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CLOV3 CONTINUOUS PIPELINE WALKING MONITORING SYSTEM: A WORLD FIRST

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ABSTRACT

The outcome of an assessment of pipeline walking is often uncertain and difficult to predict at the design stage. These uncertainties in the pipeline behaviour, combined with limited or inadequate monitoring of the pipeline response, mean that mitigation measures are often installed pre-emptively, even though they may never be needed.

This paper presents a novel Walking Monitoring System enabled by Lattice™ WMS (OISL), a low-maintenance subsea IoT platform providing continuous measurements that are reliable, accurate and unaffected by measurement drift, over extended periods.

The system, developed by OISL and deployed by the EPCI Contractor for one of the pipelines in the TotalEnergies CLOV3 project, uses a magnet and a linear array of reed switches to measure the axial movements of the in-line structure, with millimetre-level resolution. The system has an extremely low power consumption, to achieve a projected battery life of more than 10 years. The data stored in the system can then be harvested wirelessly by ROV.

The successful qualification and deployment of this system on a pipeline of the CLOV3 project is described in the paper.

This technology was critical to enable the implementation of a "wait and see" approach in the management of walking response of this pipeline.

Keywords: Pipelines, Pipeline Walking, Monitoring, Pipeline Expansion, "Wait and see", Qualification, Lattice™ WMS, IoT/IIoT, Subsea sensing, Edge processing, LCT (Loosely Coupled Transformer), Wireless, Drift-free, Autonomous Operations

1. INTRODUCTION

1.1. Pipeline Walking

Pipeline walking is an axial ratcheting behaviour that can develop in pipelines under changing operating conditions, due to a number of associated mechanisms [1][2][3][4]. These mechanisms have been observed in pipelines operating around the world and, if not mitigated, can lead to very significant end expansions, with severe consequences on the integrity of the pipeline system [5][6].

However, the walking response of pipelines is difficult to predict, as it can be very sensitive to uncertain parameters, such as the axial pipe-soil interaction response and the short- and long-term profiles of operating conditions along the pipeline, including operating cycles.

In cases where walking is predicted for the range of expected conditions, it is reasonable to pre-emptively prevent the mechanism by introducing mitigation measures as part of the pipeline construction activities; that is the traditional approach [7][8].

In many cases, however, pipeline walking is identified as a risk, but significant uncertainty remains on whether it will actually take place and if it does, how severe it will be. For these cases, considering the cost of pre-emptive pipeline walking mitigation, the adoption of a "wait and see" approach, in which the mitigation is only installed if needed, seems a more appropriate strategy.

The adoption of a "wait and see" approach, however, requires the introduction of a reliable, accurate and continuous monitoring system that records the walking rates in early life, in a simple and cost effective way, to determine the need for mitigation and to provide the parameters to design it efficiently when needed. Before the installation of the CLOV3 pipelines, no such monitoring system had been successfully implemented in the industry.

1.2. CLOV3 Project

The CLOV field is situated in Block 17, approximately 200km from the coast of the Republic of Angola, in water depths that range from 1100 m to 1400 m and in seabed conditions ranging from very soft to soft clay. The initial CLOV development was sanctioned in 2010 with a First Oil in 2014.

The CLOV3 project is an extension of the original CLOV development that includes a number of additional production wells to bring incremental resources to the CLOV FPSO. As part of the project, some of the CLOV production systems are extended, with the addition of 5 sliding PIP pipelines. These are pipelines with lengths ranging from 3.5 to 4.5 km, installed in 2025 by reel-lay.

Of the five pipelines in the CLOV3 project, it was concluded from the results of the detailed design activities that one pipeline required walking mitigation from day one. This was achieved by anchoring the line using a suction pile attached to the end structure via a chain. For three of the other pipelines, walking was predicted to stop after a number of cycles in all cases considered and the lines were therefore left unmitigated.

For one of the pipelines (FP206), however, the conclusions on the walking response were less clear cut. This is a 3.85km long straight pipeline, with a gentle but fairly uniform slope down to the hot end of about 0.5° and a low probability of forming lateral buckles once in operation.

In the analyses performed with the best estimate axial friction, walking was initially predicted when undrained conditions were considered. But as the axial soil response transitioned to drained conditions after some operating cycles, the walking was predicted to stop.

