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Maintain Flow Assurance & Production of ZPM Crude with Pressure Limitation of 16" MOL MMF-NGLJ.

Muchamad Agus Setiawan[*1], Diarista Tomasaputra[1], Mochamad Jalal Abdul Goni[1], and Irvan Sopandi Yusup[1]
[1]Pertamina Hulu Energi Offshore North West Java (PHE ONWJ)
* Email: muchamad.setiawan@pertamina.com

Abstract.
The 16" Main Oil Line (MOL) MMF-NGLJ pipeline was established in 1984, with the length of 53.54 km, and actively delivers crude oil from the ZULU, PAPA, and MIKE-MIKE (ZPM) area, with total production is 37,000 BFPD. Due to its integrity status, it is necessary to perform pressure limitation, leading to capacity reduction through the pipeline. Production optimization in the surface facility and flow assurance consideration are required to achieve the annual production target while prioritizing the safe pipeline operation.

Several methods have been carried out to achieve the objective:

- Maintain the flow rate through 16" MOL MMF-NGLJ to below 30,000 BFPD
- Reduce the impeller size of the MIKE-MIKE MOL pump due to production declining through 16" MOL MMF-NGLJ
- Routed the remaining ZPM production to 16" MOL MMF-LPRO, then commingled with production from LIMA-KLA and routed to 12" MOL LCOM-NGLB
- Perform chemical (wax asphaltene dissolver) batching to prevent the clogged pipeline due to the waxy nature of crude oil

With the minimum cost of surface facility optimization supported with flow assurance consideration and chemical (wax asphaltene dissolver) batching recommendation, the methods used have prevented leakage in pipeline 16" MOL MMF-NGLJ and achieved 100% of the annual production target.

Keyword(s): flow assurance; crude production; pressure limitation; capacity limitation; split flow.

1 Introduction

The 16" MOL MMF-NGLJ pipeline was established in 1984 and had been operating for 38 years, which is more than its design life. The pipeline actively delivers crude oil from the ZULU, PAPA, and MIKE-MIKE (ZPM) area to NGL at Central Plant Area, as shown in Figure 1. The In-Line Inspection (ILI) tools were run in 2010 with an operating pressure of 90 psig and found the deepest metal lost at 80% NWT, with a remaining thickness of 2.54 mm, as detailed in Figure 2. Based on these findings, it is necessary to take precautions to prevent leakage in the 16” MOL MMF-NGLJ pipeline and achieve the annual production target.

