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# First Application of Micro Coiled Tubing in Indonesia at Offshore Mahakam

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## Abstract

In order to answer the future challenges associated with offshore logistics, minimalist platform and job simplicity, smaller footprint of coiled tubing set is required for pumping job.

Although coiled tubing (CT) is one of the most efficient deployment method for multiple wellsite operations and various objectives. Often it is difficult to capture all the benefits of its application in some offshore wells. Limited crane capacity and deck space at the platform often provide challenges to efficiently execute a CT operation. Minimalist and crowded platforms may not allow conducive condition to set up a conventional CT system.

As part of continuous improvement in Well Intervention, smaller size of CT called Micro CT is deployed to unload the completion fluid using nitrogen pumping. This is to provide sufficient drawdown prior to clean up or perforation jobs.

Micro CT is a small coiled tubing typically with 1" outside diameter and 10,000 ft length. It is approximately half the weight and a third smaller compared to the conventional CT. The start-up project of 1st Micro CT job in Indonesia is commenced with unloading Job in Bekapai and South Mahakam wells. Five (5) unloading job are successfully performed within allocated time frame and budget. There were no major safety issues recorded. Total of 60% cost saving was generated from the reduced mobilization trips of supply boat while 40% cost saving is from improved diesel consumption efficiency. From operational aspect, less annular friction can be achieved and led save up to 35% in N2 consumption. Moreover, it saves10 – 20% rig up time in comparison to conventional CT. On top of that, those 5 unloading jobs was completed with liquid unloading efficiency of more than 70% from the target.

This paper will elaborate the experience of an Asset Operator in deploying 1st Micro CT application safely and will discuss in detail some of the measurable milestone achievement from the project.

## INTRODUCTION

Pertamina Hulu Mahakam operates in Mahakam Block which consists of 4 fields located in Offshore: Peciko, Sisi-Nubi, South Mahakam, Bekapai; and 3 fields located in Swamp: Tunu, Tambora, and Handil. Figure 1 shows illustration of fields under Pertamina Hulu Mahakam. Since its first operations in 1972,

Pertamina Hulu Mahakam has drilled more than 2300 wells. The offshore operation consists of 365 wells and 404 strings.

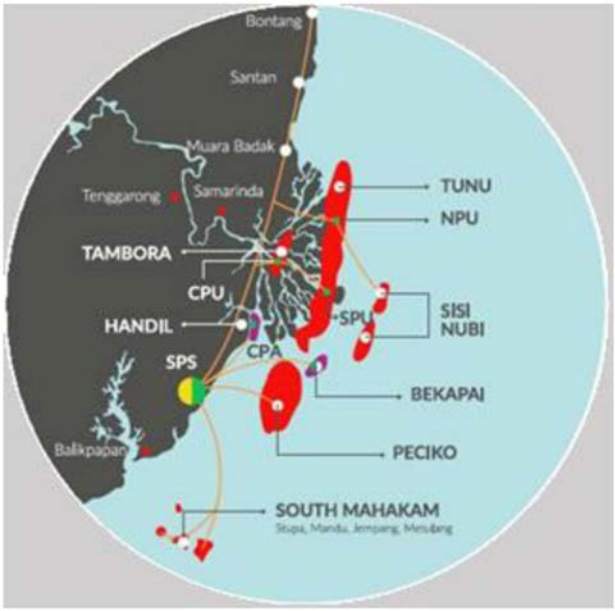


**Figure 1—Mahakam Block Area**

Offshore well interventions are supported by accommodation working barges (AWB). These barges have a high-capacity crane which is used to lift up the well intervention equipment onto the platform's upper deck. Currently three (3) barges and one (1) remote operation are running for offshore campaign.

The wells (new and existing) need to perform unload the completion fluid first using nitrogen pumping prior to perforation in order to provide sufficient drawdown during clean up. The challenges associated with these offshore operations are constraints related minimalist platform design, weather, and cost. Due to current constrains at offshore operation facilities, Micro CT is deployed for continuous nitrogen injection to help well kick off.

