be on the new aspects
- Discuss applicable design standards/codes/regulations that needs to be complied with
- Discuss plans for design verification and design validation
- Discuss scope and plan for risk assessments and barrier analysis
- Discuss the need for possible third party review and validation of the analysis

During the Preplanning Conference, if BSEE determines that the new technology will affect the barrier function then the Operator will conduct a risk and barrier analysis evaluation. Similarly, during the Preplanning Conference, if BSEE agrees to the use of an existing technology in a new or unknown condition then the Operator will perform a barrier and risk analysis. The Operator should inform BSEE of any previous submittals requesting use of this new technology by other programs for other applications if he has knowledge of them. In addition, during this discussion, BSEE may suggest the use of third-party reviews of the risk and barrier analysis, particularly for **Category 4** submissions or other factors.

In preparation for the Preplanning Conference with BSEE, the Operator should also develop any additional information surrounding their proposed use of new technology. This information will involve the degree to which the Operator proposes use of new technology involving barrier functions or barrier elements. **Table 2** provides the definitions for barrier functions and barrier elements.

Table 2: Important Definitions – Barrier Function and Barrier Element

Term	Definition
Barrier Function	*A function that needs to be realized in order to prevent, control or mitigate a major accident hazard.* Example: Shut in well – to prevent a blowout, and mitigate uncontrolled well situation.
Barrier Element	*A physical element or a subset of physical elements that are needed as part of the barrier critical system, in order for it to perform its intended function.* Example: Barrier elements needed to close and seal on open hole is the blind shear, the blind shear ram and the control system and power supply. These can include:

When preparing for the Preplanning Conference with BSEE, the Operator should follow the following steps in **Table 3**.

Table 3: Step/Action Table – How to Prepare for and Conduct the Preplanning Conference with BSEE.

Step	Action	
1.	Using the description of barrier functions and barrier elements discussed above, does your proposed use of new technology affect or influence a specific barrier function (or barrier element as applicable)	
	If	**Then**
	Yes	Prepare a description of the barrier function and barrier elements involved in your operations. If you are not sure if the new technology affects a barrier function or element, consider that it does. Go to **Step 2** in this table.
	No	**STOP** – no need to conduct a preplanning conference with BSEE. No additional risk assessments or barrier analysis needed.
2.	Is the use of the proposed new technology the first application of its kind?	
	If	**Then**
	Yes	Prepare a summary of the new technology application detailing how it is a first application of its kind. Go to **Step 3** in this table.
	No	Go to **Step 3** in this table
3.	Will the proposed new technology be used in new or unknown environments?	
	If	**Then**
	Yes	Prepare a summary of the new or unknown environments in which this new technology will be used. Go to **Step 4** in this table.
	No	**STOP** – no need to conduct a preplanning conference with BSEE. No additional risk assessments or barrier analysis needed.
4.	Conduct the Preplanning Conference with BSEE. Be prepared to discuss the proposed use of new technology with BSEE during the preplanning conference including the following: 1) The category of new technology from Part 1 2) The specific barrier function(s) and barrier element(s) involved in your operations 3) If applicable, a discussion of how your use of the technology is a first application of its kind 4) The environments in which the new technology will be used 5) Which international or domestic industry standard(s) that you will use 6) Risk acceptance criteria 7) The verification methods that you plan to employ, (e.g., Internal Verification, 3rd Party Verification.	
5.	Following the Preplanning Conference with BSEE, go to **Section 2 – Risk Assessment** – of this guide.	

Part 3: Document New Technology Assessment Results

After the Preplanning Conference with BSEE, the Operator may proceed with their Risk Assessment and Barrier Modeling and Analysis, as detailed in **Section 2**: **Risk Assessment** and **Section 3: Barrier Analysis.** Once the Operator has conducted and reviewed its Risk and Barrier analysis, the Operator should submit the results to BSEE. The new technology request is submitted with all other attachments and/or forms to be reviewed as part of a DWOP, APD, APM, etc. permit process application submittal.

New Technology Assessment Results should be determined by following the steps in **Table 4** below.

Table 4: Step/Action Table – How to Document New Technology Assessment Results

Step	Action

Step	Action
1.	Has the Operator answered and performed the following checklist questions for a New Technology Assessment: a. Has Operator contacted BSEE to schedule a preplanning conference to discuss the new technology application in order to gain BSEE agreement / initial buy-in? b. Has the Operator determined that the submission involves the use of new technology (30 CFR §250.292 (n) AND Section 1 of the Industry Process Guide)? Go to **Step 2** in this table.
2.	Operator should document New Technology Results by including the following: a.) A Description of the New Technology b.) Any Identification of Barrier Function or Elements c.) Whether Technology has been Used Before d.) The Environment that the New Technology Will Be Used Go to **Step 3** in this table.
3.	Proceed to **Section 2**.

Section 2: Risk Assessment

This section describes the steps involved in conducting a risk assessment of the new technology to identify Major Accident Hazards (MAH) and identify relevant barrier critical system(s). More detailed risk assessments, such as Quantitative Risk Assessments / Probabilistic Risk Assessments, may be needed based on the results of a preliminary risk assessment. This Section is divided into three parts.

- Part 1: Selecting the Risk Assessment Methodology
- Part 2: Conduct Risk Assessment in order to identify MAHs
- Part 3: Identifying the affected Barrier Functions

Part 1: How to Select the Risk Assessment Methodology

There are a number of different methods to conducting a risk assessment. The selection of the Risk Assessment Methodology will depend on the results of the initial hazard identification.

Appendix B: Risk Assessment Technical Note.

Table 5**Table 5** provides a brief description of the applicable risk assessment methodologies for proposed new technology used in the OCS of the U.S. For a more detailed description, see **Appendix B: Risk Assessment Technical Note**.

