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GUIDELINES FOR RISK BASED PROCESS SAFETY MANAGEMENT IN BRAZILIAN MINING

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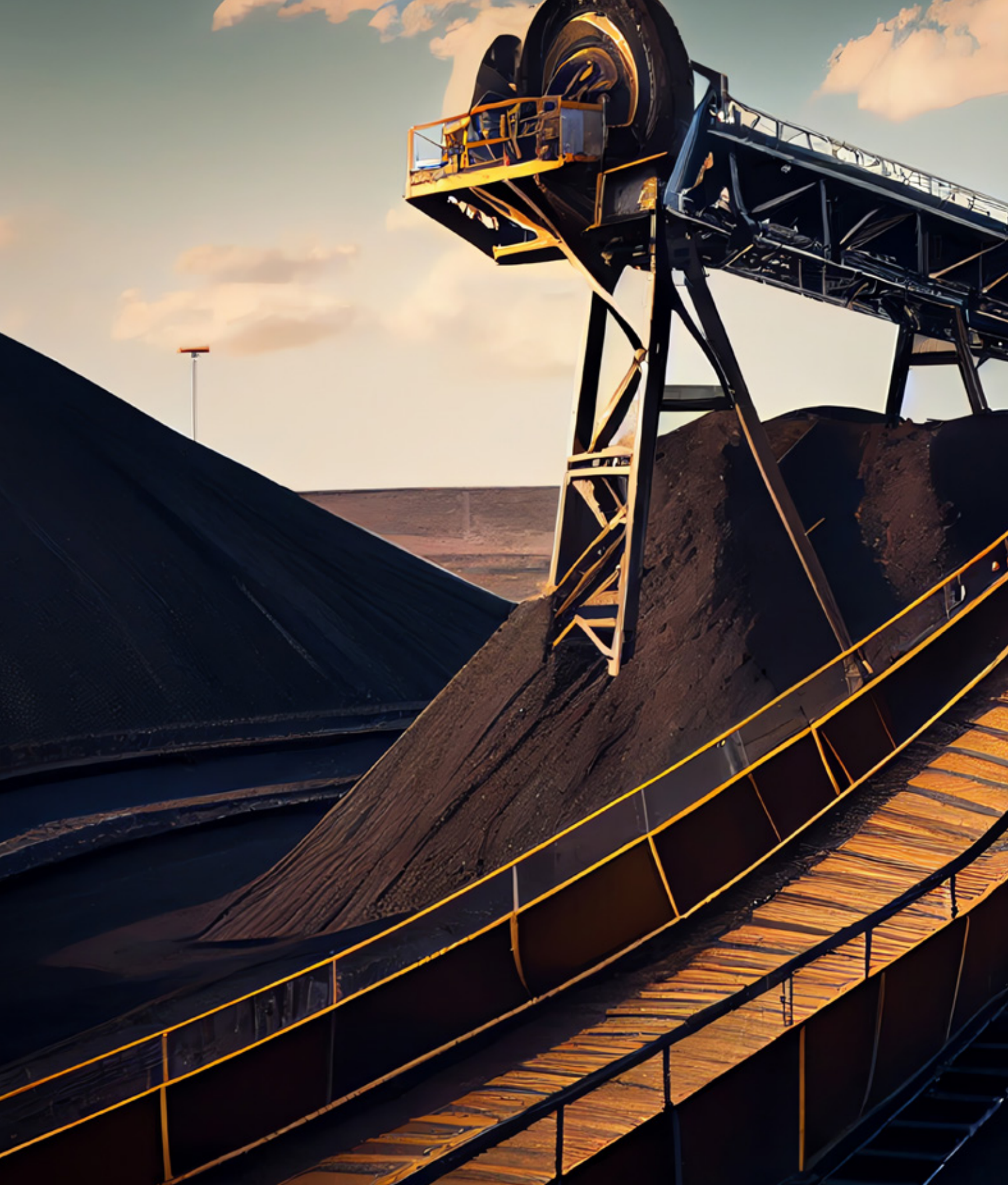

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Brazilian Mining Institute - IBRAM

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FOREWORD

The mining industry, as one of the economic pillars of Brazil, holds safety and operational integrity as fundamental principles. Technological advancements and the increasing complexity of industrial processes pose a constant challenge: the effective management of process safety. This manual, developed by the Brazilian Mining Institute (IBRAM), serves as an essential guide for all companies in the sector, directing practices that promote safety, minimize risks, and ensure the sustainability of operations.

IBRAM, aware of the responsibilities involved in the operation of industrial processes, particularly in the context of mining, understands that safety is non-negotiable. This manual has been structured to provide a comprehensive overview of best practices in process safety management, encompassing both technical and organizational aspects. Our goal is to equip companies in the sector with tools to identify, assess, and mitigate risks, preventing incidents that could jeopardize human lives, the environment, and organizational assets.

The purpose of this manual is not only to present standards and procedures but also to foster a safety culture that is integrated into daily operations. We believe that safety is the result of effective management combined with the commitment of all

stakeholders. Therefore, this document serves as a foundation for building safer work environments and consolidating a more responsible mining industry.

We hope that this manual will be a valuable resource for mining professionals and companies, contributing to the promotion of a safer and more sustainable industry. IBRAM reaffirms its ESG commitment to excellence in process safety management and is ready to continue supporting the sector in developing practices that aim to protect people and the environment.

We wish you a successful implementation of the guidelines.

Eduardo de Maio Francisco
PhD,MSc,ChE - AIChE/CCPS Fellow
Coordinator of the Preparation of this Manual

PRESENTATION

It is with great satisfaction that we introduce to you the "Guidelines for Risk Based Process Safety Management in Brazilian Mining", a work carefully prepared by the Brazilian Mining Institute (IBRAM). This guide represents a significant step forward in our journey to strengthen Brazil's Mining ESG commitments, promoting a culture of safety, responsibility and sustainability in our industry.

The publication provides a comprehensive overview of the structure and implementation options of the Process Safety Management in Mining (GSPM) model. Inspired by the principles and concepts of Process Safety Management (PSM), GSPM seeks not only to implement, but to achieve excellence in process safety in the Brazilian mining industry, contributing to operational stability, efficient planning and cost reduction.

Aimed at professionals at different hierarchical levels involved in activities related to mining and processing, this guide is a valuable source of guidance and best practices. Whether for

CEOs, directors, managers, engineers, supervisors, operators or safety professionals, the guidelines contained in this guide are essential for promoting a safe and responsible work environment.

The guide reflects the commitment of IBRAM and associated mining companies to safety and operational excellence in the Brazilian mining industry. We are confident that this publication will become a valuable resource for all professionals involved in the industry, contributing to a safer and more sustainable future.

Sincerely yours,

Raul Jungmann
Chief Executive Officer - Brazilian Mining Institute (IBRAM)

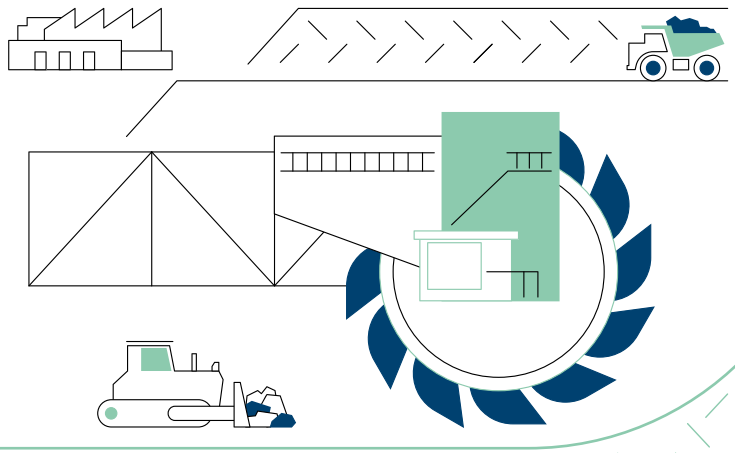
INTROCUCTION

The Brazilian Mining Institute (IBRAM) is a private, nonprofit organization, with actions focused on building a new future perspective for Brazilian mining, outlining strategies and leading the sector's transition to an even more productive, sustainable, safe and secure scenario, responsible to everyone around it.

According to IBRAM, mining can - and should - be a vector for development, a driver of advances in technology, an active contributor to a balanced and inclusive way of life, with care for people and the environment.

To that effect, in 2019 IBRAM - through the Letter of Commitment, which, subsequently, following the global trend, was transformed into responsible actions to meet the ESG (environment, social responsibility and governance) movement - took on an important deal with society: contribute to the transformation of the mining industry, mobilizing companies in the sector to think together of a better future.

Focused on driving this cultural transformation, initiatives related to operational safety were included with genuine engagement to return trust, admiration and respect from the mining industry operations to society.



For IBRAM, full identification of hazards and effective risk management are essential conditions to ensure that the operations of any business activity are at acceptable safety levels or higher than the required standards.

In the case of expanded industrial accidents, it appears that the operational risk management approach with an exclusive focus on Occupational Safety is not sufficient to respond to these new challenges in the mining industry, since the response to the factors contributing to the Events potentially capable of impacting not only workers, but also the environment, neighboring communities and the people within them cover other technical aspects related to processes – as a rule – not covered by this subject.

The committee's work has promoted the exchange of knowledge between representatives of signatory companies and synergies between initiatives from leading institutions, such as the ICMM (International Council on Mining and Metals) and the CCPS (Center for Chemical Process Safety), creating special cooperation between these bodies and Brazilian mining.

Process Safety Management (PSM – Process Safety Management) contributes significantly to making operations stable, as controlling and monitoring risks reduces the probability of production downtime due to unwanted events and provides the information necessary for the correct allocation of resources. Therefore, in addition to safety, there is a gain in planning, cost reduction and increased productivity due to the reliability of the systems.

In this context, IBRAM – supported by companies in the sector – outlined three important initiatives that seek to promote specific actions to introduce the concept of Process Safety in the segment, namely:

1. Prepare a technical guide defining guidelines and good practices aimed at implementing a Process Safety journey for mining;

2. Create a center of excellence in Process Safety in the mining industry at IBRAM, to share and develop good practices;

3. Create an internal annual report on Process Safety through specific forums between companies in the mining industry.

This advisory guide and its annexes are intended for companies associated with IBRAM and other mining companies, and materialize initiative 1 above, aiming to develop the Process Safety approach in the mining sector, in line with the Letter of Commitment signed in 2019.

OBJECTIVE

This guide describes the structure and implementation alternatives of the Process Safety Management in Mining - GSPM Model, composed of five axes divided into twelve elements, as well as the principles and characteristics of these elements and the interrelationship between them, based on the guidelines and concepts of PSM – Process Safety Management, aiming to implement and achieve excellence in Safety Processes in the mining industry..

APPLICATION

The guide must be useful for anyone involved in activities related to mining and processing processes, and also for those who carry out activities that may directly or indirectly impact the risks related to the organization's processes and operations, at all hierarchical levels: CEOs, directors, managers, process engineers, supervisors, production operators, maintenance technicians, managers and security professionals and functions of contractors, professionals in the area of Human Resources, Supplies, Legal, Engineering and Projects, Research and Development of Products and Processes, as well as people directly linked to the execution of any activities of the Process Safety Management System, in order to guide their activities.

Organizations must decide how to use this guide, based on their corporate safety security strategy, the degree of maturity of the safety security culture, organizational structure and dynamics, among other factors. Existing management systems can be leveraged, enhanced or adapted to meet the process safety requirements established by the Process Safety Management in Mining - GSPM Model.

These are some options for using this document:

- Use this guide as a reference for implementing the model in your company;
- Adapt or combine existing management systems to cover the Process Safety aspects established in this guide, reformulating current processes and complementing gaps in the management system with new processes or missing activities;
- Use this guide as a reference to improve a particular element of the existing management system.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ACRONYMS AND DEFINITIONS

Asset life cycle – stages that an asset (physical and non-physical, such as infrastructure and equipment) goes through from its creation to its extinction/demobilization. These stages include conception, design, acquisition, deployment, operation, maintenance, decommissioning, and disposal.

Audit – a systematic, independent review to verify compliance with prescribed standards of care, using a process review to ensure consistency and to enable the auditor to reach justifiable conclusions.

Coverage Area – geographic delimitation in which the activities/processes occur under the direct responsibility of the organizations.

Direct cost – includes only the costs of repair and/or replacement of the impacted asset(s), in addition to cleaning and emergency response. Indirect costs shall not be considered.

Element – basic division of a process safety management system related to a type of work to be carried out, such as, for example, change management – MOC.

Element leader – person responsible for coordinating the implementation, maintenance and improvement of the element under their supervision.

Emergency – event that requires immediate attention, as it implies a consummated or potential disaster.

Equipment – apiece of hardware that can be defined in terms of the mechanical, electrical, or instrumentation components contained within its boundaries.

External Documents – name given to the set of external references, technical standards, foreign standards and applicable national legislation.

Hazard – source or situation with the potential to cause risks to people, property, the work environment or a combination thereof.

Hazardous material – A substance with the potential to cause harm due to its chemical properties (flammability, toxicity, corrosivity, reactivity, asphyxiants) or physical properties (pressure, temperature), including non-toxic and non-flammable materials (steam, hot water, nitrogen, CO_2, compressed air). See tables 1 and 2 of Annex I.

Hazardous energy – chemical, mechanical, hydraulic, pneumatic, thermal, kinetic and radiation energy with the potential to cause harm to people, the environment, property or the community. These energies must be associated with controls that prevent their unplanned or uncontrolled release.

Highly toxic material – any material that, due to its physical (example: high volatility) and toxic properties, considering the quantities used, is a risk factor for people.

Installation – set of equipment, systems and structures in order to process part or all of the production of a good or service in a production unit. The location where a management system activity is carried out. In the early stages of the life cycle, a facility might be the company's central research laboratory, a pilot plant, or the engineering offices of a technology supplier. In later stages, the facility may be a typical processing or processing facility, storage terminal, distribution center, or corporate office. In the context of this document, a facility is a part or complete plant, unit, site, complex, or any combination thereof.

Line responsibility – responsibility and authority of people involved in the daily operations of an organization and who are essential to achieving the company's objectives set out in its corporate goals and values.

Loss of primary containment – unplanned or uncontrolled release of energy or hazardous material from primary containment (such as a pipeline, tank, transport or storage vessel), including non-hazardous materials (such as non-toxic and non-flammable), even if this release is directed to installations designed to serve as secondary containment (e.g. containment basin, dikes, etc.);

Operational Assets – a process/structure/facility involved in the use, storage, manufacture, handling or transportation of hazardous materials and/or the extraction, processing, processing, transportation or storage of ore and waste. It also refers to equipment, such as vessels, piping systems, controls, safety security systems, utilities and other elements that make up such process/structure/installation.

Operations – set of activities carried out by different areas of an organization between the start-up and shutdown of an installation and which contribute to its functioning, according to a business vision.

Process safety event – potentially catastrophic events that generate an unplanned or uncontrolled release of hazardous energy or material (loss of containment) that can result in an impact on equipment and/or operational assets, impacts on the environment or damage to people.

Note: It involves the operation or absence of controls/barriers/safeguards of operational facilities, within a pre-established coverage area intended for mining, processing, processing, production and transfer/transportation of products and materials.

Process safety - critical equipment, installation or structure – equipment, structures, installations, control and monitoring systems whose malfunction or failure could result in a catastrophic,

uncontrolled and unplanned release of hazardous energies or materials or whose proper operation is necessary to mitigate the consequences of such releases.

Probability – a measure of the expected frequency of occurrence of an event.

RBPS – Risk Based Process Safety is the set of guidelines for process safety management based on 4 pillars and 20 elements proposed by

Risk – combination between the probability and severity of an event occurring that could negatively impact people, the environment or business continuity.

Risk analysis – study or analysis of risk, associated with a set of activities or a list of potential accident scenarios. A risk analysis typically considers all three risk attributes (What could go wrong? How serious can it be? How often can this happen?). A risk analysis can provide qualitative or quantitative results.

Risk Appetite – amount and type of risks that an organization is prepared to seek, retain or assume.

Secondary Containment – equipment or assets designed to contain hazardous materials and/or energies released in primary containment. Secondary containment systems include, but are not limited to tank dikes, barriers around process equipment, drainage collection or oil collection systems, etc.

Severity – a measure of how damaging or harmful an event may be.

Structure – buildings, bases and/or parts of equipment whose function is to sustain or contain energy, such as structures of any nature, including civil, geotechnical, metallic, etc.

System axis – set of elements of the process safety management system with affinities in its scope.

Tier 1 – events with greater consequences

Tier 2 – events with minor consequences

ACRONYMS

AIChE - American Institute of Chemical Engineers

ANSI - American National Standards Institute

API - American Petroleum Institute

CCPS - Center for Chemical Process Safety

DGL - Dangerous Goods List

EAR - Waste Storage Structure

EP&R – Emergency Planning and Response

ESG - Environmental, Social & Governance

GSPM - Process Safety Management in Mining

ICMM - International Council on Mining and Metals

IT - Work Instruction

ITPM - Inspection, Testing and Preventive Maintenance Program

LOPC - Loss of Primary Containment

MOC - Management of Change

PR - Procedure

PRD - Pressure Relief Device

PSE - Process Safety Event

PSE1 - Process Safety Event Tier 1

PSE2 - Process Safety Event Tier 2

PSSR – Pre-Start-Up Safety Review

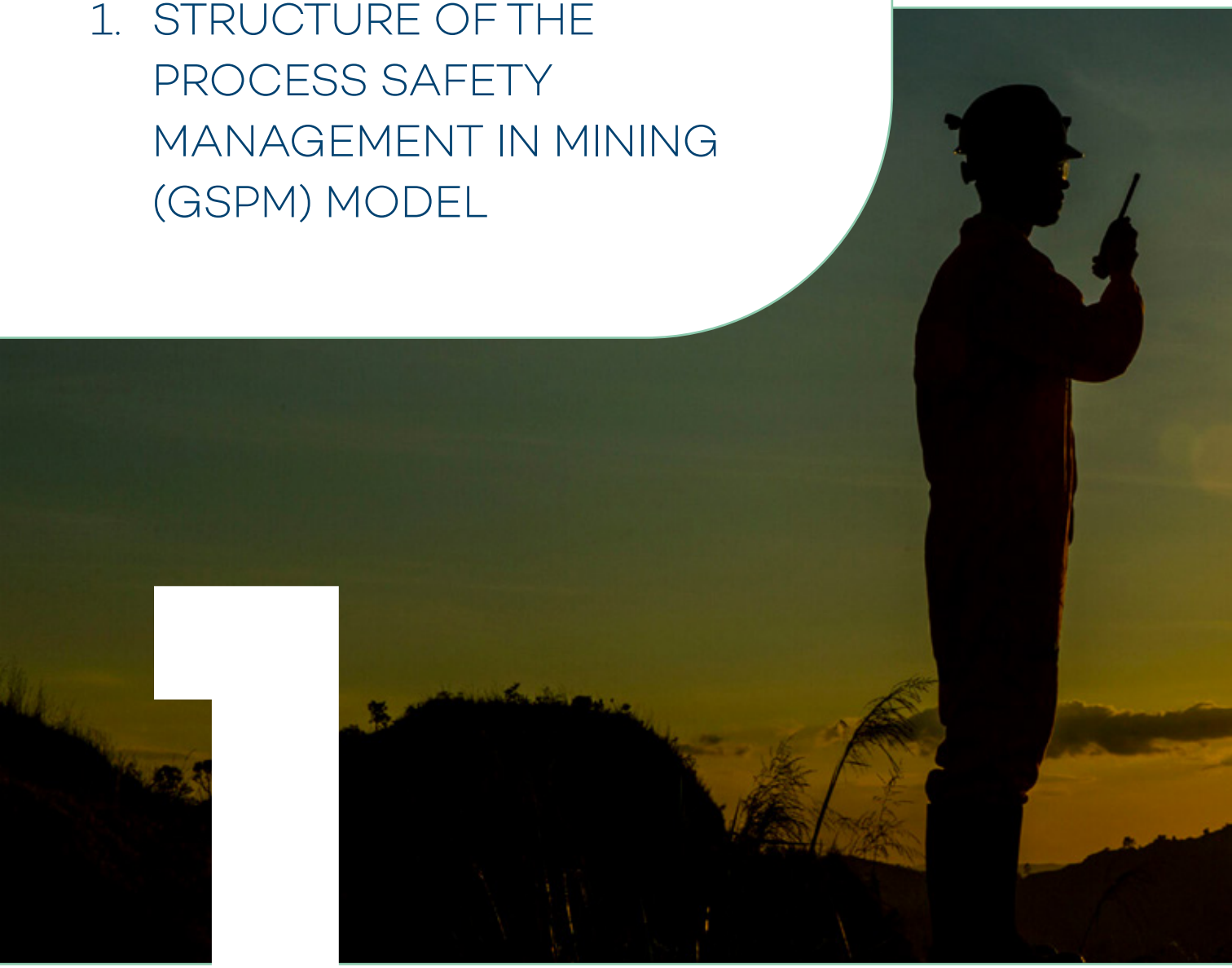
RNC - Nonconformity Report

SSMA - Safety, Health and Environment

TIH - Toxic inhalation hazard

TQ - Threshold Quantity

1. STRUCTURE OF THE PROCESS SAFETY MANAGEMENT IN MINING (GSPM) MODEL



The model developed by IBRAM for Process Safety Management in Mining (GSPM) is based on the guidelines and principles of PSM – Process Safety Management. PSM is the application of controls and management activities so that process hazards and risks are identified, understood and controlled so that process-related injuries and incidents can be eliminated, throughout their life cycle.

