









Methodology for the Proposal of a Technological Package Development in Hydrocarbon Production Facilities

Metodología para propuesta de elaboración de paquete tecnológico en instalaciones de producción de hidrocarburos

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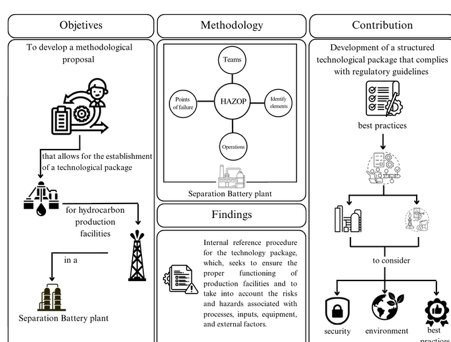


Abstract

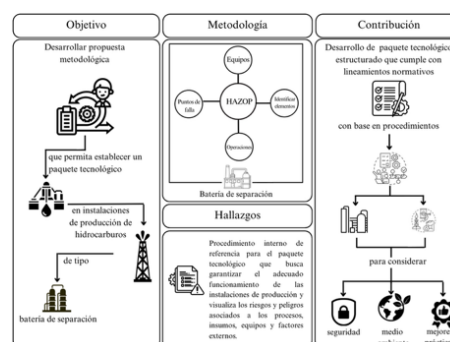
Objective: To develop a methodological proposal that allows for the establishment of a technological package for hydrocarbon production facilities in a Separation Battery plant. **Method:** The Hazard Analysis and Operational Methodology (HAZOP) is used in the development of the project, as it is a widely known and used methodology in the oil industry. **Findings:** The investigation into the operational context allows for the identification of the organization, the regulatory framework, the standards applicable to the sector, and the identification of good practices. This allows for the subsequent targeting of processes and subprocesses for information analysis and the subsequent establishment of an information matrix, allowing for the structuring of a proposal. **Contributions:** The proposal aims to contribute to the development of a structured technological package that complies with regulatory guidelines and guarantees proper operation in oil production facilities, providing a more complete understanding of the associated hazards and risk management.

Resumen

Objetivo: Desarrollar una propuesta metodológica que permita establecer un paquete tecnológico en instalaciones de producción de hidrocarburos en una planta de tipo Batería de Separación. **Método:** En el desarrollo del proyecto se emplea la Metodología de Análisis de Riesgo y Operatividad (HAZOP), debido a que es una metodología ampliamente conocida y utilizada en la industria petrolera. **Hallazgos:** La indagación en el contexto operacional permite identificar a la organización, el marco normativo, los estándares aplicables al sector y la identificación de buenas prácticas, para posteriormente focalizar procesos y subprocessos para el análisis de información, y posteriormente establecer una matriz de información, que permitan estructurar una propuesta. **Contribuciones:** La propuesta pretende contribuir al desarrollo de un paquete tecnológico estructurado que cumpla con los lineamientos normativos y garantice un funcionamiento adecuado en las instalaciones petroleras de producción, comprendiendo de una forma más completa los peligros asociados y la gestión de riesgos.



Methodology, technology package, security



Metodología, paquete tecnológico, seguridad

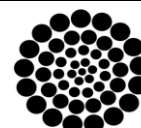
Area: Development of strategic leading-edge technologies and open innovation for social transformation

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Introduction

In the case of Mexico, from 1938 until the constitutional reform of 2013, oil exploration and extraction were the responsibility of the Mexican State through the parastatal *Petróleos Mexicanos* (PEMEX), thereby establishing a new model of organisation (Rodríguez, 2019) and regulation in supply chains, opening up to private organisations and establishing the awarding of contracts to national and international private capital companies with the aim of reactivating production in idle hydrocarbon fields (Guardado, 2024).