In the sensitivity analyses performed with the lower bound axial friction, a residual walking rate of 2.6mm/cycle remained even after the transition to drained conditions. This walking, towards the hot end of the pipeline, was predicted as the result of a combination of seabed slope and the thermal transient effects of the dead oil circulation, which cools the pipeline from the hot end. The mechanism was partially compensated for by the thermal transients under start-up conditions, which heat the pipeline from the hot end.

Considering the limited margin that was available for the expansions/contractions at the termination structures at the ends of the pipeline and the uncertainty on the walking response, it was concluded that a “wait and see” approach was the most appropriate for this pipeline.

In order to implement this approach, a reliable, accurate and continuous monitoring system was required to identify the actual response of the pipeline in operation and, if needed, to retrofit pipeline walking mitigation measures before the displacement limits of the end structures are reached.

The pipeline walking monitoring system was proposed to be installed at the hot end of the pipeline (where the walking displacement would increase the end expansion).

In order to be able to intervene in a short time scale if it is identified from the monitoring system that pipeline walking mitigation is needed, a retrofittable solution using Pipe Clamping Mattresses (PCM) [9] was designed.

2. EXISTING PIPELINE WALKING MONITORING TECHNOLOGIES

2.1. Graduated Slider Scales or Markers

The traditional method for measuring end expansions in offshore pipelines relies on a simple mechanical system comprising a graduated scale mounted on the fixed part of the flowline end structure (FLET) and a pointer attached to the sliding part of the same structure, as illustrated in Figure 1. During inspections, remotely operated vehicles (ROVs) capture video footage of the pointer and measuring scale, from which displacement readings are obtained. An initial inspection shortly after pipelay is also needed to establish the reference position for the subsequent measurements.

To complement the system, two magnetic track riders (or saddles) are attached to the scale (also show in Figure 1) to record the maximum displacement in either direction since the last time the position of the magnets was reset (which can be done by the ROV after each inspection).

This is a simple system, but its accuracy is limited to approximately 5 cm, or 2 cm in ideal conditions, based on experience from using ROV survey images.

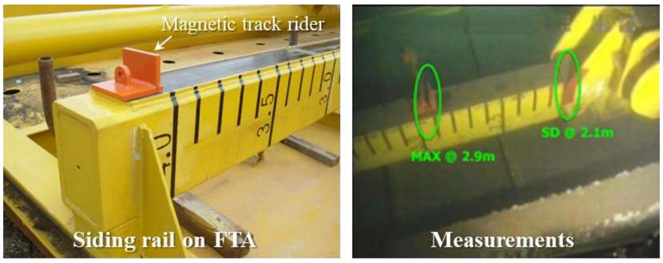

FIGURE 1: EXPANSION MONITORING USING SLIDING SCALES AND POINTER

Operationally, this approach requires commitment to time-consuming surveys, often requiring cleaning of the measurement scale and careful ROV positioning to obtain a clear reading. As a result, surveys are typically conducted at infrequent intervals of one to three years.

Whilst this type of system is easy to deploy and highly reliable (being a simple mechanical system that does not rely on any technology), its main limitations are the infrequent measurements and their limited accuracy. Such limitations make this type of system acceptable for recording overall end expansions, but inadequate for assessing variations under changing operating conditions, which are critical for performing detailed analysis and understanding the underlying mechanisms driving the walking behaviour of the pipeline.

Nevertheless, as a simple and well established system to record end expansions, this is systematically included in all the sliding in-line structures (end and mid-line) of the TotalEnergies projects and generally across the industry. Indeed, all the in-line structures in the CLOV3 project include a slider scale system as illustrated in Figure 4.

It is worth noting, that implementation of this type of system becomes even more challenging in configurations without a

FLET sliding on a fixed mudmat, such as in shallow water pipelines (where the pipeline could be terminated simply with a flange on the seabed). In these cases, flag posts placed on the seabed may serve as reference points, but in those cases measurement accuracy deteriorates even further.

2.2. Transponder Arrays

An alternative approach that allows obtaining more frequent and accurate measurements of the pipeline end expansions consist of using a series of transponders in a long baseline (LBL) array, as illustrated in Figure 2. These systems employ acoustic positioning technology to track the relative movements between a number of transponders moving with the pipeline end and other transponders placed at fixed locations on the seabed around the pipeline end.

