RB FALCON
DEEPWATER HORIZON
BOP ASSURANCE ANALYIS

Deepwater Horizon BOP Assurance

A Report Prepared by

WS ATKINS INC

on behalf of

RB Falcon

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RB Falcon

Deepwater Horizon BOP Assurance

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2	February 2001	Copy for Client Review	1	JET	TB	JET
3	March 2001	Final Report	2	JET	TB	JET

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EXECUTIVE SUMMARY

An Integrated Project Team was convened on January 8th, 2001 to provide a high level of confidence that the BOP system on the Deepwater Horizon is a reliable and safe system. The following summarizes the work completed by the RB Falcon, BP, Cameron, TSF and WEST team:

- The rig specific failures were reviewed and discussed in detail. The result of the review was that several recommendations for enhanced maintenance, equipment and procedures were developed.
- The industry failures that relate to the equipment on the Deepwater Horizon BOP System were discussed in detail. The results of this review were that a few recommendations were suggested for improved maintenance, testing and equipment change out or modification.
- A risk assessment focused on reliability was completed. Engineering and operations personnel from RB Falcon, BP, Cameron, TSF and WEST identified 260 failure modes that could require pulling of the BOP or LMRP. It was found that malfunctions of regulators, solenoids, hoses, ST Locks, connectors, shuttle valves and autoshear circuitry were the predominant failures. Additionally, several reliability-improving recommendations were proposed. The recommendations were a combination of design modifications, equipment replacement, improved PM and procedures.
- The revised running BOP procedures should be reviewed and accepted for use on the Deepwater Horizon. The BOP hang-off and retrieval procedure should be revised in a similar manner to the revision that was completed on the BOP running procedure.
- The hazards identified during the HAZID analysis should be issued to the rig so that the individuals responsible for running the BOP can be reminded of the hazards and critical steps associated with running the BOP. This information can be used to evaluate the criticality of any changes in procedure that occur due to equipment malfunctions or time constraints while running the BOP.
- The Gap analysis performed revealed that the major difference between the Deepwater Horizon and the Discoverer Enterprise BOP Assurance Analysis was the level of PM review completed. The Deepwater Enterprise team reviewed PM's in detail to make sure that the BOP maintenance is sufficient to uncover the major failure modes identified during the analysis and to ensure that the maintenance is performed at the appropriate frequency (i.e. quarterly, between well, etc.). Individual procedures were not reviewed during the Discoverer Enterprise BOP Assurance Analysis. The predominant failures from both analyses were similar; solenoids, hoses, connectors, shuttle valves and ram locking mechanisms.

It is important that all the recommendations associated with this analysis be reviewed and acted upon by the appropriate managers within RB Falcon.

1. INTRODUCTION

1.1 Background

RB Falcon (RBF) has requested that WS Atkins Inc. perform a BOP Assurance Analysis of the Deepwater Horizon BOP System. The objective of the analysis is to evaluate the Horizon BOP and identify failure scenarios that lead to situations where the LMRP of BOP must be pulled and repaired (significant down time), and to review the BOP running, retrieval and handling procedures and identify hazards associated with the procedures. The lessons learned will be used to eliminate or minimize the consequence of system failures.

1.2 Scope of Work

In order to achieve the objectives of the analysis the following tasks were completed.

- Identify failure scenarios that require the LMRP or BOP to be pulled to the surface and repaired.
- Determine which modes of operation the failure scenarios identified affect.
- Perform a failure mode, effect and criticality analysis (FMECA) on each unique LMRP and BOP Function.
- Perform a HAZID on the Horizon BOP running, retrieval and handling procedures.

The analysis was performed in a three-step process. The methodology of the analysis is detailed in Section 3 of this report. The FMECA was limited to the subsea portions of the Deepwater Horizon BOP while the HAZID included the review of both surface and subsea portions of the system.

The analysis was carried out at the RB Falcon offices in Houston, Texas. The study was conducted between January 8 and January 15, 2001. The team members that participated in the study are listed in Table 1.1.

Table 1.1: Team Members

Name	Company	E-mail
Russ Krohn	RBF	rkhron@rbfalcon.com
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2. SYSTEM DESCRIPTION

The multiplex control system uses both subsea and surface equipment to control the blowout preventer stack installed on the wellhead at the sea floor. The stack is in two sections: a lower stack connected to the wellhead and a retrievable upper stack (LMRP) connected to the lower stack. The major subsea units of the system are the subsea multiplex units, the electro/hydraulic control pods, and the retractable stabs. These units are mounted on the upper stack. In addition an accumulator system mounted on both the lower and upper stack.

The principle function of the BOP control system is to control, operate and monitor the various closing devices of the BOP stack. Although these closing devices are operated hydraulically, electrical signals control application of the hydraulic operating pressures. The multiplex BOP control system supplies both the hydraulic operating pressures and the electrical control signals in the manner described below. The accumulator pump unit develops the hydraulic pressures and routes them to the subsea control pod. Control panels at the surface originate the electrical control signals. The CCU encodes these signals and transmits them through electrical cables to the subsea multiplex unit where they are decoded and routed to the control pod. The decoded signals operate control devices that direct the hydraulic operating pressure to the selected stack functions.

General functions controlled by the multiplex BOP control systems are:

A. LMRP Functions
   1. Annular Preventer (Upper & Lower)
   2. Riser Connector
   3. Hydraulic Stabs
   4. Mud Boost Valve
   5. Bleed Valves

B. BOP Functions
   1. Blind Shear Ram
   2. Casing Shear Ram
   3. Upper Pipe Ram
   4. Middle Pipe Ram
   5. Lower Pipe Ram
   6. Stack Connector
   7. Choke & Kill Valves

In addition to the general control functions, the multiplex system also provides continuous control and monitoring of surface and subsea hydraulic pressures and fluid flow and displays status indications for the subsea electrical and electronic equipment.

The multiplex control system provides operational reliability through equipment redundancy. The two operational systems are designated yellow and blue. Each system is capable of operating all stack functions, but only one system is used at a time.

Both systems share the control panels at the CCU and Driller's Panel, and some of the electronic circuitry in the CCU. Both systems also share the hydraulic power developed at the accumulator pump unit. There are, however, two separate cable reels and two complete sets of subsea units including the control pods, multiplex cables, subsea multiplex unit and retractable stabs. Although only one system is operational at a time, both systems receive

hydraulic power and electrical control signals and switchover can be accomplished in minimum time.

3. METHODOLOGY

The objective of the analysis was to evaluate the Deepwater Horizon BOP and identify failure scenarios that lead to situations where the LMRP of BOP must be pulled and repaired (significant down time) and to review the BOP running, retrieval and handling procedures and identify hazards associated with the procedures. The lessons learned will be used to eliminate or minimize the consequence of system failures. This objective was achieved by performing the following task:

- Review the layout of the RBF BOP,
- Perform a risk assessment and FMECA of the Deepwater Horizon BOP.
- Review the BOP running, retrieval and handling procedures.
- Perform a HAZID on the deepwater Horizon BOP running, retrieval and handling procedures.

The analysis was performed in a three-phase process:

Phase I: During a brain storming session the team determined which failure scenarios lead to situations where the LMRP or BOP must be pulled and repaired. The results of the brainstorming session were evaluated to determine the relevance of the failure scenarios to each drilling operation mode. The results from this portion of the analysis were recorded in a table (see example Table 3.3) that lists the failure scenarios that lead to a pull of the LMRP or BOP. The table also details the operating modes that each failure scenario can affect. The main purpose of Phase I was to get the team members to agree on which failure scenarios require the LMRP or stack to be pulled.

Phase II: For each function identified in Phase I a failure mode, effect and criticality analysis (FMECA) was performed. The hydraulic and electrical diagrams were reviewed to determine which failure modes can lead to a loss of the function. The team was also asked to evaluate the cause; local effect, system effect, detection method, mitigation, frequency; consequence, risk rank, and recommendations for eliminating the failure or reducing the effects of the failure. The work performed in this phase of the analysis was also recorded on worksheets. The worksheet template is attached as Table 3.4 through Table 3.6.

Phase III: A HAZID was performed on the BOP running, retrieval and handling procedures. The detailed procedures were reviewed and the hazards associated with each step in the procedures were identified. The team was asked to identify the consequences, safeguards, recovery plan, and recommendations for each hazard identified. The work performed in this phase of the analysis was recorded on worksheets. The worksheet template is attached as Table 3.7.

Each failure identified was ranked according to the ranking system detailed in Table 3.1 and Table 3.2

Table 3.1: Consequence

Consequence	Consequence Definition
Very High	Potential flow to environment
High	Pull BOP
Moderate	Pull LMRP
Low	Nuisance

Table 3.2: Frequency

Frequency	Frequency Definition
Very High	Frequent: Once every 4 months
High	Probable: Once every 8 months
Moderate	Possible: Once per year
Low	Unlikely: Once per 5 years

The criticality analyses for each failure mode is determined by its placement within the matrix based on the frequency and consequence ratings. The matrix is presented in Figure 3.1. The most critical failure modes are represented by a "VH" (very high) in the upper right corner of the matrix, while the least critical failure modes will have an "L" (low) in the lower left corner of the matrix.

Figure 3.1: Criticality Matrix

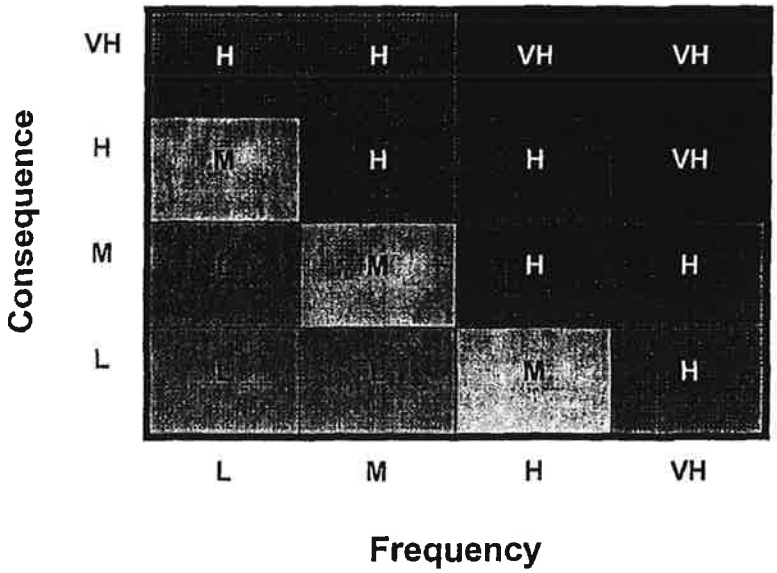


Table 3.3: Phase I: Failure Scenario vs Operation Mode

FAILURE SCENARIO			Operation Mode				
			Running/ Landing BOP	Drilling	Running Casing	Completion	Well Testing
LMRP	1.	Loss of Riser (leak of: mud seal, boost line, choke & kill line, rigid conduit, flex joint, mux cables, etc.)					
	2.	Loss of Annular (external leak)					
	3.	Total loss of one pod					
	4.	Loss of one critical function on one pod (not a major leak)					
	5.	etc.					
	6.						
	7.						
BOP	1.	Loss of Choke & Kill valve connection					
	2.	Loss of shear ram					
	3.	Loss of more than one pipe ram					
	4.	Loss of one choke or kill valve outlet (fail to open)					
	5.	etc.					
	6.						
	7.						

Table 3.4: Step Three: FMECA Template

FMECA Report Form	System: Deepwater Horizon Section: LMRP Section No.: I	Section Description:
Rev. no.: 0 Date: 01/12/01	Function: Annular Preventer Open/Close Function No.: 1	Function Description:

Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
						F	C	R	

Table 3.5: FMECA Worksheet Headings

System:	The system being analyzed. For this FMECA the Deepwater Horizon BOP is the system.
Section:	The name of the section (LMRP or BOP).
Section No.:	A Roman numeral used to identify the section.
Section Description:	A description of the section.
Rev. no:	The revision number for the worksheet.
Date:	The dates that the worksheets were filled out or revised.
Function:	The name/description of the function in the section.
Function No.:	The number of the above function.
Function Description:	A description of the function(s) of the component group.

Table 3.6: FMECA Worksheet Columns

Failure Mode:	For each function failure modes are identified and recorded. A failure mode is defined as the manner by which a failure is revealed. All units are designed to fulfill one or more functions; a failure is thus defined as non-fulfillment of one or more of these functions.
Causes:	The possible failure mechanisms (corrosion, erosion, fatigue, etc.) that may produce the identified failure modes
Local Failure Effect:	The main effects of the identified failure modes on the localized parts.
System Effect:	The main effects of the identified failure modes on the primary function of the system and the resulting operational status of the system after the failure.
Method of Detection:	The various possibilities for detection of the identified failure modes. These may involve different alarms, testing, human perception, and so on. Some failures are called *evident failures*. Evident failures are detected instantly. Another type of failure is called the *hidden failure*. A hidden failure is normally detected only during testing of the unit. The failure mode "fail to start" of a pump with operational mode "standby" is an example of a hidden failure.
Mitigation:	Possible actions to correct the failure and restore the function or prevent serious consequences are then recorded. Actions that are likely to reduce the frequency of the failure modes are also recorded.
Ranking:	Failure modes will be ranked according to a broad classification using a 4 x 4-risk matrix. Frequency and Consequence categories as outlined in Tables 1 and 2 define the matrix.
Recommendation:	Action that the team recommends for reducing the effects or occurrence of the failure.

Table 3.3.7: Phase III HAZID Template

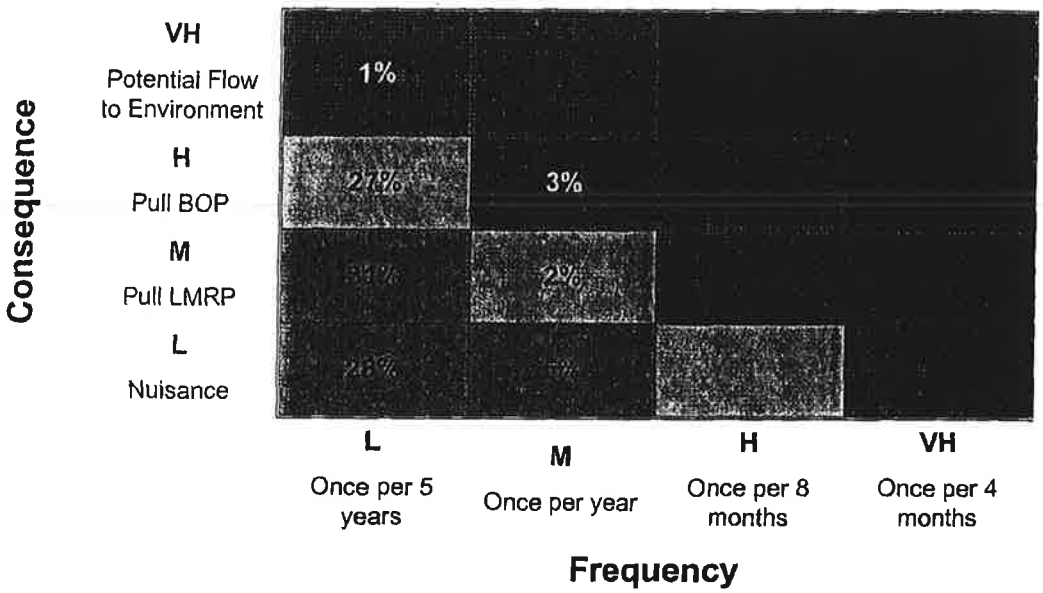
HAZID Report Form	System: Deepwater Horizon BOP Procedure: Running BOP Procedure No.: 1	Rev. no.: 0 Date: 07/11/01

Step of Procedure	Hazard	Consequence	Safeguard	Recovery Plan	Recommendation

4. RESULTS

The results of the analysis are detailed in this section of the report. Figure 4.1 details the results of the FMECA. The table shows the percentage of the total failures identified associated with each location in the risk matrix. A total of 260 failure modes were identified during the analysis.

Figure 4.1: Results



Color	Category	% of Failure Modes in Category
	Very High Risk	0%
	High Risk	4%
	Moderate Risk	29%
	Low Risk	64%

Note: 4% of the failures identified were not ranked. These failures were not ranked because they did not represent new issues that required ranking.

The failure scenarios that require the LMRP or BOP to be pulled are listed in Table 4.1. The information identified in the table is the information that the group agreed to on day one of the study. The table also details the modes of operation affected by the failure scenario.

The HAZID analysis was only completed on the running the BOP procedure; there was not sufficient time to complete the HAZID on the hang-off and retrieval procedure. However, the hazards identified for the running procedure will be similar to the hazards experienced when hanging-off or retrieving the BOP. Table 4.2 details the hazards associated with each step of the original running procedure. The numbers in the first column of the HAZID correspond with the step number identified in the original procedure.

Table 4.1: Failure Scenario vs Operation Mode

Failure Scenario		Operation Mode (Dynamic Positioning)						
		Running/ Landing BOP	Drilling	Running Casing	Completion	Well Testing	Logging	Cementing
Pull LMRP	1. Leaking Riser Connector Seal (Main Tube) or Leaking Flex Joint	Difficult to detect.	Pull LMRP.	Complete casing run and then pull LMRP.	Secure well. Pull LMRP.	Secure well. Pull LMRP.	Secure well. Pull LMRP.	Complete cement job and then pull LMRP.
	2. Leaking choke or kill line on riser	Pull BOP to point of leak.	Pull LMRP.	Complete casing run and then pull LMRP.	Secure well. Pull LMRP.	Secure well. Pull LMRP.	Difficult to detect.	Difficult to detect.
	3. Leaking Rigid Conduit	Pull BOP to point of leak.	Pull LMRP.	Case-by-case depending on location of casing. Pull LMRP.	Secure well. Pull LMRP.	Secure well. Pull LMRP.	Secure well. Pull LMRP.	Complete cement job and then pull LMRP.
	4. Damaged MUX cable (loss of one cable)	Pull BOP.	Secure well. Pull LMRP.	Complete casing run and then pull LMRP.	Secure well. Pull LMRP.	Secure well. Pull LMRP.	Secure well. Pull LMRP.	Complete cement job and then pull LMRP.
	5. Leaking Mud Boost Line	Pull BOP to point of leak.	Continue and use choke or kill line as boost line.	Continue and use choke or kill line as boost line.	Continue and use choke or kill line as boost line.	Continue and use choke or kill line as boost line.	Continue and use choke or kill line as boost line.	Continue and use choke or kill line as boost line.
	6. Leaking Hot Line (assuming hot line shut-down after BOP landing)	Pull BOP to point of leak.						

Failure Scenario		Operation Mode (Dynamic Positioning)						
		Running/ Landing BOP	Drilling	Running Casing	Completion	Well Testing	Logging	Cementing
Pull LMRP	7. Loss of one Annular	Difficult to detect.	Continue.	Continue.	Continue.	Continue.	Continue.	Continue.
	8. Bleed valve fails to open – Note: Well Control procedures will need to be reviewed and revised.	Difficult to detect.	Continue.	Continue.	Continue.	Continue.	Continue.	Continue.
	9. Loss of one pod	Pull BOP.	Secure well. Pull LMRP.	Complete casing run and then pull LMRP.	Secure well. Pull LMRP.	Secure well. Pull LMRP.	Secure well. Pull LMRP.	Complete cement job and then pull LMRP.
	10. Leaking Choke or Kill isolation valve	Pull BOP.	Continue.	Continue.	Continue.	Continue.	Continue.	Continue.
	11. Leaking Choke or Kill Connector (Bore leak)	Difficult to detect.	Secure well and pull BOP.	Complete casing run and then pull BOP.	Secure well and pull BOP.	Secure well and pull BOP.	Secure well and pull BOP.	Complete cement job and then pull BOP.
	12. Leaking LMRP Connector	Difficult to detect.	Secure well and pull BOP.	Complete casing run and then pull BOP.	Secure well and pull BOP.	Secure well and pull BOP.	Secure well and pull BOP.	Complete cement job and then pull BOP.

Failure Scenario		Operation Mode (Dynamic Positioning)						
		Running/ Landing BOP	Drilling	Running Casing	Completion	Well Testing	Logging	Cementing
Pull BOP	1. Loss of Blind Shear Ram	Difficult to detect.	Secure well and pull BOP.	Will only be detected during testing.	Will only be detected during testing.	Will only be detected during testing.	Will only be detected during testing.	Will only be detected during testing.
	2. Loss of Casing Shear Ram	Difficult to detect.	Case-by-Case decision between BP & RBF.	Case-by-Case decision between BP & RBF.	Continue.	Continue.	Continue.	Continue.
	3. Loss of Upper VBR (assuming tapered string not used)	Difficult to detect.	Continue.	Continue.	Case-by-case depending on tubing string.	Case-by-case depending on stack-up.	Continue.	Continue.
	4. Loss of Upper VBR (assuming tapered string)	Difficult to detect.	Secure well and pull BOP.	Continue except when running liner.	Secure well and pull BOP.	Secure well and pull BOP.	Complete logging operation and then pull BOP.	Complete cement job and then pull BOP.
	5. Loss of Middle VBR (assuming tapered string not used)	Difficult to detect.	Continue.	Continue.	Case-by-case depending on tubing string.	Case-by-case depending on stack-up.	Continue.	Continue.
	6. Loss of Middle VBR (assuming tapered string)	Difficult to detect.	Secure well and pull BOP.	Continue except when running liner.	Secure well and pull BOP.	Secure well and pull BOP.	Complete logging operation then pull BOP.	Complete cement job then pull BOP.
	7. Loss of Lower Pipe Ram	Difficult to detect.	Continue.	Continue.	Continue.	Continue.	Continue.	Continue.

Failure Scenario		Operation Mode (Dynamic Positioning)						
		Running/ Landing BOP	Drilling	Running Casing	Completion	Well Testing	Logging	Cementing
Pull BOP	8. Loss of more than one pipe ram	Difficult to detect.	Secure well and pull BOP.	Complete casing run then pull BOP.	Secure well and pull BOP.	Secure well and pull BOP.	Secure well and pull BOP.	Complete cement job then pull BOP.
	9. Loss of upper choke outlet (one valve fails to open)	Difficult to detect.	Continue.	Continue.	Case-by-case depending on space out.	Case-by-case depending on space out.	Continue.	Continue.
	10. Loss of lower choke outlet (one valve fails to open) Note: Hang off procedures will need to be reviewed.	Difficult to detect.	Continue.	Continue.	Case-by-case depending on space out.	Case-by-case depending on space out.	Continue.	Continue.
	11. Loss of upper kill outlet (one valve fails to open)	Difficult to detect.	Case-by-case.	Complete casing run then case-by-case for pull BOP.	Case-by-case depending on space out.	Case-by-case depending on space out.	Complete logging operation then case-by-case for pull BOP.	Complete cement job then case-by-case for pull BOP.
	12. Loss of lower kill outlet (one valve fails to open)	Difficult to detect.	Continue.	Continue.	Case-by-case depending on space out.	Case-by-case depending on space out.	Continue.	Continue.
	13. Leak at Wellhead Connector.	Difficult to detect.	Secure well and pull BOP.	Secure well and pull BOP.	Secure well and pull BOP.	Secure well and pull BOP.	Secure well and pull BOP.	Secure well and pull BOP.

NOTE: All scenarios subject to case-by-case evaluation when/if failures occur. Table evaluated assuming worst-case scenarios.

Table 4.2 Running BOP HAZID

HAZID Report Form	System: Deepwater Horizon BOP Procedure: Running BOP Procedure No.: 1	Rev. no: 1 Date: 07/17/01 "Procedure used in analysis is attached as *Appendix D*"

Step of Procedure	Hazard	Consequence	Safeguard	Recovery Plan	Recommendation
1	Wrong calculation of RKB to wellhead.	Run incorrect space out.	Rig confirms final RKB to wellhead.	Pull riser to pup joints and rerun with correct space out.	
	Failure to collect riser serial numbers.	Loss of PM data.	Action must be checked on Riser Running Sheet (Driller).	Ability to record data when riser pulled.	*Review procedure to ensure that Driller is able to personally confirm all information of Riser Running Sheet in timely fashion.*
2	Incorrect pressure setting.	Incorrect tension resulting in possible riser failure.	Information provided by Engineering. Error can be caught during riser running process.	Transfer weight slowly to tensioners.	
	Pressure gauge out of calibration.	Incorrect tension resulting in possible riser failure.	Multiple sources of pressure indication. PM.	Recalibrate gauge.	
3	Not prepared to run riser.	Additional time required.	Detailed checklist. Checklist reviewed by multiple parties.	Take time to prepare.	
4	Failure to correctly calibrate wrench torque.	Possible failure of connection.	PM. Training. Periodic checks.	Pull stack and rerun with correct torque.	*Consider adding gauge to manifold on rig floor.*

HAZID Report Form	System: Deepwater Horizon BOP Procedure: Running BOP Procedure No.: I	Rev. no.: 1 Date: 01/17/01 "Procedure used in analysis is attached as *Appendix D*"

Step of Procedure	Hazard	Consequence	Safeguard	Recovery Plan	Recommendation
5	Vessel not offset.	Possibility of tagging wellhead with stack or dropped object.	BOP Running Procedure. (Captain)	Reposition the vessel.	
	DP system or positioning system not operational.	Unable to land stack. Possibility of tagging wellhead with stack.	Procedures.		*Resolve philosophy – Parking lot issue #40.*
6	Inadequate communication.	High dynamic loads and other major problems.	Pre job meeting. PM of communication equipment.	Ability to suspend operations and correct communications.	*See Parking Lot Issue #39.*
7	Lack of preparation.	Downtime. No new issues.			
8	Setup with insufficient lifting capacity.	Dropped riser and / or BOP.	Ability to predict loads.		*Use 1000 ton setup initially and change to 750 if considered prudent later.*
	Failure to pull mousehole.	Possible damage to mousehole, transporter and/or BOP.	Procedures.	Repair damaged equipment.	
	Failure to put cover over mousehole.	Personnel injury.	Procedures and training. Personnel awareness.	Trained medic on board.	

