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Shallow Gas Drilling Cost Optimization Through Utilization of KFDJ Diverter in Offshore Bekapai, Mahakam Field

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Abstract. In the current condition of low oil prices, Oil Companies are forced to improve drilling operation efficiency and reduce drilling cost to produce hydrocarbon, moreover in mature field such as Mahakam Field operated by Pertamina Hulu Mahakam (PHM). One of main drilling challenges in Mahakam is shallow gas hazard which can lead to blowout event when drilling surface section. A new method to drill surface section with KFDJ diverter has been introduced. The KFDJ diverter system is used on jack-up rigs which replace the conventional diverter system.

Before implementing KFDJ diverter for shallow drilling, comparison between KFDJ and conventional diverter is made to perform gap analysis to PHM's company rules and to find any modification needed on equipment or procedure to keep the operation safe and smooth. Distinctive risk assessment and mitigation are prepared to mitigate any potential additional risk when drilling shallow gas section with KFDJ diverter. A comprehensive gas dispersion study was also performed to simulate gas dispersion and heat radiation during gas evacuation process. Finally, trials are done for three wells drilling with action checklists to monitor and verify risk mitigation were fully implemented.

From the gap analysis, it was found that KFDJ diverter cannot meet the requirement of PHM's company rules to able to do Complete Shut Off (CSO). To meet the PHM's company rules requirement in utilizing KFDJ diverter for shallow gas drilling, kill string is utilized as mitigation of shallow gas kick possibility during non-CSO period. The gas dispersion study result shows KFDJ has another benefit due to the higher elevation which can reduce the gas exposure to shale shaker and other rig equipment during gas evacuation process. The first trial has been done successfully in offshore Bekapai with several operation modifications. It is proven that the utilization of KFDJ diverter saves up to 12.75 hours of rig time which is equivalent to cost saving of USD 133,000 per well. Shifting from conventional diverter to KFDJ diverter can also significantly reduce the amount of heavy lifting job during installation and dismantling process of diverter equipment.

Keyword: KFDJ diverter, shallow gas drilling, drilling optimization

1 Introduction

Mahakam block is a concession area of oil and gas fields which is operated by Pertamina Hulu Mahakam (PHM). This block is located across the Mahakam offshore and delta, East Kalimantan. Mahakam block has been producing oil and gas since more than 50 years ago. Today, this field is categorized as brown field due to its marginal oil and gas reserve.

One of main drilling challenges in Mahakam is shallow gas hazard. A major concern during shallow offshore drilling operations is the detection and control of a sudden gas influx that can occur when drilling penetrates an over pressured gas-bearing formation (Starrett et al., 1990). If shallow gas kick event occurs, it is almost inevitable that a blowout will occur and lead to several categories, those are diverter system failures, flow outside casing, and cratering (Sandlin, 1986).

Significant efforts have been done to improve the efficiency of drilling process in Mahakam offshore mature field, especially during oil price downturn, so the well can be drilled in an economical manner. Invisible Lost Time (ILT) has been mapped which results to a list of initiative projects for Mahakam offshore drilling operation. One of the initiatives which has been successfully implemented in Mahakam offshore is drilling shallow gas section with KFDJ diverter to replace conventional diverter which has been used for many years. This initiative is one of PHM's drilling team priority to be implemented due to it is considered as the most feasible with significant impact.

Diverter is used as PHM best practice when drilling shallow section (Ph. Jeannet et al., 2008). It is required to be used as well control equipment due to the existence of shallow gas hazard in Mahakam. Diverter system will allow kick flow to be directed away from the rig while at the same time minimize back pressure exert to diverter system and formation (Sandlin, 1986). During drilling shallow gas section, if gas kick occurs, the risk is high that formation may fracture to the surface.

There are many types of diverter. PHM usually uses the conventional diverter which needs dedicated time and heavy lifting to install and dismantle before and after drilling surface section. The idea of shifting to KFDJ diverter is to reduce the amount of heavy lifting requirement during the installation of diverter equipment which can also significantly reduce rig operation time.

KFDJ diverter has a fixed support housing, which is securely bolted to the rotary beams and provide fixed outlets for flow line, fill-up line, and overboard lines (**Figure 1**). The diverter uses a specific insert packer type which can shut off the well for a specific range of pipe size inside. Each type of insert packer will have a different running tool to set it into the KFDJ system. This system is an integrated part of the rig so the implementation of this initiative will eliminate the heavy lifting activity of diverter installation.

Previously, KFDJ diverter has never been used in PHM during shallow gas drilling. The main reason is because that PHM's company rules stated that diverter system must be able to fully close or able to do Complete Shut Off (CSO) the wellbore when there is no string inside the hole. In contrary, KFDJ system cannot allow CSO when there is no string across the wellbore. There are two conditions which are classified as non-CSO period. The first is when there is no string inside the hole, for example after all the surface drilling bottom hole assembly (BHA) are out of the hole and during preparation of running surface casing. The second is when there is no insert packer installed during changing or removing the insert packer due to diameter of drilling bit, bottom hole assembly (BHA), casing hanger, or wellhead. Derogation with risk assessment has been made to comply the subject to company rule. The main strategy is to run a kill string across KFDJ diverter during non-CSO period when there is no string inside the hole.

Flow check prior to changing or removing insert packer is also applied as the strategy to mitigate and ensure the well is already overbalance with limited risk of kick occurs.

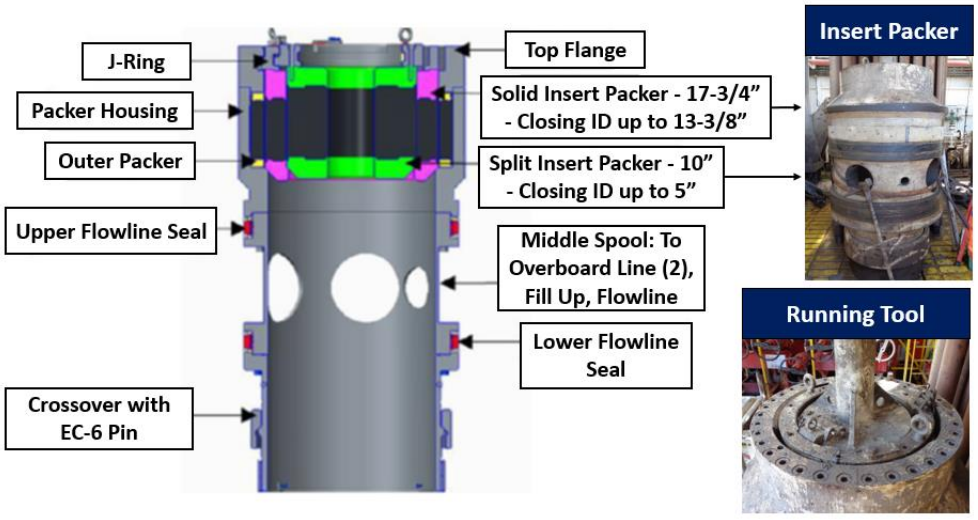

Figure 1. KFDJ Diverter Schematic

Shifting to KFDJ diverter utilization affects to the current drilling operation. The KFDJ utilization is located higher than conventional diverter which will affect the gas dispersion figure during shallow gas event. This is one of KFDJ system additional benefits because the higher gas dispersion can reduce the gas exposure to shale shaker and other rig equipment during shallow gas kick event. The diverter installation procedure is also required to be defined due to the elimination of heavy lifting for diverter installation, yet it requires a specific procedure for each type of installed insert packer. Additional testing procedure is required to fulfill company rules recommendation as KFDJ system stack up will use an overshot pipe between conductor pipe (CP) and diverter. The KFDJ diverter consists of function test, flow test, and hydrostatic test, while the conventional diverter only applies function test.