Article 19 of the Energy Reform sets out the basis for the creation of a national agency for industrial safety and environmental protection. In March 2015, the Agency for Safety, Energy and the Environment (ASEA) formally began operations with the aim of regulating and supervising the facilities and activities of the hydrocarbon sector in terms of safety and environmental protection. This agency aims to regulate compliance with the obligations of companies in the hydrocarbons sector through the implementation of an integrated management system that uses national and international standards and best practices as reference guidelines (Government of Mexico, 2016).

The Industrial Safety, Operational Safety and Environmental Protection Management System (SASISOPA) is considered the Mexican model for integrated management in the hydrocarbon sector and is the guiding principle under which ASEA manages the risks of regulated activities in this sector (Government of Mexico, 2017).

The SASISOPA compliance requirements establish that companies regulated in the hydrocarbons sector must integrate, preserve and keep up to date a package of information on the technology and safety of the project they are developing in the facilities under their responsibility (Márquez, 2025).

These regulatory frameworks and systems are the guidelines for the development of the proposal being developed in a private Mexican organisation.

Literature review

Hydrocarbon separation batteries are facilities designed to separate some of the components of crude oil, mainly in the liquid and gaseous phases, for which different technologies and equipment are used, including process lines, separators, pumps, tanks, flow meters, among others. Their main objective is to carry out an initial separation into phases that allows the materials to be transported to processing stations such as refineries or gas processors. The basic process in a separation battery can be described as follows: Reception of hydrocarbons from associated producing wells via discharge lines; Separation by density difference using two-phase (liquid and gas) or three-phase (water, crude oil and gas) separators; Storage in tanks; Transfer of liquid hydrocarbons using transfer pumps; Transfer of gaseous hydrocarbons using gas compressors; and Certification of transferred volumes using measuring equipment (Márquez, 2025).

This paper proposes a methodology for updating and implementing a technology package in a field operator that produces liquid and gaseous hydrocarbons in reservoirs on the northern coastal plain of the Gulf of Mexico.

In this regard, the literature review aims to clarify concepts such as technology package in accordance with the tenth element of the Mexican Government's Industrial Safety, Operational Safety and Environmental Protection Management System (SASISOPA), considering methodologies for safety analysis in oil facilities. The National Agency for Industrial Safety and Environmental Protection in the Hydrocarbons Sector (ASEA) is an administrative body of the Mexican Government's Ministry of the Environment and Natural Resources. Its main functions include regulating and supervising industrial safety, operational safety and environmental protection with regard to the activities of the hydrocarbons sector in the country, regulating oil barrels, natural gas, onshore wells, offshore platforms, petrol stations, pipelines, storage and distribution terminals, refineries, natural gas processing centres, LP gas distribution centres, among others; ASEA manages the risks of regulated activities in the sector through the implementation of an Industrial Safety, Operational Safety and Environmental Protection Management System (Safety and Environment Agency [ASEA], 2025).

According to Mariano, technological packages for petroleum processes are guidelines that support organisations, particularly those focused on separation batteries, as each one has a specific design that depends on the number of wells it serves and the equipment used in its operation (Mariano, 2022).

According to Tarlengco, Hazard and Operability Analysis, known as HAZOP, is a systemic approach that allows for the identification of potential problems and difficulties in complex systems. It is a structured method used to analyse and discover safety risks and process inefficiencies by evaluating both new designs and existing operations. HAZOP studies are especially crucial in high-risk industries such as chemical production, nuclear energy production, oil and gas processing, and the pharmaceutical industry, among other productive areas (Tarlengco, 2025).

Methodology

Based on the HAZOP methodology, widely used in the oil industry and compatible with the objectives of this work, some stages of the HAZOP analysis were used in the development of the technological package for hydrocarbon production facilities. Complementarily, the process nodalisation methodology is used, dividing the process into parts or nodes to analyse the entire process in a structured and systematic manner. Although the methodology specifies exactly how to nodalise, it recommends doing so at each change in the process variables, such as changes in physicochemical composition, energy use, and changes in process variables, among others.