HAZID Report Form	System: Deepwater Horizon BOP Procedure: Running BOP Procedure No.: I	Rev. no.: 1 Date: 01/17/01 "Procedure used in analysis is attached as *Appendix D*"

Step of Procedure	Hazard	Consequence	Safeguard	Recovery Plan	Recommendation
9	Open rotary hole.	Personnel injury – potential loss of life.	Procedures and training. Personnel awareness. Area to be roped off.	Man overboard procedures. Fast rescue craft (FRC). Trained medic on board.	
10	Personnel injury.	No new issues.	Procedures and training.		*Ensure that JSA exists.*
	Improper orientation of gimble spider.	Inability to properly plug in hydraulics.	Training.	Reorient gimble spider correctly.	
11	No or damaged wellhead connector ring gasket.	Wellhead leak. Possible roundtrip for stack.	Multiple checks.	Ability to replace gasket with ROV.	*Develop, review subsea checklist and ensure gasket inspection is on the checklist.*
12	Fail to put BOP control system in riser run mode.	Possible loss of stack.	Procedure and training. Multiple checks.		
13	Failure to remove end cap.	Potential plugged line.	Procedures and training. Dedicated floorhand to inspect work.	Further inspection prior to stab.	*Ensure dedicated floorhand identified during JSA.*
	Trash in line not noticed.	Potential trash in line.	Procedures and training. Dedicated floorhand to inspect work.	Safeguards considered adequate.	*Verify riser flush at some point before being run.*
14A	LMRP Connector not properly latched.	Possible loss of stack.	Procedure and training. PM.		

HAZID Report Form	System: Deepwater Horizon BOP Procedure: Running BOP Procedure No.: I	Rev no: 1 Date: 01/17/01 "Procedure used in analysis is attached as *Appendix D*"

Step of Procedure	Hazard	Consequence	Safeguard	Recovery Plan	Recommendation
14B	Failure to contact Bridge.	Vessel out of trim. Potential for personnel injury or equipment damage.	Procedures. Pre-job meeting. Equipment properly secured and stowed.	Ability to re-ballast vessel. Medic on board.	
14C	Heavy lifting.	Possible personnel injury. Damage to BOP or other equipment.	Training. PM.	Medic on board. Repair equipment.	*Develop procedure for moving BOP from storage area to BOP cart. Perform HAZID on this procedure.*
14D	Damage of hoses or cables.	Damage to BOP control system. Downtime.	Training. Communication. Adequate personnel.	Ability to repair or replace hoses on board. Spare MUX cable on shore.	
	Obstruction on track.	Damage to BOP cart or obstructing equipment. Possible inability to run BOP due to cart damage.	Training. Communication. Adequate personnel. Adequate barrier along track (handrails).	Repair cart and/or BOP.	
	Pinch points.	Personnel injury.	Adequate barrier along track (handrails). Prejob meetings.	Medic on board.	

HAZID Report Form	System: Deepwater Horizon BOP Procedure: Running BOP Procedure No.: 1	Rev no: 1 Date: 01/17/01 Procedure used in analysis is attached as *Appendix D*

Step of Procedure	Hazard	Consequence	Safeguard	Recovery Plan	Recommendation
14E					*Develop and review deck-handling procedure. (HAZID)*
15	Personnel injury.	No new issues.			
	Crossed operating hoses.	Opposite function and inability to latch.	Training. Function testing.		*Install male and female quick disconnect opposite one another.*
					Consider developing standard for hydraulic connections (e.g. open is male / close is female).
16	RRT not properly latched.	Dropped riser. Possible damage to stack and other rig floor equipment. Personnel injury.	Rising stem is up and manually pinned. (Pin must be in to assure latch.) Procedures and training. Action checked off.	Spare hydraulic tool and manual tool. Medic on board. Repair equipment.	
	Faulty or missing seals.	Leaking connection at BOP. Downtime.	Procedures and training. Multiple checks.	Pull riser back to leak point if found during pressure test.	
17	Improper torque on makeup.	Potential to drop stack.	Procedures and training. PM on wrench.	Retrieve stack.	

HAZID Report Form	System: Deepwater Horizon BOP Procedure: Running BOP Procedure No.: [redacted]	Rev no.: 1 Date: 07/17/01 Procedure used in analysis is attached as *Appendix D*

Step of Procedure	Hazard	Consequence	Safeguard	Recovery Plan	Recommendation
	Improper lubricant.	Potential to drop stack.	Procedures and training.	Retrieve stack.	
	Man-riding operations. Personnel working over water in confined spaces.	Man overboard. Personnel injury or loss of life.	PPE. FRC. Workvest. Permit-to-work. JSA. Communications.	Medic on board.	*Review man-riding procedures.*
					Ensure installation of inertia reels.
	Improper stabbing of first riser joint.	Damage to seal, seal surfaces, pins, etc.	Use of tailing arm. Proper communication between Drill Floor and Moonpool.	Replace damage equipment.	*Evaluate communication to ensure adequate for operations (equipment and processes – both visual and verbal).*
					Ensure policy to investigate incidents (at the time they occur) if damage may have occurred. "When in doubt – check it out!"
	Pinch points.	No new issues.			

HAZID Report Form	System: Deepwater Horizon BOP Procedure: Running BOP Procedure No.: 1	Rev no: 1 Date: 01/17/01 "Procedure used in analysis is attached as *Appendix D*"

Step of Procedure	Hazard	Consequence	Safeguard	Recovery Plan	Recommendation
18	Hangup on cart.	Lift up cart. Potential damage to cart or BOP.	Adequate personnel in Moonpool. Good communication between Drill Floor and Moonpool. Retracting pins on BOP cart.	Slack off, evaluate and make repairs.	*Driller to confirm communication with Moonpool before picking up or slacking off.*
					Develop standard communication signals between Driller and Drill Floor.
	Pick up too far.	Damaged MUX cables.	Training and procedures. Good communication between Drill Floor and Moonpool.	Spare MUX cable on shore.	*Develop philosophy for placement of first MUX clamp.*
	Failure to note hook weight.	Inadequate information for tensioner management.	Procedures in place.	Opportunity to capture omission at each joint.	
	Failure to install MUX clamp or incorrect installation.	Damaged MUX cable and hot line.	Procedures and training.	Pull stack. Spare MUX cable on shore.	*Ensure proper training and supervision of MUX clamp installers.*
	Failure to record bullseye indication.	Possible confusion as to BOP angle at sea floor.	Procedures and checklists.	Inclinometers on stack.	

HAZID Report Form	System: Deepwater Horizon BOP Procedure: Running BOP Procedure No.: I	Rev. no.: 1 Date: 01/17/01 "Procedure used in analysis is attached as *Appendix D*"

Step of Procedure	Hazard	Consequence	Safeguard	Recovery Plan	Recommendation
	Failure to use under hull guide when needed.	Damage to BOP, vessel, other equipment.	Procedures.		*Use under hull guide for BOP lateral support for every stack run. [Change Procedure?]*
19	Failure to rotate riser.	Downtime.	Procedures.		*Verify how riser rotation is accomplished on the Nautilus including effects of under hull guidance. Review for hazards if necessary.*
	Hang up of lines during rotation.	Damage to lines and hoses.	Adequate personnel observing operation.	Repair and continue.	
	Rotating during rough seas.	Extended exposure to rough seas resulting in equipment damage.	Operating parameters. Adequate personnel observing operation. Weather forecasting ability.	Ability to pull stack and close guide system.	
	Failure to hydraulically lock spider.	Potential to drop BOP.	Procedures. Mechanical backup. Multiple hydraulic lines.	Recover BOP.	
20	Seawater in conduit.	Possible plugged rigid conduit.	Procedure. Training. Plan to flush conduit.		

HAZID Report Form	System: Deepwater Horizon BOP Procedure: Running BOP Procedure No:: I	Rev no: 1 Date: 01/17/01 "Procedure used in analysis is attached as *Appendix D*"

Step of Procedure	Hazard	Consequence	Safeguard	Recovery Plan	Recommendation
	Failure to fill lines.	Delay in operation. No significant issue.			
21	Overpressure of booster line and conduit.	Damage booster line or rigid conduit.	Procedures. Lines color coded by pressure rating.	Pull and repair.	*Subsea eng. visually ensures correct connections before every test.*
	High pressure.	Possible personnel injury.	Rig floor cleared. Announcements made. Permit-to-work.	Medic on board.	
	BOP exposed to rough weather for extended period during test.	Potential damage to hoses and cables.	Operating parameters. Adequate personnel observing operation. Weather forecasting ability.	Ability to pull stack.	*Consider running two joints to lessen time BOP is in splash zone during rough weather.*
22	Failure to latch RRT.	Dropped BOP. Possible damage to stack and other rig floor equipment. Personnel injury.	Rising stem is up and manually pinned. (Pin must be in to assure latch.) Procedures and training. Action checked off.	Spare hydraulic tool and manual tool. Medic on board. Repair equipment.	*Ensure that DWH team develops rig specific riser running plan considering RRT, spider, communication plan and equipment.*
	Faulty seals.	No new issues.			

HAZID Report Form	System: Deepwater Horizon BOP Procedure: Running BOP Procedure No.: 1	Rev no.: 1 Date: 01/17/01 "Procedure used in analysis is attached as *Appendix D*"

Step of Procedure	Hazard	Consequence	Safeguard	Recovery Plan	Recommendation
	Excessive dynamic loading.	Exceed lifting ratings or drop BOP.	Training. Monitor weight and environment during run. Weather forecasting. Vessel orientation.		*Ensure that personnel have proper information and training.*
	Drawworks or hoisting system failure.	Potential to drop BOP.	Extensive review of braking system completed. Upgrades made.		*Ensure that personnel have proper information and training.*
	Dropped objects from riser. (Floatation, bolts, etc.)	Potential personnel injury or loss of life. Possible equipment damage.	Inspection prior to lifting. PM. Procedures to clear area. All 316 SS hardware.	Medic on board.	*Also a greater concern when pulling / retrieving (additional safeguard of use of straps on damaged equipment when pulling). Also a concern in the Moonpool.*
23	Failure to test.	No new issues.			
24	Improper space out.	Delay in operation due to string being wrong length.	ROV. Compare riser counts. Bathymetry review.	Flush and repair if necessary. (Case-by-case.)	

HAZID Report Form	System: Deepwater Horizon BOP Procedure: Running BOP Procedure No.: I	Rev. no: 1 Date: 01/17/01 "Procedure used in analysis is attached as *Appendix D*"

Step of Procedure	Hazard	Consequence	Safeguard	Recovery Plan	Recommendation
	Improper riser tally.	Delay in operation due to string being wrong length.	ROV. Compare riser counts. Bathymetry review.	Flush and repair if necessary. (Case-by-case.)	
	Note: Termination joint issues same as running riser.	No new issues.			
25	Failure to lock manual locks.	Potential to drop BOP.	Procedures.	Recover BOP. Backup telescopic joint.	
	Other telescopic joint issues same as running riser.	No new issues.			
26	High pressure.	No new issues.			
	Man-riding operations. Personnel working over water in confined spaces.	Man overboard. Personnel injury or loss of life.	PPE. FRC. Workvest. Permit-to-work. JSA. Communications.	Medic on board.	*Review man-riding procedures.*
	Improper connections.	No new issues.			
27	Failure to verify that wellhead connector is unlocked on ROV panel.	Inability to land stack.	Redundant ROVs available.	Repair ROV.	
28	Failure to install storm loops.	Damage to cables and hoses.	Procedure. Training.	Repair and replace.	

HAZID Report Form	System: Deepwater Horizon BOP Procedure: Running BOP Procedure No.: I	Rev. no.: 1 Date: 01/17/01 "Procedure used in analysis is attached as *Appendix D*"

Step of Procedure	Hazard	Consequence	Safeguard	Recovery Plan	Recommendation
29	No new issues for this step.				*Note: telescopic joint to be referred to as 'slip joint' only.(Completed)*
30	No new issues for this step.				
31	Heavy equipment moving under PLC control.	Possible personnel injury. Possible runaway equipment.	Ability to manual override and emergency stop. Handrails as barriers. Training and procedures.	Medic on board.	*Develop procedure including having personnel stationed at inline trip-saver panel.*
32	Man-riding and man over water.	No new issues.			
	Improper connections.	See previous. Plus - Bearing would not allow vessel change in heading without equipment damage.	See previous. Plus - Pump through lines before hook-up to check. Hoses coded and labeled.	Disconnect, pull, and reconnect.	*Check Bridge procedures to confirm that Drill Floor and subsea engineer are to be informed of changes in heading.*
					Train Marine crew in operations of fluid bearings.
33	No new issues.				

HAZID Report Form	System: Deepwater Horizon BOP Procedure: Running BOP Procedure No.: 1	Rev. no: 1 Date: 01/17/01 "Procedure used in analysis is attached as *Appendix D*"

Step of Procedure	Hazard	Consequence	Safeguard	Recovery Plan	Recommendation
34	Failure to be in Active Heave Mode when necessary.	Possible damage to wellhead and/or BOP	Procedures. Tensioners. Rig motion indication. Operational criteria. (OIM decision)	Pull and repair.	*Review operational criteria.*
35	Communication is a concern. No new issues.				*Review procedures for LMRP running.*
	Insufficient weight on wellhead.	Possible inability to latch.	Procedures and training. Monitoring weight.		*Ensure there is an observation window in funnel to confirm connector properly seated.*
36	Improper space out.	Restricted operating circle. Improper recoil.	Compare rod stroke physical vs. calculated. Multiple previous checks	Pull and correct space out.	
37	Improper setting of tensioner.	Possible buckling of riser. Possibly no liftoff of EDS. Possible damage to equipment.	Compare calculated vs. actual weights. Procedures and training. Regular monitoring.	Increase / decrease pressure as required.	
	Failure to put tensioner panel in 'remote' mode.	Anti- recoil is not activated. Possible equipment damage.	Procedures.	Ability to put panel in remote.	*Develop procedure and include step.*

HAZID Report Form	System: Deepwater Horizon BOP Procedure: Running BOP Procedure No.: I	Rev. no. 1 Date: 01/17/01 "Procedure used in analysis is attached as *Appendix D*"

Step of Procedure	Hazard	Consequence	Safeguard	Recovery Plan	Recommendation
38	Insufficient overpull on wellhead.	Possibly not locked on wellhead.	Procedures. Well testing	Re-latch and re-test.	
39	Wellhead sinks.	Loss of wellhead.	Proper wellhead design and installation.	Case-by case. Possible new well.	
	Insufficient weight on wellhead.	Possible loss of wellhead and BOP when liftoff occurs.	Procedures. Proper wellhead design and installation.	Case-by case. Possible new well.	
40	Failure to lock in diverter.	Inability to use all function of diverter (software interlocks).	Procedures and testing.	Repair.	
41	Failure to set in 'Drilling' mode.	EDS, autoshear and deadman not active.	Procedure.	Set to 'Drilling' mode.	*Subsea engineer responsible for setting in 'Drilling' mode.*
					Develop drilling mode checklist.
42	Failure to displace fluid in rigid conduit.	Potential for trash in conduit resulting in damaged control system.	Procedures. Training.	Flush conduit. Possible pull LMRP.	
43	Heavy lifts. No new issues.				

HAZID Report Form	System: Deepwater Horizon BOP Procedure: Running BOP Procedure No.: I	Rev no: 1 Date: 01/17/01 "Procedure used in analysis is attached as *Appendix D*"

Step of Procedure	Hazard	Consequence	Safeguard	Recovery Plan	Recommendation
44	Overpressure during test.	Damage to well.	Procedures and training. Communication.	Possible re-spud of well.	
45	No new issues				
46	No new issues.				

5. RECOMMENDATIONS

5.1 Recommendations

The following table represents the recommendations that were generated from the risk analysis. The table below details the recommendations that were generated as the result of reviewing specific failure modes. The majority of the risk identified are mitigated by the existing PM plan.

5.1.1 Very High Risk Recommendations

No very high-risk recommendations were made

5.1.2 High Risk Recommendations

Recommendation (F/C/R)	PM system to place emphasis on this shuttle valve due to the possible consequence of failure. (L/VH/H)
Failure	I.04 LMRP Connector – Failure to unlatch on demand
Causes:	Total shuttle valve failure (pod shuttle valve).
Failure Effects:	Fluid loss. Loss of primary unlatch (both pods). (Affects EDS – potential catastrophic effect)
Mitigation:	Rely on secondary unlatch, secure well and pull LMRP. PM.
Proposed Actions:	

Recommendation (F/C/R)	PM system to place emphasis on this shuttle valve due to the possible consequence of failure. (L/VH/H)
Failure	I.04 LMRP Connector – Failure to unlatch on demand
Causes:	Total shuttle valve failure (ROV shuttle valve – operating from ROV).
Failure Effects:	Fluid loss. Lose both primary and secondary unlatch before using ROV. Lose ROV unlatch. (Affects EDS – potential catastrophic effect)
Mitigation:	Rely on deadman and pull LMRP. OR Pull BOP. PM.
Proposed Actions:	

Recommendation (F/C/R)	Upgrades made by Cameron – ongoing monitoring. Include predictive testing procedure in PM. Cameron to submit written documentation confirming component numbers for all ST locks. (M/H/H)
Failure	II.01 Blind Shear Ram – Failure to open on demand II.06 Pipe Ram– Failure to seal on demand
Causes:	Generalized ST lock failure.
Failure Effects:	Failure to open. Obstructed wellbore
Mitigation:	Secure well and pull BOP. PM.
Proposed Actions:	

Recommendation (F/C/R)	Review frequency rating after test of autoshear. (M/H/H)
Failure	II.02 Blind Shear Rams – Failure to close on demand II.07 Pipe Ram – Failure to close on demand
Causes:	Autoshear inoperable.
Failure Effects:	Loss of autoshear system. Inability to shear in an unplanned disconnect.
Mitigation:	Secure well and pull BOP. PM.
Proposed Actions:	

Recommendation (F/C/R)	Follow up on wellhead connector upgrades. (M/H/H)
Failure	II.04 Wellhead Connector – Failure to unlatch on demand
Causes:	Hydrate or other debris.
Failure Effects:	Inability to unlatch.
Mitigation:	Use of methanol and warm fluids. Pull BOP.
Proposed Actions:	

Recommendation (F/C/R)	Consider to adding valve in place of 'Cut Me' tube. (M/H/H)
Failure	II.05 Wellhead Connector – Failure to primary unlatch on demand
Causes:	Failure of latch POCV to open.
Failure Effects:	Latch pressure not released. Unable to unlatch.
Mitigation:	Use 'Cut Me' tube via ROV. Pull BOP.
Proposed Actions:	

5.1.3 Moderate criticality Recommendations

Recommendation (F/C/R)	Ensure that operating parameters are adequate to prevent damage from LMRP strike or incidental contact. (L/H/M)
Failure	I.03 LMRP Connector – Failure to latch on demand
Causes:	Damage to hub on mandrel
Failure Effects:	Failure to latch. Unable to connect to BOP.
Mitigation:	Pull LMRP Secure well if necessary to pull BOP.
Proposed Actions:	

Recommendation (F/C/R)	Ensure proper installation of gasket before attempt to latch. (L/H/M)
Failure	I.03 LMRP Connector – Failure to seal on demand II.04 Wellhead Connector – Failure to seal on demand
Causes:	Damaged seal surface (Mandrel/Wellhead).
Failure Effects:	Failure to seal.
Mitigation:	Secure well and pull BOP. PM and standard operating procedures. Visual inspection of wellhead
Proposed Actions:	

Recommendation (F/C/R)	Ensure procedures are followed. (L/H/M)
Failure	I.03 LMRP Connector – Failure to unlatch on demand
Causes:	Overpressure on latch.
Failure Effects:	Inability to unlatch. (**Potential loss of EDS**)
Mitigation:	Secure well and pull BOP. Proper training and procedures.
Proposed Actions:	

Recommendation (F/C/R)	Investigate need for hydrate measures for LMRP Connector. (L/H/M)
Failure	I.03 LMRP Connector – Failure to unlatch on demand II.04 Wellhead Connector – Failure to unlatch on demand
Causes:	Hydrate or other debris. Damaged indicator rods.
Failure Effects:	Inability to unlatch.
Mitigation:	Use of methanol and warm fluids. Possibly secure well and pull BOP. For damaged indictor rods – pull BOP
Proposed Actions:	

Recommendation (F/C/R)	Investigate failure mode with Cameron (Jacqueline Hsu). (L/H/M)
Failure	I.03 LMRP Connector – Failure to unlatch on demand
Causes:	Damaged indicator rods.
Failure Effects:	Inability to unlatch.
Mitigation:	Secure well and pull BOP.
Proposed Actions:	

Recommendation (F/C/R)	Follow up with TSF w/rt flexible hose testing. (M/M/M)
Failure	I.04 LMRP Connector - Failure to maintain proper latch pressure. (M/M/M)
Causes:	Failure of 1" Poly-flex hose.
Failure Effects:	Fluid loss. Inability to maintain latch pressure. Inability to maintain latch pressure.
Mitigation:	Switch to alternate pod. Possibly secure well and pull LMRP. PM.
Proposed Actions:	

Recommendation (F/C/R)	PM system to place emphasis on this shuttle valve due to the possible consequence of failure. (L/H/M)
Failure	I.04 LMRP Connector – Failure to unlatch on demand II.05 Wellhead Connector – Failure of primary unlatch on demand
Causes:	Total shuttle valve failure (ROV shuttle valve – operating from ROV).
Failure Effects:	Loss of fluid. Lose both primary and secondary unlatch before using ROV. Lose ROV unlatch
Mitigation:	Pull BOP. PM.
Proposed Actions:	

Recommendation (F/C/R)	Ensure proper connection of PBOF cables as per procedures. (M/M/M)
Failure	I.05 SEM – Failure to fire solenoid
Causes:	Loss of pod PBOF cable and connectors.
Failure Effects:	Loss SEM (pod). Loss of pod.
Mitigation:	Rely on alternate pod. Secure well and pull LMRP. PM (visual inspection).
Proposed Actions:	

Recommendation (F/C/R)	Ensure proper connection of wet mat connectors as per procedures. (M/M/M)
Failure	I.05 SEM – Failure to fire solenoid
Causes:	Loss of Wet Mate connector
Failure Effects:	Ground. Loss of pod.
Mitigation:	Rely on alternate pod. Secure well and pull LMRP. PM (visual inspection).
Proposed Actions:	

Recommendation (F/C/R)	Ensure correct space out. Ensure pre-testing has been completed. (L/H/M)
Failure	II.01 Blind Shear Ram – Failure to shear on demand II.06 Pipe Ram - Failure to shear on demand
Causes:	Attempting to shear inappropriate material.
Failure Effects:	Inability to cut.
Mitigation:	Reposition string and re-attempt cut. Pressure test. Pre-testing cut.
Proposed Actions:	

Recommendation (F/C/R)	Verify NDE frequency. (L/H/M)
Failure	II.01 Blind Shear Ram – Failure to seal on demand II.06 Pipe Ram– Failure to seal on demand
Causes:	Damaged or defective ram block.
Failure Effects:	Inability to seal wellbore.
Mitigation:	Secure well and pull BOP. PM.
Proposed Actions:	

Recommendation (F/C/R)	Ensure clean wellbore. Follow policy of not tagging shear rams. (L/H/M)
Failure	II.01 Blind Shear Ram – Failure to seal on demand II.06 Pipe Ram– Failure to seal on demand
Causes:	Damaged packers.
Failure Effects:	Inability to seal wellbore.
Mitigation:	Secure well and pull BOP. PM.
Proposed Actions:	

Recommendation (F/C/R)	Ensure that operating parameters are adequate to prevent damage from BOP strike or incidental contact. (L/H/M)
Failure	II.04 Wellhead Connector – Failure to latch on demand
Causes:	Damage to hub on wellhead
Failure Effects:	Failure to latch. Unable to connect to wellheaad.
Mitigation:	Pull BOP.
Proposed Actions:	