These Process Safety events are potentially catastrophic and generate an unplanned or uncontrolled release of energy or hazardous materials (loss of containment) that can result in impacts to equipment and/or operational assets, impacts to the environment or damage to people. Usually, it involves the operation or absence of controls/barriers/safeguards of operational facilities, within a pre-established coverage area intended for mining, processing, processing, production and transfer/transportation of products and materials.

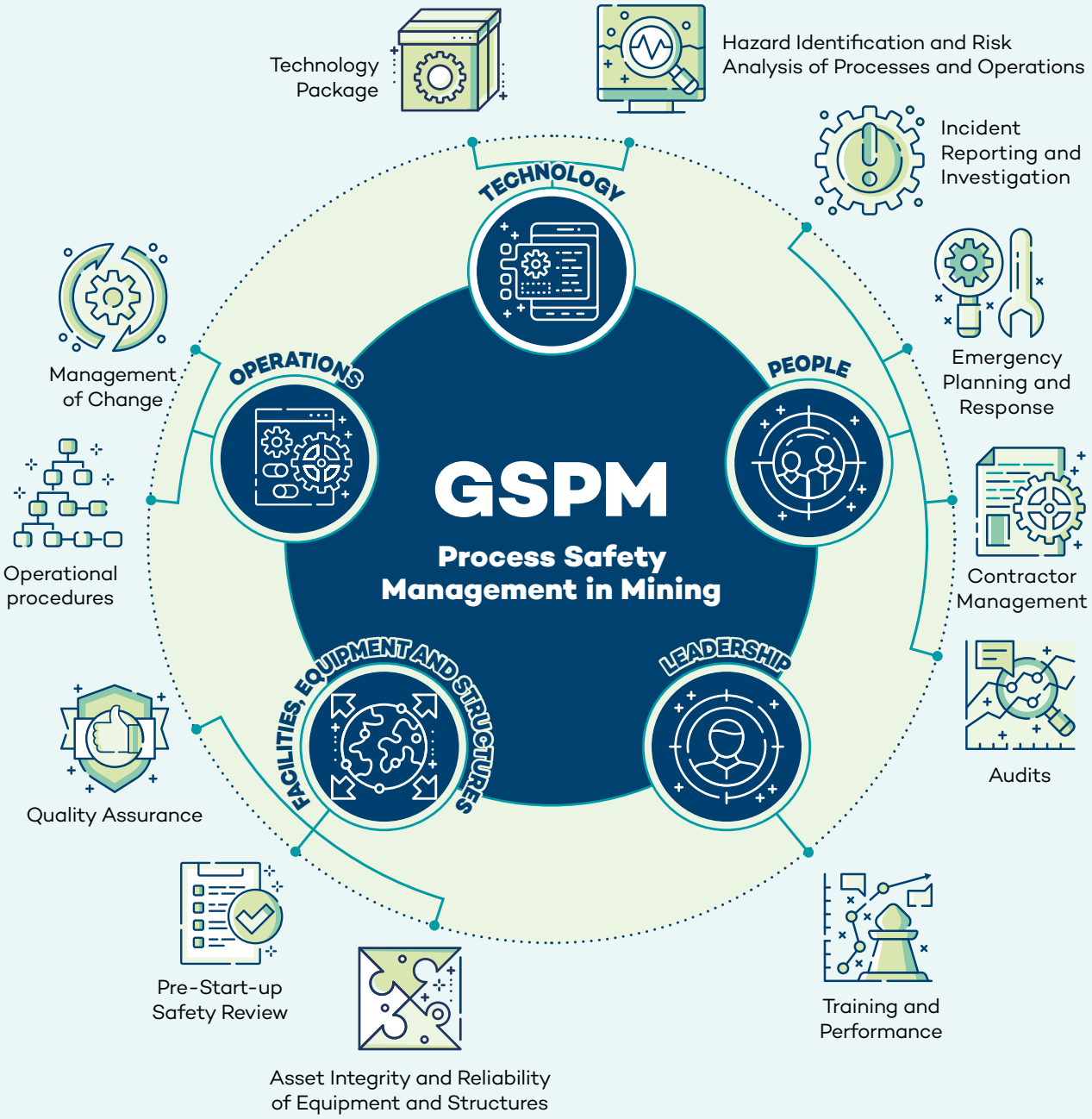
NOTE: The flowchart for characterizing a Process Safety event, as well as some examples of these events, can be found in Annex I of this technical guide.

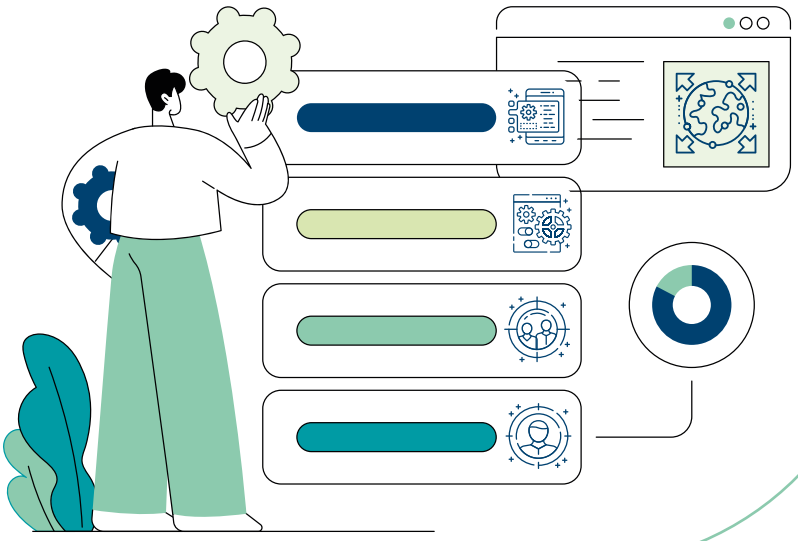
1.1 Process Safety Management in Mining (GSPM) Model

The Process Safety Management in Mining (GSPM) Model consists of five axes (Technology, Operations, Facilities, Equipment and Structures, People and Leadership) broken down into twelve elements, as shown in figure 1.

The GSPM model is aligned with the main references for the construction of Process Safety Management Systems (PSM) and with the equivalence of each element with the constituent elements of these references, but with a focus on the mining process, optimizing its understanding, application and generation of gains for the sector and all other concerned parties (stakeholders).

Figure 1: Process Safety Management in Mining - GSPM



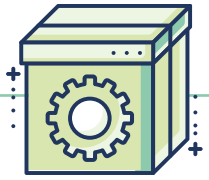


1.2 Principles and characteristics of GSPM elements

Below is provided a description of the principles that govern the elements of the GSPM and the main characteristics of its activities:

1.2.1 Technology

1.2.1.1 Technology Package



PRINCIPLE

The Technology Package element describes the processes or operations and provides the technical bases that provide identification and understanding of the associated hazards and risks involved.

Technology Package also provides operational procedures for a clear understanding of the operational sequence and parameters for those operating the process. These procedures also clearly define process operating limits, safety, health and environmental control, operational safety hazards and preventative measures to avoid operational safety incidents.

From the design stage, it is essential to identify and list all critical equipment, structures, systems and protective devices. These must be designed and installed to guarantee the safety of processes, people, the environment and to maintain the integrity of the installations. This list must be completed before the facilities are handed over for operation.

CHARACTERISTICS

Its activities are characterized by:

- List the hazards of materials, products, energy and substances;
- Lists chemical and physical data, in the form of specifications for final products, intermediates, byproducts, inputs, raw materials, mining waste and effluents;
- Reactivity data of products, materials and raw materials;
- List raw materials, waste and finished products;
- Describes aspects of the process, such as its main material transformations, mass and energy balances, unit operations, etc.;
- Process design basis (conceptual design);
- Describes the path to safe operation;

- Includes process steps and limits;
- Includes consequences of deviations from established limits;
- Describes important design data for equipment and structures;
- Defines critical equipment and structures for the GSPM;
- References the codes, standards, applicable legislation and recognized engineering practices used;
- Data and information for developing operational procedures and safe practices;
- Developed and documented for each process;
- Consistent with process safety information;
- Clear format, language and graphics. safety, health and environment;
- Alerts to Operational Safety dangers;
- Indicates preventive measures for Operational Safety incidents;
- Covers all stages and phases of the process;
- Always kept up to date;
- Verified, reviewed, approved and authorized;
- Readily accessible.

1.2.1.2 Hazard Identification and Risk Analysis of Processes and Operations

PRINCIPLE

Hazard Identification and Risk Analysis of Processes and Operations is a set of qualitative, semi-quantitative and quantitative techniques used to identify hazards, analyze scenarios and consequences arising from identified hazards and classify risk according to the organization's acceptability criteria, using, for example, a risk matrix, risk appetite criteria, etc. and definition of control measures, barriers or safeguards.

CHARACTERISTICS

- Identifies hazards and analyzes risks in projects, facilities and production systems, including structures of any nature, processing, underground mines, tunnels and transport of products and raw materials;
- Analyzes consequences and hypothetical simulation of loss of containment (dam failure, for example);
- Reviews risk analyzes based on information and learning from other events, when changes occur in the process and in applicable standards and legislation and when there is justifiable demand from concerned parties;
- Selects priority scenarios according to the organization's risk severity, risk appetite and governance criteria;
- Predicts the harmful effects caused by the identified scenarios;
- Periodically reviews the list of hazards applicable to the life cycle of mining processes and operations;

- Analysis facilities and operations following recognized methodologies, in an organized manner, based on facts, historical data and past events, human factors, standards, current good practices, technical knowledge of the process and operations (applied technology), assessment criteria for the level risk (probability, severity and risk matrix rules);

- Analysis specifications and safety information in the handling, storage and processing of final and intermediate products, by-products, effluents, ore waste, raw materials, inputs and reactive rocks, such as reactivity, toxicity, particular behavior in certain conditions offering risk, interactions geochemistry, etc.;

- Reviews risk analytics within a minimum period, according to criteria defined by the organization;

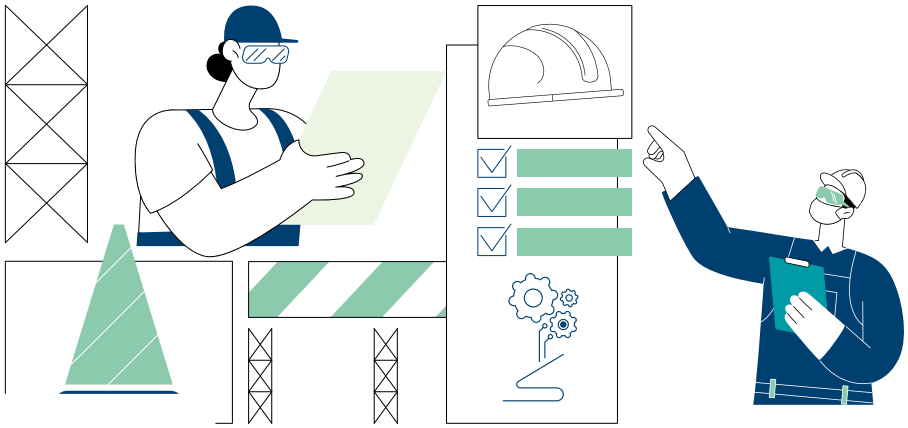
- Indicates the most appropriate risk analysis methodologies for each stage of the life cycle and the characteristics of the process and operations;

- Informs the minimum composition of the multidisciplinary team that participates in the risk analysis and indicates the competencies of its leader, according to each stage of the life cycle and characteristics of the process and operations;

- Establishes governance to document the results of risk analyses, including the scenarios analyzed, recommendations and action plans generated, enabling consultation, traceability and communication of the personnel involved;

- Establishes deadlines for retaining documents relating to risk analyzes throughout the life cycle of the process and operations, also observing legal and regulatory requirements;

- Encourages and boosts workers' participation in risk analyses.



1.2.2 Operations

1.2.1 Management of Change

PRINCIPLE

Changes in processes, technology, equipment, procedures, facilities, structures of any nature and in products, inputs and raw materials potentially impact hazard assessments and risk analyzes prior to the changes and may create new risks or alter existing ones. Therefore, all changes must be documented, analyzed and the need to update the information in the Technology Package must be assessed, depending on the nature of the change implemented. Process changes are understood to be those that propose any changes in relation to the original project.

Changes that are not like-kind replacements must receive a review of the hazards involved for process safety before implementation.

A minimum level of experience and collective knowledge of the group responsible for the change and involvement of the impacted areas is necessary so that there is a solid basis for decisions that may affect the safety of the process.

The need for complementary analyzes from other disciplines must be assessed prior to implementation. Management of Change ensures that risk control measures are applied before implementation.

Personnel changes, as well as changes in technology or facilities, potentially impact previously performed process risk reviews, which were based on the level of staff knowledge available at the time. Therefore, for organizational positions defined as critical, a preparation, succession and replacement process are necessary.

The Management of Change element is also applicable to geotechnical structures. Changes in the purpose of the structure, as well as changes in the boundary conditions and in the master plan of the area (whether occurring in a controlled manner or not), design changes throughout the work due to geotechnical uncertainties,

changing reality in the field in relation to project assumptions), among other cases, must be managed and analyzed using a structured process, also considering the impacts of the change on the geotechnical structure itself, on adjacent areas and on related operations.

Changes caused by the impact of changes in applicable legislation and standards must also be explored by the Change Management element.

CHARACTERISTICS

Management of Change is characterized by:

- Establish the process of analyzing proposed changes, document the phases necessary for their authorization and record the decisions taken, focusing on the purpose, technical basis, description of change, safety, health and environmental factors, changes in procedures operational, updating the technological package, maintenance strategy, training and communication needs, time and quantity limits, approval and authorization;

- Check whether the recommendations made during the change management process, including those arising from risk analyses, were adequately fulfilled;

- Define and understand what constitutes a change potentially capable of impacting operational safety security ;

- Define and classify the types of change (temporary or definitive, subtle or technological, etc.);

- Establish written procedures for the Management of Change process, considering the types of change and the complexity involved;

- Review all changes to the facility that are not like-kind replacements and technology changes, including changes that impact structures of any nature;

- Ensure that Process Safety requirements are considered before implementing changes;

- If necessary, indicate the need to modify operational procedures and staff training before implementation.

1.2.2.2 Operational procedures

PRINCIPLE

For the safe conduct of operations, written procedures are necessary that describe the steps, tools and methods for carrying out activities linked to processes and operations. These procedures must contain instructions for troubleshooting when a situation occurs outside of expectations or the established standard and when an emergency stop must be made. The procedures must contain basic information, so that the person performing the activity can be aware of the dangers, tools, equipment and prevention and control measures, so that they can be verified and it is possible to confirm whether the process or activity is occurring in accordance with the expected.

The scope of this element is limited to procedures relating to tasks and operations necessary to initiate, operate and terminate processes in a safe and environmentally sound manner, including emergency situations.

CHARACTERISTICS

Operational Procedures are characterized by:

- Define procedural management controls: scope of preparation, review and approval, preparation and review process, communication methods, types of documents, minimum information that must appear in the document, etc;
- Define and control the content format of each type of procedure, ensuring that the information is clear and concise and in language accessible to the target audience;
- Control reviews and lists of documents;
- Specify roles and responsibilities for each activity;
- Determine the method, tools, equipment and resources to safely carry out activities or operations.
- Define safe operating limits and procedures in cases of deviations from standard conditions or emergencies;
- Standardize the method of operation and use of resources, equipment, installations and structures;
- Develop operational procedures considering risk assessments and recommended prevention and control measures.

1.2.3 Facilities, equipment and structures

1.2.3.1 Quality Assurance

PRINCIPLE

Quality Assurance efforts are applied to all new projects, acquisitions and modifications and aim to ensure that equipment, facilities and structures relevant to Process Safety are:

- Manufactured, assembled or constructed in accordance with design specifications;
- Properly delivered and stored in accordance with design specifications and manufacturer's instructions;
- Assembled, installed and de-characterized in accordance with project specifications;

- Designed by a legally qualified professional, with proven proficiency in the subject.

CHARACTERISTICS

Quality Assurance is characterized by:

- Ensuring that the bases and criteria for equipment, facilities and structures critical to Process Safety are available to operation, maintenance, procurement and contractors;

- Ensuring that critical equipment, installations and structures for Process Safety are built, manufactured and installed or implemented in accordance with project specifications, manufacturers' recommendations, legal and regulatory requirements and risk analysis;

- Perform inspections of equipment, facilities and structures critical to Process Safety during manufacturing, assembly, delivery, installation and maintenance;

- Record inspections of equipment, facilities and structures critical to Process Safety;

- Ensure that the list of critical items and services for Process Safety is delivered and used by the area responsible for these acquisitions as a reference during the purchasing process;

- Ensure the technical competence and adequacy of the facilities of manufacturers and service providers.

1.2.3.2 Pre-Start-up Safety Review

PRINCIPLE

The Pre-Start-up Safety Review represents a final check of new, modified, decommissioning or routine equipment, installation or structure in situations where there is a relevant risk to Process Safety. This element ensures that all Process Safety elements have been duly considered and that the installation, equipment or structure is in a safe condition for operation.

It performs a structured diagnosis to determine whether the process, asset or installation is ready to kickoff operations. It also defines the corrective actions necessary to resolve any identified nonconformities. During decommissioning, it is essential to carry out a pre-kickoff safety review before starting any activities. This significantly reduces the likelihood of incidents during the process.

The Pre-Start-up Safety Review establishes the verification criteria and requirements for each starting situation, depending on the context, whether a complex, intermediate or routine start-up.

CHARACTERISTICS

Pre-Start-up Safety Reviews are characterized by:

- Carry out safety reviews on new or modified facilities and structures, through a multidisciplinary team;
- Confirm the following points during reviews:
  - ☞ Whether the construction, equipment or structure (civil, geotechnical, etc.) complies with the specifications of the Technological Package element;

- ☞ Whether the assumptions of Geotechnical projects were confirmed and corrected, if necessary, throughout construction;

- ☞ Whether all elements of the GSPM have been adequately considered;

- ☞ Whether all recommendations of the Process and Operations Risk Analysis element required before start-up have been complied with;

- ☞ Whether basic safety, health and environmental considerations are adequate;

- ☞ Whether the procedures were implemented and whether the operating team was trained.

- Ensure compliance with pre-start-up tests and inspections;

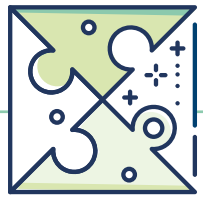
- Develop appropriate pre-start-up checklists adapted to each application, with general and particular minimum requirements, depending on the application.

- Define roles, responsibilities and the multidisciplinary team that will conduct the Pre-Start-up Safety Review;

- Define which items whose non-compliance is an impediment to the start of production operations;

- Delegate the power to the person responsible for carrying out the follow-up of the requested corrective actions, which can be completed after the installation starts, without compromising the safety of the process;

- Confirm that the installation is in a safe condition, issuing formal authorization for start-up



1.2.3.3 Asset Integrity and Reliability of Equipment and Structures

PRINCIPLE

Ensure that assets, equipment and structures are available and suitable for the purpose for which they are intended throughout their useful life, guaranteeing the availability and security of critical systems for Process Safety, in accordance with the defined technical criteria. The integrity of assets, equipment and structures is essential to guarantee the safety of people, the protection of the environment and the productivity of operations.

CHARACTERISTICS

Integrity and Reliability of Assets, Equipment and Structures is characterized by:

- Ensure that the basic requirements and performance criteria of assets, equipment and structures relevant to Process Safety are available to operation and maintenance personnel.

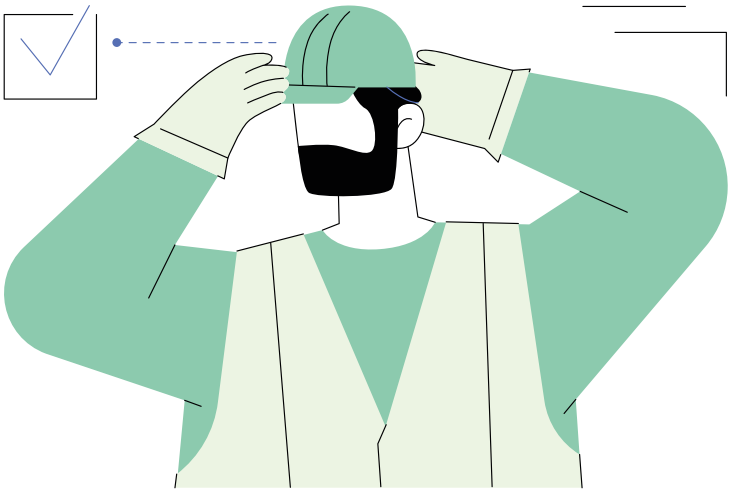
- Ensure availability and reliability of equipment, assets and structures relevant to Process Safety with the development of the maintenance and inspection strategy throughout its life cycle, prioritizing those that have the greatest impact on the risks mapped by the organization, according to process hazard analysis;

- Carry out inspection and maintenance plans for equipment, assets and structures relevant to Process Safety throughout their entire life cycle and address non-conformities that may compromise their availability and reliability, taking into account the impact that these deviations have on risks mapped in process hazard analysis;

- Establish criteria for prioritizing assets, equipment and structures related to critical items for Process Safety, based on the risk matrix and the organization's risk appetite.

