IATMI22-163

# Industrialization One Phase Well Perforation in Marginal Shallow Reservoir while Maintaining Proper Well Integrity Aspect: Successful Milestone in Tunu Field, Delta Mahakam, East Kalimantan.

Arif Setiaji Wibowo[*1], Nashara Ulpah[2], Giovanni Ariel[3], Taufiq Ismail[4], and Muhammad Sobirin[5]
[12345]PERTAMINA HULU MAHAKAM
* Email: arif-setiaji.wibowo@pertamina.com

Delta Mahakam facing continues production decline, the marginal stake in shallow reservoir is currently considered to be produced in order to combat production decline. A break thru innovation by implementing One Phase Well (OPW) is the simplest well design in Pertamina Hulu Mahakam regards to marginal shallow reservoir stake and cost optimization. Well architecture is only consisting of cemented tubing up to surface and conductor pipe. Perforation job is considered as the most challenging ever in well design context, it can be considered as the first perforation without any surface casing existence in the well in Indonesia. The most challenging part is implementation of simple well design to be justified as dual barrier concept during completing the well which has to be mitigated by proper risk assessment. Therefore, the objective of this project is to ensure safely perforate and produce OPW wells by implementing robust and fit for purpose mitigation. The method used is by performing specific risk assessment to determine robust mitigation and thoroughly justification in order to perforate and produce OPW with respecting well integrity aspect and dual-barriers concept. Highlight mitigation such as justification conductor pipe as external envelope containment by installing annulus bleed-off line completed with pressure safety valve, ensuring good cement quality as competence barrier, detailed and robust perforation decision tree, noise log for specific well case to ensure no communication behind casing/tubing, review formation strength and shale thickness above perforation depth, initial punch reservoir zone prior fully perforated and also intensive well monitoring during initial production phase until well is considered stable. Dedicated mitigation is then socialized and discussed with operation team on site/barge to ensure proper execution. Supervisor and team on site also performing debriefing to team to ensure step by step job operation communicated and executed as per plan. The project can be performed safely, with 35 one phase wells (OPW) have been executed, industrialized and contributed instantaneous production gain more than 60 MMscfd without jeopardizing safety and well integrity aspect. The collaboration between engineering in town and operational in site thru effective communication and socialization of mitigation based on risk assessment is one of the key of successful and safely operation. All mitigation stated in risk assessment has been implemented properly. No integrity issue observed during perforation, sand treatment and production by robust mitigations. Well integrity assurance is continuously performed and monitored which also synchronized in online well integrity monitoring system.

**Keyword(s):** One Phase Well; Perforation; Well Barriers; Well Integrity; Shallow Reservoir

## 1 Introduction

Delta Mahakam facing continues production decline as an evitable condition of existing mature field. One of the largest fields in Mahakam block was Tunu field, discovered in 1977. It has area more than 1350-kilometer squares with length between north and south area over 65 kilometers. Tunu field was initially produced in 1990 from main zone development. It is consist of Tunu main zone and Tunu main zone was located between 2500 until 5000 meter below subsea level (mSS). Then shallow zone was developed initially in 2008. It was located between 500 – 1500 mSS (Kurniawan, 2017). the marginal stake in shallow reservoir is currently considered to be produced in order to combat production decline.

