Proceedings World Geothermal Congress 2026
Calgary, Canada, June 8 – 11, 2026

Silica Scaling Monitoring Strategy At Muara Laboh Geothermal Power Plant After Four Years Operation: Scale Coupon Installation And Silica & Metal Loss Audit In Brine

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Keywords: silica scaling, SSI, scale coupon, metal loss audit, silica deposition, brine analysis

ABSTRACT

Muara Laboh Unit-1 Geothermal Power Plant has been operating continuously since end of 2019 with high availability and reliability. The original design of Muara Laboh surface facilities was based on the geothermal fluid taken from reservoir of less than 250^{0}C. However, more sustained resources from higher temperature reservoir (more than 290^{0}C) and correspondingly higher silica concentrations were only known during construction stage. Late modification of surface facility was required to be able to utilize the resources without creating silica problem. The additional facility should be simple, robust enough and would not jeopardize the initial Commercial Operation Date (COD) target. Muara Laboh High-High Pressure (HHP) separator station was introduced to the system in 2020. The selection of higher separation pressure in HHP separator is intended to maintain the silica saturation index (SSI) of separated brine to be less than one (i.e. under-saturated condition) to prevent scaling problem at the equipment of Muara Laboh Unit-1. Starting from end of 2023, scaling monitoring program was initiated. Brine samples were collected from several points at line. Silica and metal loss audit was performed to observe the amount of silica and other metal content at facilities and to calculate the silica polymerization rate. Scale coupon at several points at injection lines were installed to determine the actual scaling deposition rate. XRD/XRF analysis and visual inspection were performed for several silica scaling samples observed at the facilities. After analyzing all of these data, it is concluded that the scaling condition at current Muara Laboh geothermal field is still at acceptable and manageable level. The HHP system proves that the design is able to mitigate silica scale from causing major problem to the operation.

1 INTRODUCTION

Muara Laboh geothermal field started its silica scale issue in 2018 when the newly drilled wells at South-West (SW) area, which are well pads ML-H and ML-F, revealed that they generated geothermal fluid from higher temperature reservoir (more than 290^{0}C) and were linked to higher silica concentrations (Purnanto et al., 2019). Initially, the design of Steam Gathering System (SGS) for Muara Laboh was based on post-exploration drilling reservoir model, in which the geothermal fluid was extracted from reservoir temperature ranging between 235-255^{0}C from North-East (NE) area ML-A wells (Situmorang et al., 2016). It is then impossible to use the original SGS process design without modification to combine the high temperature geothermal fluids from SW wells with fluids from ML-A wells (see Figure 1). Based on the study, steam from ML-A alone can only support for eight months when the plant is operating continuously at full load around 80 MWe. According to the Power Purchase Agreement (PPA), the power plant is intended to operate for 30 years, so in order to preserve its sustainability, extraction from ML-A wells must be kept to a maximum of 20 MWe. This means that the remaining amount will be paid from the other production wells, ML-H and ML-F. consequently, the steam support from both wells was crucial to Muara Laboh's ongoing functioning.

According to Zarrouk et al. (2014), dissolved silica (SiO_2) is a prevalent mineral in geothermal fluid that can lead to scaling issues in steam field equipment, particularly in separators, heat exchangers, brine pipelines, and reinjection wells. The most common forms of silica are amorphous silica or quartz, both with unique solubility properties. Quartz controls solubility in the heated reservoir fluid (Fournier, 1986), while amorphous silica controls solubility near the surface (Fournier and Rowe, 1977).

The solution at the time was to separate high silica fluids from ML-H and ML-F at higher pressure than 8.5 bara in High Pressure (HP) separator in order to keep the separated brine's SSI below 1 (under saturated state) and safely introduce the steam from ML-H and ML-F into the system. After that, the new HHP separator was installed. A number of factors led to the selection of this mitigation strategy, including its simplicity, resilience, and lack of impact on the COD Unit-1 original timeline (Andini et al., 2025). Due to their complexity, time constraints, and (at the time) unknown technology, other options for mitigating silica scaling, such as acid dosing or scale inhibitors, were not chosen (Purnanto et al., 2019). The choice made was to install a new HHP separator in order to flash the two-phase fluid from SW wells with high silica concentrations at greater pressure. The resulting HHP

brines will travel straight to the injection well, while the separated HHP steam will be combined with the HP steam via a Let Down valve (LDV) before being delivered to the turbine.

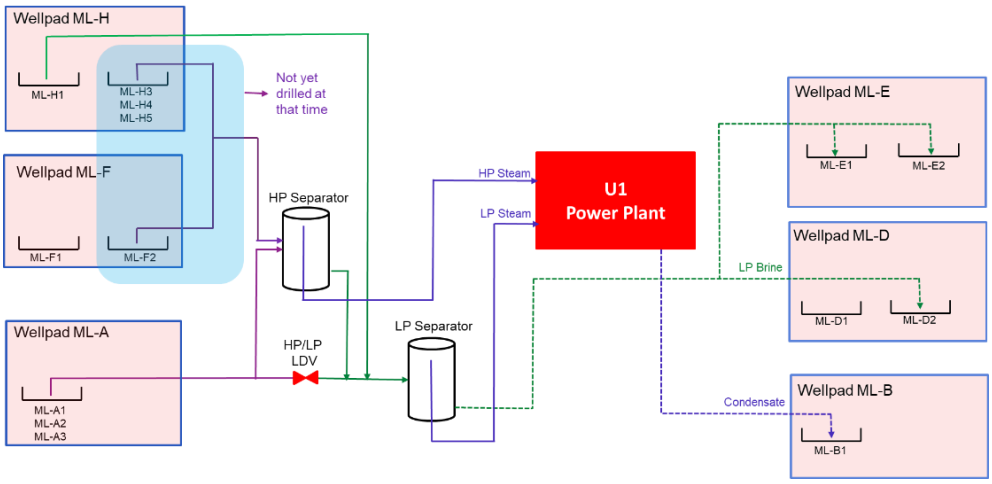


Figure 1. Muara Laboh Unit-1 General Plant Diagram – Original SGS Design (before 2018)

