

Evaluation of squeeze cementing design using the balance plug method in well SA, field 05

Shendy¹, Aprilino Alfa Kurmasela¹, Abdur Gafar Karim¹

¹ Program Studi S1 Teknik Perminyakan, Sekolah Tinggi Teknologi Migas, Balikpapan, 76127, Indonesia

Correspondence: shendyshey29@email.com

Article Info

Article history:

Received Jun 12th, 2026

Revised Aug 20th, 2026

Accepted Aug 26th, 2026

Keyword:

squeeze cementing; balance plug;
cement bond log; injectivity rate
test; well integrity

ABSTRACT

Squeeze cementing is a secondary cementing method used to improve cement bond quality, isolate problematic zones, and maintain wellbore integrity. This study evaluated the squeeze cementing design using the Balance Plug method in Well SA, Field 05, based on well data, Injectivity Rate Test (IRT) data, cement slurry data, and Cement Bond Log (CBL) and Variable Density Log (VDL) evaluation. The CBL-VDL evaluation on the perforation interval of 115.5–130 m showed an amplitude of 30 mV and a Bond Index of 20%, indicating a suboptimal cement bond that required remedial cementing. The design calculations produced a casing capacity of 0.03406 bbl/ft, a 2 $\frac{7}{8}$ -inch tubing capacity of 0.00579 bbl/ft, and an open hole–casing annulus capacity of 0.02755 bbl/ft, with a total cement slurry volume of 5.61 bbl (28.62 sacks). The formation fracture pressure was found to be 250 psi, with a safe operating limit set at 80% of the maximum pump pressure, i.e., 135 psi. After three squeeze stages were carried out, the Top of Cement (TOC) was found at a depth of 58 m. The Balance Plug method was considered feasible and safe to apply, as it met the operational design criteria and had the potential to improve cement bond quality within the target interval.



© 2026 The Authors. Published by Solutiva PetroTechno Journal (SPTJ). This is an open access article under the CC BY license (<https://creativecommons.org/licenses/by/4.0/>)

INTRODUCTION

Cementing is one of the essential stages in oil and gas well drilling operations, functioning to bond the casing to the borehole wall while isolating oil-, gas-, and water-bearing formations to prevent inter-zonal communication. Cementing is divided into primary cementing, performed after the casing is run into the well, and secondary cementing, a follow-up operation intended to correct an unsatisfactory primary cementing result (Wasu, 2023). The success of primary cementing is commonly evaluated using Cement Bond Log–Variable Density Log (CBL-VDL) and pressure testing; when the evaluation indicates poor cement bond quality, secondary cementing such as squeeze cementing is carried out to remedy the condition. Cementing failure can lead to unwanted water or gas production, thereby shortening the productive life of the well and reducing its economic value (Priambodo et al., 2020).

Squeeze cementing is a remedial method that places cement slurry into a target zone to isolate water- or gas-producing zones, repair casing leaks, and support well recompletion (Ikhsan & Nirmala, 2024). One technique commonly applied is the balance plug method, which is used in low-pressure formations and does not require a packer; it is carried out by running tubing or drill pipe to a predetermined depth before pumping slurry into the target zone (Prasetyo et al., 2018). This method is widely chosen for its operational simplicity and cost efficiency compared with high-pressure squeeze techniques or packer-based methods (Putradianto & Ramadhan, 2020).

Previous studies show that the success of balance plug squeeze operations depends heavily on the accuracy of slurry, spacer, and displacement volume calculations, as well as control of pumping pressure relative to formation fracture pressure. Rizky et al. (2022) reported a decrease in CBL amplitude from 70–80 mV to 5–10 mV after balance plug squeeze cementing, while Ricardo (2019) demonstrated successful perforation-zone closure in a loss formation using a slurry volume of 16.33 bbl. Prasetyo and Yunita (2025) and Falah et al. (2020) likewise emphasized the importance of injectivity testing, thickening time, and compressive strength as feasibility parameters in design. However, most of these studies have not specifically evaluated squeeze cementing design in the context

of a planned plug back operation with relocation of the production target (KUPL), performed with neat cement and no additives, as is the case for Well SA, Field 05.

