



Society of Petroleum Engineers

SPE-231705-MS

Integrity Assurance During Casing Drilling in Complex Areas, Supported by AI-Backed Digital Tools

P. Berrios and E. Constantino, Tenaris; J. Torres, J. Armella, and F. Diaz, YPF. Neuquen, Argentina

Copyright 2026, Society of Petroleum Engineers DOI [10.2118/231705-MS](https://doi.org/10.2118/231705-MS)

This paper was prepared for presentation at the SPE Latin American and Caribbean Petroleum Engineering Conference held in Rio de Janeiro, Brazil, 9 - 11 June 2026.

This paper was selected for presentation by an SPE program committee following review of information contained in an abstract submitted by the author(s). Contents of the paper have not been reviewed by the Society of Petroleum Engineers and are subject to correction by the author(s). The material does not necessarily reflect any position of the Society of Petroleum Engineers, its officers, or members. Electronic reproduction, distribution, or storage of any part of this paper without the written consent of the Society of Petroleum Engineers is prohibited. Permission to reproduce in print is restricted to an abstract of not more than 300 words; illustrations may not be copied. The abstract must contain conspicuous acknowledgment of SPE copyright.

At the beginning of 2024, the operator began the shale development of the Lajas project strategically targeting the Vaca Muerta formation in Neuquén. This area is part of the Loma La Lata field, one of the most prolific in Argentina, and it has historically been the subject of extensive drilling activity in both conventional and tight gas reservoirs since the 1980s, across multiple campaigns.

Based on previous experience in the area, a four-string well design was carefully chosen due to geological complexities in the Canderelos / Rayoso formations, with pressure differentials that frequently cause total losses while drilling. Additionally, as a multi-well PAD development, a deviated trajectory is required in this complex section under field-specific constraints.

Therefore, the combined use of directional drilling and casing while drilling (CWD) from the severe loss zone at around 600 m depth was adopted as the best alternative in practice.

At the beginning of the campaign and applying this combination of techniques, fatigue failures were observed in the 9 5/8" casing, preventing the operation from reaching total depth and requiring fishing and re-casing operations under challenging conditions. This prompted the immediate incorporation of vibration measurement.

The technology implemented consisted of real-time monitoring of drilling variables through the addition of a high-frequency sensor and an Artificial Intelligence model to detect and quantify vibrations in the drilling string and their impact on fatigue damage, continuously and on-site.

This paper presents the results of implementing this technique in 35 wells in operation in the Lajas field targeting Vaca Muerta during the evaluated period.

Introduction

The La Angostura Sur (LAS) block is part of the Loma La Lata – Sierra Barrosa (LLL-SB) exploitation concession and is located in the SE sector of that concession, within a broadly recognized regional context. It lies about 90 km NW of the city of Neuquén and approximately 25–30 km S-SE of the town of Añelo, forming a relevant spatial reference. Geologically, it is located within the area known as the Basin Center, at its SE end, immediately north of the Huincul High, following a clearly defined structural framework.

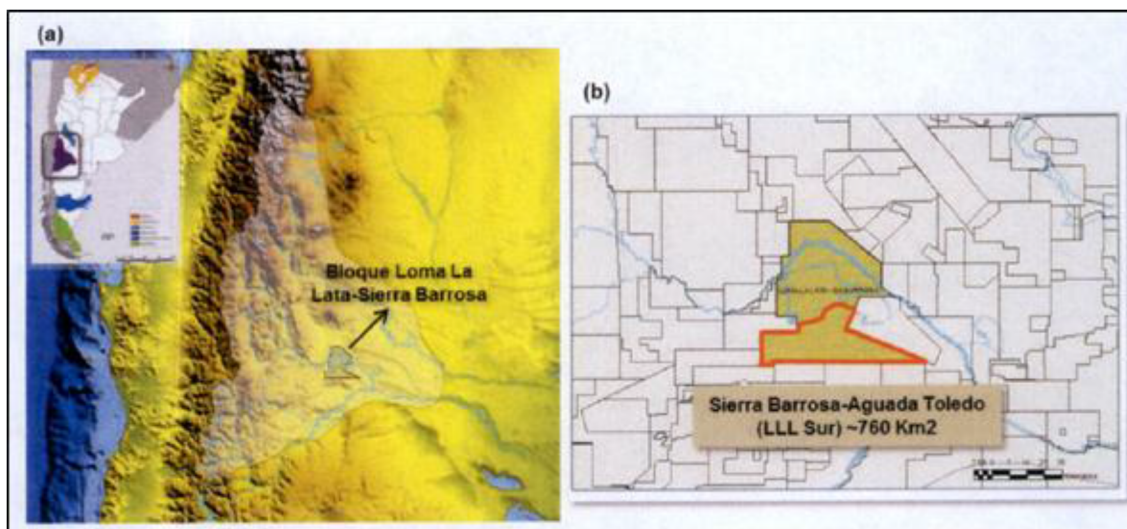


Figure 1—Geographic location of the LLL-SB Field.

The Loma La Lata – Sierra Barrosa (LLL-SB) block is an Exploitation Concession granted in 1992 and start operated in the same years under an increasingly structured framework. It has a total area of 1,972 km², while the SOUTH portion (south of Lake Barreales) covers an area of 760 km² with a clearly defined boundary. In 2013, the operator launched a tight gas project in the southwestern area of the concession as part of a broader development strategy. This project began in parallel with the first Vaca Muerta wells and involved drilling 148 wells between 2011 and 2016 (Federico Wagner, 2016), demonstrating a sustained operational effort.

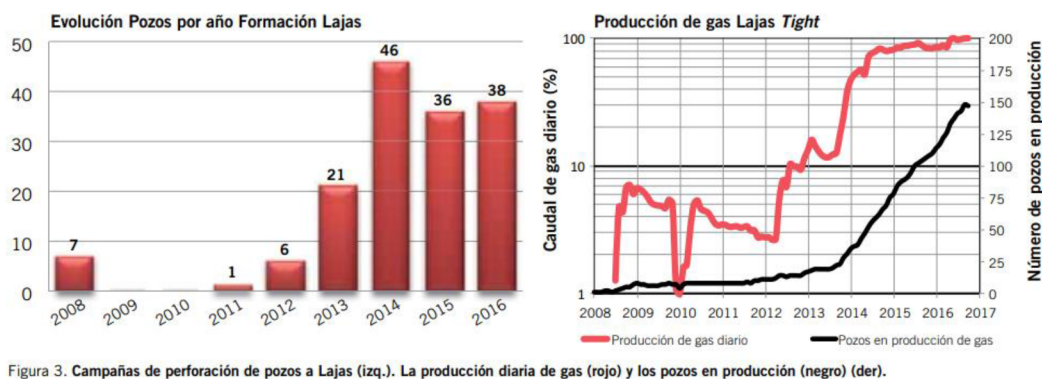


Figure 2—Lajas Tight Gas development 2011–2017 | Number wells and production (Federico Wagner, 2016).

