





DIMENSION BID
WELL INTERVENTION | PERFORATION SERVICES

PETRONAS
CARIGALI



TIONG – A06 TEMPORARY ANNULUS PLUG PUMPING

Revision: 4
Prepared for: M. Hilmi Abu Bakar / Daniel
Date Prepared: 12 May 2023
Well: A 06
Field: Tiong
Operation Region: PMA
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 DIMENSION BID <small>WELL INTERVENTION PERFORATION SERVICES</small>	DIMENSION BID COILED TUBING SERVICES		
	Tiong A-06	Annulus Lubrication	

DESIGN VERIFICATION

PREPARED BY DB

CTS Operation Engineer

Muhammad Hafiz saharuddin

14/6/2023

Date

REVIEWED BY DB

CTS Technical Advisor

Kung Yee Han

14/6/2023

Date

APPROVED BY DB

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Alif Amirul Adenan

14/6/2023

Date

APPROVED BY PCSB

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M Hilmi Abu Bakar

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APPROVED BY PCSB

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M. Izwan B. A. Jalil

Date



APPROVED BY PCSB

Head of Integrity
Well Intervention, PMA

M Azza B. Zaini

Date

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Remark: Do not execute the procedures in this document if it is not fully approved and signed by all parties.

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PERSONNEL CONTACT

Any means of following doubt / unusual parameters / Emergency, please contact Dimension Bid personnel in onshore immediately.

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4	Mohammad Faizal Ali	Operation Engineer	DB	Kemaman	013 – 736 1046
5	Muhammad Hafiz	Operation Engineer	DB	Kemaman	019 – 264 0410

REVISION HISTORY

Rev. No	Section	Date	Revised By
0	All	8/2/2023	Muhammad Hafiz Saharuddin
1	Change plug setting depth from 2,510-m to 1,840-m (3-1/2" Prod tubing) Revised volume calculation base on setting plug at depth 1,840-m. Removed step procedure at GLV 4	5/3/2023	Muhammad Hafiz Saharuddin
2	Change from Install GLV at GLM#2 to remove Dummy valve / GLV at GLM#2	6/4/2023	Muhammad Hafiz Saharuddin
3	To include step bleed and lubricate at SCP before PCP operation	12/5/2023	Muhammad Hafiz Saharuddin
4	To include injectivity test prior for bleed and lubricate operation at SCP	14/6/2023	Muhammad Hafiz Saharuddin

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OBJECTIVES

The objective of this job is;

1. To perform temporary annulus plugging through bull heading operation

BACKGROUND

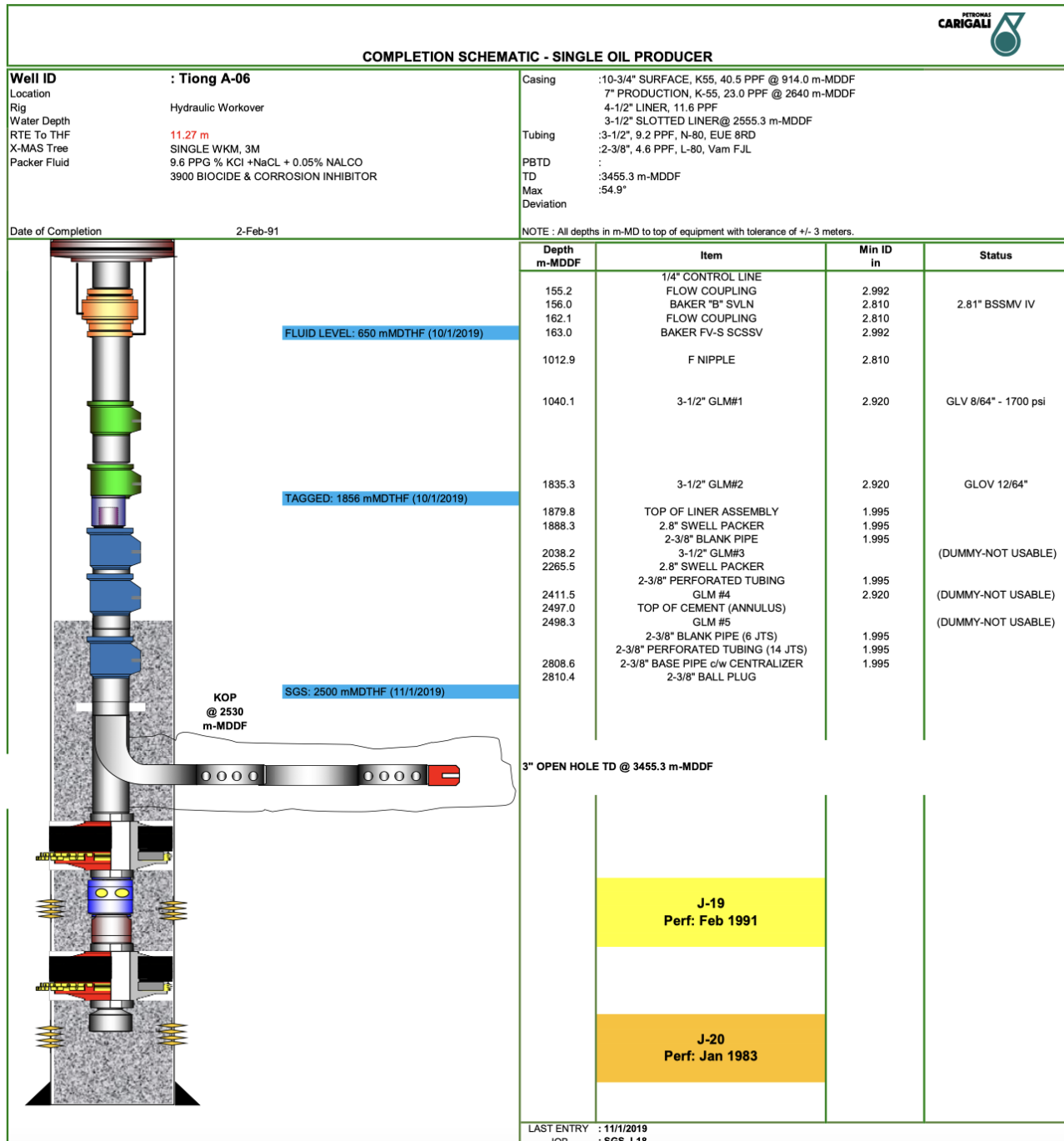
Tiong A-06 is single oil producer well. Solar unable to bleed the Annulus production casing pressure prior to repair Annulus production casing valve. PCSB approach DB to do pumping operation through Annular casing A-06 to enable the repair job on this well.



