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PROYECT EPGEO-ARPEL LATIN AMERICA: PREPARATION OF TECHNICAL GUIDES FOR MONITORING AND CONTROL WORKS OF GEOTHREATS IN PIPELINES

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SUMMARY

Since 2004, the Geotechnical Professional Team (EPGEO) from the Regional Association of Oil and Gas Companies in Latin America and the Caribbean (*Asociación Regional de Empresas de Petróleo y Gas Natural en Latinoamérica y el Caribe*, ARPEL) has been working on a knowledge management-related project for the Oil & Gas industry, consisting in the creation of three technical guides on Pipeline Integrity Management given the occurrence of geohazards in Hydrocarbon Transportation Systems.

This initiative comprises the creation of 3 guides related to:

i) Guide 1: Monitoring Geohazards for Pipeline Integrity,
ii) Guide 2: Geotechnical Mitigation Works in Pipelines,
iii) Guide 3: Geotechnical Risk in Pipelines.

The EPGEO published Guide 1 in 2016 and presented a Presentation at the 2017 IPG (IPG2017-2538) and Guide 2 it ended in 2022 and its progress was presented in the 2021 IPG (IPG2021-65014). Also, Guide 3 is being developed in the period 2023-2024.

This document shows the methodology and contents for preparing the first two guides, focusing on Guide 2, which comprises different alternatives, analyses and technical solutions to the occurrence of geohazards that might affect the integrity of a pipeline transportation system.

INTRODUCTION

The Oil & Gas industry plays an important role in the development of the different economic models and activities. Therefore, the industry needs to improve its social, environmental and technical management processes, as well as its regulatory and safety compliance areas on an ongoing basis.

Focusing on the description above, since 2013 the EPGEO has been developing activities to strengthen a regional interdisciplinary work that has resulted in the release of several documents at different international events, such as the 2015 IPG Conference, 2017 IPG Conference and 2018 INGEPET and IPG Conference 2021;, whose contents have been considered while preparing this document.

As mentioned at the 2017 IPG Conference [9], in the Oil & Gas industry segment, Climate & External Forces Hazards have been found to have a lower failure occurrence rate than other hazards worldwide; however, the rate of pipeline failures caused by geohazards in Latin America is higher than in other regions in the world [1] given the sensitivity conditions identified in the Andes mountains, understood as adverse geomorphological and triggering features affecting the stability of rights of ways [2] [3], thus posing a challenge in terms of proper geohazard management integrity programs in an STD [4] [5]. Since this is not a local challenge, companies in the Latin America region have been working together to reduce the levels of uncertainty

associated with pipeline integrity management in the event of geohazards, understanding that an enduring competitive advantage is based on knowledge [6]. This dynamic, at first addressed to financial markets and applied to this changing environment and new challenges generated by geohazards, shows a successful experience in structuring an interdisciplinary work team that moves forward on the path of sharing its knowledge and best practices, as applied to the first two targeted guides of this group, toward generating creative knowledge for the third guide. All of the above, in order to advance in managing risks that result from Climate and External Forces threats.

It is important to note that the EPGEO team prepares the guides with the effort of each of its participants. It is clear that the use, focus and destination given to the product depends exclusively on the partner who has access and the users who in one way or another have access to it.

1. TEAM CREATION AND GOALS

The Geotechnical Project Team (EPGEO) was created in 2013 within the Regional Association of Oil, Gas & Biofuel Companies in Latin America and the Caribbean (ARPEL), to respond to the identified need to share Oil & Gas transportation operators' experiences and best practices in the region [9].

This initiative was first presented at the International Conference on Terrain and Geohazard Challenges Facing Onshore Oil and Gas Pipelines, organized by British Petroleum (BP) in London in 2004, with the purpose of sharing and promoting geohazard-related commitment among designers, constructors, environmentalists and geotechnical specialists, operators and different organizations. As a result of this conference, a book with over 40 articles outlining the state of the art and experience gathered in this matter was written [7]. With the same purpose sought during the Conference, in 2011 ASME began to organize the International Pipeline Geotechnical Conference - IPG, whose third edition is being released this year. [9]

At the regional level, the first specific geohazard forum took place in the Workshop organized by ARPEL in the city of Medellin (Colombia) in May 2012. Worthy of note are the interdisciplinary Geology & Geotechnics Meetings organized every two years by COGA in Lima, Peru, since 2012.