A key development aspect during those years was the massive use of casing while drilling technology to effectively overcome zones with severe fluid losses under increasingly demanding conditions. More than 90% of the wells successfully used this technology, demonstrating a consistently reliable operational tendency. However, as in other cases, casing failures were experienced during certain critical stages. The following images, taken from the failure analysis, confirmed fatigue as the cause through a clearly documented evaluation.



Figure 3—Failure of 9 5/8" TXP BTC during casing drilling operations
(Well Laj-75) Tight gas development 2015 (Codega Dario, 2015).

To provide context, from the start of the Lajas development until now, other operators also experienced this type of failure under various operational circumstances. This motivated the decision to develop a system to measure and control vibrations during casing while drilling in a more systematic manner. (Espinosa et al., 2017)

Statement of Theory

Vibration Monitor

Fatigue failures in connections during Casing While Drilling operations reduced the pace of technology application under increasingly challenging conditions. During the evaluation of the failure origin, it was clearly identified that the problem was more related to the dynamic loads produced while drilling, particularly under variable downhole interactions. These loads do not necessarily cause immediate failures and were not adequately measured by the rig sensors and devices available at that time.

Tenaris designed a system in which a sensor measures, with greater resolution and precision, the loads applied to the casing string using a specifically engineered approach. The signals are processed by an automated system that can generate real-time alerts for the operator's engineering and operations personnel, enabling more informed decisions. The scheme below illustrates the system through a simplified conceptual representation.

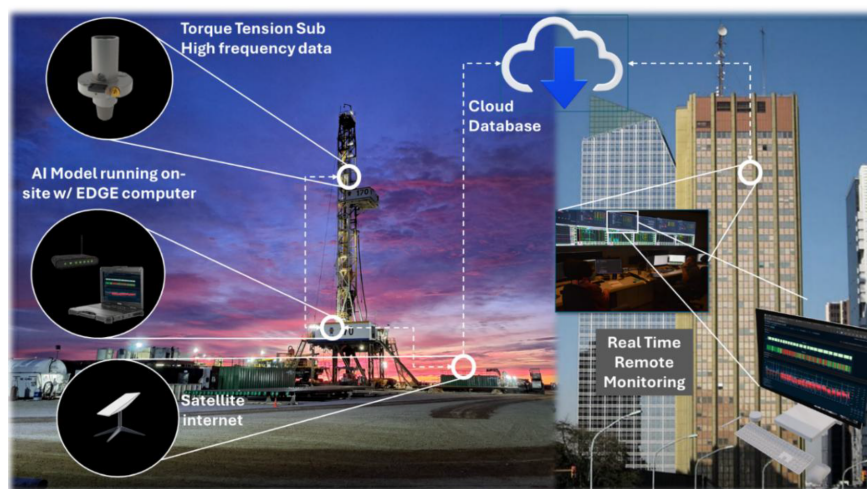


Figure 4—Schematic of the vibration monitor.

Description and Application of Equipment and Processes

The system consists of

- Torque-Tension Sub: A sensor located just below the Top Drive that collects precise, continuous high-frequency data (up to 120 Hz/s) of torque, tension, and accelerations on the three axes, which are directly linked to low-frequency EDR (Electronic Drilling Recorder) data for correlation and analysis. All this information is processed and displayed in real time in a viewer that also securely streams the data, enabling reliable real-time monitoring from anywhere with an internet-connected device (computer or mobile), whether on-site or remote.
- On-site Artificial Intelligence model: A high-capacity computer runs a machine-learning model that proactively identifies aggressive conditions based on real-time, high-resolution data collected by the sensor and rig systems in a continuous operational manner. The model was trained with information from previous wells, leveraging curated historical datasets for enhanced pattern recognition.

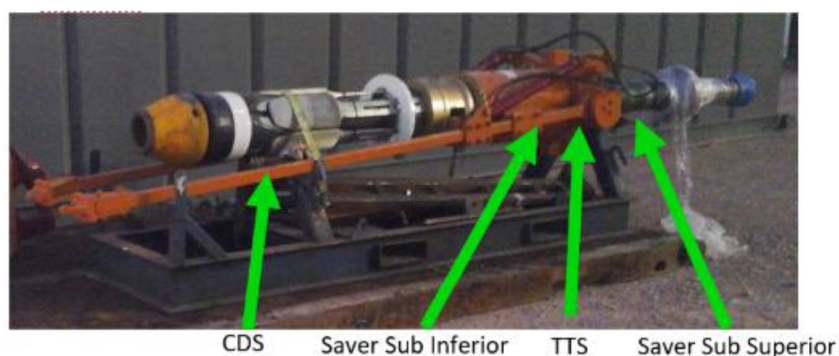


Figure 5—Upper Sub Assembly, TTS, Lower Sub, CDS.

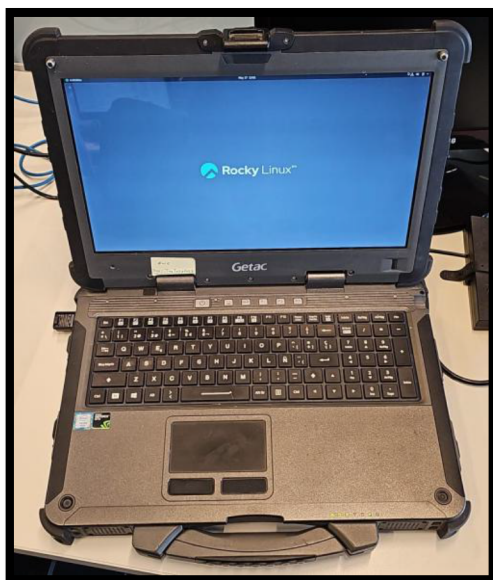


Figure 6—Edge computer.