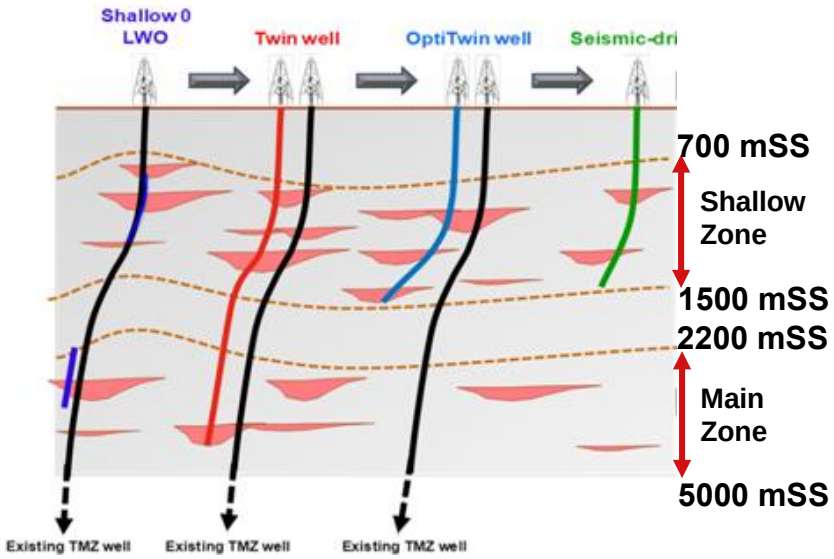


Fig. 1. Tunu typical reservoir

Pertamina Hulu Mahakam has been developed architecture in shallow zone since 2006 by drilling 2 phase in Tunu shallow area, first phase drilling using diverter to prevent from shallow gas and continue reservoir section using BOP. In 2018 – 2019 Pertamina Hulu Mahakam had successfully drill reservoir section using only diverter. In the middle of 2019 Pertamina Hulu Mahakam has successfully done surface casing perforation in three wells. This milestone lead Pertamina Hulu Mahakam to have new milestone for drilling one phase architecture well. (Hanif, et all, 2021).

A break thru innovation by implementing One Phase Well (OPW) is the simplest well design in Pertamina Hulu Mahakam regards to marginal shallow reservoir stake and cost optimization. Well architecture is only consisting of cemented tubing up to surface and conductor pipe. On one phase completion, the tubing string was cemented up to surface overlap above Top of HC (whichever the highest) as well barrier during production. Gas tight cement slurry 1.40 is used for One Phase well respectively. The idea was to remove surface casing from previously architecture, only using 3.5" tubing to minimize drilling and completion time during operations.