WELL DATA

Input Parameter	Parameter Value
Well Name	Tiong A-06
Well Type	Oil Producer
Reservoir	J-19. J-20
Reservoir Pressure	862.5 psi
Temperature at top cement	93.3 deg C
Fracture Gradient	N/A
Additional Information / Notes / Special Requirement:	
<ul style="list-style-type: none"> N/A 	

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WELL DIAGRAM



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OPERATION SUMMARY

Item	Job Description	Remark
A	Slickline Activity	1. Set plug below top of cement in Annular casing, 2,510m MDDF 2. To remove the dummy valve / GLV at depth 1,835.3m, GLM#2
B	Bullheading Operation	3. Perform pumping through Annular casing A-06

PRESSURE CALCULATION

Zone J19/20 – Treated Seawater

Reservoir pressure = 862.5 psi

Fluid	Fluid Density, ppg	Top of Cement. TVD, ft	Hyd. Pressure, psi
Treated Sea Water	8.5	5701	2,520

Fluid	Fluid Density, ppg	Top of Gel. TVD, ft (10bbl)	Hyd. Pressure, psi
Treated Sea Water	8.5	5,455	2,411



TREATMENT VOLUME

Description	Detail
Tubing Specification	3-1/2" 9.2ppf#
Prod. Casing Specification	7", 23ppf#

Type	External Pipe			Internal Pipe			Caps	From	To	From	To	Length	Total Volume (bbls)
	OD (inch)	ID (inch)	W(lb/ft)	OD (inch)	ID (inch)	W(lb/ft)	Barrel/lin (ft)	m	m	ft	ft	ft	
7" Casing surface until top of cement	7	6.366		3 1/2			0.02747	11	2,497	37	8,193	8,156	224
3 1/2 " Tubing until top of linear assembly	3 1/2	2.992					0.00870	11	1,880	37	6,168	6,131	53
3 1/2 " Tubing until top of plug	3 1/2	2.992					0.00870	11	1,840	37	6,037	6,000	52
Top of linear assembly until ball plug	2 3/8	1.995					0.00387	1,880	2,810	6,168	9,221	3,053	12
												TOTAL	341

Type	External Pipe			Internal Pipe			Caps	From	To	From	To	Length	Total Volume (bbls)
	OD (inch)	ID (inch)	W(lb/ft)	OD (inch)	ID (inch)	W(lb/ft)	Barrel/lin (ft)	m	m	ft	ft	ft	
Surface casing (B-Annulus)	10 3/4	10.05		7			0.05052	0	914	0	2,999	2,999	151
												Porous Medium	50%
												TOTAL	76

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SAFETY OPERATIONAL PROCEDURES

Prior to commencement of the Pumping operation, a pre-job meeting will be held. This should be attended by the following parties as a minimum:



OIM, WSS, Pumping Supervisor, Representatives of other service companies involved and others as necessary.