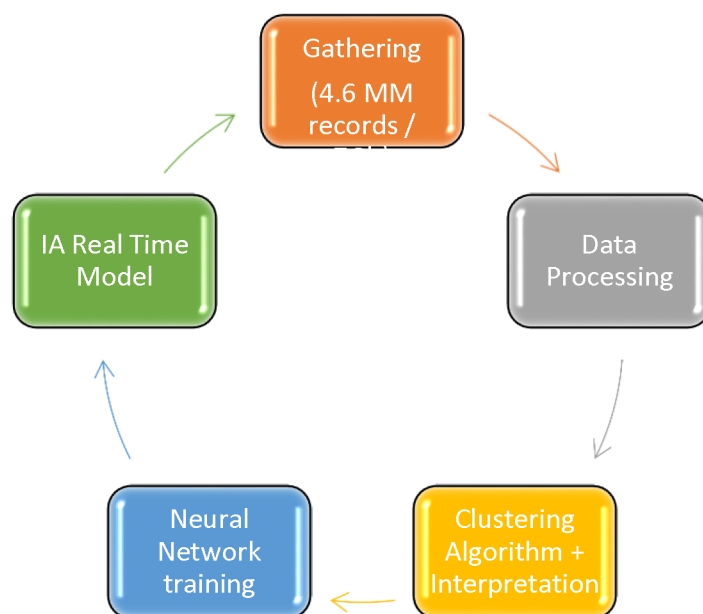


Figure 7—Process Scheme that input and output data

The data received from the TTS were successfully identified and classified by leveraging advanced behavior pattern recognition techniques on incoming, high-resolution datasets with robust, domain-informed criteria.

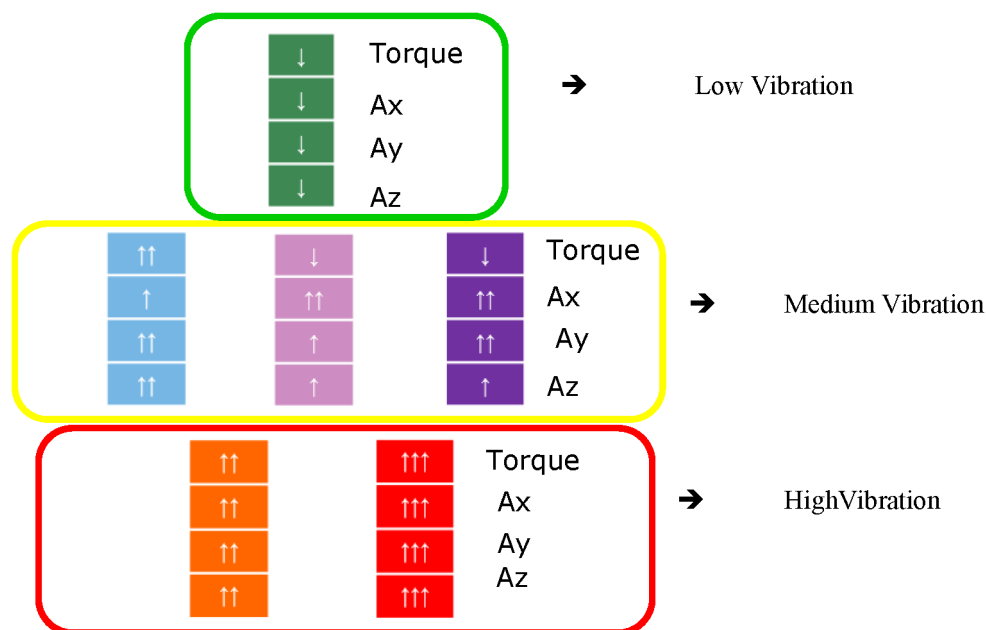


Figure 8—Patterns Model

The model works as a clustering algorithm that groups variables with similar behavior patterns, of torque and accelerations on the three axes, observed across multiple operating regimes using consistent, unsupervised criteria. These data is processed in real time and analyzed through a Neural Network model of 10×10 size, enabling continuous classification and rapid, reliable inference.

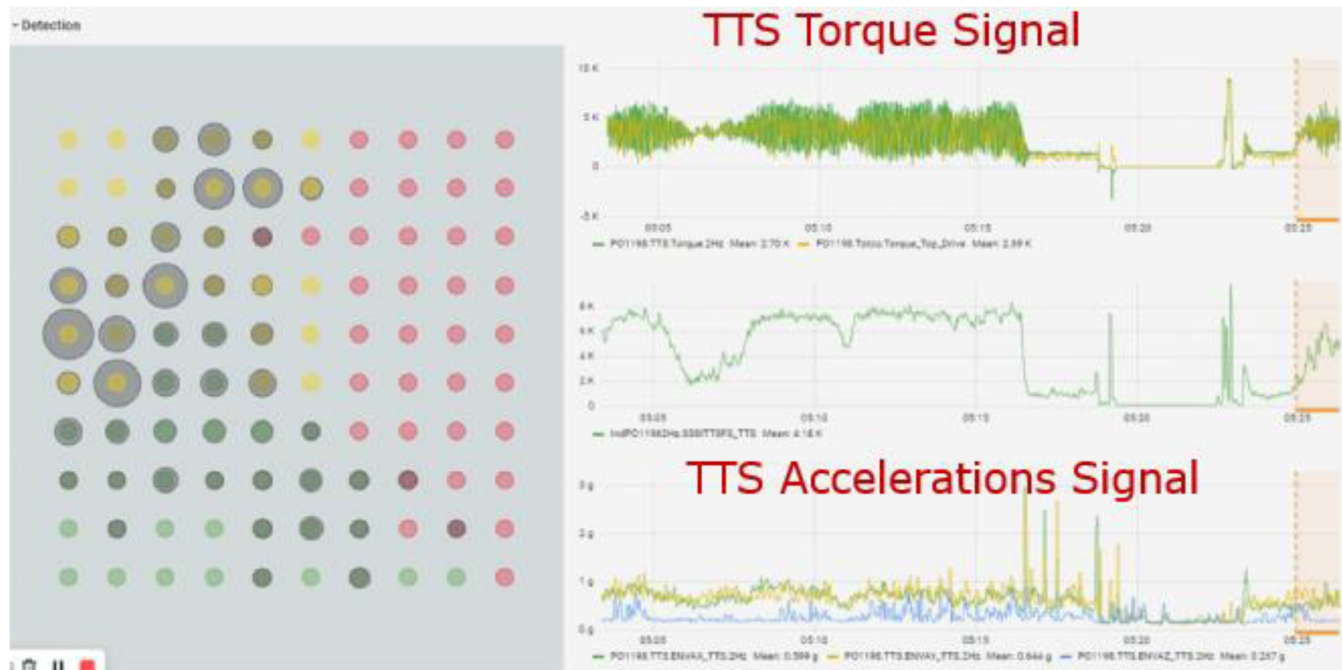


Figure 9—Print of neural network operation

- Satellite internet: Data transmission is performed via satellite to a cloud database for centralized storage and analysis, enabling continuous, near real-time access for remote monitoring and decision-making.