2 HISTORY OF SILICA SCALE ISSUE AND MONITORING AT MUARA LABOH GEOTHERMAL FIELD

2.1 Period 2018 - 2020

In 2018 all production wells were declared can supply adequate steam to support 80 MWe Muara Laboh Stage-1 development, indicating that the Stage-1 development drilling effort in 2017–2018 was successful. However, in contrast to the production wells at ML-A, the new production wells from SW area (ML-H and ML-F) are drawn from temperatures that are significantly hotter.

In response to this condition, PT Supreme Energy Muara Laboh (hereinafter SEML) conferred with consultant including numerous experts and presented a number of potential solutions for selection with regard to scaling consideration. The fluids from ML-H and ML-F were advised to be separated at higher pressure, the separated steam could be throttled to meet the turbine's HP steam need, and the separated brine could be injected into injection wells (Brown, 2018). Ultimately, SEML agreed that the SW wells must have their own separator, which later called as HHP separator.

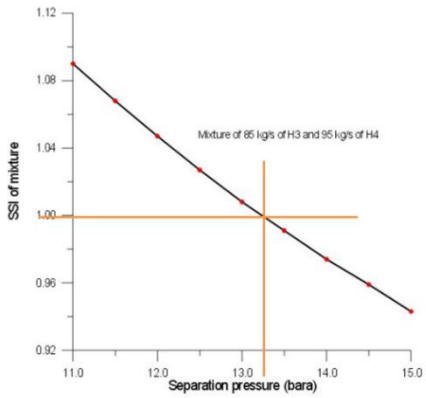


Figure 2. HHP Separation Pressure Optimization

Well Testing production data from ML-H3 and ML-H4 shown that the amorphous silica saturation temperatures of the fluids are between 193-198^{0}C or equivalent to saturated pressures of 13.4-14.9 bara. This represents the minimum separation pressure where the SSI is equal to 1. Then, after more data of SW wells condition were available, the advice from consultant for the acceptable pressure for HHP separator (result SSI = 1) if ML-H3 and ML-H4 are mixed is around 13.25 bara when the assumption of ML-H3 brine is 85 kg/s and ML-H4 brine is 95 kg/s then mixed at 13 bara. SEML decided to select 14 bara for separation pressure since the SSI should be around 0.98 (still under saturated, below 1), which was to be the ideal compromise between being high enough to prevent silica scale and low enough to permit the passage of fluids from the production well (Andini et al., 2025).

The construction of Muara Laboh Unit-1 with additional HHP separation system facilities as silica scaling mitigation design was completed in Q3 2020, nine months after COD in December 2019, and it has been operating continuously for over five years until todays.

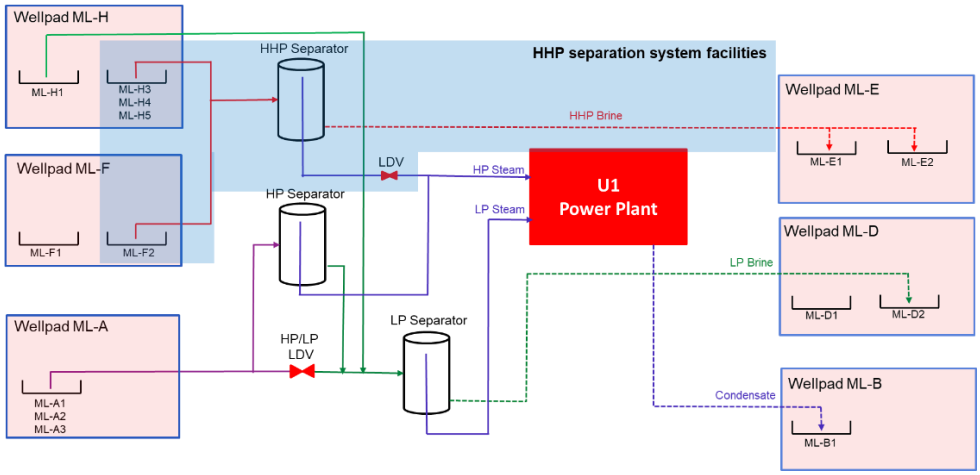


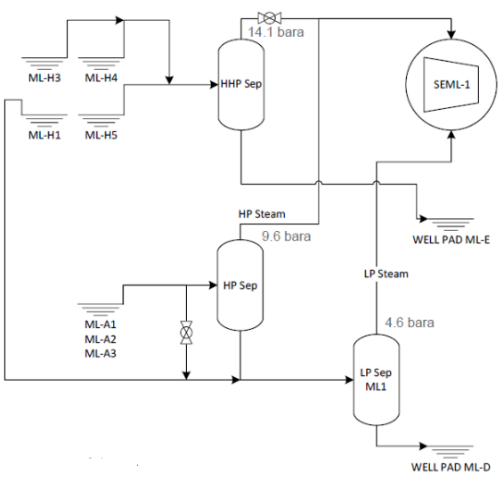
Figure 3. Muara Laboh Unit-1 General Plant Diagram – Silica Scaling Mitigation Design (after 2018)

2.2 Period 2021 - present

Following the completion of the HHP separator facilities, the configuration of SW wells has been adjusted multiple times to achieve stable operation for both surface and subsurface conditions. As of November 2021, only ML-H3, ML-H4 and ML-H5 provide SW steam (whereas ML-F2 was bleed to AFT) with contribution of around 30% from the total steam, while the remaining steam was provided by NE wells (ML-A). With this configuration, the Muara Laboh Unit-1 generation can continuously operate at a full load of 86 MWe, demonstrating steady and reliable performance.