Safety meetings should be held at the start of every shift and risk assessments must be evaluated during this time. Tool box talks should be held immediately prior to the job execution.

Note: The safety meeting must be driven by DB Supervisor addressing the following topics as a minimum:

1. Muster point.
2. Take list of personnel on site (Head count)
3. All personnel should review and be familiar with escape routes and emergency procedures.
4. Describe the **job objective, fluids and volumes to be pumped, pressures expected** during the job, and others.
5. Review **Dimension Bid Operations Policy and Procedure Manual**.
 - 5.1. Ensure at all steps carried out during the operations comply with this Manual.
 - 5.2. Management of change **MUST** be applied any time there is a need to deviate from the steps contained this procedure.
 - 5.3. A document **MUST** be created describing each the step of the deviation. This document shall also include the deviation Risk Assessment and it **MUST** be approved and signed by PCSB – Head of Well Intervention and Dimension Bid Operations Manager.
6. Exercise stops work authority if unsafe condition occurs and assess situation with all team members, resume operation after mitigation plan is in place.
7. Personnel responsibilities throughout the job.
8. Spills, fire, blow out, unexpected well behaviour.
9. Emergency shower station and eye wash station location.
10. Trapped potential energy such as pressure or coiled tubing stiffness.
11. Prepare related Job Hazard Analysis (JHA) prior commencement of any work, get approval from Client Site Representative (CSR) and review it with all personnel involved as well as to review Risk Assessment.
12. Discuss the well H₂S, CO₂, Hg (Mercury) content (if applicable).
13. Adhere all **PCSB Zeto Rules** and other guidelines.
14. Take a physical count of inventory and make sure all required materials are available on site.
15. **Barricade** the work area and display the appropriate **warning sign**.
16. On chemical mixing and handling; all personnel involved shall hold **safety meeting** and review **Safety Data Sheet (SDS)**.
 - 16.1. Personnel involve during chemical handling shall be briefed by DB Chemical Specialist onsite and extra precautions must be taken. All SDS must be available on site and reviewed prior chemical handling.
 - 16.2. All non-essential personnel shall stay away from mixing site.
 - 16.3. Use PPE including respirators, hard hats, eye protection and steel-toed boots.
 - 16.4. Verify if there is any **dead Volume** in the mixing tanks and adjust volumes to account for non-usable volume in the blender / mix tank.
 - 16.5. Consider wind direction and note all trip hazards in the mix / pumping area.

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- 16.6. Prior to mixing chemicals, clean and verify the tank/batch mixer and lines are free of any debris and or contaminants.
- 16.7. In case of spill; wash the place where any chemical has been spilt with available spill kit.
- 16.8. Take care to prevent leakage due to ejection from valves, fittings, flanges, or other joints flexible chemical hoses and pumps. Never repair the equipment during transfer into mixing tank/container.
17. Take reading of Shut in / Flowing Tubing Head Pressure (SI/F/THP), Casing Head Pressure (CHP) and fluid sample (if available) prior to operation.
18. Check gas lift condition and capability with Site Operation Representative (SOR).
19. Ensure fitness prior to perform duties assigned.
20. Ensure all barriers are in place and followed.

HEALTH, SAFETY & ENVIRONMENT

1. Evaluate possible risks to arise during the job execution.
2. Evaluate risk assessment. Report any abnormal or insecure condition on site, taking into account all the steps or procedures to follow. Discuss with PCSB HSE coordinator, the execution or suspension of the job.
3. Review SDS of each product that will be used. Verify that all personnel on location handling toxic or corrosive products have the proper PPE.
4. Review the contingency plan for spills.
5. Do not vent / release any hydrocarbons from the well to atmosphere.

Notes: - Prior to DB personnel walking on upper deck, DB Supervisor to inspect upper deck and ensure that the area it is in good condition (Gratings, Hatches, etc.)

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EQUIPMENT RIG-UP PROCEDURE

1. Hold a pre-job safety meeting. Discuss the rig up activities including the equipment lay out, lifting operations, crew roles and responsibilities and review the JHA as well.
2. Spot the equipment accordingly to space availability. Delegate only one personnel as the signalman and ensure every equipment has at least two tag line tied perpendicularly.
3. Rig up the LP hoses from fluid storage tanks to single pump unit.
4. Rig up 2" HP treating line as per DB Technical Standard from single pump to the Annular casing connection. Ensure a bleed off line is installed in the line and secure it firmly. (As per P&ID in appendix)
5. Check the THP and record it accordingly if any. Bleed off all pressure to as low as possible (if required).
6. Make up correct Annular Casing (production casing) crossover to the main treating line.
**Job Supervisor to confirm with Client Representative on well handover status prior to rigging up on the wellhead.*
7. Install a plug valve after the crossover then secure all line with safety cable.
9. Proceed to prepare for pressure test as per below.