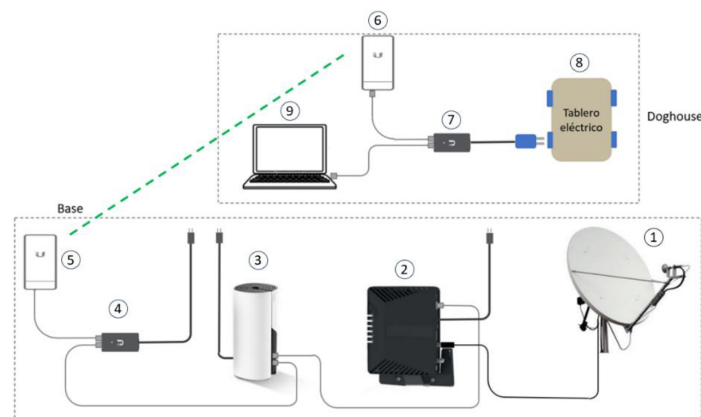


Figure 10—Antenna and peripherals connection diagram.

- Database: An internally developed cloud tool to securely store and display data for real-time monitoring and comprehensive historical analysis and reporting, ensuring centralized accessibility.
- Real-Time Monitoring: Conducted through the internally developed tool that enables interactive visualization of the data streamed in real time, continuously and securely, both on site and on any computer or mobile device connected to the cloud application with appropriate credentials.

The main output of this entire system is a pattern-classification algorithm that categorizes the drilling vibration condition every second in an automated, consistent, and operationally relevant manner.

The model result can be classified in three different colors (green, yellow or red) depending on the internal classified criteria of the result that vibration condition and associated severity level.

Events considered damaging (red) are counted against a maximum cumulative events threshold defined from experience gathered in other operations and documented operational learnings to guide timely mitigation actions.

The image below is a screenshot of our cloud-based tool.

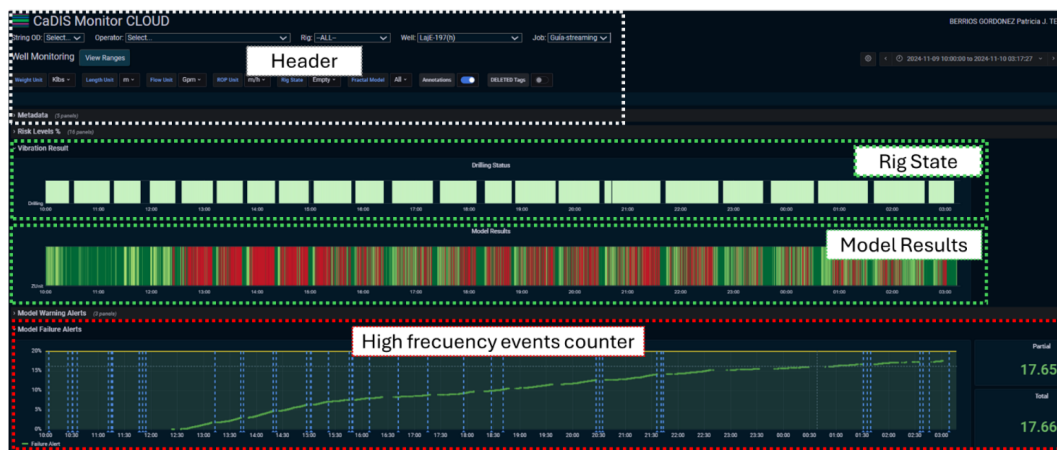


Figure 11—View of the cloud-based vibration monitoring system.

Lajas – Vaca Muerta Development (2024)

In 2024, the operator decided to start developing an unconventional field strategically located in the southeastern part of the block, north of the Huincul High. The project contemplated drilling more than 200 wells targeting Vaca Muerta over approximately four years, in multiple phases and stages. Leveraging the experience gained in low-pressure gas development, the operator's engineering team decided to use casing-while-drilling technology to overcome problems specifically related to fluid losses.

The following diagram clearly shows the initial design of a typical well and indicates CWD in the intermediate section with nominal 9 5/8" casing from 600 m to approximately 950 m. CWD is typically implemented when total drilling fluid losses are detected in the Candeleros / Rayoso stratigraphic section

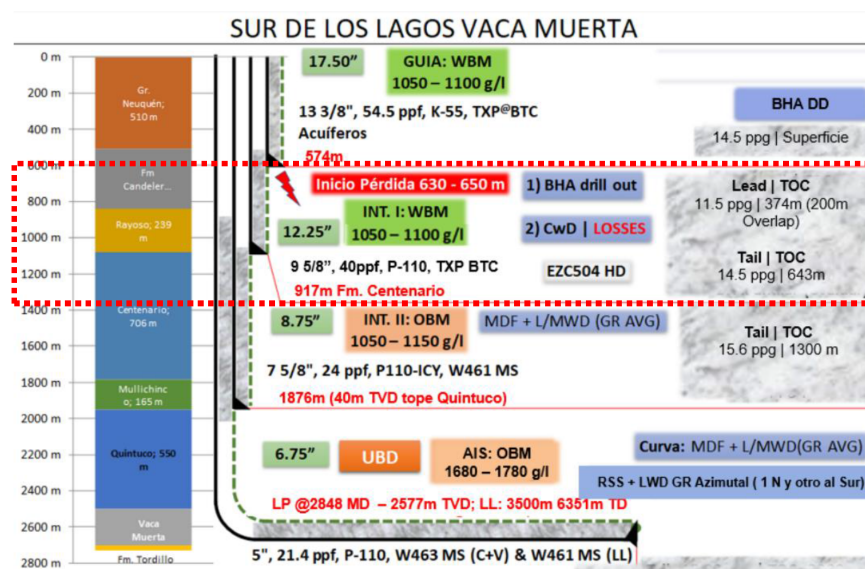


Figure 12—Well schematic in Lajas Vaca Muerta.