Table 5: Important Definitions – Risk Assessment Methodologies

Risk Assessment	Description
Hazard Identification	The HAZID study is a brainstorming exercise of the possible causes and consequences of hazardous events.
Hazard and Operability (HAZOP) Analysis	The HAZOP study technique is a systematic review of the system design to identify and evaluate safety hazards of the system, and to identify operability problems that could compromise the system's ability to achieve the design intent.
Event Tree Analysis (ETA)	ETA is an analysis technique that uses decision trees to model the possible outcomes of an event that can produce an accident of interest.

Risk Assessment	Description
Fault Tree Analysis (FTA)	FTA is a technique that graphically models how logical relationships between equipment failures, human errors, and external events can combine to cause specific accidents of interest.
Layer of Protection Analysis (LOPA)	LOPA is a technique to systematically identify and assess the number and strength of layers of protection against major accident hazards. This information is used to make decisions on existing or proposed layers of protection.
What-if Analysis	What-if analysis is a problem-solving approach that uses loosely structured questioning to (1) suggest upsets that may result in accidents or system performance problems and (2) make sure the proper safeguards against those problems are in place.
Bowtie Analysis	Similar to LOPA, bowtie analysis is a technique for identifying layers of protection for major accident hazards, but bowtie enables analysts to consider multiple scenarios simultaneously.
Failure Modes and Effects Analysis (FMEA)	FMEA is a reasoning approach best suited to reviews of mechanical and electrical hardware systems. The FMEA technique (1) considers how the failure modes of each system component can result in system performance problems and (2) makes sure the proper safeguards are in place.
Change Analysis	Change analysis looks logically for possible risk effects and proper risk management strategies in changing situations (e.g., when system layouts are changed, when operating practices or policies change, when new or different activities will be performed).
Trend Analysis	Trend analysis is a technique to analyze historical accident and near miss data over time to identify consistent trends to predict future accidents.
Pareto Analysis	Pareto analysis is a ranking technique based only on past data that identifies the most important items among many. This technique uses the 80-20 rule, which states that about 80 percent of the problems are produced by about 20 percent of the causes.
Relative Ranking/Risk Indexing	Relative ranking/risk indexing uses measurable features of an operation or facility to calculate index numbers that are useful for comparing risks of different options.
Pairwise Comparison	Pairwise comparison is a risk ranking technique for multiple issues that relies on a collection of Subject Matter Experts (SMEs) systematically rating the relative risks between combinations of two issues.
Preliminary Risk Analysis (PrRA)	PrRA is a simplified approach to accident-based risk assessment. The main goal of the technique is to define the risk related to important accident scenarios.
Interface Analysis	Interfaces are An approach to systematically identify, assess and manage non-technical interface risks.
Management Oversight Risk Tree(MORT)	MORT is a comprehensive, analytical, disciplined method for determining the causes and contributing factors of major incidents.
Probabilistic Risk Assessment (PRA)	Probabilistic risk assessment is an integration of FMEA, FTA, and other techniques to assess the potential for failure.
Safety and Risk Evaluation using Bayesian Nets (SERENE)	The SERENE method is concerned with the functional safety of complex systems. Takes into account both random and systematic failures.
Integrated System Hazard Analysis	Specific integrated analyses are appropriate to evaluate interactions, such as Human – Human Interface Analysis; and, Machine – Abnormal Energy Exchange, Software Hazard Analysis.

Table 6 provides the steps the Operator should take to select the appropriate risk assessment Methodology.

Table 6: Step/Action Table – How to Select a Risk Assessment Methodology

Step	Action
1.	Select an Appropriate Risk Assessment Methodology as referenced in **Table 5** and in **Appendix B: Risk Assessment Technical Note.**
2.	Proceed to **Part 2.**

Part 2: How to Identify the Major Accident Hazards

As part of any risk assessment, the identification of any MAHs should be documented. MAHs are significant events that could occur during installation or operation. Because each application for an offshore installation is unique in terms of its design, operating environment and application of new technology it is impossible to provide a standard definition of MAHs that will fit every application. The most effective way to identify MAHs is by conducting an HAZID workshop, where SMEs apply their knowledge and experience to the task of identification. The following are examples of some of the MAHs that should be considered in the risk assessment:

- Fire
- Explosion
- Uncontrolled Flooding
- Major damage to the structure
- Loss of stability
- Loss of well control
- Release of dangerous substances (flammable, corrosive, pollutant, etc.)
- Collision or Allision
- Personal injury or death

Table 7: Step/Action – How to Identify Major Accident Hazards

Step	Action
1.	Conduct a risk assessment in order to identify MAHs: In general, the MAHs for the relevant operation will have to be identified. Further, how these MAHs are affected by changes in technology or conditions needs to be addressed.
2.	Proceed to **Part 3**.

The results of the HAZID will form the baseline of any subsequent work and as such is an integral part of the application process. The focus of the HAZID will depend on which workflow is relevant; e.g. whether new conditions or new technology are most prevalent, or a combination of the two. The HAZID should identify if there are any possible degradations of barriers or an increase in the consequence of an unwanted incident identified. It should be an expressed focus of the HAZID workshop to identify unknowns related to the new technology and/or conditions, to ensure that the design takes into account the threats and associated responses. For additional details, please **Appendix B: Risk Assessment Technical Note**.

Part 3: How to Identify the Affected Barrier Functions and Barrier Critical System

Once the risk assessment has been completed and the MAHs have been identified the next step is to identify the barriers, affected barrier functions, and barrier critical system that are related to each MAH identified. **Table 8** provides some important definitions that are helpful in identifying critical system functions.

Table 8: Important Definitions – Identifying Critical Barrier System and Barrier Functions

Term	Definition	Example
Barrier Function	*A function that needs to be realized in order to prevent, control or mitigate a major accident hazard.*	Shut in well – to prevent a blowout, and mitigate uncontrolled well situation.
Barrier Critical System	*A defined system that by performing its intended function(s) realizes the barrier function, either alone or together with other barrier critical systems of the same barrier function.*	Casing/Cement, Wellhead, BOP, Marine Drilling Riser and Drill string.