During 2021-2023, it was found that while the silica concentration in brine has fluctuated slightly over time, the SSI range (0.88 to 1.11) indicates that pure amorphous silica scaling is very minor because the SSI is still less than 1.2. In this condition, there is an induction period in which silica scaling is delayed rather than occurring instantly (Brown, 2018).

Other than amorphous silica (SiO_2) as the most common silica scaling found in Muara Laboh, it was also noticed that metal silicate can also be the scaling potential source at Muara Laboh Unit-1, where the silica reacts with metals and form a scaling which also create a problem for the facilities. Aluminium silicate (Al_2SiO_3) as well as Arsenic trisulfide (As_2S_3) are the most potential metal silicate that may present (Gallup, 2023). Gallup (2023) also stated that the examination of the amorphous aluminous silica saturation index (AASSI) was also potential since the aluminium-rich silica scale is commonly found in the majority of Indonesian and Philippines geothermal sites. The AASSIs at Muara Laboh varied from 1.08 to 1.36. The Al-rich AASSI up to 1.3 is regarded as modestly scale-forming and still low enough to create significant scaling potentials for Muara Laboh Unit-1 operation.



Location	SiO_2	Al_2SiO_3	As_2S_3
ML-A1	●	● (0.26 ppm, SI<1)	●
ML-A3	●	● (0.32 ppm, SI<1)	●
ML-H1	●	● (0.41 ppm, SI<1)	●
ML-H3	● (0.96)	● (1.03 ppm, SI>2)	●
ML-H4	● (1.04)	● (1.07 ppm, SI>2)	●
ML-H5	● (1.10)	● (0.44 ppm, SI<1)	●
HHP Sep	● (1.02)	● (1.01 ppm, SI>2)	●
HP Sep	●	● (0.29 ppm, SI<1)	●
LP Sep ML1	●	● (0.24 ppm, SI<1)	●
ML-D2	●	● (0.25 ppm, SI<1)	●
ML-E1	●	● (1.01 ppm, SI>2)	●

● Saturation Index < 1
● Saturation Index > 1
● Has tendency to form scaling if some changes occurs(pH & concentration)

H3/H4/H5 data from TFT Jun 2023
A1/A3 data from SEML Lab
ML E1/D2 from simulation

Figure 4. Silica Saturation Index (SSI) Simulation at Muara Laboh Unit-1 Surface System (after Ecolab, 2023)

Furthermore, in 2023 SEML has collaborated with external consultant to run the simulation which present consistent fact where metal silicate may also potential to harm the facilities in addition to amorphous silica, including predict the saturation index (see Figure 4). For amorphous silica, the silica concentration from HP and LP wells are still under saturated as the Silica Saturation Index (SSI) for this system is still below 1, including the samples were taken at LP separator and LP brine injection well (ML-D2). However, silica concentration from HHP wells (ML-H and ML-F) were majority in over saturated value (SSI > 1) since from the data, only ML-H3 showed slightly under saturated condition (SSI = 0.96) while ML-H4 and ML-H5 shown over saturated condition (SSI = 1.04 and 1.10 respectively). The SSI at HHP separator outlet (after mixture of ML-H3, ML-H4 and ML-H5) still provide SSI of 1.02 which indicating over saturated. All in all, the SSI from HHP system is somewhat greater than 1. For metal such as aluminum silicate, the HHP system may experience scaling since the Saturation Index (SI) for the system are above 2, indicating an over-saturated condition. However, the HP & LP system showed lower data and SI below 1 but still has tendency to form scaling if some changes (such as pH and concentration) occur. Moreover, the scaling potential for arsenic trisulfide can be considered low.

From the SSI analysis, it can be concluded that the potential silica deposition comes from SW HHP system, started from ML-H3, H4 and H5 wells through HHP separator and ended at HHP brine injection well ML-E1.

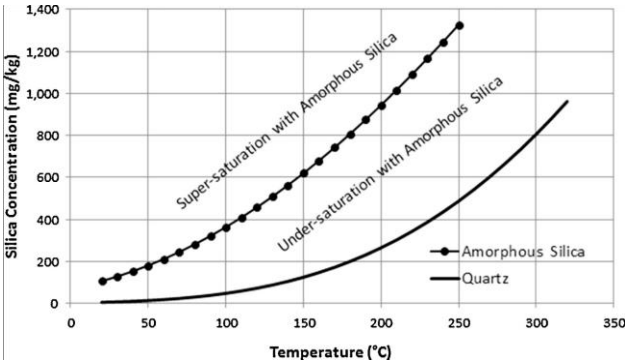


Figure 5. Temperature Dependence of the Solubility of Amorphous Silica in Surface Facilities (Zarrouk and Purnanto, 2014 - after Fournier and Rowe, 1977 and Fournier, 1986)

Refer to previous study and simulation, installing a retractable scale coupon at the brine injection line was then recommended as a way to monitor the possibility for silica scaling, particularly in relation to Al-rich amorphous silica scaling (apart from the pure amorphous SSI). Obtaining quantifiable data on the scaling rate at the current Muara Laboh Unit-1 condition as a baseline is the aim of the scaling coupon. If the change was seen after the future Unit-2 is later put into operation, this monitoring will also contribute more.