Unlike what is being done massively in other Vaca Muerta areas, the Lajas project also exhibited the particularity that the section requiring CWD is not completely vertical, particularly under field-specific operating conditions; in this zone, conventional drilling with a directional BHA is performed and the deviated section is initiated in a controlled manner. When the loss zone is encountered, the drilling scheme switches to CWD, adding additional stresses to the casing while traversing points with marked dog-leg severity (DLS), thus necessitating heightened attention to parameters and practices.

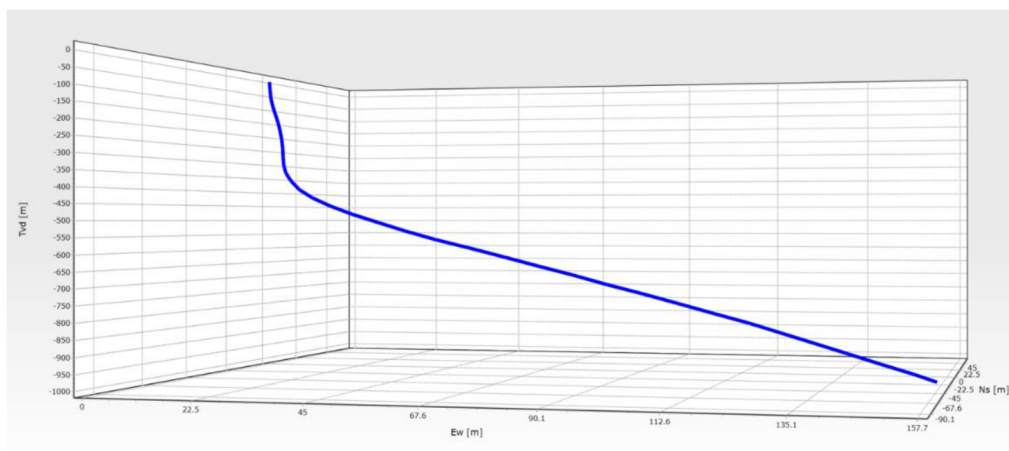


Figure 13—Typical trajectory of a Lajas well.

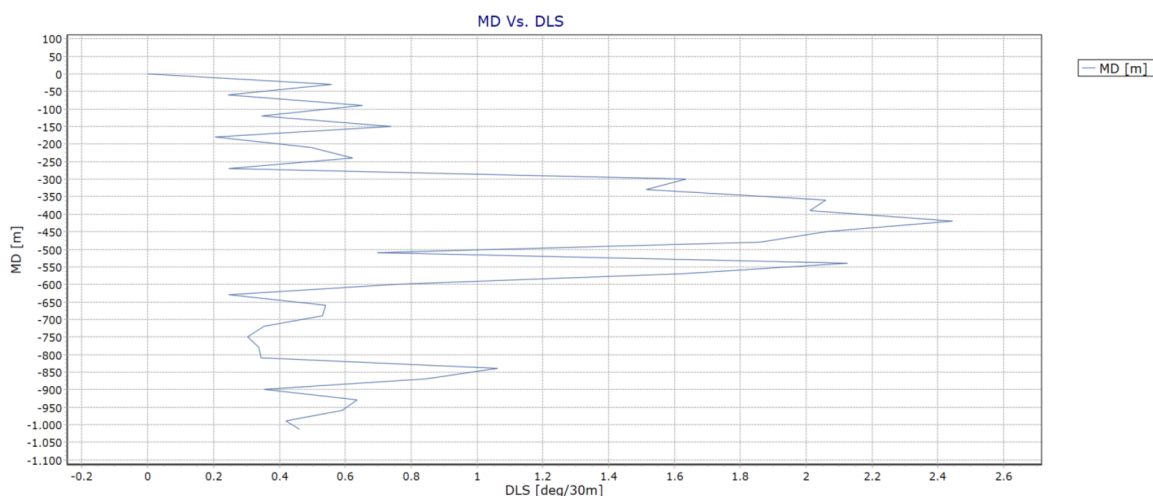


Figure 14—DLS in a Lajas well.

Failures during Casing-While-Drilling

When the project started in January 2024 with the pilot well L-1s, significant mud losses were experienced during CWD under increasingly challenging conditions and the operating variables clearly indicated a problem, ultimately forcing operations to stop before reaching total depth (TD). At the start of the next drilling phase, the operator confirmed the presence of cement inside the casing string through standard verification procedures. These events may have been related to a connection with a crack, thereby causing several operational delays across activities.

As planned, the project continued with new development wells in which the vibration monitoring tool was implemented to measure vibrations and estimate accumulated casing fatigue in a more consistent manner.

However, in August 2024, at PAD L4, the decision was made to proceed without the measurement tool for specific operational reasons. The first well was drilled successfully, but while drilling the second well,

L-4, a sudden pressure drop and loss of hook load were recorded in real time. Upon retrieving the material, a parted connection at the last engaged thread was confirmed by inspection. Failure analysis confirmed fatigue as the mechanism, as shown in the following images and documented notes, causing operational delays and downtime similar to what happened in January of the same year in the pilot well L-1s.



Figure 15—Casing failure. L-4 August 2024.

Based on this experience and with support from Tenaris, the operator decided to use our Models vibration consistently in all subsequent Lajas wells drilled up to February 2025, following standardized operational guidelines.

The Tenaris vibration monitor uses an AI model to proactively identify hazardous conditions for the casing based on data from previous wells, the model learns from experience through iterative pattern recognition. The system displays this information to the user in real time and allows drilling parameters to be modified to reduce casing damage through timely, informed adjustments. The image below is a screenshot of the application; hazardous vibration events (red) decrease as rpm (blue line) are reduced under otherwise comparable conditions. Notably, a difference of only 5 rpm can change the vibration condition of the casing string in a measurable and operationally significant way.



Figure 16—Screenshot of the Tenaris vibration monitoring application.