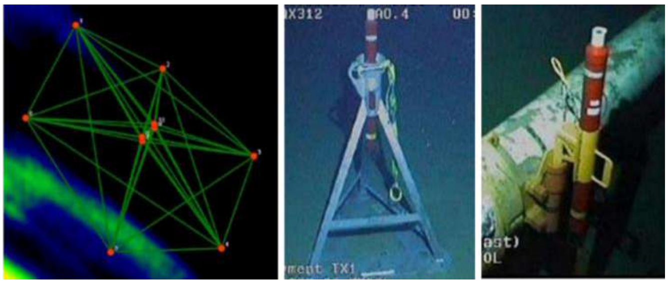

FIGURE 2: EXPANSION MONITORING USING TRANSPONDER ARRAY WITH FIXED AND MOVING TRANSPONDERS

To achieve sufficient accuracy with this type of solution, a relatively large number of transponders is required – typically five fixed and five moving units.

The measurement data can be recorded and then recovered at regular intervals by ROV or connected to the subsea controls system if a suitable connection point is available in the vicinity.

The battery life of these transponders, however, is limited, which means that they need to be replaced at regular intervals. The replacement interval depends on the frequency at which data is recorded but will typically be every 6 months. This adds logistical challenges and operational costs and makes this solution expensive to install and maintain.

In addition, the transponders require calibration against seawater temperature to minimise measurement drift. Despite this, some drift is still observed under stationary conditions, and this must be ‘corrected’ over operating cycles, which is not easy.

Without drift, the measurement accuracy achieved by this type of solution is typically in the order of one to two centimetres.

While transponders can be relocated and reused, they remain vulnerable to accidental displacement, particularly in areas with high subsea activity.

Although this solution has been trialled by other Operators, its track record to date is very limited and the operational feedback is poor.

For the CLOV3 pipeline, this option was evaluated but ultimately discarded in favour of the selected solution described in the following section, due to the issue of measurement drift, and the need to replace regularly a large number of batteries.

3. SELECTED WALKING MONITORING SYSTEM

3.1. Introduction

As noted previously, a reliable, accurate, and continuous walking monitoring system was required to implement the “wait and see” approach on the CLOV3 FP206 pipeline. The two methods described in the previous section were deemed inadequate for this purpose, highlighting the need for a new solution.

In parallel with the development of the CLOV3 project, the Anchoring Pipeline Technology (APT) Joint Industry Project, led by Crondall and in which TotalEnergies participated, promoted the concept of a continuous displacement monitoring system. Such a system would allow cyclic end expansion measurements to be directly compared against operating data, making it possible to directly calibrate the pipeline walking response and establish the walking rate over a limited number of cycles and establish the walking behaviour of the pipeline.

To meet these objectives, minimum functional requirements for the Walking Monitoring System (WMS) were defined:

- Provide continuous monitoring, with time-stamped hourly recordings of the pipeline end displacement.
- Readings to have an accuracy of at least 1cm.
- Provide cyclic displacements over time without measurement drift.
- Condense recorded, time-stamped information into daily maximum and minimum displacements, retrievable wirelessly by ROV during routine campaigns, at intervals to be determined as the walking response of the pipeline becomes clearer.
  Alternatively, connect the system to a subsea control module in the vicinity using wireless technology.
- Have a very low power consumption to allow an expected battery life of at least 10 years without replacement.
- System to be installable into a new pipeline in-line structure before installation or retrofittable by ROV into a structure already installed.
  In either case, allow the possibility for the WMS to be recoverable and replaced by ROV.

Several systems were evaluated against these criteria, and the WMS described in this paper was identified as the preferred solution. It meets all functional requirements and offers a practical and robust solution for monitoring pipeline walking behaviour.