This professional exchange resulted in the idea of developing regional publications that gathered such good practices in the format of guides, in order to generate technical literature further to the publication of technical articles at conferences, with the purpose of documenting the geohazard-facing pipeline integrity management to contribute to the creation of a geotechnics concept applied to the hydrocarbon sector [9].

Currently the group is made up of companies from the region that have contributed to the development of Guides 1 [8] and Guide 2[eleven]. Some of them are: CENIT (Colombia), OCENSA(Colombia), PETROBRAS (Brazil), RECOPE (Costa Rica),TGN (Argentina), TGP (Peru), YPF (Argentina) and YPFB(Bolivia), who are working on the elaboration of the Guide 3 of risk management for Geohazards in Pipelines.

2. WORK METHODOLOGY

As mentioned above, the EPGEO mainly focuses on sharing the experiences of professionals from hydrocarbon transportation system operators/owners in Latin America and the Caribbean, in relation with the best practices for pipeline integrity management in the event of geohazards. This poses the challenge of implementing such knowledge management [2] to translate the individuals' tacit knowledge into an organization explicit knowledge [6]. In this particular case, individuals are the transportation operators in each country, and the organization is Latin America and the Caribbean.

The EPGEO technical discussion strategy is organizing virtual meetings to develop activities associated to the overall group objectives and the analysis of technical documents under development that allow us to share lessons learned and analyze specific situations that might be adjusted to each operator's environment.

In this way, around 120 video conferences have taken place since 2014, where the experience achieved and the wish to build new knowledge have been the most relevant features. In addition, three onsite workshops were organized in Cartagena (Colombia) in October 2014, Bogota (Colombia) in July 2015 and Buenos Aires (Argentina) in January 2017, all of which have consolidated the spirit and aim of the group while strengthening regional integration.

IT tools have also been used to ensure progress in creating the group documents and their cross review. As members contribute with these documents, their contributions are discussed in each of the meetings.

Furthermore, one of the opportunities for improvement identified for hazard management was the reinforcement of geohazard-related technical skills for all professionals involved in the hydrocarbon pipeline transportation system maintenance in the region. This has resulted in a training course that introduces basic geotechnics concepts and elaborates on how they are related to any threat to infrastructure integrity. ARPEL organizes this course on a regular basis for all the people who are interested in this topic.

These activities demonstrate the group's interest in becoming an international reference regarding pipeline integrity management in the event of geohazards, which is beginning to gain visibility

among pipeline integrity regulatory entities, such as those that organized this conference, thus seeking to sustain knowledge and build scenarios that can provide the opportunity for continuous improvement.

3. RESULTS

One of the group's first results was the 2016 issue of the Monitoring & Inspection Guide for Pipeline Integrity Management in the event of Geohazards [8] for ARPEL members, which was presented at the 2017 Geotechnical International Conference [9].

Guide 1 documented the best practices and lessons learned in monitoring and inspecting pipelines, rights of way, triggering agents and terrain instability threatening pipeline integrity. It also identified geohazards and their relation with potential containment loss events based on their typology and size [8].

Its scope included the description of the geohazards and their monitoring and supervision mechanisms, their application, as well as: filing and information management criteria; a description of the supervisory and inspection activities for surface recognition and evidence revealing terrain instability and failure; terrain monitoring, hazard triggers and the measurement of the geohazard effect on the pipeline, and the geographic information systems as a tool to manage geohazards [8].

Concrete experiences from applying the techniques were consolidated at the end of Guide 1, in order to further clarify and apply such concepts.

In August 2023, ARPEL members were published the Guide to Pipeline Geotechnical Mitigation Works [11], which was made mainly through the use of tools technologies through virtual meetings to exchange experiences and discuss the contents of the guide, which is held at least 60 videoconferences in the last three years.