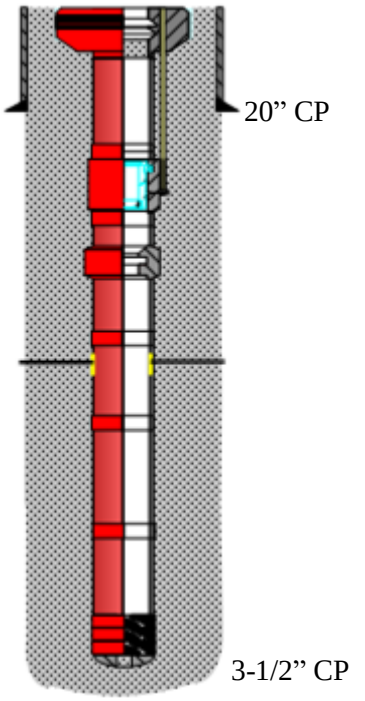


Fig. 2. One Phase Well Architecture

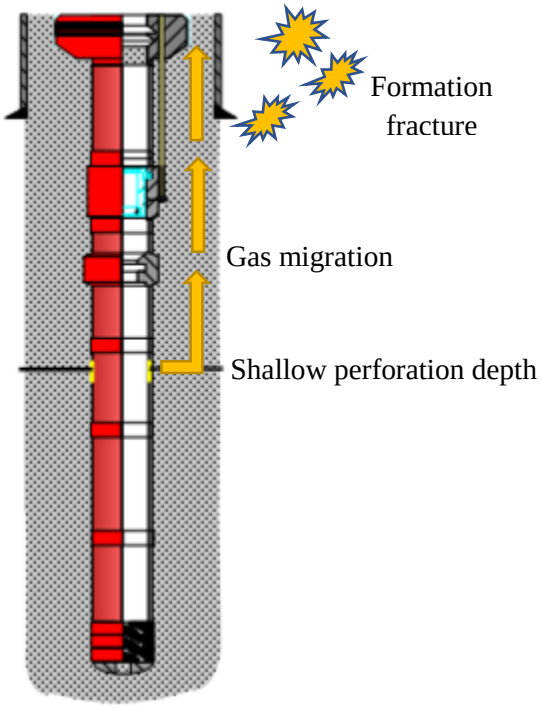


Fig. 3. Risk of hydrocarbon release

Perforation job is considered as the most challenging ever in well design context after drilling completed since there will be only 3-1/2” cemented tubing (one column cement barrier) and 20” CP. The risk of continues gas migration thru potential micro channeling cement and fracture formation at CP shoe to be thoroughly mitigated. It can be considered as the first perforation without any surface casing existence in the well in Indonesia. Once tubing perforated, cement behind tubing (A-annulus) will have direct contact with source of inflow/reservoir. The perforated reservoir is directly exposed to formation on shallow depth. Cement above perforation and DHSV will be considered as internal barrier, since it will have direct contact to source of inflow/reservoir. The external barrier consists of X-Mass Tree and wellhead system. Moreover, conductor pipe is consider acting as surface casing with limited pressure contain capability. The most challenging part is implementation of simple well design to be justified as dual barrier concept during completing the well which has to be mitigated by proper risk assessment. Therefore, the objective of this project is to ensure safely perforate and produce OPW wells by implementing robust and fit for purpose mitigation.

## 2 Method and Procedure

The method used is by performing specific risk assessment to determine robust mitigation and thoroughly justification in order to perforate and produce OPW with respecting well integrity aspect and dual-barriers concept. Highlight mitigation such as justification conductor pipe as external envelope containment by

installing annulus bleed-off line completed with pressure safety valve, ensuring good cement quality as competence barrier, detailed and robust perforation decision tree, noise log for specific well case to ensure no communication behind casing/tubing, review formation strength and shale thickness above perforation depth, initial punch reservoir zone prior fully perforated and also intensive well monitoring during initial production phase until well is considered stable. Dedicated mitigation is then socialized and discussed with operation team on site/barge to ensure proper execution. S
debriefing to team to ensure step by step job operation comm