PRESSURE TEST PROCEDURE

1. Job Supervisor to hold a pre-pressure testing safety meeting.
2. Perform EMC 1 for the single pump unit.
3. Prime the unit completely.
4. Ensure the entire valve are lined up above the master valve.
5. Start flush the treating lines with treated seawater.
6. Ensure the swab valve and master valve at the x-mas tree are closed.
7. Perform pressure test for the treating lines up to 500 psi and hold for 5 minutes. Inspect the lines for leaks and observe any pressure drop.
8. Increase pressure to 3000 psi and hold for 10 minutes. Inspect the lines for leaks and observe any pressure drop.
9. Once completed, bleed off pressure through the bleed off line by fully opening the master plug valve (2x1 plug valve) then slowly open the control valve (2x1 plug valve). Ensure pressure is bled to zero.

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OPERATIONAL PROCEDURE

Conduct safety meeting with all personnel on location detailing the program, pressure limitations, personnel responsibilities, emergency well control drill, and safety precautions.

SLICKLINE OPERATION & PRE-PREPARATION PRIOR FOR ANNULUS PUMPING

1. Pumping supervisor to witness the following slickline intervention and record it in treatment and daily report.
2. Slickline to conduct TCC run to ensure the tubing path is clear from obstruction prior to installation of plug below 2,510m/8,235.3ft MDDF (depth top of cement inside Annular casing).
3. Record any fluid level or any HUD encountered.

Description	Depth
Fluid level	
HUD	

4. Slickline to set plug at depth 1,840m/6,037ft MDDF,

Description	Depth
Plug	1,840m / 6,037 ft

5. Once slickline completed, proceed to pump and fill up tubing prior for tubing integrity test (TIT).
6. Perform Positive pressure test to ensure that the plug is holding.
7. Prepare treated sea water as per below for pumping activity;

Treated Sea Water (TSW)				100	BBL	Description
Seq.	Product	Concentration		Volume		
1	Sea Water	992	gptg	4,166	gal	Base Fluid
2	ACM H2S Clear 200	2	gptg	8	gal	CO2 & H2S Corrosion Inhibitor
3	ACM BACT 200	2	gptg	8	gal	Micro Biocide Control
4	ACM OXYFREE 100	2	gptg	8	gal	Oxygen Scavenger
Mixing Instruction: <ol style="list-style-type: none"> 1. Prepare Sea Water into the mixing tank. 2. Add ACM H2S Clear 200 into the tank and circulate the mixture. 3. Add ACM BACT 200 & ACM OXYFREE 100 into the tank and circulate the mixture until homogenous. 						

Note: The above recipe is for 100bbls of TSW. Please prepare another batch of Treated Sea Water once needed.

8. Manipulate Surface valve to the following position prior pumping activity;

Description	Position
Flow Cross Pumping Valve (DB lines)	Open
Swab Valve	Open
Lower Master Valve	Open

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Production Wing Valve	Close
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8.1. While opening up Lower master valve, count turns for future reference.

9. Prior start pumping activity, complete the following:

9.1. Record shut in tubing head pressure (SITHP) and Annular casing pressure. Include in daily report.

Annular Casing Pressure (psi)	SITHP (psi)

9.2. Bleed off tubing and casing pressure to minimum as possible.

10. Open plug valve at the surface line that connects to pump-in tee and start pumping. Fill up completion tubing followed with pressure test.

10.1. Pressure test 500 psi and wait for 30 minutes.

10.2. If pressure holding good proceed to step 11

11. Slickline to open GLV#2 (1,835.3m), for circulation port prior to pumping operation.

BLEED AND LUBRICATE AT SURFACE CASING (B-ANNULUS)

12. Rig up 2" HP treating line as per DB Technical Standard from single pump to the Surface casing connection. Ensure a bleed off line is installed in the line and secure it firmly.

13. Check the SCP and record it accordingly if any.

14. Make up correct Surface Casing crossover to the main treating line.

*Job Supervisor to confirm with Client Representative on well handover status prior to rigging up on the wellhead.

15. Make up correct Surface Casing crossover to the main treating line. Perform pressure test.



16. Bleed off all pressure to as low as possible (if required).

17. Check Surface casing pressure, ensure our pumping pressure higher than surface casing pressure prior to open the gate valve (If unable to bleed to zero).