2 Methodology

The project is initiated by mapping all invisible lost time (ILT) in Mahakam offshore drilling operation. KFDJ diverter utilization is one of the priorities among the lists due to its availability and readiness. The KFDJ equipment is already available and pre-installed in the rig and has become an integrated part with the jack-up rig. However, it has never been utilized during surface section drilling. The study flowchart for implementing KFDJ diverter to replace conventional diverter is shown in **Figure 2**.

Figure 2. Study Flowchart for KFDJ Diverter Implementation

A comparison between KFDJ diverter and conventional diverter is made to perform gap analysis to the PHM's company rules. The comparison is also made to find any modification needed on equipment or procedure to keep the operation safe and smooth. The comparison includes the diverter working procedure, equipment, stack up comparison, and specification. A comprehensive gas dispersion study is also performed to simulate gas dispersion and heat radiation during gas evacuation process.

A comprehensive gas dispersion simulation must be done in order to see the difference in gas dispersion figure on both systems. Simulation has been carried out by using DNV Phast 6.7. The result of the figure then will be compared between conventional diverter and KFDJ diverter. Proper mitigation strategy for KFDJ diverter will be defined once there is a significant difference with conventional diverter dispersion figure. There are two scenarios that are used for the simulation: Base case scenario and worst case scenario. Base case is assuming there is 4 m^3 gas influx that enters the wellbore, worst case scenario is assuming the worst situation which is full gas evacuation across the wellbore.

Distinctive risk assessment and mitigation are prepared in order to mitigate any potential risk when drilling shallow gas section with KFDJ diverter. This risk assessment include strategy to comply company rules and reduce associated risk when shifting to KFDJ diverter system. The job risk analysis (JRA) document is made as a guideline for KFDJ diverter implementation.

Modifications on equipment are required to drilling shallow section when shifting to KFDJ diverter. Several changes in surface drilling procedure is also made, especially for the nipple up and nipple down diverter process, diverter test, and packer installation. These changes on procedure affect to job sequence during drilling shallow section. Then, action checklist is made to monitor and verify risk mitigation is fully implemented. Finally, the first trials of KFDJ diverter implementation have been successfully completed for shallow section drilling in Bekapai, Mahakam Field.

3 Result and Discussion

3.1 KFDJ and Conventional Diverter Comparison

There are four main concerns when shifting to KFDJ diverter utilization for drilling shallow section, those are disability to allow CSO, higher elevation with smaller overboard lines ID, insert packer utilization, and overshot utilization in diverter stack up between CP and diverter. The disability to allow CSO and overshot utilization leads to gap analysis to the company rules. The higher elevation with smaller overboard lines ID affects to gas dispersion figure during shallow gas kick event. Procedure modification is required due to insert packer utilization if drilling with KFDJ diverter system.

3.1.1 Gap Analysis to Company Rules

The main concern of KFDJ diverter utilization is that it cannot allow complete shut-off (CSO). When using conventional diverter, the annular bag is able to do completely shut off the well even when there is no drillpipe in the well. The closure or opening of diverter and valves has succeeded for a quick response less than 45 seconds. The annular bag is also able to close the well with various sizes of string across the diverter. This is aligned to PHM's company rules that state diverter shall be of bag preventer type allowing Complete Shut Off (CSO) as kicks may occur without BHA through the rotary table. The closure or opening of the diverter and valves shall be sequential for a quick response. Minimum response times to close diverter, flow line valves, and simultaneously open the preselected overboard line shall be less than 45 seconds.

There is also another concern of KFDJ diverter due to it requires overshot utilization in the stack-up between CP and diverter. Based on PHM's company rule, if an overshot is used between the CP and diverter, it is recommended to pressure test the equipment at a reasonable pressure level compatible with the well architecture. Hence, diverter test modification is required with respect to the company rules and operation safety.

3.1.2 Gas Dispersion Simulation

The main difference between KFDJ diverter and conventional diverter is its elevation distance from rotary table. Conventional diverter is located 17.22 m below rotary table, while KFDJ diverter is located only 3.48 m below rotary table. The schematic can be seen in **Figure 3** below.

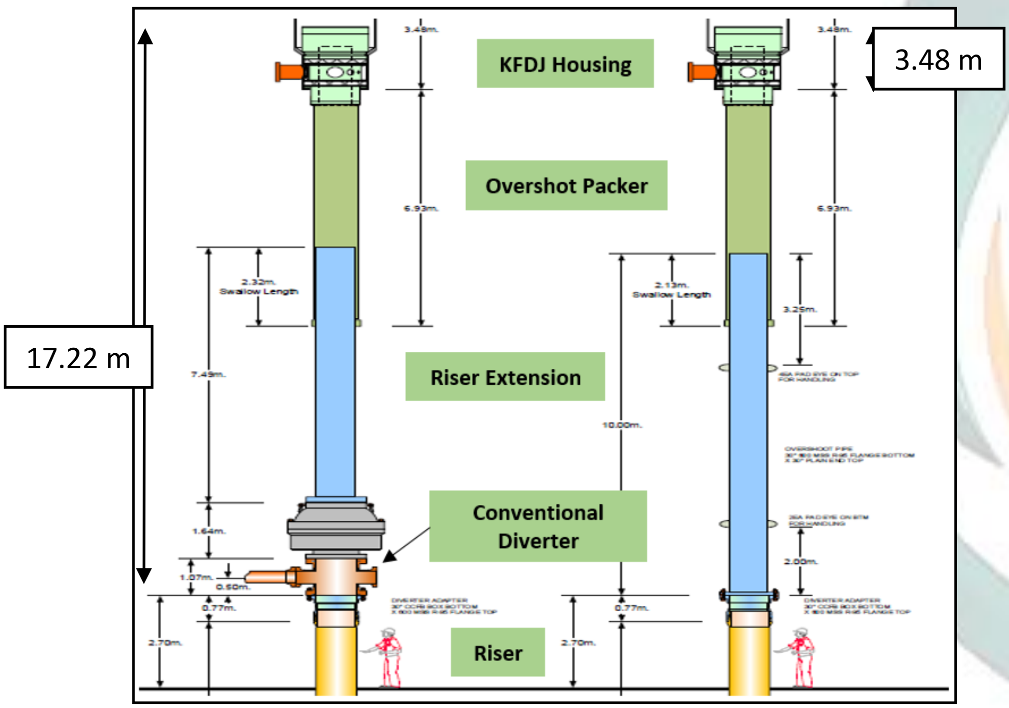

Figure 3. Diverter Stack Up: Conventional (Left) and KFDJ (Right)