- Document and keep inspections and maintenance of equipment, assets and structures relevant to Process Safety on file and available.

- Carry out continuous monitoring of the performance of equipment and assets and the conditions of structures through monitoring systems, regular inspections, analysis and data management, supporting decision making for scheduling maintenance activities based on risk scenarios and categorization of items, according to the risk-based asset prioritization criteria.



1.2.4 People

1.2.4.1 Incident Reporting and Investigation

PRINCIPLE

Serious and potentially serious incidents may recur if corrective measures are not taken. An in-depth investigation of all serious and potentially serious incidents is necessary to continually improve safety performance.

The Incident Communication and Investigation element also defines a policy and process for communicating events and lessons learned.

CHARACTERISTICS

Incident Communication and Investigation is characterized by the following measures and activities:

- Define incident classification criteria, both in terms of the nature and severity of the actual and potential impact of the event;

- Define a formal incident investigation process containing:

  ☞ Standard methodologies for investigation according to the type and actual or potential severity of the event;

  ☞ Develop an incident investigation plan,

  ☞ The multidisciplinary team that must form the research group;

  ☞ Deadlines for completing incident investigations;

  ☞ Guidelines for managing and verifying the effectiveness of actions arising from investigations.

- Define an incident communication plan, according to the type of event and its actual and potential severity;

- Define conclusions, propose recommendations and disseminate the results and lessons learned from the incident investigation in accordance with the communication plan and governance established by the organization;

- Prepare the action plan based on the results of the incident investigation and with actions prioritized according to the criteria set by governance;

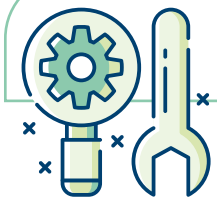
- Monitor the full implementation of recommended actions, within previously agreed deadlines and assess their effective effectiveness;

- Direct the investigation with a focus on the real causes of the event, based on facts and data and not excluding systemic issues (contributing factors) involved in the occurrence of events;

- Indicate the profile (experience, maturity, competence and impartiality for decision-making) of the members of the investigation committee, according to the actual and potential severity and complexity of the event;

- Seek and ensure that all available evidence has been analyzed and documented, considering information about process technology, aspects related to tools and equipment, environment, people, organization and compliance with recognized and established technical and legal standards;

- Keep investigation records and reports according to the period defined by the organization.



1.2.4.2 Emergency Planning and Response

PRINCIPLE

This element addresses the activities necessary for detailed planning for a response to potential emergencies, including assignments (roles and responsibilities), procedures, protocols, resource sizing and guidelines with the aim of directing immediate and effective responses to emergencies with the purpose of minimizing damage or damage to people, community, environment, assets and the organization's reputation.

The target scenarios of the Emergency Plan & Response – EP&R must come from regular surveys and reviews of process risks, and the organization must establish the criteria to define the relevant scenarios for which there shall be specific emergency plans in place.

CHARACTERISTICS

It is characterized by:

- Define the criteria for creating specific emergency response plans for certain scenarios, such as risk severity, response time, location, available infrastructure, nature of the risk, etc.;
- Size and specify the resources and structure for planning and responding to identified emergency scenarios;
- Receive information from risk analysis and prepare emergency and contingency response plans based on the information received, especially analysis of consequences;

- Carry out training that includes periodic exercises and involvement of local and off-site emergency response organizations (training, training and simulated exercises), involving communities and other organizations that may form part of the Mutual Assistance Plan – MAP, such as, for example, Defense State and municipal civil, if any, environmental agencies, Fire Department, emergency teams from other organizations, etc. that operate in the same region,

- When any of the parties cannot be involved directly in the simulation, they must at least be informed;

- Define the communication plan and strategy to be followed in case of emergency situations, covering all concerned parties;

- Define the criteria for activating a crisis committee;

- Define roles and responsibilities for the implementation, maintenance and execution of the EP&R;

- Carry out critical analysis of the results of simulated exercises, real occurrences and scope of lessons learned by other sites and other organizations and review the EP&R, when applicable;

- Inspect and monitor the status, availability and operability of resources used in emergency response;

- Monitor and comply with applicable EP&R technical and legal requirements;

- Establish integration between emergency response plans (mutual assistance plans, mutual aid plans, cooperation agreements, etc.).

1.2.4.3 Contractor Management

PRINCIPLE

Establishes the practices, requirements and standards for companies and contracted workers to perform their functions so that the company's level of operational risk is not increased, ensuring safe operation and the organization's safety performance goals. Contractors and their workers working within the limits established by the organization must also be integrated into the company's safety culture, being aware of the process safety aspects involved in their activities. The organization must ensure that this information is available with the necessary detail and that it is disseminated with adequate depth to hired workers, according to their performance.

This element does not include the acquisition of goods, supplies, manufacturing of equipment and structures outside the organization's facilities (these items are covered by the Assured Quality Assurance element).

CHARACTERISTICS

Its activities are characterized by:

- Establish criteria for selection, hiring, monitoring and evaluation of the service level of contractors, with regard to process safety, involving people qualified to establish such criteria;
- Define the scope of application of the Contractor Management system;
- Establish roles and responsibilities of the Contractor Management system;

- Ensure that the personnel of contractors are adequately trained and communicated about the dangers and risks of the installation, standards and procedures to maintain a safe operating condition and in case of emergencies;

- Develop and maintain a list of qualified suppliers to provide services;

- Establish and maintain a constant process for prospecting and qualifying contractors;

- Conduct regular audits and inspections to ensure contractors are adhering to established safety standards.

1.2.4.4 Audit

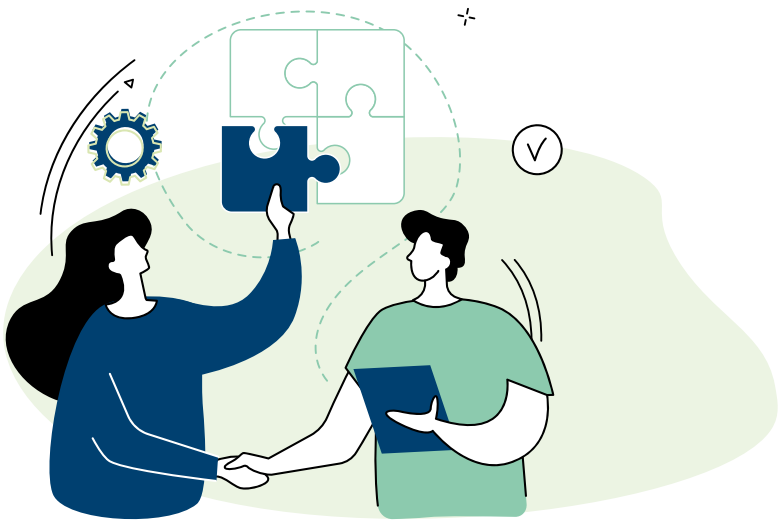
PRINCIPLE

The audit provides data to evaluate compliance with the established Process Safety Management in Mining (GSPM) program and to identify points for improvement and identification of nonconformities. The treatment of these points and the critical analysis of the results demonstrate the efficiency and robustness of the program. Critical analysis can also reveal trends that can strengthen or compromise system performance.

CHARACTERISTICS

Its activities are characterized by:

- Carrying out periodic audits of the elements of the GSPM program, according to the established schedule;
- Conducting audits in the organization, according to criteria defined in the audit plan;
- Use of supporting documentation (verification checklists, internal and external standards, procedures, reports of previous audits, etc.) and evaluation of documents, including those originating from other audits that are not directly linked to the GSPM program, but that have an impact on the performance of the Process Safety management audit system;
- Establish the selection criteria for independent internal auditors and for hiring third-party audits, according to the audited scope and type of audit.



1.2.5 Leadership

1.2.5.1 Training and Performance

PRINCIPLE

Ensuring that workers at all levels, own and/or contractors, receive adequate training and demonstrate effective performance is essential to maintaining equipment and process structures in safe operating conditions. It is crucial that these professionals are physically and mentally prepared to make decisions in accordance with the organization's values and policies. Additionally, leaders must establish a conducive and safe environment that promotes process safety and asset integrity, facilitating assertive decisions.

A minimum level of experience and knowledge is required from professionals who interact with the process, ensuring a solid basis for decisions that may affect safety.

Support areas must also have the minimum knowledge necessary so that their decisions do not negatively impact the safety of operations, facilities, assets and structures.

In operations of greater complexity, for functions mapped as critical for Process Safety, it is necessary to train qualified, ready and trained replacements to immediately assume the official member's responsibilities, ensuring the continuity of operations, facilities, assets and structures.

The organization must also have mapped the skill, knowledge and proficiency levels required for critical Process Safety functions, in addition to the training plan necessary to fulfill these requirements. This mapping must consider, in addition to the technical aspects, that the behavior must be compatible with the process safety culture, especially for titles with a leadership role.

The training and performance of leaders is a critical factor in the success of the Process Safety management program in an organization, since these people have a strong impact on the culture and behaviors of the people who make up the organization.

All other elements of GSPM may be in place, but without adequately trained and performing personnel, the chances of safe process operation are greatly reduced. The organization must define competency, qualification and performance requirements for each critical role for Process Safety.

All tasks must be carried out safely in accordance with established procedures and/or safe work practices, following the principles of Process Safety, both in the case of tasks carried out by our own team and tasks carried out by personnel from contractors.

Contractors, where required, must have training and performance compatible with the activities to be carried out. Specific contractor management is fundamental to this guarantee.

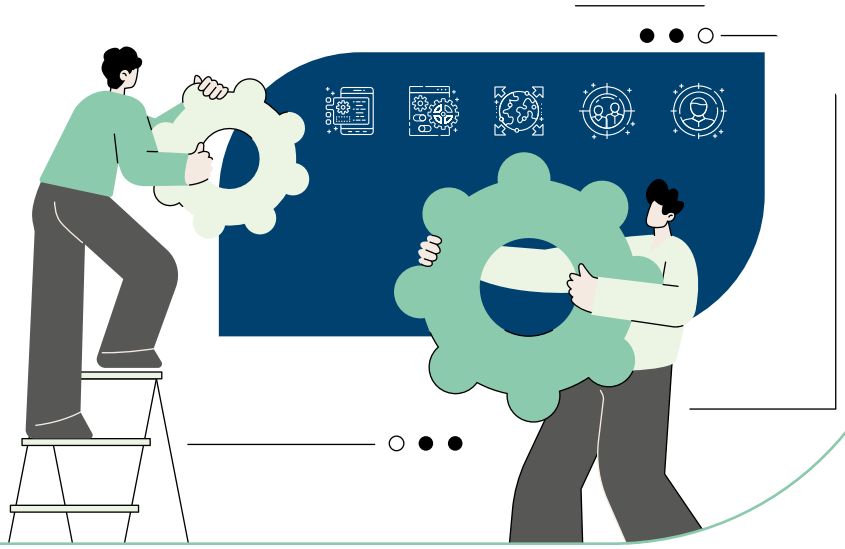
CHARACTERISTICS

The main characteristics of the element are:

- Manage training and performance evaluation activities;
- Define skills, qualification and performance requirements for each critical function for Process Safety;
- Define, implement, critically analyze and promote revisions in the training system for critical functions for Process Safety, whenever necessary;
- Define qualification criteria for the selection of training instructors, ensuring their qualification and technical proficiency related to the subject, experience in the subject in question, communication skills and ability to act as mentors.
- Define performance criteria for critical functions for Process Safety, either through the definition of active indicators or proactive ones;
- Apply performance evaluation programs for critical functions for Process Safety, especially for those with a leadership role, to form a line of succession and list of temporary replacements;
- Map critical functions for Process Safety;
- Offer and carry out training and qualification of functions that interact with or support operations.

- Assess operational discipline through adherence to standards, policies and procedures established by the organization;

- Establish programs and initiatives to create and maintain an environment conducive to broad participation of workers, both employees and contractors, in issues concerning to Process Safety.



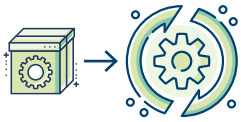
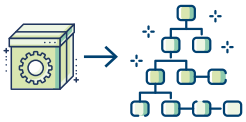
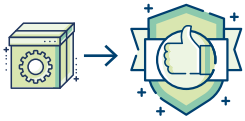
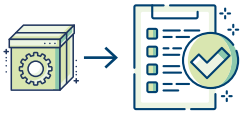
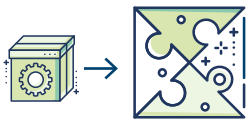
1.3 Interaction among GSPM elements

1.3.1 Technology

1.3.1.1 Technology Package

The **Technology Package** interacts with the following elements:

Hazard Identification and Risk Analysis of Processes and Operations	Receives information about the process, its technology, assets, structures and equipment to support and support the assessment of risks and consequences, guiding changes to the project bases and processes;

 **Management of Change**	Updates information related to modifications to the design base of equipment, facilities, procedures and technology, considering the assessment of the impacts generated by the proposed changes;
 **Operational procedures**	They consolidate updated information about the process, considering the safe means and way of carrying out one or more operations, providing a clear and detailed understanding of the parameters and operation requirements;
 **Quality Assurance**	Sends the list, installation requirements and technical specification of Critical Equipment and Structures to the GSPM of the projects and modifications to which they are related and guarantees that the specified installation will happen;
 **Pre-Start-up Safety Review**	Obtaining information on risk materials, equipment and structures linked to the process, confirming whether the project or installation is being delivered in a way that can operate safely and in accordance with project requirements and specifications;
 **Asset Integrity and Reliability of Equipment and Structures**	Obtaining information on the prioritization of assets, equipment and structures and basic guidelines for maintenance, according to the operation and maintenance manuals.

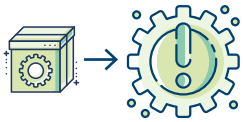
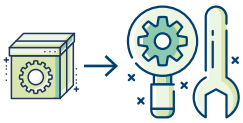
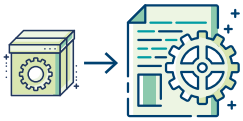
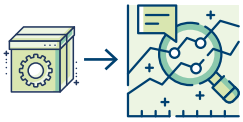
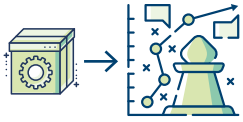
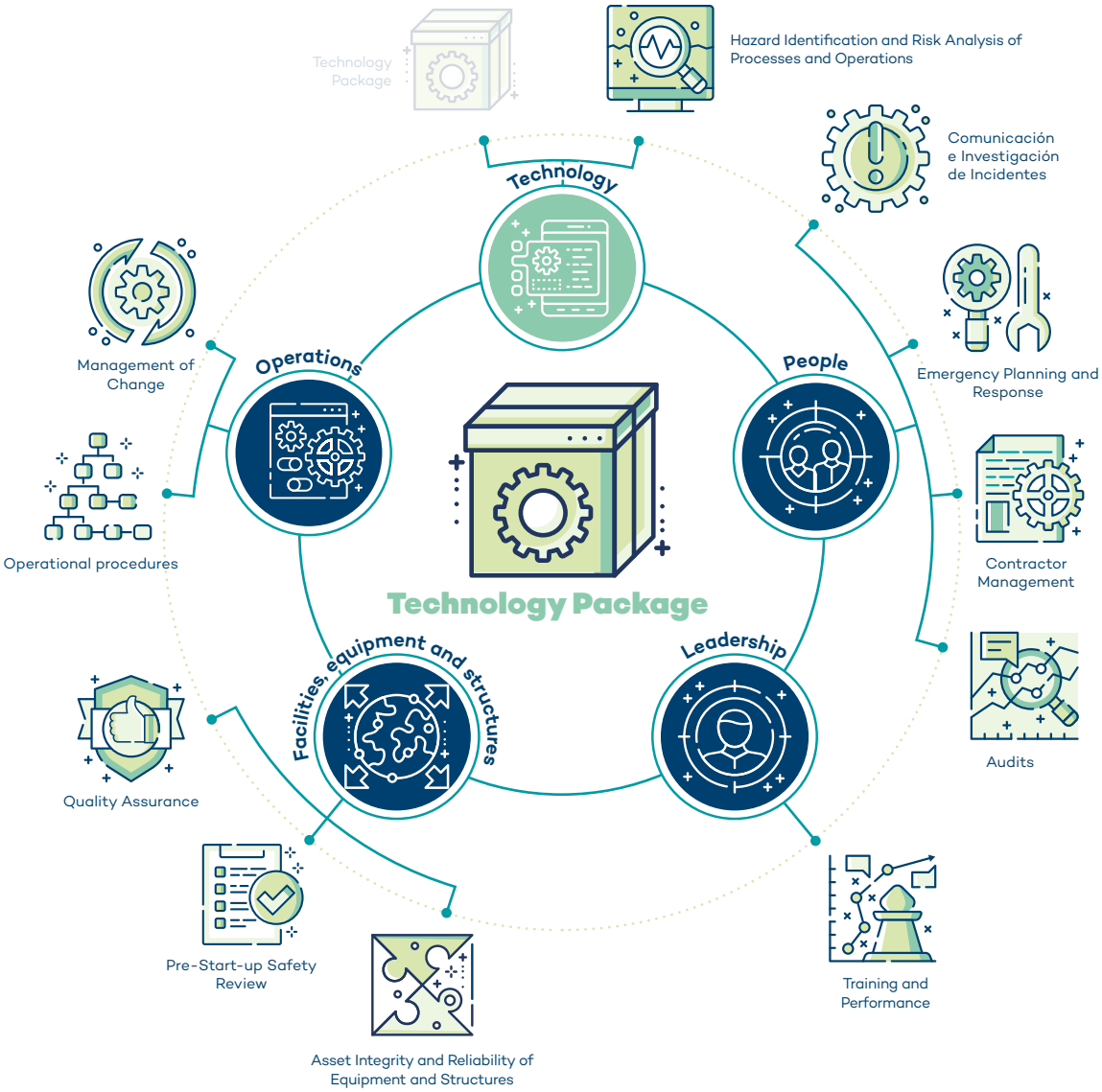
	**Incident Reporting and Investigation**	Shares lessons learned from investigations and the history of process incidents, thus being able to question the need to change technical documentation, design, procedures and other elements of process technology;
	**Emergency Planning and Response**	Sends information for preparing the response and mitigation strategy, sizing and defining the resources to be used in risk scenarios in the event of an emergency;
	**Contractor Management**	Supporting the pre-qualification of outsourced companies and the criteria for post-contractual evaluation, ensuring the necessary knowledge of third-party employees for process safety;
	**Audits**	Having all the process information that will support operations compliance audits;
	**Training and Performance**	Sends updated information to support training, qualification and knowledge recycling of people involved in operations and maintenance.