18. Perform Injectivity test prior for bleed and lubricate activity: -

18.1. Fill up B-Annulus Sect with Gel, once complete fill up

Pumping schedule for Injectivity Test						
Stage	Description	Fluid	Vol (bbl)	Pump Rate (bpm)	Remarks	MASTP (psi)
1	Fill up completion volume	Gel	15 bbls / till return is observed at surface / Pressure Build up	0.15 (as minimum as possible) – 1.5	15 bbls volume with assumption 50% porosity In B-Annulus, if after 15 bbls of gell well still not full, switch to fill up using TSW	50% from MAWOP
2	Fill up completion volume	TSW	till return is observed at surface /	0.15 (as minimum as	15 bbls volume with assumption 50% porosity In B-Annulus,	50% from MAWOP

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			Pressure Build up	possible) – 1.5		
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Notes: If during stages to fill up annulus section using gel, pressure already spike due to fluid column in B-Annulus section already full even without complete pump 15 bbls of gel, switch to perform injectivity test using TIW

18.2. Once pressure build up/return observed at surface, perform injectivity test: -

Rate (bpm)	Pump Pressure (psi)	Time (min)	Volume (bbl)	THP (psi)	PCP (psi)	SCP (psi)	ICP (psi) if available
...						(as minimum as possible)	
0.5							
0.7							
1.0							
1.5							
2.0							
2.5							
3.0							
3.5							
...						(as maximum as possible)	



18.3. The maximum SCP pressure during injectivity test is 50% from MAWOP (to prevent further crack in cement section inside SCP).

18.4. In the event unable to perform injectivity test, due to lowest pump rate for high pressure pump already reach to maximum allowable pressure, switch to graco pump (subject to availability)

19. Once complete record all the data for Injectivity test, perform bleed and lubricate. Volume to be pump as per below for bleed and lubricate: -

Annular pumping schedule						
Stage	Description	Fluid	Vol	Pump Rates	Remarks	MAWOP / MSTP (PSI)
			(bbl)	(bpm)		
1	Temporary plug solution	Gel	15	0.3 – 1.5	to temporary plug the leak area inside the casing (to cover at least 20% of surface casing volume(50%porous))	939

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					If able to cure the leak, doesn't have to complete the pump volume	
2	Treated Sea Water	TSW	16	0.3 – 1.5	If able to cure the leak, doesn't have to complete the pump volume	

Notes: Volume above is for 1 Volume of surface casing (B-Annulus) with 50% porosity (assumption), based on Final well report and VIVID Archer report, indicate that the surface casing and production casing were cemented until surface.

Bleed of pressure to 0 psi (if pressure present during the pumping activity), Monitor the Surface casing pressure, Annular casing pressure and THP pressure for 24 hours.

20. Initiate pumping with idle rate, slowly increase the pump rate (subject to pumping pressure).

21. Based on approved Maximum wellhead operating pressure (MAWOP) for Tiong A-6, the Maximum pressure for SCP is 939 psi, if pressure increase to 900 psi, stop pump and wait fluid to settle down, repeat step 20 until complete pumping volume or able to cure the leak completely in Surface casing.

Notes: - Based on VIVID Leak detection report, potentially leak at surface casing shoe

22. Once complete bleed and lubricate operation at B-Annulus, proceed with Step 23.

Notes: - During this Bleed and lubricate operation, if the operation require longer time due to wait for fluid to settle down, while waiting for fluid to settle down, proceed with Annulus pumping procedure as per below step (switch line from Surface casing to Production tubing/Production casing)

ANNULUS PUMPING TO TEMPORARY PLUG THE LEAK AREA INSIDE PRODUCTION CASING

23. Ensure that treating line to pump into the production tubing.

24. Prepare gel as per below for pumping activity;



D801 Gel				15	BBL	Description
Seq.	Product	Concentration		Volume		
1	Sea Water	992	gptg	625	gal	Base Fluid
2	Gel	40.5	pptg	26	lbs	Gelling Agent
Mixing Instruction: 1. Prepare sea water in the mixing tank. 2. Add D801 Gel into the tank and circulate the mixture until homogenous.						

Note: The above recipe is for 15 bbls of gel. Please prepare another batch once needed.

25. Manipulate Surface valve to the following position prior pumping activity;

Description	Position
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Flow Cross Pumping Valve (DB lines)	Open
Swab Valve	Open
Lower Master Valve	Open
Production Wing Valve	Closed
A - Annular casing	Open

25.1. While opening up Lower master valve, count turns for future reference.

26. Prior start pumping activity, complete the following:

26.1. Record shut in tubing head pressure (THP) and Annular casing pressure, Include in daily report.

Annular casing pressure (psi)	SITHP (psi)

26.2. Bleed off tubing and casing pressure to low as possible.

27. Open plug valve at the surface line that connects to pump-in tee and start pumping to fill up 1 annular volume casing vs completion tubing, or observe constant solid return at surface.