3 SILICA SCALING MONITORING STRATEGY

When Muara Laboh first started operating in 2019, samples were sent to external laboratory on a quarterly basis for silica monitoring. But beginning in 2023, SEML established its own field laboratory and has routinely used its own laboratory to measure silica concentrations more frequently. The silica content of brine can be ascertained using advanced laboratory equipment like Ion Chromatography (IC) and Inductively-Coupled Plasma (ICP), which can then be used as a basis for monitoring the silica content and SSI at the Muara Laboh. Additionally, it was suggested that other than silica monomeric, Al-rich amorphous silica scaling could be problematic and should be closely watched in injection brines (Gallup, 2023). The scaling rates should be relatively low due to high temperature injection practiced at the field but still shall be checked, since this type of scaling can be identified by combined X-ray diffraction (XRD)/X-ray fluorescence (XRF) analysis. Retractable scale coupons were also advised to be installed in the brine injection line to monitor silica scaling tendency.

For Muara Laboh Unit-1, it was agreed that after four years operation to perform continuous monitoring for silica polymerization and metal reduction analysis process from the upstream to downstream. SEML initiates a joint-project with Ecolab to perform silica scaling monitoring with several strategies as below.

a. Collect brine samples from multiple locations along the line and conduct silica and metal loss audit in order to observe the amount of silica and other metal content at the facilities.
b. Install scale coupons at multiple injection line locations in order to determine scaling deposition rate
c. Perform XRD/XRF analysis and visual inspection for several silica scaling deposition samples observed at the facilities

Two parameters—the percentage of silica polymerization and the deposition rate, which must be less than 10%—are used as target for scale growth inhibition. Additionally, the actual scaling deposition rate must be less than 1 mm/year. It is noted that variations in reservoir chemistry and operation parameters can affect the deposition rate and polymerization percentage. While the scaling rate can be determined through scale coupon installation, the silica polymerization and deposition rates can be ascertained through sampling and analysis.

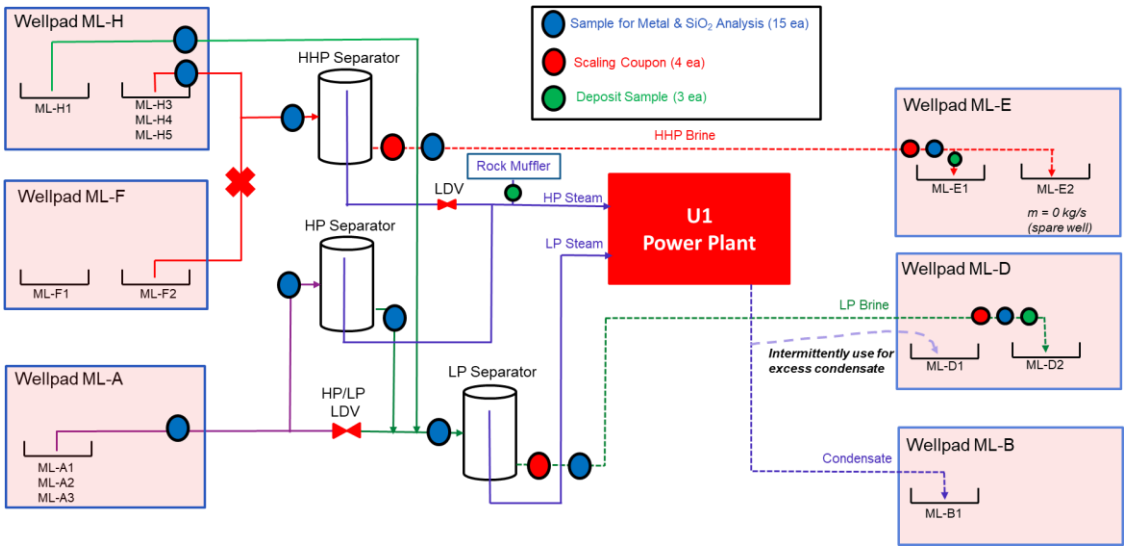


Figure 6. Location for Brine Sample and Scaling Coupon Installation

3.1 Silica and Metal Loss Audit & Analysis

Silica and Metal Loss Audit is performed with collecting samples from 15 locations, started from the headers of each production wells (ML-A1, A2, A3, H1, H3, H4, and H5), the inlet and outlet of HHP, HP and LP separator, up to header of each injection well (ML-E for HHP brine and ML-D for LP brine). The silica and metal contents are determined by analysing samples taken from each location. The information can be used to calculate the silica and metal loss, as well as the SSI and silica concentration.

3.1.1 Silica Analysis

To have comparison with internal laboratory result, SEML also sent the sample to external laboratory to obtain the silica analysis during nine months period after four years operation (November 2023 until August 2024) and then run the analysis and calculation. According to the results, total silica concentration in Muara Laboh Unit-1 during that time ranged from 517-1035 ppm in average. In general ML-H3, H4 and H5 (SW wells) and in ML-E header (HHP injection wells) have greater silica concentrations than ML-H1 and ML-A (NE wells) and ML-D2 (LP injection wells). This can lead to conditions that are more likely to generate silica and metal silicate throughout the pipeline.