To identify the affected barrier system functions, follow the steps in **Table 9**.

Table 9: Step/Action Table – How to Identify the Affected Barrier Functions

Step	Action
1.	Identify affected barrier functions for control, prevention and/or mitigation of the defined MAH(s): Barrier functions established against the relevant MAHs should be identified and any impact of new technology or conditions should be identified.
2.	Proceed to **Part 4**.

Part 4: Document Risk Assessment Results

The primary purpose of the Risk Assessment is to determine if the application of new technology provides the level of safety that is acceptable. It will be the responsibility of the Operator to define its risk tolerability criteria and to meet the specified criteria. Approval of the new technology application will be based on the Operator's achievement of the acceptance criteria as defined by the Operator.

This section provides information on now to select a Risk Assessment Methodology, identify MAHs, and identify barrier elements. When the barrier model and analysis is complete, the Operator should have the following results as shown in **Table 10**.

Table 10: Step/Action Table – How to Document Risk Assessment Results

Step	Action
1.	Document the Risk Assessment Results by: a. Completing a Risk Assessment. b. Identifying MAHs associated with the new technology. c. Identifying the affected barrier function(s)/barrier critical system(s) that control or mitigate the MAHs.
2.	Proceed to **Section 3.**

As part of the new technology application submission, the Operator implementing the use of new technology is required to perform the risk assessment as indicated in **Appendix B: Risk Assessment Technical Note**

Section 3: Barrier Analysis

This section provides guidance for Operators developing barrier models and then analyzing the attributes for each of the barrier functions. This section includes:

- An introduction to the Barrier Model
- Barrier Terms and Definitions
- Barrier Element Attribute Checklists

Part 1: Introduction to the Barrier Model

The intent of the barrier model is to describe how the barrier function can be realized and the systems and elements that are critical in the realization of this function. This is described through a success path structure.

By combining system breakdown and function breakdown, the barrier model is designed to identify functional redundancies between systems or elements within system, as well as considering the system level composition of the barrier function. The focus is on the physical barrier elements, and their ability to perform their function reliably, through execution of physical tasks, but the model also includes the operational tasks that are needed in order to perform the physical tasks. The barrier model also includes a way to assess all the attributes that influence the barrier element's ability to perform the required physical and operational tasks.

The barrier model hierarchy has the following levels:

- Barrier Functions
- Barrier Critical System
- Barrier Critical System Function
- Barrier Element, which include
    - Physical Tasks
    - Operational Tasks
    - *Tier I*, *Tier II* & *Tier III* attributes with success criteria

Barrier Model Definitions

Table 11 provides important terms and definitions for each tier in the barrier model template. For additional details, please see **Appendix C: Barrier Analysis Technical Note**.

Table 11: Important Definitions – Barrier Model

Term	Definition	Example

Term	Definition	Example
Barrier Function	*A function that needs to be realized in order to prevent, control or mitigate a major accident hazard.*	• *Shut in well – to prevent a blowout, and mitigate uncontrolled well situation*
Barrier Critical System	*A defined system that by performing its intended function(s) realizes the barrier function, either alone or together with other barrier critical systems of the same barrier function.*	• *Casing/Cement, Wellhead, BOP, Marine Drilling Riser and Drill string*
Barrier Critical System Function	*A function that is performed by the barrier critical system in order to realize the barrier function, either alone or together with other functions of the same barrier critical system.*	• *Functions needed to be performed by the BOP to shut in well is to disconnect LMRP, strip drill string, close and seal on open hole, and shear drill pipe and seal well bore*
Barrier Element	*A physical element or a subset of physical elements that are needed as part of the barrier critical system, in order for it to perform its intended function.* These can include (below):	• *Barrier elements needed to close and seal on open hole is the blind shear, the blind shear ram and the control system and power suppl.*
	Physical Tasks *Task performed automatically or initiated by a human action as intended by the design of the barrier element, in order to realize/perform the barrier critical system function.* Example: Power systems must deliver sufficient hydraulic power	• *Power systems must deliver sufficient hydraulic power*
	Operational Tasks *Human action that is needed by the barrier element or the barrier critical system in order to realize/perform the barrier critical system function.* Example: the Operator must activate the control system (push the button)	• *The Operator must activate the control system (push the button)*
Attributes (Tier I, II and III)	*External or internal characteristic features or conditions that influence the success of the barrier element, to perform the required physical or operational task that is needed by the barrier critical system.*	• *Tier I - Design* • *Tier II - Design Parameter* • *Tier III - Rated Working Pressure*
Success Criteria	*The specific criteria for an attribute that needs to be met to ensure the ability of the barrier elements to perform its intended tasks successfully.*	• *Power system is designed to meet the codes and standards*

Part 2: How to Develop Barrier Model(s)

Barrier modeling and analysis involves the review of barrier(s) to understand what needs to succeed in order for it to perform its intended function(s). Typically, for this purpose a barrier model is developed and analyzed to determine the ways in which the barrier can succeed as well as fail to perform its function. **Figure 3** provides an illustration of the barrier model template.