3.2. OISL Walking Monitoring System

The Walking Monitoring System (Lattice WMS) installed on the CLOV3 FP206 pipeline was developed by Ocean Information Services Ltd (OISL) and consists of three primary components:

- WMS Sensor, which includes the following parts and is illustrated in Figure 3 and shown in Figure 4:
  - A linear array of reed switches, housed in an atmospheric enclosure, together with edge processing electronics and long-life primary batteries. The sensor is attached to the fixed part of the FLET.
  - A permanent magnet, mounted on the moving part of the sliding FLET, which passes over the reed array as the pipeline undergoes axial displacements. Sequential switch actuation provides displacement data with millimetre-level resolution.
- ROV Controller: A compact, ROV-mountable unit that establishes a wireless inductive link to the WMS sensor. The controller relays harvested data to topside via RS232 and the ROV multiplexer.
- User Interface: A lightweight Windows application that provides operators with connection diagnostics and data export in standard CSV format.

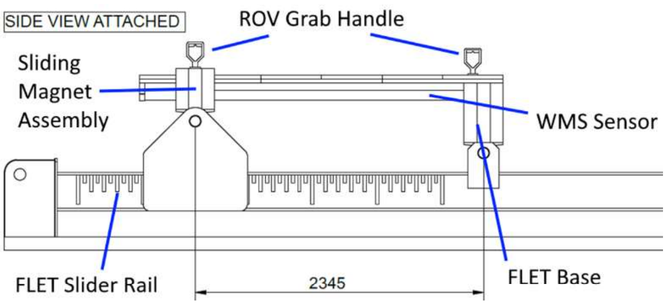

FIGURE 3: WMS CONCEPT

FIGURE 4: LATTICE WMS INTEGRATED ON CLOV3 FLET

The mechanical reed-switch linear sensor approach used for the WMS has the following advantages in the subsea context:

- Robustness to individual failures: the loss of one or more switches does not compromise displacement measurement
- No recalibration requirement: The WMS sensor linearity is defined mechanically by the positioning of the reed switch PCBs within the enclosure and hence cannot change. This linearity is verified as part of the factory acceptance test.
- Longevity: extremely low power consumption, with projected battery lives of more than 10 years (Li–MnO_2 chemistry)
- The WMS can also be customised: It supports up to 256 reed switches, with the length and resolution of the sensor modifiable by altering their number and separation.

The data recovery is enabled by the Lattice Link inductive communication system:

- Magnetic coupling is immune to turbidity, biofouling, and acoustic noise
- Data harvest is a simple process that is completed in minutes, with the ROV sitting between 2m and 5m from the WMS sensor
- The link is deterministic and only active in the presence of the ROV controller, minimising power usage and ensuring security
- For autonomous operation, the WMS can also be interrogated by subsea control modules (SCM/SEM) or by autonomous vehicles (AUVs)

A high level block diagram of the OISL WMS is presented in Figure 5.

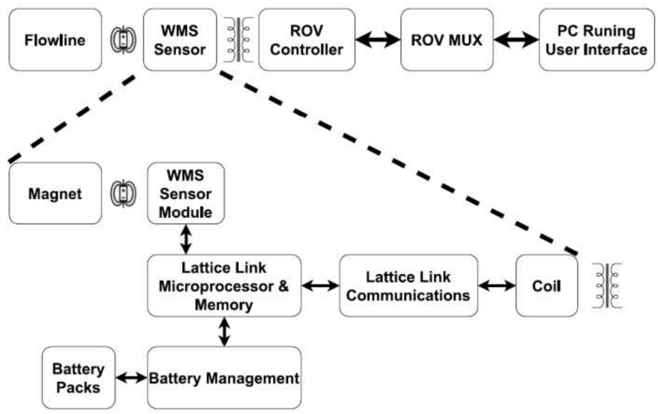

FIGURE 5: HIGH-LEVEL BLOCK DIAGRAM OF THE OISL WALKING MONITORING SYSTEM

The system has dedicated mounting points to attach it to the FLET and grab bars to allow retrieval and re-installation by ROV if needed (see Figure 6).

The key features of the OISL WMS developed for the CLOV3 FP206 pipeline are summarised in Table 1.

3.3. Auxiliary Measurements

It is important to note that in order to interpret the data recorded by the WMS, it is also necessary to collect other information of the pipeline in operation.

In particular, the time history of operating conditions of the pipeline (at least temperature and pressure and, if possible, contents density) is needed to interpret the observed pipeline end displacements.

The location and shape of any buckle that may trigger along the pipeline are also needed and the spot measurements of expansion at other in-line structures along the pipeline (in the case of CLOV3 FP206, only the other pipeline end) are also useful.