28. After complete fill up, proceed to pump as per below table:



28.1. Record the following parameters while pumping. Include the following table in daily report.

Time (min)	Pump Pressure (psi)	Volume (bbl)	THP (psi)	Annular Casing Pressure (psi)	Remark

For GLV#2 Circulation port refer below table: -

Annular pumping schedule (for GLV#2 circulation port)					
Stage	Description	Fluid	Vol	Pump Rates	Remarks
			(bbl)	(bpm)	
1	Temporary plug solution	Gel	10	0.3 – 1.5	to temporary plug the leak area inside the casing (full Annular casing volume until cement section 224
2	Treated Sea Water	TSW	52	0.3 – 1.5	Gel were now be positioned at GLV#2 (At annular side)
Line up treating line to pump into annulus of casing versus completion tubing. Ensure that pumping line to Tubing and flow wing valve is in close position.					
3	Treated Sea Water	TSW	60	minimum rate	To push gel into leak area. After complete pump 60 bbl, <ul style="list-style-type: none"> if no pressure builds up, continue to monitor the pressure, If before reach 60 bbl pumping volume pressure build up, pressurize 100 psi from surface to squeeze the

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					gel into leak area, once pressure drop to 50 psi re-apply the pressure to 100 psi until complete pump 60 bbls. If no pressure drops, continue monitor the pressure.)
Bleed of pressure to 0 psi (if pressure applied during the pumping at annular side), Monitor the Annular casing pressure and THP pressure for 24 hours.					

29. If Annular pressure maintain 0 psi, handover the well to solar alert, for them to proceed with Casing valve maintenance.

29.1. If there is increase in annular casing pressure, repeat step 12 until 17 with 10 bbl LCM followed with TSW, recipe as per below:

If there's no vacuum condition during the pump, proceed to pump LCM (Fine & Medium),

Loss Circulation Material (Fine & Medium)				15	BBL	Description
Seq.	Product	Concentration		Volume		
1	Injection Water	951	gptg	14.3	bbls	Base Fluid
2	Gel	60	pptg	38	lbs	Gelling Agent
3	CaCO ₃ (Fine)	476	pptg	300	lbs	Loss Circulation Material
4	CaCO ₃ (Medium)	476	pptg	300	lbs	Loss Circulation Material
Mixing Instruction: <div><div>1.</div><div>2.</div><div>3.</div></div> <div>Prepare injection water in the mixing tank.</div> <div>Add Gel powder into the tank and circulate the mixture until homogenous.</div> <div>Add Calcium Carbonate (Fine & Medium) into the mixture and circulate until homogeneous.</div>						

Note: The above recipe is for 15 bbls of LCM. Please prepare another batch of LCM once needed.

If got vacuum condition during the pump, proceed to pump LCM (Medium & Coarse).

Loss Circulation Material (Medium & Coarse)				15	BBL	Description
Seq.	Product	Concentration		Volume		
1	Injection Water	951	gptg	14.3	bbls	Base Fluid
2	Gel	60	pptg	38	lbs	Gelling Agent
3	CaCO ₃ (Medium)	476	pptg	300	lbs	Loss Circulation Material
4	CaCO ₃ (Coarse)	476	pptg	300	lbs	Loss Circulation Material
Mixing Instruction: <div><div>1.</div><div>2.</div><div>3.</div></div> <div>Prepare injection water in the mixing tank.</div> <div>Add Gel powder into the tank and circulate the mixture until homogenous.</div> <div>Add Calcium Carbonate (Medium & Coarse) into the mixture and circulate until homogeneous.</div>						

Note: The above recipe is for 15 bbls of LCM. Please prepare another batch of LCM once needed.



30. After completion of Solar Alert activity, handover the well back to production

31. Proceed to rig down the surface pumping line as per below step.

SURFACE PUMPING LINE RIG-DOWN PROCEDURE

1. Conduct safety meeting with all relevant personnel and discuss the following but not limited to trapped pressure, heavy lift, simultaneous activities, standard rig down procedures.