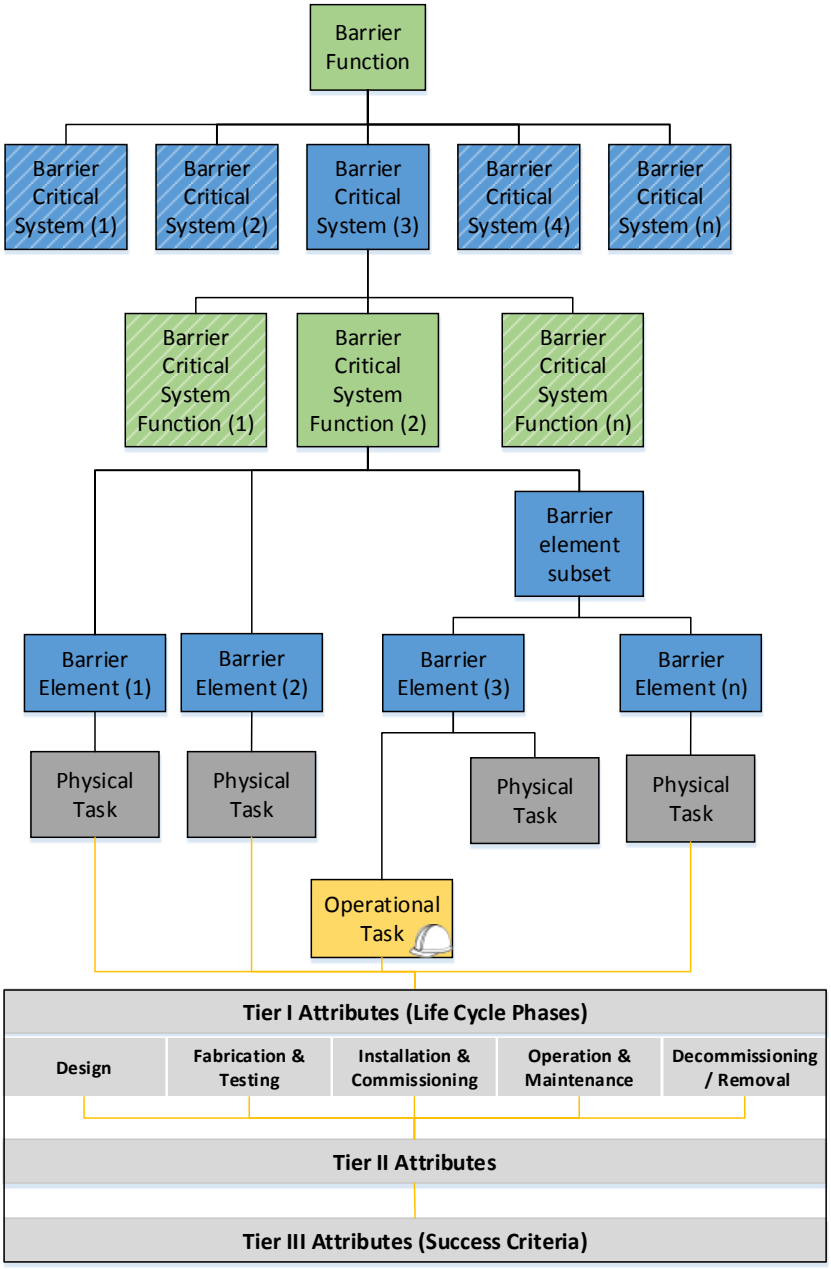

Figure 3: Barrier Model Template

A good understanding of the success logic is critical in determining the requirements and related activities for ensuring the integrity of the barrier. This success path logic enables the identification of interconnectivities and interdependencies early in the barrier analysis. The tree structure of the model helps in visualizing and thereby making it easier to identify interdependencies between systems and elements.

One of the prerequisites for barrier analysis is the identification of the major accident scenario(s) with relevant barrier(s) and their corresponding role(s)/function(s) in risk reduction.

See **Appendix C: Barrier Analysis Technical Note** for key features of the barrier model template.

Developing the Barrier Model

Common modeling methods and techniques are used for building a barrier model for analyzing specific barriers especially when it involves new technologies. **Table 12** outlines the basic steps to develop a barrier model.

Table 12: Step/Action – How to Develop a Barrier Model

Step	Action
1.	**Identify** the *Barrier Function(s)* related to each of the MAH(s) identified during the risk assessment (**Section 2**)
2.	For each Barrier Function, **list** the *Barrier Critical System* that is designed to perform the barrier function(s).
3.	For each Barrier Critical System, **list** the *Barrier Critical System Function(s)* that is to be performed in order to realize the barrier function. (Note: One barrier critical system can be performing one or more barrier critical system functions.)
4.	For each Barrier Critical System Function, **list** the *Barrier Element(s)* that are needed in order for it to perform its intended function.
5.	For each Barrier Element, **list** the *Physical Tasks* that each barrier element needs to perform in order for the barrier element to fulfil the barrier critical system function.
6.	For each Barrier Element, **list** the *Operational Tasks* that each barrier element needs to perform in order for the barrier element to fulfil the barrier critical system function. Note: Operational tasks usually involve human interaction for the barrier element to perform its function.

There are some important concepts to keep in mind when developing a barrier model. These include:

- Success of the barrier function is to prevent, control or mitigate the hazardous situation is predicated on the barrier elements ability to perform its tasks
- The barrier model identifies and visualize interdependencies
- Not all elements of the barrier is needed to perform a specific function:
  (Functional breakdown ≠ System breakdown)
- One barrier element can be relevant for multiple barrier critical functions
- Similar to a Fault tree structure with success logic, as opposed to fault logic

Part 3: How to Develop Barrier Element Attributes

Once the barrier model is built, an analysis of the barrier element(s) should be conducted. This involves identifying and understanding the relevant attributes that can influence the barrier's ability to perform its barrier function. During the analysis, various barrier element attributes are examined in accordance with established success criteria. These attributes are structured into three tiers.

Barrier Attributes

Tier I Attributes

The first tier covers the life cycle phases that are usually assessed during the development of a new design. See **Figure 4**.