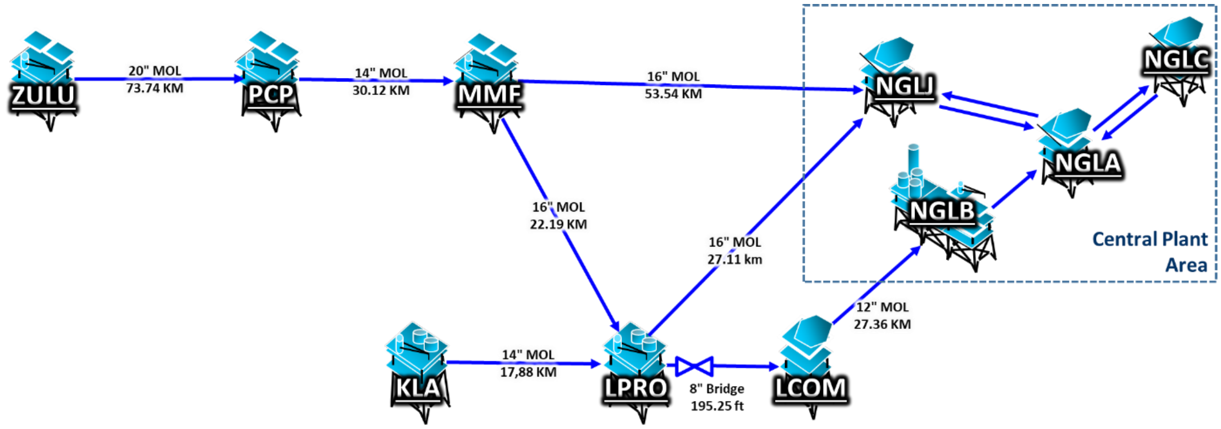

Figure 1. Pipeline Network ZULU, PAPA, MIKE-MIKE (ZPM) Area to NGLJ

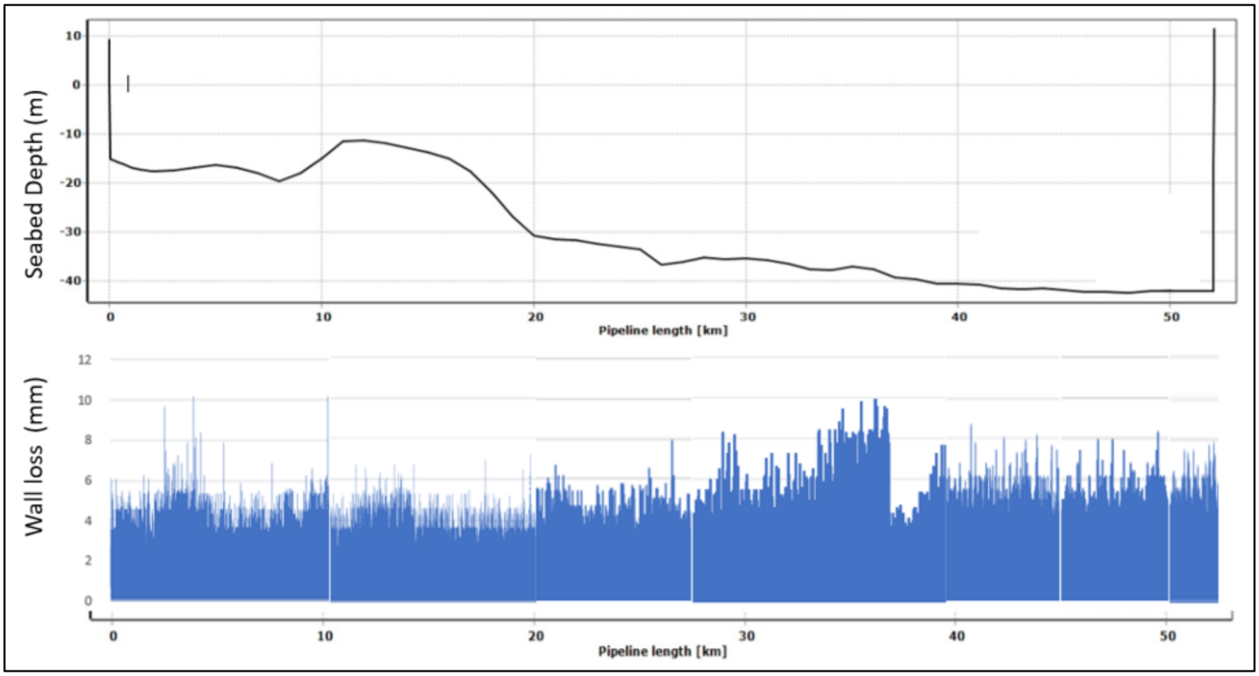

Figure 2. Metal Loss vs. Pipeline Bathymetry 16” MOL MMF-NGLJ

2 Data and Method

2.1 The Calculation for Pipeline Derating Pressure

The pipeline derating pressure is calculated based on the ASME B31.4, as detailed in Equations (1) and (2). Related to wall loss dimension as per in-line inspection (ILI) result in 2010, the deepest metal lost was 80% NWT and the remaining wall thickness was 2.54 mm. From the calculation result, the maximum operating pressure is 110 psig.

$$P_d = 1.1P_i \left[\frac{1 - 0.67\left(\frac{c}{t_n}\right)}{1 - \frac{0.67c}{t_n\sqrt{G^2 + 1}}} \right] \quad (1)$$

$$G = \frac{0.893L}{\sqrt{Dt_n}} \quad (2)$$

Where:

Pipeline Outside Diameter, D	= 16 inch
Pipe Nominal Wall Thickness, t_n	= 0.5 inch
Initial Operating Pressure, P_i	= 150 psig
Equation Selection Value, G	= 1.45
Maximum Depth of the Corroded Area, c	= 0.4 inch
Longitudinal Length of Corroded Area, L	= 4.60 inch
Derating Pressure, P_d	= 110 psig

2.2 Flow Assurance Modeling

Flow rate sensitivity was conducted to estimate the pipeline pressure during normal operation and cleaning pigging activity, as detailed in Table 1. The flow rate used for the sensitivity is 27,000 BFPD, 30,000 BFPD, and 33,000 BFPD with the same water cut of 86%. The sensitivity result shows that the MMF pressure during normal operation increases with the flow rate increase. Meanwhile, the MMF pressure during pigging activity rises by 38 to 47 psi compared with the normal operating pressure. The pig velocity increases along with the flow rate increase, and the pig travel time becomes shorter.

From the pipeline pigging analysis, it can be concluded that the cleaning pigging activity cannot be performed due to the backpressure exceeding the limitation of 110 psig, as detailed in Figure 3. Therefore, another method must be determined to prevent the clogged pipeline due to the waxy nature of crude oil.