In Well SA, Field 05, the existing production zone has experienced declining productivity, prompting a plan for plug back operations to relocate the production target to a different interval. CBL and VDL results show an amplitude of 30 mV and a Bond Index of 20%, indicating poor bonding, which necessitates squeeze cementing using the balance plug method. This study aims to evaluate that squeeze cementing design, covering the calculation of volumetric capacities, the required slurry and support-fluid volumes, and the operating pressure relative to the formation pressure limit, as a technical reference for remedial cementing in wells with similar characteristics.

RESEARCH METHODS

This study is secondary data-based research conducted over two months (February 11–April 10, 2026) at PT. XZ Tarakan. Three types of data were used: well data, Injectivity Rate Test (IRT) and cement data.

Well Data

The field data for Well "SA-05" used as the basis for the squeeze cementing operation planning calculations are presented below.

Tabel 1 Well Data SA-05

Parameter	Total	Unit
Well Depth	478.5	M
Outside Diameter Casing	6,625	Inch
Inside Diameter Casing	5,921	Inch
Outside Diameter Tubing	2,875	Inch
Inside Diameter Tubing	2,441	Inch
Interval Perforasi	115,5 - 130	M

Injectivity Rate Test (IRT)

Injectivity Rate Test (IRT) data used to evaluate the formation's injectivity and provide the basis for estimating the cement slurry volume to be injected.

Tabel 2 Injectivity Rate Test (IRT) Well SA-05

Data Injectivity Rate Test		
SPM	50	Stroke/min
TIME (MENIT)	5	Menit
Pressure (PSI)	150	Psi
Volume (BBL)	3,6	Bbl

Cement Data

Cement Data includes the cement slurry density, slurry yield, and the mixing water composition used during the squeeze cementing operation.

Tabel 3 Cement Data Well SA-05

Parameter	Total	Unit
Yield Slurry	1.10	Cuft/sack
Densitas Slurry	15.80	Ppg
Konsentrasi Mixing Water	5.42	Gal/sack

RESULTS AND DISCUSSION

Capacity Calculation Results

Tabel 4 Capacity Calculation Results

Parameter	Total	Unit
Casing capacity	0.03406	bbl/ft
Tubing capacity (2 $\frac{7}{8}$ in)	0.00579	bbl/ft
Annulus capacity (open hole–casing)	0.02755	bbl/ft
Annulus capacity (casing–tubing)	0.02603	bbl/ft

Cement Slurry Volume and Support Fluid Calculation Results

Tabel 5 Cement Slurry Volume and Support Fluid Calculation Results

Parameter	Total	Unit
Total slurry volume needed	5.61	bbl
Injectivity volume	2.16	bbl
Spacer ahead	4.59	bbl
Spacer behind	1.02	bbl
Displacement	0.43	bbl
Mixing water	155.13	gal

Operational Parameter Calculation Results

Tabel 6 Operational Parameter Calculation Results

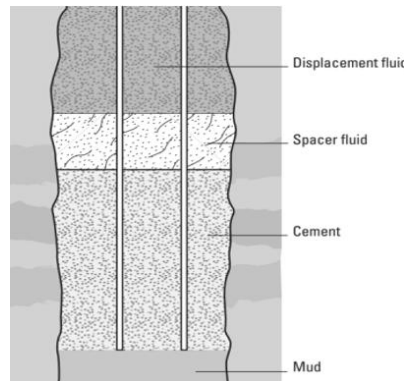
Parameter	Total	Unit
Slurry height, tubing in	176.25	ft
Slurry height, tubing out	164.65	ft
Raise up	138.74	ft
Reverse circulation	1.61	bbl
Formation fracture pressure	250	psi
Maximum pump pressure	169	psi
Operating pressure limit (80%)	135	psi
Top of Cement (TOC) after squeeze	58	m