Presentation of Data and Results

Timeline

From that point on, all subsequent wells were drilled with the vibration monitoring system, under a consistent, field-wide implementation approach. The following timeline shows the evolution of the project from January 2024 to February 2025, highlighting relevant phases, milestones, and outcomes. Wells in blue and green used the Tenaris vibration monitoring service; in gray, wells that did not, serving as a baseline for comparison and analysis. Wells marked with an "X" presented failures during CWD, as recorded in operational reports and documented field logs.

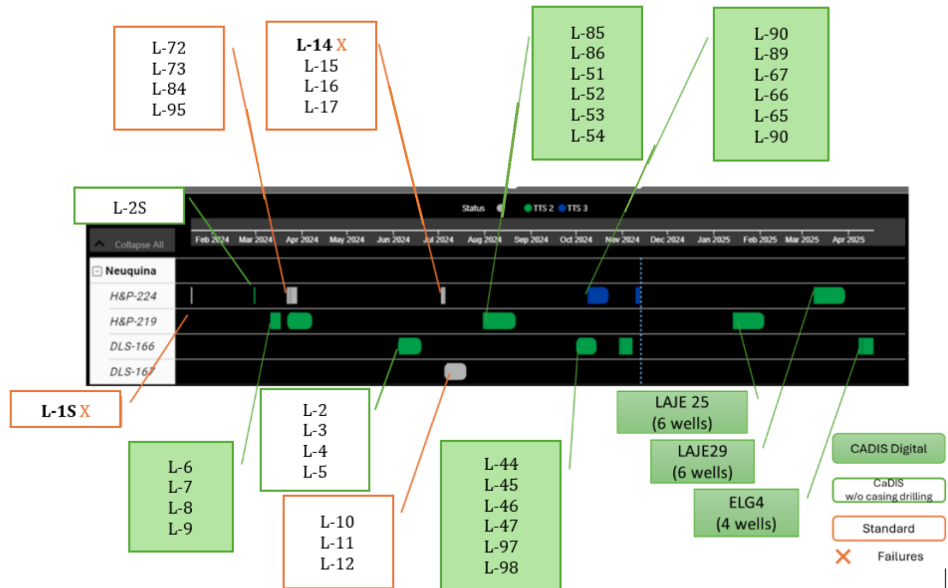


Figure 17—Timeline of CWD in Lajas 9 5/8" – 2024/2025.

Results of Using the Vibration Monitor

The following table summarizes the number of strings drilled with CWD up to February 2025, with the breakdown of the number of failures observed and documented in detail:

Table 1—Failures Summary Well

Casing Drilling	Vibration Monitoring	Successful	Failure	Total	Failure Rate
Yes	No	9	2	11	18%
	Yes	35	0	35	0%
Without need for Casing Drilling	No	5	0	5	NA
Total Wells		49	2	51	NA

As mentioned above, in the wells where the vibration monitor was used, casing installation was ensured in all cases, even under severe loss conditions, through coordinated, data-informed operational decision-making. A key factor for success was streaming model results and rig information in real time, securely and continuously, for immediate visibility. The Operations team, Company Representative, Engineering

and Real Time Intelligence Center of the operators used the insights from the model to adjust parameters, collaboratively and in a timely, procedural manner.

In particular, RPM and WOB applied during drilling were the main factors to modify the condition, serving as the primary, operationally controllable levers. The following screenshot shows the result of the AI vibration model and the rpm in well L-89, as an illustrative, representative example. On the left side, below 25 rpm, vibration levels were high, while reducing to 20 rpm significantly lowered them, clearly and measurably under otherwise comparable conditions.



Figure 18—Cloud-based application.

We evaluated all wells together comprehensively, across the campaign. The first chart visually compares the percentage of vibration mode for each well and shows, in strict chronological order, the progressive evolution of different vibration levels recorded by the monitor, with a clear, measurable decrease of high vibration (Type 1 and Type 2) as the service matured over time.

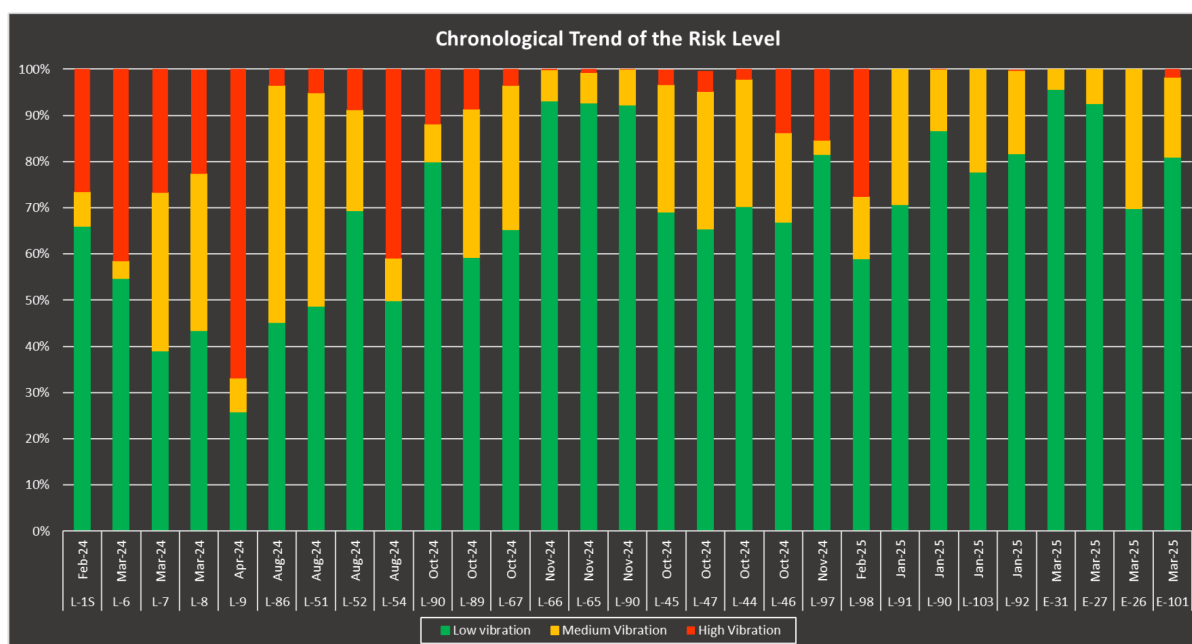


Figure 19—Chronological evolution of risk level recorded by the vibration monitor.