## METHOD

A roadmap was initiated in order to plan all the assessment parameters and evaluate them in sequence. Within 2020, all stages from preparation to execution and also post job surveillance and project closure reports were successfully completed.

Coil tubing technology has become commodity and widely accessible for intervention work in upstream operations. The generic CT size commonly used is 1-3/4". There is no evidence of used cases smaller size, especially in Indonesia where no job has been done using micro-CT. In addition to the CTU (Coiled Tubing Unit) size which is much smaller than the conventional CT, the coil size was much smaller than the usual one, which is 1".

Generally, liquid unloading in the well is done by pumping N2 into the well through CT equipment. This work is carried out in order to obtain sufficient underbalance pressure to drain the Hydrocarbon (HC) in the reservoir after the perforation. Bringing the CT unit to the offshore area can be challenging, with heavy and large equipment requiring several cycles of mobilization and efforts related to the lifting the unit from the tugboat to the deck of AWB (Accommodation Work barge) and then from the AWB to the top deck of the production platform. In contrast, Micro CT makes the lifting and logistics less complex. The placement is also an important factor for the continuity of work, with the small size of Micro CT, all liquid unload work units can be placed on the platform. Micro CT was chosen as deployment method for unloading job due

several considerations. One of which is prove as used case and reference next operation on a minimalist platform.

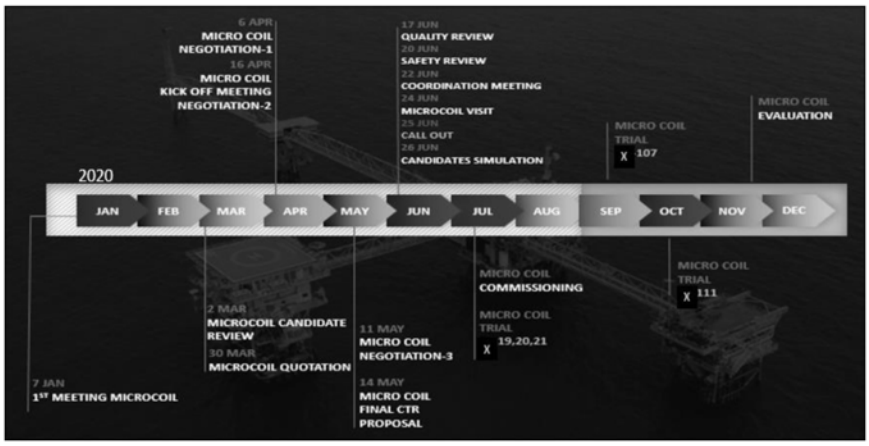


**Figure 2—Road Map Project**

## Conventional CT

Liquid unloading job in the Offshore Mahakam area has become quite routine, especially to support work on new wells. Conventional CT units are brought to the platform through several fairly long stages, starting from preparation at the land base then sent to the PHM jetty and then transported by tugboat to AWB. This conventional CTU mobilization stage requires 4-5 trips. Arriving at the AWB deck, the unit is then lifted to the top deck production platform. The risk when lifting the unit is something that we need to pay attention to, considering that this type of lifting includes complex lifting, including during rig up and rig down work.

The placement of the unit on the top deck is also a common concern, because a large enough unit will greatly affect the deck space for other units such as wireline units. If this is not possible, this will increase the duration to start a job in the well, which is to swab the unit first from the deck barge and top deck platform to obtain sufficient space.

The coil size that has been used in PHM is 1-3/4" which is used in wells with 3.5" and 4.5" tubing. This is during the job will find friction that is quite large in the well and affects the consumption of N2, meaning that with large friction a large pump rate is needed to lift the fluid in the well. Some Simulation results show that smaller wellbores where annular friction loss is a limiting factor, a smaller diameter of CT string may be preferred.

## Micro CT

As mentioned above, the planning of this project started in early 2020. In this project, our team is divided into engineering team, operation team, and contractual team. Since the beginning, the good collaboration of these three parts has been one of the factors for the smooth and safe implementation of this project.