All this information can then be used to refine and calibrate the finite element models used to understand and predict the walking response of the pipeline. This will allow more accurate and reliable predictions on the future behaviour of the pipeline and more certainty on the need to retrofit mitigation measures and the time available to do so.

Although not described further in this paper, plans are in place to collect all this data for the CLOV3 pipelines, as part of their integrity management plan.

TABLE 1: KEY FEATURES OF THE WMS FOR CLOV3

Sensor length / excursion range	1.5 m
Measurement resolution	10 mm
Battery design life	16 years
Battery chemistry	Li-MnO_2
Depth rating	1500m
Dry weight	105 kg
Submerged weight	43 kg
ROV Interrogation method	LCT (Loosely Coupled Transformer)
Interrogation interval	1/hr (user configurable)
Data download time	<2min /year of history
Edge processing	Yes
System Calibration	N/A (drift-immune)
Replacement	ROV hot-swap capable

4. QUALIFICATION OF OISL WMS

4.1. Qualification Plan

The primary objective of the qualification programme was to demonstrate fitness for purpose for long-term subsea deployment, rather than pursuing exhaustive component-level certification.

No prescriptive international standard was identified that specifically addressed the qualification of subsea pipeline monitoring systems and so a tailored qualification framework was developed.

To establish this framework, principles were drawn from the API Recommended Practice for the qualification of subsea equipment [10] and the qualification testing section of the API Standard for Subsea Production and Processing Control Systems [11].

The qualification philosophy adopted a progressive, risk-based methodology consistent with API RP 17Q [10] principles. Functional performance, environmental robustness, mechanical integrity, and system reliability were validated through a structured sequence of physical tests and system-level verification activities. This ensured that critical risks were systematically mitigated while maintaining efficiency in the qualification process.

As part of the process, a Failure Modes, Effects and Criticality Analysis (FMECA) was conducted to address reliability considerations. This assessment identified critical functions and interfaces and guided the selection and depth of qualification tests.

The program was developed to cover the entire lifecycle of the monitoring system, from manufacturing and factory acceptance testing through offshore logistics and integration, culminating in long-term subsea service. This comprehensive coverage was intended to provide confidence that the system would perform reliably throughout its operational life in challenging subsea environments.

A spare WMS was manufactured for the purposes of these qualification tests.

4.2. Electrical and Functional Qualification Tests

Electrical and functional qualification included electrical load tests to verify correct power-up behaviour, steady-state power consumption and power management logic.

Functional endurance tests were performed using an accelerated test approach to emulate extended monitoring durations, simulating repeated measurement acquisition and multiple data retrieval cycles over a condensed timeframe. These tests demonstrated stable sensing behaviour, repeatable displacement detection and reliable data logging without cumulative drift.

System-level functional tests verified correct data acquisition, internal processing, storage and retrieval.

Wireless communication and data retrieval tests were conducted using ROV-based interrogation to confirm reliable data transfer without the need for physical connection or system intervention.

4.3. Mechanical and Environment Qualification Tests

Mechanical qualification included dedicated clipping tests to verify the integrity of the mechanical attachment to the FLET. These tests confirmed correct engagement of the clipping mechanism, adequate retention capability under handling and installation loads, and compatibility with the FLET configuration. The clipping tests also verified that the attachment system did not adversely affect the sensing function or measurement accuracy.

Vibration tests were performed to simulate dynamic loads associated with transportation, handling and installation operations.

Hydrostatic pressure tests were conducted to validate structural integrity and sealing performance under external pressure representative of subsea deployment conditions.

Temperature tests were conducted to verify functional performance under thermal conditions representative of manufacturing and factory test activities in Scotland, followed by conditions representative of transit, onshore/offshore storage, handling and integration activities in Angola and finally the subsea environment once installed.

For each environmental test, functional verification was systematically performed before and after exposure to confirm measurement stability and the absence of performance degradation.

4.4. FLET Integration Qualification Tests

The final stage of qualification consisted of testing the integration of the monitoring system with the FLET structure.

These tests verified mechanical compatibility, confirmed that the sensing mechanism operated freely in the as-installed configuration, and demonstrated functional performance under imposed axial displacements representative of expected pipeline movements. The integration tests also confirmed that the system could withstand handling, installation and deployment sequences without loss of functionality or measurement fidelity.