Recommendation (F/C/R)	Ensure procedures are followed. (L/H/M)
Failure	II.04 Wellhead Connector – Failure to unlatch on demand
Causes:	Overpressure on latch.
Failure Effects:	Inability to unlatch.
Mitigation:	Pull BOP. Employ ROV to overpressure. Proper training and procedures.
Proposed Actions:	

Recommendation (F/C/R)	Consider continually monitoring pilot pressure system health during completion, well testing and well control situations. (L/H/M)
Failure	II.05 Wellhead Connector – Failure to latch on demand II.05 Wellhead Connector – Failure to maintain proper pressure on latch II.05 Wellhead Connector - Failure to primary unlatch on demand.
Causes:	Regulator failure (catastrophic leak).
Failure Effects:	Loss of pilot/supply pressure. Loss of pod
Mitigation:	Switch to alternate pod. Pull BOP.
Proposed Actions:	

Recommendation (F/C/R)	Ensure that MOC process is in placed and followed. (Change of OEM spares / fluids) (L/H/M)
Failure	II.05 Wellhead Connector - Failure to primary unlatch on demand.
Causes:	Plugged filters.
Failure Effects:	Pass dirty fluid. Plugged solenoid valves. Loss of pod.
Mitigation:	Switch to alternate pod to secure well. Pull BOP. PM. Clean fluid practices.
Proposed Actions:	

Recommendation (F/C/R)	Ensure that PM and operating procedures address shuttle valve mounting and maintenance. (L/H/M)
Failure	II.05 Wellhead Connector - Failure to latch on demand
Causes:	Failure of receptacle tubing.
Failure Effects:	Fluid loss. Inability to latch from active pod.
Mitigation:	Pull BOP. PM.
Proposed Actions:	

5.1.4 Low Criticality Recommendations

Recommendation (F/C/R)	Consider replacing packer between long duration wells. (M/L/L)
Failure	I. 01 Upper Annular Preventer – Failure to seal on demand
Causes:	Old or worn packing element
Failure Effects:	Inability to seal with annular, loss of upper annular.
Mitigation:	Open annular and switch to lower annular. Packer tested and visually inspected between wells.
Proposed Actions:	

Recommendation (F/C/R)	Consider drifting after surface test. (L/L/L)
Failure	1.01 Upper Annular Preventer – Failure to open on demand
Causes:	Defective element.
Failure Effects:	Inability to fully open annular. Obstructed wellbore. Loss of annular
Mitigation:	Swedge open annular. Switch to lower annular. Surface test.
Proposed Actions:	

Recommendation (F/C/R)	Consider continually monitoring pilot pressure system health during completion, well testing and well control situations. (L/M/L)
Failure	I.02 Upper Annular Preventer failure to close on demand I.02 Upper Annular Preventer failure to open on demand I.04 LMRP Connector – Failure to latch on demand I.04 LMRP Connector – Failure to maintain proper latch pressure I.04 LMRP Connector – Failure to unlatch on demand II.02 Blind Shear Ram – Failure to close on demand II.02 Blind Shear Ram – Failure to open on demand II.07 Pipe Ram – Failure to close on demand
Causes:	Regulator failure (catastrophic leak).
Failure Effects:	Loss of pilot/supply pressure. Loss of pod
Mitigation:	Switch to alternate pod. Isolate pod at conduit valve package. Pull LMRP.
Proposed Actions:	

Recommendation (F/C/R)	Ensure that MOC process is in placed and followed. (Change of OEM spares / fluids) (L/M/L)
Failure	I.02 Upper Annular Preventer failure to close on demand I.02 Upper Annular Preventer failure to open on demand I.04 LMRP Connector – Failure to latch on demand I.04 LMRP Connector – Failure to maintain proper latch pressure I.04 LMRP Connector – Failure to unlatch on demand II.02 Blind Shear Ram – Failure to close on demand II.02 Blind Shear Ram – Failure to open on demand II.05 Wellhead Connector - Failure to latch on demand II.05 Wellhead Connector - Failure to maintain proper latch pressure. II.07 Pipe Ram – Failure to close on demand II.07 Pipe Ram – Failure to open on demand
Causes:	Plugged filters.
Failure Effects:	Pass dirty fluid. Plugged solenoid valves. Loss of pod.
Mitigation:	Switch to alternate pod to secure well. Pull LMRP. PM. Clean fluid practices.
Proposed Actions:	

Recommendation (F/C/R)	Determine type of POCV in pod and if it is the upgrade – use to determine failure frequency. (Bolie resolved issue – frequency is 'L'.) (L/M/L)
Failure	I.02 Upper Annular Preventer failure to close on demand
Causes:	POCV stuck closed.
Failure Effects:	Loss of supply pressure. Loss of pod.
Mitigation:	Switch to alternate pod. Pull LMRP.
Proposed Actions:	

Recommendation (F/C/R)	Ensure that PM and operating procedures address shuttle valve mounting and maintenance. (L/L/L)
Failure	I.04 LMRP Connector – Failure to latch on demand
Causes:	Failure of receptacle tubing.
Failure Effects:	Fluid loss. Inability to latch from active pod.
Mitigation:	Block function and switch to alternate pod. PM.
Proposed Actions:	

Recommendation (F/C/R)	Cameron to investigate failure associated with solenoid. (LM/L)
Failure	I.04 LMRP Connector – Failure to maintain proper latch pressure
Causes:	Solenoid valve failure.
Failure Effects:	Fluid loss. Inability to maintain latch pressure from active pod. Inability to maintain latch pressure from active pod.
Mitigation:	Switch to alternate pod. Possibly secure well and pull LMRP. PM.
Proposed Actions:	

Recommendation (F/C/R)	Ensure procedures are updated in this situation. (L/L/L)
Failure	II.02 Blind Shear Ram – Failure to close on demand II.07 Pipe Ram – Failure to close on demand
Causes:	Total shuttle valve failure (pod shuttle valve).
Failure Effects:	Fluid loss. Inability to close ram (low pressure) from both pods.
Mitigation:	Block function. Rely on high pressure or ROV shear.
Proposed Actions:	

Recommendation (F/C/R)	Follow up with TSF w/rt flexible hose testing. (M/L/L)
Failure	II.05 Wellhead Connector - Failure to maintain proper latch pressure.
Causes:	Failure of 1" Poly-flex hose.
Failure Effects:	Fluid loss.
Mitigation:	Block function and continue. PM.
Proposed Actions:	

Recommendation (F/C/R)	Cameron to investigate failure associated with solenoid. (L/L/L)
Failure	II.05 Wellhead Connector - Failure to maintain proper latch pressure.
Causes:	Solenoid valve failure.
Failure Effects:	Fluid loss.
Mitigation:	Block function and continue. PM.
Proposed Actions:	

5.2 Parking Lot Issues

The issues listed below in Table 5.1 were placed on the parking lot list during the meeting. The issues listed in this section detail the additional concerns that were captured during the analysis that were not associated with a specific failure mode

Table 5.1 Parking Lot Issues

#	Action	Responsible	Target date	Status
1.	Follow up on Data Logging (Cycle Count) upgrade with Cameron.	Richard Coronado to report to Kevin Wink	Jan 10, 2001	RBF to submit formal request to Cody Moffitt w/ Cameron Controls.
2.	Provide DWHC drawings for for Risk Assessment.	Gary Leach	Jan 10, 2001	Closed. Drawing received Jan. 9, 2001
3.	Review copy of previous FMEA to ensure that we are not repeating the existing study.	RBF & James Tidwell	Jan 10, 2001	Closed. Original FMEA based on safety not operations availability.
4.	Supply study team with updated deadman panel drawings.	RBF	Jan 8, 2001	Closed. Copies supplied to team.
5.	Determine secondary means of power for hydraulic system and report results to BP .	Drew Weathers	Jan 17, 2001	
6.	Provide drawing of Conduit Readback Panel.	Bolie Williams	Jan 9, 2001	Closed. Drawing Provided to Kevin Wink and Gary Leach Jan 9, 2001
7.	Determine if loss of RCB will cause the loss of one pod.	Review During FMECA	Jan 11, 2001	Need more details from Cameron.
8.	Determine if RCB has been upgraded to latest Cameron design.	Richard Coronado to supply drawings.	Jan. 9, 2001	Drawings supplied Jan. 9. 2001

#	Action	Responsible	Target date	Status
9.	Determine test frequency for testing riser while running BOP (first run and routine).	Gary Leach for first run, DWH Operations Team to determine frequency for routine tests via risk assessment		Greg's industry review shows: 5 responses: 5 to 10 average, majority 10 (4 contractors, 1 manufacturer) "start with 5 if everything continues going great, go to 10.
10.	Determine operation philosophy for the hot line (energized or not) once BOP landed.	Gary Leach to discuss with Cameron during Running/Retrieval review. Greg Childs will review other operators philosophies and present	Jan. 11 2001	–
11.	Determine why gas bleed valve is located on lower annular (Philosophy question).	RBF		Closed. Position paper used to make decision.
12.	What is BP operation philosophy if bleed valve fails to open?	BP		Closed. Continue Drilling
13.	Ensure that procedure reflects operation philosophy in respect to isolation valve.	Ken Reed	Jan. 12, 2001	Closed. Procedure reviewed.

#	Action	Responsible	Target date	Status
14.	Ensure that lock pressure philosophy (collet connectors, and all connectors) and failure modes are reviewed during FMECA.	James Tidwell	Jan. 10, 2001	Closed. Part of FMECA.
15.	BP and RBF to review operation philosophy where casing shear is non-operational prior to drilling ahead and ahead of running casing.	BP/RBF		Closed. Conclusion: continue all operations except for running casing where stack would be pulled (depends on casing size).
16.	Get TSF standard Well Control procedures.	Ed Stidston to Gary Leach	Jan. 12, 2001	
17.	Team to catalog and prioritize "case-by-case" failure scenarios identified in analysis.	James Tidwell	Jan 12, 2001	
18.	Determine relief valve manufacturers for HPU. (Kratch quality is questionable). –	Bolie Williams	Jan. 12, 2001	
19.	Identify pod pilot regulator model and (Deadband if possible) review failure modes.	Bolie Williams	Jan. 9, 2001	Closed. Regulator has wide deadband. Correct regulators installed.
20.	TSF to forward results of hose analysis to RBF team once analysis completed.	Ed Stidston	Jan. 31, 2001	

#	Action	Responsible	Target date	Status
21.	Determine if upgrade to Seacon PBOF has been installed on DWH.	Richard Coronado	Jan. 17, 2001	
22.	Find out from Cameron what differential pressure is allowed on AX, CX, and bonnet gaskets (outside to inside). Deepstar report may address this issue.	Bolie Williams Dick Metcalf (to get Deepstar report)	Jan. 12, 2001	AX, CX, and bonnet gaskets are all rated for 0 psi external. A bonnet gasket is in development that can take 3,000 psi (preliminary number, still testing)
23.	Verify ST lock capabilities for 3-1/2 to 6-5/8 VBRs on 6-5/8 pipe.	Bolie Williams	Jan. 12, 2001	18 ¾ 10K VBR is rated for 5 to 7 5/8. 18 ¾ 15K VBR is rated for full range w/ RAMLOCKS. With ST Locks, will not hold seal with no close pressure on 7 5/8 pipe and MAY hold pressure on 6 5/8 pipe. Will seal on all sizes WITH close pressure.
24.	RBF requested that Cameron provide explanation of non-conformity process. RBF to work with Cameron to report and follow up on non-conformities.	Bolie Williams to work with John Wilson to clarify issue		Bolie reported to John Wilson on 9 January, 2001 – Quality Manager of Cameron Controls (David Coe) to provide
25.	Determine existing seal plate material. Determine if upgrade is required	Bolie Williams Gary Leach	Jan 31, 2001	

#	Action	Responsible	Target date	Status
26.	Update flow diagrams SK 122108-21-05 sheet 1 of 3 (vent and supply are connected on drawing)?.	Bolie Williams	Jan. 31, 2001	
27.	Get copy of EB-842M from Gary Leach to Subsea Engineer. (Lubrication of connector hob.) [–	Gary Leach	Jan. 12, 2001	
28.	Investigate indicator rod failures. Determine if potential to affect LMRP unlatch.	Jacqueline Hsu (Bolie Williams to coordinate)		
29.	Review EB687C and determine proper hold pressure.	Gary Leach	Jan. 10, 2001	
30.	Cameron to investigate failures associated with solenoids.			
31.	Add hotline bypass lines to stack schematic.	Matt Goule		
32.	Develop complete drawing of rigid conduit flow path from the rigid conduit package through the pod and junction plates to a function.	Bolie Williams and Drew Weathers		
33.	Perform gap analysis between DWH and Enterprise study. Complete worksheets for pipe ram FMECA.	James Tidwell		

#	Action	Responsible	Target date	Status
34.	Review riser deck operations upon completion of Running / Retrieval review.			
35.	RBF DWH (rig specific) riser operating procedures for tensionsers to be provided to Don Weisinger.	Bill Ambrose	Jan. 12, 2001	
36.	Review and formalize Rig specific BOP Pre-run checklist.			
37.	RBF to supply BP with operational & maintenance policy for lifting equipment (sling, shackles, etc.).	Gary Leach		
38.	Include riser running load issues in Pre-planning / tech limit team building sessions.	Don Weisinger		
39.	Ensure that riser running load issue information is issued fleet wide (DP rigs) and that a copy is sent to BP.	Bill Ambrose		
40.	Determine acceptable weather conditions (DP rig) for landing the LMRP/BOP.	Don Weisinger, Bill Ambrose		
41.	Review procedures and processes and identify HAZIDs and Risk Assessments that need to be performed.	Russ Krohn		

#	Action	Responsible	Target date	Status
42.	RBF to provide operations manual (in relation to operational limits) to BP.	Russ Krohn		
43.	Develop philosophy and procedures for stand-by mode during planned storm disconnect.	Gary Leach, Russ Krohn		
44.	Consider having properly sized storm packer on board at all times.	Don Weisinger		
45.	RBF to provide BP with list of standard vessel procedures.	Kevin Wink		
46.	Ensure that written procedures have been developed, reviewed, and are available to the vessel. Ensure proper training in accordance with procedures.	Kevin Wink		

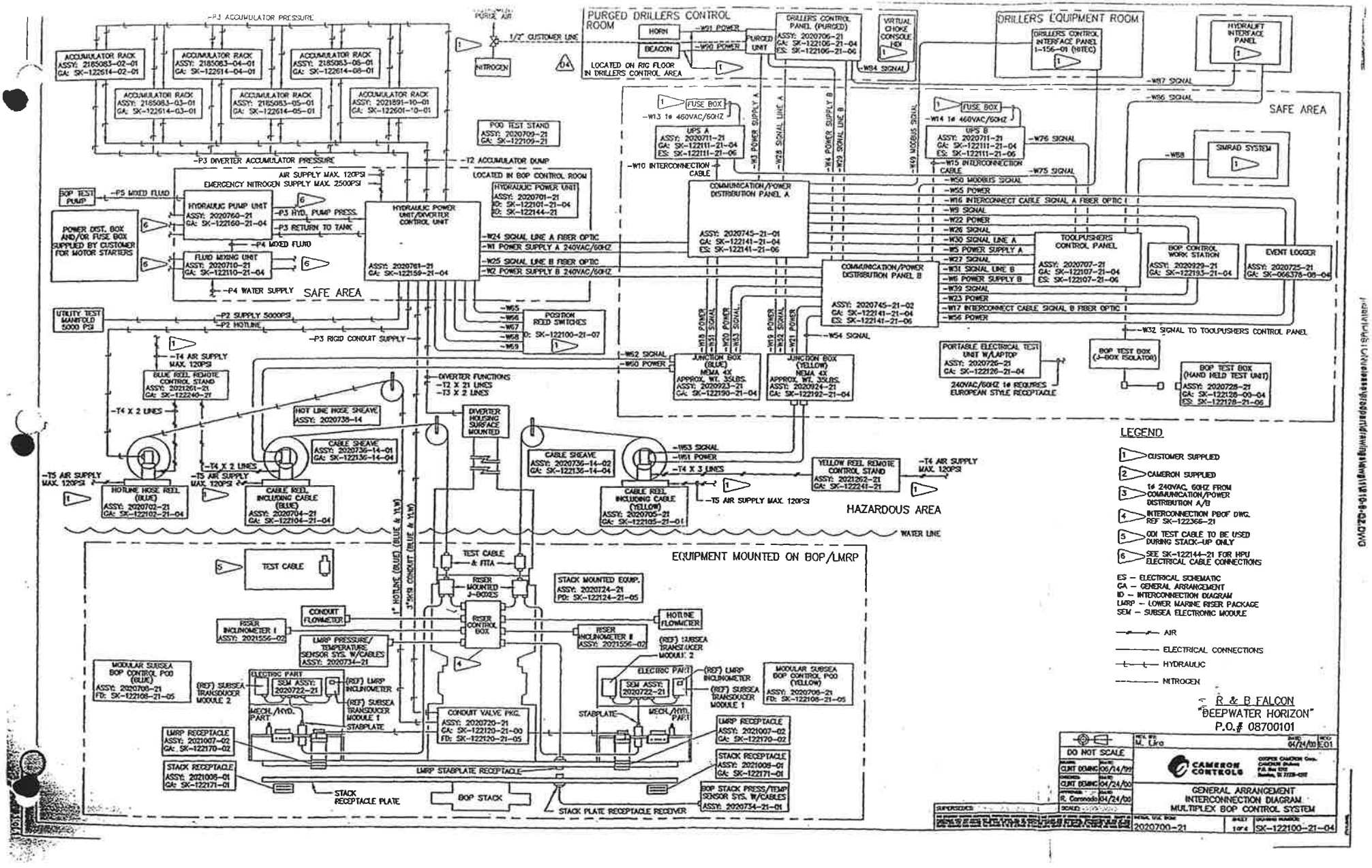
6. GAP ANALYSIS

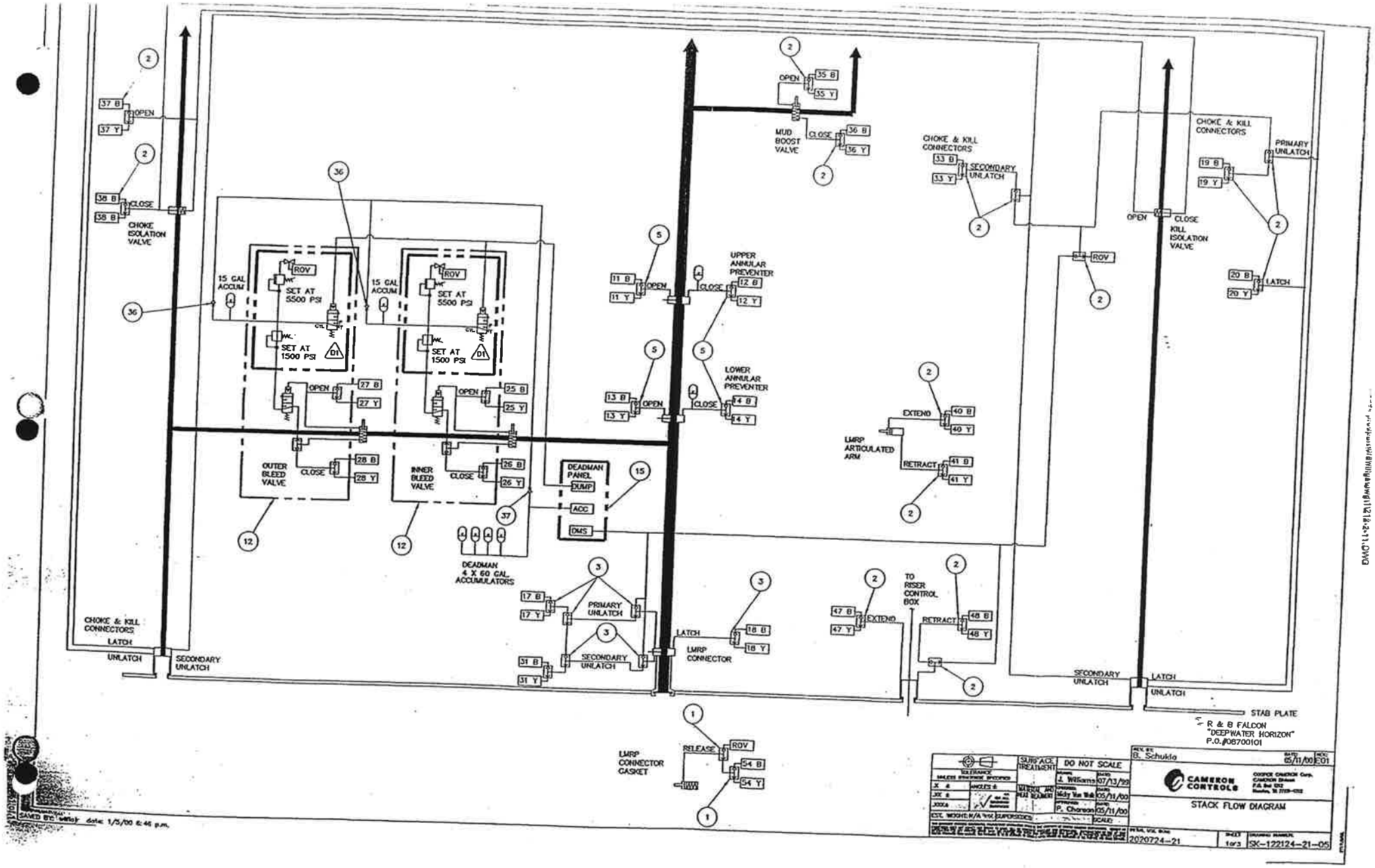
A thorough review of the Discoverer Enterprise BOP analysis was conducted upon completion of the Deepwater Enterprise BOP Assurance Analysis. The Gap analysis was conducted to see if major differences were observed in the results of the two analyses.

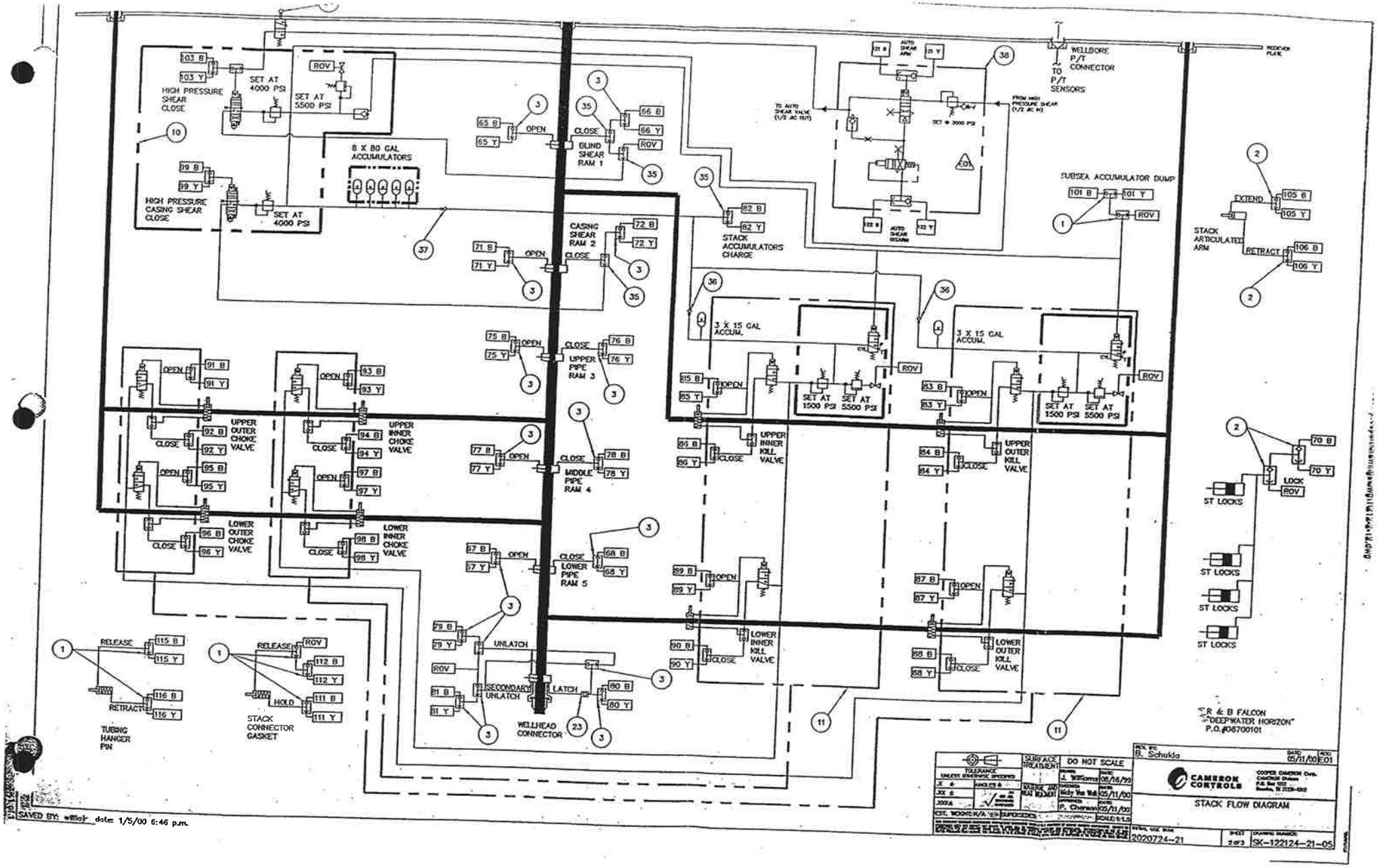
The Gap analysis performed revealed that the major difference between the Deepwater Horizon and the Discoverer Enterprise BOP Assurance Analysis was the level of PM review completed. The Deepwater Enterprise team reviewed PM's in detail to make sure that the BOP maintenance is sufficient to uncover the major failure modes identified during the analysis and to ensure that the maintenance is performed at the appropriate frequency (i.e. quarterly, between well, etc.). Individual procedures were not reviewed during the Discoverer Enterprise BOP Assurance Analysis. The predominant failures from both analyses were similar: solenoids, hoses, connectors, shuttle valves and ram locking mechanisms.