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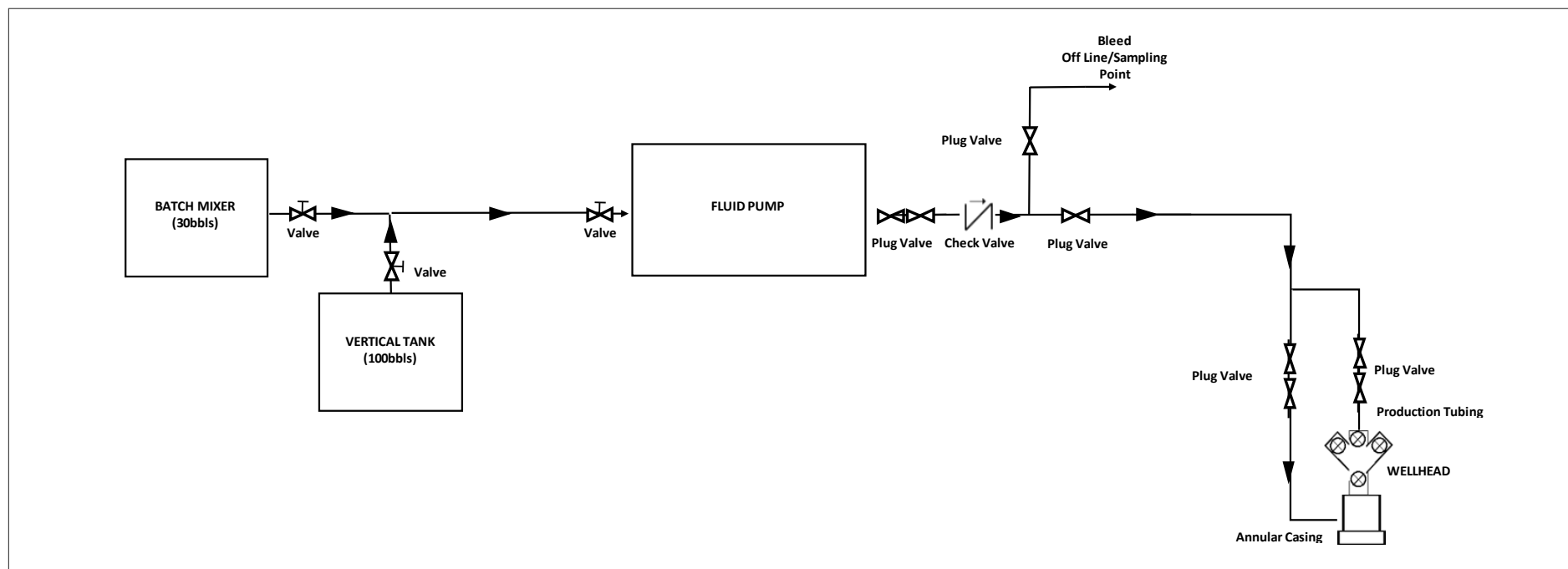
 DIMENSION BID <small>WELL INTERVENTION PERFORATION SERVICES</small>	DIMENSION BID COILED TUBING SERVICES		
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2. Rig down surface treating lines as per following guidelines:
 - 2.1. Ensure that all wellhead valves are closed.
 - 2.2. Ensure that all surface lines are flushed with fresh or sea water.
 - 2.3. Bleed off pressure in all surface lines to zero (0) psi
 - 2.3.1. Verify that there is no pressure trapped between valves
 - 2.3.2. It is recommended to have all valves in surface line opened to atmosphere prior to breaking up connections.
 - 2.4. Remove restrain from surface lines.
 - 2.5. Proceed to break connection.
 - 2.6. Rig down pumping-tee, riser / lubricator and cross-over.
 - 2.7. Properly place the surface treating lines in the iron basket

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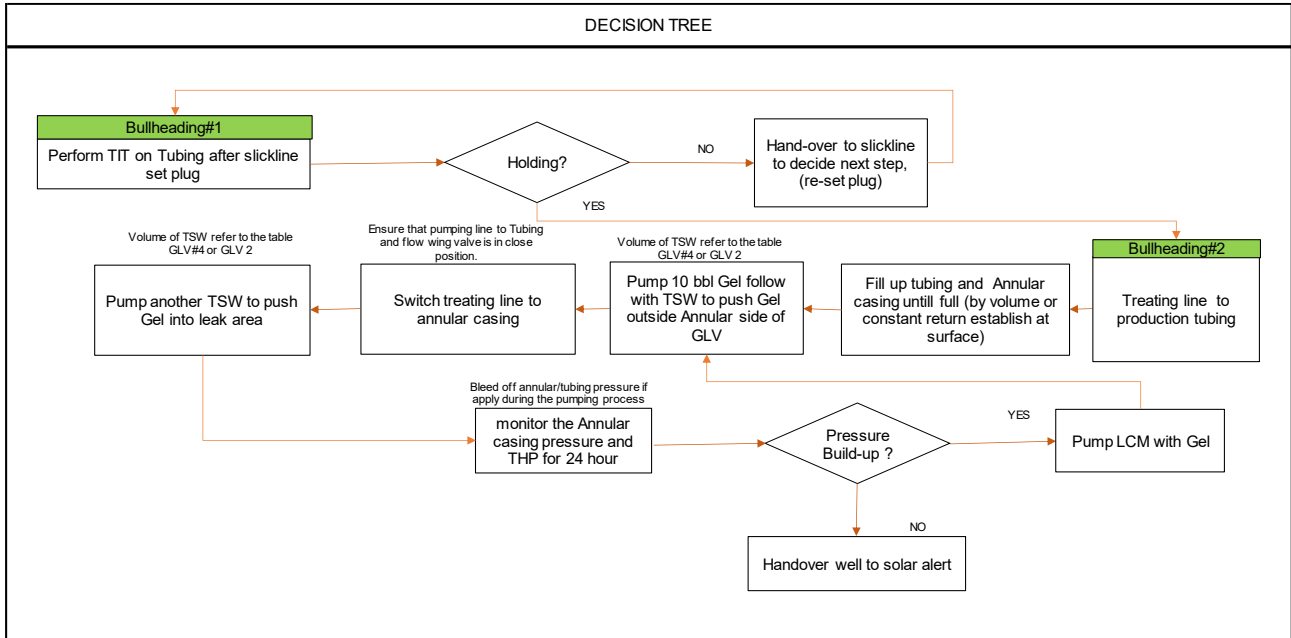
APPENDIX