Table 1. Flow Rate Sensitivity Result.

Parameter		**Case 1**	**Case 2**	**Case 3**
Flow Rate		27,000 BFPD	30,000 BFPD	33,000 BFPD
Water Cut		86%	86%	86%
Normal Pressure	MMF	78 psig	86 psig	95 psig
	NGLJ	35 psig	35 psig	35 psig
Pigging Pressure	MMF	116 psig	129 psig	142 psig
	NGLJ	35 psig	35 psig	35 psig
Pig Velocity		1.41 ft/s	1.59 ft/s	1.75 ft/s
Pig Travel Time		33 hours, 07 minutes	29 hours, 49 minutes	27 hours, 06 minutes

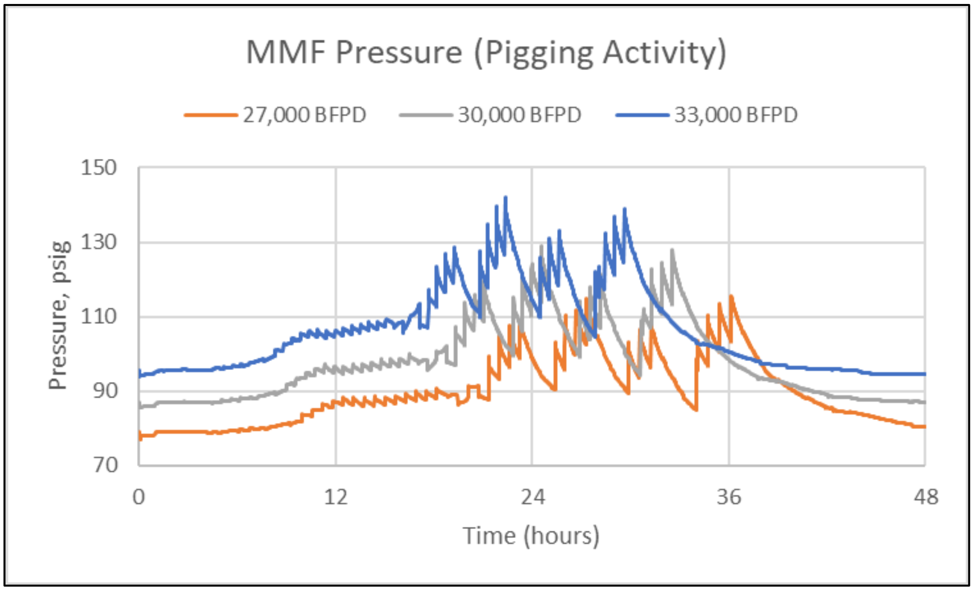

Figure 3. Pipeline Pressure during Cleaning Pigging Activity

2.3 Maintain the Flow Rate through 16" MOL MMF-NGLJ

The explanation in section 2.2 shows that the flow rate through 16" MOL MMF-NGLJ should be maintained at 30,000-33,000 BFPD to keep the normal operating pressure below 110 psig. Having considered the pressure fluctuation due to the control valve at the MIKE-MIKE MOL Pump discharge, the flow rate below 30,000 BFPD is selected to keep the pressure below 90 psig, with the following distribution:

- ZULU Production = 14,000 BFPD
- PAPA Production = 10,000 BFPD
- MIKE-MIKE Production = 5,000 BFPD

2.4 Reduce the Impeller Size of the MIKE-MIKE MOL Pump

Due to flow rate reductions as described in Section 2.3, it is necessary to reduce the impeller diameter of the MIKE-MIKE MOL Pump from the previous size of 11.75 inch. The flow rate of 40,000 BFPD is used to determine the impeller size considering the future development of the ZULU, PAPA, and MIKE-MIKE (ZPM) area. Referring to the hydraulic simulation, the backpressure at MMF Launcher is 166 psig, and the pressure at discharge MMF MOL Pump is assumed to be 176 psig considering the control valve effect.

The MMF MOL pump performance curve shows that the size of 10.8 inch diameter is selected for the new impeller, as detailed in Table 2 and Figure 4.

Table 2. Plot MMF MOL Pump Performance Curve.