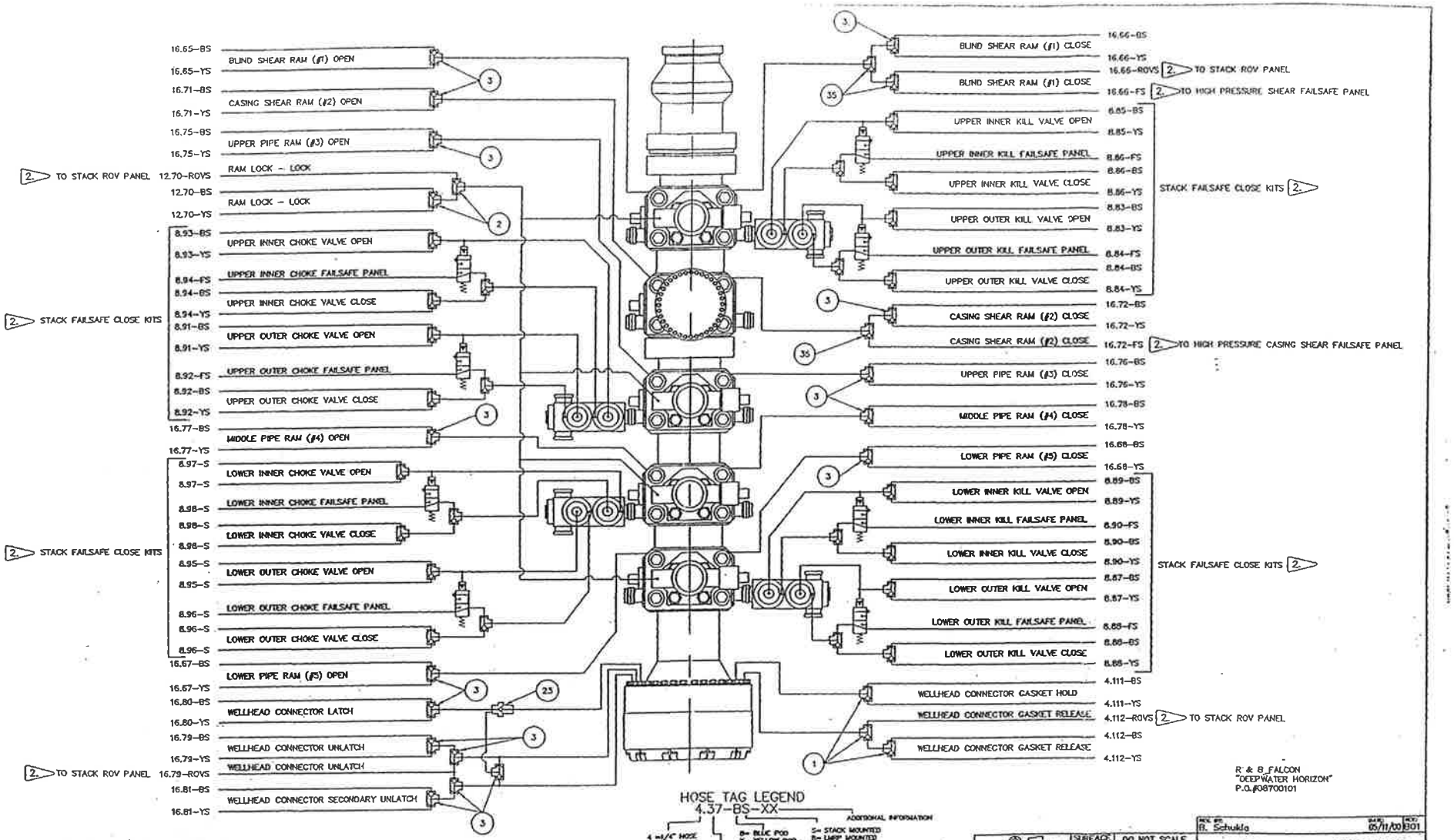
Appendix A

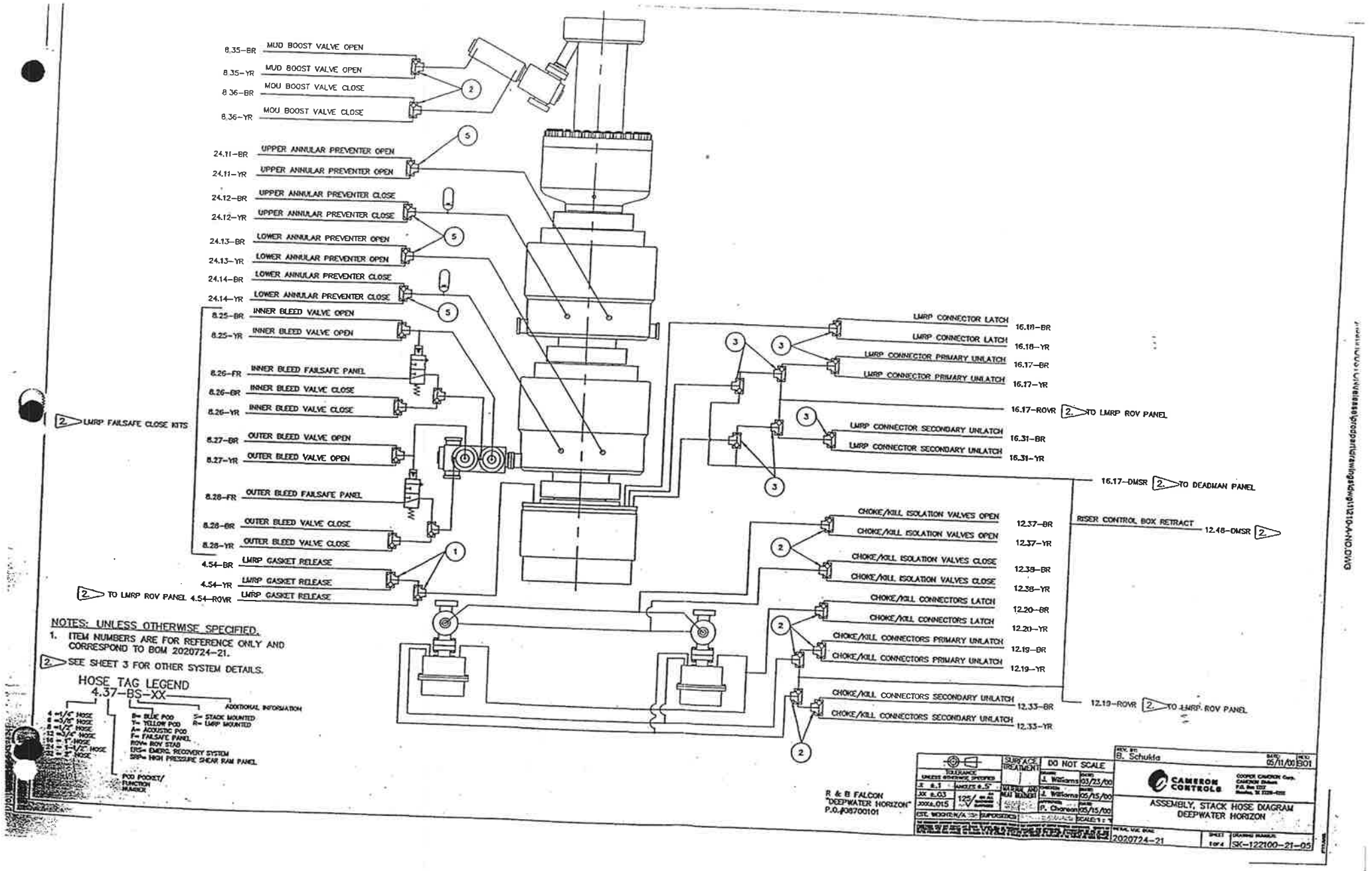
APPENDIX A
DRAWINGS

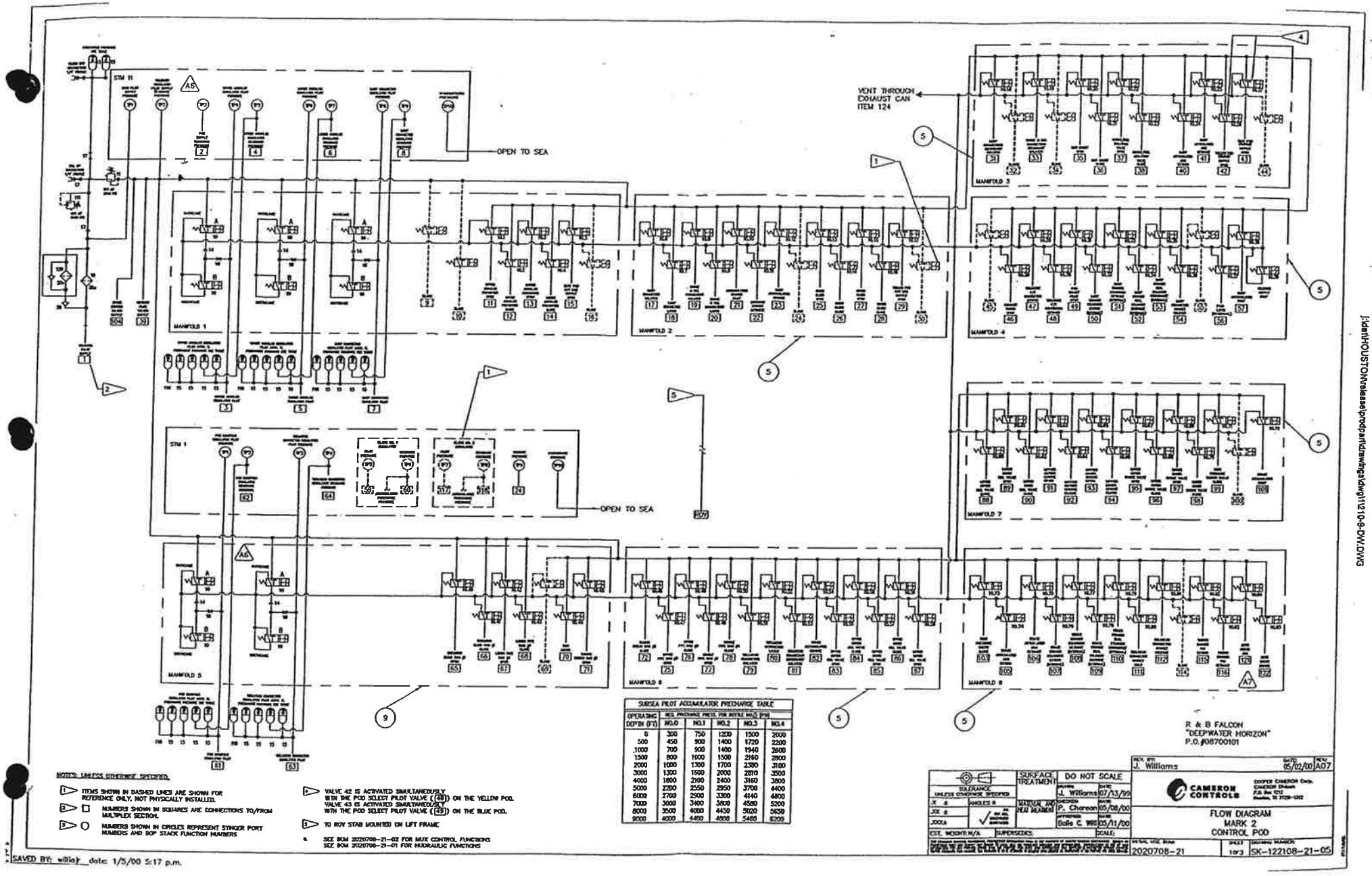


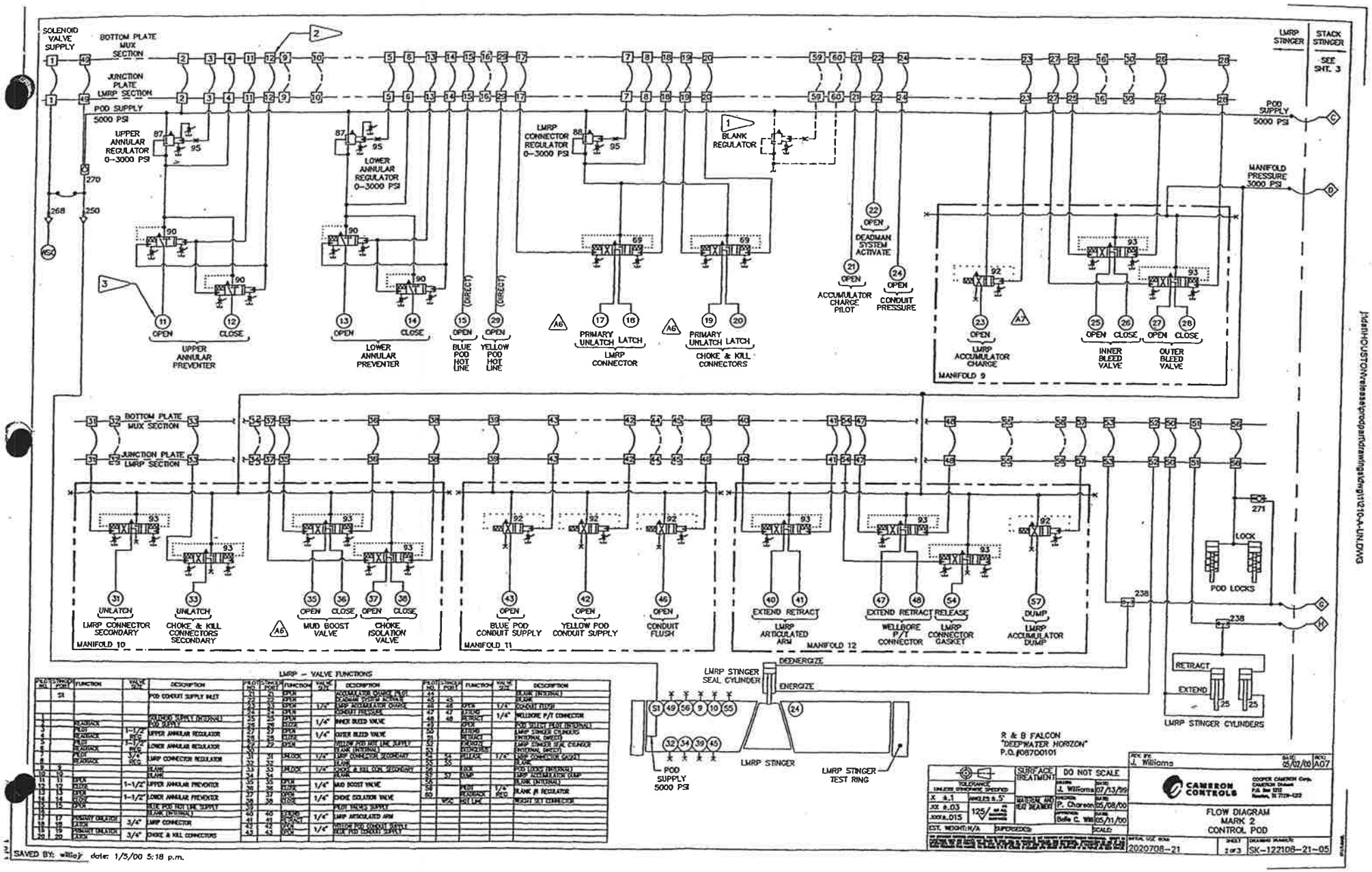












LMRP – VALVE FUNCTIONS

PILOT NO.	SINGLE PORT	FUNCTION	VALVE SIZE	DESCRIPTION
	51			POD CONDUIT SUPPLY INLET
1				SOLENOID SUPPLY (INTERNAL)
2		FEEDBACK		POD SUPPLY
3		PILOT	1-1/2" REG.	UPPER ANNULAR REGULATOR
4		FEEDBACK		
5		PILOT	3-1/2" REG.	LOWER ANNULAR REGULATOR
6		FEEDBACK		
7		PILOT	3/4" REG.	LMRP CONNECTOR REGULATOR
8		FEEDBACK		
9	9			BLANK
10	10			BLANK
11	11	OPEN	1-1/2"	UPPER ANNULAR PREVENTER
12	12	CLOSE		
13	13	OPEN	1-1/2"	LOWER ANNULAR PREVENTER
14	14	CLOSE		
15	15	OPEN		BLUE POD HOT LINE SUPPLY
16	16	CLOSE		BLANK (INTERNAL)
17	17	PRIMARY UNLATCH	3/4"	LMRP CONNECTOR
18	18	PRIMARY LATCH		
19	19	PRIMARY UNLATCH	3/4"	CHOKE & KILL CONNECTORS
20	20	LATCH		

PILOT NO.	SINGLE PORT	FUNCTION	VALVE SIZE	DESCRIPTION
21	21	OPEN		ACCUMULATOR CHARGE PILOT
22	22	OPEN		DEADMAN SYSTEM ACTIVATE
23	23	OPEN		LMRP ACCUMULATOR CHARGE
24	24	OPEN	1/4"	CONDUIT PRESSURE
25	25	OPEN		INNER BLEED VALVE
26	26	CLOSE		
27	27	OPEN		OUTER BLEED VALVE
28	28	CLOSE		
29	29	OPEN		YELLOW POD HOT LINE SUPPLY
30	30	CLOSE		BLANK (INTERNAL)
31	31	UNLATCH		LMRP CONNECTOR SECONDARY
32	32	UNLATCH		CHOKE & KILL CON. SECONDARY
33	33	LATCH		
34	34			BLANK
35	35	OPEN		MUD BOOST VALVE
36	36	CLOSE		
37	37	OPEN		CHOKE ISOLATION VALVE
38	38	CLOSE		
39	39			BLANK
40	40	EXTEND		LMRP ARTICULATED ARM
41	41	RETRACT		
42	42	OPEN		YELLOW POD CONDUIT SUPPLY
43	43	OPEN		BLUE POD CONDUIT SUPPLY
44	44			BLANK (INTERNAL)
45	45			BLANK
46	46	OPEN		CONDUIT FLUSH
47	47	EXTEND		WELLBORE P/T CONNECTOR
48	48	RETRACT		
49	49			LMRP STINGER SEAL CYLINDER (INTERNAL SHEET)
50	50			
51	51			
52	52			
53	53			
54	54	RELEASE		LMRP CONNECTOR GASKET
55	55			
56	56			LMRP CONNECTOR (INTERNAL SHEET)
57	57	DUMP		LMRP ACCUMULATOR DUMP
58	58			BLANK (INTERNAL)
59	59			POD SELECT PILOT (INTERNAL)
60	60			LMRP STINGER SEAL CEMENT (INTERNAL SHEET)
61	61			
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63	63			
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R & B FALCON
"DEEPWATER HORIZON"
P.O. #0870D0101

SURFACE TREATMENT	DO NOT SCALE	DRAWN J. Williams	DATE 05/02/00
TOLERANCE UNLESS OTHERWISE SPECIFIED		CHECKED J. Williams	DATE 07/13/99
X ±.1	ANGLES ±.5°	MATERIAL AND HEAT TREATMENT	APPROVED P. Charon	DATE 05/08/00
XX ±.03	125		APPROVED Bella C. Wu	DATE 05/11/00
XXX±.015			SCALE:	
EST. WEIGHT: N/A	SUPERSEDES:			

CAMERON CONTROLS
COOPER CAMERON Corp.
CAMERON Division
P.O. Box 1212
Houston, TX 77251-1212

FLOW DIAGRAM
MARK 2
CONTROL POD

METRIC SIZE (mm)	SHEET	DRAWING NUMBER
2020708-21	2 of 3	SK-122108-21-05

SAVED BY: willoj date: 1/5/00 5:18 p.m.

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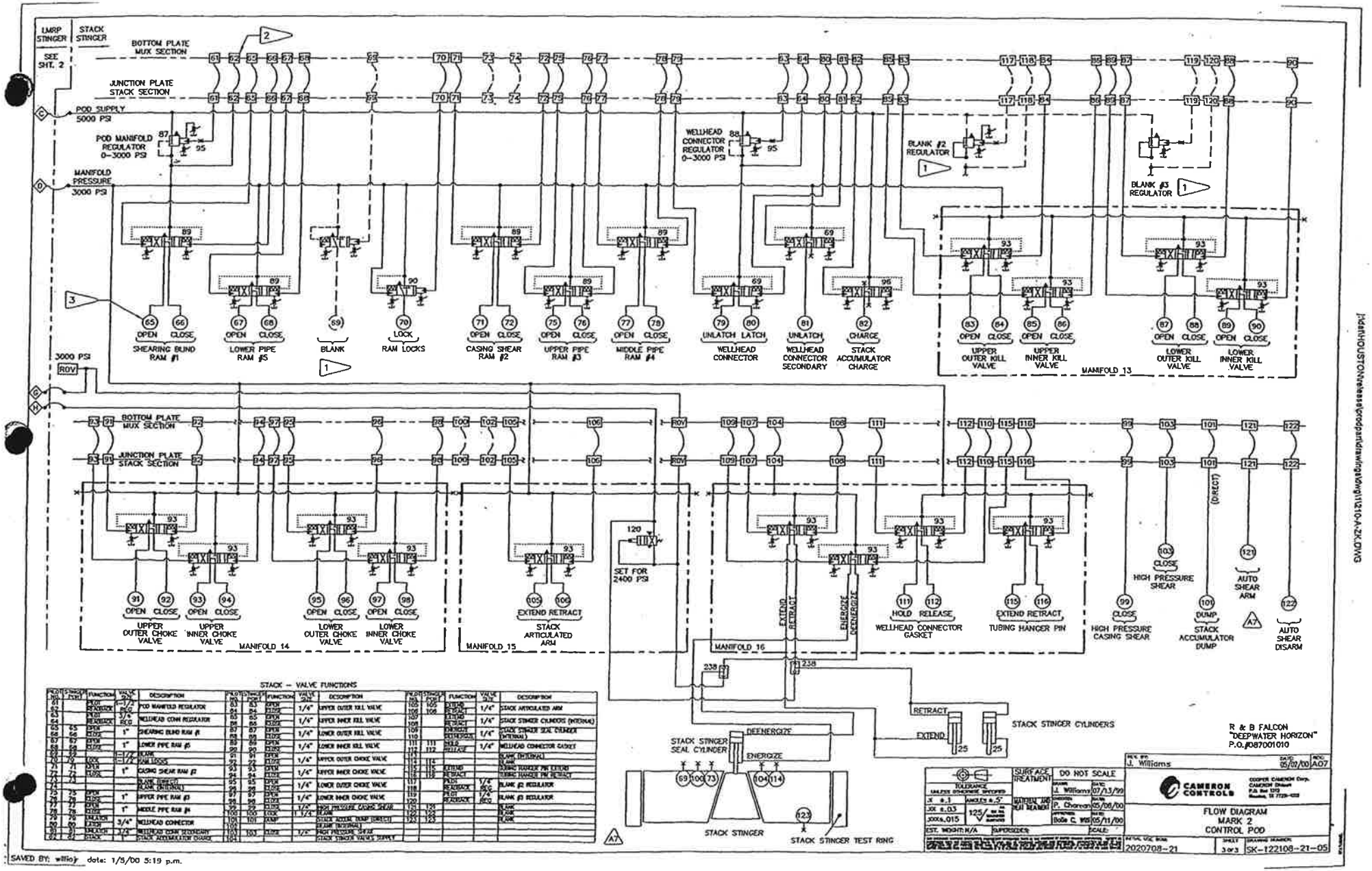

Appendix B

APPENDIX B
FMECA WORKSHEETS

APPENDIX B
FMECA WORKSHEETS

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No.	Section Description: Houses annulars, pods, mini-collet connector (MRL control), deadman system, and various valves
Rev. no. 1 Date: 01/17/01	Function: Upper Annular preventer - open/close Function No.: 01	Function Description: Seals the wellbore in open hole, tubulars, and casing