Figure 2: Graphic diagram of the interaction of the Technological **Technology Package**



1.3.1.2 Hazard Identification and Risk Analysis of Processes and Operations

The **Hazard Identification and Risk Analysis of Processes and Operations** element interacts with:

Technology Package	From which it receives operational procedures, specifications and safety information on products, byproducts, waste, effluents, raw materials and inputs, safe practices for the development of operational activities and basic engineering process documentation and geotechnics that underlies the execution of risk analysis studies, which sends recommendations with a view to reviewing the documentation issued with the aim of increasing the safety of processes and operations;
Management of Change	For information assessment of hazards and risks introduced by changes in raw materials, products, processes, structures of any nature and equipment.
Pre-Start-up Safety Review	For which the Hazard Identification and Risk Analysis of Processes and Operations element sends a list of recommendations and seeks evidence that the recommendations were complied with to authorize the commencement of the process;

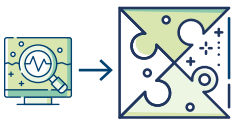
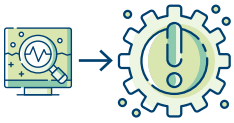
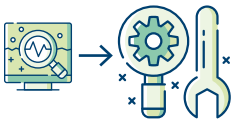
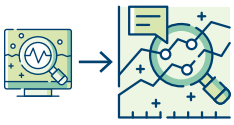
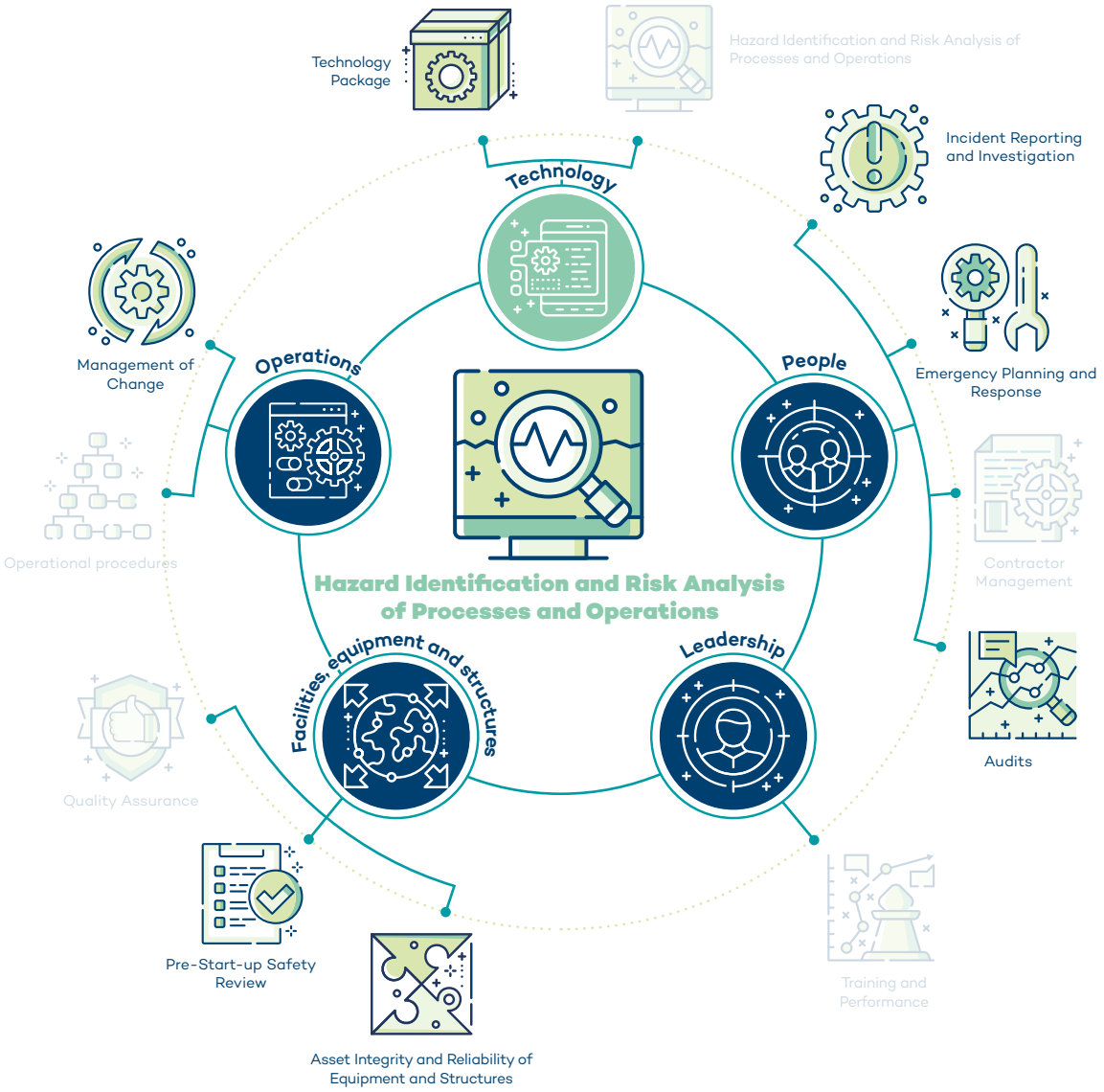
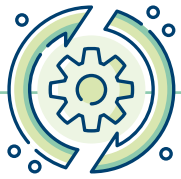
 **Asset Integrity and Reliability of Equipment and Structures**	To associate controls that guarantee integrity and safeguards, associated with the risks of failure of assets, equipment and structures.
 **Incident Reporting and Investigation**	Report all incidents that occurred on the facilities and service fronts to be investigated, as well as the results of the respective investigations, for use in process hazard analysis;
 **Emergency Planning and Response**	Which provides consequence analysis and containment and mitigation actions, to support emergency response planning;
 **Audit**	Using as a primary system requirement the consistency assessment of the Hazard Identification and Risk Analysis of Processes and Operations element, especially with regard to the degree of adherence to the implementation and maintenance of recommended prevention and control measures.

Figure 3: Graphical diagram of the interaction of the **Hazard Identification and Risk Analysis of Processes and Operations**

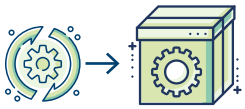
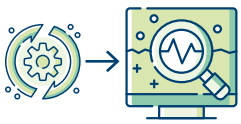
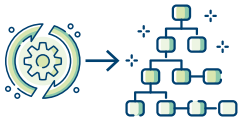


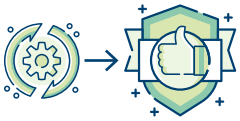
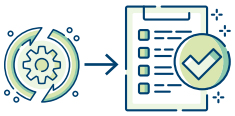
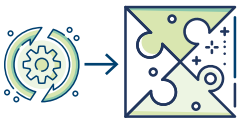
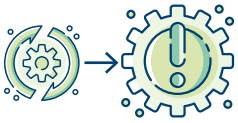
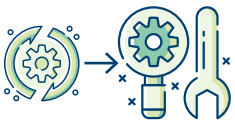
1.3.2 Operations

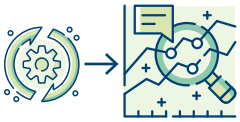
1.3.2.1 Management of Change



The **Management of Change** interacts with the following elements:

 **Technology Package**	To update information on the equipment design basis, operational parameters and process safety, development and adaptation of operational procedures and safe practices, updating emergency response plans and updating maintenance and inspection plans for assets, civil and geotechnical structures (ramps, galleries, slopes, etc.) and equipment;
 **Hazard Identification and Risk Analysis of Processes and Operations**	To identify new hazards that may be introduced due to the change and reassessment of existing risks, preventing new hazards from being introduced into the process or the risk level being increased in an inadvertent or uncontrolled manner;
 **Operational procedures**	Providing information on which procedures must be updated depending on changes applied to the process, in assets, civil, geotechnical structures and equipment;

 **Quality Assurance**	To analyze inspection reports on the manufacture, delivery and installation of equipment, assets and structures that undergo modifications, ensuring that the recommendations and the change management plan are applied according to pre-established criteria;
 **Pre-Start-up Safety Review**	To assess whether the modifications were carried out as foreseen in the project or change management plan, meeting the Process Safety requirements;
 **Asset Integrity and Reliability of Equipment and Structures**	To update maintenance and reliability parameters and requirements relating to assets, equipment and structures affected by changes;
 **Incident Reporting and Investigation**	To receive recommendations for technology changes, avoiding accidents by surveying the needs for modifications raised during the investigation;
 **Emergency Planning and Response**	Assessing whether new risks or risks altered by the change affect or alter existing EP&R
 **Contractor Management**	Enabling contractors to access the change management process, within the limits of action and managing changes and the impacts of changing contracts or suppliers in the process in which they operate;



Audit

Through documentation and records, Change Management provides audits with information to be assessed for compliance with established standards.

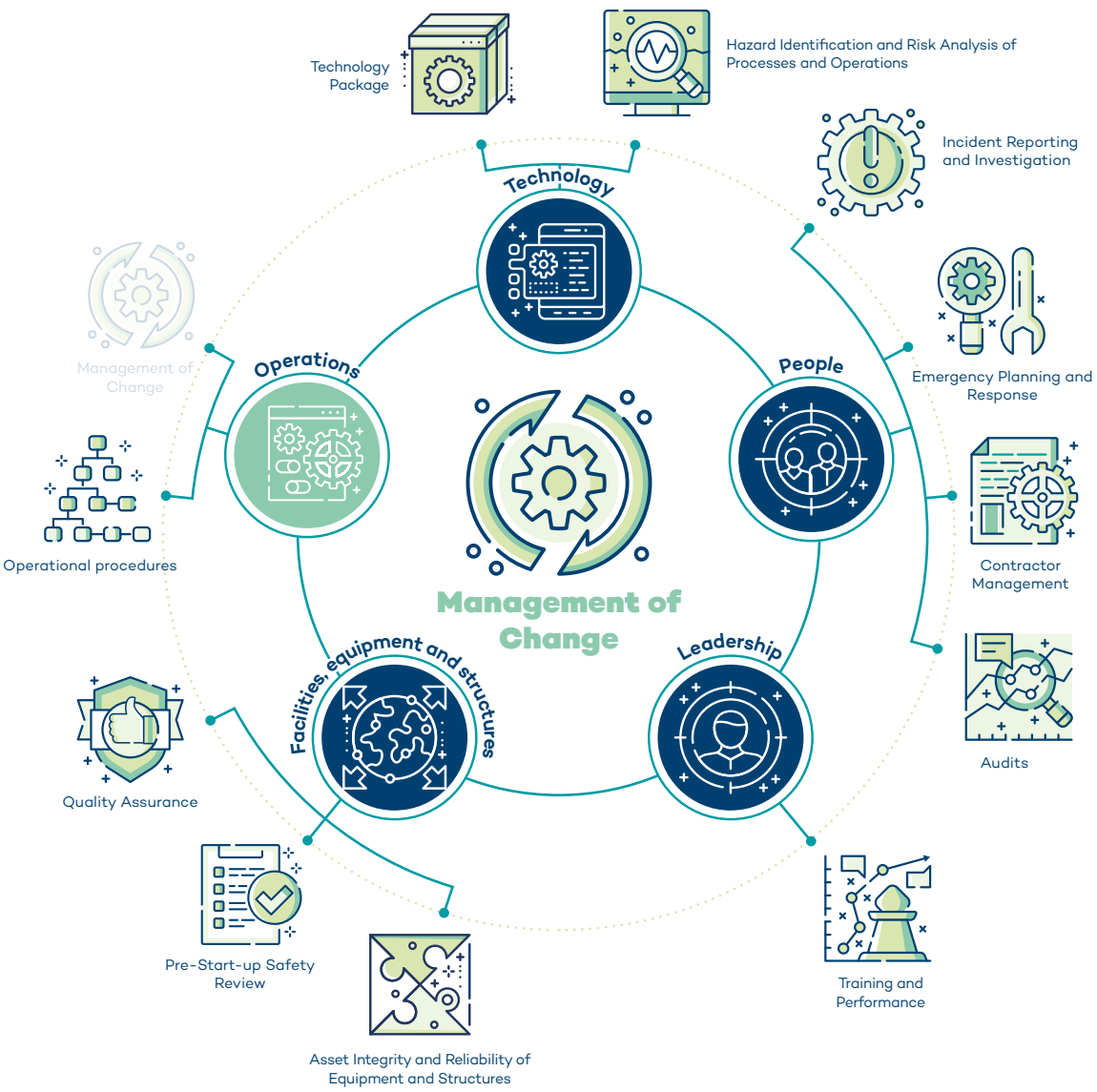
Training and Performance

Providing data to update training on risks whose level, causes or control have changed due to the implemented changes and data to review all procedures related to the change, and other documents arising from changes in processes.

Updates and maintains information on the survey of training requirements, competencies and updated basic training to assist with personnel movement criteria, as well as training support for all workers who undergo functional movement in order to ensure sufficient levels of knowledge.

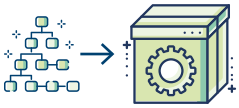
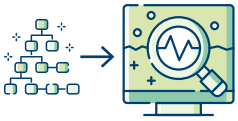
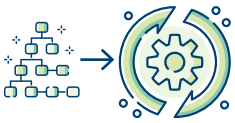
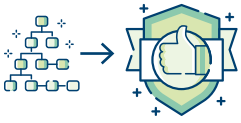
It also ensures GSPM training for workers recently allocated to significant process areas so that they are able to identify a change and possible impacts on technology and process variables and characteristics on the risk level of operations.

Figure 4: Graphical diagram of the interaction of the **Management of Change**



1.3.2.2 Operational procedures

The **Operational procedures** interacts with the following elements:

 **Technology Package**	To obtain basic information for preparing written procedures that describe how the system must be operated safely, what are the normal and abnormal operating limits and conditions, including information on the procedures to be adopted in case of deviation from normal conditions;
 **Hazard Identification and Risk Analysis of Processes and Operations**	Complementing the information in the Technological Package for preparing operational procedures with additional information from risk analyzes of processes, activities and operations that define how operational procedures must be executed to prevent the materialization of a risk scenario identified during the analyses;
 **Management of Change**	From where it obtains data to update procedures due to changes made to processes, equipment, facilities, operations, structures or even the team;
 **Quality Assurance**	To ensure that operational procedures incorporate maintenance requirements for pre-operation, regulatory and safety standards, contributing to the assured quality assurance of equipment that is part of risk activities;

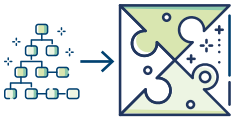
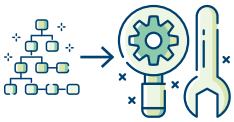
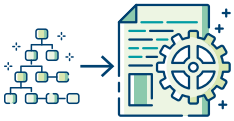
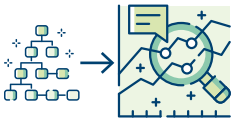
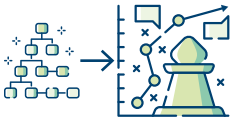
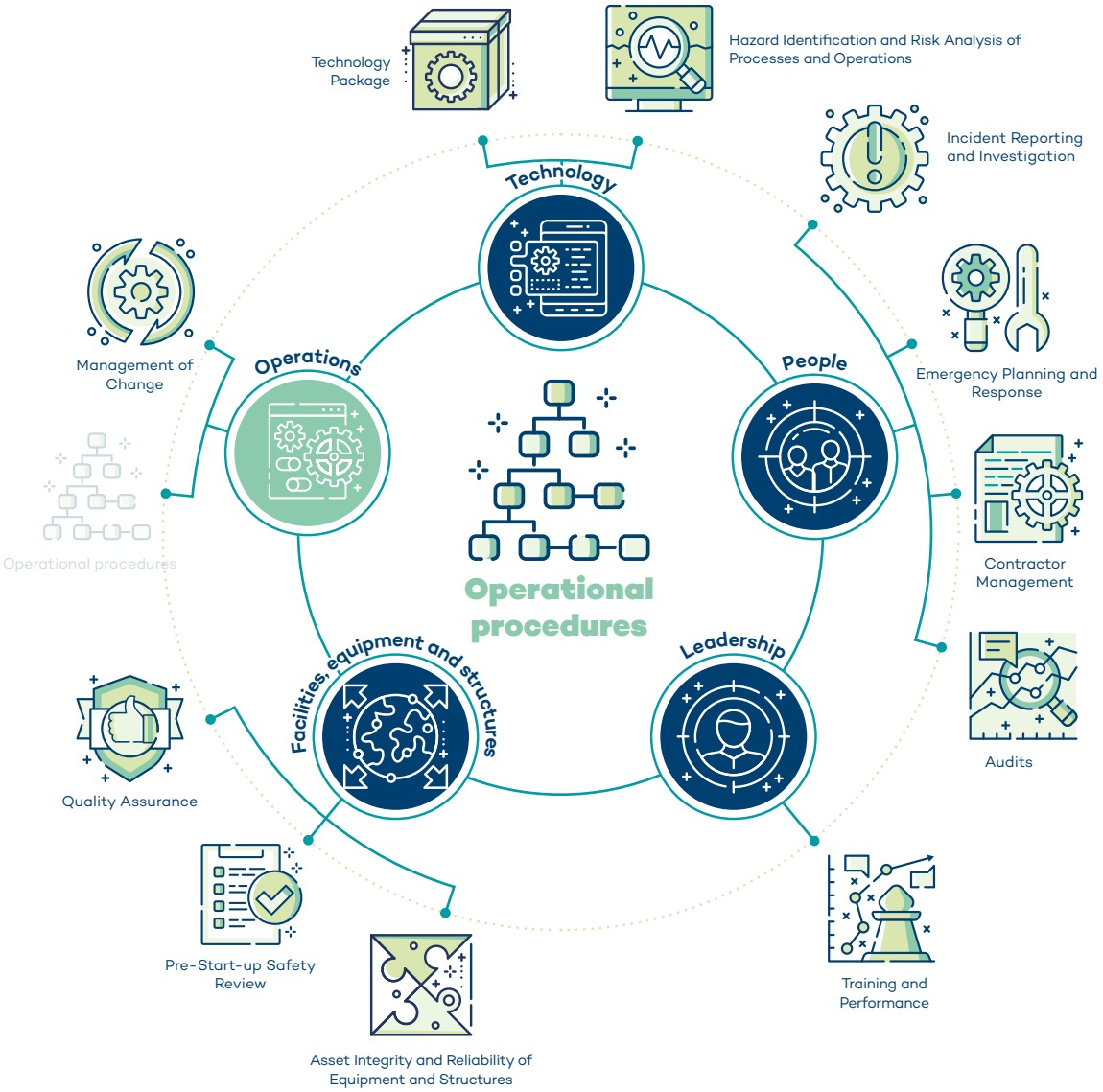
 **Pre-Start-up Safety Review**	By verifying compliance with requirements and recommendations for operational procedures arising from risk analysis or change management;
 **Asset Integrity and Reliability of Equipment and Structures**	To obtain information about critical equipment and structures for process safety, in addition to restrictions on its operation.
 **Incident Reporting and Investigation**	To receive recommendations for changing procedures arising from lessons learned in event investigations;
 **Emergency Planning and Response**	Contemplating the actions that must be taken in the event of an emergency, preventing the severity of the event from being increased or even from the event materializing;
 **Contractor Management**	Documenting information for companies and contracted workers about the procedures to be carried out to prevent the occurrence of unwanted events;
 **Audit**	Provides audits with information regarding the most appropriate and safe way to carry out tasks/activities that may impact process safety to be assessed for compliance and adherence to established standards.
 **Training and Performance**	Providing data to update training related to new procedures or updated procedures, ensuring that people who need to be trained know and understand its content and that it is applied appropriately.

Figure 5: Graphical diagram of the interaction of the **Operational procedures**

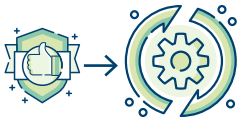


1.3.3 Facilities, Equipment and Structures

1.3.3.1 Quality Assurance

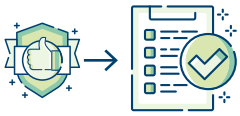
The **Quality Assurance** interacts with the following elements:

Technology Package	For which it provides requirements, technical and geological parameters and verification and inspection mechanisms to ensure that the specifications and objectives of the project were considered in the processes of manufacturing, acquisition, transportation and storage, building and assembly of equipment, facilities and critical materials. If any changes to the project or process documentation are necessary, the Assured Quality Assurance element can provide information for updating the Technological Package, as in the case of updating the design of modified equipment and structures (as built);
Hazard Identification and Risk Analysis of Processes and Operations	For which it provides the requirements, technical specifications, geological parameters and verification mechanisms to be considered in verifying the implementation, delivery or construction of the equipment, asset or structure;



Management of Change

Which provides inspection reports on the manufacture, delivery and installation of critical equipment, facilities and structures for the GSPM and Non-Conforming Quality Inspection Report, the mechanisms and requirements for purchase and replacement of critical items existing in the project bases for that the objectives and premises are achieved.