Description	Unit	Value
Flow Rate	BFPD	40,000
	GPM	1167
Pressure at Launcher MMF	psig	166
Pressure at Discharge MMF MOL Pump	psig	176
	ft	405
Impeller Size	inch	10.8

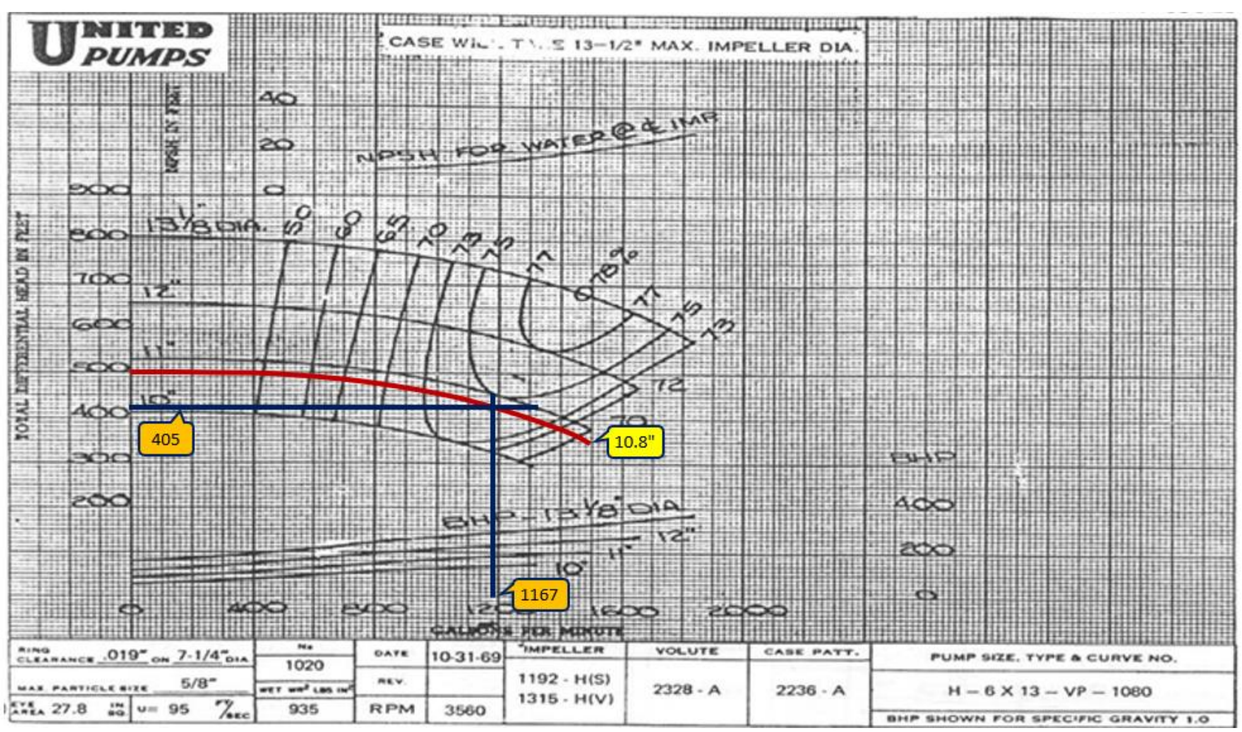

Figure 4. MMF MOL Pump Performance Curve

2.5 Routed the Remaining ZPM Production to 16" MOL MMF-LPRO

Refer to the production profile of the ZULU, PAPA, and MIKE-MIKE (ZPM) area, the crude oil production before pressure limitation in the 16" MOL MMF-NGLJ pipeline is approximately 37,000 BFPD, as detailed in Figure 5. Therefore, it is necessary to split the ZPM production around 8,000 of 37,000 BFPD to 16" MOL MMF-LPRO, commingled with LIMA-KLA production, then routed to 12" MOL LCOM-NGLB with the maximum flow rate of 33,000 BFPD (due to limitation at 8" Bridge LPRO-LCOM), as described in Figure 6.