The base case scenario is simulated based on assumption when there is 4 m^3 of influx enters the wellbore before the well is shut in and the influx is circulated through the overboard line with maximum pumping speed. The result on **Figure 4** uses a conservative approach, it assumes that the gas dispersion on surface spreads radially, while in actual, the form of gas dispersion should form a gas cloud which will be oriented away from the rig floor position. There is a quite significant difference between dispersion coming from KFDJ diverter and conventional diverter. In conventional diverter, the dispersion area is within cantilever base area up to cantilever area where some of drilling equipment like shale shaker, mud pump, and mud pump engine is located in those area. On the other hand, KFDJ diverter dispersion area is located around the rig floor elevation where a limited number of personnel might be working on the area. From the figure below, it can be concluded that the risk for shallow hazard for both case is considered to be equal. Proper mitigation has been made for KFDJ diverter in order to reduce personnel exposure on the rig floor such as windshield and heatshield installation. But the most important thing is to prevent the shallow gas incident to happen, sufficient hydrostatic pressure must be maintained throughout the shallow gas section.

Side View

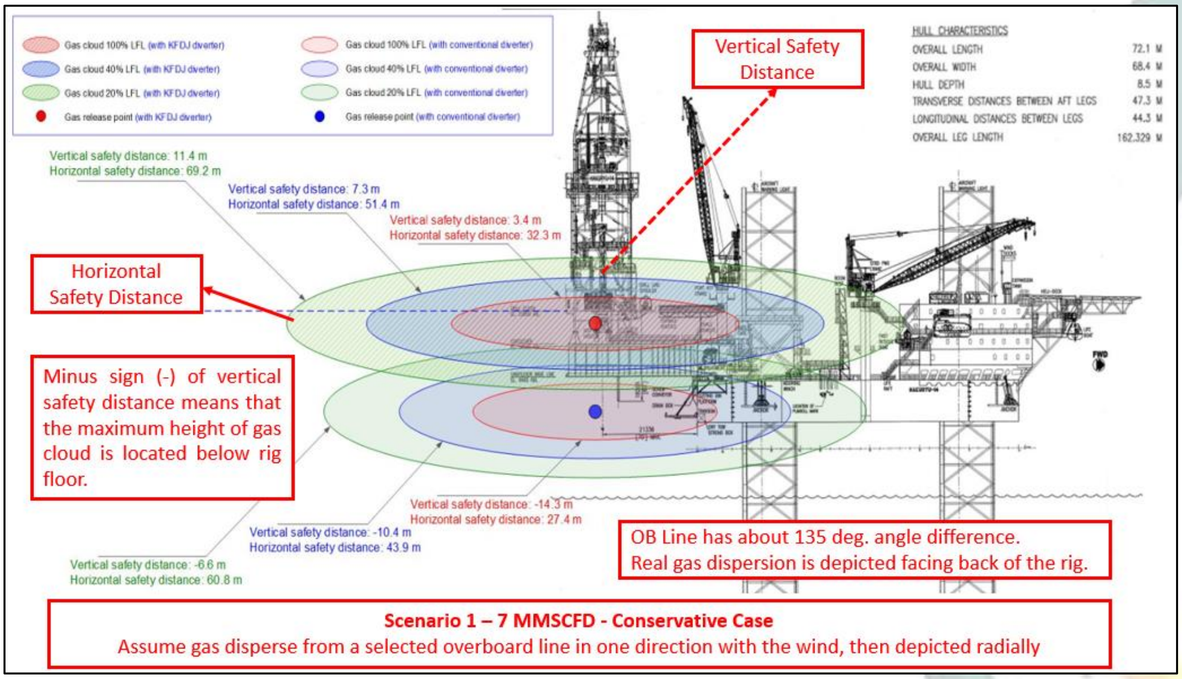

Figure 4. Base Case Gas Dispersion Simulation (Side View)

From the top view (**Figure 5**), the difference is not significant, it can be seen that the radial dispersion (from top view) by KFDJ diverter is slightly larger compared to conventional diverter. The main factor which contributes to this result is the internal diameter size of overboard line. In conventional diverter, the internal diameter of overboard line is 14" while in KFDJ, it uses a smaller internal diameter (12") which yields in a higher flow rate. Based on Company Rules, a minimum internal diameter for overboard line is 12", so KFDJ diverter still can comply to the Company Rules.

Worst case scenario simulates when the kick is uncontrollable and all the wellbore is filled with the influx. The maximum gas flowrate on surface is simulated by using OLGA. The hole size is 17.5" with 500 m open hole depth, and the influx is coming from shallow gas reservoir with permeability around 930 mD and porosity around 24.4% with 6 m reservoir thickness. The gas flow rate that can be expected on the tip of overboard line is around 139 MMSCFD. The velocity of the gas is too high that DNV Phast 6.7

cannot simulate the dispersion due to the limitation of the software. It is then decided that gas velocity in the simulation is limited to 500 m/s as per software limitation.