Pre-Start-up Safety Review

Which provides inspection reports on new, altered and recovered equipment, facilities and structures, relevant to the GSPM, Non-Conforming Quality Inspection Report and Receipt of Relevant Equipment Bases and Projects;

Asset Integrity and Reliability of Equipment and Structures

For which it provides mechanisms so that civil and geotechnical equipment, installations and structures, spare parts and critical materials are designed in compliance with legal requirements, the best technical references and best practices, manufacturer recommendations and risk assessments;

Comunicación e Investigación de Accidentes

For which it provides information to verify compliance with manufacturing, storage, assembly and installation requirements that may affect safety performance, in order to avoid incidents;

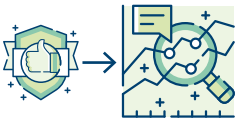
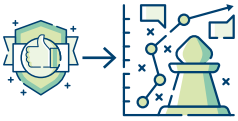
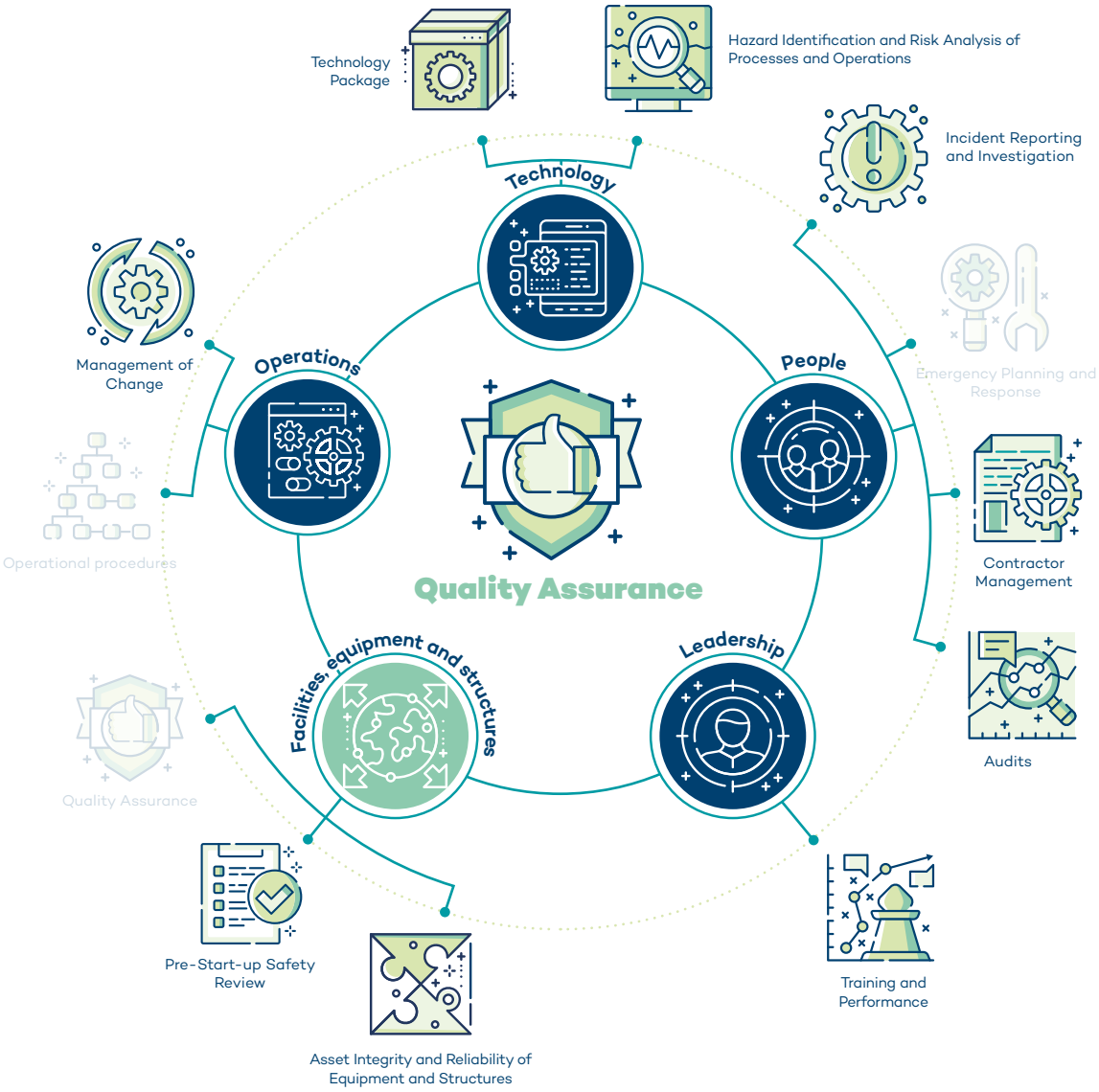
	**Contractor Management**	To ensure that design, assembly, equipment supply and service provision requirements that have an impact on Process Safety are included in contractual provisions;
	**Audit**	Provides audits with information regarding the quality and reliability requirements of assets to be assessed for compliance with established standards
	**Training and Performance**	To ensure that people involved in the process of acquisition, design, maintenance and contractors are trained and qualified in the project bases necessary to comply with quality assurance requirements related to the implementation of equipment, installations, civil and geotechnical structures.

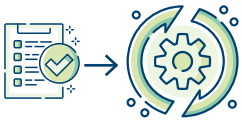
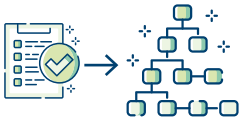
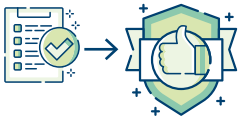
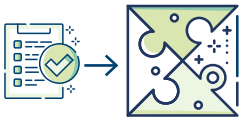
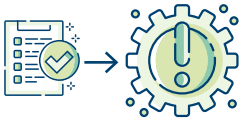
Figure 6: Graphical diagram of the interaction of the **Quality Assurance**



1.3.3.2 Pre-Start-up Safety Review

The **Pre-Start-up Safety Review** is related to the elements:

Technology Package	To request clarification on information on risk materials and energies, equipment, structures and processes with a focus on commissioning or first start-up; and also indicate the tests and checkpoints listed in the procedures prepared by this element for long stops or those carried out after making changes to the process, assets or structures;
Hazard Identification and Risk Analysis of Processes and Operations	Which provides all the recommendations that the Pre-Start-up Safety Reviews element must take into account during the performance of its work, through a complete follow-up based on objective evidence of the implementation of the recommendations established for the start-up. In the case of commissioning a new project, all risk analysis recommendations, especially those related to more severe scenarios, must be checked as to their implementation;

 **Management of Change**	From which you receive notification of the need to carry out a pre-start-up safety review for a new installation, stopped for a relatively long period or modified. It also indicates verification items generated as a result of the change process;
 **Operational procedures**	Checking whether all documents necessary for the operation of the process, asset, structure or equipment have been updated or prepared;
 **Quality Assurance**	To request clarification on aspects considered in the construction, manufacturing, installation and acquisition of facilities, equipment and structures, that is, qualification of suppliers, purchasing process, manufacturing inspection, transportation, storage, receipt, installation. etc.;
 **Asset Integrity and Reliability of Equipment and Structures**	That provides information on testing equipment, inspections of critical structures, reliability of engineering analyses, maintenance procedures and safety checks of interlocks to be carried out before start-up, depending on the situation (after commissioning, after moving or after a longer period not in use);
 **Incident Reporting and Investigation**	That provides incident investigation and analysis information and investigation report recommendations that may be considered in the pre-start-up safety check;

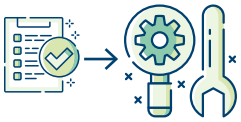
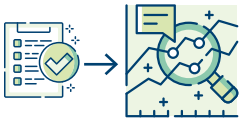
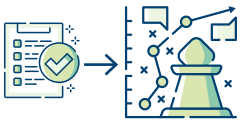
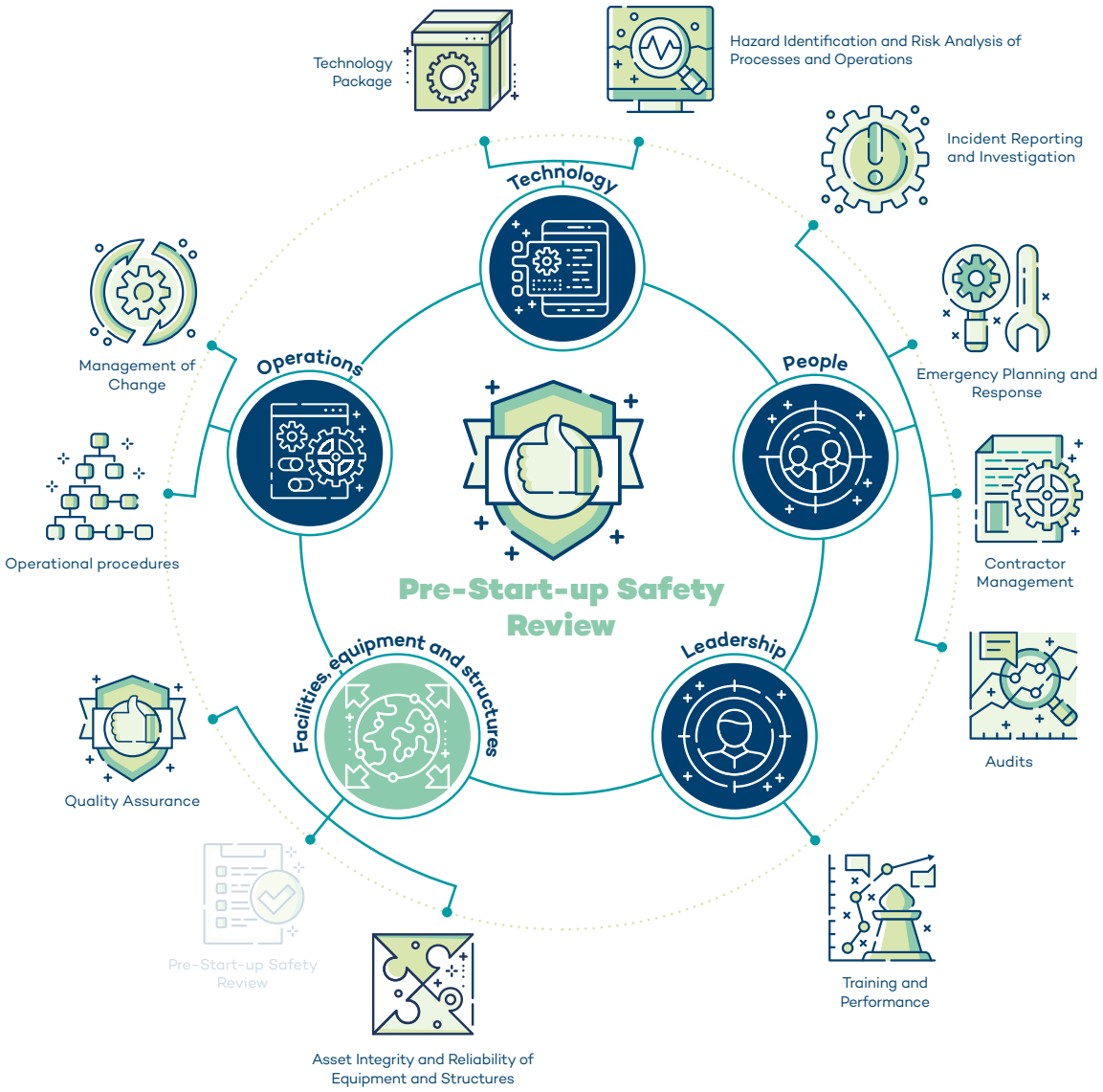
	**Emergency Planning and Response**	Which provides the aspects that will be decisive in authorizing the start-up of new, inactive for periods or modified installations and that must be verified;
	**Contractor Management**	Checking whether contractors are aware of potential risk scenarios related to start-up and operation;
	**Audit**	Provides information audits to be assessed for compliance with established standards;
	**Training and Performance**	Providing the training and competency aspects that must be considered by the Pre-Start-up Safety Reviews element to ensure that safety conditions have been met. It also verifies the knowledge of the team involved in the operations of the documents and procedures created or updated.

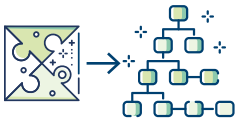
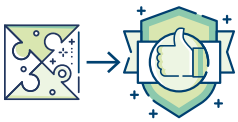
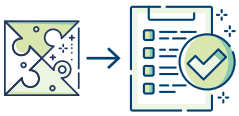
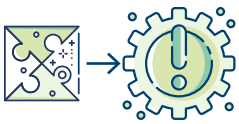
Figure 7: Graphical diagram of the interaction of the **Pre-Start-up Safety Review**



1.3.3.3 Asset Integrity and Reliability of Equipment and Structures

The **Asset Integrity and Reliability of Equipment and Structures** interacts with the following elements:

Technology Package	Which it receives, through operation manuals, the technical specifications of the assets, the basic information to structure inspection, monitoring and maintenance plans. The Technological Package provides parameters that must be monitored and their limits for stopping the operation or maintenance schedule, allowing the early identification of any anomaly or excessive wear, which makes it possible to carry out predictive and corrective maintenance before a failure occurs;
Hazard Identification and Risk Analysis of Processes and Operations	Which considers the condition of assets and their potential failures, contributing to their integrity through the implementation of mitigation and preventive maintenance measures identified in the risk analysis;
Management of Change	From which it receives information to reassess inspection, monitoring and maintenance plans for assets and structures (introduction of new equipment into the system, change in asset characteristics, change in operational parameters, etc.);

 **Operational procedures**	Providing information for building decision-making flows and triggers related to the integrity of assets mentioned in operational procedures, such as sensors, alarms, process variables such as temperature, pressure, vibration, pore pressure, mass displacement, etc.;
 **Quality Assurance**	That ensures that assets and structures are delivered for operation and maintenance within specified standards, whether new or modified, and provides the initial reference for comparing depreciation status and defining the maintenance strategy;
 **Pre-Start-up Safety Review**	From which it receives, through the PSSR checklist, information on the conditions of assets and structures before the start of operations, verifying the compliance of the integrity of these assets and structures, through the implementation of safe procedures and adequate team training;
 **Incident Reporting and Investigation**	In the event of incidents and/or failures, after investigation and/ or failure analysis, through lessons learned, relevant information on improvements, measures to improve the maintenance of equipment, structures, among others, are communicated to all interested parties, to improve the Integrity and Reliability of Assets, Equipment and Structures;

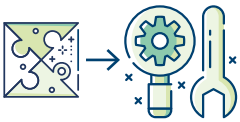
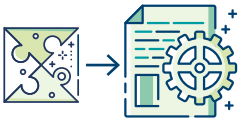
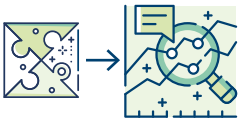
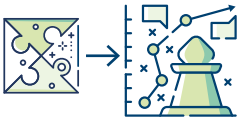
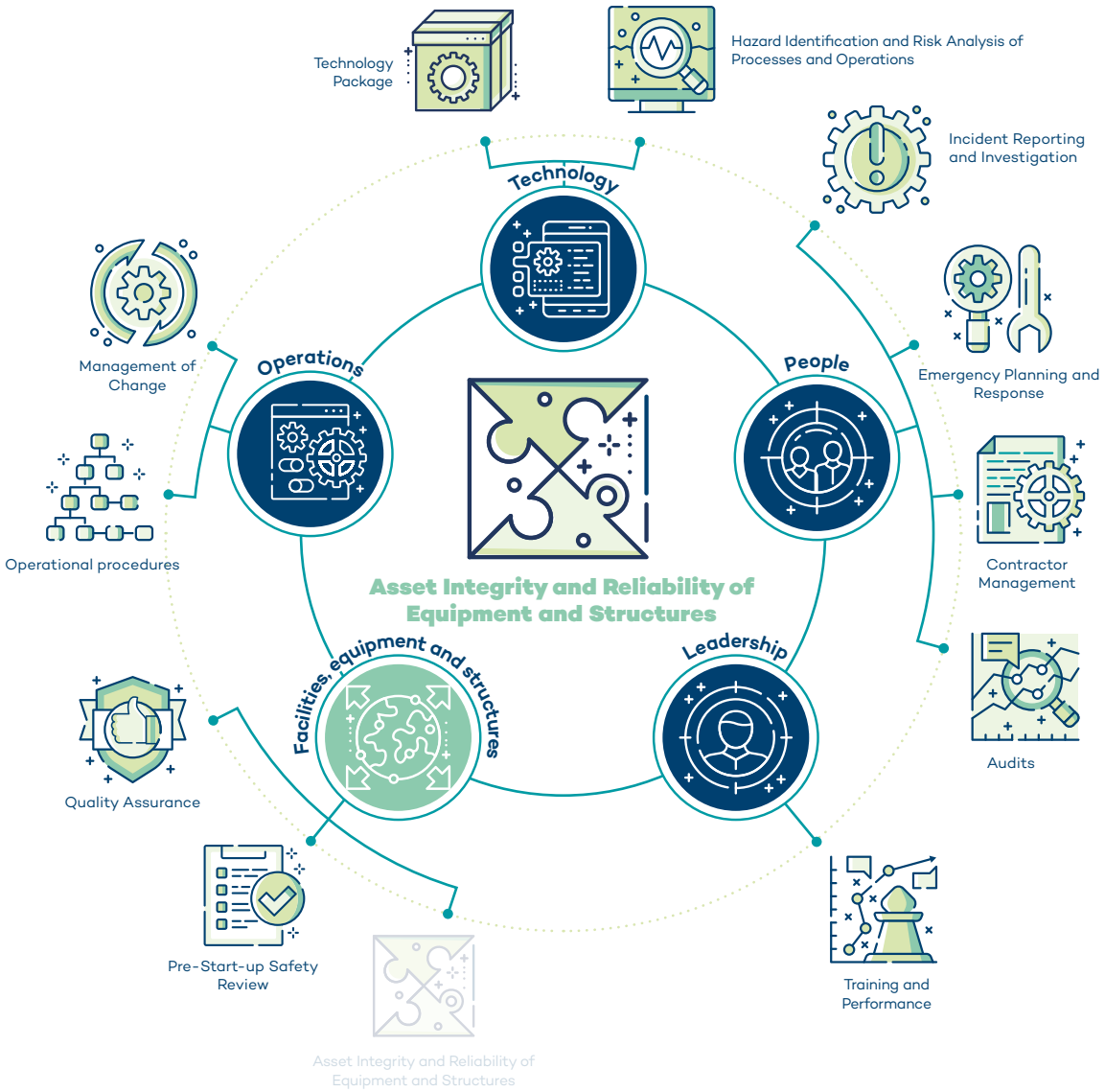
	**Emergency Planning and Response**	Ensuring the availability of the necessary resources for the EP&R effectively within the enterprise and together with the external response organizations, when operational or production areas are shared by more than one company, as in the case of mini-mines;
	**Contractor Management**	Providing the integrity and reliability requirements of equipment, assets and structures used in services that impact process safety or the integrity of assets, structures and equipment critical to process safety, such as specialized inspection and maintenance services, equipment supplied on loan;
	**Audit**	Provides audits with information regarding the operability, reliability, maintenance and inspection requirements of assets to be assessed for compliance with established standards;
	**Training and Performance**	Ensuring that the team that carries out activities related to the integrity and reliability of assets, equipment and structures critical to process safety has the skills to carry it out.

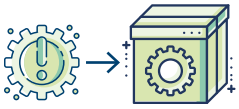
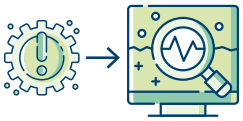
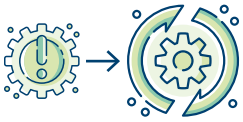
Figure 8: Graphical diagram of the interaction of the **Asset Integrity and Reliability of Equipment and Structures**



1.3.4 People

1.3.4.1 Incident Reporting and Investigation

The **Incident Reporting and Investigation** element interacts with all other elements, as to conduct a quality investigation, inputs from activities of other elements of the GSPM are necessary. Furthermore, learning from investigations may indicate weaknesses or opportunities for improvement in one or more elements of the system. Some practical examples of interaction are the following:

 **Technology Package**	Investigation results can guide the development of new technologies and innovations to improve process safety. Information from investigations can be used to ensure projects comply with industry-specific safety standards and regulations;
 **Hazard Identification and Risk Analysis of Processes and Operations**	Effective communication and accident investigations contribute to the identification of new risks and improve existing risk analysis;
 **Management of Change**	Investigated incidents may result in recommendations for changes to processes, and these changes must be managed through effective change management processes;