Based on the data above, the casing capacity was found to be 0.03406 bbl/ft, the 2 $\frac{7}{8}$ -inch tubing capacity 0.00579 bbl/ft, the open hole–casing annulus capacity 0.02755 bbl/ft, and the casing–tubing annulus capacity 0.02603 bbl/ft. These values formed the basis for calculating the total required cement slurry volume, obtained by summing the casing volume (0.67 bbl), the open hole–casing annulus volume (0.54 bbl), the injectivity volume at 60% of the IRT result (2.16 bbl), and the top-of-cement volume for 20 m above the top perforation (2.23 bbl), yielding a total slurry volume of 5.61 bbl, equivalent to 28.62 sacks of cement.

In addition, the required support fluids were obtained, consisting of a spacer ahead of 4.59 bbl, a spacer behind of 1.02 bbl, a displacement of 0.43 bbl, and a mixing water requirement of 155.13 gal, which were used to clean the wellbore, prevent contamination of the cement slurry by drilling mud, and push the slurry toward the target zone in accordance with the balance plug design. The cement column height calculations yielded a slurry height of 176.25 ft for tubing in and 164.65 ft for tubing out, with a tubing raise-up length of 138.74 ft and a reverse out circulation requirement of 1.61 bbl. The pressure calculations showed a formation fracture pressure of 250 psi, a maximum pump pressure of 169 psi, and a safe operating pressure limit of 80% of the maximum pump pressure, i.e., 135 psi, while the Top of Cement (TOC) after the squeeze cementing operation was located at a depth of 58 m, indicating that the cement column had successfully covered the target interval as designed.

Picture

The balance plug technique is commonly used for cement plug placement and is generally applied in low-pressure formations without requiring a packer (Azzahra, 2023). In its execution, tubing or drill pipe is run to a predetermined depth, after which spacer fluid is pumped ahead of and behind the cement slurry to clean the wellbore and prevent contamination by drilling mud. The cement slurry is then pumped until a balanced height is achieved both inside and outside the tubing, after which the tubing is slowly pulled up so that the cement remains in the targeted zone (Azzahra, 2023). This method is considered simple because it does not require special equipment and uses only a standard cementing unit, making it more cost-efficient and operationally practical compared with high-pressure squeeze techniques or methods that rely on a packer (Amalia, 2024). The placement sequence of displacement fluid, spacer fluid, cement, and mud within the wellbore during a balance plug operation is illustrated in Figure 1.



Picture 1 Schematic of Cement Slurry Placement Using the Balance Plug Method

Source: Azzahra (2023)

This study addresses the squeeze cementing design for a well exhibiting medium poor cement bonding. CBL log data for Well "SA" identified medium poor bonding at the upper barrier (115.5–118.5 m) and lower barrier (127–130 mMD), with an amplitude of 30 mV and a Bond Index (BI) of 20%, indicating an unfilled void that could serve as a fluid flow path. Squeeze cementing using the Balance Plug method was therefore performed, chosen for its cost and operational efficiency compared with packer-based methods.

Field execution required three squeeze stages to achieve an optimal result. The first squeeze used 6.5 bbl of slurry (31 sacks of cement, 3.7 bbl fresh water) with a 2 bbl displacement; the pressure test dropped from 100 psig to 0 psig within 25 minutes, indicating the cement bond had not sealed the target zone. The second squeeze used 4 bbl of slurry (21 sacks of cement), pumped in stages (0.5 bbl at 70 psig, then 0.2 bbl up to 100 psig; total 0.7 bbl), with 2.5 bbl reversed out; the first pressure test held at 270 psig (from 300 psig), but the second test dropped from 100 psig to 0 psig within 8 minutes, indicating a persistent leak. The third squeeze used 7.2 bbl of slurry (37 sacks of cement, 4 bbl fresh water), a 1.5 bbl displacement, 1.5 bbl reversed out, and squeeze pressures of 100–140 psi, yielding the best result: 120 psi held for 5 minutes, with a final pressure test of 100 psi holding at 60 psi.