Overall, there was little variation in the data during the monitoring period and from the below graphic it can be seen that the SSI at ML-H4 and ML-H5 reached around 1.0-1.3. The diagram below illustrates the latest result of silica analysis of August 2024:

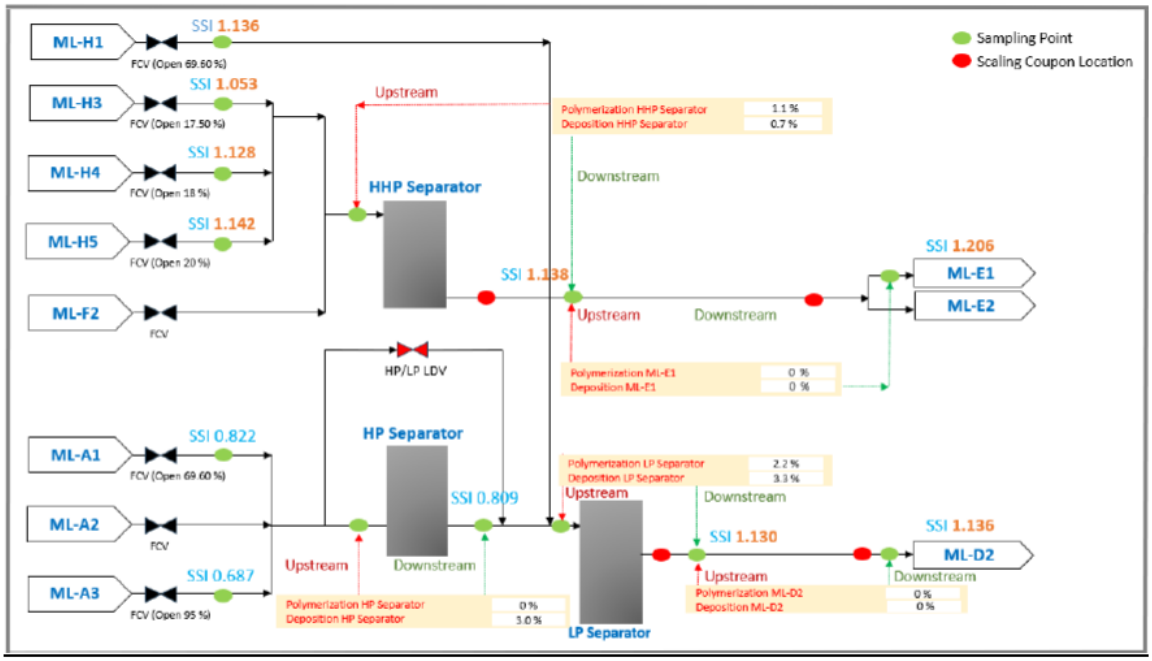


Figure 7. Silica Concentration and SSI result in August 2024 – External Result

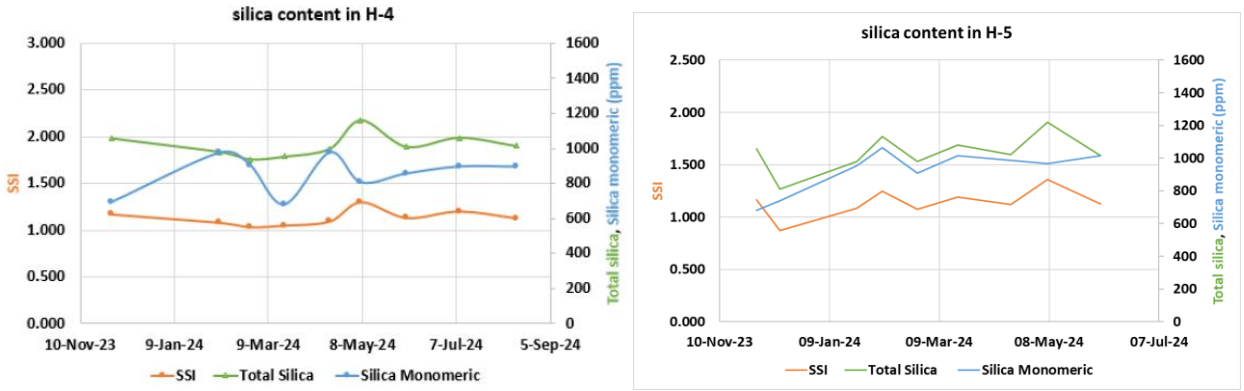


Figure 8. Silica Content and SSI in ML-H4 and ML-H5 from November 2023 until August 2024

This silica concentration data is consistent with combination of external and internal laboratory analysis covering the period of 2021-2025 (see Figure 9), which indicate that the SSI of brines from SW (HHP wells) varied between 0.85 and 1.15. The silica concentration of HHP lines ranged from about 750 to 1050 ppm, with ML-H5 having the highest value. On the other hand, the SSI of brines from NE (LP wells) are relatively low enough to be kept below 0.90, with silica concentrations only ranging from 400 to 550 ppm. According to the trend, the SSI for HHP wells occasionally reach an oversaturated condition (SSI > 1) but did not surpass 1.2.