SURFACE PUMPING RIG-UP DIAGRAM



APPENDIX

DECISION TREE





HEC DEGRADATION TEST (for 5 & 20 ppb in 43 and 99 deg C)

a) 5 ppb HEC

5 ppb HEC								
Period Day	0	1	2	3	4	5	6	7
Static Temp (°C)	43	43	43	43	43	43	43	43
Density	9.8 ppg	9.8 ppg	9.8 ppg	9.8 ppg	9.8 ppg	9.8 ppg	9.8 ppg	9.8 ppg
Rheo Tem (°C)	43	43	43	43	43	43	43	43
600	100	98	95	94	93	93	91	89
300	80	77	76	75	74	74	72	70
200	69	67	64	62	61	59	57	56
100	50	47	46	45	43	42	39	39
6	12	11	11	10	9	9	8	7
3	8	8	7	6	6	5	4	4
PV	20	21	19	19	19	19	19	19
YP	60	56	57	56	55	55	53	51
Degradation		6.67 %	5.00 %	6.67 %	8.33 %	8.33 %	11.67 %	15.00 %
Viscosity (cP)	50.0	49.0	47.5	47.0	46.5	46.5	45.5	44.5
5 ppb HEC								
Period Day	0	1	2	3	4	5	6	7
Static Temp (°C)	99	99	99	99	99	99	99	99
Density	9.8 ppg	9.8 ppg	9.8 ppg	9.8 ppg	9.8 ppg	9.8 ppg	9.8 ppg	9.8 ppg
Rheo Tem (°C)	99	99	99	99	99	99	99	99
600	100	80	65	52	46	35	21	9
300	80	55	48	36	30	25	19	10
200	69	26	23	18	15	12	10	5
100	50	15	12	10	7	5	2	2
6	12	14	6	4	2	0	0	0
3	8	6	2	1	0	0	0	0
PV	20	25	17	16	16	10	2	-1
YP	60	30	31	20	14	15	17	11
Degradation		50.00 %	48.33 %	66.67 %	76.67 %	75.00 %	71.67 %	81.67 %
Viscosity (cP)	50.0	40.0	32.5	26.0	23.0	17.5	10.5	4.5

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d) 20 ppb HEC

20 ppb HEC								
Period Day	0	1	2	3	4	5	6	7
Static Temp (°C)	43	43	43	43	43	43	43	43
Density	9.8 ppg	9.8 ppg	9.8 ppg	9.8 ppg	9.8 ppg	9.8 ppg	9.8 ppg	9.8 ppg
Rheo Tem (°C)	43	43	43	43	43	43	43	43
600	300	298	298	296	295	294	293	292
300	300	292	292	291	289	288	287	285
200	286	280	279	276	272	270	268	265
100	264	251	250	248	247	245	243	241
6	240	167	165	163	161	159	157	155
3	135	106	104	102	99	97	95	91
PV	0	6	6	5	6	6	6	7
YP	300	286	286	286	283	282	281	278
Degradation		4.67 %	4.67 %	4.67 %	5.67 %	6.00 %	6.33 %	7.33 %
Viscosity (cP)	150.0	149.0	149.0	148.0	147.5	147.0	146.5	146.5
20 ppb HEC								
Period Day	0	1	2	3	4	5	6	7
Static Temp (°C)	99	99	99	99	99	99	99	99
Density	9.8 ppg	9.8 ppg	9.8 ppg	9.8 ppg	9.8 ppg	9.8 ppg	9.8 ppg	9.8 ppg
Rheo Tem (°C)	99	99	99	99	99	99	99	99
600	300	207	157	130	109	85	62	51
300	300	136	93	69	62	47	36	32
200	286	120	58	43	37	28	24	16
100	264	108	46	40	32	23	17	10
6	240	63	38	29	20	15	11	6
3	135	46	21	16	10	7	3	1
PV	0	71	64	61	47	38	26	19
YP	300	65	29	8	15	9	10	13
Degradation		78.33 %	90.33 %	97.33 %	95.00 %	97.00 %	96.67 %	95.67 %
Viscosity (cP)	150.0	103.5	78.5	65.0	54.5	42.5	31.0	25.5

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D801 VISCOSITY CHART