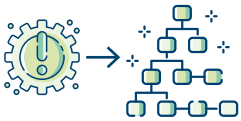
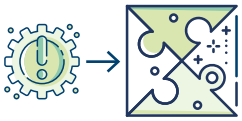
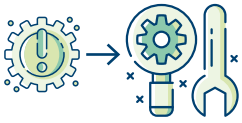
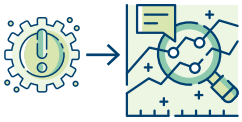
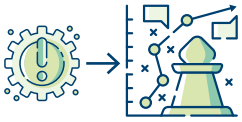
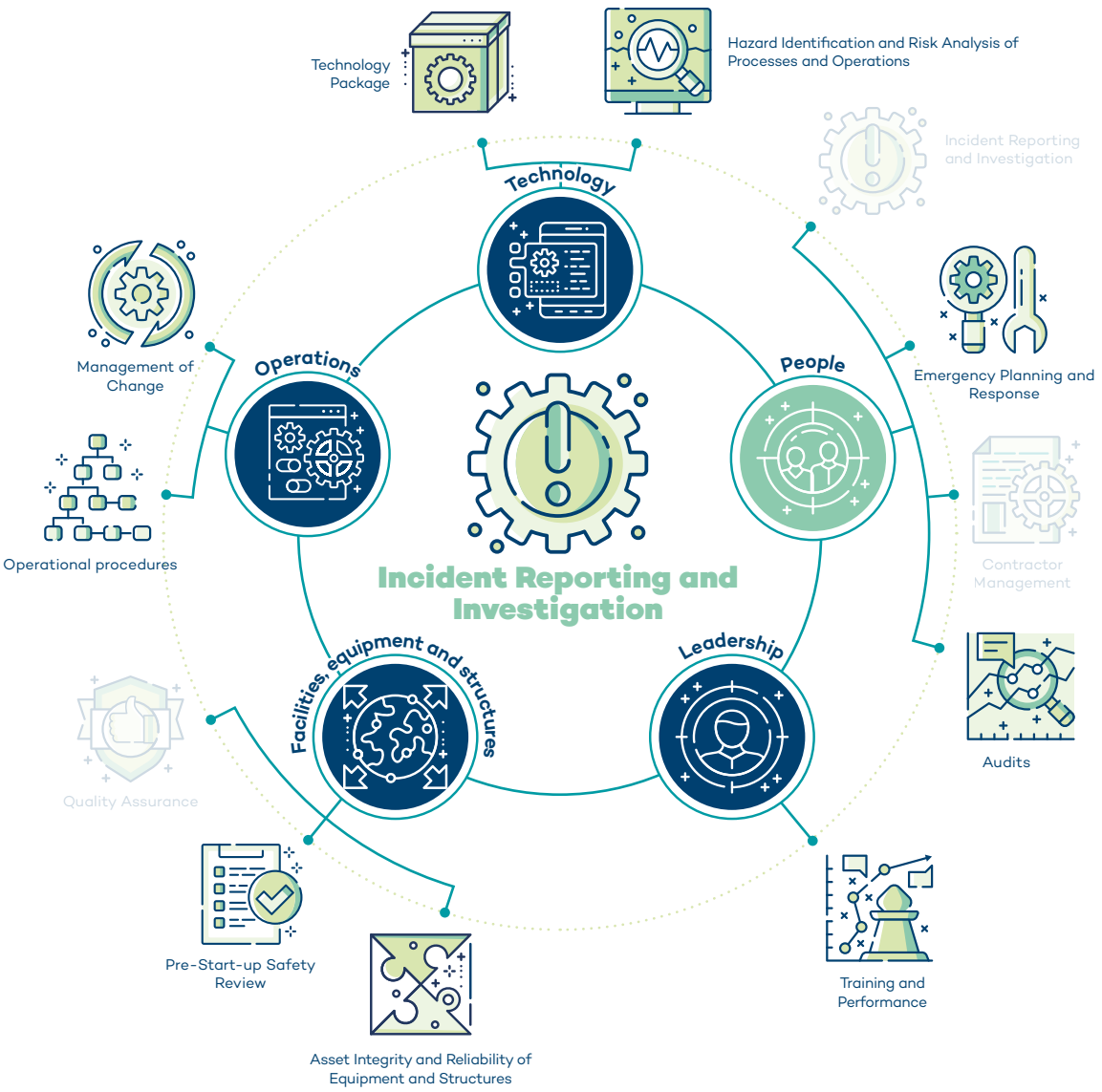
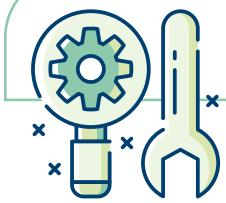
	**Operational procedures**	The results of investigations may lead to updates to operating procedures as means of mitigating any risks identified;
	**Pre-Start-up Safety Review**	Lessons learned from investigations can lead to updates to pre-start-up procedures. This may include adding additional checks, reviewing procedures or adjusting checklists to ensure a safe start-up;
	**Asset Integrity and Reliability of Equipment and Structures**	Investigation findings can influence preventative maintenance practices and inspection schedules to prevent similar failures in the future;
	**Emergency Planning and Response**	Investigation results can impact emergency response plans and evacuation systems, ensuring more effective preparedness;
	**Audits**	The results of investigations can influence the scope and emphasis of safety audits, helping to identify additional areas for improvement;
	**Training and Performance**	Information from investigations can be used to improve training programs and increase awareness of specific risks.

Figure 9: Graphical diagram of the interaction of the **Incident Reporting and Investigation**

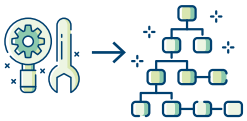
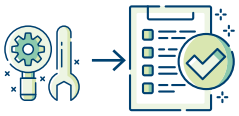
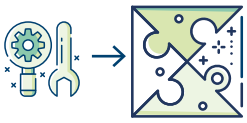
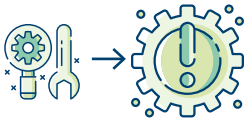




1.3.4.2 Emergency Planning and Response

The **Emergency Planning and Response** interacts with:

Technology Package	From which information is received regarding the sizing of equipment, resources, sensors and alarms used in the event of an emergency. It also receives information to develop procedures for emergency shutdowns of the site, to map out the scenarios for which a specific response plan must be designed. After the emergency or simulation, the assessment may involve the need for change management, requiring a review of the content of the technological package due to flaws, deficiencies or opportunities for improvement identified in the physical resources used.
Hazard Identification and Risk Analysis of Processes and Operations	Providing the list of scenarios which, if materialized, could generate an emergency and the analysis of consequences to feed the ERP;
Management of Change	From where information is received concerning changes to the Technological Package (facilities, production processes, equipment, structures, assets, inventory) or people who may influence the ERP. It also manages changes to the ERP arising from the evaluation of simulations and the response to real events.

	**Operational procedures**	Through the inclusion of steps and procedures for action in case of emergency for each of the mapped risk scenarios, in a way that prevents their evolution or initially minimizes the consequences, through clear instructions on what must be done in each scenario.
	**Pre-Start-up Safety Review**	Providing the requirements to be verified, both in the protective system and in the ERP, for a safe start-up or installation of the system.
	**Asset Integrity and Reliability of Equipment and Structures**	By ensuring the availability and reliability of technological systems, structures and assets used in emergency response, such as safe chambers, emergency exits, autonomous suppression systems, security and safety sensors, alarms and process control systems that play a fundamental role in the early detection of events that may influence emergency response times. For the aforementioned control systems, checking the reliability of each of their elements and the system as a whole is crucial to ensure adequate response in sufficient time to meet requirements imposed by the emergency;
	**Incident Reporting and Investigation**	In disclosing the immediate action taken after the occurrence and the results of these actions. Also providing feedback on the ERP, in the case of improvements to be implemented or new scenarios identified during the investigation process, which must be considered therein;

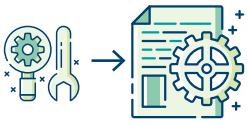
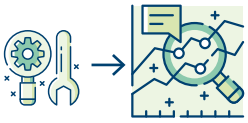
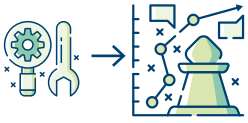
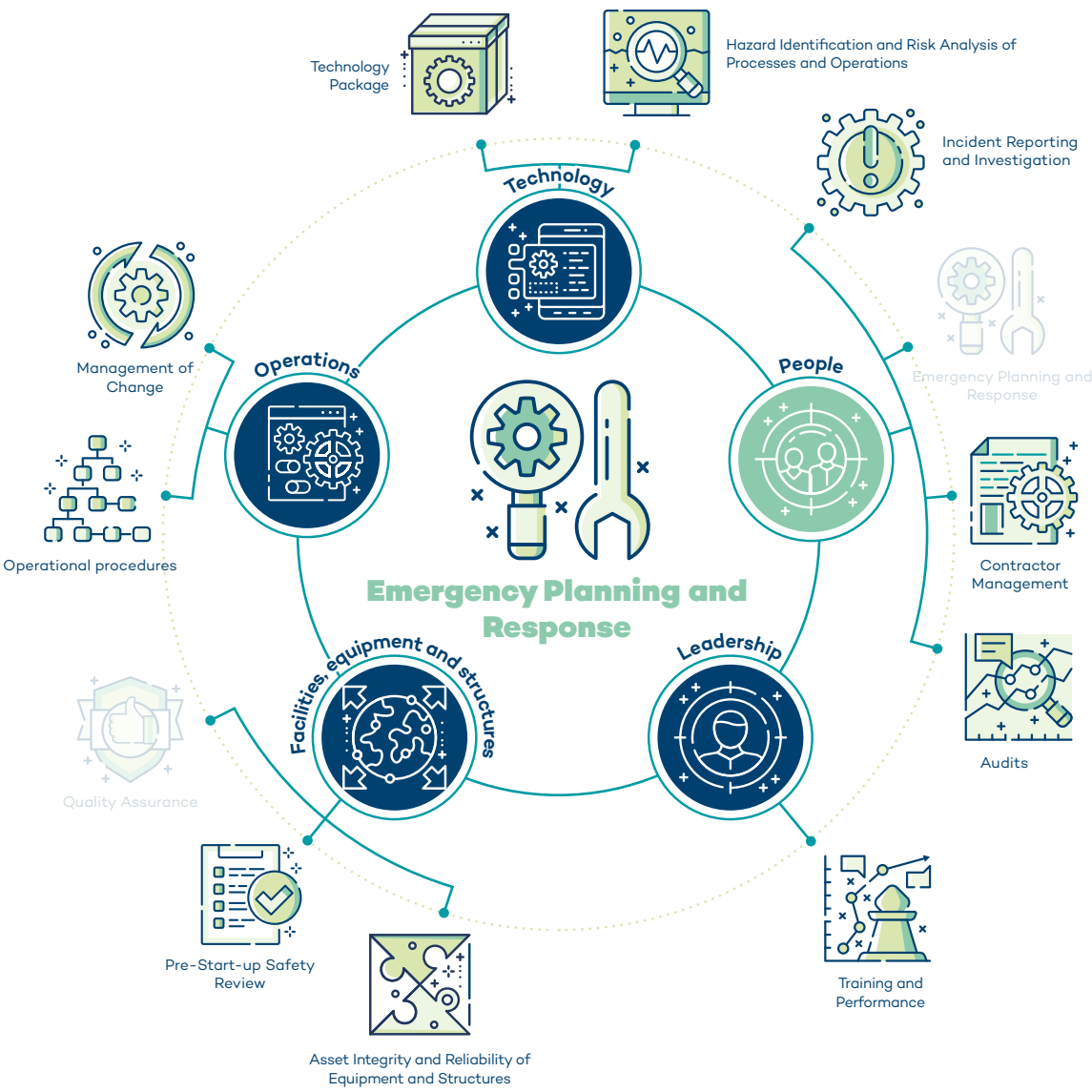
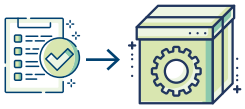
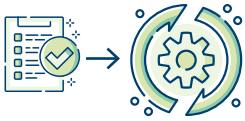
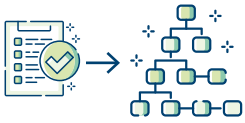
	**Contractor Management**	By ensuring knowledge of all workers hired in EP&R of the establishment and including these individuals in drills of sites where they carry out their activities. In the case of outsourced specialized services, such as services involving explosives and electricity, contractors can contribute to improving the ERP of the site where they operate;
	**Audit**	Provides audits with information regarding action plans in emergencies to be assessed for compliance and adherence to established standards;
	**Training and Performance**	Which provides support and control of ERP training, information and general guidance to its own team, communities, contractors, government bodies and external agencies. It also specifies specific training for each professional responder, according to their role in the emergency. It also monitors emergency response performance for drills and real events.

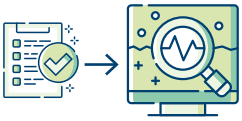
Figure 10: Graphical diagram of the interaction of the **Emergency Planning and Response** element.

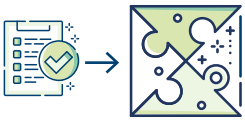
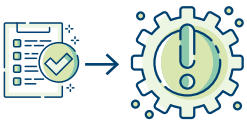


1.3.4.3 Contractor Management

The **Contractor Management** interacts with:

 **Technology Package**	From where information is obtained concerning process parameters and operations to carry out activities within the normal thresholds and conditions of operations, as well as restrictions and prohibitions that may impact performance of activities, as in the case of providing information on geological and hydrological characteristics, hydrogeological, physical and mine equipment, reactive rocks, which are relevant to operations, such as, for example, drilling and blasting;
 **Management of Change**	Assessing the impact on the activities of contractors and the impact caused by them, in addition to the need to change risk communication, procedures or even the performance of activities so new risks are not added to operations or that the current risk level is not increased;
 **Operational procedures**	Formally communicating to contractors the expected standards, risks and controls to prevent new risks from being added to operations or the risk level from being increased. Contractors shall also design procedures applicable to their activities, which must be validated by the client organization;

	**Hazard Identification and Risk Analysis of Processes and Operations**	Provide the contractor with relevant concerning about existing risk scenarios that may impact the activities and operations in which the companies and contracted workers are involved and what controls are used to avoid an event;
		Keeping information about risks and their respective controls updated between the contractor and client throughout the period during which activities are carried out;
		Identifying hazards and analyzing risks to support the assessment of the contractor's ability and competence to manage process safety risks inherent to carrying out activities exclusive under its purview;
		Integrating the risk analyzes of activities prepared by the contractor and related to its expertise and the risk analyzes of the area where it will work, identifying possible impacts on the site and supporting the shared adoption of prevention and control measures.
	**Quality Assurance**	Communicating, controlling and monitoring practices, requirements and standards so activities and services related to projects of structures, assets and facilities critical to the safety of processes carried out within the company's facilities are observed in accordance with the Technology Package;

	**Pre-Start-up Safety Review**	Providing and receiving information (Technology Package, regulatory requirements, risk analysis control actions, etc.) for verification during the quality review and specification of contracted services that may impact the safe start of operations throughout the entire life cycle of the asset;
	**Asset Integrity and Reliability of Equipment and Structures**	Obtaining and providing information on assets, structures and systems critical to process safety, their maintenance requirements and on the standards and methods for performing contracted services related to this element. It is incumbent on the company that contracts the services to validate the standards of the contractor;
	**Incident Reporting and Investigation**	Obtaining and providing information about events and lessons learned, whether internal or external, feeding the client's Incident Investigation and Communication process and updating the Contractor Management system for the purposes of preventing new events from occurring and evolving current practices to avoid occurrence of other events. Events involving contractors must be investigated by a single team made up of representatives from the organization and the contractor and learning must be shared and disseminated internally by both parties;

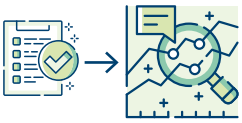
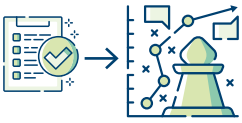
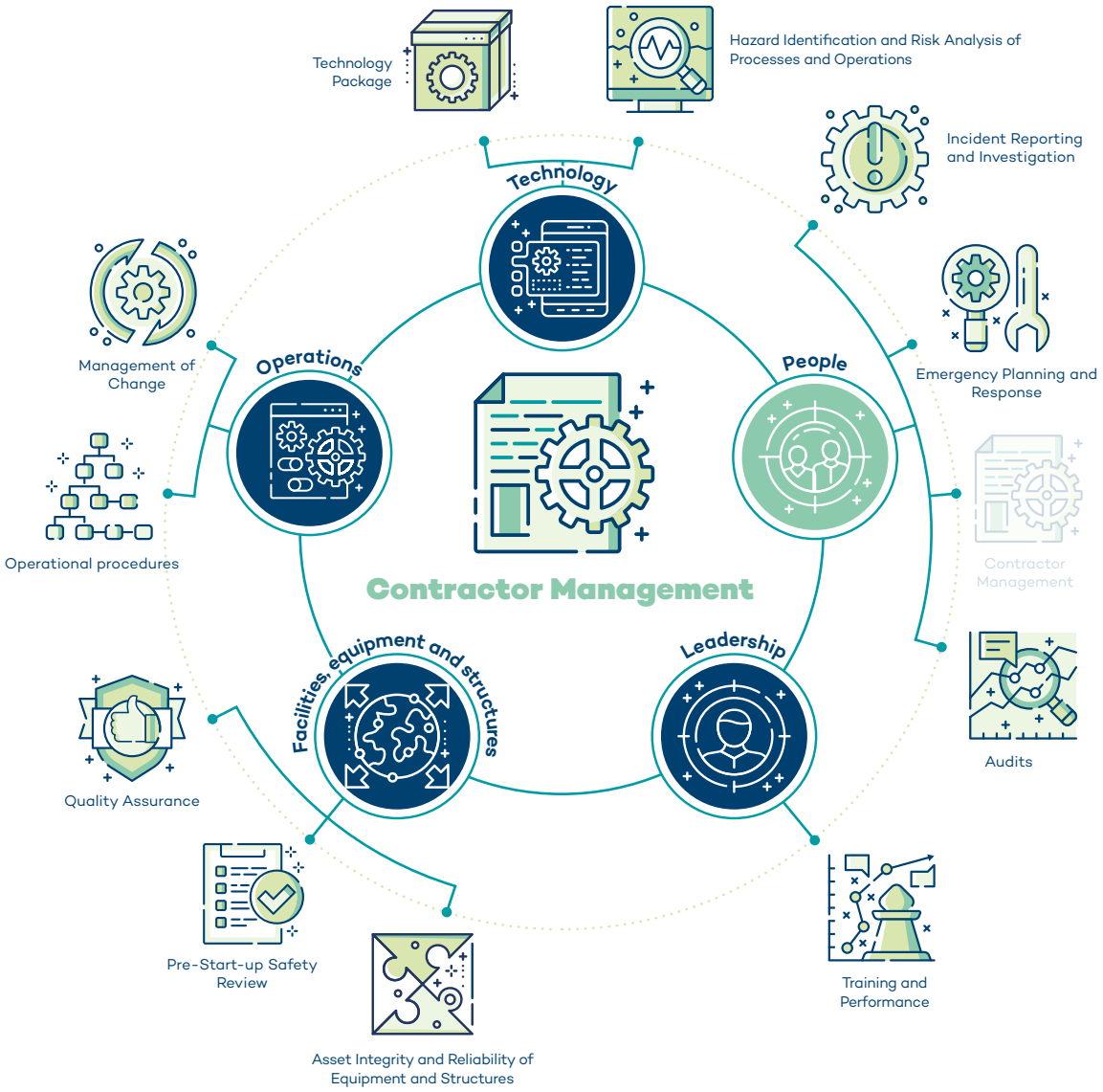
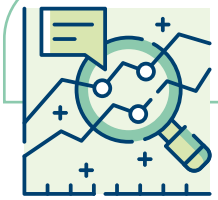
	**Emergency Planning and Response**	Through dissemination and training of emergency response procedures to workers of contractors and considering the interference that these workers and their activities may cause in the planning of response to events;
	**Audits**	Provide information audits to be evaluated for compliance with established standards;
	**Training and Performance**	Through training of workers hired to prevent new risks from being introduced into operations or pre-existing risks from being increased. Specifies the minimum training requirements for contractors' workers so that they can safely perform their activities when interacting with the process or with elements that affect Process Safety, such as, e.g., safety barriers or critical controls.