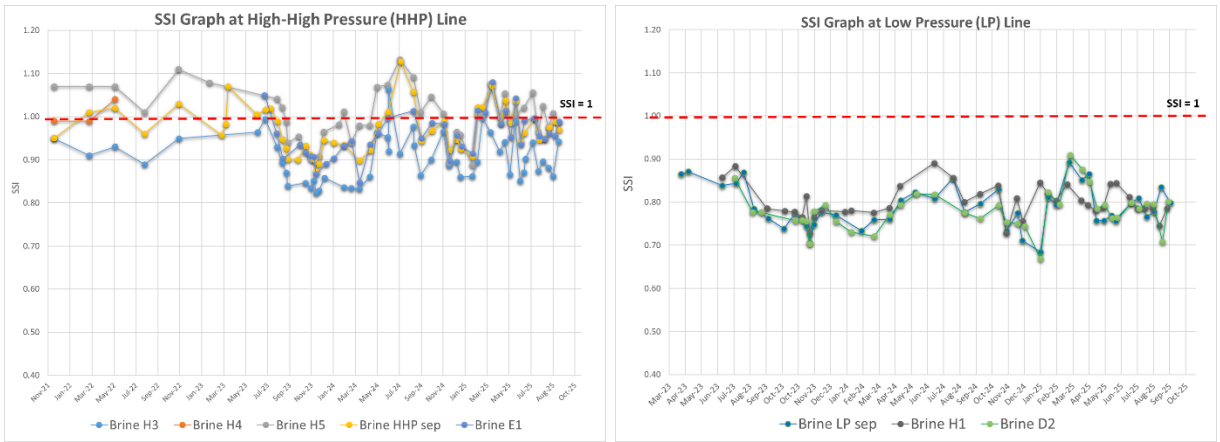


Figure 9. SSI at HHP and LP Lines from Internal Recapitulation

The percentage of silica polymerization and deposition rate must also be determined, as the SSI is not the only parameter used to identify scale growth in the piping system. Calculating the difference between the monomeric silica concentrations at the upstream side (the HHP separator downstream) and downstream side (the ML-E1 reinjection well) of the pipeline yields the polymerization rate; if the downstream silica concentration is significantly lower than the upstream silica concentration, there will be some silica deposit along the pipeline. A similar method is employed to calculate the deposition rate, however total silica concentration is utilized rather than monomeric silica.

Table 1. Silica Polymerization and Deposition Rate from several sampling locations

No	Location	Polymerization Rate	Deposition Rate	Remarks
1	HHP Separator	5%	3%	Difference of downstream & upstream separator
2	HP Separator	4%	2%	Difference of downstream & upstream separator
3	LP Separator	1%	2%	Difference of downstream & upstream separator
4	ML-E1 Well	4%	7%	Difference of well header & downstream separator
5	ML-D2 Well	4%	1%	Difference of well header & downstream separator

The silica polymerization and deposition rate during brine sampling analysis at many locations throughout the period November 2023 up to June 2024 was able to be maintained below 10% on average, according to the calculation using silica concentration data. The ML-E1 well has the highest proportion of silica deposition (7%) which was expected given that it is connected to HHP brine. The polymerization rate at ML-E1 throughout the monitoring period is depicted in the figure below.

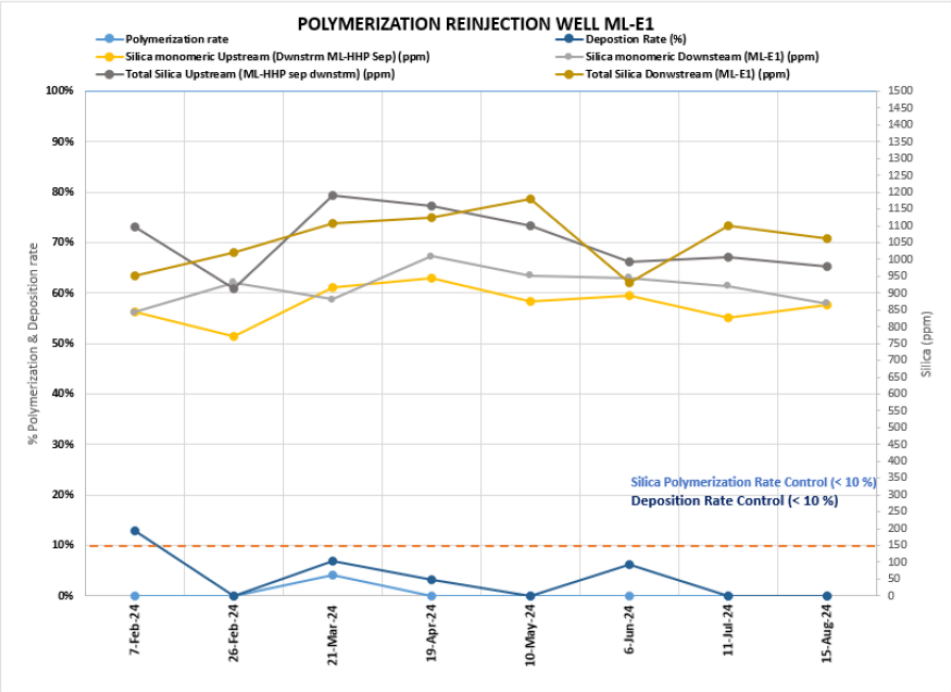


Figure 10. Trend of Silica Polymerization and Deposition Rate at ML-E1 Well

3.1.2 Metal Loss Audit & Analysis

Metal loss audit was also observed in addition to silica. A number of metal contents, including manganese (Mn), iron (Fe), aluminium (Al), and arsenic (As), must be monitored. Both the metal loss percentage and scaling potential risk for all metals were examined in the investigation. By comparing the results of the separator upstream and downstream areas, the metal loss was determined.