Mobilization of the unit to the base contractor carried out followed by preparation of unit commissioning. What's interesting is that we carried out full commissioning online because at that time there were already many cases of covid-19 pandemic which made it impossible to do offline commissioning, we certainly deal with this online commissioning in various ways so that it can run comprehensively and can be accounted for, for example, asking the contractor to send related documents for us to review first so that when online commissioning only focuses on function testing all equipment to be used.

This project of Micro CT will be held for the first time in the Mahakam area, so one other important aspect is the Quality and Safety Review which was attended by several division representatives to discuss all quality and safety issues including the preparation of JRA (Job Risk Assessment) to support the work. Activities such as survey visits to platforms and candidate simulations were carried out in parallel. In the

middle of 2020, this project can finally be started by doing the first work on the BL platform to support N2 pumping in the new Bekapai well (XL-20/21/19). Then continue to support the existing well South Mahakam (XM-107/XP-111). Some notes and improvements were made before carrying out the next work in each well, within the allocated timeframe and budget.

After all preparations completed the unit mobilization begins to be carried out in the field. Micro CT mobilization is enough to do with 2 trips using a tugboat, the rig up process is also relatively faster by 1-2 hours than normal conventional CT. Smaller footprint allows safe distance between equipment spread and safer walkway access for personnel during operation or emergency. Smaller injector head/gooseneck/ jacking frame, poses less height exposure risk to personnel during rig up and rig down operation. With its small and light weight, it will also make it easier to set up the unit on the top deck production platform because it can use the existing crane in the platform instead of using a crane barge. The capacity of the platform cranes in the offshore ranges from 9-10 tons, so it is not possible to carry out lifting to set up on the top deck. crane barges are often constrained by weather issues.

In the first operation on the XL-20, failure was found in the power pack unit while preparing to stab in coil into the injector head, unable to raise up the level arm reel. Troubleshoot unveil that the piston slide shoe in the hydraulic pump was damaged and hydraulic pump was required to be replaced with the new one. Then when RIH was at a depth of 900m the tools couldn't pass until six attempts; suspected of being unable to pass through GLV accessories, finally it was decided to POOH and add a straight bar in BHA to avoid help ups in the well.

A new concern found during the first operation was the significant losses in 500 gal N2 tanks due to faster vapor pressure build up compared to bigger N2 tanks. Also the absence of a manifold for continuous supply of the pump N2. With the use of small N2 tanks, it is possible for the next job to be in remote operation mode, meaning without AWB support because all units can be placed on the top deck platform. This can be seen during the last work on a small South Mahakam platform, where all Micro CT units can be placed to the platform for liquid unloading work.

Table 1 indicate the comparison in terms of footprint and weight of the spread between Micro CT and Conventional CT. Micro CT equipment complete with small N2 pump was set up on the platform with each lift less than 3.5 ton, except for Micro CT string which is about 6 ton lift. This addresses the challenge in which the remote platform was limited in space, and platform crane was rated to only 10 ton. Figure 3 in the attachment depicts the set-up of Micro CT equipment on Bekapai platform, Bekapai platform having bigger space for unit set up. Figure 4 in the attachment depicts the equipment layout on South Mahakam platform which one of smallest platform in Offshore Mahakam.

**Figure 3—Equipment set up on Bekapai platform**

**Figure 4—Equipment set up on South Mahakam platform**

**Table 1—Comparison between Micro CT and Conventional CT equipment**

| | Weight (ton) | | Dimension (sq/ft) | |
|---|---|---|---|---|
| | Micro CT | Conven.CT | Micro CT | Conven.CT |
| Power Pack | 6.6 | 7.9 | 72 | 72 |
| Control Cabin & Hose Reel | 6.4 | 8.3 | 48 | 133 |
| CT Reel | 3.0 | 4.0 | 64 | 75 |
| Nitrogen Converter | 6.1 | 11.0 | 91 | 139 |
| Nitrogen Tanks | 3.2 | 12.5 | 29 | 80 |
| Injector Head & BOP | 6.3 | 14.9 | 60 | 99 |
| totals | 31.6 | 58.5 | 364 | 598 |
| | 46% less | | 40% less | |

## RESULTS

All 5 wells were executed as planned, with all achieving the objectives of creating sufficient underbalance to kick off the well. Below figure shows Jobsmaster, real time software used by contractor to monitor well and operating parameters during job executions. XL-20 well Jobmaster graph on Figure 5 show Micro CT safely passed thru safely at 905m (previous restriction), continue pumping N2 at 150scfm. Once Micro CT reach target depth of 2100m, increased pump rate to 300 – 350scfm, Micro CT circulating pressure was 2000psi. Continuous return of fluid is observed at surface. Once no more fluid return is observed at surface, stop pumping and POOH Micro CT to surface. Total liquid N2 pumped was 1,473gals.