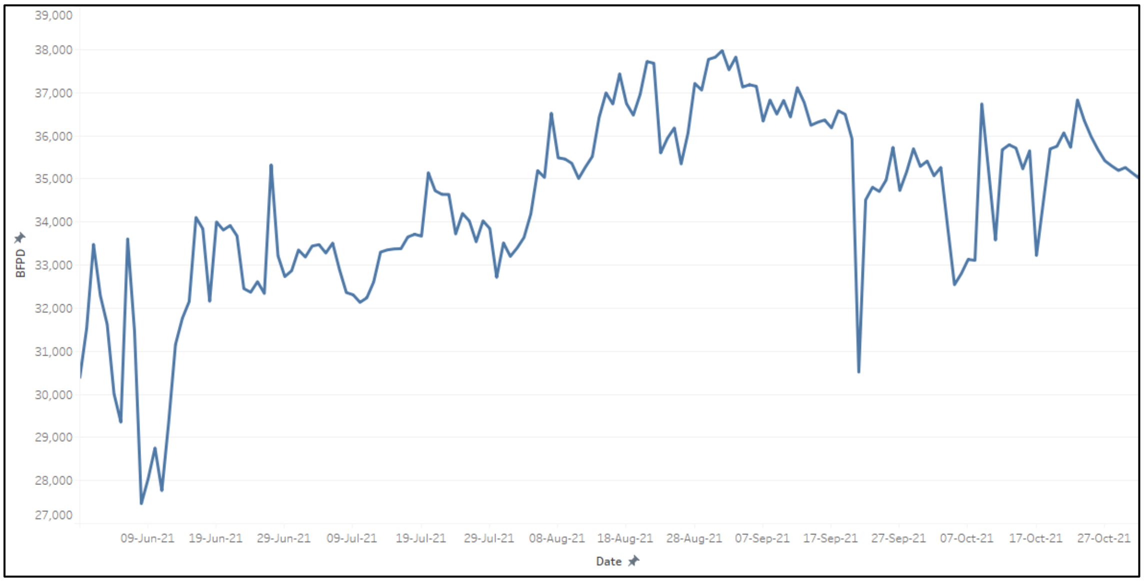

Figure 5. Production Profile of ZULU, PAPA, and MIKE-MIKE (ZPM) Area

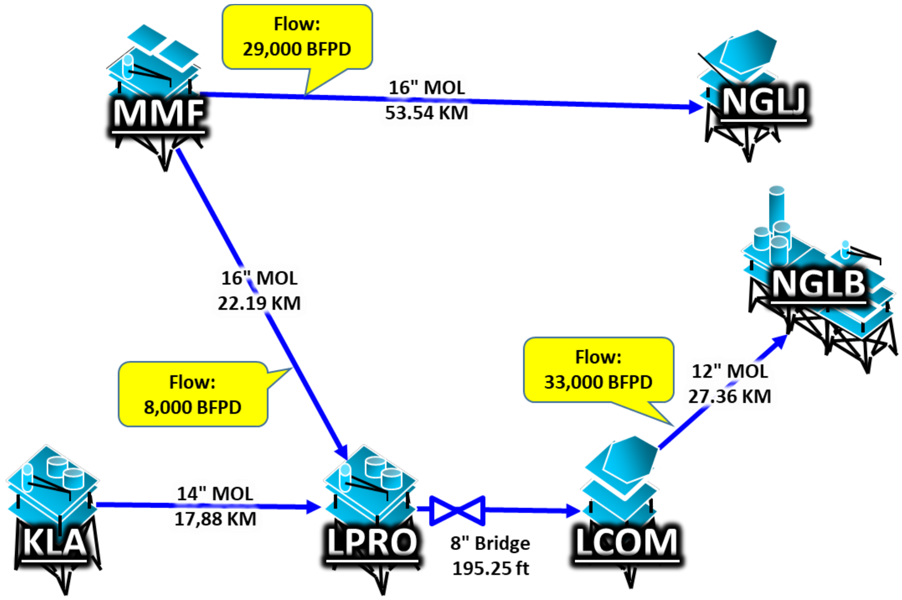

Figure 6. Split Flow Schematic of ZPM Production

2.6 *Chemical (Wax Asphaltene Dissolver) Batching*

Debris accumulation due to wax and sand deposition inside the pipeline can reduce inside diameter and cause back pressure/blockage. Section 2.2 above describes that the cleaning pigging activity cannot be performed due to backpressure exceeding the limitation of 110 psig. Therefore, the chemical batching method is selected as part of preventive maintenance. The wax asphaltene dissolver batching can prevent debris accumulation and wax deposition inside the pipeline.

The dissolver is a synergistic blend of aromatic solvents and organic acids. It primarily removes organic deposits inside the pipelines, particularly asphaltenes or waxes. The mixture is flammable and harmful by inhalation and contact with the skin. It also may irritate the eyes and skin. The dissolver is applied by diluting up to 0.5% in crude oil or carrier solvent, depending on the application.

The chemical is injected into the pipeline every month using the batching method, which is the chemical injection method other than continuous injection and chemical squeeze. Batching method is selected since wax treatment at the flowline has been applied for many wells.

3 Result and Discussion

By minimum cost of surface facility optimization supported by flow assurance consideration and chemical (wax asphaltene dissolver) batching recommendation, the methods currently used have been proven can prevent leakage in pipeline 16" MOL MMF-NGLJ and achieved 100% of the yearly production target.

4 References

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