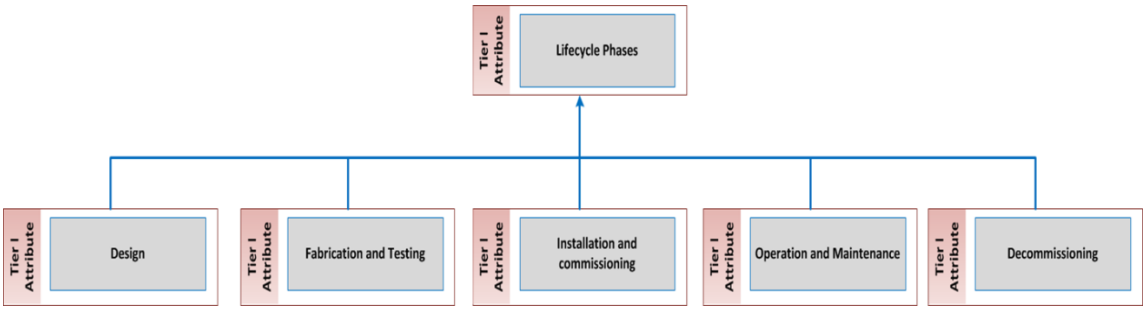

Figure 4: Tier I Attribute Types

Tier I attributes are identified in the submission. The *Tier I* attributes include:

- **Design** –The Operator will need to explain why the design is suitable and adequate to meet the barrier function. The Operator should compare the new technology to comparable existing technology and describe the benefits of the new technology.
- **Fabrication and Testing** –The Operator should articulate how the new technology has been procured and fabricated/constructed to meet the defined design specifications and that testing has been undertaken to confirm all of the defined design specifications have been met.
- **Installation / Commissioning** –The Operator should describe how the new technology will be installed correctly and how suitable commissioning tests will be completed before the systems are operated. The Operator should provide procedures for adequate storage, installation, testing and commissioning. The procedures should clearly explain how the barrier(s) installation and commissioning will not pose any immediate or future safety hazards.
- **Operation and Maintenance** – The Operator should provide information about the processes, procedures, maintenance and testing that will preserve the design function of the barrier. The Operator should clearly explain design limitations, procedures, operation and maintenance activities that specifically meet the design specification and procedural requirements for the new technology.
- **Decommissioning** – The Operator should provide information about the processes and procedures for the removal/decommissioning of the barrier. The Operator should provide information about the disassembly of the barrier and interactions with other equipment that need to be considered.

Tier II Attributes

The second tier breaks these down into aspects that are required to be assessed as part of each life cycle phase. For example, "Design Attributes" can be decomposed into specific design parameters, which are driven by relevant Codes, Standards and Regulations as shown in **Figure 5.**

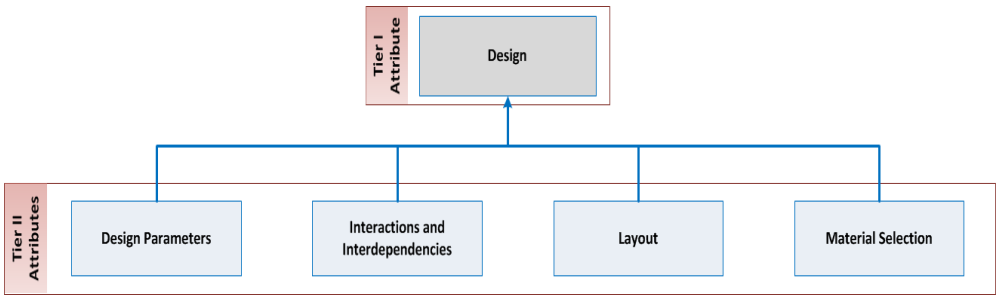

Figure 5: Tier II Attributes

Tier II Attributes – *Tier II* attributes support each phase of the *Tier I* attributes. **Table 13** provides a list of the minimum level of *Tier II* attributes that should be addressed in the submission.

Table 13: Important Definitions – Tier II Attribute Descriptions

Tier II Attribute	Attribute Features
Design phase	Design Parameters
	Interactions / Dependencies
	Layout
	Material Selection
Fabrication and Testing phase	Material Procurement & Quality Assurance
	Welding and Non-Destructive Examination (NDE)
	Testing and Validation
Installation and Commissioning phase	Inspection
	Storage
	Examination Pre-installation
	Installation
	Testing and Validation Post-Installation
	Commissioning
Operation and Maintenance phase	Limits
	Procedures
	Operation
	Maintenance
Decommissioning/Removal phase	Process
	Disassembly
	Interaction / Dependencies

See **Appendix C: Barrier Analysis Technical Note** for further *Tier II* attribute descriptions.

Tier III Attributes

Tier III details are usually derived from relevant codes, industry standards and technical specification. *Tier III* attributes are linked to each *Tier II* attributes within each of the life cycle phases. *Tier III* attributes require the greatest level of detail that should be submitted to BSEE for review and evaluation of any proposed new technology. The *Tier III* attributes detail the considerations that Operator assesses for each *Tier II* attribute. Each *Tier III* attribute is evaluated against the success criteria of the physical and operational tasks for the barrier element/ barrier critical system. With each *Tier III* attribute, Operators should provide supporting documentation for all testing, design specifications, third party testing and

evaluation reports, and emergency procedures. BSEE reviewers will evaluate each of the *Tier III* attributes and supporting documentation to ensure each *Tier III* attribute meets the acceptable safety and risk criteria required by BSEE. **Figure 6** provides example *Tier III* attributes.

The Operators should ensure that all *Tier III* attributes are addressed in their submission. The Operator should address each *Tier III* attribute listed in **Figure 6**.