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							P	C	R	
A.	Failure to close on demand.	Blown seal.	Loss of fluid out vent ports. Inability to close annular.	Loss of system fluid. Loss of Upper Annular.	Constant flow on subsea flow meters. Possible visual indication via ROV.	Block function and switch to lower annular. Regular testing.	L	L	L	
B.		Mechanical damage to internal components.	Inability to close annular.	Loss of Upper Annular.	Incorrect flow on flow meters.	Open annular and switch to lower annular. Function testing.	L	L	L	
C.		Corrosion.	Inability to close annular.	Loss of Upper Annular.	Incorrect flow on flow meters.	Open annular and switch to lower annular.	L	L	L	
D.	Failure to seal on demand.	Old or worn packing element.	Inability to seal with annular.	Loss of Upper Annular.	Failed pressure test. Mud returns.	Open annular and switch to lower annular. Packer tested and visually inspected between wells.	M	L	L	*Consider replacing packer between long duration wells.*

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No: 1	Section Description: Houses annulars, pods, mini-collet connector, MUX Connector, dead man system and various valves
Rev no.: 1 Date: 01/17/01	Function: Upper Annular Preventer – Open/Close Function No: 1.01	Function Description: Seals the wellbore on openhole, tubulars, and wireline

#	Failure Mode	Causes	Local Effects	System Effects	Method of Detection	Mitigation	Ranking			Recommendation
							P	C	R	
E.	Failure to seal on demand.	Defective packing element.	Inability to seal with annular.	Loss of Upper Annular.	Failed pressure test. Mud returns.	Open annular and switch to lower annular. Packer visually inspected before installation.	L	L	L	
F.		Closing on non-standard equipment.	Inability to seal with annular.	Potential loss of annular.	Failed pressure test. Mud returns. Unexpected flow meter reading.	Check space out. Retest annular and possibly switch to lower annular. Operational procedures and training of personnel.	L	L	L	
G.		Packer not fully energized.	Inability to seal with annular.	Potential loss of annular.	Failed pressure test. Mud returns. Unexpected flow meter reading.	Switch to lower annular.	L	L	L	
H.	Failure to open on demand.	Defective element.	Inability to fully open annular.	Obstructed wellbore. Loss of annular.	Inability to pass tools through annular. Weight indication.	Swedge open annular. Switch to lower annular. Surface test.	L	L	L	*Consider drifting after surface test.*

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No.: 3	Section Description: Houses annulars, pods, mini-collet connector, LMRP connector, hydraulic system and control valves.
Rev. no.: 1 Date: 01/17/01	Function: Upper Annular Preventor - Open/Close Function No.: 3.01	Function Description: Seals the wellbore - on open hole, tubulars, and wireline.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
I.	Failure to open on demand.	Mechanical damage to internal components.	Inability to fully open annular.	Obstructed wellbore. Loss of annular.	Inability to pass tools through annular. Weight indication.	Secure well and pull LMRP. PM (Function and operator tests.)	L	M	L	
J.		Corrosion.	Inability to fully open annular.	Obstructed wellbore. Loss of annular.	Inability to pass tools through annular. Weight indication.	Secure well and pull LMRP.	L	M	L	
K.		Debris or obstruction.	Inability to fully open annular.	Obstructed wellbore. Loss of annular.	Inability to pass tools through annular. Weight indication. Low fluid count.	Secure well and pull LMRP.	L	M	L	

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No.: 01	Section Description: Houses annulars, pods, mini-collet connector, LMRP connector, deadman system and various valves.
Rev. no.: 1 Date: 01/17/01	Function: Upper Annular Preventer - Hydraulics Function No.: 02	Function Description: Hydraulic circuitry to operate annular.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking F	Ranking C	Ranking R	Recommendation
A.	Failure to close on demand	Failure of surge circuit.	Fluid loss. Inability to close annular.	Loss of annular.	Fluid count. Eventual alarm.	Block function and switch to lower annular. PM.	L	L	L	
B.		Total shuttle valve failure.	Fluid loss. Inability to close annular.	Loss of annular.	Fluid count. Eventual alarm.	Block function and switch to lower annular. PM.	L	L	L	
C.		Failure of 1-1/2" hose.	Fluid loss. Inability to close annular from active pod.	Loss of function redundancy.	Fluid count. Eventual alarm.	Switch to alternate pod. PM.	L	L	L	
D.		Failure of receptacle tubing.	Fluid loss. Inability to close annular from active pod.	Loss of function redundancy.	Fluid count. Eventual alarm.	Switch to alternate pod. PM.	L	L	L	
E.		Failure of stinger seal.	Fluid loss. Inability to close annular from active pod.	Loss of function redundancy.	Fluid count. Eventual alarm.	Switch to alternate pod. PM.	L	L	L	
F.		Shear seal valve failure (pilot side).	Inability to close annular.	Loss of function redundancy.	No flow count. No pressure drop on readback.	Switch to alternate pod.	L	L	L	

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No.: 1	Section Description: Houses annulars, pods, mini-collet connector, LMRP connector, deadman system and various valves.
Rev. no.: 1 Date: 01/17/01	Function: Upper Annular Preventer – Hydraulics Function No.: 02	Function Description: Hydraulic circuitry to operate annular.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking F	Ranking C	Ranking R	Recommendation
G.	Failure to close on demand	Solenoid valve failure.	Inability to close annular.	Loss of function redundancy.	No flow count. No pressure drop on readback.	Switch to alternate pod.	L	L	L	
H.		Manual pilot regulator leak.	Fluid loss.	Fluid loss.	Increased pump operation. Excess fluid use. Visual indication with ROV.	No mitigation required – monitor situation.	L	L	L	
I.		Total manual pilot regulator failure (catastrophic leak).	Loss of pilot pressure.	Loss of pod.	Low pilot readback pressure.	Switch to alternate pod. Isolate pod at conduit valve package. Pull LMRP.	L	M	L	*Consider continually monitoring pilot pressure system health during completion, well testing and well control situations.*
J.		Deadband problem will be evaluated if determined that it exists. No Issue – no need to evaluate.								

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No.: 1	Section Description: Houses annulars, pods, mini-collet connector, LMRP connector, deadman system and various valves.
Rev. no.: 1 Date: 08/17/01	Function: Close – Annular Preventer – Hydraulics Function No.: 02	Function Description: Hydraulic circuitry to operate annular.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking F	Ranking C	Ranking R	Recommendation
K.	Failure to close on demand	Plugged filters.	Pass dirty fluid.	Plugged solenoid valves. Loss of pod.	Function failure.	Switch to alternate pod to secure well. Pull LMRP. PM. Clean fluid practices.	L	M	L	*Ensure that MOC process is in placed and followed. (Change of OEM spares / fluids)*
L.		Plugged solenoid common vent.	Unable to close annular.	Loss of pod.	No fluid count.	Switch to alternate pod to secure well. Pull LMRP. PM. Clean fluid practices.	L	M	L	
M.		Shear seal valve failure (supply side).	Inability to close annular.	Loss of function redundancy.	Unexpected flow count. Unexpected pressure drop on readback.	Block function. Switch to alternate pod.	L	L	L	
N.		Upper annular regulator leak.	Fluid loss.	Fluid loss.	Increased pump operation. Excess fluid use. Visual indication with ROV.	No mitigation required – monitor situation. PM.	M	L	L	

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No:	Section Description: Houses annulars, pods, mini-collet connector, LMRP connector, hydraulics system and various valves.
Rev. no.: 1 Date: 01/17/01	Function: Upper Annular Preventer – Hydraulics Function No: 02	Function Description: Provides the circuitry to operate annular.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
O.	Failure to close on demand	Upper annular regulator failure (catastrophic leak – stuck wide open).	Loss of supply pressure.	Loss of pod.	Low supply readback pressure. Excessive fluid use.	Switch to alternate pod. Pull LMRP.	L	M	L	*Consider continually monitoring supply pressure system health during completion, well testing and well control situations. (High level recommendation.)*
P.		POCV stuck closed.	Loss of supply pressure.	Loss of pod.	No supply readback pressure. No fluid use.	Switch to alternate pod. Pull LMRP.	L	M	L	Determine type of POCV in pod and if it is the upgrade – use to determine failure frequency. (Bolie resolved issue – frequency is 'L'.)

FMECA Report Form	System: Deepwater Horizon BOP Section: Upper Annular Section No.: 1	Section Description: Houses annulars, pods, mini-collet connector, kill connector, dead man system and various valves.
Rev. no.: 1 Date: 01/17/01	Function: Upper Annular Preventer – Hydraulics Function No.: 02	Function Description: Hydraulic circuitry to operate annular.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking E	Ranking C	Ranking R	Recommendation
Q.	Failure to open on demand	Total shuttle valve failure.	Fluid loss. Possible inability to fully open annular.	Possibly obstructed wellbore. Loss of annular.	Fluid count. Eventual alarm.	Swedge open annular then block function and switch to lower annular. PM.	L	L	L	
R.		Failure of 1-1/2" hose.	Fluid loss. Possible inability to fully open annular from active pod.	Loss of function redundancy.	Fluid count. Eventual alarm.	Switch to alternate pod. PM.	L	L	L	
S.		Failure of receptacle tubing.	Fluid loss. Possible inability to fully open annular from active pod.	Loss of function redundancy.	Fluid count. Eventual alarm.	Switch to alternate pod. PM.	L	L	L	
T.		Failure of stinger seal.	Fluid loss. Inability to open annular from active pod.	Loss of function redundancy.	Fluid count. Eventual alarm.	Switch to alternate pod. PM.	L	L	L	
U.		Shear seal valve failure (pilot side).	Inability to open annular from active pod.	Loss of function redundancy.	No flow count. No pressure drop on readback.	Switch to alternate pod.	L	L	L	

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No: 1	Section Description: Houses annulars, pods, mini-collet connector, LMRP connector, Deadman system and various valves
Rev. no: 1 Date: 01/17/01	Function: Upper Annular Preventer – Hydraulics Function No: 02	Function Description: Hydraulic circuitry to operate annular.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
V.	Failure to open on demand	Solenoid valve failure.	Inability to open annular.	Loss of function redundancy.	No flow count. No pressure drop on readback.	Switch to alternate pod.	L	L	L	
W.		Manual pilot regulator leak.	Fluid loss.	Fluid loss.	Increased pump operation. Excess fluid use. Visual indication with ROV.	No mitigation required – monitor situation.	L	L	L	
X.		Total manual pilot regulator failure (catastrophic leak).	Loss of pilot pressure.	Loss of pod.	Low pilot readback pressure.	Switch to alternate pod. Isolate pod at conduit valve package. Pull LMRP.	L	M	L	*Consider continually monitoring pilot pressure system health during completion, well testing and well control situations.*
Y.		Plugged filters.	Pass dirty fluid.	Plugged solenoid valves. Loss of pod.	Function failure.	Switch to alternate pod to secure well. Pull LMRP. PM. Clean fluid practices.	L	M	L	*Ensure that MOC process is in placed and followed. (Change of OEM spares / fluids)*

FMECA Report Form	System: Deep Water Horizon BOP Section: Section No.: 1	Section Description: Houses annulars, pods, mini-collet connector, [illegible] connector, manifold, [illegible] system and various valves.
Rev. no.: 01 Date: 01/17/01	Function: Upper Annular Preventer - Hydraulics Function No.: 02	Function Description: Provide capacity to operate annular.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							S	C	R	
Z.	Failure to open on demand	Plugged solenoid common vent.	Unable to open annular.	Loss of pod.	No fluid count.	Switch to alternate pod to secure well. Pull LMRP. PM. Clean fluid practices.	L	M	L	
AA.		Shear seal valve failure (supply side).	Inability to open annular.	Loss of function redundancy.	Unexpected flow count. Unexpected pressure drop on readback.	Block function. Switch to alternate pod.	L	L	L	
BB.		Upper annular regulator leak.	Fluid loss.	Fluid loss.	Increased pump operation. Excess fluid use. Visual indication with ROV.	No mitigation required – monitor situation. PM.	M	L	L	

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No.: 1	Section Description: Houses annulars, pods, mini-collet connector, LMRP connector, hydraulic system and various valves
Rev. no.: 1 Date: 01/17/01	Function: Upper Annular Preventer (UAP) Annulars Function No.: 02	Function Description: Provide the capability to operate annular

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking F	Ranking C	Ranking R	Recommendation
CC.	Failure to open on demand	Upper annular regulator failure (catastrophic leak – stuck wide open).	Loss of supply pressure.	Loss of pod.	Low supply readback pressure. Excessive fluid use.	Switch to alternate pod. Pull LMRP.	L	M	L	*Consider continually monitoring supply pressure system health during completion, well testing and well control situations. (High-level recommendation.)*
DD.		POCV stuck closed.	Loss of supply pressure.	Loss of pod.	No supply readback pressure. No fluid use.	Switch to alternate pod. Pull LMRP.	L	M	L	
EE.	Failure to seal on demand.	See 'Failure to Close on Demand' – No New Issues.								

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No: 2.0	Section Description: Hydril annulars, pods, mini-collet connector, LMRP connector, hydraulic system and various valves
Rev. no: 2.1 Date: 01/01/01	Function: LMRP Connector Unlatch / Unlatch Function No: 2.18	Function Description: Connects LMRP to BOP

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							R	C	R	
A.	Failure to latch on demand.	Seal failure.	Failure to latch.	Unable to connect to BOP.	Indicator rod. Unexpected flow.	Pull LMRP. PM.	L	M	L	
B.		Mechanical damage to internal components.	Failure to latch.	Unable to connect to BOP.	Indicator rod. Unexpected flow.	Pull LMRP. PM.	L	M	L	
C.		Debris.	Failure to latch.	Unable to connect to BOP.	Indicator rod. Unexpected flow.	Pull LMRP. PM.	L	M	L	
D.		Damage to hub on mandrel.	Failure to latch.	Unable to connect to BOP.	Indicator rod. Unexpected flow. Visual inspection with ROV.	Pull LMRP Secure well if necessary to pull BOP.	L	H	M	*Ensure that operating parameters are adequate to prevent damage from LMRP strike or incidental contact.*
E.		Corrosion.	Failure to latch.	Unable to connect to BOP.	Indicator rod. Unexpected flow.	Pull LMRP. PM.	L	M	L	

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No: [illegible]	Section Description: House annulars, pods, mini-collet connector, LMRP connector, deadman system and various valves
Rev no: 1 Date: 01/17/01	Function: LMRP Connector – Latch / Unlatch Function No: [illegible]	Function Description: Connects LMRP to BOP

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking F	Ranking C	Ranking R	Recommendation
F.	Failure to seal on demand.	Improper or damaged gasket.	Failure to seal.	Failure to seal.	Failed pressure test.	Replace gasket and retest.	L	L	L	
G.		Damaged seal surface (Connector).	Failure to seal.	Failure to seal.	Failed pressure test.	Pull LMRP.	L	M	L	
H.		Damaged seal surface (Mandrel).	Failure to seal.	Failure to seal.	Failed pressure test. Possible visual indication with ROV.	Secure well and pull BOP. PM and standard operating procedures.	L	H	M	*Ensure proper installation of gasket before attempt to latch.*
I.	Failure to maintain latch pressure.	Seal Failure.	Loss of latch pressure.	Loss of hydraulic operating fluid. Potential for loss of wellbore fluids.	Unexpected flow at flow meter. Excessive use of hydraulic fluid. Visual indication with ROV.	Secure well and pull LMRP.	L	M	L	
J.	Failure to unlatch on demand.	Overpressure on latch.	Inability to unlatch.	Inability to unlatch. **(Potential loss of EDS)**	No or minimal flow. Failure evident.	Secure well and pull BOP. Proper training and procedures.	L	H	M	*Ensure procedures are followed.*

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP	Section Description: Hous annulars, pods, mini-collet connector, LMRP connector, hydraulic system and control valves
Rev. no.: 1 Date: 01/17/01	Function: LMRP Connector – Latch / Unlatch Function No.: 08	Function Description: Connects LMRP to BOP

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
K.	Failure to unlatch on demand.	Hydrate or other debris.	Inability to unlatch.	Inability to unlatch.	No or minimal flow. Failure evident.	Use of methanol and warm fluids. Possibly secure well and pull BOP.	L	H	M	*Investigate need for hydrate measures for LMRP Connector.*
L.		Damaged indicator rods.	Inability to unlatch.	Inability to unlatch.	Minimal flow. Failure evident. Second indicator flag would not travel full stroke.	Secure well and pull BOP.	L	H	M	*Investigate failure mode with Cameron (Jacqueline Hsu).*
M.		Mechanical damage to internal components.	Inability to unlatch.	Inability to unlatch.	Minimal flow. Failure evident. Second indicator flag would not travel full stroke.	Secure well and pull BOP. PM.	L	H	M	

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No.: 1	Section Description: House annulars, pods, mini-collet connector, LMRP connector, deadman system and various valves.
Rev. no.: 1 Date: 01/17/01	Function: LMRP Connector - Latch / Unlatch Function No.: 03	Function Description: Connects LMRP to BOP.

#	Failure Mode	Causes	Local/Inline Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							L	C	R	
N.	Failure to unlatch on demand.	Corrosion.	Inability to unlatch.	Inability to unlatch.	Minimal flow. Failure evident. Second indicator flag would not travel full stroke.	Secure well and pull BOP. PM.	L	H	M	

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No.: 1	Section Description: Houses annulars, pods, mini-collet connector, LMRP connector, deadman system and various valves.
Rev. no.: 1 Date: 01/17/01	Function: LMRP Connector - Hydraulics Function No.: 04	Function Description: Connects LMRP to BOP.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking F	Ranking C	Ranking R	Recommendation
A.	Failure to latch on demand	Total shuttle valve failure.	Fluid loss. Inability to latch.	Inability to latch.	Fluid count. Indicator rod.	Pull LMRP. PM.	L	M	L	
B.		Failure of 1" Poly-flex hose.	Fluid loss. Inability to latch from active pod.	Inability to latch from active pod.	Fluid count. Indicator rod.	Block function and switch to alternate pod. PM.	M	L	L	
C.		Failure of receptacle tubing.	Fluid loss. Inability to latch from active pod.	Inability to latch from active pod.	Fluid count. Indicator rod.	Block function and switch to alternate pod. PM.	L	L	L	*Ensure that PM and operating procedures address shuttle valve mounting and maintenance.*
D.		Failure of stinger seal.	Fluid loss. Inability to latch from active pod.	Inability to latch from active pod.	Fluid count. Indicator rod.	Block function and switch to alternate pod. PM.	L	L	L	
E.		Shear seal valve failure (pilot side).	Inability to latch from active pod.	Loss of function redundancy.	No flow count. No pressure drop on readback. Indicator rod.	Switch to alternate pod. PM.	L	L	L	

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No.: 3	Section Description: Houses annulars, pods, mini-collet connector, LMRP connector, hydraulic system and various valves
Rev. no.: 1 Date: 01/17/01	Function: LMRP Connect – Hydraulics Function No.: 03	Function Description: Connects LMRP to BOP

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							E	C	R	
F.	Failure to latch on demand	Solenoid valve failure.	Inability to latch from active pod.	Loss of function redundancy.	No flow count. No pressure drop on readback. Indicator rod.	Switch to alternate pod. PM.	L	L	L	
G.		Manual pilot regulator leak.	Fluid loss.	Fluid loss.	Increased pump operation. Excess fluid use. Visual indication with ROV.	No mitigation required – monitor situation.	L	L	L	
H.		Total manual pilot regulator failure (catastrophic leak).	Loss of pilot pressure.	Loss of pod.	Low pilot readback pressure.	Switch to alternate pod. Isolate pod at conduit valve package. Pull LMRP.	L	M	L	*Consider continually monitoring pilot pressure system health during completion, well testing and well control situations.*
I.		Plugged filters.	Pass dirty fluid.	Plugged solenoid valves. Loss of pod.	Function failure.	Switch to alternate pod to secure well. Pull LMRP. PM. Clean fluid practices.	L	M	L	*Ensure that MOC process is in placed and followed. (Change of OEM spares / fluids)*

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No.: 1	Section Description: Houses annulars, pods, mini-collet connector, LMRP connector, hydraulic system and various valves.
Rev. no.: 1 Date: 01/17/01	Function: LMRP Connector – Hydraulics Function No.: 04	Function Description: Connects LMRP to BOP.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							I	C	R	
J.	Failure to latch on demand	Plugged solenoid common vent.	Unable to close annular.	Loss of pod.	No fluid count.	Switch to alternate pod to secure well. Pull LMRP. PM. Clean fluid practices.	L	M	L	
K.		Shear seal valve failure (supply side).	Inability to latch.	Loss of function redundancy.	Unexpected flow count. Unexpected pressure drop on readback. Indicator rod.	Block function. Switch to alternate pod.	L	L	L	
L.		LMRP riser connector regulator leak.	Fluid loss.	Fluid loss. Possible effect to unlatch function. (Potential EDS effect)	Increased pump operation. Excess fluid use. Visual indication with ROV.	Switch pods. If leak effects EDS – pull LMRP. PM.	M	L	L	*Note: Regulator leak tolerance for LMRP connector lower than for annulus.*

FMECA Report Form	System: Deepwater Horizon BOP Section: Lower Section No.: 1	Section Description: Houses annulars, pods, mini-collet connector, LMRP connector, control system and various valves.
Rev. no.: 1 Date: 01/17/01	Function: LMRP Connector – Hydraulics Function No.: 04	Function Description: Connects LMRP to BOP

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
M.	Failure to latch on demand	LMRP riser connector regulator failure (catastrophic leak – stuck wide open).	Loss of supply pressure.	Loss of pod.	Low supply readback pressure. Excessive fluid use. Indicator rod.	Switch to alternate pod. Pull LMRP.	L	M	L	*Consider continually monitoring supply pressure system health during completion, well testing and well control situations. (High level recommendation.)*
N.		POCV stuck closed.	Loss of supply pressure.	Loss of pod.	No supply readback pressure. No fluid use.	Switch to alternate pod. Pull LMRP.	L	M	L	
O.	Failure to maintain proper latch pressure.	Failure of increase / decrease solenoid.	Inability to maintain proper latch pressure.	Possibility to impair unlatch and EDS.	Pressure readbacks.	Switch to alternate pod.	L	L	L	
P.		Loss of regulator pilot pressure.	Inability to maintain adequate pilot pressure.	Loss of ability to latch / unlatch with active pod.	Pressure readbacks.	Switch to alternate pod. Secure well and pull LMRP.	L	M	L	

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No.: 1	Section Description: Houses annulars, pods, mini-collet connector, LMRP connector, dead man's, stem and various valves
Rev. no.: 1 Date: 01/17/01	Function: LMRP Connector - Hydraulics Function No.: 04	Function Description: Connects LMRP to BOP

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
Q.	Failure to maintain proper latch pressure.	Total shuttle valve failure.	Fluid loss. Inability to maintain latch pressure.	Inability to maintain latch pressure.	Fluid count. Pressure readbacks.	Secure well and pull LMRP. PM.	L	M	L	
R.		Failure of 1" Poly-flex hose.	Fluid loss. Inability to maintain latch pressure.	Inability to maintain latch pressure.	Fluid count. Pressure readbacks.	Switch to alternate pod. Possibly secure well and pull LMRP. PM.	M	M	M	*Follow up with TSF w/rt flexible hose testing.*
S.		Failure of receptacle tubing.	Fluid loss. Inability to maintain latch pressure from active pod.	Inability to maintain latch pressure from active pod.	Fluid count. Pressure readback.	Switch to alternate pod. Possibly secure well and pull LMRP. PM.	L	M	L	
T.		Failure of stinger seal.	Fluid loss. Inability to maintain latch pressure from active pod.	Inability to maintain latch pressure from active pod.	Fluid count. Pressure readback.	Switch to alternate pod. Possibly secure well and pull LMRP. PM.	L	M	L	
U.		Shear seal valve failure (pilot side).	Fluid loss. Inability to maintain latch pressure from active pod.	Inability to maintain latch pressure from active pod.	Fluid count. Pilot pressure readback.	Switch to alternate pod. Possibly secure well and pull LMRP. PM.	L	M	L	

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No.: 1	Section Description: Houses annulars, pods, mini-collet connector, LMRP connector, hydraulic system and various valves.
Rev. no.: 1 Date: 01/17/01	Function: LMRP Connector - Hydraulics Function No.: 04	Function Description: Connects LMRP to BOP.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking F	Ranking C	Ranking R	Recommendation
V.	Failure to maintain proper latch pressure.	Solenoid valve failure.	Fluid loss. Inability to maintain latch pressure from active pod.	Inability to maintain latch pressure from active pod.	Flow count.	Switch to alternate pod. Possibly secure well and pull LMRP. PM.	L	M	L	*Cameron to investigate failure associated with solenoid.*
W.		Manual pilot regulator leak.	Fluid loss.	Fluid loss.	Increased pump operation. Excess fluid use. Visual indication with ROV.	No mitigation required – monitor situation.	L	L	L	
X.		Total manual pilot regulator failure (catastrophic leak).	Loss of pilot pressure.	Loss of pod.	Low pilot readback pressure.	Switch to alternate pod. Isolate pod at conduit valve package. Pull LMRP.	L	M	L	*Consider continually monitoring pilot pressure system health during completion, well testing and well control situations.*

EMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No.: 1	Section Description: Houses annulars, pods, mini-collet connector, LMRP connector, deadman system and various valves
Rev. no.: 1 Date: 01/17/01	Function: LMRP Connector – Hydraulics Function No.: 3.04	Function Description: Connects LMRP to BOP

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking: F	C	R	Recommendation
Y.	Failure to maintain proper latch pressure.	Plugged filters.	Pass dirty fluid.	Plugged solenoid valves. Loss of pod.	Function failure.	Switch to alternate pod to secure well. Pull LMRP. PM. Clean fluid practices.	L	M	L	*Ensure that MOC process is in placed and followed. (Change of OEM spares / fluids)*
Z.		Shear seal valve failure (supply side).	Inability to maintain latch pressure.	Inability to maintain latch pressure. **(Affects EDS)**	Unexpected flow count. Unexpected pressure drop on readback.	Switch to alternate pod. Secure well and pull LMRP. PM.	L	M	L	
AA.		LMRP riser connector regulator leak.	Fluid loss.	Fluid loss. Possible effect to unlatch function. **(Potential EDS effect)**	Increased pump operation. Excess fluid use. Visual indication with ROV.	Switch pods. If leak effects EDS – pull LMRP. PM.	M	L	L	*Note: Regulator leak tolerance for LMRP connector lower than for annulus.*

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No.: 1	Section Description: Houses annulars, pods, mini-collet connector, LMRP connector, deadman system and various valves
Rev. no.: 4 Date: 01/17/01	Function: LMRP Connector - Hydraulics Function No.: 04	Function Description: Connects LMRP to BOP

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							P	C	R	
BB.	Failure to maintain proper latch pressure.	LMRP riser connector regulator failure (catastrophic leak – stuck wide open).	Loss of supply pressure.	Loss of pod.	Low supply readback pressure. Excessive fluid use. Indicator rod.	Switch to alternate pod. Pull LMRP.	L	M	L	*Consider continually monitoring supply pressure system health during completion, well testing and well control situations. (High level recommendation.)*
CC.		POCV stuck closed.	Loss of supply pressure.	Loss of pod.	No supply readback pressure. No fluid use.	Switch to alternate pod. Pull LMRP.	L	M	L	
DD.	Failure to unlatch on demand.	Total shuttle valve failure (pod shuttle valve).	Fluid loss. Loss of primary unlatch.	Loss of primary unlatch (both pods).	Failure detected on demand. Indicator rod. Fluid count.	Rely on secondary unlatch, secure well and pull LMRP. PM.	L	M	L	

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No.: 1.4	Section Description: Houses annulars, pods, mini-collet connector, MRP connector, deadman system and various valves.
Rev. no.: 1 Date: 01/17/01	Function: LMRP Connector – Hydraulic Function No.: 04	Function Description: Connects LMRP to BOP.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking F	Ranking C	Ranking R	Recommendation
EE.	Failure to unlatch on demand.	Total shuttle valve failure (pod shuttle valve).	Fluid loss. Loss of primary unlatch.	(Affects EDS – potential catastrophic effect)	Failure evident.		L	V H	H	PM system to place emphasis on this shuttle valve due to the possible consequence of failure.
FF.		Total shuttle valve failure (ROV shuttle valve – operating from pod).	Loss of fluid.	Lose either primary or secondary unlatch. Lose ROV unlatch.	Indicator rod. Fluid count.	Rely on available unlatch circuit or deadaman. Pull LMRP. PM.	L	M	L	
GG.		Total shuttle valve failure (ROV shuttle valve – operating from ROV).	Loss of fluid.	Lose both primary and secondary unlatch before using ROV. Lose ROV unlatch.	Indicator rod. Fluid count.	Rely on deadman and pull LMRP. OR Pull BOP. PM.	L	H	M	PM system to place emphasis on this shuttle valve due to the possible consequence of failure.

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No: 2	Section Description: Houses annulars, pods, mini-collet connector, riser connector, deadman system and various valves.
Rev. no: 1 Date: 01/17/01	Function: LMRP Connector – Hydraulics Function No: 02	Function Description: Connects LMRP to BOP

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							P	C	R	
HH.	Failure to unlatch on demand.	Total shuttle valve failure (ROV shuttle valve – operating from ROV).	Loss of fluid.	(Affects EDS – potential catastrophic effect)	Failure evident.		L	V H	H	PM system to place emphasis on this shuttle valve due to the possible consequence of failure.
II.		Total shuttle valve failure (deadman shuttle valve – operating thru pod).	Loss of fluid.	Loss and ROV and deadman for both pods. Loss of either primary or secondary unlatch from active pod.	Fluid count. Indicator rods.	Rely on available unlatch circuit. Pull LMRP.	L	M	L	
JJ.		Total shuttle valve failure (deadman shuttle valve – operating thru deadman or ROV).	Loss of fluid.	Loss of ability to unlatch.	Failure evident.	Secure well and pull BOP.	L	H	M	As previous.
KK.		Failure of 1" hose (blue or yellow). Add B/Y designation to rest of report.	Fluid loss. Inability to primary unlatch from active pod.	Loss of function redundancy.	Fluid count. Eventual alarm.	Switch to secondary unlatch on active pod. Eventually pull LMRP. PM.	M	M	M	As previous.

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No.: 1.2	Section Description: Houses annulars, pods, quick-collet connector, LMRP connector, hydraulic system and various valves
Rev. no.: 1 Date: 01/17/01	Function: LMRP Connector – Hydraulics Function No.: 04	Function Description: Connects LMRP to BOP

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
LL.	Failure to unlatch on demand.	Failure of receptacle tubing.	Fluid loss. Inability to primary unlatch from active pod.	Loss of function redundancy.	Fluid count. Eventual alarm.	Switch to secondary unlatch on active pod. Eventually pull LMRP. PM.	L	M	L	
MM		Failure of stinger seal.	Fluid loss. Inability to primary unlatch from active pod.	Loss of function redundancy.	Fluid count. Eventual alarm.	Switch to secondary unlatch on active pod. Eventually pull LMRP. PM.	L	M	L	
NN.		Shear seal valve failure (pilot side).	Fluid loss. Inability to primary unlatch from active pod.	Loss of function redundancy.	No flow count. No pressure drop on readback.	Switch to secondary unlatch on active pod. Eventually pull LMRP. PM.	L	M	L	
OO.		Solenoid valve failure.	Fluid loss. Inability to primary unlatch from active pod.	Loss of function redundancy.	No flow count. No pressure drop on readback.	Switch to secondary unlatch on active pod. Eventually pull LMRP. PM.	L	M	L	
PP.		Manual pilot regulator leak.	Fluid loss.	Fluid loss.	Increased pump operation. Excess fluid use. Visual indication with ROV.	No mitigation required – monitor situation.	L	L	L	

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No.:	Section Description: Houses annulars, pods, mini-collet connector, SVR connection, deadman system and various valves.
Rev. no.: 1 Date: 01/17/01	Function: LMRP/Connector - Hydraulics Function No.: 104	Function Description: Connects LMRP to BOP

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking F	Ranking C	Ranking R	Recommendation
QQ.	Failure to unlatch on demand.	Total manual pilot regulator failure (catastrophic leak).	Loss of pilot pressure.	Loss of pod.	Low pilot readback pressure.	Switch to alternate pod. Isolate pod at conduit valve package. Pull LMRP.	L	M	L	Consider continually monitoring pilot pressure system health during completion, well testing and well control situations.
RR.		Plugged filters.	Pass dirty fluid.	Plugged solenoid valves. Loss of pod.	Function failure.	Switch to alternate pod to secure well. Pull LMRP. PM. Clean fluid practices.	L	M	L	Ensure that MOC process is in placed and followed. (Change of OEM spares / fluids)
SS.		Plugged solenoid common vent.	Unable to open annular.	Loss of pod.	No fluid count.	Switch to alternate pod to secure well. Pull LMRP. PM. Clean fluid practices.	L	M	L	

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No.: 1	Section Description: Houses annulars, pods, mini-collet connector, LMRP connector, deadman system and various valves.
Rev. no.: 1 Date: 01/17/01	Function: LMRP Connector – Hydraulics Function No.: 204	Function Description: Connects LMRP to BOP.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
TT.	Failure to unlatch on demand.	Shear seal valve failure (supply side).	Inability to primary unlatch on active pod.	Loss of function redundancy. Loss of secondary unlatch in active pod.	Unexpected flow count. Unexpected pressure drop on readback.	Block functions. Switch to alternate pod. Pull LMRP.	L	M	L	
UU.		LMRP connector regulator leak.	Fluid loss.	Fluid loss.	Increased pump operation. Excess fluid use. Visual indication with ROV.	No mitigation required – monitor situation. PM.	M	L	L	Add note about tolerance – see latch.
VV.		LMRP connector regulator failure (catastrophic leak – stuck wide open).	Loss of supply pressure.	Loss of pod.	Low supply readback pressure. Excessive fluid use	Switch to alternate pod. Pull LMRP.	L	M	L	Consider continually monitoring supply pressure system health during completion, well testing and well control situations. (High level recommendation.)

FMECA Report Form	System: Deepwater Horizon BOP Section: EMRP Section No.: 4	Section Description: Houses annulars, pods, mini-collet connector, LMRP connector, lead-in system and various valves.
Rev. no.: 1 Date: 01/17/01	Function: LMRP Connector Hydraulics Function No.: 04	Function Description: Connects LMRP to BOP.

#	Failure Mode	Causes	Local Failure Effect	System Effects	Method of Detection	Mitigation	Ranking			Recommendation
							E	C	R	
W	Failure to unlatch on demand.	POCV stuck closed.	Loss of supply pressure.	Loss of pod.	No supply readback pressure. No fluid use	Switch to alternate pod. Pull LMRP.	L	M	L	
XX.	Failure to seal on demand.	See Closed – No New Issues.								

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No.: 01	Section Description: Houses annulars, pods, mini-collet connector, LMRP connector, deadmans, stem and various valves.
Rev. no.: 1 Date: 01/17/01	Function: SEM Function No.: 05	Function Description: Control electrical signals to hydraulic signals.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
A.	Failure to fire solenoid	Water ingress to solenoid valve electronics (including cable and Pie connector).	Inability to fire valve.	Loss of single function from one pod.	Alarm at panel.	(see individual solenoid function worksheets for mitigations and rankings)				
B.		Complete SEM failure.	Loss of pod.	Loss of pod redundancy.	Alarms.	Switch to alternate pod. Secure well and pull LMRP.	L	M	L	
C.		Loss of SEMA or SEMB.	Loss of redundancy in active pod.	Loss of redundancy in single pod.	Alarm.	Automatic switch to alternate SEM(A or B). Monitor situation.	L	L	L	
D.		Loss of pod PBOF cable and connectors.	Loss SEM (pod).	Loss of pod.	Alarms.	Rely on alternate pod. Secure well and pull LMRP. PM (visual inspection).	M	M	M	*Ensure proper connection of PBOF cables as per procedures.*

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No.: 01	Section Description: Houses annulars, pods, mini-collet connector, LMRP connector, deadman system and various valves.
Rev. no.: 1 Date: 01/17/01	Function: SEM Function No.: 05	Function Description: Convert electrical signals to hydraulic signals.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							E	C	R	
E.	Failure to fire solenoid	Loss of Wet Mate connector.	Ground.	Loss of pod.	Alarms.	Rely on alternate pod. Secure well and pull LMRP. PM (visual inspection).	M	M	M	*Ensure proper connection of wet mat connectors as per procedures.*
F.		J-box failure.	Ground.	Loss of pod.	Alarms.	Rely on alternate pod. Secure well and pull LMRP. PM (visual inspection).	L	M	L	
G.		Loss of FITA (Field Installable Termination Assembly).	Ground.	Loss of pod.	Alarms.	Rely on alternate pod. Secure well and pull LMRP. PM (visual inspection).	L	M	L	
H.		Loss of Riser Control Box (RCB).	Unable to evaluate with information on hand.							*Waiting on evaluation from Cameron.*

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No: 1	Section Description: Houses annulars, pods, mini-collet connector, LMRP connector, dead man system and various valves
Rev. no.: 1 Date: 01/17/01	Function: Conduit Valve Package Function No.: 06	Function Description: Hydraulic supply to pods

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking F	Ranking C	Ranking R	Recommendation
A.	Loss of Yellow / Blue pod conduit supply	Loss of conduit.	Loss of supply.	Loss of conduit supply to both pods.	No/low flow on meter. No/low pressure on meter.	Secure well and pull LMRP. PM.	L	M	L	
B.		POCV failure.	Loss of supply to single pod.	Loss pod.	Sluggish response or no supply.	Secure well and pull LMRP. Emergency use via hot line. PM.	L	M	L	
C.		POCV pilot shuttle valve failure.	Loss of supply to single pod.	Loss pod.	Sluggish response or no supply.	Secure well and pull LMRP. Emergency use via hot line. PM.	L	M	L	
D.		Conduit flush valve fails open.	Loss of supply.	Loss of conduit supply to both pods.	No/low flow on meter. No/low pressure on meter.	Jump ROV and continue operations. PM.	L	L	L	
E.	Loss of Yellow / Blue hot line supply	Loss before or during running.	Loss of pressure.	System reliant on trapped pressure in 10 gal. accumulator.	Excessive flow at surface.	Case-by-case depending on stage of operation. Possibility of pulling LMRP.	L	M	L	*BOP will be brought to the surface with the LMRP.*

FMECA Report Form	System: Deepwater Horizon BOP Section: LMRP Section No.: 1	Section Description: Houses annulars, pods, mini-collet connector, LMRP connector, dead man system, and choke valves.
Rev. no.: 1 Date: 01/17/01	Function: Conduit Valve Package Function No.: 06	Function Description: Hydraulic Supply to pods.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking F	Ranking C	Ranking R	Recommendation
F.	Loss of Yellow / Blue hot line supply	Loss after latching.	Loss of hot line pressure.	Loss of backup pressure.	Difficult to detect (if hot line not active) or excessive flow (if hot line active).	Note situation and continue operation.	L	L	L	
G.	Loss of Rigid conduit flush	POCV or pilot failure.	Unable to directly flush rigid conduit.	Possibility to plug filters.	No conduit flush action.	Flush through pods and continue.	L	L	L	
H.	Loss of Conduit readback	Failure of unbalanced shuttle valve or associated hose.	Loss of conduit readback.	1 of 3 conditions satisfied for deadman.	Difficult to detect. Possibly noticed on event logger (low readback).	Secure well and pull LMRP.	L	M	L	

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: 1	Section Description: Housesrams, shears, accumulators, wellhead connector, stack, riser etc
Rev. no.: 1 Date: 01/17/01	Function: Blind Shear Ram – Open / Close Shear Function No.: 04	Function Description: Shear and secure well

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking F	Ranking C	Ranking R	Recommendation
A.	Failure to close	Blown seal.	Possible incomplete closing.	Loss of blind shear ram.	Excessive fluid count. No weight loss on indicator.	Secure well and pull BOP. PM.	L	H	M	
B.		Mechanical damage to internal components.	Possible incomplete closing.	Loss of blind shear ram.	Unexpected fluid count. No weight loss on indicator.	Secure well and pull BOP. PM.	L	H	M	
C.		Corrosion.	Possible incomplete closing.	Loss of blind shear ram.	Unexpected fluid count. No weight loss on indicator.	Secure well and pull BOP. PM.	L	H	M	
D.		Debris.	Possible incomplete closing.	Loss of blind shear ram.	Unexpected fluid count. No weight loss on indicator.	Clear obstruction and continue operation.	L	L	L	
E.	Failure to shear on demand	Damaged blades.	Inability to cut.	Inability to cut.	Unexpected fluid count. No weight loss on indicator.	Secure well and pull BOP. PM.	L	H	M	

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: 4b	Section Description: Hous[illegible] rams, shears, accumulators, wellhead connector, [illegible]
Rev. no.: 1 Date: 01/17/01	Function: Blind Shear Ram - Open / Close Shear Function No.: 01	Function Description: Shear and seal the well

#	Failure Mode	Causes	Local Failure Effect	System Effects	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
F.	Failure to shear on demand	Defective blades.	Inability to cut.	Inability to cut.	Unexpected fluid count. No weight loss on indicator.	Secure well and pull BOP. PM.	L	H	M	
G.		Attempting to shear inappropriate material.	Inability to cut.	Inability to cut.	Unexpected fluid count. No weight loss on indicator.	Reposition string and re-attempt cut. Pressure test. Pre-testing cut.	L	H	M	*Ensure correct space out. Ensure pre-testing has been completed.*
H.	Failure to seal on demand	Damaged or defective ram block.	Inability to seal wellbore.	Inability to seal wellbore.	Wellbore flow or failed pressure test.	Secure well and pull BOP. PM.	L	H	M	*Verify NDE frequency.*
I.		Damaged packers.	Inability to seal wellbore.	Inability to seal wellbore.	Wellbore flow or failed pressure test.	Secure well and pull BOP. PM.	L	H	M	*Ensure clean wellbore. Follow policy of not tagging shear rams.*
J.		Inadequate fold over and closure of fish.	Inability to seal wellbore.	Inability to seal wellbore.	Wellbore flow or failed pressure test.	Secure well and pull BOP.	L	H	M	

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: 01	Section Description: Houses rams, shears, accumulators, wellhead connector, kick valves, etc.
Rev. no.: 1 Date: 01/17/01	Function: Blind Shear Ram - Open / Close / Shear Function No.: 01	Function Description: Shear and secure well

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
K.	Failure to open on demand.	Blown seal.	Possible incomplete or slow opening.	Possibly obstructed wellbore.	Unexpected fluid count.	Cycle until fully open. Then secure well and pull BOP. PM.	L	H	M	
L.		Mechanical damage to internal components.	Possible incomplete or slow opening.	Possibly obstructed wellbore.	Unexpected fluid count.	Secure well and pull BOP. PM.	L	H	M	
M.		Corrosion.	Possible incomplete or slow opening.	Possibly obstructed wellbore.	Unexpected fluid count.	Secure well and pull BOP. PM.	L	H	M	
N.		Debris.	Possible incomplete or slow opening.	Possibly obstructed wellbore.	Unexpected fluid count.	Attempt to clear. Secure well and pull BOP. Well maintenance.	L	H	M	

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No: 01	Section Description: Houses rams, shears, accumulators, wellhead connector, kick valves, etc.
Rev. no.: 1 Date: 01/17/01	Function: Blind Shear Ram – Open / Close / Shear Function No: 04	Function Description: Shear and secure well

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking F	Ranking C	Ranking R	Recommendation
O.	Failure to open on demand.	Generalized ST lock failure.	Failure to open.	Obstructed wellbore.	No fluid count.	Secure well and pull BOP. PM.	M	H	H	*Upgrades made by Cameron – ongoing monitoring.* *Include predictive testing procedure in PM.* *Cameron to submit written documentation confirming component numbers for all ST locks.*

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: 1	Section Description: Houses rams, shears, accumulators, wellhead connector, stack, riser.
Rev. no.: 1 Date: 01/17/01	Function: Blind Shear Ram – Hydraulics Function No.: 02	Function Description: Shear and secure well

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking F	Ranking C	Ranking R	Recommendation
A.	Failure to close on demand **(HP Panel)**	Failure of sequence valve.	Premature locking attempts.	Closing with tail rod damage.	Difficult to detect.	Secure well and pull BOP. PM.	L	H	M	
B.		Total shuttle valve failure (ram shuttle valve).	Fluid loss. Inability to close ram.	Loss of ram.	Fluid count.	Secure well and pull BOP. PM.	L	H	M	
C.		Total shuttle valve failure (pod shuttle valve).	Fluid loss. Inability to close ram (low pressure) from both pods.	Inability to close ram (low pressure) from both pods.	Fluid count.	Block function. Rely on high pressure or ROV shear.	L	L	L	*Ensure procedures are updated in this situation.*
D.		Total shuttle valve failure (ROV/HP shuttle valve.).	Fluid loss.	Significant loss of ability to shear. Lose ad ability to close with ROV. Loss of EDS.	Fluid count. Visual indication with ROV.	Increase low pressure. Secure well and pull BOP. PM.	L	H	M	
E.		Failure of 1" hose from shuttle valve to panel.	Fluid loss.	Significant loss of ability to shear. Loss of EDS.	Fluid count. Visual indication with ROV.	Increase low pressure. Secure well and pull BOP. PM.	M	H	H	*See previous. (TSF hose study)*

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: 11	Section Description: Houses rams, shears, accumulators, wellhead connector, stack valves etc.
Rev. no.: 1 Date: 01/17/01	Function: Fluid Shear Ram – Hydraulics Function No.: 02	Function Description: Shear and secure well.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							P	C	R	
F.	Failure to close on demand **(HP Panel)**	Failure of tubing in HP panel.	Fluid loss.	Significant loss of ability to shear. Loss of EDS.	Fluid count. Visual indication with ROV.	Increase low pressure. Secure well and pull BOP. PM.	L	H	M	
G.		Shear seal valve failure (pilot side).	Inability to close HP shear.	Significant loss of ability to shear. Loss of EDS.	No flow count. No pressure drop on readback.	Increase low pressure. Secure well and pull BOP. PM.	L	H	M	
H.		Pilot shuttle valve failure.	Inability to close HP shear.	Significant loss of ability to shear. Loss of EDS.	No flow count. No pressure drop on readback.	Increase low pressure. Secure well and pull BOP. PM.	L	H	M	
I.		Pod pilot shuttle valve.	Inability to close HP shear.	Significant loss of ability to shear. Loss of EDS.	No flow count. No pressure drop on readback.	Increase low pressure. Secure well and pull BOP. PM.	L	H	M	
J.		Failure of receptacle tubing and stinger seal.	Fluid loss. Inability to close HP shear from active pod.	Loss of function redundancy.	Fluid count. Eventual alarm.	Switch to alternate pod. Secure well and pull BOP. PM.	L	H	M	
K.		Shear seal valve (in pod) failure (pilot side).	Fluid loss. Inability to close HP shear from active pod.	Loss of function redundancy.	No flow count. No pressure drop on readback.	Switch to alternate pod. Secure well and pull LMRP. PM.	L	M	L	

EMECA Report Form	System: Deepwater Horizon BOP Section: LOP Section No.: II	Section Description: Houses rams, shears, accumulators, wellhead connector, stack valves, etc.
Rev. no.: 1 Date: 01/17/01	Function: Blind Shear Ram Hydraulics Function No.: 02	Function Description: Shear and secure well

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							E	C	R	
L.	Failure to close on demand **(Pod)**	Solenoid valve (in pod) failure.	Fluid loss. Inability to close HP shear from active pod.	Loss of function redundancy.	No flow count. No pressure drop on readback.	Switch to alternate pod. Secure well and pull LMRP. PM.	L	M	L	
M.		Manual pilot regulator leak.	Fluid loss.	Fluid loss.	Increased pump operation. Excess fluid use. Visual indication with ROV.	No mitigation required – monitor situation.	L	L	L	
N.		Total manual pilot regulator failure (catastrophic leak).	Loss of pilot pressure.	Loss of pod.	Low pilot readback pressure.	Switch to alternate pod. Isolate pod at conduit valve package. Pull LMRP.	L	M	L	*Consider continually monitoring pilot pressure system health during completion, well testing and well control situations.*

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: II	Section Description: Houses rams, shears, accumulators, wellhead connector, stack, valves etc.
Rev. no.: 1 Date: 01/17/01	Function: Blind Shear Ram - Hydraulics Function No.: 02	Function Description: Shear and secure well

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking F	Ranking C	Ranking R	Recommendation
O.	Failure to close on demand **(Pod)**									
P.		Plugged filters.	Pass dirty fluid.	Plugged solenoid valves. Loss of pod.	Function failure.	Switch to alternate pod to secure well. Pull LMRP. PM. Clean fluid practices.	L	M	L	*Ensure that MOC process is in placed and followed. (Change of OEM spares / fluids)*
Q.		Plugged solenoid common vent.	Unable to close ram.	Loss of pod.	No fluid count.	Switch to alternate pod to secure well. Pull LMRP. PM. Clean fluid practices.	L	M	L	
R.		Shear seal valve (in pod) failure (supply side).	Reduced ability to HP shear with active pod.	Loss of function redundancy.	Minimal unexpected flow count. Unexpected pressure drop on readback.	Secure well and pull LMRP. PM.	L	M	L	

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No: 30	Section Description: Houses rams, shears, accumulators, wellhead connector, stack valves etc.
Rev. no.: 1 Date: 01/17/01	Function: Blind Shear Ram – Hydraulic Function No.: 02	Function Description: Shear and secure well

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking F	Ranking C	Ranking R	Recommendation
S.	Failure to close on demand **(Pod)**	Manual pilot regulator – no new issues.								
T.		HP shear seal valve failure (supply)	Inability to close HP shear.	Significant loss of ability to shear. Loss of EDS.	Unexpected flow count.	Increase low pressure. Secure well and pull BOP. PM.	L	H	M	
U.		HP shear regulator leak.	Fluid loss.	Fluid loss.	Increased pump operation. Excess fluid use. Visual indication with ROV.	No mitigation required – monitor situation. PM.	M	L	L	