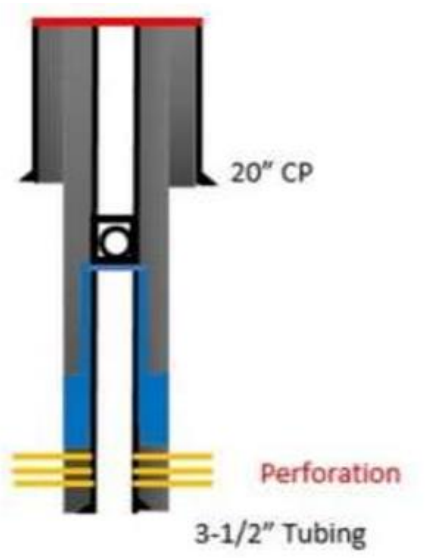


Fig. 4. Barrier Justification Approach

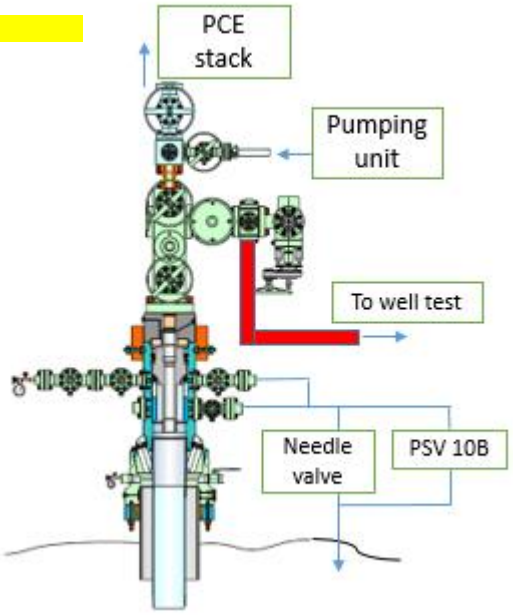


Fig. 5. Surface stack up with bleed offline in annulus

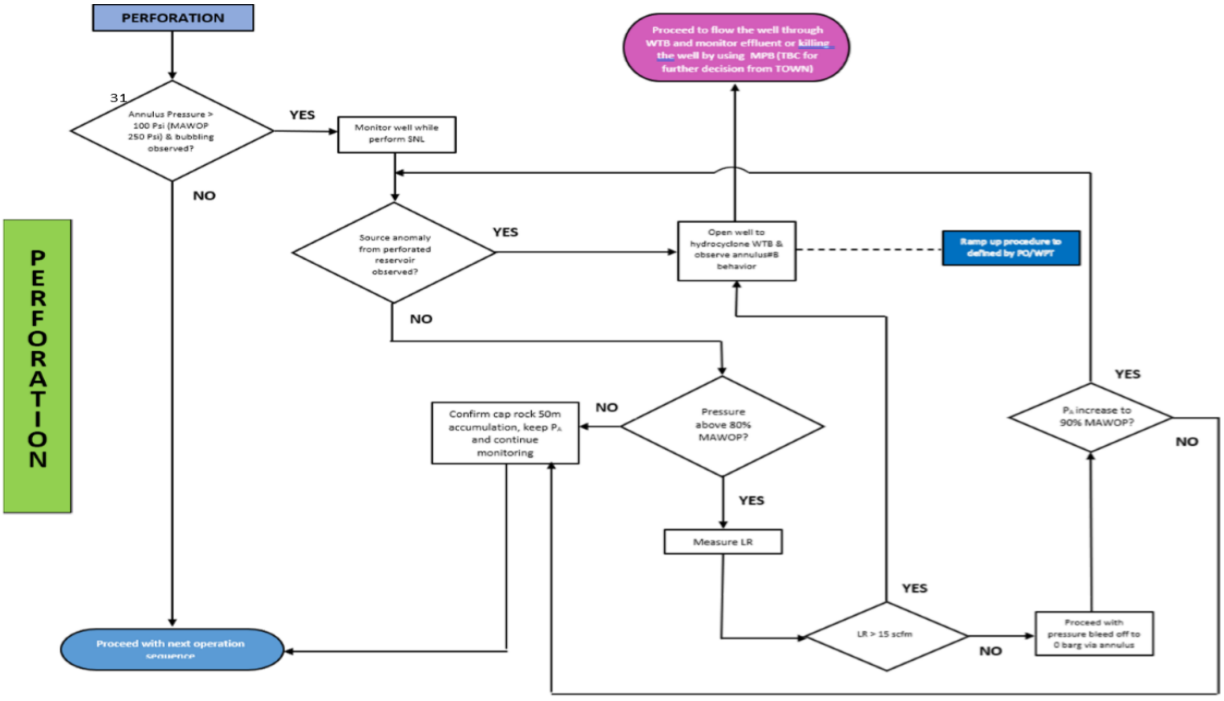

Fig. 6. Decision Tree Anomaly Pressure

## 3 Result and observation

By performing perforation in one phase well with single envelope, the associated risk is related to annulus cement channeling that leads excessive SCP (sustained casing pressure) and fractured formation at CP shoe that leads to uncontrolled HC release to surface. However, by implementing mitigation stated in risk assessment comprehensively and risk of hydrocarbon release in the event of catastrophic incident at surface will be in very low percentage of probability. It is in line with actual operation that can be performed safely without integrity issue. Below is the summary list of One Phase Wells :