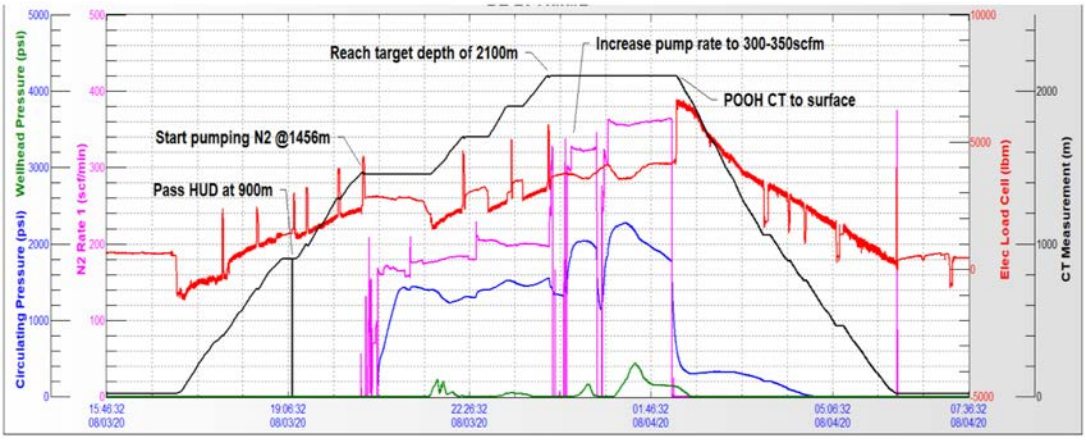


**Figure 5—XL-20 jobmaster graph for monitoring job parameters**

Figure 6 show XM-107 jobmaster graph, Micro CT started RIH to target depth for well kick off. Since fluid level was known to be at 1800m, Micro CT RIH without pumping N2. Once CT at 2,000m, started pumping N2 at 150 – 200scfm. Return was routed to production flowline with WHP 360psi. Micro CT continue to RIH and stationed at 3,000m as the top most perforation was at 3,100m. Continue pumping N2 at 200scfm and observed no increase of WHP. Cumulative liquid recovery was only 0.3 bbls. Return was then switched from production flowline to cold vent, with lower WHP at 109psi, increased N2 pump rate to 350scfm. After pumped for 5 hours, cumulative liquid recovery was 11.3 bbls. Soon after there's indication of lost prime, low liquid N2 level. Decision was made to POOH CT to surface. Total liquid N2 pumped was 3,273gals.