Top View

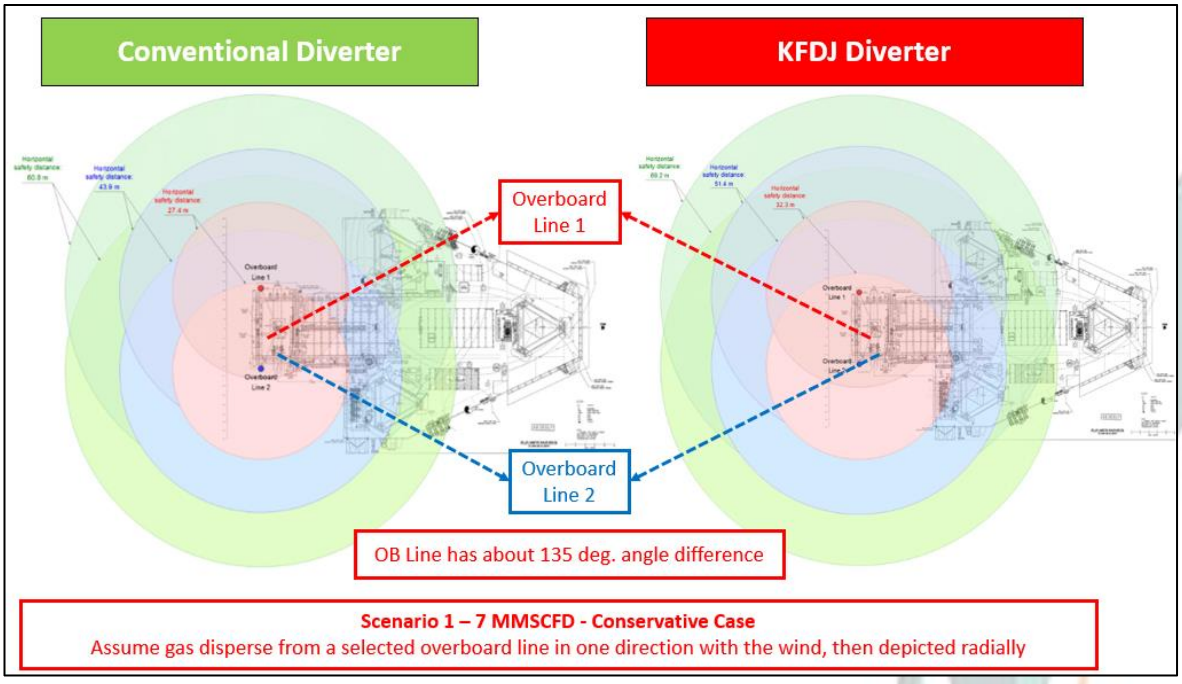

Figure 5. Base Case Gas Dispersion Simulation (Top View)

Figure 6 shows gas dispersion result with worst case scenario. As can be seen, the figure shows that the dispersion is disastrous, it covers almost every part of the jack-up rig. Even though the event is very unlikely to happen, this impact should be taken into serious consideration. Ensuring sufficient hydrostatic pressure throughout shallow gas section is paramount because it is the only barrier that we have during drilling. Based on the simulation result, it is concluded that the consequences of gas dispersion on conventional diverter and KFDJ diverter are equal.

As can be seen in the **Figure 7**, the difference is not significant. Once again, there is only a slight difference due to slight change in the internal diameter of the overboard lines. The important point that needs to be highlighted is that the impact of full gas evacuation is disastrous and should be avoided at all.

Side View

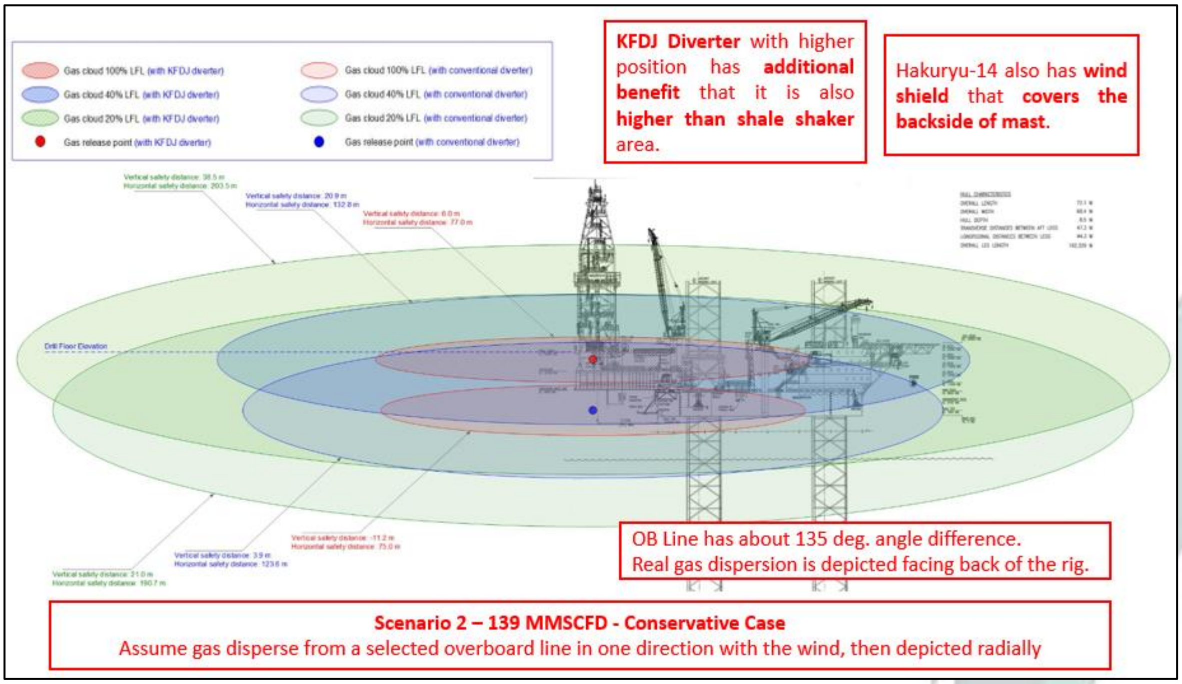

Figure 6. Worst case gas dispersion simulation (side view)