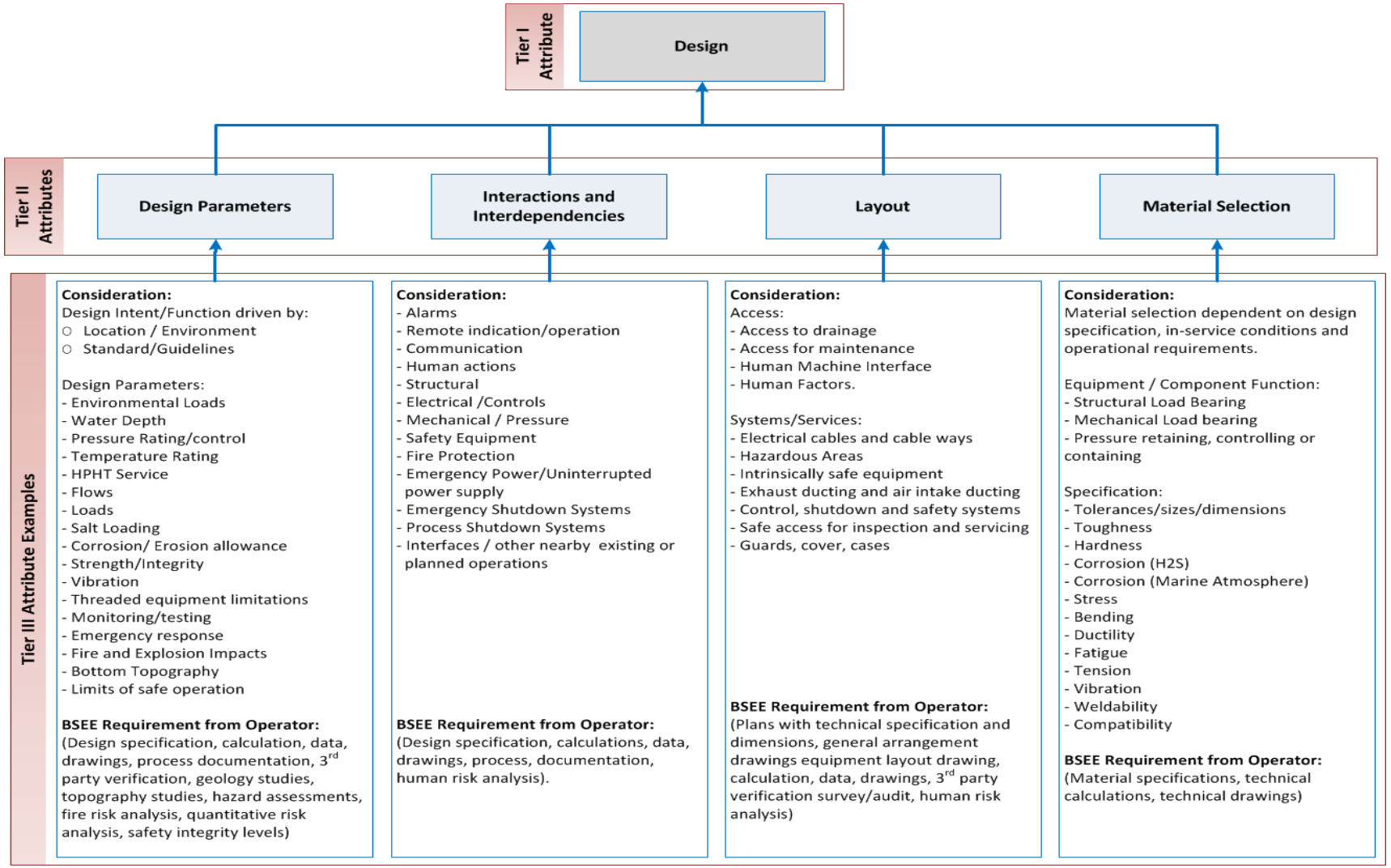

Figure 6: Tier III Attributes

Barrier Element Success Checklist

In the final step of the new technology Barrier Assessment, Operators should link the *Tier III* attributes to success criteria. To assist the Operator, and BSEE, a *Barrier Element Success Checklist* has been developed to complement and link the barrier elements life cycle phase attributes to its success criteria. **Figure 7** provides an illustration of a blank *Barrier Element Success Checklist*. A specific example of a completed BOP Shear Ram checklist is provided in **Appendix D: Example of Barrier Analysis BOP Blind Shear Ram Checklist.** Operators may obtain a blank Barrier Element Success Checklist from BSEE's website.

Barrier Function:															
Barrier Critical System:															
Element:															
1-1 DESIGN PARAMETERS															
Checklist Ref.	**Barrier Critical System Function**	**Task Type**	**Task**	**Success Criteria**	**Success Criteria**	**Applicant Assurance**	**First Check Date**	**First Check Result (Y/N)**	**First Check ID**	**Second Check Date**	**Second Check**	**Second Check ID**	**Supervisory Check Date**	**Supervisor ID**	**Remarks**
These are the parameters driven by relevant Codes, Standards and Regulations and also by the location/environment of the offshore unit. E.g. environmental hazards, pressure/temperature ratings, loads, corrosion/erosion allowance, strength/integrity, impacts etc.															
1-2 INTERACTIONS / DEPENDENCIES															
Checklist Ref.	**Barrier Critical System Function**	**Task Type**	**Task**	**Success Criteria**	**Success Criteria**	**Applicant Assurance**	**First Check Date**	**First Check Result (Y/N)**	**First Check ID**	**Second Check Date**	**Second Check**	**Second Check ID**	**Supervisory Check Date**	**Supervisor ID**	**Remarks**
The interactions/dependencies that are required for the barrier to achieve its intended function should be identified and assessed. E.g. alarms, remote indication, human actions and emergency power etc.															

Figure 7: Barrier Element Success Checklist

Each checklist is separated into individual sheets for the different life cycle phases (Design, Fabrication / Testing, Installation / Commissioning, Operation / Maintenance, and Decommissioning / Removal). The Operator should fill out the first seven columns of the checklist. The checklist ensures that the Operator addresses each life cycle phase and the success criteria for the relevant *Tier III* attributes. The Operator should provide documentation that verifies the capacities or capabilities of *Tier III* attributes identified to demonstrate that the *Tier III* attributes support the physical or operational tasks of the barrier.

Each checklist is separated into individual sheets for the different life cycle phases (Design, Fabrication / Testing, Installation / Commissioning, Operation / Maintenance, and Decommissioning / Removal). Each sheet is used to record information about the barrier element attributes for each life cycle phase in order to analyze the success criteria for each of the relevant *Tier III* attributes. Each sheet of the checklist is organized to capture the following information:

- **Barrier Function –** The top-level function of the barrier (e.g. Shut in Well in event of a kick scenario).
- **Barrier Critical System –** One of the critical system in achieving the barrier function (e.g. BOP).
- **Barrier Element –** Element of the system in this case is the Shear Rams of the BOP.
- Barrier Critical System Function – Description of function of the barrier critical system (e.g. for the BOP, the close and seal on open hole).
- **Task Type –** Detail if the task required in maintaining the barrier critical system function is Operational or Physical.
- **Task –** Description of the Operational or Physical task required for performing the barrier critical system function e.g. for the shear ram a physical task is close and seal on open hole.