The next step in the HAZOP methodology is to apply a series of guide words to each node to determine the consequences of a deviation in the process variables. The most common guide words are: higher or lower pressure, higher or lower temperature, higher or lower flow, etc.

Based on these premises, a matrix of interactions between the nodes of the facility's process and the technical information available for the configuration of the technological package in hydrocarbon production facilities was developed.

Box 1

Table 1

Requirements matrix for the technology package in the organisation's facilities

Node	Hazardous materials and substances	Processus	Equipment	Risk management	Licences
Node 1					
Node 2					
Node 3					
Node 4					
Node 5					
Node 6					
Node 7					
Node N.					

Source: Authors

The initial phase for identifying and structuring elements in the technology package consists of identifying the nodes in the installation process where technical information about materials, equipment, and processes is required (Almanza, 2022). This phase involved a survey visit, which was documented by means of an attendance list and photographic records.

The first nodes to be defined are: Hydrocarbon reception, Separation, Well measurement, Gas utilisation, Crude oil storage, Crude oil homogenisation and pumping, Gas compression, Measurement and transfer of custody, Gas regulation and flaring, Chemical injection, Hazardous atmosphere monitoring, Drains and sumps, and Electrical supply.

The next step was to form a multidisciplinary group with personnel from the Operations, Maintenance, Infrastructure, Safety, and Quality areas to identify the technical information needed for each node, considering the area of expertise of the personnel from the various administrative units of the organisation.

During the session with the multidisciplinary group, each of the elements was defined in general terms with the aim of providing an overview of each of the elements and the type of information they should contain in accordance with best practices, international standards and the experience of the multidisciplinary team.

The following describes the necessary information elements determined in the interactions between the sub-processes and the classification of information.

Collection Stage:

Forty-nine wells converge per discharge line, at an average distance of 1,500 metres, and two collection heads are available.

Hazardous substances and materials.

- Material and energy balance.

Equipment

- Technical specifications of the facility.
- Index of lines and services.
- Inventory of equipment, valves, and instruments.
- Criticality analysis.
- Maintenance plan.

Process

- Collection system.
- Process flow diagram.
- Piping and instrumentation diagram (PID).
- General Location Plan (GLP).
- Operating philosophy.
- Operating procedures.

Safety systems

- Hydrocarbon Sector Risk Analysis (ARSH).
- Emergency response plan (PRE).
- Drills.
- Risk atlas.
- Fire risk study.
- Permit System for Risky Work (SPTR).
- Investigation and evaluation of hazards and environmental aspects (IEPPA).

Licences

- Single Environmental Licence.

Separation stage:

The facilities have three two-phase separators, which operate by density type and enable gas-liquid separation.

Hazardous substances and materials

- Inventory of hazardous materials and substances.
- Hazardous substance safety data sheet.

- Chemical analysis of crude oil.
- Gas chromatography.

Equipment

- Separator technical data sheet.
- Safety valve calibration certificates.

Process

- Separation operating procedures.

Requirements and licences

- RSP compliance notice. Requirement to comply with NOM-020-STPS-2011 to prevent risks in the workplace and damage to facilities.

Well measurement stage:

Interconnected to the collection manifolds and the separator is the measurement ring, which was designed to enable the measurement of wells that converge in the facility without mixing sweet and sour gas streams, thus continuing to use sweet gas for engine combustion in the facility.

Equipment

- Technical data sheets for well measurement equipment.
- Calibration certificates for well measurement equipment.

Process

- Well measurement operating procedures.

Gas utilisation stage:

The separators have a gas outlet bypass for use as fuel for the operation of instruments such as: separator level controllers, installation engines, and compression module.

Equipment

- Technical data sheet for fuel gas measurement equipment.
- Calibration certificates for fuel gas measurement equipment.

Process

- Gas utilisation operating procedures.

Storage stage:

The separation battery has an installed storage capacity of 1,120 barrels with two vertical storage tanks.

Article

Equipment

- Technical specifications for storage tanks.
- Calibration certificates for safety valves.