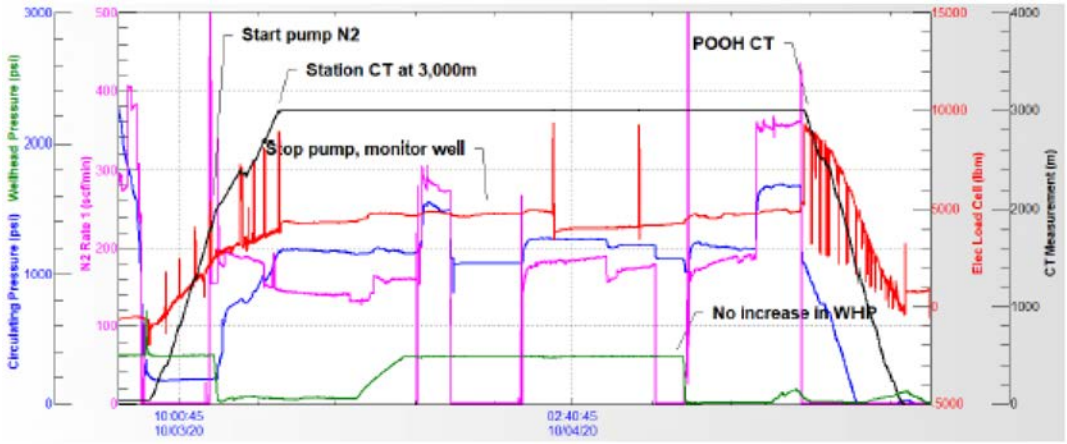


**Figure 6—XM-107 jobmaster graph for monitoring job parameters**

Below table shows the summary result of the 5 wells executed.

First loadout of Micro CT was in July 2020 for 3 wells, and subsequently 1 well in Sept 2020, and the final well was executed in Nov 2020. Total operating days from rig up to backload was 30 days for the 5 executed wells. Table 2 on XL wells indicates the efficiency generated during the liquid unloading process, showing an efficiency of 70% in the process of unloading liquid from the well. With this result, the objective is to get UB before the perforation has been achieved, the well flows well after the perforation work. Meanwhile, in XM/XP wells, the pumping work of N2 aims to start up wells so that they can return to production, technically there are no issues during operation, liquid recovered is in accordance with the previous simulation. After discussing with the sub surface team, an anomaly was found in this reservoir which resulted in the well not being able to flow.

**Table 2—Summary result of all 5 wells executed**

| *UNLOAD* | XL-20 | | XL-21 | | XL-19 | |
|---|---|---|---|---|---|---|
| | 4.5" tbg | | 3.5" tbg | | 3.5" tbg | |
| | Design | Real | Design | Real | Design | Real |
| Total Liquid Recovered (bbl) | 110 | 187 | 85 | 151 | 85.4 | 127 |
| Total N2 pumped (scf) | 160,000 | 137,100 | 113,271 | 67,000 | 114,000 | 95,400 |
| Total N2 vol (gal) | 1,719 | 1,473 | 1,217 | 720 | 1,224 | 1,204 |
| Liquid Level (mBRT) | 2,100 | 980 | 2,665 | 1,977 | 2,740 | 2,298 |
| well result | UB achieved, well flow | | UB achieved, well flow | | UB achieved, well flow | |

| *START UP* | XM-107 | XP-111 | XP-111 |
|---|---|---|---|
| | 4.5" tbg | 4.5" tbg | 4.5" tbg |
| Total Liquid Recovered (bbl) | 11.3 | 129.3 | 65.9 |
| Total N2 pumped (scf) | 256,700 | 414,000 | 539,500 |
| Total N2 vol (gal) | 3,273 | 4,646 | 5,777 |
| perforation | No | No | Yes |
| well result | not flow | not flow | weak flow |

The above chronology is summarized in Table 3 and Table 4 below

**Table 3—XL-20 well chronology**

| DATE | DAILY OPERATION SUMMARY XL-20 |
|---|---|
| 21 – 22nd July 2020 | • Lifting of equipment from tugboat to AWB and platform |
| 23 – 24th July 2020 | • Position CTU equipments, fluid pump, gas buster and vertical tank<br>• Problem with powerpack hydraulic pump. |
| 25 – 28th July 2020 | • Lifted N2 converter and N2 tank from tugboat to AWB.<br>• Rig up CTU equipment and surface line<br>• Rig up BOP and riser to wellhead.<br>• Fixed hydraulic pump on powerpack. Tested good. |
| 29 - 30th July 2020 | • Stab in Micro CT into injector head<br>• Pull test Micro CT and pressure test Micro CT connector<br>• Pressure test BOP.<br>• Function test hydraulic gate valve.<br>• Make up Micro CT BHA.<br>• Pressure test stack up and BHA check valve. |
| 31st July – 1st Aug 2020 | • Waiting on bad weather<br>• Lifted up N2 converter from AWB to platform<br>• Rig up and pressure test line from N2 converter to Micro CT reel. |
| 2nd Aug 2020 | • RIH Micro CT at 905m pumping 150scfm. Attempted 6 times but failed.<br>• POOH Micro CT to surface. Total liquid recovered 102 bbls.<br>• Added 3ft straight bar to BHA.<br>• Powerpack hydraulic pump failure. Attempt to replace with new hydraulic pump and replace with new hydraulic oil. |
| 3 - 4th Aug 2020 | • RIH Micro CT pumping N2 at 150 scfm.<br>• Reached target depth 2100m, increase rate to 300scfm.<br>• Once no return is observed, POOH Micro CT to surface.<br>• Total fluid recovered for this well is 187bbls.<br>• Preparation for the next well |