| No | Field | Well Name | Well Type | Final Drilling Date | First WLI Operation Date | Est. Date Flowline Installed | MAWOP Ann#A (bar) | Ann#A Pressure (bar) | Date | Anomaly pressure (SCP)* | SNL prior Perfo | SCMT | Perfo | SNL post perfo | SCON/screen | Initial Clean Up |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | TUNU SOUTH | TN-G91 | OPW | 7-Mar-20 | 11-Jun-20 | 96 | 16 | 8.5 | 3-Jul-22 | Yes | DONE | DONE | DONE- NO issue | - | DONE -no issue | DONE - Qgas : 2.701 MMscfd |
| 2 | TUNU SOUTH | TN-AA223 | OPW | 6-May-20 | 3-Oct-20 | 150 | 14 | 2.5 | 6-May-22 | No | DONE | DONE | DONE- NO issue | DONE | DONE -no issue | DONE - Qgas : 2.429 MMscfd |
| 3 | TUNU SOUTH | TN-AA208 | OPW | 16-May-20 | 20-Oct-20 | 157 | 14 | 9.0 | 10-Sep-21 | Yes | DONE | DONE | DONE- NO issue | DONE | DONE - no issue | DONE -Q-gas: 2.498 MMscfd |
| 4 | TUNU SOUTH | TN-AA207 | OPW | 17-May-20 | 16-Jun-20 | 30 | 14 | 12.5 | 10-Sep-21 | Yes | DONE | DONE | DONE- NO issue | DONE | DONE - no issue | DONE -Q-gas: 0.913 MMscfd |
| 5 | TUNU SOUTH | TN-S193 | OPW | 9-Aug-20 | 19-Dec-20 | 132 | 13 | 10.30 | 13-Aug-21 | Yes | DONE | DONE | DONE- NO issue | DONE | DONE - no issue | DONE - Qgas : 2.530 MMscfd |
| 6 | TUNU SOUTH | TN-S194 | OPW | 16-Aug-20 | 1-Jan-21 | 138 | 13 | 6.2 | 4-Nov-21 | No | DONE | DONE | DONE- NO issue | DONE | DONE - no issue | DONE - Qgas : 2.699 MMscfd |
| 7 | TUNU SOUTH | TN-S95 | OPW | 16-Aug-20 | 8-Jan-21 | 145 | 13 | 0 | 6-Jul-22 | No | DONE | DONE | DONE- NO issue | DONE | DONE - no issue | DONE - Qgas : 2.151 MMscfd |
| 8 | TUNU SOUTH | TN-AA383 | OPW | 25-Aug-20 | 4-May-21 | 252 | 12 | 2.9 | 12-Apr-22 | No | DONE | DONE | DONE- NO issue | - | DONE - no issue | DONE - Qgas : 2.613 MMscfd |
| 9 | TUNU SOUTH | TN-AA342 | OPW | 11-Sep-20 | 19-Mar-21 | 189 | 13 | 0 | 5-Nov-21 | No | DONE | DONE | DONE- NO issue | - | DONE - no issue | DONE - Qgas : 1.115 MMscfd |
| 10 | TUNU SOUTH | TN-AA343 | OPW | 13-Sep-20 | 20-Mar-21 | 188 | 13 | 0 | 5-Nov-21 | No | DONE | DONE | DONE- NO issue | - | DONE - no issue | DONE - Qgas : 1.105 MMscfd |
| 11 | TUNU SOUTH | TN-G84 | OPW | 23-Sep-20 | 31-Oct-21 | 403 | 16 | 10.7 | 30-Apr-21 | Yes | DONE | DONE | DONE- NO issue | DONE | DONE - no issue | DONE - Qgas : 2.325 MMscfd |
| 12 | TUNU NORTH | TN-L83 | OPW | 28-Sep-20 | 30-Oct-20 | 32 | 13 | 0 | 4-Jul-22 | No | DONE | DONE | DONE- NO issue | DONE | DONE screen - no issue | DONE - Qgas : 0.592 MMscfd |
| 13 | TUNU NORTH | TN-L86 | OPW | 1-Oct-20 | 31-Oct-20 | 30 | 13 | 0 | 4-Jul-22 | No | DONE | DONE | DONE- NO issue | DONE | DONE - no issue | DONE - Qgas : 0.433 MMscfd |
| 14 | TUNU NORTH | TN-L91 | OPW | 14-Oct-20 | 27-Mar-21 | 164 | 13 | 0 | 27-Jun-22 | No | DONE | DONE | DONE- NO issue | - | DONE - no issue | DONE - Qgas : 1.050 MMscfd |
| 15 | TUNU SOUTH | TN-T165 | OPW | 7-Dec-20 | 14-Jan-21 | 38 | 13 | 0 | 1-Mar-21 | No | DONE | DONE | DONE- NO issue | DONE | DONE - no issue | DONE - Qgas : 1.265 MMscfd |
| 16 | TUNU SOUTH | TN-T164 | OPW | 8-Dec-20 | 16-Jan-21 | 39 | 13 | 0 | 1-Mar-21 | No | DONE | DONE | DONE- NO issue | DONE | DONE - no issue | DONE - Qgas : 1.177 MMscfd |