Process

- Storage operating procedures.

Hazardous substances and materials

- Inventory of materials and substances (fuels, lubricants, etc.).
- Substance safety data sheet.

Homogenisation and pumping stage:

The contents of the storage tanks are transferred by means of a pumping system, which is connected to a suction head where a duplex piston pump driven by a gas engine moves the liquid hydrocarbon through a pipeline.

Equipment

- Technical data sheet for pumping equipment.

Process

- Homogenisation and pumping operating procedures.

Compression stage:

The total natural gas (sweet-sour mixture) produced by the primary separation of the installation is compressed, measured and sent to the Compression Station.

Hazardous substances and materials.

- Inventory of materials and substances
- Substance safety data sheet.

Equipment

- Compression equipment technical data sheets.
- Emergency shutdown system technical data sheets.
- Control loop diagram.

Process

- Compression module operating procedures.

Measurement and transfer of custody stage:

For the quantification and certification of liquid hydrocarbons, the separation battery has a measuring skid. This system consists of a Coriolis mass meter as the primary measuring element, which in turn has a basket filter, static mixer, temperature and pressure transmitters, and a flow computer.

Equipment

- Technical data sheets for measurement systems.
- Calibration certificates for measurement and custody transfer equipment.

Process

- Operational procedures for measurement and custody transfer.

Gas regulation and flaring stage:

The separation battery has a burner for venting and flaring gas. Currently, 100% of the gas received through discharge lines is used, either for compression or fuel, so the venting and flaring system is only available in the event of a shutdown in the compression module.

Equipment

- Technical data sheet for the regulation system.
- Technical data sheet for the gas meter to burner.

Process

- Operating procedures for regulation and burner.

Chemical injection stage:

In order to minimise the concentration of hydrogen sulphide in the hydrocarbon, equipment for injecting a hydrogen sulphide sequestering chemical is installed, which, by means of a pneumatic pump, injects the product into the separator inlet. To prevent the formation of scale in the process lines, a scale inhibitor chemical is also injected.

Hazardous substances and materials.

- Inventory of chemical substances.
- Chemical safety data sheet.

Article

Equipment

- Injection system technical data sheets.

Process

- Chemical injection operating procedures.

Hazardous atmosphere monitoring stage:

To mitigate the risk posed by the presence of hazardous gases in the process, an audible and visible alarm system is in place, which is activated by three sensors located in the separator area, tank area and operator's cabin.

Equipment

- Technical data sheets for hazardous atmosphere detection systems.
- Calibration certificates for hazardous atmosphere detection systems

Process

- Operating procedures for monitoring hazardous atmospheres.

Drain and sump stage:

The equipment that has a drain line to the oily sump is: Separators, measuring skid and pump.

Hazardous substances and materials.

- Inventory of hazardous waste.

Equipment

- Technical data sheet for ecological station.

Process

- Operating procedures for waste management.

Power supply stage:

The facility's electrical power is supplied by the Federal Electricity Commission and, in addition, there is a natural gas-powered electric generator installed in the Compression Module, which supplies electricity to the Battery and Module. The motor generator is started up and the power supply is switched manually on the electrical panel of the Separation Battery.

Equipment

- Technical data sheet for electric motor generator. Electrical supply - Process.
- Motor generator operating procedures.

- Electrical classification plans.
- Single-line diagrams.
- Physical grounding system.

Derived from the application of interactions according to the selected methodology, a list of elements of the technology package was generated containing the information necessary to comply with SASISOPA provisions, best practices and standards in the hydrocarbons sector, defining the following structure:

The following describes the necessary information elements determined in the interactions between the sub-processes and the classification of information: Hazardous substances and materials, Equipment, Process, Safety systems, and Licences.