The second guide is deployed by Chapters: Introduction, Glossary, Pipeline Design, Pipeline Construction, Operation & Maintenance, Pipeline Technical Abandonment, Applied Geomatics and Case Studies.
The chapter-based structure shown in Figure 1 considers two main pillars: Work Description (Chapter 3) and Asset Lifecycle (Chapters 4-7) in such a way that the most representative milestones for geohazard management in each cycle stage can be observed by quoting them in terms of Chapter 3 contents.

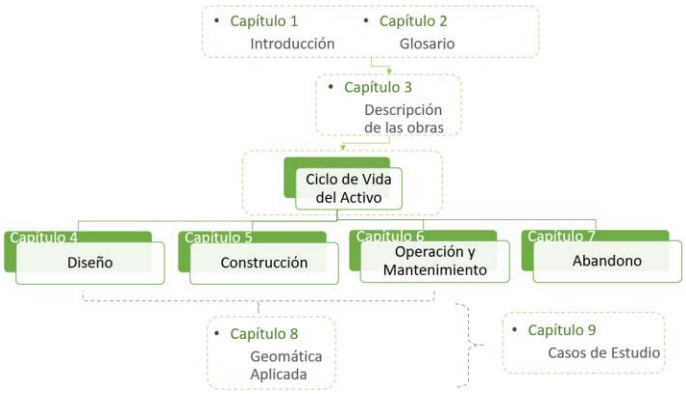

FIGURE 1. Relation between the Guide chapter-based structure and the Asset Lifecycle. Source: EPGEO (2020).

In Chapter 3, the Work Description was structured so a use-type relationship could be established as a practical classification for the reader, as follows:

- Drainage management works (surface, subsurface, at river crossings and ravines)
- Stabilization works.
- Underwater line works.

Finally, Chapter 8—focused on the application of Geomatics principles to Geohazard Management—and Chapter 9—a summary that shares some of the experiences from the companies involved in the creation of Guide 2—should be particularly noted.

Therefore, Guide 2 consolidates best practices, lessons learned and execution alternatives for civil and geotechnical works to prevent, mitigate or correct actual or potential geohazard effects in hydrocarbon transportation systems.

Moreover, it seeks to compile stabilization and control measures, construction processes and problem-solving methodologies in the industry to assess their efficacy and proper scope, as well as to promote the use of the Geomatics expertise required to set IT applications and systems for technical information traceability and decision-making support purposes.

Thus, and based on the expertise demonstrated by the subject-matter experts from each operator involved, a document was prepared containing valuable reference information for all pipeline or integrity geotechnical professionals, supported by professionals with extensive industry experience.

4. NEXT CHALLENGES

Based on the experiences from previous events, given the EPGEO continuity and the usefulness of these tools in the management of pipeline integrity in the event of geohazards for the technical community and operators, the EPGEO intends to

complete the guide trilogy with the third guide, which will address **geohazard risk analysis**.

At present, risk-based analyses are critical for decision-making when assessing topics that are sensitive to the business and prioritizing investments. To this end, risk analyses are usually conducted considering all threats to asset integrity [10].

When the third guide is completed, the full spectrum of pipeline geotechnics will have been covered: Inspection, Monitoring, Works, Mitigations and Risks.

5. EXAMPLES

Here are some examples of control and mitigation techniques for geotechnical processes, as well as of civil works referred to in Guide 2.

FIGURE 2. Riverine defense with concrete blocks.
Source: Internet (2020). Current breakers are drainage works applied to the management of surface waters, which are built perpendicular to the line of maximum slope of the right-of-way, in order to capture and evacuate runoff water out of it and prevent it from making extensive routes. where the surface of the land is unprotected.

FIGURE 3. Riverine defense with concrete blocks.
Source: Internet (2020).

FIGURE 4. Horizontal drain capture chamber for piezometric level abatement. Source: Internet (2020).
Water flows into the well from horizontal perforated tubes, with the water being pumped out. Drains can be drilled with some upward inclination to penetrate more than one aquifer horizon. These drains are placed using pneumatic hammers or by injection. The length of the drains varies depending on the area to be drained, and can vary from 30 to 100 m in length.

FIGURE 5. Concrete coating for slope protection.
Source: Internet (2020).