Top View

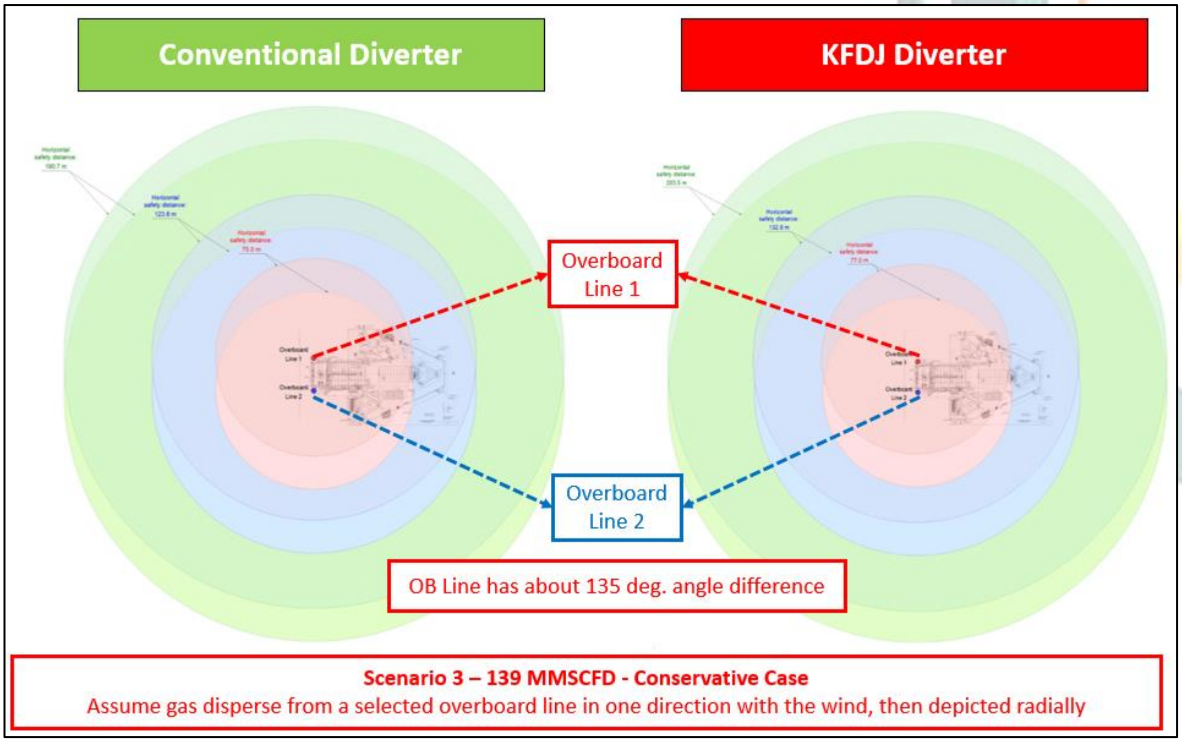

Figure 7. Worst case gas dispersion simulation (top view)

3.1.3 Insert Packer Utilization

One of the unique characteristics of KFDJ is that it has two layers of packer which should be installed depends on the diameter of the string inside the hole (**Figure 1**). The outer packer is 17-3/4" solid type packer and the inner packer is 10" split type packer. The insert packer is replaceable depends on string size across the diverter bag. The solid type packer can seal until 13-3/8" diameter string while the split type packer can seal up to 5" diameter string. When running pipe or equipment with diameter bigger than insert packer inside diameter (ID), the insert packer needs to be removed first. In drilling mode, both solid type packer and split type packer should be installed in the diverter bag, while in running casing mode, only solid type packer that should be installed inside the diverter bag. The procedure to set and remove the insert packer from KFDJ diverter is different between these two types. Therefore, the insert packer for KFDJ diverter system will affect the drilling operation procedure.

3.2 Risk Mitigation and Prevention

Derogation has been made to comply with the subject with company rule. Risk assessment has also been made to mitigate all possible risk regarding the utilization of KFDJ diverter which substitutes conventional diverter. There are several risk reduction initiatives that must be completed when drilling shallow gas section with KFDJ diverter. The complete lists can be seen on the **Attachment A**. Main mitigation strategy for KFDJ diverter utilization is divided into two. The first one is kill string utilization and flow check strategy, the second is KFDJ diverter testing and running procedure.

3.2.1 Kill String Utilization and Flow Check Strategy

A kill string that consists of safety valve (closed), pumping tee, 5 m of 5" drill pipe, and an elephant foot (**Figure 8**) must be run across the KFDJ diverter bag during no complete shut off (no CSO) period. There are two conditions when there is no string inside the wellbore. The first is after surface bottom hole assembly has been laid down on surface and during preparation to run surface casing, the second is during changing insert packer when pulling 16" drilling bit and stabilizer, and when pulling casing hanger and wellhead.

Even though a kill string can be used as a mitigation strategy, there is still a short window period where the kill string cannot be set in place. For example, when the stabilizer and bit are passing the diverter bag, and when the kill string is being run into the hole. Hence, proper well monitoring should be carried continuously during this period.

The best way to do well monitoring is through a proper flow check, 15 minutes of flow check must be done at several depths. The first one is at well TD, the second one is when the bit is at the last casing point during pulling out of hole, and the third one is when the stabilizer is right under diverter packer.

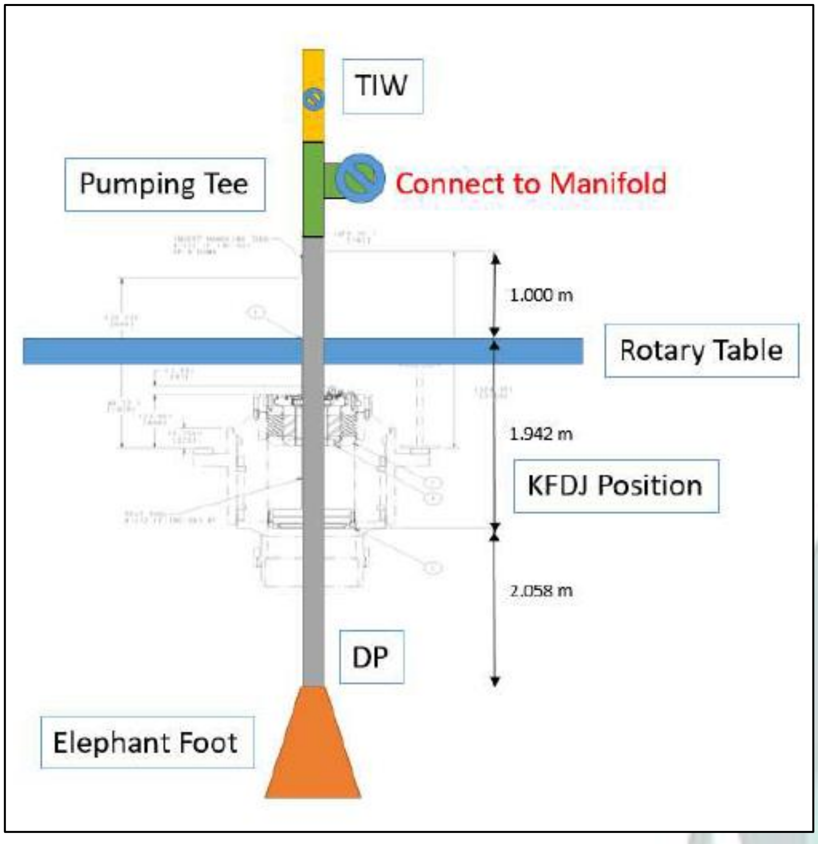

Figure 8. Schematic of a kill string

3.2.2 KFDJ Diverter Test

Table 1. KFDJ Diverter Test

No.	Test Name	General Description	Success Indicator
1	Function Test	The diverter bag is closed in interlock drilling mode	Diverter bag must fully close around 5" drill pipe and have no leakage in the system, both overboard valves must open automatically and flow line valves must be closed automatically. Closing time diverter must be less than 45 s.
2	Flow Test	Keep open 1 overboard valve, pump with sea water to overboard with 4000 LPM for 5 minutes.	There is no leak on the seals of overshot packer to bell nipple.
3	Hydrostatic Test	Displace the well with weighted water based mud	There is no leak on the seals of overshot packer.

KFDJ diverter installation position is not set exactly above the conductor pipe, a riser or overshot pipe must be used between conductor pipe and KFDJ diverter bag, the sealing is provided by an overshot packer. As per Company Rules, adequate means must be done to check the integrity of the system. This means that there should be an additional test to test the sealing of overshot packer. However, it will be difficult if the overshot packer is tested to 500 psi as it will definitely cause leaking. Three tests have been done to check the sealing of overshot packer. Those test can be seen in **Table 1** above.