Box 2**Table 2**

Application of the matrix in the hydrocarbon collection sub-process

Hazardous Substances and Materials	Equipment	Process	Risk management	Requirements and licences
Material and energy balance	*Installation technical specifications *Index of lines and services *Census of valves (operational, auxiliary and safety) *Census of equipment (critical, auxiliary, safety) *Census of instruments *Criticality analysis *Maintenance plan	*Collection system *Process flow diagram *Piping and instrumentation diagram *General location plan *Operating philosophy *Operating procedures	* ARSH *PRE *Drills *Risk Atlas *Fire Assessment *IEPAA *SPPTR Risk	*Single Environmental Licence

Source: Authors

Based on the application of interactions from the selected methodology, a list of elements from the technology package was generated that contain the information necessary to comply with SASISOPA provisions, best practices, and standards in the hydrocarbons sector, defining the structure presented in Table 3. At this stage of the project, the technology procedure relating to the Field Operator process was updated with regard to the Technology Related to the Process in the organisation's Integrated Management System Facilities, describing the methodology used to obtain the list of elements of the technology package, considering the flow chart of operations shown in Figure 1.

Box 3

Table 3

List of items in the technology package

Process
Operating philosophy
Collection system
General location plan
Process flow diagram
Piping and instrumentation diagram
Electrical classification plans
Single-line diagrams
Physical grounding systems
Control loop diagrams
Separation battery operating procedure
Compression module operating procedure
Operating procedure for measurement and custody transfer
Waste management procedure
Equipment
Installation technical data sheet
Index of lines and services
Census of equipment, valves and instruments
Criticality analysis
Maintenance plan
Safety valve calibration certificates
Separator technical data sheet
Well measurement equipment technical data sheet
Well measurement equipment calibration certificates
Fuel gas measurement technical data sheet
Calibration certificates for fuel gas measurement equipment
Technical specifications for storage tanks
Technical specifications for pumping equipment
Technical specifications for compression equipment
Technical specifications for emergency shutdown systems
Technical specifications for measurement and custody transfer systems
Calibration certificates for measurement and custody transfer systems
Gas burner meter technical data sheet
Injection system technical data sheet
Hazardous atmosphere detection equipment technical data sheets
Hazardous atmosphere detector calibration certificates
Ecological station technical data sheet
Electric motor generator technical data sheet
Materials and substances
Material and energy balance
Inventory of hazardous substances and materials
Chemical analysis of crude oil
Gas chromatography
Crude oil safety data sheet
Natural gas safety data sheet
Lubricants safety data sheet
Fuels safety data sheet
Chemicals safety data sheet
Inventory of hazardous waste
Risk management
Hydrocarbon sector risk analysis ARSH
Emergency response plan PRE
Risk Atlas
Fire risk assessment
Permit system for hazardous work SPPTR
Investigation and assessment of hazards and environmental aspects IEPAA
Drill programme
Licences
Single environmental licence LAU
Notice of compliance for pressure vessels