Table 2. Metal Content and Loss Audit Percentage

Location		pH	Metal Content (ppm)				Scaling Potential Risk				Metal Loss (%)			
			Arsenic	Fe	Al	Mn	As Trisulfide	Fe-Silicate	Al-Silicate	Mn-Silicate	As Loss	Fe Loss	Al Loss	Mn Loss
Prod. Well	ML-H1	7.33	11	0.04	0.29	0.03	Moderate	Low	Low	Low	-	-	-	-
	ML-H3	7.12	4.9	0.03	1.06	0.02	Moderate	Low	Moderate	Low	-	-	-	-
	ML-H4	6.79	5	0.03	1.09	0.02	Moderate	Low	Moderate	Low	-	-	-	-
	ML-H5	6.22	6.25	0.06	0.48	0.02	Moderate	Low	Low	Low	-	-	-	-

	ML-A1	6.73	7.25	0.05	0.19	0.04	Moderate	Low	Low	Low	-	-	-	-
	ML-A3	7.02	6.75	0.03	0.26	0.02	Moderate	Low	Low	Low	-	-	-	-
HHP Sep.	U/S	7.05	5.11	0.03	0.69	0.02	Moderate	Low	Moderate	Low				
	D/S	6.78	4.22	0.05	0.67	0.02	Moderate	Low	Moderate	Low	22%	0%	4%	0%
HP Sep.	U/S	7.18	7	0.04	0.34	0.02	Moderate	Low	Low	Low				
	D/S	7.06	7.33	0.09	0.34	0.02	Moderate	Low	Low	Low	2%	9%	9%	0%
LP Sep.	U/S	7.45	8.67	0.07	0.26	0.02	Moderate	Low	Low	Low				
	D/S	7.43	7.56	0.14	0.25	0.02	Moderate	Low	Low	Low	11%	14%	8%	3%
Inj. Well	ML-E1	6.73	3.44	0.08	0.66	0.02	Moderate	Low	Moderate	Low	19%	12%	13%	2%
	ML-D2	7.26	7.33	0.37	0.29	0.02	Moderate	Low	Low	Low	9%	37%	29%	2%

According to the table's results, the percentage of metal losses appears "significant" due to the comparatively low value of metal and the differences in value between upstream and downstream. Arsenic (As) has the greatest value and the most metal loss, which can result in the deposition of arsenic sulfide. However, the fluid's non-acidic pH (roughly neutral pH 6-7.5) can lower the risk to a low level. Arsenic sulfide is less soluble under neutral to acidic conditions (pH 3–7). Similar to arsenic, aluminium silicate has a considerable risk of scaling, but because the fluid is comparatively neutral as shown in the figure below, the risk can be lowered to low. In this situation, certain metals are less likely to react with sulfide.

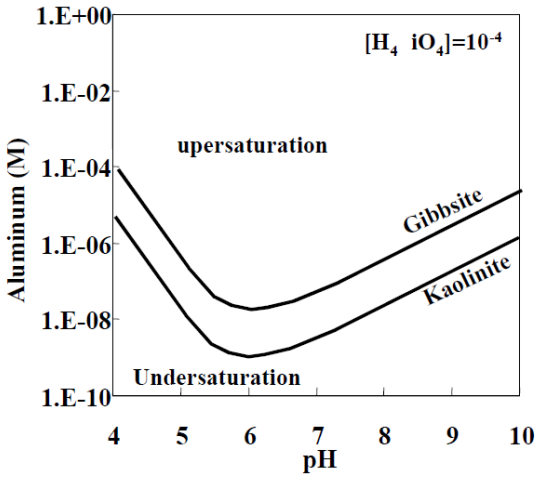


Figure 11. Aluminum Silicate (Kaolinite) Solubility versus pH (Gabelich et al, 2005)

3.2 Scale Coupon Installation and Monitoring

Installing scale coupons is also necessary following the completion of the silica and metal loss audit since it more accurately depicts the system's actual scaling growth. Four locations were selected for the installation of scale coupons in the Muara Laboh geothermal field: the HHP separator outlet, the LP separator outlet, the header of the HHP reinjection well ML-E1 and the header of the LP reinjection well ML-D2. HHP separator outlet and header of ML-E1 well represent silica deposition rate from SW wells (ML-H) while LP separator outlet and header of ML-D2 well represent silica deposition rate from NE wells (ML-A).

According to von Hirtz (2015), a rate of silica deposition exceeding 1 mm/year may seal the pores and fine fractures in the receiving formation, thereby reducing injectivity. In order to prevent scale growth in the piping system, the target for the silica deposition rate in Muara Laboh should be less than 1 mm/year.

After four years of operation, the scale coupon monitoring in Muara Laboh was initiated in mid-2024. The first installation date was July 2024 with the removal date in October 2024. Following that, there was a second monitoring period between December 2024 and March 2025, directly followed by a third period with removal date on June 2025. The fourth installation date was conducted on 26 June 2025, while the removal installation date is scheduled in Q4 2025. Data from October through December 2024 were excluded since Muara Laboh conducted a major outage during that time, which prevented the SGS from operating normally and may affected the scale coupon data's representativeness.

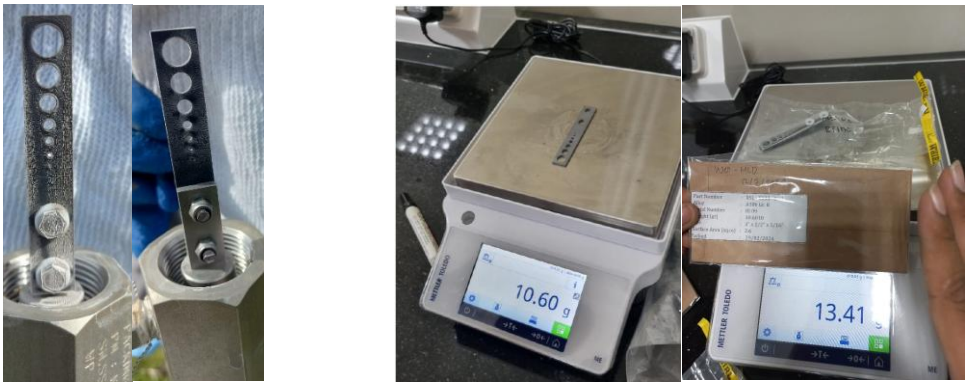


Figure 12. Scale Coupon at ML-D2 period Jul-Oct 2024; Visual Monitoring (left) and Weight Measurement (right)

The scaling deposition rate at every sampling point is consistently significantly lower than the reference target of 1 mm/year, as demonstrated by the one-year monitoring. The overall scaling was between 0.000 and 0.050 mm/year with the maximum scaling rate, which is recorded at the ML-E1 header (HHP brine line), is 0.359 mm/year. It is evident from this data that the scaling rate is extremely modest and will not negatively impact the process as a whole.