3.3 Operation Modification and Implementation

Shifting to KFDJ diverter for drilling shallow section requires modification on drilling equipment and procedure. The list of equipment that is required to be modified or prepared is shown below.

1. Specific KFDJ diverter insert packer with running tool (**Figure 1**)
2. Kill string (**Figure 8**)
3. Riser length and connection type adjustment for KFDJ diverter stack up (**Figure 3**)

There is also list of procedure which is required to be modified or prepared is shown below.

1. Diverter installation (**Attachment B**)
2. Set and remove solid and split insert packer (**Attachment C**)
3. Diverter test (**Table 1**)
4. Flowcheck (as mentioned on **Section 3.2.1**)

From all of operation modification, the overall job sequence of drilling shallow section will be:

1. Nipple up KFDJ diverter after clean out CP,
2. Running 16" or 17-1/2" BHA into the hole:
   a. Install 10" split packer after 1st stand of BHA below KFDJ diverter,
   b. Continue RIH BHA.
3. Drilling open hole surface section.
4. Tripping out surface section BHA and L/D BHA:
   a. Flowcheck then Remove 10" split insert packer before last stand of BHA (Non-CSO period),
   b. Continue lay down BHA (Non-CSO period).
5. Run and slip kill string on rotary table. Install 10” split insert packer (Non-CSO period).
6. Preparation for running surface casing (Non-CSO period).
7. Remove kill string and 10" insert packer (Non-CSO period).
8. Tripping in surface casing:
   a. Remove 17-3/4" solid insert packer before running casing hanger (Non-CSO period),
   b. Continue run casing hanger (Non-CSO period),
   c. After running casing hanger/wellhead, then install back 17-3/4" solid insert packer (Non-CSO period),
   d. Continue operation.
9. Cementing surface section.
10. N/D KFDJ Diverter.

Based on trials result, there are no major difficulties when shifting to KFDJ diverter. Action checklist to monitor and verify risk mitigation is fully implemented. It is also proven that the utilization of KFDJ diverter can significantly reduce heavy lifting operation during diverter installation process. This means that the major risk related to heavy lifting can be significantly reduced. Furthermore, additional cost which is resulted from platform's crane rental can be eliminated and platform production shortfall can be avoided.

In terms of drilling optimization, saving of 12.75 hours of rig time can be obtained from simplifying diverter installation process. The reduction in rig operation time contribute to saving around USD 133,000 per well for Pertamina Hulu Mahakam. As can be seen from **Figure 7** below, main saving comes from nipple up and nipple down process. Almost 12.5 hours can be saved from nipple up process, this is achievable because heavy lifting process to install diverter bag and overboard lines can be eliminated, as those are already integrated to the rig structure. A longer time is needed for diverter test and insert packer installation. This is mainly because diverter packer does not have overshot packer so the testing is simpler than KFDJ diverter. Additional 3 hours is also needed for installation and removal of KFDJ insert packer, this is because KFDJ has two layers of packers which should be installed depends on the size of the string inside the diverter bag.

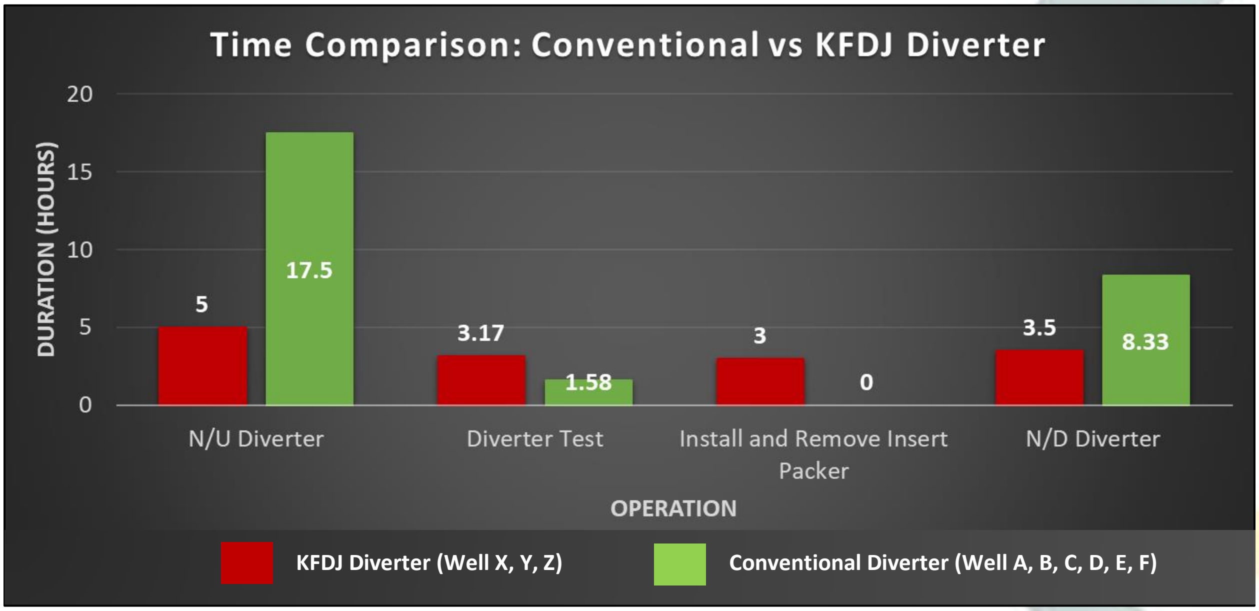

Figure 7. Time Comparison between Conventional Diverter vs KFDJ Diverter

4 Conclusion

KFDJ diverter has been implemented successfully in offshore Bekapai, Mahakam field. The trial has been successful without any issue. Risk assessment and derogation has been made in order to comply with company rules.

Through the utilization of KFDJ diverter to drill shallow gas section, Pertamina Hulu Mahakam can reduce 12.75 hours of rig operation time per well. The cost saving is equal to USD 133,000 per well.

Moreover, diverter installation process can be done more safely due to significant reduction in heavy lifting process during nipple up and nipple down diverter and overboard lines.

Further improvement is needed, especially to have a more robust way to test overshot packer which is connected to riser extension for a faster testing process. In the future rig contract, it is recommended to accommodate the utilization of KFDJ diverter.