Source: Authors

Box 4

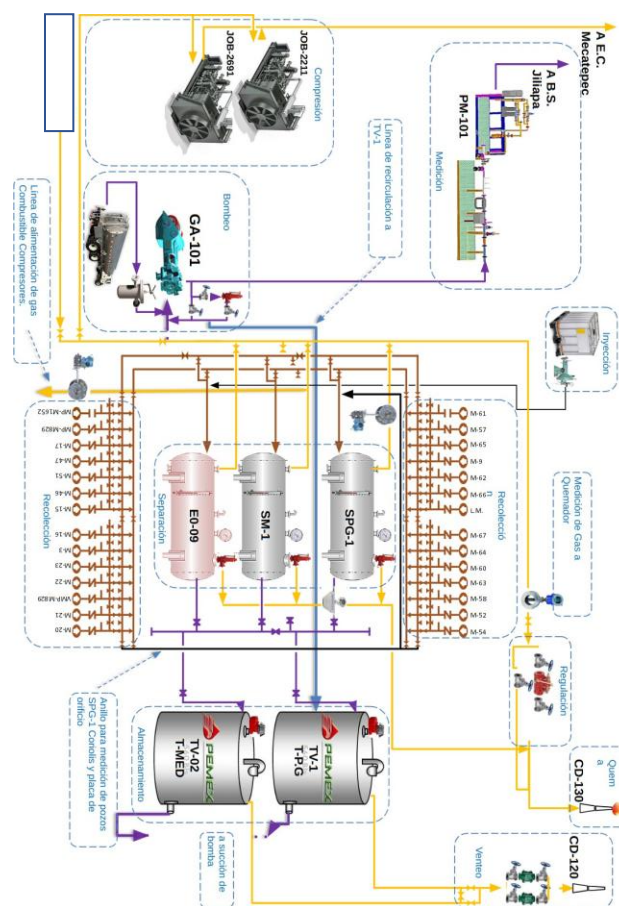


Figure 1

Operations flow chart

Source: Authors

Results

The project aimed to develop a methodology to identify, integrate, update, and manage the elements that make up the Separation Battery technology package, in order to ensure compliance with the requirements to be implemented during the project life cycle of element IX of SASISOPA 'Best Practices and Standards' defined for the oil industry in Mexico (Official Gazette of the Federation, 2020).

This was achieved through a review of regulations, standards and best practices in the hydrocarbons sector, which determined that the applicable regulations generally correspond to ISO 9001 - Quality (International Organisation for Standardisation, [ISO], 2025a), ISO 14001 – Environment (ISO, 2025b), ISO 45001 Standard – Health and Safety (ISO, 2025c), NOM-018-STPS-2015 – Harmonised System for the Identification and Communication of Hazards and Risks from Hazardous Chemicals in the Workplace (Official Gazette of the Federation, 2015), NOM-010-STPS-2014 Chemical agents contaminating the working environment (Official Gazette of the Federation, 2014), NOM-020-STPS-2011 Pressure vessels, cryogenic vessels, steam generators or boilers (Official Gazette of the Federation, 2011), among the main ones; Subsequently, the methodology for updating and administering the elements that make up the technology package was developed, followed by the procedure that establishes the guidelines for the development, updating, and administration of the organisation's technology packages.

Box 5

TECNOLOGÍA RELATIVA AL PROCESO EN INSTALACIONES		REVISIÓN 03	FECHA 04 de Febrero de 2025
		CÓDIGO	
5. RESPONSABILIDAD			
Coordinador de Infraestructura Construcción.	<ul style="list-style-type: none"> Liderar el grupo multidisciplinario para desarrollar e integrar la información de la Tecnología relativa al proceso de las instalaciones de superficie nuevas y las existentes. Asegurar que el personal responsable del área actualice el paquete tecnológico siempre que la instalación sufra alguna modificación, actualización u otros que la organización determine. 		
Coordinador de Operaciones de Producción	<ul style="list-style-type: none"> Participar en el desarrollo del documento de la Tecnología relativa al proceso de las instalaciones de superficie nuevas y existentes en el área contractual bajo su responsabilidad. 		
Coordinador Mantenimiento	<ul style="list-style-type: none"> Participar en el desarrollo del documento de la Tecnología relativa al proceso de las instalaciones de superficie nuevas y existentes en el área contractual bajo su responsabilidad. 		
Coordinador de SSMA	<ul style="list-style-type: none"> Participar en el desarrollo del documento de la Tecnología relativa al proceso de las instalaciones de superficie nuevas y existentes en el área contractual bajo su responsabilidad. 		
Custodio	<ul style="list-style-type: none"> Asegurar que la información que integra el paquete tecnológico esté vigente y disponible de manera física y digital en la batería de separación. Asegurar que se actualicen los registros de acuerdo con lo establecido en este procedimiento. 		
Gerente de Activo	<ul style="list-style-type: none"> Asegurar los recursos para lograr la implementación de este procedimiento en el área contractual bajo su responsabilidad. 		