Table 4—XM-107 well chronology

| DATE | DAILY OPERATION SUMMARY XM-107 |
|---|---|
| 28th – 30th Sept 2020 | Offload Micro CT equipment from tugboat to AWB.<br>• Site assessment on AWB and platform area<br>• Set up Micro CT equipment on platform |
| 1st Oct 2020 | Continue rig up Micro CT equipment on platform<br>• Install stack up on wellhead<br>• Function test equipment on platform<br>• Stab in CT into injector<br>• Pull test CT Connector<br>• Pressure test BOP body and rams |
| 2nd Oct 2020 | • Rig up pumping line<br>• Set up cradle at barge ad cellar deck<br>• Install hydraulic disconnect and simulate disconnect at barge<br>• Flush CT<br>• Pressure test pumping line to 3000psi<br>• Pressure test stack up. |
| 3rd – 4th Oct 2020 | • Start RIH for well kick off.<br>• Start pump N2 at depth 2,000m at 150scfm.<br>• Continue RIH and station CT at 3,000m.<br>• Increase pump rate to 300scfm and monitor returns.<br>• Stop pump monitor well for 3 hours.<br>• Start pump N2 and monitor return.<br>• WHFP 109 psi; total cumulative liquid recovered 11.3bbls<br>• Decision to POOH CT to surface; Total liquid N2 used 3,273 gals.<br>• Start rig down Micro CT equipment |
| 5th Oct 2020 | • Rig down Micro CT equipment complete.<br>• Backload Micro CT equipment to AWB.<br>• Offload Micro CT equipment from AWB to tugboat.<br>• Personnel demob to Balikpapan. |

## Lesson Learned

While the operation was executed within expectation and without any major issues, few key lessons learned was captured and was shared during post-job review.

1. Ensure sufficient spare part are available on board to avoid standby time during waiting mobilization from contractor yard.
2. The small N2 tank of 500gal was experiencing higher losses rate due to faster vapor pressure build up compared to bigger N2 tanks. Mitigation was to ensure the 500gal tank minimized standby and transit time on the vessel, plus allocating more back up liquid N2 onshore.
3. Utilization of manifold to ensure continuous supply of liquid N2 from 500gals tanks to small N2 converter to avoid disruption during pumping.
4. Ensure min 8ft of stiff BHA (incorporating straight bar) during running Micro CT to avoid unnecessary hang ups in completion jewelries.

## Micro CT Added Value compared to Conventional CT

1. Reduction of number of trips for supply vessels, translating to about 60% of logistic cost savings to operator.
2. Better liquid unloading efficiency due to less annular friction, potential savings up to 35% of N2 per well.

3. Less diesel fuel consumptions, actual 40% lower in diesel fuel consumptions, resulting in cost savings and less carbon footprint.
4. Smaller footprint equipment, allows safe distance between equipment and safer walkway access for personnel during operation or emergency.
5. Smaller injector head/gooseneck/jacking frame, thus poses less height exposure risk to personnel during rig up, also increasing efficient by 1-2 hours.

## CONCLUSIONS

Five (5) unloading job are successfully performed within allocated time frame and budget. There were no major safety issues recorded. Total of 60% cost saving was generated from the reduced mobilization trips of supply boat while 40% cost saving is from improved diesel consumption efficiency. From operational aspect, less annular friction can be achieved and led save up to 35% in N2 consumption. Moreover, it saves10 – 20% rig up time in comparison to conventional CT. On top of that, those 5 unloading jobs was completed with liquid unloading efficiency of more than 70% from the target.

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