Figure 11: Graphical diagram of the interaction of the **Contractor Management**

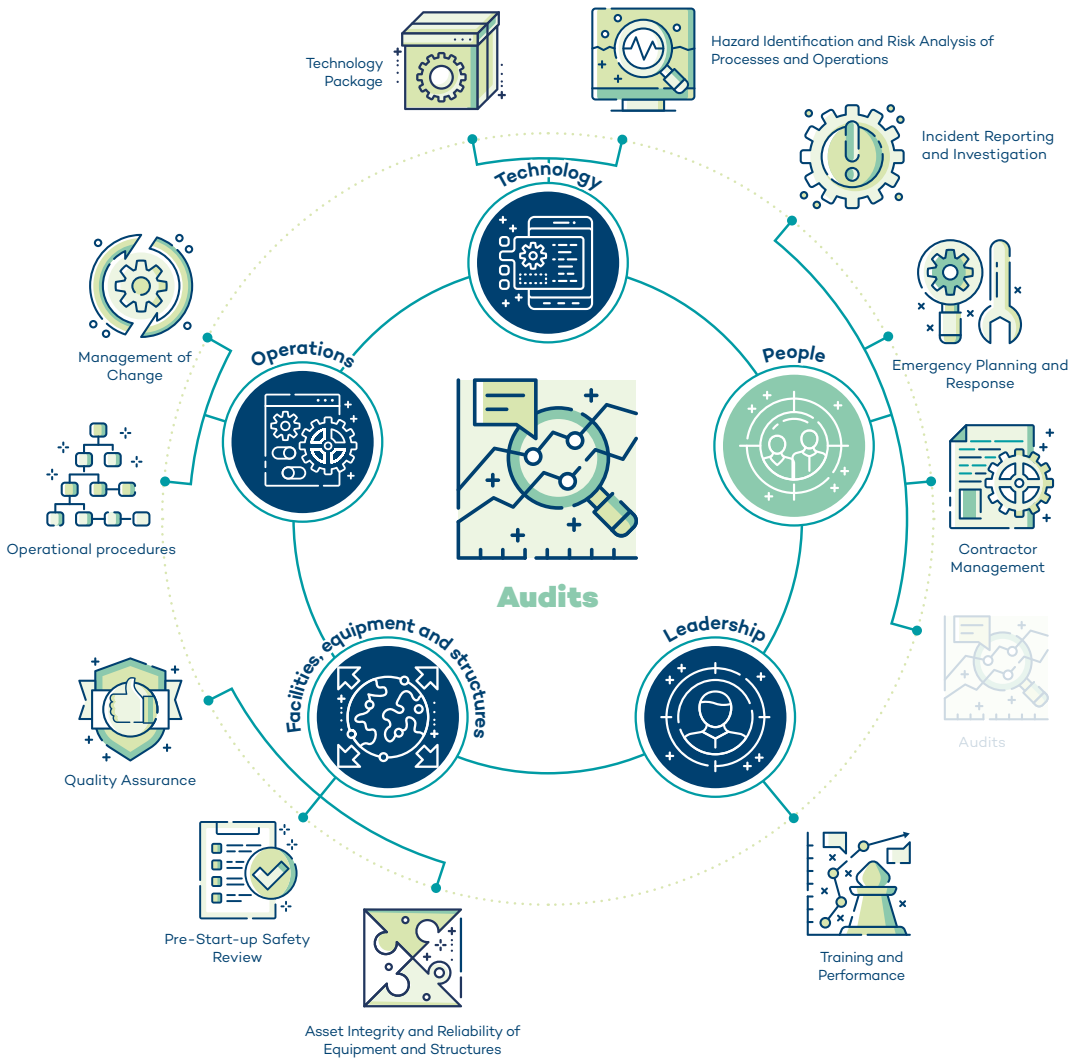




1.3.4.4 Audit

The **Audit** element interacts with all other elements in aspects related to verifying their adequacy through the establishment of an audit program

Figure 12: Graphical diagram of the interaction of the **Contractor Management** element

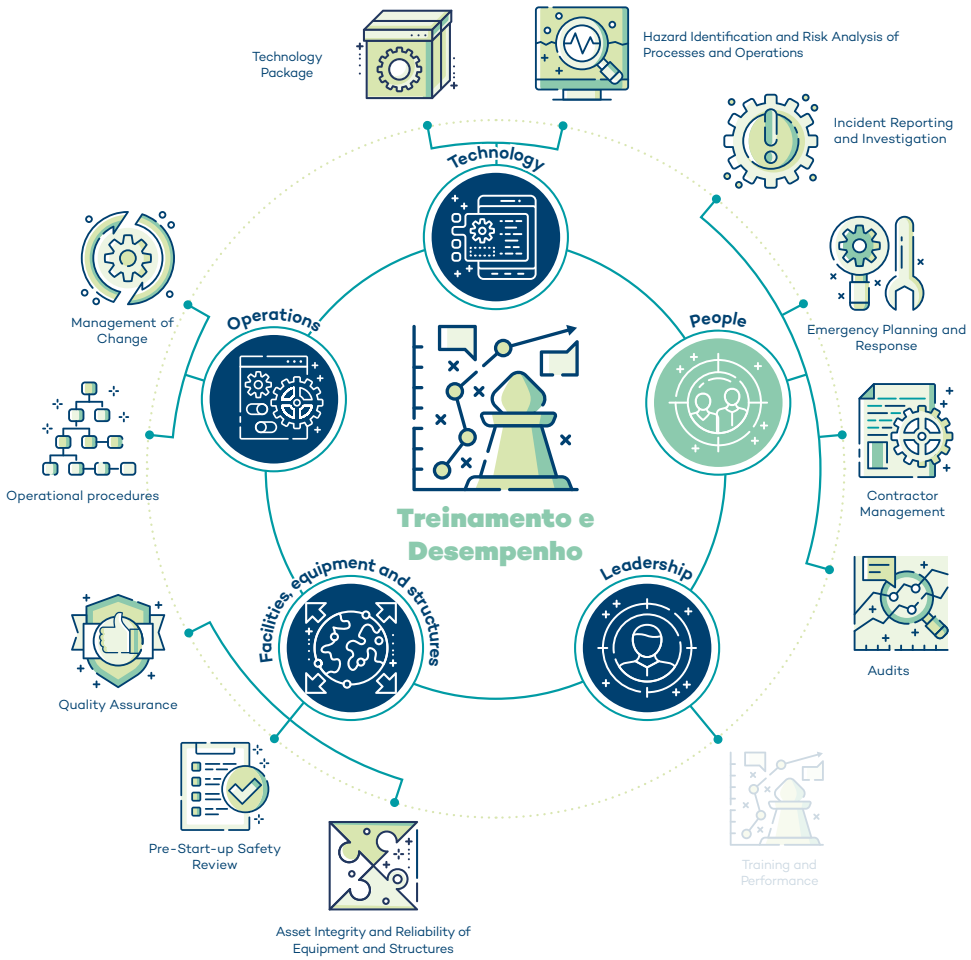


1.3.5 Leadership

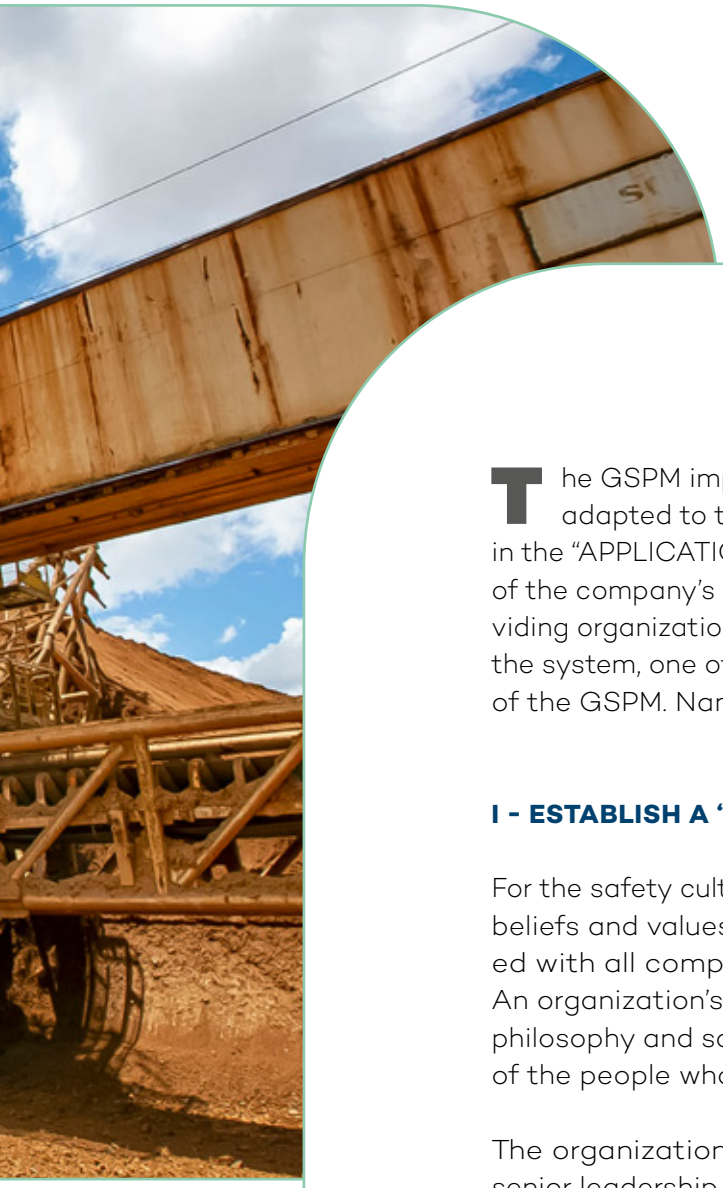
1.3.5.1 Training and Performance

The **Training and Performance** element interacts with all other elements in aspects related to verifying their adequacy with the establishment of a training and performance program.

Figure13: Graphical diagram of the interaction of the **Contractor Management** element



2. PRINCIPLES FOR IMPLEMENTING GSPM



The GSPM implementation strategy must be evaluated and adapted to the context of each organization, as described in the "APPLICATION" section of this technical guide. Regardless of the company's choice, four key steps are fundamental to providing organizational support for the continuous improvement of the system, one of which establishes the actual implementation of the GSPM. Namely:

I - ESTABLISH A "SAFETY CULTURE":

For the safety culture to be effective, it must integrate the basic beliefs and values of an organization. It must be interconnected with all company activities every single day of the year. An organization's safety culture is established by the mission, philosophy and safety principles demonstrated in the behavior of the people who comprise it.

The organizational commitment to safety must come from senior leadership and ensure that all people involved in the organization's processes and activities have attitudes and work to avoid accidents and incidents outside and inside work

II - PROVIDE LEADERSHIP AND COMMITMENT FROM SENIOR LEADERSHIP:

Senior leadership and commitment form the foundation of a lasting effort to achieve and sustain excellence in GPSM. The true commitment of leadership that aims to achieve excellence and continuous improvement in process safety is characterized by actions that support and continually reinforce the company's goals and policies. It is important that these actions begin at the highest competent leadership level and extend through each level of the organization.

The responsibilities of senior leaders are:

- Establish the principle that safety is an organizational line responsibility;
- Develop and communicate GSPM policies, principles and standards;
- Establish clear responsibilities for the group's performance in relation to specific goals and/or objectives related to Process Safety;
- Allocate resources to implement GSPM policies and standards and to maintain continuous improvement of Process Safety;
- Implement and disseminate the organization's safety mission and philosophy;
- Provide and encourage a wide range of employee involvement at all hierarchical levels and in Process Safety activities, including operators, mechanics, technicians, engineers, specialists and managers, ensuring the necessary resources and support;

- Verify the degree of compliance with established Process Safety policies and standards and implement appropriate corrective measures;

- Personally participate in activities that visibly demonstrate commitment to Process Safety;

- Include GSPM in the organization's integrated management system.

III - IMPLEMENT A DETAILED GSPM PROGRAM:

As already mentioned in item 3, organizations can implement the GSPM in full as proposed in this guide or adapt or combine existing management systems to cover the Process Safety aspects established in this guide, reformulating current processes and complementing gaps in the management system with new processes or missing activities or even use this guide as a reference to improve a particular element of the existing management system.

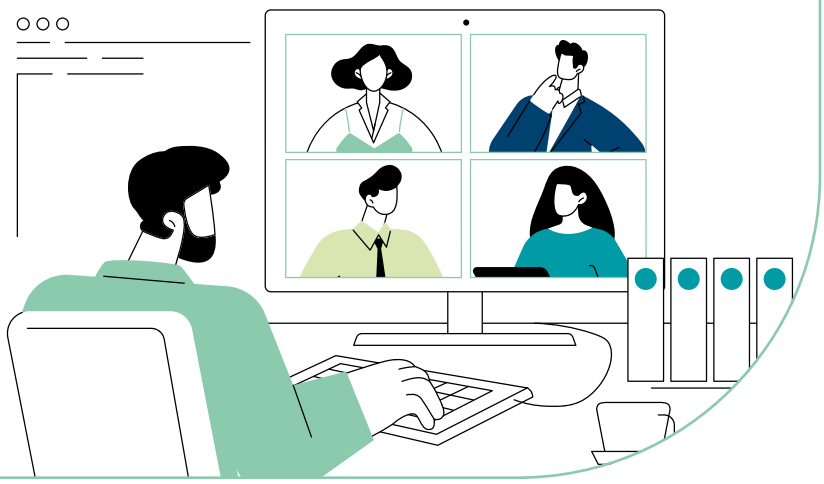
IV - ACHIEVING "OPERATIONAL EXCELLENCE":

An organization achieves operational excellence when each of its members develops a deep dedication and commitment to carrying out each task safely. At this stage, the recognition and encouragement of initiatives that demonstrate this commitment and commitment to safety must be inherent at all levels of leadership.

2.1 GSPM Implementation

The GSPM activities must be integrated into the routines of each organization and adapted to its structure and local context and the same procedure extends to the strategy selected for operationalization. Among the various options, there is the creation of an independent multidisciplinary working group for the implementation and improvement of the GSPM or the integration of this group within theme-based committees on a local regional or even international level. It does not matter which option is chosen; What is crucial is that there is integration between the work groups, the company's strategy and that due visibility is given to senior leadership on the topic.

A typical model for operationalizing the GSPM is presented below. This is an independent and multidisciplinary GSPM committee, which may or may not report its activities within the organization's central ESG forum. This model is frequently adopted, with adaptations to the structure, roles and responsibilities, according to the local and organizational context. It is suggested to use this example as a reference for operationalizing the GSPM, as this format is not, at any time, mandatory for operationalization



2.2 GSPM Committee

GSPM Sponsor

Member of senior leadership competent to provide resources and authority so that the GSPM coordinator can evolve in its activities.

It is the responsibility of the GSPM Sponsor to help ensure that adequate resources are made available to demonstrate leadership, overall management commitment, and appoint a GSPM coordinator.

GSPM Coordinator

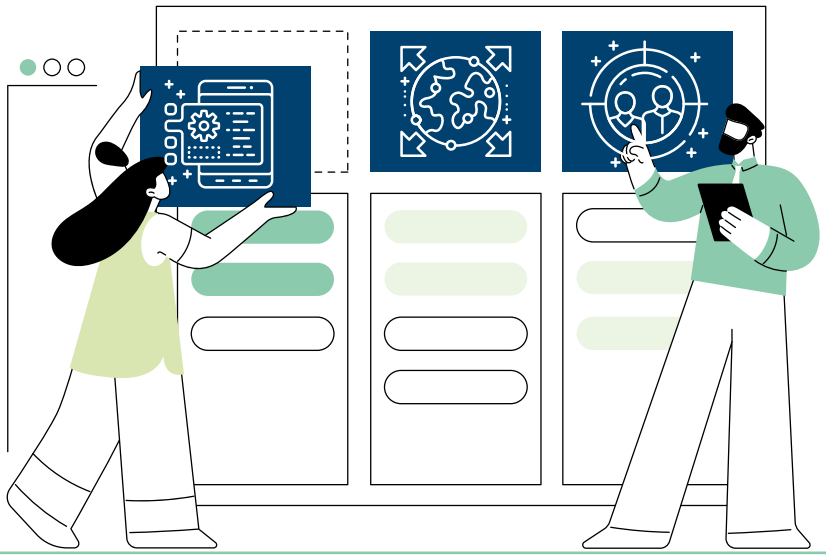
Also designated as GSPM Leader. Responsible for disseminating process safety knowledge, mainly within the GSPM Committee. That person has the role of articulator and facilitator of GSPM implementation and improvement activities, mainly between the leaders of the axes and elements of the system.

System axis leader

Responsible for articulating and coordinating activities related to the implementation and improvement of each element that is grouped within a specific GSPM axis. Works in tandem with leaders from other areas and under the leadership of the GSPM Coordinator.

Element Leader

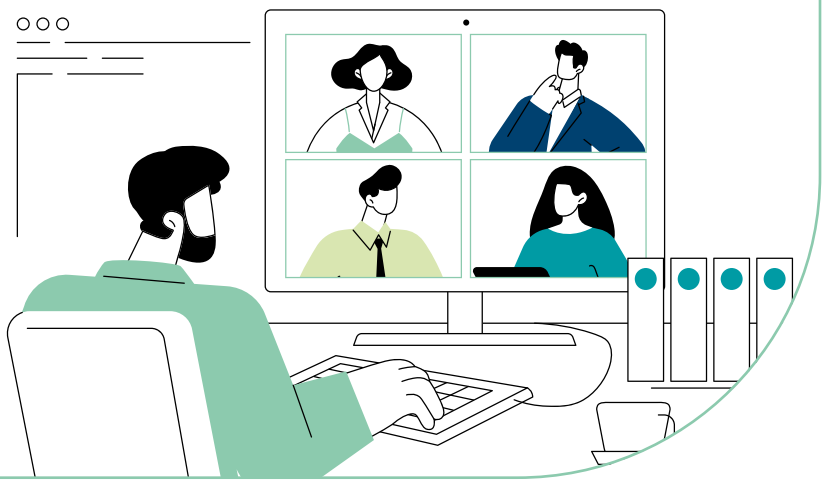
Specialist professional with decision-making power to implement or improve processes related to a specific element of the GSPM. Works under the coordination of the Leader of the Axis to which its element is related.



2.3 Responsabilities of Leaders of Axis/Elements

- Motivate the team;
- Display leadership and commitment;
- Be responsible for decision-making and effective communication within and outside the element;
- Hold meetings with all members of the element as applicable;
- Send the indicators and the P x R Schedule (Scheduled x Accomplished) monthly to the person responsible within the established deadline;
- Keep procedures and documents related to their element up to date;
- Delegate and organize the performance of the tasks of his element;

- Participate in training, when necessary, and ensure the presence of employees under his responsibility, when requested;
- Ensure that adequate time is being spent carrying out tasks linked to GSPM;
- Comply with the schedule according to the established deadline;
- Participate in your element's GSPM audits;
- Ensure that identified non-conformities are addressed and verified for their effectiveness within the established deadlines;
- Keep the GSPM coordinator informed and updated about the activities and implementation of his element;
- Be aware of the problems and difficulties of your element and report them, when necessary, to the coordinator of the GSPM subcommittee;
- Designate a member of your team to represent him in cases of absence (vacation, travel, leave – backup).



2.4 Responsabilities of the GSPM Coordinator

- Motivate his Team / Elements under his responsibility;
- Demonstrate Leadership and Commitment;
- Be responsible for decision-making and effective communication with and outside elements in alignment with the business leader/senior organizational leadership;
- Hold meetings with all element leaders as applicable;
- Participate in training, when necessary, and ensure the presence of elements under his responsibility, when requested;
- Ensure that adequate time is being spent carrying out tasks linked to GSPM;
- Ensure compliance with the schedule of the elements under his responsibility according to the established deadline;

- Participate in GSPM audits of the elements under his responsibility;

- Be attentive to information and updated about problems, activities and implementation of its elements, listening to them and assisting them when necessary.

- Disseminate the updated version of the GSPM guide to Element leaders/managers of the areas involved in the sites;

- Participate in Pre-Start Safety Reviews of new units or existing units that have undergone major modifications;

- Manage GSPM indicators and prepare a monthly report monitoring the performance of each element and forward it to element leaders, after analysis by the GSPM Committee;

- Audit the work unit's GSPM programs;

- Provide technical assistance on GSPM to work units;

- Coordinate the exchange of information between business units or areas of the organization;

- Coordinate the transfer of responsibilities related to GSPM between organizations (sites, directorates and headquarters);

- Help ensure that adequate attention is paid to GSPM during activities (e.g., formation of joint ventures, acquisitions, outsourced operations, process decommissioning, and process discontinuation).

2.5 GSPM Leading Indicators

All GSPM elements adopted by the organization, as described in the “APPLICATION” section of this technical guide, they must have their own indicators that will serve as a parameter to measure the performance of their activities and project implementation. These indicators must be assessed monthly by the Safety Committee. For each of the indicators, at least one goal will be defined and its performance will be evaluated and corrected if necessary in order to achieve the effective implementation of the system.

APPENDIX

1. MINING INDUSTRY PROCESS SAFETY LEADING INDICATORS IDENTIFICATION GUIDE

1.1 Goal

Establish requirements, criteria and general principles associated with the process of identifying and recording Process Safety Events for the mining industry in order to support the preparation of the Annual Performance Analysis Report through proactive and reactive indicators, as a result of the 2019 Letter of Commitment.

1.2 Application

The requirements described in this procedure apply to companies in the mineral sector associated with the Brazilian Mining Institute (IBRAM).

1.3 Requirements

1.3.1 General Requirements

Companies associated with IBRAM must understand a single vision regarding the construction of proactive and reactive process safety indicators across the mining industry, including a common set of definitions and criteria that will serve individual companies and the sector as a whole as a mechanism to identify and classify events in order to drive continuous improvement in company performance.

The objective of identifying indicators associated with operational safety is to complement companies' existing management regarding occupational safety, the environment and other related topics.

The construction of the systematics for this guide follows the guidelines of the Guide for Selecting Leading and Legging Indicators (2021) and the experiences of mining companies, considering the specificities of the mining sector.

Considering that an essential element of any continuous improvement program is the measurement and trending of performance data, it is recommended to continually improve process safety performance in organizations. It is essential that there are proactive and reactive process safety indicators considering the following characteristics (CCPS 2021):

Reliable: must be measurable using an objective or independent scale. To be measurable, an indicator needs to be specific and distinct;

Repeatable: similar conditions will produce similar results and different trained teams measuring the same event or data point will obtain the same result;

Consistent: Units and definitions are consistent across the company. This is particularly important when indicators from one area of the company are compared with those from another;

Independent from External Influences: the indicator leads to correct conclusions and is independent of the pressure to achieve a specific result;

Relevant: the indicator is relevant to the operational discipline or management system being measured; they have a purpose and lead to an actionable response when outside the desired range;

Comparable: the indicator is comparable with other similar indicators. Comparability can be over time within a company or across an industry.