The use of neat cement without additives limited the cement bond quality achieved. Adding fluid loss additive (to reduce fluid loss into the formation), expanding additive (to improve cement-casing-formation contact), and dispersant (to lower slurry viscosity for microannulus penetration without excess water) is recommended to achieve success in a single squeeze stage.

The design evaluation yielded a total cement volume of 5.61 bbl (28.62 sacks), derived from the casing volume (0.67 bbl), open hole–casing annulus volume (0.54 bbl), injectivity volume (2.16 bbl), and top-of-cement volume (2.23 bbl). Slurry height was 176.25 ft for tubing-in (slurry level 250.28 ft) and 164.65 ft for tubing-out (slurry level 261.88 ft). Spacer ahead volume was 4.59 bbl and spacer behind 1.02 bbl, with a spacer height of 176.25 ft and spacer level of 74.02 ft. Raise-up calculations gave a total fluid volume of 7.77 bbl and a fluid column height of 228.08 ft, requiring the tubing to be raised 138.74 ft (10 joints), with a displacement volume of 0.43 bbl.

Pressure calculations yielded a Maximum Fracture Pressure of 250 psi (gradient 0.585 psi/ft at 426.53 ft depth) and a Maximum Pump Pressure of 169 psi (fracture pressure minus a total hydrostatic pressure of 81 psi from the cement, spacer, and completion fluid columns), with a safe operating limit

of 80%, i.e., 135 psi. After squeezing, a total cement volume of 8.03 bbl produced a cement column height of 235.93 ft, placing the Top of Cement (TOC) at a depth of 58 m.

Cementing success is strongly influenced by the accuracy of slurry volume planning and placement, as the formation's relatively high injectivity poses a risk of slurry entering the formation without effectively sealing the target zone. Controlling fluid loss through suitable additives, along with proper management of injection pressure, pumping rate, and displacement volume, is necessary to seal the leaking zone effectively without repeated squeeze cementing.

CONCLUSION

The evaluation of the squeeze cementing design using the balance plug method in Well SA, Field 05, produced a casing capacity of 0.03406 bbl/ft, a tubing capacity of 0.00579 bbl/ft, and an open hole–casing annulus capacity of 0.02755 bbl/ft, with a total cement slurry requirement of 5.61 bbl (28.62 sacks), a spacer ahead volume of 4.59 bbl, a spacer behind volume of 1.02 bbl, a displacement of 0.43 bbl, a tubing raise-up of 138.74 ft, and a reverse circulation requirement of 1.61 bbl. The formation fracture pressure was found to be 250 psi, with a safe operating limit of 135 psi, and the Top of Cement after squeeze was located at a depth of 58 m. Field execution required three squeeze stages due to the use of neat cement without additives; therefore, the addition of fluid loss additive, expanding additive, and dispersant is recommended to improve cement bond effectiveness in future remedial cementing operations. Overall, the balance plug method is considered feasible and safe to apply, as it meets the operational design criteria and improves cement bond quality and zonal isolation within the target interval.