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Attachment A

No.	Task	Hazard; Risk & Consequence	Initial Risk			Risk Reduction Measures	Residual Risk			Action Party	Target Date	Last Minute Risk Assessment
			S	P	R		S	P	R			
1	**Non-Complete Shut Off condition:** **A. No string at hole** i.e all the surface BHA are out of the hole and preparation of running surface casing. **B. No insert packer installed** during changing / removing the insert packer due to OD of bit, BHA / casing hanger / wellhead.	**Hazard 1;** Uncontrolled well kick incident (blowout) during Non-Complete Shut Off (CSO) Condition										
		Human Consequence	6	4	24		3	3	9			
		Multiple Fatalities (Internal > 5) due to fire and explosion following blow out				Follow current Shallow Gas best practice procedure (eg: Any SG incident initiate mustering, MW monitoring, No Hot Work Permit, maximum 70 T load on derrick for rig evacuation , etc).	X	X		Co-Man	Continous	PJSM - Shallow Gas Drills
						Ensure 1 supervisor (Co-man/Toolpusher/OIM/Rig superintendent) on rig floor during shallow gas drilling	X	X		Co-Man	Continous	
						Socialization regarding 1 barrier only during shallow gas drilling, 100% LEL & 40% LEL in every pre-spud, induction, and Poster. 100% LEL zone has to be clear of personnel during Shallow Gas incident.		X		Co-Man	Continous	
						Ensure shallow gas checklist has been completed.	X	X		Co-Man	Continous	
						Ensure crew understand KFDJ operation and run kill string by performing training and drill, particularly identify operation without string in the hole, inability for complete shut off		X		Rig Supt.	Continous	
						Electrical internal inspection for explosion proof and thermograph inspection on electrical equipment every year (all equipment is explosion proof inside 40% LEL Zone).	X	X		Rig Supt.	Continous	
						Ensure no heat source that may be exist during incident in zone 40% LEL. The platform boom tip during SG section wont be activated as ESD-1 logic is platform shut down without depressurization.	X	X		Rig Supt.	Continuous	
						Initiate deluge system during SG incident to disperse HC released.	X	X		Rig Supt.	Conditional	
						Visually check wind and heat shield if any poor condition observed before drilling surface section.	X	X		Rig Supt.	Continous	
						Ensure that the 17-3/4" insert packer and 10" insert packer with the running tools are located on the rig floor.		X		Rig Supt.	Continous	
						Ensure kill string is always available on the rig floor during non-CSO period with good and proper placement (avoid tripping hazard).		X		Co-Man	Continous	
						Define procedure to run kill string, including well killing method. Kill string should be run and slip on rotary table after POOH surface section BHA (during RIH casing preparation).		X		Co-Man	Continous	
						Flowcheck for minimum 15 minutes before pulling top BHA under KFDJ diverter.		X		Co-Man	Conditional	
						Trip tank alarm during non-CSO period to be more stringent to detect anomaly in more sensitive manner.		X		Rig Supt.	Continous	
						Wet Drill to install the kill string.		X		Co-Man	Conditional	
						Continously monitor trip tank while RIH casing preparation.		X		Mud Logger	Continous	
						Ensure KFDJ Diverter function test, flow test, and hydrostatic test is completed properly.		X		Rig Supt.	Continous	
		Environment Consequence	5	4	20		3	3	9			
		Large scale environment pollution from influx fluid (oil)				Follow all risk reduction measures for human consequences section.	X	X		As mentioned	Continous	PJSM - Shallow Gas Drills
						Installation of oil boom as per Oil Spills Contigency Plan.	X			Rig Supt.	Conditional	
		Material Loss	6	4	24		3	3	9			
		Loss of well, platform and rig. Material losses > 100 M €				Follow all risk reduction measures for human consequences section.	X	X		As mentioned	Continous	PJSM - Shallow Gas Drills
		Media Impact	5	4	20		3	3	9			
		International press / TV				Follow all risk reduction measures for human consequences section.	X	X		As mentioned	Continous	PJSM - Shallow Gas Drills
		Production Shortfall	5	4	20		3	3	9			
		Loss of production due to platform shutdown > 1 Mboe				Follow all risk reduction measures for human consequences section.	X	X		As mentioned	Continous	PJSM - Shallow Gas Drills
						No production from all wells in the platform during well control situation (platform ESD 1 activated with manual blowdown).	X			Co-Man	Conditional	

Severity of Consequence	1 Minor	2 Moderate	3 Serious	4 Very Serious	5 Catastrophic	6 Disastrous
Production Shortfall	< 2K boe	≥ 2K boe	≥ 20K boe	≥ 200K boe	≥ 1M boe	≥10M boe
Media Reaction	Local rumour or no media consequence	Local rumour / regional press	Regional press + regional TV national rumour	National press + national TV	International press + international TV	International press + international TV for prolonged period
Material Loss	< 20K €	≥ 20K €	≥ 200K €	≥ 2M €	≥10M €	≥100M €
Environment Impact	Minor spill with no environmental impact	Minor pollution with a very limited environmental impact	Moderate pollution with limited environmental consequences	Pollution having significant environmental consequences	Large-scale pollution of ecosystems having a recognized ecological value	Pollution having massive and durable consequences for vast ecosystems having a high ecological value
Personnel Safety	First aid or medical treatment or restricted work days	Single lost-time injury (LTI) with no disability	Single lost-time injury (LTI) with disability or multiple lost-time injuries	Internal: 1 Fatality &/or several disabilities Public: Disabilities	Internal: >1 Fatalities Public: 1 Fatalities	Internal: >5 fatalities Public: >2 Fatalities

Production Shortfall (or Gain)	Personnel Safety, Environment Impact, Material Loss & Media Reaction	Probability / Likelihood of Occurrence		1 Minor	2 Moderate	3 Serious	4 Very Serious	5 Catastrophic	6 Disastrous
Incident almost inevitable under current conditions (or for gain) Certain fully successful modification outcome	Expected to occur several times during plant lifetime	**Very Likely** $> 10^{-1}$	6	6	12	18	24	30	36
Incident probable with additional factors (or for gain) High likelihood of fully successful modification outcome	Could occur several times during over plant lifetime	**Likely** $10^{-1} - 10^{-2}$	5	5	10	15	20	25	30
Incident possible with additional factors (or for gain) Some uncertainty of successful modification outcome	Could occur once for every 10 to 20 similar plants over 20 to 30 years of plant lifetime	**Unlikely** $10^{-2} - 10^{-3}$	4	4	8	12	16	20	24
Combination of rare factors required to cause an incident (or for gain) High uncertainty of successful modification outcome	One time per year for at least 1000 units. One time for every 100 to 200 similar plants in the world over 20 to 30 years of plant lifetime. Has already occurred in the company but corrective action has been taken	**Very Unlikely** $10^{-3} - 10^{-4}$	3	3	6	9	12	15	18
Freak combination of factors required to cause an incident	Has already occurred in the industry but corrective action has been taken	**Extremely Unlikely** $10^{-4} - 10^{-5}$	2	2	4	6	8	10	12
No similar incident in industry	Event physically possible but has never or seldom occurred over a period of 20 à 30 years for a large amount of sites (> few thousands, ex: wagons, process drums,…)	**Remote** $< 10^{-5}$	1	1	2	3	4	5	6

for more detail definitions, refer MHK-COMP-RUL-EP HSE -0102 HSE Event Definitions Reporting & Recording