1.3.2 Specific Requirement

Considering the CCPS guidelines, the conceptual proposal of this guide is to work on two types of indicators:

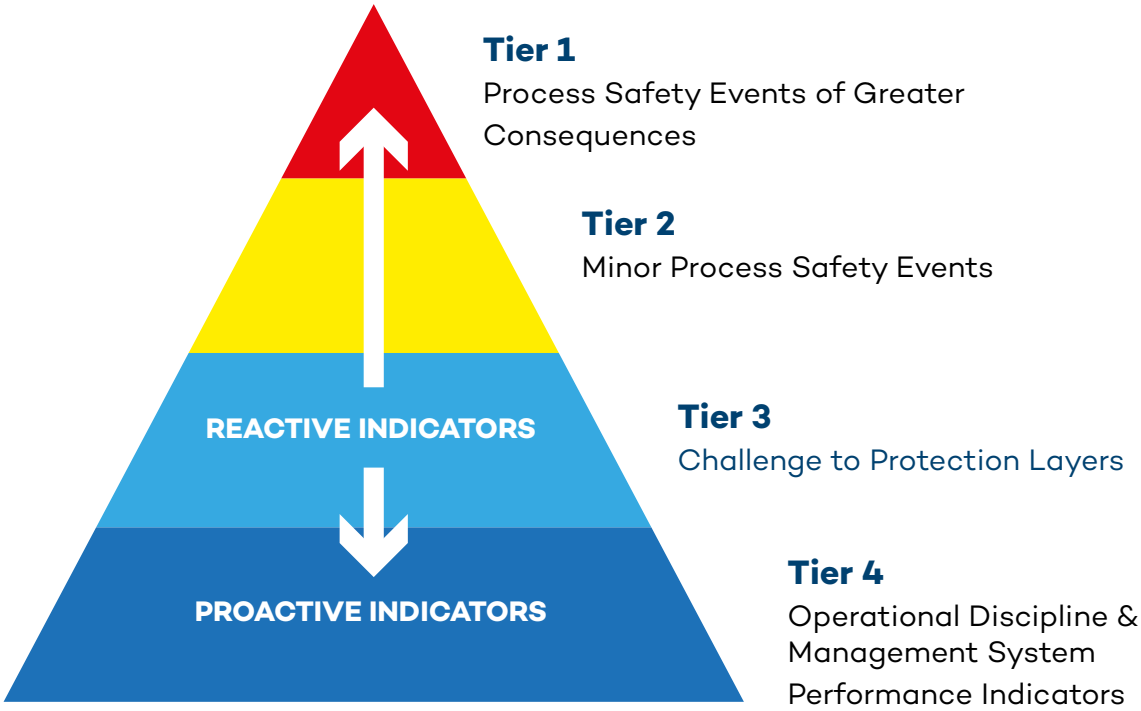
- **Reactive Indicators** – a retrospective set of indicators based on incidents and accidents that have occurred and that meet an established threshold of severity;

- **Proactive Indicators** – a set of indicators aimed at prevention that indicate the performance of main work processes, operational discipline or layers of protection that help to avoid possible incidents and accidents.

The set of indicators is represented at different levels of the pyramid, as illustrated in Figure 1.

The pyramid is divided into four separate levels based on the severity of the accident or incident that occurred or could have occurred. These levels correspond to the four Tiers observed in API RP 754 [1], ranging from the most consequential accidents, classified at Tier 1 level, and proactive performance assessments, which occur at Tier 4 level.

Figure 1: **Tiers and respective types of Indicators**



(https://www.aiche.org/sites/default/files/docs/pages/ccps_process_safety_metrics_-_v3.1_-_pt_final.pdf - página 9

The pyramid proposes the distribution between reactive indicators - associated with events with real losses - and proactive indicators - associated with the successful operation of protection barriers, as well as the performance assessment of the management system aimed at the safety of operational processes.

It is recommended that companies in the mining segment analyze the indicators at each level to help them monitor their process safety performance, according to the guidelines in the Guide for Selecting Leading and Legging Indicators (2021).

However, for the purposes of preparing the Annual Performance Analysis Report, **IBRAM'S initial proposal** is to present a methodology that considers the stages of identification and classification of **Tier 1 and Tier 2** as a guide for identifying events with greater severity.

By sharing information in the Annual Report, companies will enable benchmarking analysis, contributing to boost engagement in the implementation of the theme and propose continuous improvements in process safety performance for the mining industry.

1.3.3 Process steps

A Process Safety Event (PSE) are occurrences arising from the production process of the mineral sector, potentially catastrophic, which can result in an impact on equipment and/or operational assets, impacts on the environment or damage to people.

To apply the concept in mining, not only the release of hazardous material was considered, but also of **hazardous energy**, using, in an expanded form, the concept of Loss of Primary Containment (LOPC).

It is important to highlight that the event involves the performance or absence of controls/barriers/safeguards of operational facilities, within a pre-established coverage area intended for the activities of development, mining, processing, processing, production and transfer/transportation of products and materials.

As a way to facilitate the application of the methodology to identify and classify a Process Safety Event, two steps must be followed:

I. respond to a flow with strategic questions that, using lead professionals to some reflections that may or may not result in the identification of an operational process safety event;

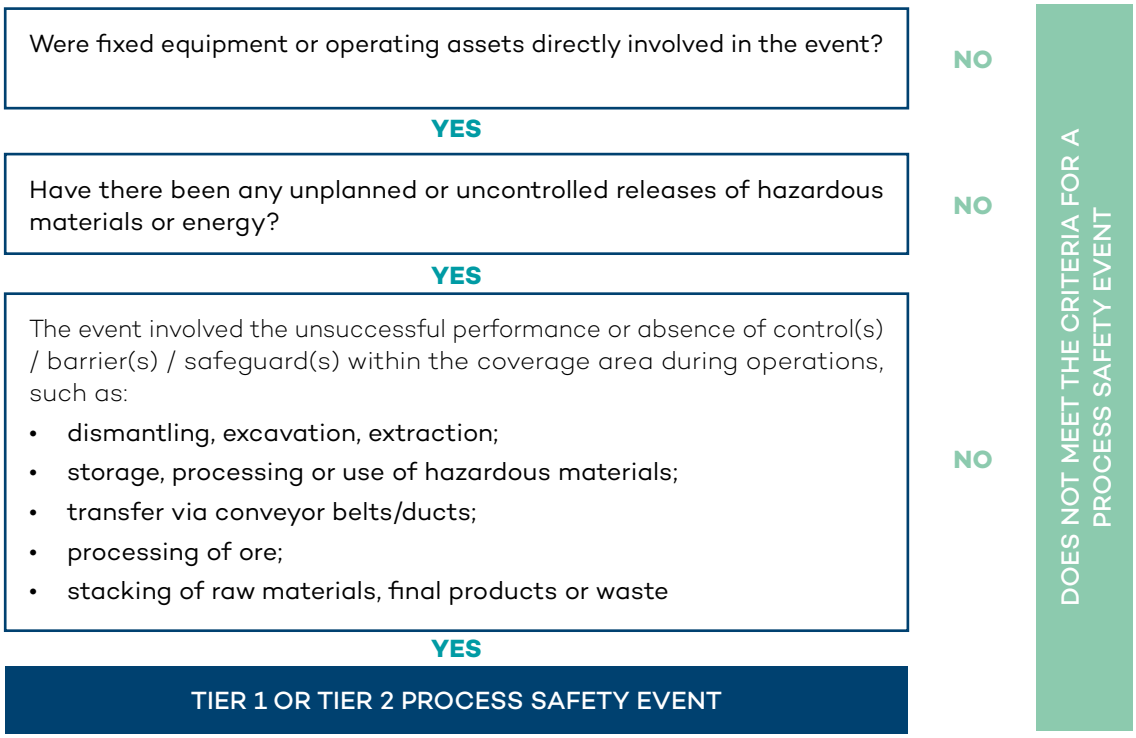
II. analyze the criteria developed considering the specificities of mining operations in order to identify the different levels of severity, resulting in the classification of events with real losses into Tier 1 and Tier 2.

It should be noted that every event is important and must be identified, recorded and treated in line with the strategy of companies associated with IBRAM to prevent accidents with catastrophic potential in human lives, the community, the environment, operational continuity and company reputation.

STEP 1

PROCESS SAFETY EVENT IDENTIFICATION FLOWCHART

Figure 2: **Process Safety Event Identification Flowchart**



STEP 2

CRITERIA FOR CLASSIFICATION OF PROCESS SAFETY EVENTS

Tier 1	Tier 2
A fire or explosion or unplanned/unintentional detonation that results in a direct cost greater than or equal to US$ 100,000 to the Company; (CCPS)	A fire or explosion or unplanned/unintentional detonation that results in a direct cost greater than or equal to US$2,500 to the Company; (CCPS)
Ultra launch that goes beyond the enclosure of the area defined in the Fire Plan and that goes beyond the limits of the project	Ultra launch that goes beyond the enclosure of the area defined in the Fire Plan within the limits of the project with a time of more than 24 hours for the safe resumption of the dismantling process (drilling and loading)
Officially declared community evacuation or community shelter in place; (CCPS)	Declared on-site evacuation or community shelter-in-place depending on actual occurrence in operations
Release of material that exceeds limit quantities within a period of one hour; (CCPS – including mining parameters) See table 1	Release of material that exceeds limit quantities within a period of one hour; (CCPS – including mining parameters) See table 2
Disabling (permanent) fatality or injury to employees, contractors and/or community member as a result of an operational process safety event;	Recordable injury (with high potential for fatality, with lost time) of an employee or contractor as a result of an operational Hospital admissions of community members;

Tier 1	Tier 2
Total transverse rupture of the conveyor belt with deformation of the equipment support structure. Fall of the counterweight is inherent to total transverse breaking	Total transverse rupture of the conveyor belt with damage (loss of function) of secondary structures (such as component supports, drive system, drums, rollers, chutes, flow control devices, moving heads, belt turners, moving chute, stands, side protections and cover).
Environmental impact that goes beyond the limits of the enterprise with adverse effects on the environment, restoring the integrity of the environment over a period of more than 5 years or not reestablishing its integrity (irreversible damage);	Environmental impact that goes beyond the limits of the enterprise with adverse effects on the environment, restoring the integrity of the environment in a period longer than 1 week to 5 years (reversible damage).
EAR and/or dam failure with real consequence of high, very high or extreme failure (Global Industry Standard for Tailings Management reference), with moderate transfer/compensation for communities <US$100 million.	Over-topping of the dam or dikes with structural compromise of the dam, but without opening a breach. Slope failures in the massif or dam abutments or Tailings Storage Structure (EAR) without total or partial uncontrolled release of the reserved material.
Rupture of pipelines (mineral pipeline, waste pipeline and others) with adverse effects on the environment, restoring the integrity of the environment within a period of more than 5 years or not reestablishing its integrity	Rupture of pipelines (mineral pipeline, waste pipeline and others) with adverse effects on the environment, restoring the integrity of the environment in a period of more than 1 week and less than 5 years (reversible damage)

Tier 1	Tier 2
Underground mine - Collapse of essential geotechnical infrastructures and main access to people and equipment: portals; main and emergency ramps; (shaft/ loading station); and ventilation galleries with damage equal to or greater than US$ 100,000 direct cost;	Underground mine - Collapse of essential geotechnical infrastructures and main access to people and equipment: portals; main and emergency ramps; vertical well (shaft/loading station); pumping galleries and ventilation galleries with damage of less than US$100,000 in direct cost and more than US$2,500.
Underground mine - Explosion events, fire in underground equipment and gassing that require the use of the refuge chamber by one or more workers, employees or service providers with a stay time of more than 6 hours.	Underground mine - Explosion events, fire in underground equipment and gassing that require the use of the refuge chamber by one or more workers, either employees or service providers, with a stay of less than 6 hours.
Rupture of a geotechnical asset (except dam and EAR) that has a direct cost of repairing damage to the structure itself, as well as those resulting from its possible impact on fixed equipment or infrastructure, with values exceedingUS$ 2 MM/BR$ 10 MM;	Rupture of a geotechnical asset (except dam) that has a direct cost of repairing damage to the structure itself, as well as those resulting from its possible impact on fixed, mobile or infrastructure equipment, with values equa to or greater than US$ 500k/ BR$ 2.5MM.

Tier 1	Tier 2
Rupture of a geotechnical asset (except dam) reaching an area where people are constantly occupied, or frequent traffic of equipment/vehicles and with an effect on restricting access to the workplace, or on pedestrian circulation, or on passenger transport, or on drainage of products or operation and with a plan time for the safe resumption of activities exceeding 24 hours, measured from the interruption caused by the event until the safe release for resumption of activities.	Rupture of a geotechnical asset1 (except for dam) reaching an area of permanent occupation of people, or frequent transit of equipment/vehicles and with an effect on restricting access to the workplace, or on the circulation of pedestrians2 or on the transport of passengers3, or on the flow of products4 or on the operation5 and with time for the safe resumption of activities6 under than 24 hours, measured from the interruption caused by the event until the safe release for resumption of activities

1 Structures or assets, such as piles of materials, waste or waste, pits, underground excavations and embankments (natural and man-made). 1 Structures or assets, such as piles of materials, waste or waste, pits, underground excavations and embankments (natural and man-made).

2 Total interruption of the movement of people when pedestrian crossings and/or walkways are reached in or around operational areas.

3,4 Highways, internal and external access in or around operational areas: occupation of the full width of at least one of the carriageways.

5 The replacement of mining or material disposal fronts, as well as accesses impacted by the rupture of an asset, do not distort the occurrence. The same rationale must be considered for industrial assets impacted by geotechnical ruptures.

6 The execution of activities to reestablish the safe condition of a geotechnical asset must be performed after the issuance of the PTS - Work Permit and ART – Task Risk Analysis, with mandatory evaluation and approval by the Geotechnics team.

Note 1

To classify geotechnical events, the flow for geotechnical events must be considered (appendix 02). Moreover, the following parameters must also be considered:

- **Constant** occupation: area where there is the presence of person(s) of 10% or more of the working day (=>10%) (example: considering work authorization depending on the mining plan).
- **Sporadic** occupation: area where there is the presence of person(s) for less than 10% of the journey (<10%).
- Frequent traffic of equipment/vehicles: area where there is traffic of 10% or more per day (24 h) (=>10%).
- Occasional traffic of equipment/vehicles: area where there is traffic less than 10% of the day (24 h) (<10%).

Note 2

All geotechnical assets must be considered as a coverage area for classifying process safety events. Geotechnical assets out of operation and in stopped mines should also be considered

Table 1: **Release quantity of hazardous materials – Tier 1:**

Classification	Tier
Products in Zone TIH A (e.g. nickel carbonyl, etc.)	⩾ 5kg
Products in TIH Zone B (e.g. chlorine, hydrogen sulfide, etc.)	⩾ 25 kg
Products in TIH Zone C (e.g. sulfur dioxide, etc.)	⩾ 100 kg
Products in Zone TIH D (e.g. ammonia, carbon monoxide, ethylene oxide,etc.)	⩾ 200kg
Flammable gases or flammable liquids with a boiling point < 35 °C and flash point < 23 °C (e.g. natural gas, methane, propane, acetylene, hydrogen, LNG LPG, etc.)	⩾ 500kg
Flammable liquids with boiling point > 35 °C and flash point < 23 °C (e.g. gasoline, ethanol, methanol, etc.)	⩾ 1000kg
Flammable liquids with flash points > 23 °C and < 60 °C (e.g. diesel, low sulfur diesel, biodiesel, kerosene, most aviation fuels, etc.)	⩾ 2000kg
Liquids with a flash point > 60 °C released at a temperature equal to or greater than their flash point (e.g. lubricants, ethylene glycol, propylene glycol, molten sulfur, etc.)	⩾ 2000kg
Combustible product below P.F. or Combustible Dust (e.g. coke, coal, ores containing high concentration of pyrite, etc.)	⩾5000kg
inert gas (e.g. nitrogen, argon, carbon dioxide, steam, etc.)	⩾ 2000kg
oxidizing (Gas, Liquid or Solid) (e.g. oxygen, peroxides, persulfates, perchlorates, etc.)	⩾ 2000kg
corrosive product above P.E. or atomized (e.g. hydrogen chloride, sulfuric acid mist, etc.)	⩾ 500kg
corrosive products below the P.E. (e.g. sulfuric acid, sodium hydroxide, hydrochloric acid, lime, etc.)	⩾ 2000kg
explosives (e.g. ANFO, emulsions)	⩾ 1000kg
molten or hot material (e.g. molten slag, molten metal, hot calcine, hot dust, etc.)	⩾ 10.000kg

Table 2: **Release quantity of hazardous materials – Tier 2:**

Classification	Tier
Products in Zone TIH A (e.g. nickel carbonyl, etc.)	⩾ 0,5kg
Products in TIH Zone B (e.g. chlorine, hydrogen sulfide, etc.)	⩾ 2,5kg
Products in TIH Zone C (e.g. sulfur dioxide, etc.)	⩾ 10kg
Products in Zone TIH D (e.g. ammonia, carbon monoxide, ethylene oxide, etc.)	⩾ 20kg
Flammable gases or flammable liquids with a boiling point < 35 °C and flash point < 23 °C (e.g. natural gas, methane, propane, acetylene, hydrogen, LNG LPG, etc.)	⩾ 50kg
Flammable liquids with a boiling point > 35 °C and flash point < 23 °C (e.g. gasoline, ethanol, methanol, etc.)	⩾ 100kg
Flammable liquids with flash points > 23 °C and < 60 °C (e.g. diesel, low sulfur diesel, biodiesel, kerosene, most aviation fuels, etc.)	⩾ 200kg
Liquids with a flash point > 60 °C released at a temperature equal to or greater than their flash point (e.g. lubricants, ethylene glycol, propylene glycol, molten sulfur, etc.)	⩾ 200kg
Combustible product below P.F. or Combustible Dust (e.g. coke, coal, ores containing high concentration of pyrite, etc.)	⩾500kg
inert gas (e.g. nitrogen, argon, carbon dioxide, steam, etc.)	⩾ 200kg
oxidizing (Gas, Liquid or Solid) (e.g. oxygen, peroxides, persulfates, perchlorates, etc.)	⩾ 200kg
corrosive product above P.E. or atomized (e.g. hydrogen chloride, sulfuric acid mist, etc.)	⩾ 50kg
corrosive products below the P.E. (e.g. sulfuric acid, sodium hydroxide, hydrochloric acid, lime, etc.)	⩾ 200kg
explosives (e.g. ANFO, emulsions)	⩾ 100kg
molten or hot material (e.g. molten slag, molten metal, hot calcine, hot dust, etc.)	⩾ 1000kg

1.4 Leading Indicators Report

Indicators must be used to monitor the performance of results and can indicate changes in the effectiveness of the company or sector, contributing to driving continuous improvement in process safety in companies.

IBRAM's proposal is initially aimed at monitoring and reporting of Tier 1 and Tier 2 Process Safety Event indicators, which represent the absolute number of occurrences per company. Despite being on the list of reactive indicators, the strategy adopted seeks to encourage companies in the mineral sector to identify which types of events correspond to process safety events in mining and, therefore, understanding the theme to the industry

- **PSE1:** absolute number of Tier 1 Process Safety Events per month
- **PSE2:** absolute number of Tier 2 Process Safety Events per month

1.5 Conclusion

Monitoring occupational safety indicators alone is not enough to assess the safety of operations and, therefore, it is of fundamental importance to broaden the view of all aspects that can contribute to improving processes.

For IBRAM, hazard identification and risk management are essential conditions to ensure that the operations of any economic activity are at acceptable safety levels or higher than the required standards.

In this context, the identification and monitoring of these indicators aim to feed the annual reports on operational safety, through specific forums between companies in the mining industry, educational institutions and nongovernment al bodies.

By identifying, recording and treating these process safety events, IBRAM aims to contribute to the cultural transformation of companies, encouraging them to add other actions that can promote the prevention of serious industrial accidents to their current management system practices, improving strategic guidance in mining.

EXAMPLES OF PROCESS SAFETY EVENTS

1. During operation, a fire occurred on the belt conveyor due to the accumulation of material on the roller. The event had a direct cost of resuming operations of over US$ 100 thousand dollars. This event shall be considered Tier 1.

2. During the waste disposal operation, a rupture in the waste pipeline was identified, projecting the material into the watercourse close to the community, affecting the protected area and human consumption, resulting in irreversible damage. This event shall be considered Tier 1.

3. After the diesel tank filling activity, it was identified by the operator that 3000 kg of product had been overflowed into the tank's containment basin, caused by a failure of the pumping system. This event must be considered Tier 1, because, although the product was retained in the containment basin, the primary containment (tank) was lost.

4. During activity in an underground mine, a 10-ton piece of mineral detached from the front of the mine in operation, fatally striking the employee. This event must be classified as Tier 1, as the release occurred due to a failure in operational safety (uncontrolled or unplanned release of dangerous material/energy), resulting in fatality.

5. The driver was transporting water in a water truck when, while passing over a steep incline, the vehicle lost grip, hit a side drainage ditch and overturned. The driver suffered a injury with leave. This event should not be classified as a process safety event, as the water truck is a support equipment for the production process.

6. Open pit mine: after post-dismantling, the crest of the slope face was secured (removal of loose blocks) and released for mining. During the progress of the mining plan (area of constant occupation), there was a displacement that affected the manned equipment (excavator), impacting the operation, with a safe resumption time of two (2) days until removal of the excavator and assessment of the risks related to ruptures. There were no injuries, but the time for safe resumption of operations was more than 24 hours, which is why this event shall be classified as Tier 1.

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API RP 754, Third Edition, august 2021

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