| 17 | TUNU SOUTH | TN-AA237 | OPW | 14-Dec-20 | 21-Mar-21 | 97 | 13 | 0 | 22-May-21 | No | DONE | DONE | DONE- NO issue | - | DONE - no issue | DONE - Qgas : 0.895 MMscfd |
| 18 | TUNU SOUTH | TN-AA235 | OPW | 17-Dec-20 | 20-Mar-21 | 93 | 13 | 0 | 22-May-21 | No | DONE | DONE | DONE- NO issue | - | DONE - no issue | DONE - Qgas : 1.562 MMscfd |
| 19 | TUNU SOUTH | TN-AA238 | OPW | 20-Dec-20 | 21-Mar-21 | 91 | 13 | 0.3 | 4-Mar-22 | No | DONE | DONE | DONE- NO issue | - | DONE - no issue | DONE - Qgas : 1.327 MMscfd |
| 20 | TUNU SOUTH | TN-T161 | OPW | 27-Dec-20 | 2-May-21 | 126 | 12 | 6.8 | 14-Jul-21 | No | DONE | DONE | DONE- NO issue | - | DONE - no issue | DONE - Qgas : 1.343 MMscfd |
| 21 | TUNU SOUTH | TN-A185 | OPW | 29-Dec-20 | 12-Mar-21 | 73 | 13 | 0 | 4-Jul-22 | No | DONE | DONE | DONE- NO issue | DONE | DONE - no issue | DONE - Qgas : 1.488 MMscfd |
| 22 | TUNU SOUTH | TN-T162 | OPW | 10-Jan-21 | 5-May-21 | 115 | 13 | 0 | 14-Jul-21 | No | DONE | DONE | DONE- NO issue | - | DONE - no issue | DONE - Qgas : 0.3891 MMscfd |
| 23 | TUNU SOUTH | TN-T163 | OPW | 24-Jan-21 | 4-May-21 | 100 | 12 | 0 | 11-Jun-22 | No | DONE | DONE | DONE- NO issue | - | DONE - no issue | DONE : Qgas : 1.457 MMscfd |
| 24 | TUNU SOUTH | TN-A165 | OPW | 16-Feb-21 | 6-Jul-21 | 140 | 14 | 0 | 17-Oct-21 | No | DONE | DONE | DONE- NO issue | - | DONE - no issue | DONE : Qgas : 0.714 MMscfd |
| 25 | TUNU SOUTH | TN-A167 | OPW | 27-Feb-21 | 10-Jul-21 | 133 | 14 | 0 | 17-Oct-21 | No | DONE | DONE | DONE- NO issue | - | DONE - no issue | DONE - Qgas : 0.982 MMscfd |
| 26 | TUNU SOUTH | TN-AA385 | OPW | 17-Nov-21 | 29-Dec-21 | 42 | 13 | 0 | 13-May-22 | No | - | DONE | DONE- NO issue | - | DONE - no issue | DONE - Qgas : 1.445 MMscfd |
| 27 | TUNU SOUTH | TN-AA332 | OPW | 7-May-21 | 2-Sep-21 | 118 | 16.5 | 5.9 | 7-Jul-22 | No | - | DONE | DONE- NO issue | - | DONE -no issue | DONE - Qgas : 1.493 MMscfd |
| 28 | TUNU SOUTH | TN-AA312 | OPW | 8-May-21 | 3-Sep-21 | 118 | 13 | 0 | 9-Feb-22 | No | - | DONE | DONE- NO issue | - | DONE -no issue | DONE - Qgas : 1.271 MMscfd |
| 29 | TUNU SOUTH | TN-AA239 | OPW | 1-Jun-21 | 26-Jul-21 | 55 | 13 | 6.2 | 3-Apr-22 | No | DONE | DONE | DONE- NO issue | - | DONE - no issue | DONE - Qgas : 1.091 MMscfd |
| 30 | TUNU SOUTH | TN-AA240 | OPW | 5-Jun-21 | 22-Jul-21 | 47 | 13 | 0.7 | 6-Aug-21 | No | DONE | DONE | DONE- NO issue | - | DONE Screen - no issue | DONE - Qgas : 0.174 MMscfd |
| 31 | TUNU SOUTH | TN-AA384 | OPW | 8-Nov-21 | 26-Dec-21 | 48 | 13 | 0 | 13-Feb-22 | No | - | DONE | DONE- NO issue | - | DONE - no issue | DONE - Qgas : 1.054 MMscfd |
| 32 | TUNU SOUTH | TN-AA361 | OPW | 21-Nov-21 | 27-Dec-21 | 36 | 14 | 10.3 | 16-Jun-22 | Yes | - | DONE | DONE- NO issue | - | DONE - no issue | DONE - Qgas : 1.093 MMscfd |
| 33 | TUNU SOUTH | TN-AA362 | OPW | 25-Nov-21 | 31-Dec-21 | 36 | 13 | 0 | 24-Jan-22 | No | - | DONE | DONE- NO issue | - | DONE - no issue | DONE - Qgas : 1.406 MMscfd |
| 34 | TUNU SOUTH | TN-AA323 | OPW | 1-Jan-22 | 5-Feb-22 | 35 | 13 | 0 | 10-Apr-22 | No | - | DONE | DONE- NO issue | - | DONE - no issue | DONE - Qgas : 0.986 MMscfd |
| 35 | TUNU SOUTH | TN-AA322 | OPW | 5-Jan-22 | 30-Jan-22 | 25 | 13 | 1.4 | 9-Apr-22 | No | - | Done | DONE- NO issue | - | DONE - no issue | DONE - Qgas : 0.902 MMscfd |