- *Risk Level 1* – *First priority, risk level to be obligatory reduce to level 2 or 3*
- *Risk Level 2* – *Tolerable risk level if demonstrated to be ALARP*
- *Risk Level 3* – *Broadly acceptable risk level*

Major Consequence

Severe Consequence

Attachment B

Nipple Up KFDJ Diverter

1. Prepare permit to work (PTW) and tool box talk (TBT).
2. Install 60 ft. rig-up slings to the TDS.
3. Using the crane, lift the 30" Riser extension. Complete with the CCFB bottom box connector to the Catwalk machine.
4. Connect the Riser extension to the TDS rig-up slings.
5. Using the TDS, hoist up the 30" riser extension while slowly manipulating the catwalk machine to aid tailing in the Riser extension. Retract TDS and touch Riser extension down on the rig floor.
6. Remove the master bushing.
7. Using TDS, lower the Riser extension assembly down through and land off on the CCFB pin connector. Cameron to witness connection. Rotate 30" riser extension to lock in onto connector.
8. Using man rider, remove shackles from the top of the 30" riser extension and recover slings to the rig floor.
9. Pick up Overshot with crane to catwalk and attach TDS rig up slings to the lifting collar.
10. Tail in the overshot with the CWM and set down in rotary table. Check and clean EC6 connection.
11. Remove slings from the lifting collar.
12. Ensure 17-3/4" solid insert packer has already installed inside KFDJ Diverter. Then, Connect TDS slings with manual elevators to KFDJ Diverter and install into housing.
13. Stab in diverter into overshot. Then make up with threaded ring and lock with Allen key studs both sides.
14. Driller picks Diverter and remove Overshot lifting clamp.
15. Driller to lower and line up the diverter in the housing and land out in housing and overshot.
16. Install hydraulic control lines to Diverter and overshot.
17. Bring KFDJ Diverter control unit on line and pressurize system.
18. Active Diverter Lockdown dogs and apply 10 Kips over pull test using the bails to pull and not the rig up slings.
19. Release and remove Diverter running tool.

Attachment C

- **Install 10" Split Insert Packer during RIH BHA (within BHA Interval, before drilling)**

**Install 10" split insert packer after 1st stand of BHA is run and slipped in hole because the size of bit and stabilizer is bigger than 10" which cannot pass the split insert packer.*

1. Ensure all stabilizers in BHA has already pass through the KFDJ Diverter before installation.
2. Connect BHA string to TDS. TDS will hold the BHA weight temporarily.
3. Run the string down onto the rotary table. Ensure the stick up has sufficient height to allow picking up the insert packer.
4. Prepare handling gear connected to air winch sling.
5. Hook handling gear onto the 10" split insert packer (which has been prepared in advance on rig floor)
6. Remove the master bushing assembly in rotary table.
7. Pick the 10" split insert packer into the KFDJ Diverter and lock it.
8. Unlatch the air winch sling from 10" split insert packer.
9. Install back master bushing assembly.
10. Continue running in hole BHA and drilling.

- **Retrieve 10" Split Insert Packer during Pump OOH BHA (within BHA Interval)**

** Retrieve 10" split insert packer before 1st stand of BHA pass through KFDJ Diverter in hole because the size of bit and stabilizer is bigger than 10" which cannot pass the insert packer.*

1. Before top of drill collar pass through KFDJ Diverter (one stand above drill collar), perform flow check minimum 15 minutes. If static, continue operation. If not static, do as per shallow gas procedure.
2. Monitor well on the trip tank continuously until **kill string assy.** has been set.
3. Continue pump out of hole surface section BHA. Stop when the stabilizer below the KFDJ Diverter.
4. Set slip to the BHA string. Connect BHA string to TDS. TDS will hold the BHA weight temporarily.
5. Remove the slip, run the string down onto the rotary table. Ensure the stick up is not too high but has enough height to allow the insert packer picked up.
6. Prepare handling gear connected to air winch sling.
7. Remove master bushing assembly in rotary table.
8. Hook handling gear onto the 10" split insert packer inside KFDJ Diverter.
9. Unlock the 10" split insert packer and pick up to the rig floor.
10. Unlatch the air winch sling from 10" split insert packer.
11. Install back master bushing assembly into rotary table (optional/depends on BHA size).
12. Continue operation to pull out of hole all BHA

- **Retrieve 17-3/4" Solid Insert Packer before Make Up Casing Hanger Assy.**

**After the last joint of casing (below hanger assembly) have made up to the casing string, retrieve 17-3/4" solid insert packer due to the size of casing hanger assembly is bigger than 17-3/4" which cannot pass the insert packer.*

1. Monitor well on trip tank continuously until 13-3/8" casing hanger assembly is landed and 17-3/4" solid insert packer has been installed back.
2. Connect casing string to CDS. CDS will hold the casing weight temporarily. Ensure the stick up is sufficient to allow the insert packer to be picked up.
3. Prepare handling gear connected to air winch sling.
4. Remove the Flush Mounted Slip (FMS) that has been used during running in hole surface casing.
5. Hook handling gear onto the 17-3/4" solid insert packer and unlock it.
6. Pick the 17-3/4" solid insert packer out of the rotary table. The insert packer will still encircle the casing string above rotary table (stick up) that is hanged by CDS.
7. Install back FMS assembly.
8. Run the casing string down onto the rotary table, then set slips to the casing string.
9. Disconnect the CDS from casing string.
10. Lift the 17-3/4" solid insert packer out of casing string to the rig floor.
11. Pick up casing hanger assembly.
12. Make up casing hanger assembly to the casing string.
13. Take casing string weight on CDS.
14. Continue run casing hanger assembly through rotary table.

- **Install Back 17-3/4" Solid Insert Packer after Run Casing Hanger**

**Install back 17-3/4" solid insert packer to allow Complete Shut Off (CSO) ability of KFDJ Diverter during cementing job until well is completed.*

1. Monitor the trip tank continuously until 17-3/4" solid insert packer has been installed back.
2. Run the casing string (with Casing hanger assy. installed) down into the rotary table until casing hanger Assy. pass through KFDJ Diverter, then set slips to the casing string. Ensure the stick up is sufficient to allow the insert packer be picked up.
3. Prepare handling gear connected to air winch sling.
4. Hook handling gear onto the 17-3/4" solid insert packer. Put the 17-3/4" solid insert packer onto the rotary table. The 17-3/4" solid insert packer will encircle the casing string.
5. Connect casing string to CDS. CDS will hold the casing weight temporarily.
6. Remove the Flush Mounted Slip (FMS) that has been used during running in hole surface casing.
7. Pick the 17-3/4" solid insert down and set into KFDJ Diverter and lock it.
8. Unlatch the air winch sling from 17-3/4" solid insert packer.

9. Install back FMS assembly.
10. Continue operation to land 13-3/8” Casing Hanger