Some of these tests were repeated with the WMS that was actually installed, as part of the SIT described in the next section.

5. CLOV3 INSTALLATION

5.1. System Integration Test

Although the OISL WMS was designed to allow installation onto a FLET already on the seabed, the base case scenario for the CLOV3 project was to have it integrated on the FLET at the construction yard. This avoided an additional subsea operation and had the benefit of allowing the in-situ testing of the WMS and the start of data collection immediately after the completion of the installation of the pipeline and FLET.

The integration of the WMS into the FLET at the construction yard, however, presented a challenge due to the limited space available. The foundations of the CLOV3 FLETs consist of mudmats which are initially folded and eventually opened to have a wider surface once on the seabed. In the folded condition, there is only a narrow band, with many surrounding items such as sensors, anodes, padeyes, ROV grab bars and lifting slings, where the WMS needs to be fitted. This is illustrated in Figure 10.

Under these conditions, it was essential to have a thorough System Integration Test (SIT) program to ensure that the integration of the WMS onto the FLET would maintain all its functionalities. The SIT program included the following activities:

- Assembly of the WMS components after transportation
- Attachment of the WMS onto the FLET
- Sliding test
- Communication test
- Verification of clash and gap with other components

In addition to this, during the engineering phase, the ROV access to all the functionalities of the WMS was assessed by a 3D simulation. This geometrical study also allowed to identify key elements and to focus the checks from the SIT onto these specific elements.

- WMS Assembly:
  In order to prevent any damage during shipment from Europe to Angola of the WMS, the system was sent in a disassembled state. The first step of the integration of the WMS was then the assembly of its components.
  The ROV grab bars were bolted to the WMS sliding block and WMS fixed block. These ROV grab bars (illustrated in Figure 6) would be used for any disconnection and reconnection of the WMS, in case future maintenance or repair was required.
  The retaining clips shown in Figure 6 were bolted to the WMS sliding block and WMS fixed block. These clips are the structural element used to connect the WMS to the FLET. These clips have to be flexible enough to allow an ROV to push or pull the WMS in case future maintenance or repair was required.

FIGURE 6: ROV GRAB BAR, RETAINING CLIPS & SIT ATTACHMENT TEST

- Attachment to the FLET:
  The attachment of the WMS to the FLET was a straightforward operation. The WMS was lifted using the ROV grab bars, landed on the FLET above the connecting pins and push down manually to engage the retaining clips. A visual inspection (see Figure 6) confirmed that the pins were safely engaged and that the WMS was in a good condition.
- Sliding test:
  Once the WMS was attached to the FLET, a sliding test was performed in a configuration representative of the as-installed conditions; with the FLET mudmat kept fixed on the ground and the sliding piping module moved in a controlled manner. In this test, the piping module was moved over its full sliding range as shown in Figure 7, and the displacements were recorded by the WMS.
  As the piping module moved, the WMS slid successfully, without any distortion or misalignments between the parts. A visual inspection confirmed that the WMS was in a good condition after this test.
- Communication test:
  A communication test between the WMS and the ROV Controller was performed. This confirmed that the displacement recorded by the WMS during the sliding test were successfully transferred to the ROV Controller and to the user interface tablet (see Figure 8). It also confirmed that the recorded displacements were matching with the observations from the sliding tests.

FIGURE 7: SIT SLIDING TEST

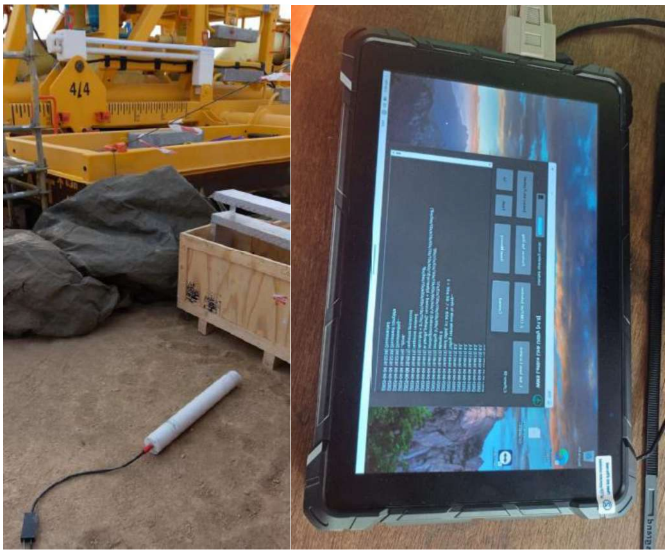

FIGURE 8: SIT COMMUNICATION TEST

- Verification of clash and gap with other components: Before deployment, final checks were performed to ensure the mudmat could be folded with no damage to the WMS or loss of functionality.