- **Success Criteria –** Performance requirement or success criteria for each attribute in the success path of the barrier element so that it can perform its intended function.
- **Basis –** Reference to applicable Codes and Standards, Technical or Functional Specification etc. from which the success criteria for the attribute is derived.
- **Applicant Assurance –** Assurance provided by the leaseholder verifying that each barrier element attribute can meet the required success criteria (e.g. relevant design documents or test reports).
- **BSEE Review Quality Assurance Processes –** Processes required by BSEE to ensure all Quality Assurance requirements for the new technology review have been met.

The Operator should complete their portion of the checklists and provide it with their application submission for BSEE review. The checklists are designed to expedite the review process by providing a consistent format and structure that will allow BSEE reviewers to determine quickly if the Operator has provided all the relevant information. The remaining nine columns of the checklist are for BSEE's quality assurance processes. The checklist also provides accountability by documenting who and when review activities occur.

The performance influencing factors for each barrier element are related to different life cycle phases of the new technology as this provides a better overview with respect to what specific factors need to be considered and when they are of significance to the new technology. During the life cycle of an oil and gas asset, activities are carried out to ensure that the integrity of the asset is maintained from design through to decommissioning. Similarly, the building blocks for the barrier model needs to take into consideration the different life cycle phases in order to maintain overview and control of the safety challenges and the different operations that are required during various phases of the product's life cycle. In other words, the overall success for the barrier critical system or barrier element is achieved when all attributes for the performance influencing factors in each life cycle phase collectively succeed. This process can also be used to identify areas that may not successfully meet the relevant codes/ standards or the functional requirements as defined in the functional specification for the new technology.

Conducting the Barrier Analysis

Table 14 outlines the steps to follow to conduct the barrier analysis.

Table 14: Step/Action – How to Conduct the Barrier Analysis

Step	Action
1.	Identify the *Tier I* attributes for each of the life cycles of the barrier element that was identified in the barrier model developed in **Part 2** of this Section. See **Figure 4** for an example.
2.	For each *Tier I* attribute, identify the associated *Tier II* attributes. See **Figure 5** for an example.
3.	For each *Tier II* attribute, identify the relevant *Tier III* attributes, which are derived from Codes, Standards and the technical specifications of the equipment being analyzed. See **Figure 6** for an example.
4.	Complete the Barrier Element Success Checklist (See **Appendix D: Example of Barrier Analysis BOP Blind Shear Ram Checklist** for a completed example). The checklists have been developed to complement and link the barrier element's life cycle phase attributes to the attribute's success criteria.

Part 4: Document Barrier Model and Analysis Results

This part provides information on how to document barrier model and analysis results. The Operator should follow the steps in **Table 15** to ensure that the Barrier Model and Analysis are complete.

Table 15: Step/Action Table – How to Document Barrier Model and Analysis Results

Step	Action
1.	Document the Barrier Analysis Results by; a. Completing Barrier Model for Each Barrier Function related to a Major Accident Hazard b. Completing Attribute Checklist
2.	Proceed to **Section 4**

Section 4: How to Submit New Technology Assessment Results to BSEE

This section provides guidance on how to submit new technology assessment results to BSEE for final review, which includes the *Operator New Technology Process Review Checklist*.

Part 1: How to Verify that the New Technology Assessment is Complete

Once the Operator determined his or her application included new technology, conducted a risk assessment, and provided the barrier modeling and analysis, the new technology assessment results need to be submitted to BSEE.

Table 16 provides the proper steps to verify that the new technology assessment is complete. A copy of the checklist is contained in **Appendix E: Operator's New Technology Process Review Checklist**. Operators are encouraged to include this completed checklist with their submission to BSEE.

Table 16: Step/Action – How to Verify that the New Technology Submission is Complete

New Technology Process Review Checklist	
Step	**Action**
1.	Yes □ No □ Has the Operator determined that the submission involves the use of new technology (30 CFR §250.292(n) AND **Section 1** of the *Industry New Technology Process Guide*)? *Check the appropriate category:* □ Category 1*. Known Technology, Known Conditions □ Category 2. Known Technology, Different or Unknown Conditions □ Category 3. New (Unknown) Technology, Known Conditions □ Category 4. New (Unknown) Technology, Different or Unknown Conditions *NOTE: *If Category 1, no additional risk assessment or barrier analysis is required*.
2.	Yes □ No □ Has Operator contacted BSEE to schedule a Preplanning Conference to discuss the new technology application in order to gain BSEE agreement / initial buy-in?
3.	Has Operator discussed the proposed submission with BSEE in order to: Yes □ No □ Verified the new technology category, i.e. Category 2,3, or 4)? Yes □ No □ Identified the minimum risk assessment and barrier analysis that should be conducted for the submission? Yes □ No □ Identified the need of independent 3rd party verification for the new technology proposal?
4.	Has Operator conducted a risk assessment using the appropriate risk assessment methodology? Yes □ No □ Has Operator identified MAHs associated with the new technology? Yes □ No □ Has Operator identified the affected barriers that control or mitigate the MAHs?

New Technology Process Review Checklist	
Step	**Action**
5.	Yes □ No □ Has Operator completed the barrier analysis and validated the success criteria for the barrier element attributes?
6.	Yes □ No □ Has Operator demonstrated that barrier critical system functions and elements satisfy the success criteria based on the barrier analysis?
7.	Yes □ No □ Has Operator sought independent 3rd party verification of the risk assessment and barrier analysis, as discussed with BSEE during the preplanning conference?
NOTE: *Operators should include all of the new technology risk assessment and barrier modelling documents, including any independent 3rd party review/certification documentation as part of the permit application. Operator should include this with their submission to BSEE*.	