From the scale coupon visualization, the scale characteristics tend to be combination of metal silicate (dark color scale) and amorphous silica (light-brown color scale).

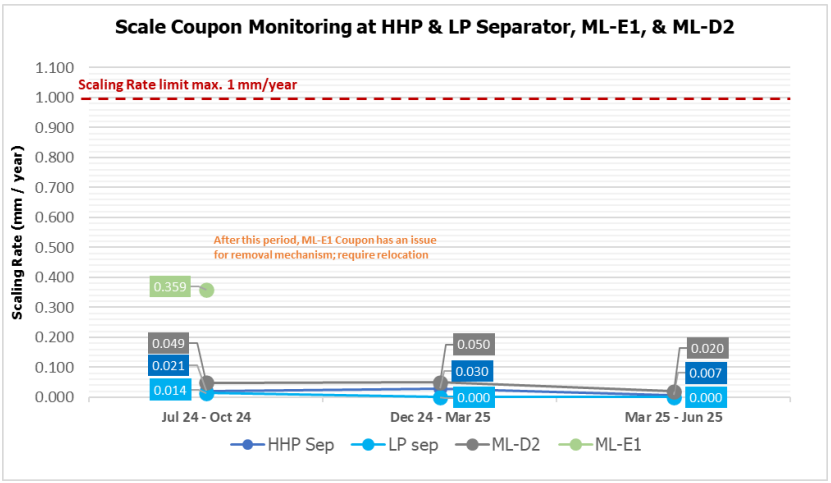


Figure 13. Scaling Rate Measurement after Scale Coupon Monitoring



Figure 14. Scaling Coupon Visualization after Monitoring Period

3.3 XRD/XRF Analysis and Visual Observation for Deposition Samples

Three samples were collected in order to determine the presence or absence of silica deposition. The locations were the header of ML-E1 (A), Flow Control Valve ML-D2 (B) and HP Steam Vent (C) – see Figure 7. According to XRD analysis, amorphous silica and certain iron minerals make up scales A and B while sulfate minerals, which are frequently found in steam lines, make up scale C. According to XRF analysis, scales A and B are dominated by silica, iron, and aluminium oxide, which suggests that iron and aluminium silicate may form inside the pipe. In contrast, scale C is composed of iron and sulfur because steam contains Non-Condensable Gas (NCG), which might lead to corrosion. The color of the scale will also help identify if it is pure amorphous silica (white) or amorphous aluminium silica (grey).

The formation of silica deposition near the downstream of HHP brine line was also visually observed. When the observation was made in November 2023, it was discovered that the flow tee and the inner surface of the pipeline within the S-bend pipe of ML-E1 (HHP brine injection well) were both clean and free of scale deposits.



Figure 15. Visual Observation of HHP brine line (ML-E1 Header) in November 2023

4 CONCLUSION

The Silica Scaling Mitigation (SSM) at Muara Laboh Unit-1 is performed by maintaining the brine temperature sufficiently high through operating the HHP separator at pressure of 14 bara. The HHP facilities have been in operation since October 2020. Up to this point, there is no major scaling problem that disrupt operation and it has been demonstrated that controlling temperature prevents silica accumulation at surface facilities.

According to the brine chemistry to date, three potential scaling at SEML are identified: Silica, Al-silicate, and As-sulfide. The majority of the locations in Muara Laboh Unit-1 exhibit low scaling potential and operate at SSI < 1.0. However, special attention is required for the HHP production wells (ML-H and ML-F) and the HHP reinjection well ML-E, as it has an SSI >1.0, even though it is still maintained below 1.2. However, given that the silica deposition rate and polymerization rate are calculated to be below 10%, they are deemed low and pose less risk for potential scaling.

Some metals, like Arsenic, were found to have concentration levels of moderate intensity in brine during the metal audit. Nevertheless, the likelihood of Arsenic Sulfide deposition forming is considered low because the brine has a neutral pH. Aluminum also carries a moderate risk, but this will be lowered to low for the same reason (the brine's neutral pH). Results from scale coupon monitoring and visual inspection shall be used to benchmark and confirm data from brine analysis with low deposition rates. The result indicates that the scaling rate is consistently below 1 mm/year, allowing for the conclusion that scaling formation and deposition in SEML Unit 1 can be effectively maintained and controlled below the industry's best practice/standard. XRD/XRF analysis and visual observation were also used as reference to ensure that silica deposition at Muara Laboh Unit-1 were well maintained and proved that the Silica Scaling Mitigation design was successful after more than four years operation.

This study and monitoring are also critical for the design of Muara Laboh Unit-2 since this data can be used as baseline before Stage-2 Project as the Stage-2 will utilize more steam from SW/HHP wells.

Acknowledgements

The authors wish to thank the management of PT. Supreme Energy Muara Laboh (SEML) for the permission to publish this work. The invaluable suggestions from Mr. Wahyu Mulyana and the quality of the operational work from Mr. Ghilman Azka, Mr. Olgi Hadi Lhendra and Ecolab International Indonesia as well as inputs form SEML Subsurface Department have been much appreciated.

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