The dynamic behavior of each well is inherently unique, and a dedicated vibration measurement tool is necessary to make timely real-time decisions. This decreasing risk level is the direct result of applying disciplined drilling strategies and real-time parameter tuning that allowed us to identify some trends and recurring patterns:

- The variability of vibration type is significant between different wells within the same PAD, even under comparable operating conditions.
- High Type-2 vibrations, which we correlate with the maximum vibration level, do not occur as frequently in practice.

The next chart compares the number of events with high Type-1 and Type-2 vibrations against a threshold defined by the model for consistent benchmarking. We added total drilling time in hours to try to correlate both variables and contextualize exposure. Analysis highlights as follows:

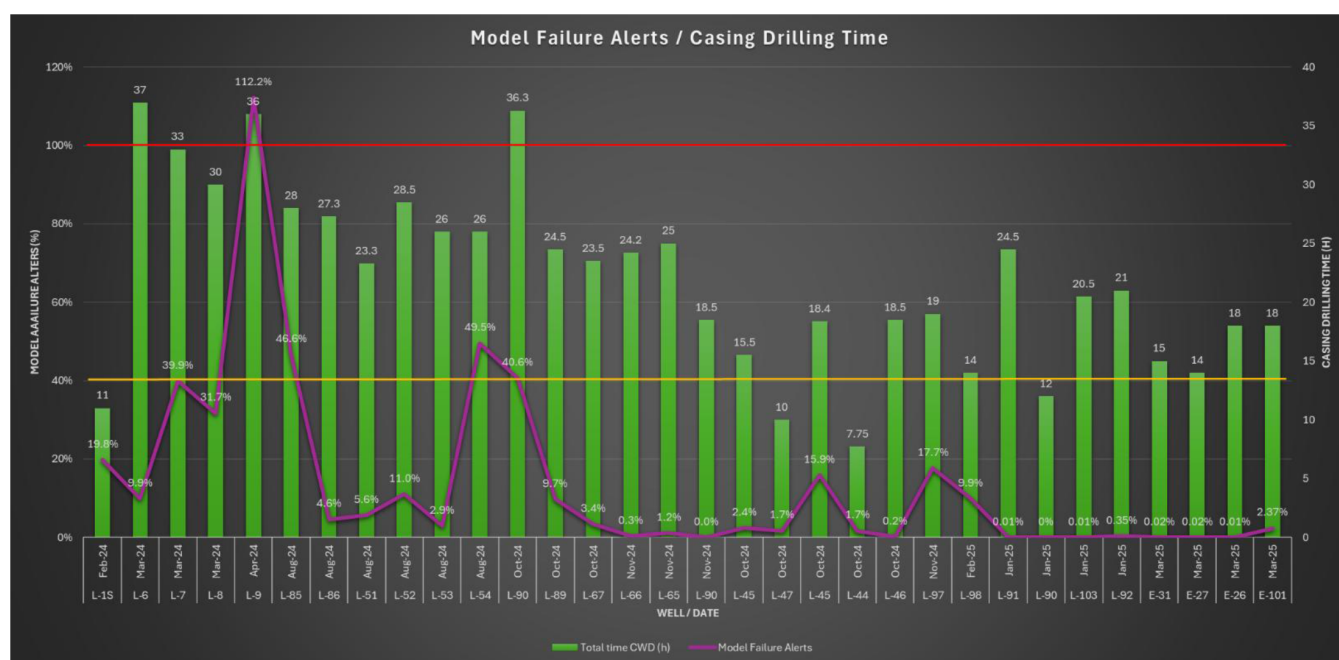


Figure 20—Failure alerts detected by the system per PAD / well.

There is no clear, observable correlation between a high level of model failure alerts and drilling time - vibration modes vary significantly between wells in the same PAD and even more between different PADs, under comparable operating conditions and contexts.

In wells with high vibration levels, drilling parameters were promptly modified to limit time spent in critical conditions through targeted, real-time adjustments.

Well L-9 exceeded 100% of the model's maximum allowed failure alerts, while three other wells exceeded the 40% threshold with no failures (as seen in the timeline), providing an informative contrast. We considered this well for in-depth analysis so the model could continue learning, as this preset threshold might have been surpassed due to unidentified high Type-1 vibration behavior without registering high Type-2 vibrations, which are the most severe, at least within the observed intervals.

Regarding drilling parameters, since the beginning we observed that RPM and WOB had the greatest impact on vibration results; thus, our recommendations focused on controlling these variables as primary, operationally controllable levers.