It is a mortar or concrete transported through a hose and projected pneumatically at high speed onto a surface. The surfaces to be covered can be concrete, natural terrain, stone, masonry, steel, wood, polystyrene, etc.
For the application of this technique, two different processes are used: "wet mixing" and "dry mixing", the latter being more satisfactory and its use more widespread.

FIGURE 6. Concrete coating for water control.
Source: Internet (2020).
El sistema de las Mantas de Hormigón consiste básicamente en un tejido flexible impregnado, que endurece cuando se hidrata, formando una capa de hormigón a prueba de agua y fuego, entregando una solución multifuncional y de inmejorables ventajas.

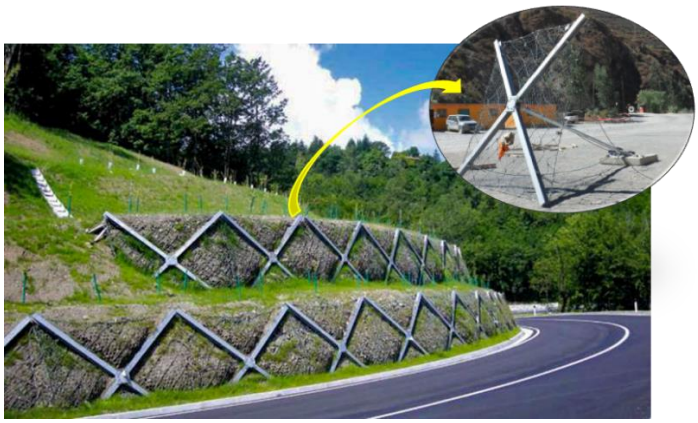

FIGURE 7. ERDOX technique for slope stabilization.
Source: Internet (2020).
The ErdoX® system is the fastest and most effective solution for carrying out riverside defense works.
Installation performance is up to 6 times faster compared to traditional solutions with gabions, rockfill and reinforced concrete.
The riverside defense in the photograph has a total extension of 250 ml with a height of 3.60 m. It has been done in 12 days.
The assembly and installation of the Erdox® system is carried out with a small staff, on average 3-4 people. The filling of the structures is carried out by machine using, where possible, the same material from the area.

6. ACHIEVEMENTS

The development of Guide 1 and Guide 2, already published, achieved meet the expectations of those who participated in its development, by the Latin American technical community and different companies that develop geotechnical solutions, which saw in them a consultation and support tool for the development of new products and technologies.

Working on these publications for so many years has helped us understand the different problems that geographical diversity poses to Latin America. Peru, Colombia, Ecuador, Bolivia, Brazil, Costa Rica and Argentina have understood and obtained feedback from the experiences, errors and achievements in each country. Also, understanding the different names of protective items, works or geographical features has contributed to enlarging the vocabulary and improving the overall understanding and culture.

Last but not least, it allowed to generate links between companies and people, embodied in the excellent relationship that the EPGEO team has been strengthening.

FIGURE 8. Example of a virtual meeting. Source: EPGEO (2020).

7. CONCLUSIONS

As concluded in Guide 1 [9], the knowledge of geohazard management is found in operators' experiences and technical bibliography that do not focus on the specific conditions of hydrocarbon transportation systems. Therefore, they must be consolidated in a set of guides for maintenance professionals to conduct integrity management in the event of geohazards in all transportation business stages, resulting in a shared vision of its understanding in a particular regional scope.
Therefore, strengthening communication mechanisms between operating companies and owners of pipelines for the transportation of hydrocarbons in the region has allowed us to systematically apply a knowledge-managing methodology that can positively affect companies at the regional level, while contributing to the proper management of negative events affecting the transportation infrastructure.

By applying the insights gathered by this group, we seek to contribute to reducing geohazard-related loss of containment rates in the region, based on an adequate DDV and pipeline monitoring program, risk assessment techniques applicable to geohazards, and an effective DDV intervention program involving civil and geotechnical works.

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Finally, and for all, we would like to highlight the selfless participation of each of the actors in this guide, who have dedicated extra time from their formal schedules to collaborate with such important geotechnical reference material.

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