Table.1 Summary of One Phase Wells perforation and production

Based on table above, 5 wells with anomaly annulus pressure higher than 100 psi but still below MAWOP value and leak rate still acceptable (< 3 scfm) as graphic below. There is no significant increase in sustain annulus pressure prior perforation and post perforation with implemented optimize mitigation. Sustain pressure anomaly in OPW occurs since drilling completed (not because of perforation impact). As

implemented mitigation in OPW, cement bond logging have to be performed to support data from 12 cement checklist to shown there are competence cement up to surface in annulus A as reliable barrier and there is no degradation from perforation until production. CBL/VDL data from 35 One Phase Well are shown good competence cement above perforation.

## 4 Conclusion

The project can be performed safely, with 35 one phase wells (OPW) have been executed, industrialized and contributed instantaneous production gain more than 60 MMscfd without jeopardizing safety and well integrity aspect. The collaboration between engineering in town and operational in site thru effective communication and socialization of mitigation based on risk assessment is one of the key of successful and safely operation. All mitigation stated in risk assessment has been implemented properly. No integrity issue observed during perforation, sand treatment and production by robust mitigations. Well integrity assurance is continuously performed and monitored which also synchronized in online well integrity monitoring system.

## Appendices

Technical detail that it is necessary to include, but that interrupts the flow of the article, may be consigned to an appendix.

## References

[1] I. Abidiy, d. D. Faissal, R. Rachman, Y. Bawono, A.S Wibowo. 2022. Draining the Last Challenging Shallow Resources by Redefining and Optimizing Barrier System in Deep Zone Wells. Forthy-Six Annual Convention and Exhibition. IPA22-E-55

[2] AI. Handoko, P. Bimastianto, MD. Maulana, C. Agriawan, RA Brahmantio, I. Abidiy, T. Setiawan (2017). Shallow Light Architecture: A Viable and Cost-Effective Solution for Marginal Reserves in Tunu Shallow Development. SPE 186936. Presented at the SPE/IATMI Asia Pacific Oil & Gas Conference and Exhibition held in Jakarta, Indonesia, October 17-19th 2017 – Total E&P Indonésie.

[3] MD. Maulana, Setiohadi, AI. Handoko, S. Sugiarto, C. Agriawan .2019. 3.4 Days – Evolution of the Fastest Development Wells in Mahakam. IPA19-E-566. Presented at the IPA Forty-Third Annual Convention & Exhibition, September 2019 – Pertamina Hulu Mahakam

## Acknowledgments

The authors thank and appreciate Pertamina Hulu Mahakam (PHM) for their support and permission to publish this paper.