Figure 2

Responsibilities in the process

Source: Authors

To subsequently apply the designed sequence, which summarises 16 activities, as follows:

1. Assign personnel to the multidisciplinary group to develop or update the technology package.
2. Assign a group leader.
3. Include all areas of the organisation.
4. Identification of sub-processes and nodes to consider technical information.
5. Initial overview of information gathering to validate processes and nodes.
6. Identification by sub-processes and nodes of materials, substances, equipment, among others.
7. Technical meeting to determine complementary information in accordance with applicable regulations.
8. Integration of information from the technology package requirements matrix.
9. Integration of the elements and structure of the technology package.
10. Create a checklist for the integration of the package elements to identify the degree of compliance of the facilities.
11. Assign responsible persons by area for updating information that represents an area of opportunity.
12. Ensure updating through a checklist and its validation.
13. Integration of the technology package by type of facility in accordance with its documentation.
14. Make the technology package information available in printed form and on a duly specified digital medium.
15. The facility custodian shall verify that the technology package is up to date, available, and accessible to personnel involved in each process, sub-process, or node, from management to operational levels.
16. The facility custodian shall prepare a quick reference guide, which shall be distributed to all personnel.

Conclusions

This study developed the methodology for establishing the structure and elements that a Separation Battery technology package must contain in order to meet the requirements of industrial safety, operational safety, environmental protection, and best practices and standards in the hydrocarbons sector in Mexico. The work carried out enabled the development of an internal reference procedure for the technology package, which, when implemented and updated, seeks to ensure the proper functioning of production facilities and to take into account the risks and hazards associated with processes, inputs, equipment, and external factors.

Areas of opportunity include identifying the level of compliance of the technology package through a documentary review of the facility with respect to the structure of elements established in the procedure, evidence of operation and compliance, from which areas of opportunity can be identified and analysed based on the multidisciplinary groups already established in the organisation for the development of the methodology and previous work.

Among the main limitations identified was the time required to coordinate the schedules of the people participating in the multidisciplinary groups. Therefore, establishing alternative meeting mechanisms, such as videoconferences, video calls, collaborative work in the cloud or online, are alternatives to face-to-face work that can contribute to achieving the planned results. Future work could include evaluating the feasibility of applying the methodology developed to other separation batteries within the same company.

Identifying the most efficient mechanisms for disseminating the technology package in order to expand it.

Integrating a proposal to update the technology package based on the areas of opportunity identified by multidisciplinary groups within the organisation.

It is also relevant to evaluate the methodology in other oil facilities of the organisation to compare its operability or, where appropriate, to take actions to complement the actions for its implementation.

Declarations

Conflict of interest

The authors declare that they have no conflict of interest. They have no competing financial interests or known personal relationships that could have influenced the article presented in this article.

Author contribution

Mendoza-Espinoza Héctor Eduardo: Contributed to the project idea, analysis, research method and technique, writing.

Escorza-Sánchez Yolanda Marysol: Contributed to research method and technique, writing.

Márquez-López Ángel de Jesús: Contributed to the project idea, analysis, research method and technique, writing

Availability of data and materials

The information and data used or analysed during this study are available upon reasonable request from the corresponding author, subject to prior written authorisation from the company where the project was carried out.

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The research did not receive any funding; however, one of the authors is a collaborator with the organisation where it was carried out.

Abbreviations

ASEA	Safety, Energy and Environment Agency
ARSH	Risk Analysis of the Hydrocarbons Sector
DTI	Piping and Instrumentation Diagram
HAZOP	Hazard and Operability Study Risk and Operability Analysis Methodology
IEPPA	Investigation and evaluation of hazards and environmental aspects
LP	Liquefied Petroleum
NOM	Official Mexican Standard
PEMEX	Petróleos Mexicanos
PLG	General Location Plan
PRE	Emergency Response Plan
RSP	Pressure Vessels
SASISOPA	Industrial Safety, Operational Safety and Environmental Protection Management System
SPPTR	Permit System for High-Risk Work

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