Appendix A: Case Studies

Case Study 1: Ultra Deepwater Drilling with a Subsea BOP

Case Study 2: Drilling a Well Using a MODU with a Surface BOP

Case Study 3: Managed Pressure Drilling (MPD)

Case Study 4: HPHT and High Corrosive Environment

Case Study 5: Drilling from a Semi-Submersible in the Artic

Appendix B: Risk Assessment Technical Note

Appendix C: Barrier Analysis Technical Note

Appendix D: Example of Barrier Analysis BOP Blind Shear Ram Checklist

Barrier Function: Shut in the Well															
Barrier Critical System: BOP															
Element: Blind Shear Ram BOP															
1-1 DESIGN PARAMETERS															
Checklist Ref.	**Barrier Critical System Function**	**Task Type**	**Task**	**Success Criteria (Attribute)**	**Success Criteria Basis**	**Applicant Assurance**	**First Check Date**	**First Check Result (Y/N)**	**First Check ID**	**Second Check Date**	**Second Check Result (Y/N)**	**Second Check ID**	**Supervisory Check Date**	**Supervisor ID**	**Remarks**
These are the parameters driven by relevant Codes, Standards and Regulations and also by the location/environment of the offshore unit. E.g. environmental hazards, pressure/temperature ratings, loads, corrosion/erosion allowance, strength/integrity, impacts etc.															
1-1-1	Close and Seal on Open Hole	Physical	Close and Seal on Open Hole	Rams designed to have, as a minimum, a RWP equal to the MAWHP to be encountered	API 53 (7.1.1.2)	Designers specification (document reference) details that the subsea BOP RWP equal to the MAWHP to be encountered of 15,000 psi Calculations are submitted Design certified during design review	xx	xx	xx	xx	xx	xx	xx	xx	
…															
1-2 INTERACTIONS / DEPENDENCIES															
Checklist Ref.	**Barrier Critical System Function**	**Task Type**	**Task**	**Success Criteria (Attribute)**	**Success Criteria Basis**	**Applicant Assurance**	**First Check Date**	**First Check Result (Y/N)**	**First Check ID**	**Second Check Date**	**Second Check Result (Y/N)**	**Second Check ID**	**Supervisory Check Date**	**Supervisor ID**	**Remarks**
The interactions/dependencies that are required for the barrier to achieve its intended function should be identified and assessed. E.g. alarms, remote indication, human actions and emergency power etc.															
1-2-1	Close and Seal on Open Hole	Physical	Close and Seal on Open Hole	Dependency: Control system required to be capable of actuating the rams	API 53 (7.3.1.2)	Design specification details that control system will automatically actuate components in the BOP stack including Blind Shear Rams Design of control system shall be designed, manufactured, and installed API 16D Design certified during design review	xx	xx	xx	xx	xx	xx	xx	xx	
…															
1-3 LAYOUT															
Checklist Ref.	**Barrier Critical System Function**	**Task Type**	**Task**	**Success Criteria (Attribute)**	**Success Criteria Basis**	**Applicant Assurance**	**First Check Date**	**First Check Result (Y/N)**	**First Check ID**	**Second Check Date**	**Second Check Result (Y/N)**	**Second Check ID**	**Supervisory Check Date**	**Supervisor ID**	**Remarks**
The layout of the barrier needs to be assessed in terms of protection from potential damage (e.g. hazardous areas and guards/covers etc.) and also for access for maintenance, inspection and human interface etc.															
1-3-1	Close and Seal on Open Hole	Physical	Close and Seal on Open Hole	Stack configuration to be in accordance with API 53	API 53	Design specification details that the BOP stack configuration meets the requirements of API 53 Design certified during design review	xx	xx	xx	xx	xx	xx	xx	xx	
…															

Appendix E: Operator's New Technology Process Review Checklist

Completed	NA	OPERATOR – New Technology Process Review Checklist
□	□	Yes □ No □ Has the Operator determined that the submission involves the use of new technology (30 CFR §250.292(n) AND **Section 1** of the *Industry New Technology Process Guide*)? *Check the appropriate category:* □ Category 1*. Known Technology, Known Conditions □ Category 2. Known Technology, Different or Unknown Conditions □ Category 3. New (Unknown) Technology, Known Conditions □ Category 4. New (Unknown) Technology, Different or Unknown Conditions *NOTE: *If Category 1, no additional risk assessment or barrier analysis is required*.
□	□	Yes □ No □ Has Operator contacted BSEE to schedule a Preplanning Conference to discuss the new technology application in order to gain BSEE agreement / initial buy-in?
□	□	Has Operator discussed the proposed submission with BSEE in order to: Yes □ No □ Verified the new technology category, i.e. Category 2,3, or 4)? Yes □ No □ Identified the minimum risk assessment and barrier analysis that should be conducted for the submission? Yes □ No □ Identified the need of independent 3rd party verification for the new technology proposal?
□	□	Has Operator conducted a risk assessment using the appropriate risk assessment methodology? Yes □ No □ Has Operator identified Major Accident Hazards (MAH) associated with the new technology? Yes □ No □ Has Operator identified the affected barriers that control or mitigate the MAHs?
□	□	Yes □ No □ Has Operator completed the barrier analysis and validated the success criteria for the barrier element attributes?
□	□	Yes □ No □ Has Operator demonstrated that barrier critical system functions and elements satisfy the success criteria based on the barrier analysis?
□	□	Yes □ No □ Has Operator sought independent 3rd party verification of the risk assessment and barrier analysis, as discussed with BSEE during the preplanning conference?
NOTE: *Operators should include all of the new technology risk assessment and barrier modelling documents, including any independent 3rd party review/certification documentation as part of the permit application. Operator should include this with their submission to BSEE*.		