REFERENCES

- Amalia, N. (2024). *Perencanaan squeeze cementing dengan kombinasi metode hesitation dan balance plug* (Laporan tugas akhir, Institut Teknologi Petroleum Balongan).
- Azzahra, F. (2023). *Perencanaan squeeze cementing pada Sumur AZR-26 lapisan TAF-3.1* (Skripsi, Institut Teknologi Sains Bandung).
- Core Laboratories. (n.d.). *G&G evaluation Simenggaris Block* (Internal report).
- Falah, M. R., Darmawan, J. K., Kasmungin, S., Pratiwi, R., & Yanti, W. (2020). Analisis pelaksanaan proses *squeeze cementing* pada Sumur X-009 Lapangan X. *KOCENIN Serial Konferensi, 1*, Webinar Nasional Cendekiawan Ke-6 Tahun 2020.
- Fitrianti, F., Firdaus, M., & Satria, M. Y. S. (2020). Evaluasi pekerjaan *squeeze cementing* dengan metode *hesitate* pada sumur minyak. *Lembaran Publikasi Minyak dan Gas Bumi, 54*(2), 69–79.
- Hidayati, S., Guritno, E., Argenton, A., Ziza, W., & Del Campana, I. (2007). Re-visited structural framework of the Tarakan Sub-Basin, Northeast Kalimantan–Indonesia. *Proceedings of the IPA Thirty-First Annual Convention and Exhibition*.
- Ikhsan, A., & Nirmala, G. S. (2024). Evaluasi program *squeeze cementing* di Sumur X pada Lapangan Pertamina EP Zona 7 Jatibarang Cirebon. *Jurnal Eksplorasi dan Produksi Migas, 2*(2), 74–82.
- Irnanda, P. N. (2018). *Analisis karakteristik overpressure pada Lapangan CGK, Cekungan Tarakan, Kalimantan Utara* (Skripsi, Institut Teknologi Bandung).
- Pradana, H. Y. (2016). Analisis *squeeze cementing* berdasarkan data log CBL pada Sumur HA-11 [Squeeze cementing analysis based on CBL log data on Well HA-11]. *Proceedings Seminar Nasional Cendekiawan*.
- Prasetyo, E., Arief, T., & Prabu, U. A. (2018). *Perencanaan squeeze cementing metode balance plug pada Sumur X dan Sumur Y di Lapangan Ogan PT Pertamina EP Asset 2 Prabumulih*. Universitas Sriwijaya.
- Prasetyo, W., & Yunita, L. (2025). Squeeze cementing planning using balance plug method in loss formation on "TBN-10" well. *Kurvatek, 10*(2), 199–206. <https://doi.org/10.33579/krvtk.v10i2.6246>

- Prayudha, N. A. (2018). *Tugas akhir program pendidikan (TA)*.
- Priambodo, A., Julianto, C., Nugroho, M. R., & Tulloh, H. (2020). Studi perencanaan dan pelaksanaan *squeeze cementing* metode *bradenhead squeeze* untuk *water shut-off* pada sumur minyak dengan *water cut* tinggi. *Prosiding Seminar Nasional Sains dan Teknologi Terapan*, 1(1), 403–410.
- Putradianto, R. R., & Ramadhan, D. S. (2020). Squeeze cementing using *bradenhead squeeze* method on "DSR-29" Well, Tarakan Field, PT Medco E&P Indonesia. *Journal of Petroleum and Geothermal Technology*, 1(1), 15–27. <https://doi.org/10.31315/jpgt.v1i1.3322>
- Revi, T. Z., & Wahyuni, M. G. S. (2018). Squeeze cementing dengan menggunakan metode *Bradenhead squeeze*. *Jurnal Petro*, 7(1), 32–36.
- Ricardo, R. (2019). *Analisis squeeze cementing dengan menggunakan metode balance plug pada formasi loss di Lapangan RC Sumur X* (Tugas akhir, Universitas Islam Riau).
- Rizky, R., Eko, E., & Candra, C. (2022). Analisa pekerjaan *squeeze cementing* dengan metode *balance plug* berdasarkan data CBL dan VDL pada Sumur "GZ" Lapangan "BHARA". *Jurnal Offshore: Oil, Production Facilities and Renewable Energy*, 6(1), 21–28.
- Rubiandini, R. (2009). *Teknik operasi pemboran 1*. Institut Teknologi Bandung.
- Wasu, A. R. R. (2023). *Modul cementing pemboran*. Universitas Trisakti.
- Yadav, K., & Sircar, A. (2017). Review of deep drilling techniques for high enthalpy geothermal reservoirs. *International Journal of Advanced Research*, 5(6), 2359–2370. <https://doi.org/10.21474/IJAR01/4681>