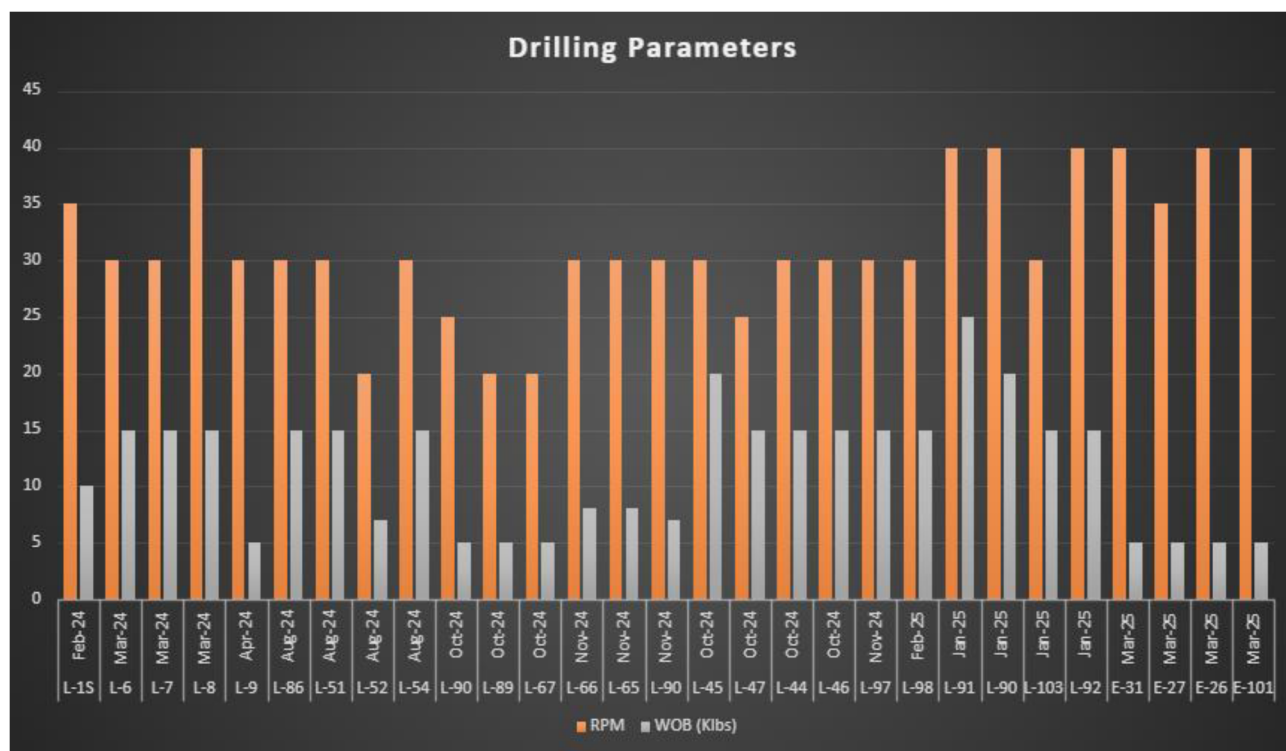


Figure 21—RPM and WOB of assisted wells.

Initially, the recommendation was always to reduce and/or control both variables proactively and consistently; however, in the latest runs we observed that it was possible to drill with higher RPM and lower WOB under otherwise comparable conditions without affecting vibration levels, which translated into a clear trend of improved ROP in wells drilled in the area during the evaluated period.

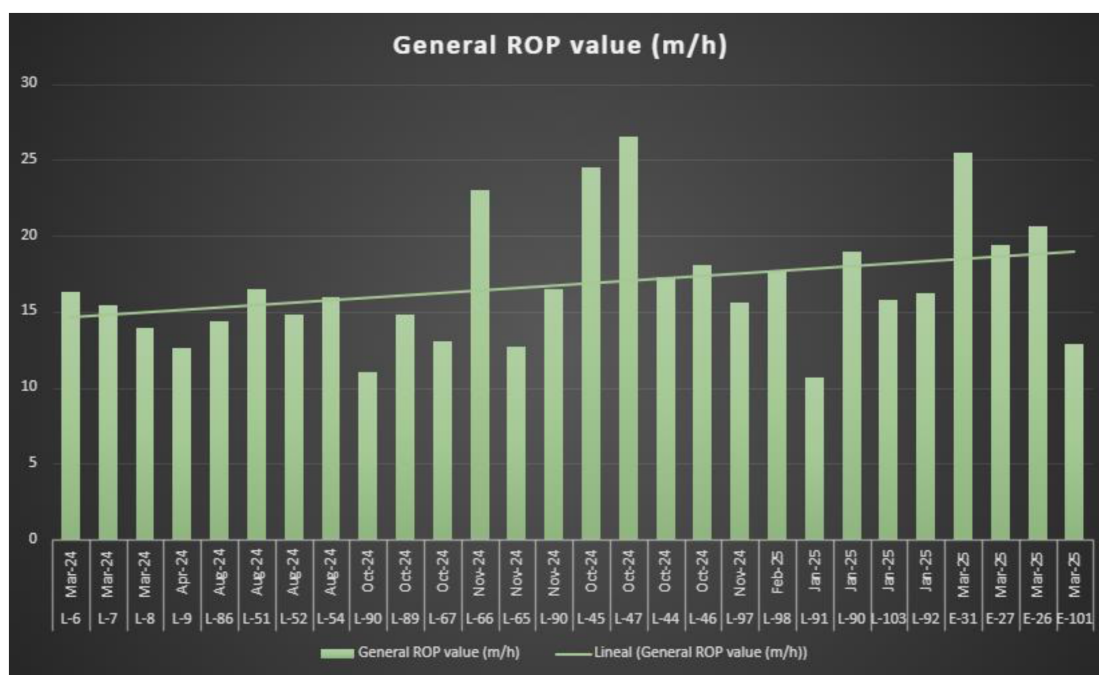


Figure 22—Chronological evolution of ROP in assisted wells.

Conclusions

- Successful use of CWD technology: the operator has effectively used casing-while-drilling technology to address fluid-loss issues in the Lajas field, part of the Loma La Lata – Sierra Barrosa concession, consistently and under field-specific operating conditions. This technology has been fundamental in both Tight Gas projects and the current Shale Oil development in Vaca Muerta.
- Challenges and failures: Despite the success, demanding drilling conditions have led to some casing failures due to fatigue, occasionally under high-stress, downhole dynamic scenarios. These failures highlight the need for continuous comprehensive monitoring and optimization of drilling techniques, with disciplined parameter control and iterative improvements.
- Vibration Monitoring: To mitigate these failures, Tenaris introduced the vibration monitor, which combines high-frequency sensors with an AI model that identifies hazardous conditions for the casing, leveraging historical patterns learned from previous wells. Processing occurs on-site on a high-capacity computer, and results are displayed in the cloud in real time, with secure, continuous streaming and interactive visualization. This innovative solution has significantly reduced the failure rate by providing real-time data and enabling immediate parameter adjustments thanks to satellite internet remote access, facilitating timely decision-making.
- Impact of the vibration monitor: Since its implementation in the Lajas project, the tool has been used in 35 wells with a 100% success rate, demonstrating its effectiveness in preventing casing failures, within the evaluated period and operational context. The system's real-time monitoring and data analytics capabilities have been crucial to this success, supporting proactive interventions and consistent performance.

References

- Camallo Vanina, E. G. (2024). 24M16 YPF NOC Well LaJE-14(H). Campana, BsAs: MPME-AR.
- Codega Dario, R. N. (2015). RTE TESA-SC-10-1 – Failure in 9 5/8" Casing during CWD well Laj-75(d). Neuquén: Tenaris.
- Espinosa, C., Codega, D., Caglieri, A., Grill, S., Guttner, H., & Roldan, C. (2017). Five Years of Drilling with Casing in Argentina and Bolivia. Lessons Learned from the Field. SPE Latin America and Caribbean Petroleum Engineering Conference. Buenos Aires: SPE.
- Federico Wagner, P. A. (October 2016). Lajas Tight Gas Development in the Cupen Mahuida Area. *Petrotecnia*, pp. 16–30.