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: II	Section Description: Houses rams, shears, accumulators, wellhead connector, choke valves, etc.
Rev. no.: 1 Date: 01/17/01	Function: Blind Shear Ram – Hydraulics Function No.: 02	Function Description: Shear and seal the well

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
V.	Failure to close on demand **(Pod)**	HP shear regulator failure (catastrophic leak – stuck wide open).	Loss of supply pressure for HP shear.	Loss of HP shear. Loss of EDS, autoshear, deadman. Loss HP casing shear.	Excessive fluid use.	Increase low pressure. Secure well and pull BOP. PM.	L	H	M	*Consider continually monitoring supply pressure system health during completion, well testing and well control situations. (High level recommendation.)*
W.		Dump valve failure.	Loss of supply pressure for HP shear.	Loss of HP shear. Loss of EDS, autoshear, deadman. Loss HP casing shear.	Excessive fluid use.	Increase low pressure. Secure well and pull BOP. PM.	L	H	M	

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: II	Section Description: Houses rams, shears, accumulators, wellhead connector, stack valves, etc.
Rev. no.: 1 Date: 01/17/01	Function: Blind Shear Ram – Hydraulics Function No.: 02	Function Description: Shear and secure well

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking F	Ranking C	Ranking R	Recommendation
X.	Failure to close on demand **(Pod)**	Relief valve failure.	Loss of supply pressure for HP shear.	Loss of HP shear. Loss of EDS, autoshear, deadman. Loss HP casing shear.	Excessive fluid use.	Close ROV valve. PM.	L	L	L	
Y.		Accumulator leak.	Loss of supply pressure for HP shear.	Loss of HP shear. Loss of EDS, autoshear, deadman. Loss HP casing shear.	Excessive fluid use.	Increase low pressure. Secure well and pull BOP. PM.	L	H	M	
Z.		Total stacked accumulator charge shuttle valve (#82) failure.	Loss of ability to recharge accumulators.	Loss of ability to shear (any method) more than once.	Fluid count. Eventual alarm.	Block function. Secure well and pull BOP. PM.	L	H	M	
AA.		Autoshear inoperable.	Loss of autoshear system.	Inability to shear in an unplanned disconnect.	Flow count.	Secure well and pull BOP. PM.	M	H	H	*Review frequency rating after test of autoshear.*
BB.	Failure to lock on demand.	Failure of sequence valve tubing / hose.	Fluid loss.	Failure to lock. (Successfully close)	Fluid count. Visual indication with ROV.	Maintain closing pressure on rams, secure well and pull BOP. PM.	L	H	M	

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: 1	Section Description: Houses rams, shears, accumulators, wellhead connector, stack valves etc.
Rev. no.: 1 Date: 01/17/01	Function: Blind Shear Ram – Hydraulics Function No.: 02	Function Description: Shear and secure well.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
CC.	Failure to lock on demand.	Same Issues as failure to close on demand								
DD.	Failure to open on demand	Failure of sequence cap (and tubing).	Fail to open rams or mechanical damage to rods and ST locks.	Fail to open rams or mechanical damage to rods and ST locks.	Flow count.	Secure well and pull BOP. PM.	L	H	M	
EE.		Shuttle valve failure.	Fluid loss. Inability to open rams.	Inability to open rams.	Flow count.	Secure well and pull BOP. PM.	L	H	M	
FF.		Failure of 1" hose.	Fluid loss. Possible inability to fully open ram from active pod.	Loss of function redundancy.	Fluid count. Eventual alarm.	Switch to alternate pod. Secure well and pull BOP. PM.	M	H	H	*Follow up with TSF w/rt flexible hose testing.*
GG.		Failure of receptacle tubing or stinger seal.	Fluid loss. Possible inability to fully open ram from active pod.	Loss of function redundancy.	Fluid count. Eventual alarm.	Switch to alternate pod. Secure well and pull BOP. PM.	L	H	M	
HH.										
II.		Shear seal valve failure (pilot side).	Inability to open ram from active pod.	Loss of function redundancy.	No flow count. No pressure drop on readback.	Switch to alternate pod. Secure well and pull LMRP. PM.	L	M	L	

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: 1	Section Description: Houses rams, shears, accumulators, wellhead connector, stack valves etc.)
Rev. no.: 1 Date: 01/17/01	Function: Blind Shear Ram – Hydraulics Function No.: 02	Function Description: Shear and secure well

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
JJ.	Failure to open on demand	Solenoid valve failure.	Inability to open ram.	Loss of function redundancy.	No flow count. No pressure drop on readback.	Switch to alternate pod. Secure well and pull LMRP. PM.	L	M	L	
KK.		Manual pilot regulator leak.	Fluid loss.	Fluid loss.	Increased pump operation. Excess fluid use. Visual indication with ROV.	No mitigation required – monitor situation.	L	L	L	
LL.		Total manual pilot regulator failure (catastrophic leak).	Loss of pilot pressure.	Loss of pod.	Low pilot readback pressure.	Switch to alternate pod. Isolate pod at conduit valve package. Pull LMRP.	L	M	L	*Consider continually monitoring pilot pressure system health during completion, well testing and well control situations.*

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: 1	Section Description: Houses rams, shears, accumulators, wellhead connector, check valves etc.
Rev. no.: 1 Date: 01/17/01	Function: Blind Shear Ram – Hydraulics Function No.: 02	Function Description: Shear and secure well

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							E	C	R	
MM	Failure to open on demand	Plugged filters.	Pass dirty fluid.	Plugged solenoid valves. Loss of pod.	Function failure.	Switch to alternate pod to secure well. Pull LMRP. PM. Clean fluid practices.	L	M	L	*Ensure that MOC process is in placed and followed. (Change of OEM spares / fluids)*
NN.		Plugged solenoid common vent.	Unable to open ram.	Loss of pod.	No fluid count.	Switch to alternate pod to secure well. Pull LMRP. PM. Clean fluid practices.	L	M	L	
OO.		Shear seal valve failure (supply side).	Inability to open ram.	Loss of function redundancy.	Unexpected flow count. Unexpected pressure drop on readback.	Block function. Switch to alternate pod. Secure well pull LMRP. PM	L	M	L	
PP.		Pod manifold regulator leak.	Fluid loss.	Fluid loss.	Increased pump operation. Excess fluid use. Visual indication with ROV.	No mitigation required – monitor situation. PM.	M	L	L	

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: [illegible]	Section Description: Houses rams, shears, accumulators, wellhead connector, stack valves, etc.
Rev. no.: 1 Date: 01/17/01	Function: Blind Shear Ram Hydraulics Function No.: 02	Function Description: Shear and secure well.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking F	Ranking C	Ranking R	Recommendation
QQ.	Failure to open on demand	Pod manifold regulator failure (catastrophic leak – stuck wide open).	Loss of supply pressure.	Loss of pod.	Low supply readback pressure. Excessive fluid use.	Switch to alternate pod. Pull LMRP.	L	M	L	*Consider continually monitoring supply pressure system health during completion, well testing and well control situations. (High level recommendation.)*
RR.		POCV stuck closed.	Loss of supply pressure.	Loss of pod.	No supply readback pressure. No fluid use.	Switch to alternate pod. Pull LMRP.	L	M	L	
SS.	Failure to seal / shear on demand.	See 'Failure to Close on Demand' – No New Issues.								

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: III	Section Description: Houses rams, shears, accumulators, wellhead connector, stack valves etc.
Rev. no.: 1 Date: 01/17/01	Function: Close/Open Kill Valve Function No.: 03	Function Description: Typical kill or choke valve with fail safe close

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							I	C	R	
A.	Failure to open on demand.	Blown seal.	Inability to open valve.	Loss of outlet.	Unable to circulate. Fluid count. Visual indication by ROV.	Rely on alternate outlet. PM.	L	L	L	
B.		Mechanical damage to internal components.	Inability to open valve.	Loss of outlet.	Unable to circulate. Fluid count. Visual indication by ROV.	Rely on alternate outlet. PM.	L	L	L	
C.		Corrosion.	Inability to open valve.	Loss of outlet.	Unable to circulate. Fluid count. Visual indication by ROV.	Rely on alternate outlet. PM.	L	L	L	
D.		Debris in bore.	Inability to open valve.	Loss of outlet.	Unable to circulate. Fluid count. Visual indication by ROV.	Rely on alternate outlet.	L	L	L	
E.	Failure to close on demand.	Mechanical damage to internal components.	Inability to close valve.	Loss of redundancy at outlet.	Fluid count.	Note situation and switch to alternate outlet.	L	L	L	

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: II	Section Description: Houses rams, shears, accumulators, wellhead connector, stack, valves, etc.
Rev. no.: 1 Date: 01/17/01	Function: Upper annular kill valve – Open / Close Function No.: 03	Function Description: Typical kill or choke valve with fail-safe close.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
F.	Failure to close on demand.	Corrosion.	Inability to close valve.	Loss of redundancy at outlet.	Fluid count.	Note situation and switch to alternate outlet.	L	L	L	
G.		Debris or physical obstruction.	Inability to close both valves.	Loss of outlet.	Fluid count.	Switch to alternate outlet. Possible pull of BOP.	L	H	M	*Consequences depend on which outlet affected – refer to failure scenarios*

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: II	Section Description: Houses rams, shears, accumulators, wellhead connector, kill valves, etc.
Rev. no.: 1 Date: 01/17/01	Function: Upper middle kill valve – Hydraulic Function No.: 02-B	Function Description: Typical kill or choke valve with fail-safe close

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking F	Ranking C	Ranking R	Recommendation
A.	Failure to close on demand (with wellbore pressure)	Failure of failsafe shuttle valve.	Loss of hydraulic assist close.	Inability to hydraulically close valve.	Unexpected flow.	Rely on alternate valve. PM.	L	L	L	
B.		Failure of pod shuttle valve.	Loss of hydraulic assist close from pod.	Loss of some redundancy.	Unexpected flow.	Block function and rely on alternate valve. PM	L	L	L	
C.		No further new issues								
D.	Failure to failsafe close	Loss of return spring on shear seal valve	Loss of hydraulic assist close from failsafe kit.	Loss of hydraulic assist close from failsafe kit.	Difficult to detect.	Note situation and continue operation. PM.	L	L	L	
E.		Failure of manual set regulator.	Loss of failsafe panel and inner / outer wing valves.	Loss of fluid. Loss of failsafe panel.	Fluid count.	Secure well and pull BOP. PM.	L	H	M	
F.		Failure of relief valve.	Loss of failsafe panel and inner / outer wing valves.	Loss of fluid. Loss of failsafe panel.	Fluid count.	Close valve with ROV intervention and continue. PM.	M	L	L	

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No: 5	Section Description: Houses rams, shears, accumulators, wellhead connector, stack, valves etc.
Rev. no.: 1 Date: 01/17/01	Function: Operation of kill valve – Hydraulics Function No.: 03.E	Function Description: Typical kill or choke valve with fail-safe close kit.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
G.	Failure to failsafe close	Failure of dump valve.	Loss of failsafe panel and inner / outer wing valves.	Loss of fluid. Loss of failsafe panel.	Fluid count.	Secure well and pull BOP. PM.	L	H	M	
H.		Loss of accumulator charge. (on bleed valve only)	Potential loss of supply to failsafe close valve.	Loss of failsafe panel.	Difficult to detect.	Rely on spring, alternate valve, pod.	L	L	L	
I.	Failure to open on demand	Failure of shuttle valve.	Loss of ability to open.	Loss of ability to open. Loss of outlet.	Unexpected flow.	Rely on alternate outlet. PM.	L	L	L	*Consequence varies depending on outlet – see chart.*
J.		Failure of pilot on shear seal valve.	Unable to shift valve.	Reduced ability to open. Lose outlet.	Unexpected flow.	Switch to alternate outlet.	L	L	L	*Consequence varies depending on outlet – see chart.*
K.		Hose failure.	Unable to shift valve.	Lose ability to open. Lose outlet.	Unexpected flow.	Switch to alternate outlet.	L	L	L	*Consequence varies depending on outlet – see chart.*

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No: 01	Section Description: Houses rams, shears, accumulators, wellhead connector, stack valves etc.
Rev. no: 1 Date: 01/17/01	Function: To Open/Close/Latch/Unlatch Function No: 09	Function Description: Connects BOP to Wellhead

#	Failure Mode	Causes	Local Failure Effect	System Effect	Methods of Detection	Mitigation	Ranking: F	C	R	Recommendation
A.	Failure to latch on demand.	Seal failure.	Failure to latch.	Unable to connect to wellhead.	Indicator rod. Unexpected flow.	Pull BOP. PM.	L	H	M	
B.		Mechanical damage to internal components.	Failure to latch.	Unable to connect to wellhead.	Indicator rod. Unexpected flow.	Pull BOP. PM.	L	H	M	
C.		Debris.	Failure to latch.	Unable to connect to wellhead.	Indicator rod. Unexpected flow.	Pull BOP. PM.	L	H	M	
D.		Damage to hub on wellhead.	Failure to latch.	Unable to connect to wellhead.	Indicator rod. Unexpected flow. Visual inspection with ROV.	Pull BOP.	L	H	M	*Ensure that operating parameters are adequate to prevent damage from BOP strike or incidental contact.*
E.		Corrosion.	Failure to latch.	Unable to connect to wellhead.	Indicator rod. Unexpected flow.	Pull BOP. PM.	L	H	M	

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: 11	Section Description: Houses rams, shears, accumulators, wellhead connector, stack valves etc.
Rev. no.: 1 Date: 01/17/01	Function: Wellhead Connector - Latch - Unlatch Function No.: 02	Function Description: Connects BOP to Wellhead

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking F	Ranking C	Ranking R	Recommendation
F.	Failure to seal on demand.	Improper or damaged gasket.	Failure to seal.	Failure to seal.	Failed pressure test.	Replace gasket and retest.	L	L	L	
G.		Damaged seal surface (Connector).	Failure to seal.	Failure to seal.	Failed pressure test.	Pull BOP. PM.	L	H	M	
H.		Damaged seal surface (Wellhead).	Failure to seal.	Failure to seal.	Failed pressure test. Possible visual indication with ROV.	Pull BOP. Visual inspection of wellhead.	L	H	M	*Ensure proper installation of gasket before attempt to latch.*
I.	Failure to maintain latch pressure.	Seal Failure.	Loss of latch pressure.	Loss of hydraulic operating fluid. Potential for loss of wellbore fluids.	Unexpected flow at flow meter. Excessive use of hydraulic fluid. Visual indication with ROV.	Secure well and pull BOP. PM.	L	H	M	
J.	Failure to unlatch on demand.	Overpressure on latch.	Inability to unlatch.	Inability to unlatch.	No or minimal flow. Failure evident.	Pull BOP. Employ ROV to overpressure. Proper training and procedures.	L	H	M	*Ensure procedures are followed.*

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: 1	Section Description: Houses rams, shears, accumulators, wellhead connector, stack, valves, etc.
Rev. nos.: 1 Date: 01/17/01	Function: Wellhead Connector – Latch / Unlatch Function No.: 04	Function Description: Connects BOP to wellhead.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
K.	Failure to unlatch on demand.	Hydrate or other debris.	Inability to unlatch.	Inability to unlatch.	No or minimal flow. Failure evident.	Use of methanol and warm fluids. Pull BOP.	M	H	H	*Follow up on wellhead connector upgrades.*
L.		Damaged indicator rods.	Inability to unlatch.	Inability to unlatch.	Minimal flow. Failure evident. Second indicator flag would not travel full stroke.	Pull BOP.	L	H	M	*Investigate failure mode with Cameron (Jacqueline Hsu).*
M.		Mechanical damage to internal components.	Inability to unlatch.	Inability to unlatch.	Minimal flow. Failure evident. Second indicator flag would not travel full stroke.	Pull BOP. PM.	L	H	M	
N.		Corrosion.	Inability to unlatch.	Inability to unlatch.	Minimal flow. Failure evident. Second indicator flag would not travel full stroke.	Pull BOP. PM.	L	H	M	

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: II	Section Description: Houses rams, shears, accumulators, wellhead connector, stack, valves etc.
Rev. no.: 1 Date: 01/17/01	Function: Wellhead Connector - Hydraulics Function No.: 05	Function Description: Connects BOP to Wellhead

#	Failure Mode	Causes	Local Failure Effects	System Effects	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
A.	Failure to latch on demand	Failure of POCV (external leak).	Fluid loss. Possible inability to latch.	Possible inability to latch.	Fluid count. Indicator rod. Visual indication with ROV.	Pull BOP. PM.	L	H	M	
B.		Total shuttle valve failure.	Fluid loss. Inability to latch.	Inability to latch.	Fluid count. Indicator rod.	Pull BOP. PM.	L	H	M	
C.		Failure of 1" Poly-flex hose.	Fluid loss. Inability to latch from active pod.	Inability to latch from active pod.	Fluid count. Indicator rod.	Pull BOP. PM.	M	H	H	
D.		Failure of receptacle tubing.	Fluid loss. Inability to latch from active pod.	Inability to latch from active pod.	Fluid count. Indicator rod.	Pull BOP. PM.	L	H	M	*Ensure that PM and operating procedures address shuttle valve mounting and maintenance.*
E.		Failure of stinger seal.	Fluid loss. Inability to latch from active pod.	Inability to latch from active pod.	Fluid count. Indicator rod.	Pull BOP. PM.	L	H	M	
F.		Shear seal valve failure (pilot side).	Inability to latch from active pod.	Loss of function redundancy.	No flow count. No pressure drop on readback. Indicator rod.	Pull BOP. PM.	L	H	M	

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: 1	Section Description: Houses rams, shears, accumulators, wellhead connector, stack, risers
Rev. no.: 1 Date: 01/17/01	Function: Wellhead Connector – Hydraulics Function No.: 05	Function Description: Connects BOP to wellhead

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
G.	Failure to latch on demand	Solenoid valve failure.	Inability to latch from active pod.	Loss of function redundancy.	No flow count. No pressure drop on readback. Indicator rod.	Pull BOP. PM.	L	H	M	
H.		Manual pilot regulator leak.	Fluid loss.	Fluid loss.	Increased pump operation. Excess fluid use. Visual indication with ROV.	No mitigation required – monitor situation.	L	L	L	
I.		Total manual pilot regulator failure (catastrophic leak).	Loss of pilot pressure.	Loss of pod.	Low pilot readback pressure.	Pull BOP. PM.	L	M	L	*Consider continually monitoring pilot pressure system health during completion, well testing and well control situations.*
J.		Plugged filters.	Pass dirty fluid.	Plugged solenoid valves. Loss of pod.	Function failure.	Pull BOP. PM. Clean fluid practices.	L	M	L	*Ensure that MOC process is in placed and followed. (Change of OEM spares / fluids)*

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: 1	Section Description: Houses rams, shears, accumulators, wellhead connector, kill & choke valves, etc.
Rev. no.: 1 Date: 01/17/01	Function: Wellhead Connector (Vetco H-4) Function No.: 1.0	Function Description: Connects BOP to Wellhead

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
K.	Failure to latch on demand	Plugged solenoid common vent.	Unable to latch.	Loss of pod.	No fluid count.	Pull BOP. PM. Clean fluid practices.	L	M	L	
L.		Shear seal valve failure (supply side).	Inability to latch.	Loss of function redundancy.	Unexpected flow count. Unexpected pressure drop on readback. Indicator rod.	Pull BOP. PM.	L	M	L	
M.		Wellhead connector regulator leak.	Fluid loss.	Fluid loss. Possible effect to unlatch function.	Increased pump operation. Excess fluid use. Visual indication with ROV.	Switch pods. PM.	M	L	L	*Note: Regulator leak tolerance for wellhead connector lower than for annulus.*

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No: [illegible]	Section Description: Houses rams, shears, accumulators, wellhead connector, stack valves etc.
Rev. no: 1 Date: 01/17/01	Function: Wellhead Connector Hydraulics Function No: 05	Function Description: Connects BOP to Wellhead.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
N.	Failure to latch on demand	Wellhead connector regulator failure (catastrophic leak – stuck wide open).	Loss of supply pressure.	Loss of pod.	Low supply readback pressure. Excessive fluid use. Indicator rod.	Pull BOP. PM.	L	M	L	*Consider continually monitoring supply pressure system health during completion, well testing and well control situations. (High level recommendation.)*
O.		POCV stuck closed.	Loss of supply pressure.	Loss of pod.	No supply readback pressure. No fluid use.	Pull BOP. PM.	L	M	L	
P.	Failure to maintain proper latch pressure.	Failure of increase / decrease solenoid.	Inability to maintain proper latch pressure.	Possibility to impair unlatch.	Pressure readbacks.	Switch to alternate pod.	L	L	L	
Q.		Loss of wellhead connector regulator pilot pressure.	Inability to maintain adequate pilot pressure.	Loss of ability to latch / primary unlatch with active pod.	Pressure readbacks.	Switch to alternate pod.	L	L	L	

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: II	Section Description: Houses rams, shears, accumulators, wellhead connector, stack, valves etc.
Rev. no.: 1 Date: 01/17/01	Function: Wellhead Connector – Hydraulics Function No.: 05	Function Description: Connects BOP to Wellhead.