5.2. WMS Deployment

Once the SIT was successfully completed, the WMS was safely secured to the FLET by the addition of an aluminium frame and cargo straps, as illustrated in Figure 9. Such lashing ensured that the WMS would remain secured to the FLET and could not fall during installation.

The final step in the preparation of the FLET for installation was the folding of the wings of the mudmat. During that step a clash with the reinforcing beam of the wings was identified and the ROV handle of the aluminium frame had to be shifted upwards by a few centimetres. The narrow space between the folded wings and the sliding pipping module is shown in Figure 10.

FIGURE 9: LASHING OF WMS ON FLET

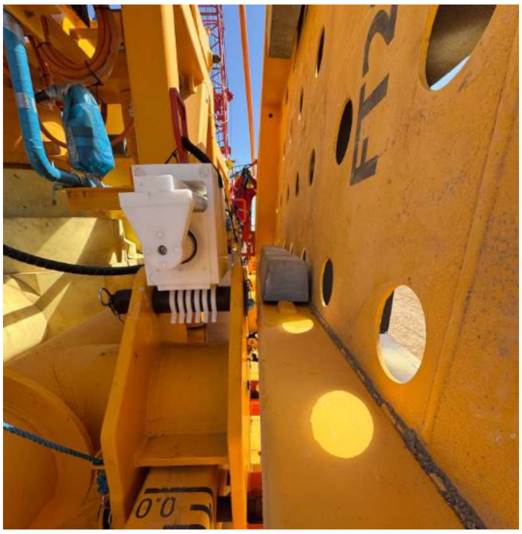

FIGURE 10: WMS ON FLET WITH MUDMAT WINGS FOLDED

The WMS was fully integrated on the FLET structure in a way that avoided the need for any intervention from personnel during the offshore operation. As such, the installation of the WMS with the FLET went smoothly and nothing was noticed nor reported.

The WMS was installed on the first end FLET, i.e. the FLET used for pipelay initiation. A view of the FLET during tie-in on the pipelay vessel is shown in Figure 11. In the image, the WMS is hidden by the folded mudmat and therefore not visible.

During pipeline initiation, the FLET was landed on the seabed as planned. A visual inspection confirmed that the WMS was not damaged and that the lashing was intact (see Figure 14). The lashing was then removed by ROV; the cargo straps were cut by ROV knife, and the aluminium frame was removed by pulling on the ROV handle, as shown in Figure 13.

A view of the WMS on the seabed ready to measure the movements of the FLET is shown in Figure 14.

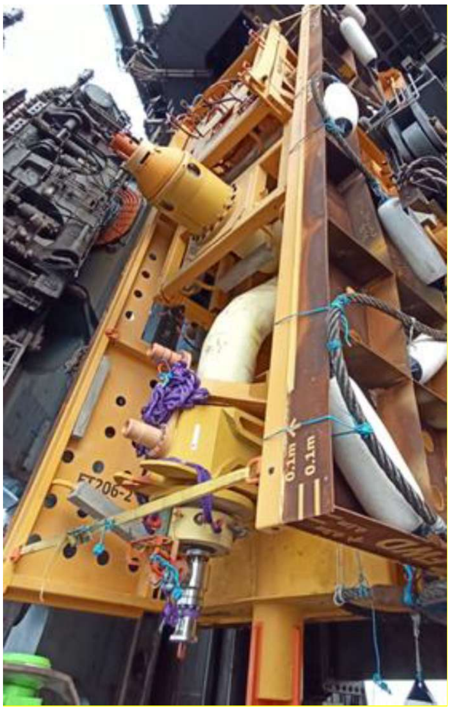

FIGURE 11: FIRST END FLET WITH WMS DURING TIE-IN OPERATION IN PIPELAY VESSEL

FIGURE 12: LATTICE WMS ON SEABED WITH LASHINGS

FIGURE 13: REMOVAL OF ALUMINIUM FRAME BY ROV

FIGURE 14: WMS AFTER INSTALLATION

6. INITIAL DATA HARVEST

For the commissioning of the WMS, two data harvests were made with the ROV used for the pipeline installation activities:

- An initial harvest just after the installation to confirm that the WMS was working
- A second harvest after the final leak test, just before the hand-over of the system to TotalEnergies

From the records of the 53 days of measurements presented in Figure 15, the following events are noted:

- The initial retraction of the FLET, once the sliding system was released.
- The retraction continued over a few days, due to the gradual cool down of the pipeline, from the temperature whilst on the deck of the pipelay vessel during installation to the ambient temperature on the seabed.
  As expected for a PIP system with a U-value of around 1 W/m²K and discussed in [12], this process took a few days.
- Expansion of about 1cm during first hydrotest (single line) and second hydrotest (loop)
- No expansion during the final leak test performed at a lower pressure.

At the time of writing this paper data harvested from the start-up of the field is not yet available.

Once this becomes available, it will be used together with the other monitoring data to validate the pipeline walking FE models and conclude on the actual response of the pipeline. Once this is available it will be presented in a future paper.

7. CONCLUSIONS AND WAY FORWARD

This paper presents the qualification and first deployment of a novel system to monitor the axial displacements of a pipeline in-line structure, for use in the assessment of the walking response of the pipeline.

The system, developed by OISL and deployed by the EPCI Contractor for one of the pipelines in the TotalEnergies CLOV3 project, uses a magnet and a linear array of reed switches to measure the axial movements of the in-line structure, with millimetre-level resolution. The system has an extremely low power consumption, to achieve a projected battery life of more than 10 years. The data stored in the system can then be harvested wirelessly by ROV.

This system provides a low-maintenance solution to obtain continuous measurements that are reliable, accurate and not affected by measurement drift, over extended periods.

This technology is a critical enabler for the implementation of the “wait and see” approach in the management of pipeline walking. The measurements obtained by the WMS provide the confidence that it will be possible to identify the walking mechanism as soon as it develops and with sufficient time to allow for the implementation of any mitigation measures needed.

This approach will allow significant cost savings by preventing the pre-emptive installation of costly pipeline walking mitigations, before it is confirmed that such mitigations are actually needed.

This paper presents the details of the qualification program performed to demonstrate that the Walking Monitoring System meets the functional, durability and reliability requirements necessary for continuous monitoring of pipeline axial walking in deepwater environments.

The initial data harvested from the TotalEnergies CLOV3 FP206 pipeline indicate that the system was successfully deployed and is currently collecting data on the pipeline response. Once additional data is collected, this will be used to conclude on the need for any pipeline walking mitigations for this pipeline.

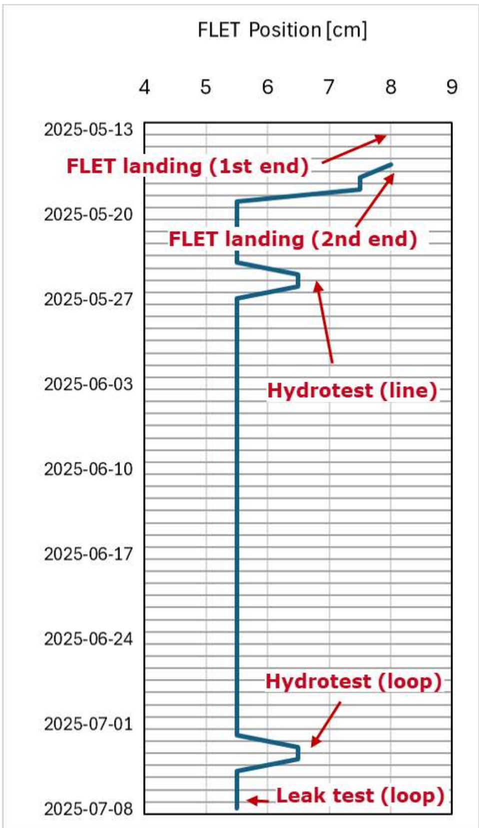

FIGURE 15: FIRST DATA HARVEST

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