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
R.	Failure to maintain proper latch pressure.	Total POCV failure.	Fluid loss. Inability to maintain latch pressure.	Inability to maintain latch pressure.	Fluid count. Pressure readbacks.	Secure well and pull BOP. PM.	L	H	M	
S.		Failure of 1" Poly-flex hose.	Fluid loss.	Fluid loss,	Fluid count. Pressure readbacks.	Block function and continue. PM.	M	L	L	*Follow up with TSF w/rt flexible hose testing.*
T.		Failure of receptacle tubing.	Fluid loss.	Fluid loss,	Fluid count. Pressure readbacks.	Block function and continue. PM.	L	L	L	
U.		Failure of stinger seal.	Fluid loss.	Fluid loss,	Fluid count. Pressure readbacks.	Block function and continue. PM.	L	L	L	
V.		Shear seal valve failure (total pilot side failure).	Fluid loss.	Possible inability to primary unlatch from active pod.	Fluid count. Pilot pressure readback.	Switch to alternate pod. Monitor and continue. PM.	L	L	L	
W.		Solenoid valve failure.	Fluid loss.	Fluid loss,	Fluid count. Pressure readbacks.	Block function and continue. PM.	L	L	L	*Cameron to investigate failure associated with solenoid.*

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: 1	Section Description: Houses rams, shears, accumulators, wellhead connector, stack, risers, etc.
Rev. no.: 1 Date: 01/17/01	Function: Wellhead Connector – Hydraulics Function No.: 05	Function Description: Connects BOP to Wellhead

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
X.	Failure to maintain proper latch pressure.	Manual pilot regulator leak.	Fluid loss.	Fluid loss.	Increased pump operation. Excess fluid use. Visual indication with ROV.	No mitigation required – monitor situation.	L	L	L	
Y.		Total manual pilot regulator failure (catastrophic leak).	Loss of pilot pressure.	Loss of pod.	Low pilot readback pressure.	Switch to alternate pod. Isolate pod at conduit valve package. Pull LMRP.	L	M	L	*Consider continually monitoring pilot pressure system health during completion, well testing and well control situations.*
Z.		Plugged filters.	Pass dirty fluid.	Plugged solenoid valves. Loss of pod.	Function failure.	Switch to alternate pod to secure well. Pull LMRP. PM. Clean fluid practices.	L	M	L	*Ensure that MOC process is in placed and followed. (Change of OEM spares / fluids)*

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: 11	Section Description: Houses rams, shears, accumulators, wellhead connector, stack valves etc.
Rev. no.: 1 Date: 01/17/01	Function: Wellhead Connector – Hydraulics Function No.: 05	Function Description: Connects BOP to Wellhead

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking F	Ranking C	Ranking R	Recommendation
AA.	Failure to maintain proper latch pressure.	Shear seal valve failure (supply side).	Fluid loss.	Inability to primary unlatch from active pod.	Unexpected flow count. Unexpected pressure drop on readback.	Switch to alternate pod. Monitor and continue. PM.	L	L	L	
BB.		Wellhead connector regulator leak.	Fluid loss.	Inability to primary unlatch from active pod.	Increased pump operation. Excess fluid use. Visual indication with ROV.	Switch pods. Monitor and continue. PM.	M	L	L	*Note: Regulator leak tolerance for wellhaead connector lower than for annulus.*
CC.		Wellhead connector regulator failure (catastrophic leak – stuck wide open).	Loss of supply pressure.	Loss of pod.	Low supply readback pressure. Excessive fluid use. Indicator rod.	Switch to alternate pod. Pull LMRP.	L	M	L	*Consider continually monitoring supply pressure system health during completion, well testing and well control situations. (High level recommendatio n.)*

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: II	Section Description: Houses rams, shears, accumulators, wellhead connector, stack, valves etc.
Rev. no.: 1 Date: 01/17/01	Function: Wellhead Connector – Hydraulics Function No.: 05	Function Description: Connects BOP to Wellhead

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
DD.	Failure to maintain proper latch pressure.	POCV stuck closed.	Loss of supply pressure.	Loss of pod.	No supply readback pressure. No fluid use.	Switch to alternate pod. Pull LMRP.	L	M	L	
EE.	Failure to primary unlatch on demand.	Failure of latch POCV to open.	Latch pressure not released.	Unable to unlatch.	No flow. Indicator rod.	Use 'Cut Me' tube via ROV. Pull BOP.	M	H	H	*Consider to adding valve in place of 'Cut Me' tube.*
FF.		Total shuttle valve failure (pod shuttle valve).	Fluid loss. Loss of primary unlatch.	Loss of primary unlatch (both pods).	Failure detected on demand. Indicator rod. Fluid count.	Rely on secondary unlatch and ROV unlatch, secure well and pull BOP. PM.	L	H	M	
GG.		Total shuttle valve failure (ROV shuttle valve – operating from pod).	Loss of fluid.	Lose primary unlatch from pod. Lose ROV unlatch.	Indicator rod. Fluid count.	Rely on secondary unlatch circuit. Pull BOP. PM.	L	H	M	

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: 1	Section Description: Houses rams, shears, accumulators, wellhead connector, stack valves etc.
Rev. no.: 1 Date: 01/17/01	Function: Wellhead Connector – Hydraulics Function No.: 05	Function Description: Connects BOP to Wellhead

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
HH.	Failure to primary unlatch on demand.	Total shuttle valve failure (ROV shuttle valve – operating from ROV).	Loss of fluid.	Lose both primary and secondary unlatch before using ROV. Lose ROV unlatch.	Indicator rod. Fluid count.	Pull BOP. PM.	L	H	M	*PM system to place emphasis on this shuttle valve due to the possible consequence of failure.*

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: 1	Section Description: Houses rams, shears, accumulators, wellhead connector, stack valves, etc.
Rev. no.: 1 Date: 01/17/01	Function: Wellhead Connector - Hydraulics Function No.: 05 2	Function Description: Connects BOP to Wellhead

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
II.	Failure to primary unlatch on demand.	Failure of 1" hose (blue or yellow).	Fluid loss. Inability to primary unlatch from active pod.	Loss of function redundancy.	Fluid count. Eventual alarm.	Switch to secondary unlatch on active pod. PM.	M	L	L	*Follow up with TSF w/rt flexible hose testing.*
JJ.		Failure of receptacle tubing.	Fluid loss. Inability to primary unlatch from active pod.	Loss of function redundancy.	Fluid count. Eventual alarm.	Switch to secondary unlatch on active pod. PM.	L	L	L	
KK.		Failure of stinger seal.	Fluid loss. Inability to primary unlatch from active pod.	Loss of function redundancy.	Fluid count. Eventual alarm.	Switch to secondary unlatch on active pod. PM.	L	L	L	
LL.		Shear seal valve failure (pilot side).	Fluid loss. Inability to primary unlatch from active pod.	Loss of Primary latch and unlatch on active pod.	No flow count. No pressure drop on readback.	Switch to secondary unlatch on active pod. PM.	L	L	L	
MM		Solenoid valve failure.	Fluid loss. Inability to primary unlatch from active pod.	Loss of function redundancy.	Fluid count. Eventual alarm.	Switch to secondary unlatch on active pod. PM.	L	L	L	
NN.		Manual pilot regulator leak.	Fluid loss.	Fluid loss.	Increased pump operation. Excess fluid use. Visual indication with ROV.	No mitigation required – monitor situation.	L	L	L	

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: II	Section Description: Houses rams, shears, accumulators, wellhead connector, kill & choke valves, etc.
Rev. no.: 1 Date: 01/17/01	Function: Wellhead Connector – Hydraulics Function No.: 05	Function Description: Connects BOP to Wellhead

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
OO.	Failure to primary unlatch on demand.	Total manual pilot regulator failure (catastrophic leak).	Loss of pilot pressure.	Loss of pod.	Low pilot readback pressure.	Switch to alternate pod. Isolate pod at conduit valve package. Pull BOP.	L	H	M	*Consider continually monitoring pilot pressure system health during completion, well testing and well control situations.*
PP.		Plugged filters.	Pass dirty fluid.	Plugged solenoid valves. Loss of pod.	Function failure.	Switch to alternate pod to secure well. Pull BOP. PM. Clean fluid practices.	L	H	M	*Ensure that MOC process is in placed and followed. (Change of OEM spares / fluids)*
QQ.		Plugged solenoid common vent.	Unable to unlatch.	Loss of pod.	No fluid count.	Switch to alternate pod to secure well. Pull BOP. PM. Clean fluid practices.	L	H	M	

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No.: II	Section Description: Houses rams, shears, accumulators, wellhead connector, flex joint, etc.
Rev. no.: 1 Date: 01/17/01	Function: Wellhead Connector – Hydraulics Function No.: 05	Function Description: Connects BOP to Wellhead

#	Failure Modes	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking			Recommendation
							F	C	R	
RR.	Failure to primary unlatch on demand.	Shear seal valve failure (supply side).	Inability to primary unlatch and latch on active pod.	Loss of function redundancy.	Unexpected flow count. Unexpected pressure drop on readback.	Block functions. Switch to alternate pod. Pull BOP.	L	H	M	
SS.		Wellhead connector regulator leak.	Inability to primary unlatch and latch on active pod.	Loss of function redundancy.	Unexpected flow count. Unexpected pressure drop on readback.	Block functions. Switch to alternate pod. Monitor and continue.	L	L	L	*Note: Regulator leak tolerance for wellhaead connector lower than for annulus.*
TT.		Wellhead connector regulator failure (catastrophic leak – stuck wide open).	Loss of supply pressure.	Loss of pod.	Low supply readback pressure. Excessive fluid use	Switch to alternate pod. Pull BOP.	L	H	M	*Consider continually monitoring supply pressure system health during completion, well testing and well control situations. (High level recommendation.)*

FMECA Report Form	System: Deepwater Horizon BOP Section: BOP Section No: 01	Section Description: Houses rams, shears, accumulators, wellhead connector, stack, valves etc
Rev. no.: 1 Date: 01/17/01	Function: Wellhead Connector – Hydraulics Function No: 05	Function Description: Connects BOP to Wellhead

#	Failure Mode	Causes	Local Failure Effect	System Effect	Method of Detection	Mitigation	Ranking F	Ranking C	Ranking R	Recommendation
UU.	Failure to primary unlatch on demand.	POCV stuck closed.	Loss of supply pressure.	Loss of pod.	No supply readback pressure. No fluid use	Switch to alternate pod. Pull BOP.	L	H	M	
VV.	Failure to seal on demand.	See Closed – No New Issues.								

Appendix C

APPENDIX C
LESSONES LEARNED INDUSTRY

Anomalies or Industry Failures List Compiled by WEST Hou Inc.
Note: The anomalies are divided by system/component and subdivided by manufacturer where applicable. The listing should not be considered all inclusive. The majority of the anomalies listed have received adequate repairs and/or required replacements.
Control System
Control Fluid Cleanliness
High Flow Rates in Control Systems and Damage to Components
Potential Single Point Failures in Remotely-Mounted Shuttle Valves
ROV Systems Fault
Inadequately Sized Relief Valves on Cameron HPU Systems
Leaking Cameron Celle HPU Relief Valves
HPU Relief Valves Failing
Breakers on Cameron HPU System
Drift Off Due to Failure of the Differential Global Positioning System
Incorrect Seal Kits
Gilmore Shuttle Valves Oscillating
Gilmore Shuttle Valve Switchback (shuttle shifts toward the opposite pod)
Gilmore Shuttle Valves Wash Out of O-ring
Cameron 1/2" Unbalanced Shuttle Valves Failure in Seats
Cameron 1/2" Unbalanced Shuttle Valves Hydrostatic Lock
Cameron 1/4" Manual Regulator - Pressure Surges and Spikes
Corrosion in Cameron Regulators and Directional Control Valves
Cameron 350 Bar Pressure Transducer Failures
Cameron Ceramic Seal Seats Cracking in Pod Valves and Regulators
Cameron 3/4" and 1 1/2" Pilot Operated Check Valves Leaking
Cameron Flow Meter
Cameron Quick Dump Valves Losing O-rings
Cameron Solenoid Valve - Discontinuation of Solenoid Type 15
Cameron Solenoids and Water Ingress
Water Ingress into MUX Cable Caused Loss of Pressure Read-Back

Anomalies or Industry Failures List Compiled by WEST Hou Inc.
Cameron 1/4", 3-Position Pod Valve Leaks
Cameron 1/4", 2-Position Pod Valves Shear Seal Spring Problem
Cameron 3/4", 4-way, 2-Position Valve Not Cycling
Cameron 1" Pod Control Valves Leaking
Cameron MUX Pod Start-up Valve and Premature Closing
Cameron Pod Damage by Shock Loading
Cameron LMRP Mini Pod Dual 1/4" Retractable Connector Leaks
Hard Piping on BOP Stack Failed
Parker Polyflex Hose Failures
Usable Accumulator Volume in Deepwater and Corrections for Gas Compressibility
Hydrasun Hose Fittings and Potential Leaking
Cameron Accumulator Floats Hanging Up Surface and Subsea
Cameron Accumulators - Sinking Floats in Nitrogen Systems Subsea
Low Pressure Ratings of Seacon Connectors on Cameron MUX Systems
Cameron Subsea Electronic Module (SEM) Corrosion
Incorrect Operation of Subsea Electronic Module (SEM)
Cameron Subsea Electronic Module (SEM) Overheating
Cameron MUX SEM Software Updates
Leaking Cable to Cameron Riser Control Box (RCB)
Timing Errors in EDS Resulting in Damaged Cameron Pod Seals
Cameron Accidental EDS Activation
Shaffer Lower Stack Receiver Leak
Shaffer Secondary Unlock Shuttle Valves Failure to Unlock
Shaffer Hydraulic System Component Failures
Shaffer Supply Regulator Leaking
Shaffer Shear Ram SPM Valve and Damage During Surface Testing
Shaffer SPM Valve Problems
Shaffer DDV Fluid Tips
Shaffer Jacking Cylinder Gland Nut Failure
Shaffer Pressure Transducers Reading Out of Range

Anomalies or Industry Failures List Compiled by WEST Hou Inc.
Shaffer Connector Regulator Failure
Shaffer CMC Speed Control Valve
FMC Ball Valves in Shaffer MUX Systems
Shaffer SPM Valve Spools and Maintenance Requirements
Shaffer MUX Direct Drive Valves and Trapped Hydrostatic Pressure
Failure of MUX Cable Connection in Shaffer MUX System
Seacon MUX Cable Connectors on Shaffer MUX Systems
Fluid Leakage from MUX Cable in Shaffer MUX System
Faulty Tubing on New Shaffer Pod
MUX Pod System Electronic Architecture (SEA) Failure on Shaffer MUX Systems
Shaffer Alarms on Cimplicity/NT Operator Interface Terminals
Shaffer Pod Block Configuration and Inability to De-energize Functions
ONX OIT (Operator Interface Terminal) Screen Lock-up on Shaffer MUX Systems
Lack of Control Panel Stops and Possible EDS Activation on ABB Seatec System
Oil Air Accumulator Failure of Bladders
Annular BOPs
Cameron DL Annulars - Intrusion of Salt Water Through Weepholes
Shaffer 18 3/4" 10K Spherical - Packing Element Damage and Performance
Shaffer 18 3/4" 5K Annular Failure to Test on 5 1/2" Pipe
Ram BOPs
Cameron TL Bonnet Seal Leaks
Corrosion of Wellbore and Hydraulic Seal Areas in BOP Bonnets
Cameron 3 1/2" x 7 5/8" 10K TL Flexpacker Problems
Cameron TL BOP Bonnet Operating Cylinder with Flaking Chrome Plating
Loose Connecting Rod Button on Cameron TL BOP
Increased Shear Pressure Requirements in Deepwater
Cameron Shearing Blind Ram Failure to Wellbore Pressure
Cameron 18 3/4" 10K Dual V Shear Rams Failure to Test
Cameron 18 3/4" 15K Dual V Shear Rams Failure to Test

Anomalies or Industry Failures List Compiled by WEST Hou Inc.
Cameron Casing Shear Ram Bolts
Cameron 15K TL Casing Shear Rams and Trapped Debris
Cameron Casing Shear Rams and Damage to Blades
Cameron Casing Shear Rams Delay of Closure
ST Lock Testing on Cameron Variable Bore Rams
Cameron ST Lock Difficulties
Slip-Eze Bearings in Cameron ST Locks
Failure of Lubricomp Bearings on ST Locks
Cameron Sequence Valve for TL Rams with RamLocks and ST Locks
Cameron ST Lock Springs Installed Incorrectly in the Sequence Caps
Cameron TL Rams with RamLocks - Constricted Movement of Operating Piston
Hydril Ram Bonnet Seal Carrier
Hydril 18 3/4" 15K Blind Shear Ram Failure to Seal due to Shearing of a Bolt in the MPL
Hydril MPL Locks - Slip-Eze Bearings and Overhauling Nuts
Shaffer SLX BOPs and Potential Collapse of Door Seal Cartridge
Shaffer V Shear Ram Failure to Wellbore Test
Shaffer V Shear Rams and Replacement Bolts
Blind Shear Rams on a Shaffer 18 3/4" 15K BOP
Shaffer UltraLocks Performance
Shaffer UltraLock II Not Unlocking
Stewart & Stevenson QLS Shear 18 3/4" 15K Shear Rams
Stewart & Stevenson 18 3/4" 15K QLS Variable Bore Rams
Stewart & Stevenson 18 3/4" 15K QLS Automatic Locking System
Connectors and Gaskets
Hydrates Formation in Deepwater and Difficulty of Failure to Unlatch
Choke/Kill Connection Release Problems
MMS Regulations for Accidental Disconnect of Riser
Cameron AX Gasket Out of Tolerance
Cameron CX Gaskets Issues

Anomalies or Industry Failures List Compiled by WEST Hou Inc.
Bent Cameron AX Gasket Retaining Pins
Cameron Mini Collet Connector and AX Replacement
Alignment Problems Between LMRP and Stack
Cameron Type HC Connectors Failure to Disconnect
Cameron Type HC Connectors - Coated Actuator Piston
Cameron HC Connector Backdriving
Hydril Hydraulic Choke/Kill Connector Failure to Extend
Vetco HAR H-4 Bent VX Gasket Retaining Pins
Vetco H-4 LMRP Connector Difficulties to Unlatch
High Strength Studs and Hydrogen Embrittlement
Valves and Choke/Kill Systems
WOM Magnum Valve, 15,000 psi mwp Extrusion of O-rings
WOM Valves and Broken Operator Springs
Lead-filled Target Flanges and Retention Issues
Copper State Hose Failure
Goodall Hose Construction
Shaffer 3 1/16" 15K Type HB Valve Bonnet Gasket Failures
Shaffer Hydraulic Retractable Choke and Kill Connector Primary Unlock Failure
Shaffer Mud Boost Valve
Shaffer 15,000 psi HB Valves Leaking
Riser Systems
Choke and Kill Line Pin Hard Facing Flaking Off
Riser Hydraulic Line Pin Corrosion and Control Fluid Cleanliness (M-C-22)
Cracks in Telescopic Joint Tensioner Rings
Dropped Stack-Vetco BT-4 Packer Housing Bolt Failure
Dropped Stack-Cameron Outer Barrel Failure
Shaffer DT-2 Riser Locking Dog Assembly Retaining Screw Replacement
Shaffer DT-2 Riser Telescopic Joint Latching Dogs Misalignment
Shaffer Riser Tensioner Ring Damage

Anomalies or Industry Failures List Compiled by WEST Hou Inc.
Riser Spider Gimbal
Interchangeability of Vetco Type MR Dog-Type Riser
Stewart and Stevenson SSQR-F Riser Nickel Plating Flaking
Stewart and Stevenson SSQR-F Riser Non-stress Relieved Welds
Stack Frames
LMRP Disconnect Angle Limitations
Collapse of BOP Stack Frame Member

Appendix D

APPENDIX D
REVISED RUNNING BOP PROCEDURE

Reviewed by HAZID Team, January 2001,Revised 011701

3.1.1.11 - Run Riser and BOP Procedure

General Information

Applies To: Deepwater Horizon
Revision Date: **January 2001 - HAZID**
Approving Authority: Rig Manager
Purpose / Objective:
To deploy the blow out preventer stack on the subsea casing wellhead, safely and with no adverse environmental affects, providing a means of well control and riser system for drilling fluid returns during drilling operations.
The blow out preventer (BOP) stack consists of two basic sections: A lower stack with a wellhead connector, (5) five ram-type preventers and a lower marine riser package (LMRP) with a riser connector (to attach to the lower BOP), and (2) two annular preventers and a flex joint. The BOP stack is the first line of defense for controlling "kicks" experienced with a well.
The BOP stack is run on joints of riser with a telescopic joint (slip joint) and diverter at the top. The marine riser tensioners support the weight of the LMRP, riser and outer barrel of the slip joint once the BOP stack is landed.
References:
R&B Falcon Accident Prevention Bulletins 02-93, 01-93.
HSE Manual Sections
3.6 - Safety Harnesses/Reels/Lines
3.8 - Life Saving Equipment
4.3 - Pneumatic Tools
4.22 - Blowout Prevention Equipment
R&B Falcon Operational Policy #21 - Subsea BOP Deployment & Retrieval
Cameron Operations Manual
Material Requirements
Safety Precautions
Verification / Reporting Requirements:

Job Positions Involved:
Installation Manager (IM), Toolpusher, Subsea Engineer, Driller, Assistant Driller, Derrickman, Floorman, Crane Operator, Deck Crew

Summary:
The riser running procedure will differ, between the various types of drilling units operated by R&B Falcon Corporation. The important points for a successful operation include:

1. Ensure the riser lifting equipment, slings, shackles, and tag lines, conform to the safe working load requirements.
2. Ensure the riser hydraulic riser running tool (RRT) is seated correctly, and the retaining dogs fully engaged. If using manual RRT, torque as per the manufacturer's specification.
3. Ensure the tailing in, and restraining lines are rated for the specific task.
4. Check all "O" rings, gaskets and pin and box connections for defects.

Procedure:

Preparation: (starts in skate)

1. Confirm, space out from RKB to the wellhead, and calculate the riser string for the slip joint to be in mid stroke, when the BOP is latched. Make a riser run tally and give copies to the Driller and

Crane operators. Ensure riser joint serial numbers are recorded so days in service can be tracked.

2. Charge all APV and ensure all MRT pistons are full stroke and pressure adjusted for water depth with seawater in riser. Consult the riser tension program/analysis.
3. Confirm that the Subsea Engineer is prepared to run riser.,
4. Ensure spare riser components (choke, kill, booster, rigid conduit seals etc.) and lubricants are available on the rig floor, with impact and torque wrenches,. Ensure the wrenches are set at 22,500 ft/lbs of torque for make up for riser bolts – check periodically.
5. Confirm the vessel is offset, to the wellhead, preferably downstream, and positioning systems are fully operational.
6. Inform the Bridge of the ongoing operation. Insure good communications between the Driller, rig floor, crane operator and MUX reel operator in Moon pool, this is a must for a smooth operation. Ensure Marine Crew and Drill Crew are aware how changes in heading can affect load. Communicate at intervals.
7. Rig floor to have riser bolts, never-seize, slings, shackles, snatch blocks, torque wrenches, etc., ready. Crane operator to have all saddles removed and all shackles and slings ready to run riser. Have as much ready prior to starting job as possible.
8. Change out the links and elevators, for the 1000-ton capacity equipment and remove the mouse hole. Dependent on water depth and riser configuration, it may be possible to park the TDS and rig for 750-ton equipment.
9. Remove master bushing and outer ring from rotary table. This should not be done until riser gimbal is on rig floor and ready to install so the rotary opening is not left uncovered for longer than necessary.
10. Install the riser spider and gimbal and test functions same, install spider access stairs & handrails
11. Insure BOP has a new proper Wellhead Connector ring gasket.
12. Place BOP control system in riser run mode (refer to riser run mode sheet in subsea computer).

Running Riser BOP:

Note: Deadman system should be inactive during the running of the BOP and Riser & Auto Shear Function should be in Disarm on Drillers Panel, Initiate Deadman & Auto- Shear Function after BOP is landed and all systems confirmed.

13. Remove auxiliary line protectors and inspect riser choke/kill/booster, and rigid conduit lines for trash and / or damaged or missing seals prior to job. High pressure wash down of all auxiliary lines, if not done previously.
14. **A.** Visual inspection LMRP Connector indicator. **B.** Call Bridge before: **C.** Move BOP from BOP storage area to BOP cart. **D.** Move BOP cart to well center. , **E.** Set first joint of riser on the riser cart.
15. Pickup hydraulic riser running tool, confirm proper operation and note hook weight.
16. Pickup first bare joint of riser & make sure RRT Is "Fully" Latched (driller to visually confirm and check off on riser running sheet) before picking and noting hook weight. **Note: this applies to all joints of riser that is lifted off riser skate & riser spider before picking up.** Visually inspect the choke, kill, booster and rigid conduit seals and pin seals. Have spares for riser joints on the rig floor throughout the job.
17. Lower joint to the BOP riser flex joint and make up bolts to 22,500 ft/lbs torque. Lower one torque wrench from rig floor to personnel on walk around at riser flex joint. Use never-seize only on all riser bolts, do not use copper coat. Periodically check wrench settings.
18. Visual inspection of LMRP Connector indicator. Pickup riser and BOP from the transporter, note hook weight. Retract pins and move cart back, install landing and return to work position. Install MUX clamps at each connection. Get bullseye indicators reading and record.(Note before lowering BOP depending on weather condition Under hull guide system will be used)
19. Turn BOP 90 degrees counter clockwise and land first joint on spider. Ensure spider hydraulic lock pins are engaged (via visual indication). Notify control room that BOP is in water.
20. Fill choke, kill, and booster lines with seawater. **Fill rigid conduit with fresh water only**.
21. Subsea engineer to confirm proper hook up before test. Test choke, kill, booster, and rigid conduit lines according to operator test procedures after first joint is in water. **(NOTE: Booster**

Line & Ridged Conduit Line DO NOTE EXCEED 5000 PSI) Number of joints run between test will be determined by IM.

22. Continue running riser noting , all information is filled out on the riser run sheet.
    - RRT fully latched
    - Seals intact and lubricated.
    - Weight
23. After running the desired number of riser joints, test,
24. Ensure correct riser tally, then pick up the Termination joint and run.
25. Pick up slip joint (ensure manual locks are activated). Note weight and make up to termination joint
26. Lower the termination joint to the BOP transporter level and connect goosenecks to termination joint. Pressure test all goosenecks.(ensure all personal are clear of the area before testing) **Also do Not Exceed 5000 PSI on Boost Line & Ridged Conduit Line**.
27. ROV inspect BOP & Wellhead and have the ROV verify that W/H connector is unlocked on ROV panel
28. Put the storm loops in the MUX cables and hotline hose.
29. Land slip joint below the packing element in riser spider (unlock manual locks) and stroke out inner barrel using hot line to unlock latching dogs on outer barrel. Note weight.
30. Lower slip joint down to load bearing area on slip joint. Make sure fluid bearing housing is above locking pin cylinder on load ring before skidding tensioners to well center
31. Notify Bridge and skid the Riser Tensioners to well center
32. Close the tensioner Load Ring around the slip joint. And lock the load ring. Verify that indicator is out and locking pin cylinder is locked. Connect hydraulic, air, and lubricating lines to the slip joint and fluid bearing hose
33. Lower the slip joint down.
34. Before moving rig over well depending on current weather condition it might be necessary to be on compensator (ACTIVE HEAVE MODE)
35. Slack off riser string set 100,000 lbs on wellhead and latch onto wellhead. Notify Bridge that BOP connected to wellhead – Drill Floor to be notified of all heading changes.
36. Check for correct space out. (MRT rod stroke)
37. Insure tensioning system is set. Per riser tensioner program. Set anti-recoil at tensioner panel to 'Remote' mode. Verify BOP is latched with fluid gallon count and visual with ROV at wellhead connector indicator flag on ROV panel.
38. Note weight indicator after tensioners have taken full weight; apply approx. 50 to 75 thousand pounds overpull on wellhead to insure connector is locked onto wellhead. Weight on wellhead and overpull will be determined by IM and Company Representative.
39. Set wet weight of BOP on well head to insure structural pipe will support BOP (check with IM and Company Man).
40. Makeup diverter flex joint to inner barrel of slip joint. Land and lock in diverter.
41. Set BOP control system in drilling mode.
42. Displace rigid conduit with mixed BOP fluid. (2 times volume)
43. Rig down riser equipment.
44. Close upper shear rams and pressure test. (Check with Company Man & IM to determine pressure for test)
45. Open upper shear rams.
46. Test BOP according to test sheet and Operator test pressure chart.